BIODIVERSITY IN BELGIUM

ROYAL BELGIAN INSTITUTE OF NATURAL SCIENCES

Biodiversity in Belgium

Edited by
Marc Peeters, Anne Franklin & Jackie L. Van Goethem

Royal Belgian Institute of Natural Sciences

Brussels

2003

Contribution to the United Nations International Day for Biological Diversity, on the twenty-second of May.

Authors:
Biodiversity and extinctions, present and past - K. Wouters & A. Franklin
A country profile - A. Franklin, M. Peeters & V. Leentjes
Prokaryotic and botanic diversity - G. Rappé & J. Rammeloo
Zoological diversity - M. Peeters & J.L. Van Goethem
Belgian ecosystems listed in the Habitats Directive - E. Kuijken, M. Dufrêne & J. Tack
Biodiversity of the Regions and North Sea:
- Biodiversity in the Brussels Capital Region - M. Gryseels
- State of Nature in Flanders - E. Kuijken, J. Tack & L. De Bruyn
- Biodiversity in Wallonia - E. Branquart, C. Debruyne, L.-M. Delescaille & Ph. Goffart
- Biodiversity of the Belgian marine areas - F. Kerckhof & J.-S. Houziaux

Citation:
PEETERS, M., FRANKLIN, A. & VAN GOETHEM, J.L. (eds), 2003. Biodiversity in Belgium. Royal Belgian Institute of Natural Sciences, Brussels: 416 pp.

Published:
August 2003

Printed by ERASMUS, Wetteren, on recycled paper.

ISBN 90-73242-08-8

Legal depot: D/2003/0339/1

NUR: 922, 941, 942, 940, 120, 130

Cover illustration: Virelles (Damien Hubaut / Wildlife Pictures).

Acknowledgements

The editors are deeply grateful to the authors for the time spent on drafting the texts, and to the peer-reviewers for their constructive and valuable feedback.

We would like to extend special thanks to Dominique CASEAU for her assistance in the language improvement of the manuscripts. Han DE KOEIJER and Diana OORTMAN provided useful support to the revision and typing of the texts. We express our appreciation to Vinciane LOWIE and Harry VAN PAESSCHEN for their graphic contribution, and to Claudine CLAES and Yves BARETTE for their computer know-how in the processing of illustrations.

Finally, we acknowledge the financial support of the Ministry of Social Affairs, Public Health and Environment and the Belgian Federal Science Policy Office.

House sparrow, *Passer domesticus* (Thierry HUBIN / RBINS).

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Contents

Foreword

'Biodiversity in Belgium' is the result of an ambitious collective effort by experts from federal and regional scientific institutes, as well as from universities in Belgium and abroad. This country study provides a detailed report on the status and trends of Belgium's biological diversity by bringing together, and integrating, large quantities of data usually widely scattered in both scientific and grey literature, as well as numerous not yet published information provided by a wide range of experts.

This comprehensive information source will undoubtedly be helpful and prove indispensable not only to researchers, but also to policymakers, educators and everyone who is concerned with the preservation of Belgium's environment.

We hope that this study will serve as an important tool in evaluating options for the future actions needed to halt the loss of biodiversity, one of the most serious -if poorly understood and underestimated- environmental threats of our era. The governmental agreement approved in July 2003 specifically addresses biodiversity, both in its internal and external dimensions, and with full respect to international environmental agreements and legislation. Responsible consumption and an active support to conserve biodiversity are amongst our primary goals.

Brussels, 26 August 2003.

Freya VAN DEN BOSSCHE,
Minister for the Environment,
Consumers Interests and Sustainable Development.

Fientje MOERMAN,
Minister of Economy, Energy,
External Trade and Science Policy.

Bertrix (Thierry HUBIN / RBINS).

Preface

From microscopic bacteria to gigantic whales, from barren deserts to luxurious tropical forests, life on Earth is extraordinarily diverse. The concept of 'biological diversity' or 'biodiversity' highlights this multiplicity: biodiversity is the variety of the world's organisms, including their genetic diversity and the assemblages they form. Biodiversity also refers to the natural biological wealth that is essential to human life and well-being.

Yet, despite its importance for humanity, our knowledge of biodiversity remains poor and many questions remain unanswered. Even in Belgium, a widely explored country, only higher plants and a few zoological groups have been studied extensively. The majority of invertebrate groups, fungi and unicellular organisms are poorly known. Paradoxically, millions of telephone numbers are precisely catalogued but there is no exhaustive inventory of species living in Belgium.

In order to address the lack of information, the Inter-ministerial Conference for the Environment decided to prepare a monograph on biodiversity in Belgium. This huge task was entrusted to the Royal Belgian Institute of Natural Sciences, in its quality of Belgian National Focal Point to the Convention on Biological Diversity. The importance of the initiative was stressed again by Mrs Magda AELVOET, former federal Minister for the Environment, at a symposium held in 1999 at the Institute.

The preparation of this monograph, the first of its kind for Belgium, was not that easy. Finding specialists of poorly-known biological groups, bringing together key actors -often overloaded with work- for the redaction of the manuscript was a challenge. The monograph has been axed primarily around two chapters addressing botanical and zoological species diversity. They attempt to give a thorough overview of the groups present in Belgium. Ecosystem diversity is presented in the particular context of the EU Habitats Directive. Moreover, the monograph also reflects the distribution of competences between the regions and the federal level. A section is specifically dedicated to the regional aspects of biodiversity and focuses on trends, threats and actions in the three regions and in Belgian marine waters.

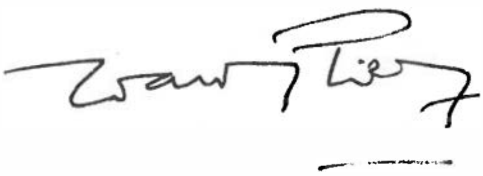
The monograph does not pretend to be exhaustive. A logic follow-up would be the compilation of a directory of all species living in Belgium, usefully complemented by annotations at the species level. Genetic diversity is not addressed, as compiling such information is a huge task in itself, and *ex-situ* biodiversity in Belgium is another essential subject that should be considered in the future.

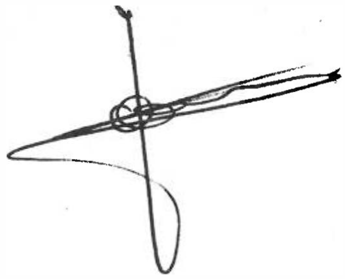
After this first general overview of biodiversity in Belgium, one of the upcoming challenges is the elaboration of a National Biodiversity Strategy. It is not only a formal obligation under the Convention on Biological Diversity, but also a practical necessity to suggest priority themes and goals to policy-makers. In addition to the gaps in knowledge and the major threats to biodiversity highlighted in this monograph, the strategy will also be able to rely on existing and planned regional strategies to effectively address biodiversity conservation issues.

During the World Summit on Sustainable Development in Johannesburg, also known as Rio + 10, biodiversity was recognised as one of the fundamental cornerstones for sustainable development, and the Convention as the key instrument to address biodiversity issues. The Summit also confirmed that massive practical and urgent action in all parts of the world is now needed to meet the three goals of the Convention: *the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources.*

This monograph is undoubtedly a milestone for enhancing and improving Belgium's future work towards the Convention.

Brussels, 22 May 2003.





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CHAPTER 1

BIODIVERSITY AND EXTINCTIONS, PRESENT AND PAST

Karel WOUTERS & Anne FRANKLIN

1. INTRODUCTION

The concept of 'biological diversity' was used for the first time in 1980 in reference to the number of species that live together in a community. The contracted form 'biodiversity' made its first appearance during the 'National Forum on BioDiversity' held in Washington D.C. in 1986. The proceedings of this forum were subsequently published in 1988 in a book called 'BioDiversity' (WILSON & PETER 1988). The publication of this book, which quickly became a worldwide best seller, was an important milestone in the use of the concept. Since then, there has been a remarkable and nearly exponential growth of the number of scientific publications dealing with biodiversity, including several important reference works on the subject (WILSON 1992, GROOMBRIDGE 1992, HEYWOOD & WATSON 1995, LEVIN 2001). Scientific research has in turn led to increased political involvement, better media coverage and, to some extent, improved public awareness. Why this sudden interest? It had been known for a long time that diversity was a fundamental characteristic of life. But the new and important discoveries during the past two decades led to major changes in our ideas on the biological diversity of our planet. A few of these new developments are presented in this chapter.

2. DEFINITION

The most common definition of biological diversity, or biodiversity, currently in use is formulated in Article 2 of the 'Convention on Biological Diversity' signed during the UN Conference on Environment and Development in Rio de Janeiro (1992). It reads as the following: "Biological diversity means the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (GLOWKA *et al.* 1994). At least 25 other formulations of the concept of biodiversity have been recorded (VAN GOETHEM 1999b). In the definition given above, the diversity of life is considered at three different levels: the genetic, species and ecosystem levels. In reality, these three levels form a continuum wherein diversity is also expressed at the levels of populations, communities, niches, landscapes, continents, zoogeographical regions, etc. Biodiversity represents more than the sum of all ecosystems, species or genetic material together. It also refers to the variability between and among them. Diversity can therefore be considered as an attribute of life itself.

Because species contain an assortment of genes and are often part of complex ecosystems, species diversity is the easiest level of organisation to understand and the most straightforward parameter to characterise biodiversity. Concretely, this means: how many species are there in a given area, in an ocean or a river, etc.

3. How many species?

Natural scientists in the 18th century, and already before that, understood the necessity of giving a name to animals and plants that surrounded them if they wanted to communicate effectively on their biology. It was Carolus LINNAEUS, a Swedish botanist and physician, who laid the basis for the description of biodiversity. The first edition of his *Species Plantarum* (1753), the fifth edition of his *Genera Plantarum* (1754) and the tenth edition of his *Systema Naturae* (1758) still stand as the starting points for the modern methods of biological classification. In these books, he introduced the binomial nomenclature system and outlined his scheme for classifying organisms according to their similarities. In binomial nomenclature, each animal or plant species is identified by a scientific name composed of two elements, the generic name and the specific name. This type of nomenclature has been accepted internationally and is laid down in international codes that state how organisms should be named. LINNAEUS' naming system received in this way a universal character. Besides species and genera, there are a series of higher classification categories such as families, orders, classes, etc. It is the task of systematics, in addition to the description of species, to work out a classification system where all organisms can find their place. After LINNAEUS, and especially following the acceptance of the theory of evolution, it became more evident that the classification system should be natural, i.e. it should reflect natural relationships between organisms, which in turn are the results of natural evolution.

Since LINNAEUS, many systematicians have worked towards the description and classification of the diversity of life, an immense task. On basis of the 'Zoological Record', the world's biggest and oldest database in animal sciences, it can be inferred that the number of new animal species described per year during the past 20 years has been relatively constant, with an average of 11,600 species per year from 1979 to 1988 and a current rate of descriptions of about 13,000 species per year. Most of those species are arthropods, and principally insects. A slow down in the description of new species is not yet in sight (HAWKSWORTH & KALIN-ARROYO 1995, VAN GOETHEM 1999a). The estimation of the total number of organisms already described is nevertheless not an easy task. The precise figure is yet uncertain. One of the reasons is that there is no recognised central register of names for described species, and therefore some species have been described more than one time. This could happen when two scientists were unaware of each other's work or when different forms of the same species were given different names. For example, the European ten-spot ladybird (*Adalia decempunctata* L.), commonly found in Belgium, has at least 40 different synonyms, many of these having been used for the colour morphs (STORK 1997)! Many of those synonymies are not yet clarified. On the other hand, it also appears that, mostly in older publications, several different species have been described under one species name. Solving those particular cases requires additional and sometimes completely new research. Notwithstanding these problems of nomenclature, it is possible to estimate the number of already described organisms to about 1.8 million species. As far as the global number of species is concerned, it was estimated until recently to reach about 3 to 5 million species. In this regard, the difference between the number of known species and the actual number of species, although quite important, did not seem to generate an insurmountable amount of work.

4. New findings

In the 1980s, the scientific world came through new insights as a consequence of research on organisms living in the canopies of tropical rainforests. Canopies were notoriously difficult to reach and indirect sampling techniques were developed (and are still used) to collect study material. Some researchers gathered data by fogging trees with pyrethrum, a natural non-residual insecticide. Animals, mostly insects, falling from the canopy were collected in specially designed collecting sheets. Other researchers used air balloons (or canopy rafts) to land on the tree crowns and to collect material by hand. Yet another technique consisted in erecting huge cranes to reach canopies from the ground. The first results from this completely new research area were published in 1982 by Erwin, an entomologist from the Smithsonian Institution. He studied Coleoptera from one tree species (*Luehea seemannii*) in the tropical rainforest of Panama and found that the vast majority of captured species were new for science. Moreover, he showed that many of the new species were found only on that tree species. On the basis of his findings, he roughly extrapolated the number of species on Earth to be about 30 millions. Similar studies were carried out later by other researchers, in other regions of the world and for other animal groups. Although estimations were somewhat different from study to study, the ratio of unknown to known species always appeared to be considerably greater that what had previously been expected.

These canopy studies dealt mostly with insects, but recent studies on other groups confirm these findings. For example, there should be about 1.5 million species of fungi and moulds worldwide, instead of the 70,000 species already described (Hawksworth 1991). The number of cave species (now 1,444 species recorded) is estimated between 50,000 and 100,000 (Culver & Holsinger 1992). The number of living bacteria and Protoctista lies also well above the recorded number. In oceans, in the deep seas as well as in interstitial waters, a unique biodiversity awaits to be discovered. The difference between known and expected numbers is probably not as impressive as for insects, but, given adequate research possibilities, there should be a considerable increase in the amount of described species.

These new findings, and the resulting estimations, are still much discussed in the scientific literature. Predictions vary from a low 5 million to more than 100 million species on Earth. However, revisions of the estimations made by Erwin and other authors do not support hyperestimates of 30 to 100 million species. They rather indicate a species richness for arthropods of about 5 to 10 million species (Basset *et al.* 1996, Odegaard 2000).

The question of whether there are now 10, 30 or 50 million species of organisms living on Earth, even though important, is not so relevant. It leads nonetheless to a few fundamental considerations:

a) The number of living species on Earth is considerably greater than the known number. The number of known species probably amounts to only a few percents of the worldwide quantity.
b) At the current rate of description, classification and inventory, it will take many centuries before knowing biodiversity in its simplest form, i.e. named and described species. In addition, substantial work still needs to be achieved on the comprehension of phylogenetical relationships, of autoecological and synecological aspects or of genetic, physiological and biochemical diversity.

c) It is remarkable that at the beginning of the 21st century, such an important parameter as the total biodiversity remains unknown. In the light of present changes on Earth, often referred to as 'global change', and of the measures that need to be taken in this regard, the understanding of biodiversity is certainly indispensable.

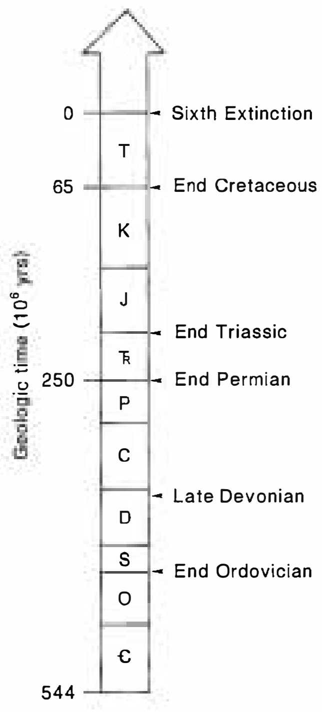
5. Fossil biodiversity

The first clear evidence of fossil organisms dates back to about 3,500 million years. These first fossils are believed to be the remains of prokaryotes. Animal life is recorded as early as the end of the Precambrian (Vendian), but biodiversity starts to increase significantly from the lower Cambrian (544 Ma). A wide range of animals appears at the time, many with skeletons. During the Cambrian and Ordovician, biodiversity rises quickly, to reach a plateau that lasts from the Silurian to the Permian. The Permian-Triassic mass extinction leads to a severe decline in biodiversity, but it recovers in the Mesozoic and Cenozoic to increase subsequently to the levels of today.

This increase was estimated using stratigraphic data of about 4,000 families and more than 30,000 genera of marine invertebrate species (Sepkoski 1984, 1997). The diagrammes resulting from this analysis, which were used in numerous subsequent publications, have led to the general acceptance that modern biodiversity levels are the highest that Earth has ever known. In a recent paper however, Alroy *et al.* (2001) report on the creation of a new database that catalogues each marine fossil record individually. The analysis of the data suggests that the apparent increase in biodiversity in the Mesozoic and Cenozoic is closely correlated to the sampling intensity of different geological periods. Most interestingly, their standardised estimations lead to approximately equal figures for biodiversity in the two time periods studied (of about 150 million years each, one in the middle of the Paleozoic, and one from the mid-Mesozoic to the mid-Cenozoic), suggesting that the supposed increase in biodiversity during the Mesozoic and Cenozoic may merely result from biases in the Sepkoski database (Newman 2001) or from an artefact of variation in the amount of rock available for study (Peters & Foote 2001).

6. Extinctions in geological time

Modern biodiversity is the result of more than 3.5 billion years of evolution. For a long time, the increase in diversity was trivial, but, as said above, the beginning of the Phanerozoic sees a spectacular rise that does not seem an artefact of the fossil record. People often refer to this period as the 'Cambrian explosion'. The number of species does not continue to rise infinitely however, as after species appear and persist for a more or less long period of time, they also cease to exist, giving way to other species better adapted to prevailing circumstances. This process of disappearance or extinction is a fundamental part of the evolutionary process. Besides these permanent 'background extinctions', biological diversity has been interspersed repeatedly and profoundly by periods of mass extinctions during the course of the Earth's history. On the basis of synoptic compilations of stratigraphic ranges of genera, Sepkoski (1986) identified no fewer than 29 extinction events in the Phanerozoic. Mass extinctions are known for the disappearance of great numbers of species or of whole higher taxonomic groups during geologically very short periods of time. Due to their large-scale character, they have been of major importance for the development of life on Earth and have, through their considerable influence on the existing ecosystems, determined the course of evolution. Mass extinctions have been known for a long time in palaeontology, but have received increased attention since the 1980s. The 'Big Five' correspond to mass extinctions that had a very profound effect on life at the End Ordovician (435 Ma), Late Devonian (365 Ma), End Permian (250 Ma), End Triassic (203 Ma) and End Cretaceous (65 Ma). Because only a relatively limited number of fossil species that lived in those periods was found, extinction rates were estimated from the number of families or genera that died out during these mass extinctions. For the 'Big Five', the extinction rates ranged from 16% to 50% for families and from 47% to 82% for genera. Species losses are usually extrapolated using the number of species that occur in present families and genera, with the consequence that it cannot be known for certain whether current numbers are representative of the far geological past. Rough estimations for the 'Big Five' range from 70% to 95% species extinct calculated on basis of families and from 76% to 95% on basis of genera (JABLONSKI 1994, HALLAM & WIGNALL 1997). Strikingly, an estimation of more than 95% species extinct was reached twice for the End Permian, the greatest extinction that the Earth has ever encountered. The precise causes and time spans of each of the mass extinctions are the subject of much debate, but it should be remembered that the mass extinctions happened on the geological time scale and each took more than hundred thousand to million years. In comparison to present extinctions, these are tremendously long periods. As far as causes are concerned, the late Permian mass extinction appears to have been associated with global physical and climate changes, tectonically-induced marine transgressions and increased volcanic activity, whereas the extinction at the end of the Cretaceous might be linked to climate change following an extra-terrestrial impact but this remains quite controversial (HALLAM & WIGNALL 1997).



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Time distribution of the 'big five' mass extinctions in the fossil record, and of the sixth undergoing extinction.

7. Recent extinctions

Natural patterns in global biodiversity are at present affected by the human species. The central issue is: are things getting better or worse, and how quickly? It seems very likely that recent modern extinction rates are higher than would be expected without the influence of man (Groombridge & Jenkins 2000). Present extinction events are difficult to record with precision, but the challenge has been undertaken by the World Conservation Monitoring Centre (WCMC) and The World Conservation Union (IUCN). A species is considered extinct when it has not been observed for at least fifty years. This criterion is not exclusive, as it is not easy to determine with certainty when the last specimen from a given species disappeared. Occasionally, specimens of species regarded as extinct were found again well after fifty years, sometimes following repeated searches in given areas. It is principally among well-recorded groups of animals and plants that known extinctions are relatively representative of actual extinctions. It is much more difficult to come through examples of extinctions of insects or fungi. The list of extinct organisms contains currently about 690 species of animals (IUCN 2002) and 380 species of plants (IUCN 1997), amounting to about 0.05% and 0.15% of the total number of already described animal and plant species respectively. This is likely to be an underestimation of the real number of extinctions. The list for animals is mainly composed of vertebrates, of which nearly 200 birds and mammals. Moreover, the list contains many island species. Small regions such as islands are particularly under strong pressure from extinctions, but they are also easier to sample due to their smaller size and well-defined physical limits. Finally, the underestimation of the number of extinct organisms lies also in regions with complex ecosystems such as tropical rainforests and coral reefs.

In addition to extinct species, many species are in decline or in danger, facing extinction if negative trends in their populations are not reversed. A classification of the risk faced by species, the 'Red List' system, has been developed by IUCN and its Species Survival Commission and is now generally accepted as a standard worldwide. There are seven categories of threat, depending on the amount of risk associated to the disappearance of the species in a nearby future: extinct, extinct in the wild, critically endangered, endangered, vulnerable, near threatened, and least concern. A species is listed as threatened if it falls in the critically endangered, endangered or vulnerable categories (IUCN 2002). The number of animals in the 'Red Lists' of species threatened at the international level amounts to about 5,460 species, while for plants the number reaches 33,400 species (IUCN 1997, 2002). In other words, this means that about 11% of the birds, 18% of the mammals, 5% of the fishes and 12.5% of the vascular plants are threatened in one way or another (Barbault & Sastrapradja 1995). For the great majority of the 1.8 million of described organisms however, it is not possible to judge their status by using available data.

The recent extinction rates are much inferior to those of the mass extinctions. In comparison to the 95% rate of species extinctions of the End Permian, or even to the 70% to 76% of the End Cretaceous, the few hundred already extinct species of modern times seem quite unimportant. One could conclude here that life on Earth is currently in good shape and that biodiversity fears no risk. However, considering that there is only a low number of known species compared to the great number of potentially occurring species, it is likely that the biodiversity crisis is much greater than estimated above. It cannot be excluded that many species, not yet known to mankind, are disappearing or have already disappeared: the 'anonymous extinction'.

Many recent scientific publications send worrying signals showing that there may possibly be an undergoing extinction phase as great as or even greater than the mass extinctions of geological times. The loss of species biodiversity seems to be linked most strongly (but not exclusively) to the disappearance of natural habitats. Because of the latitudinal gradient in biodiversity, the biggest losses occur in the tropical belt, mostly in tropical rainforests but also in aquatic ecosystems such as coral reefs. Tropical rainforests loose about 1.6% of their surface area each year and only 55% of their original cover remains to this date. With the disappearance of the rainforest, many species are also doomed to disappear. The scale of the current extinction rate in the rainforest can be estimated roughly using the theory of island biogeography of MACARTHUR & WILSON (1967). The theory establishes a relation between the area and the number of species that can be found in a given region. This theory yields the following equation: $S = CA^Z$, where A is the area, S the number of species, C a constant mainly linked to the group considered and Z a parameter depending from the group, the region, etc. On the basis of this model, a ten-fold increase in the surface area leads to a doubling of the number of species, and conversely, a ten-time reduction of the surface area halves the number of species. When tropical rainforests are considered as islands, this leads to an estimation of about 0.2% to 0.3% of species of primary forests disappearing each year (WILSON 1988). Using the estimation that tropical rainforests host about 10 million species (principally insects), this leads to a yearly loss of 20,000 to 30,000 species. If the current deforestation continues at the present rate, it is not excluded that about a fourth or more of all species on Earth will have disappeared within fifty years (NORTON 1986). According to CHAPIN *et al.* (2000), humans have already caused the disappearance of 5% to 20% of species in many groups. WILSON (1988) suggests that "the loss in number of species due to current destruction of rainforests (setting aside for the moment extinction due to the disturbance of other habitats) would be about 1,000 to 10,000 times that before human intervention". A somewhat lower estimate, 100 to 1,000 times greater than pre-human extinction rates, is proposed by PIMM *et al.* (1995) and LAWTON & MAY (1995). These are disturbing numbers, even though it can be argued that the basis on which the estimations are built is not entirely correct. The actual total number of species in tropical rainforests is unknown; it is only known that it reaches several millions. Furthermore, the description of the rainforest as an island is only a very crude approximation. But this approximation is not entirely unfounded as the structure of the tropical rainforest is in itself extremely diversified and can be seen as many small islands of particular habitats, each of which having its own characteristics and biological diversity.

It is not surprising that the reality of biodiversity and of ecosystems, with their amazingly intertwined structure, is much more complex than available data suggest. How inaccurate available data and how diverging estimated extinction rates may be, they all tend in the same direction: an important extinction phase seems to be happening, the so-called 'sixth extinction'. This idea was first put forward by E.O. WILSON in 1986 and later received wider attention through the publication of the book 'The Sixth Extinction' by LEAKEY & LEWIN (1996). Comparisons between the current extinction and the 'Big Five' mass extinctions however need to be undertaken with a few remarks in mind, as records from extinctions in geological time are difficult to compare with modern data. Palaeontological extinction rates were principally identified on the basis of marine invertebrates, but available data today mostly concern endangered terrestrial organisms. As the present status of marine animals is not well known, it is difficult to relate palaeontological marine extinction rates to global modern biodiversity.

While fossil extinction rates were mainly estimated on the basis of families or genera, present day extinction rates are exclusively based on the loss of species. Data on the disappearance of recent families and genera are not yet available. Moreover, the time factor remains difficult to interpret. Present day extinctions occur in historical time, namely in dozens or hundreds of years, which is an extremely short period seen from a geological time perspective (hundred thousand or millions of years). Finally, plant biodiversity seems now to be endangered for the first time. In the geological past, plants appear to have suffered from successive great extinctions only on a limited scale. This implies that few palaeontological data are available on the extinction of plants, and its direct effect on ecosystems. As primary producers, plants sustain most other life forms and are essential building blocks of ecosystems. It seems quite evident that the disappearance of plant species will have an important effect on the functioning of ecosystems.

8. The importance of biodiversity

Palaeontological studies show that after mass extinctions and a strong decrease in biodiversity through the loss of species, recovery can only arise from the evolution of new species. This appearance of new species (= speciation) is rather a slow process, taking from hundred thousand to million years. The impact of a rapid loss of biodiversity on the functioning of ecosystems and on their ability to provide ecological services has been a central issue in ecology for some years already. Both observations and theoretical research have led to conflicting views, with proponents of the hypothesis that processes in ecosystems are rather insensible to changes in biodiversity being opposed to proponents of the theory that even small changes in diversity have dramatic and unpredictable effects on the functioning of ecosystems. It is only recently that relevant experimental research was developed in the laboratory and in the field. Pioneer experiments by Naeem and colleagues (1994) and Tilman & Downing (1994) are presented below. In the 'Ecotron' experiment of Naeem *et al.*, terrestrial communities were recreated under laboratory conditions, with biodiversity as the only changing parameter. Different organisms were put together in 16 isolated cells, i.e. primary producers, reducers, primary and secondary consumers. Diversity in the cells varied from a low 9 species to a high 31 species. After a period of 206 days, it appeared that the most diverse communities also had the highest productivity and stability. The Ecotron-communities were merely an elementary reflection of the real world, but fieldwork experiments by Tilman & Downing lead to similar results. They studied the diversity of 207 grassland plots, where species diversity was changed as a function of nitrogen inputs. After five years, plots with the highest diversity were also those that resisted best to an exceptional event in the form of a major drought. The loss of biomass and diversity were the lowest in those plots. Ecosystems with high biodiversity were therefore the most stable. Biodiversity increased drought resistance and ecosystem stability because more diverse plots were more likely to contain drought-resistant species that grew and compensated for the loss of drought-sensitive species. Major variations appeared however in populations of different species. This experiment illustrates that biodiversity is a very important parameter for ecosystems. It also shows that for each species taken separately biodiversity brings no guarantee of survival, but rather that the instability and fluctuations of individual species are major parameters for the global stability of the ecosystem. There is a trade-off between species characteristics (i.e. species complementarity) that brings greater benefits to the ecosystems. In addition to stability, understood in ecological terms as resistance against changes in the environment, species also prove to be very important for the recovery of ecosystems after more or less important natural disturbances. This introduces the notion of 'ecosystem resilience', where resilience refers to the capacity of the ecosystem to absorb shocks while maintaining function. When change occurs, resilience provides the components for renewal and reorganisation (FOLKE *et al.* 2002). In other words, even though some species may seem superfluous when diversity is high, they prove crucial for the resistance and recovery of the system when diversity falls under a given threshold (LOCKWOOD & PIMM 1994, LAWTON 1994). Several experiments have also shown that primary production seems to be higher with greater biodiversity. Two alternative mechanisms can account for the results, leading to key interpretation problems of experimental data: the species complementarity and the sampling effect, the first being an ecological phenomenon and the second a statistical consequence of the experimental design. LOREAU & HECTOR (2001) devised a method to differentiate between the two and were able to show that species complementarity is a most important mechanism behind the increase in productivity.

If species are so important, the following question comes naturally to mind: can we afford to loose species? Available scientific data are still insufficient to answer the question or to give a concrete judgment for the future. It is known that an important extinction phase is in progress and that many modern species are already extinct or threatened to disappear. Besides the intrinsic value of species as a result of million years of evolution, as part of intricate phylogenetic trees and as carriers of specific genetic information, species are also important for the long-term stability and productivity of ecosystems, of which they are vital functional entities. Two models present diverging explanations of the impact of the loss of biodiversity on ecosystem stability (CHERFAS 1994). In the first model, ecosystems will become slowly and gradually unstable trough the gradual loss of species, before disappearing in the end. In the second model, all species do not have the same value. Some species are less important than others and their loss is not fundamental for ecosystem stability. On the contrary, other species have a key function in the functioning of the ecosystems and their loss would lead to a rapid and catastrophic breakage of the system. However, it has now become evident that, whatever the underlying process, the disappearance of species can lead to instability, vulnerability and eventually to the break down of ecosystems.

Why is it imperative to keep ecosystems in 'good shape'? Human development depends on the generation of ecosystem goods such as food, timber, building material, genetic resources and medicines. The list of ecosystem services is even longer and includes water purification, flood control, carbon sequestration, soil formation, nutrient assimilation, pollination, seed dispersal, disease regulation, as well as aesthetic and cultural benefits. Higher ecosystem vulnerability increases their risk to suffer from stresses and shocks. As ecosystems are degraded, society becomes more vulnerable because options for change are reduced. Human dependence on natural resources is such that it is of the self-interest of society to sustain the capacity of ecosystems to supply their goods and services.

9. Measures

The challenge is to preserve biological diversity and maintain ecosystem functioning as well as to secure prosperous social and economic development (Folke *et al.* 2002). In other words, it is necessary to ensure the balance between the three pillars of sustainable development: economy, society and environment. The outlook is not extremely cheerful. Demographers predict a doubling of the world's population during the 21st century. This population increase will lead to further economic growth and unsustainable patterns of production and consumption. If economic growth is, like today, paired with the accelerated loss of natural habitats, then the major part of the Earth's biodiversity is likely to be threatened. The acquisition of a better and more profound insight into the importance of biodiversity and of ecosystem functioning requires much additional research on a relatively short-term basis. At the same time, politicians and policy-makers need to take rapid initiatives to counter the loss of biodiversity, not only through measures for species conservation but for the maintenance of natural ecosystems and habitats as well. Such actions need to be complemented with measures for the management of biodiversity in human-dominated environments.

The first solutions for the sustainable use of natural resources and sustainable development were proposed during the 1992 UN Conference on Environment and Development (also called the Rio Earth Summit). It led to the adoption of Agenda 21, a comprehensive plan of actions to be taken globally, nationally and locally in every area in which humans impact on the environment. The Rio Earth Summit also saw the historic signature of two international legally binding agreements, the Convention on Climate Change and the Convention on Biological Diversity. The conference and the numerous international meetings that followed, in which our country takes actively part (Van Goethem 1999a), give an optimistic sign that solutions are under way. These solutions will not be easy however and can only be realised through intense and persistent international concertation. Ten years after Rio, world leaders have come together again in Johannesburg for the World Summit on Sustainable Development to evaluate what has been accomplished since 1992. Despite the abundance of treaties, instruments and policy measures established on paper, results in the field are not very encouraging. The UN Secretary General designated biodiversity as one of the five priority thematic areas for the Johannesburg summit, together with water, health, energy and agriculture (WEHAB 2002). The profile of biodiversity has never been higher on the political agenda. Let us hope that the agreed framework for action will lead to real changes in the future.

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Karel WOUTERS
Anne FRANKLIN
Department of Invertebrates
Royal Belgian Institute of Natural Sciences
Vautierstraat 29
1000 Brussels

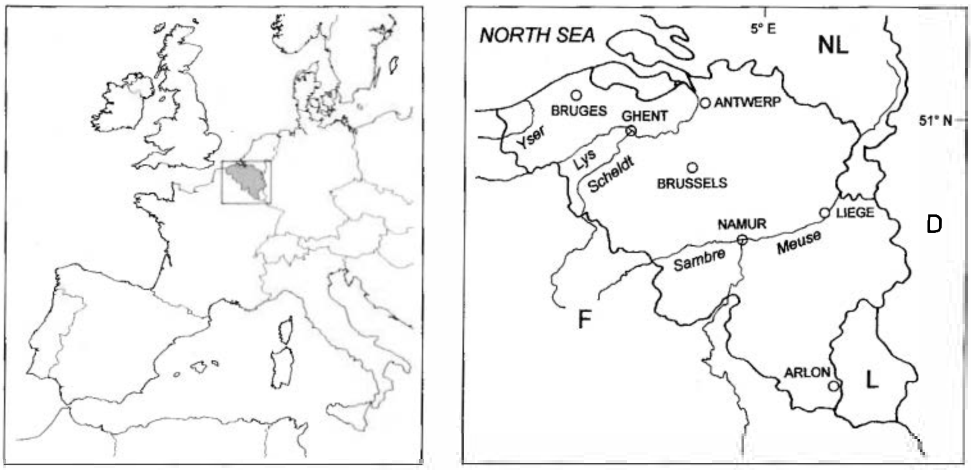
Chapter 2

A country profile

Anne Franklin, Marc Peeters & Vicky Leentjes

1. Belgium in a nutshell

"Belgium is a disconcerting country where paradoxes thrive". This is how Jacques Denis introduces Belgium in his book 'The Geography of Belgium' (1992). Indeed, Belgium is a small country with a surface of only 30,528 km^2. Yet for such a small area, it shows a very high diversity of landscapes with the high plateaus of the Ardenne in the south, the large river valleys of the Meuse and Scheldt, the fertile loess areas in the centre, the coastal low-lying polders, etc. This specificity is due to a unique combination of natural features (climate, geology, etc.) and human activities (mainly land use for agriculture, industry



Total surface area: 33,990 km^2 (incl. Belgian waters)
Terrestrial surface area: 30,528 km^2
Population: 10,309,725 (2002)
Population density: 338 inhabitants/km^2 (2002)
Highest point: Signal de Botrange (694 m)
Land cover: 58% agriculture, 20% forests, 19% urban, 3% other (2002)
Length of road network: 149,028 km (2002)
Constitution: monarchy
Government type: federal parliamentary democracy
Independence: 4 October 1830
Provinces: 10
Official languages: Dutch, French, German
Currency: euro (EUR)
Gross national product: 252.5 billion EUR (2002, estimate)
Annual growth rate: 0.7% (2002, estimate)

1

Location and main features of Belgium (drawing by H. Van Paesschen). Statistical data from the National Institute of Statistics (NIS-INS, http://www.statbel.fgov.be).

and housing). Historically, the Kingdom of Belgium is a young nation: its present borders have been delimited in the 20th century. But it is also a country of long-standing civilisation. Several cultural backgrounds coexist side by side. The political and administrative organisation of the country is complex, with different levels of competences that interlink closely. Despite these paradoxes, 'Belgium, heart of Europe' is not just a catch phrase. Not only does Belgium host the geographical centre of the 15 countries of the European Union (in the small village of Oignies-en-Thiérache), but it is also at the confluence of two major bio-geographical regions of Europe (Atlantic and Continental) and is one of Europe's main economic and urban nerve centres.

This chapter presents the major bio-geographical features of the country and outlines its administrative organisation, giving an overview of the main factors influencing biodiversity and the structures competent for its conservation.

2. Topography and main regional units

One of the most famous Belgian songs, by Jacques Brel, refers to Belgium as 'the flat country' (Le plat pays / Mijn vlakke land). Belgium certainly deserves this nickname, as the altitude reaches the impressive height of ... 694 m at its highest peak. Near the coast, the 'polders' even lie below sea level.

Flat, however, does not mean monotonous. At the macroscale, Belgium can be divided into three major topographic units: the Sambre and Meuse axis in the centre of the country, the regions south of the axis and the areas north of it. The central region displays a rolling landscape; the southern part of the country is hilly with large plateaus intersected by deep valleys, whereas the northern region is mostly characterised by a flat topography.

2.1. The Sambre and Meuse axis

The Sambre and Meuse axis spreads in an oblique way first along the Sambre river from the French border, then along the Meuse river to the Dutch border. It includes the alluvial plains of the two rivers as well as their valley slopes. The troughs are situated at about 100 m above sea level, with many alluvial terraces some tens of metres higher. The morphology of this region is strongly influenced by the underlying geology. The northern scarp of the axis is made of calcareous limestone deposits, which feature the famous caves of Neanderthal men in Spy and Engis.

2.2. South of the Sambre and Meuse axis

The area south of the Sambre and Meuse axis is located mostly above 200 m. This part of Belgium is formed by an erosional relief that developed in hard and folded Paleozoic sedimentary rocks, yielding a landscape made of steep-sided valleys intertwined with high plateaus of relatively constant altitudes. The area can be subdivided into three broad units, the Middle Plateaus, the Ardenne and the Belgian Lorraine, which can themselves be refined into smaller entities.

The **Middle Plateaus** are situated between the Sambre and Meuse valleys and the Famenne depression. They do not get much higher than 300 m, except for the Herve Plateau, in the east, which rises to a height of 350 m. This plateau is formed by a long ridge in a southwest-northeast direction and numerous small down-warped valleys, the heads of which are affected by landslides. Its typical landscape is that of the bocage, a network of pastures and orchards interspersed with hedgerows. Two main rivers cross the Middle Plateaus: the Meuse and the Ourthe.

The Condroz, the second largest geomorphological region in southern Belgium, makes up the central part of the Middle Plateaus. The topography is formed by a succession of parallel crests, locally reaching 325 to 350 m, and depressions at 225-250 m. The crests correspond to sandstone outcrops, while the depressions are carved out in limestone and schists. Poor, dry soils and a sunny, but windy, climate have led to the maintenance of large residual forested areas on the plateaus. The Marlagne-Ardenne Condroz is a narrow region of a few km wide that stretches out as a ridge from west to east across Wallonia, between the Sambre and Meuse axis and the Condroz. It can be described as a miniature Ardenne at an elevation of around 225 m.

The Fagne-Famenne is a long depression spreading from west to east between the Condroz and the Ardenne. It splits into two parallel parts, according to the proportion of schist and limestone in the rock. In the north (150-180 m), most of the rock is schist with a few isolated limestone hillocks. It is the schistose Fagne-Famenne, often simply referred to as the Fagne-Famenne. The cold, heavy clay soils, often waterlogged, have led to the predominance of pastures and forests in this area. The southern part is quite the opposite: it is mostly made of limestone, with outcrops of schist. This is the limestone Fagne-Famenne, with an altitude at

2

Topography of Belgium.

around 250 m. It is in this area that the most spectacular karstic systems of Belgium are found. Acid waters descending from the Ardenne created the most important caves of the country, like those of Han-sur-Lesse, Rochefort and Remouchamps. Botanists generally refer to the southern part of the Fagne-Famenne, with its south-facing limestone slopes, as the Calestienne. Due to particular living conditions -a shallow layer of soil rich in calcium, which warms and dries up rapidly- the hillsides of the Calestienne shelter a very specific Mediterranean-tinted vegetation of exceptional richness. The insect fauna is also particularly rich, hosting among others the discreet mountain cicada (*Cicadetta montana*).

The **Ardenne** is the most important geomorphological region south of the Sambre and Meuse axis and the most elevated area of the country. Covering more than 5,000 km^2, it belongs to the western part of the schistose massif of the Rhine basin, which spreads further into France and the Grand Duchy of Luxembourg. It rises progressively from west to east, through a series of small plateaus separated by deep valleys. Altitudes range from 300 m near Chimay, close to the French border, to 694 m on the plateau of the Hautes Fagnes, where the Signal de Botrange constitutes the highest point in Belgium. The landscape alternates between vast forested areas (mainly semi-natural beech forests and spruce plantations) and agricultural land where pastures predominate. Heathlands and peat bogs are found on the poor soils of the high plateaus.

Several distinctive sub-regions can be characterised. FOURNEAU (1990) identifies five major ones. The first is formed by the large depressed zones of the area of Vielsalm and the Amblève river. The second corresponds to karstic phenomena in the region of Stavelot-Malmedy. This is a rare feature in the Ardenne, which normally does not host any calcareous substrates. A third sub-region originates from spectacular steeps created by differential erosion of the underlying substrate (Colenhan, Chefosse, Borzeux and Erlinchamps). A fourth area is the Pays de Theux, a landscape of small, elongated condrozian-type hills alternating with small depressions in the middle of a more traditional Ardenne landscape. A last very particular sub-region is formed by the peat bogs and small annular hillocks that scatter the plateau of the Hautes Fagnes. These hillocks or 'palses' result from the peri-glacial climate and correspond to levees of soft material of 2 to 3 m high, usually ring-shaped, gentle-sided and reaching a diameter from 15 to 200 m. Their centre has subsided following climate warming, leaving place to central zones of more humid bogs or ponds. The hillocks host dryer heath vegetation while the more humid centres have a flora typical of *Sphagnum* acid bogs. The Hautes Fagnes are now designated as a Natural Park and host Belgium's largest nature reserve (3,800 ha).

The **Belgian Lorraine**, south of the Ardenne, forms the very southern tip of Wallonia. It corresponds to a small fragment of the Paris Basin, a vast sedimentary basin spreading over half of northern France and the southern part of the Grand Duchy of Luxembourg. The region is considered as a plateau but it is actually more complex, as it is shaped into a succession of three depressions (the valleys of the Semois, Ton and Vire rivers) alternating with the higher elevations of three cuestas. Cuestas are elongated hills with asymmetric slopes. In the Belgian Lorraine, the steep slopes (or 'fronts') are oriented northwards, while the gentle slopes (or 'backs') face south. The depressions generally correspond to friable rocks such as clay, marl and sand, and the cuestas to more resistant and compact rocks such as sand- and limestone. The altitude ranges from 200 m in the valley of the Chiers to 465 m near the source of the Semois. Thanks to its particular geology and topography, the Belgian Lorraine is characterised by exceptionally rich biological resources. It is often referred to as the 'Belgian Provence' as many Mediterranean species can be found on the warm south-facing slopes.

2.3. North of the Sambre and Meuse axis

The region north of the Sambre and Meuse axis belongs almost entirely to the Scheldt basin. It is situated below 200 m, except for a few sites bordering the Sambre and Meuse axis, and gradually decreases to sea level in a north, north-western direction. Most rivers do not flow directly to the coast but rather follow a southwest-northeast direction, parallel to the Belgian shoreline. The hydrographic basin is locally vigorously chiselled by rivers and their tributaries, such as along the upper courses of the Scheldt, the Dender, the Senne and the Dyle. These valleys are most often asymmetric: the principal river valleys display steep east-facing slopes while the steepest gradients for their tributaries are observed on north-facing slopes.

The northern part of Belgium consists of nine large morphological units: the Haine Valley, the Haut Pays, the large interfluvial hilly area, the Flemish Valley, the northern cuestas, the Kempen Plateau, the Limburg section of the Meuse Valley (called in this case by its Flemish name, the Maas), the coastal plain with the polders and the coast.

The large **Haine Valley** is situated in the western part of the country, north of the Sambre and Meuse axis. It is a synclinal valley mostly lying below 30 m that follows an east-west direction and includes large basins with peat and alluvial deposits. It hosts valuable humid areas.

The southern flank of the Haine Valley is dominated by the **Haut Pays**, which shows the characteristics of a plateau, with some steep-sided valleys evoking those located south of the Sambre and Meuse axis. The area east of the upper course of the Haine river presents a much higher elevation than the surrounding area and forms the Anderlues Plateau culminating at 212 m. To the west of the upper Haine, the relief is only slightly differentiated and rarely exceeds 120 m.

Between the coastal plain and the Meuse lies a **large interfluvial hilly area** cut by the valleys of several important rivers flowing in a north-eastern direction. It can be divided in a series of secondary interfluves. The most western interfluve is the one between the coastal plain and the river Lys. Although it is generally low-lying, it contains three cuestas, one of these (Tielt) reaching 50 m. Close to the French border, near Ieper, this interfluve also hosts the most western part of a hilly area referred to as the Flemish Hills. The highest point is Mount Kemmel, which, at 156 m, towers the plains of the Lys and the Yser. The smallest and least diversified interfluve is the one between the Lys and the upper Scheldt. It is topped by a loess layer covering an important fluvial terrace. The two secondary interfluves between the Scheldt and the Dender and between the Dender and the Senne are slightly more elevated and show more pronounced fluvial features. The Flemish Ardennes is a hilly country located between the Scheldt and the Dender, its highest point being the Pottelberg (157 m). It is a varied landscape, with wooded hills and numerous old Scheldt meanders, ponds and streams. Further to the south-east, the major interfluve progressively rises to reach large continuous and flat areas that have long been considered as low plateaus: from west to east, the Plateaus of Hainaut, Brabant and Hesbaye. All are located between 100 and 200 m of altitude. The Hainaut Plateau, at around 100 m, is made of a succession of gentle-sided valleys and soft interfluves in a south-west to north-east orientation. The Brabant Plateau differs from the previous by a higher elevation (200 m) and by an abrupt change in height of several tens of metres at its western border. The Hills' Country (Pays des Collines), west of the Hainaut Plateau, forms the prolongation of the hilly areas of Flanders. It is a small region with symmetric hillocks reaching about 150 m. The Hesbaye Plateau is characterised by a gently undulating surface crossed by two major rivers, but does not have its own hydrographic network. The landscape of the large interfluvial hilly area is mostly dominated by agricultural land on the plateaus, with some of the hilly areas being more wooded and pastoral.

To the north of the interfluve complex lies the large depression formed by the **Flemish Valley** and its eastern and southern branches. The valley forms a vast sandy plain to the north of Ghent, where it reaches a width of 60 km and an altitude of 4 to 10 m. The Flemish Valley has ramifications in all the major river valleys. The southern branch spreads for 20 km south of Ghent, while the eastern branch extends till Diest. The sandy cover of the valley is crossed by alluvial plains and is dotted with numerous eroded sandy hills. The rivers draining the Flemish Valley and its tributaries form large meanders within the alluvial plains. Important river dune complexes, up to 10 m high, can be found along the alluvial plains. In some locations in the alluvial plains, elevated sandy hillocks (called 'donken') are present. The lower courses of the Scheldt, the Rupel, the Senne as well as the entire Durme river are under tidal influence, giving this area a peri-marine character. Important dikes prevent the semi-diurnal flooding of the alluvial plain, but risks of inundation cannot entirely be excluded when exceptional tides concur with stormy weather at the coast. This sandy landscape has been transformed into agricultural land (i.e. horticulture and market-gardening).

The **northern cuestas** extend between the north of the oriental branch of the Flemish Valley and the Dutch border. This area includes the clayey cuesta of Boom, the large depression of the Schijns and the Kleine Nete rivers and the clayey Kempen cuesta. The Boom cuesta has a 'front' height ranging from 25 to 50 m and consists of three sub-cuestas, while the Kempen cuesta rises between 20 and 30 m and forms an interfluve between the basins of the Scheldt and the lower Meuse. The 'back' of the Kempen cuesta drops very gently to the north, accommodating large flat stretches with important dune areas (i.e. Kalmthout nature reserve). The 'Heath of Kalmthout' (Kalmthoutse Heide), the second biggest nature reserve in Belgium (about 800 ha of public land), is a typical representative of lowland heaths. Its semi-natural vegetation, largely influenced by man, is dominated by heather and a variety of grasses, with a scattered presence of trees (mostly pine and birch).

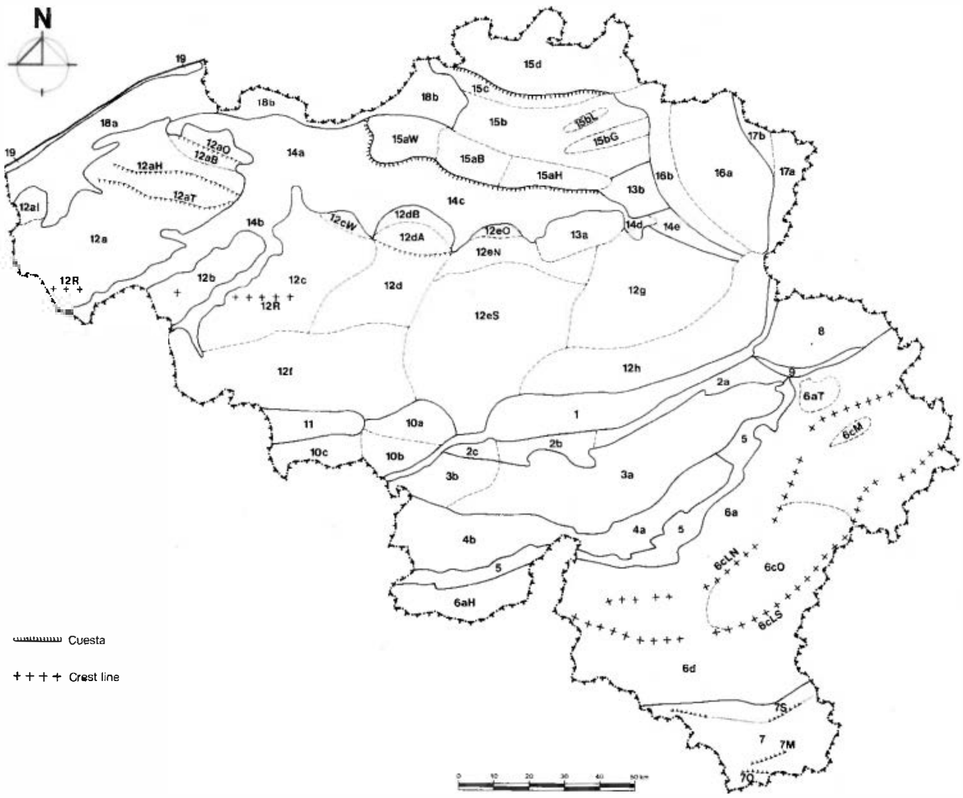
The **Kempen Plateau** is situated more to the east. It is a large, levelled plain with a gentle slope to the north. Its altitude decreases from about 100 m in the southernmost part to 30 m near the Dutch border. Its southern border is characterised by a well-marked and steep slope near the Maas (Meuse) Valley, reaching a difference in level of 40 m in some places. The entire plateau is topped by a thick layer of rough gravel, with boulders occasionally reaching several tonnes, covering a sandier substrate. The Kempen Plateau hosts important continental dune fields. Heaths, dunes and conifer woods are the main landscape elements on the poorer sandy soils, while grasslands and pastures occupy the more fertile soils.

The **Limburgse Maas** (or Maasland) is the part of the Meuse Valley situated downstream of Maastricht, along the Belgian-Dutch border. The valley bottom consists of two elements: the low terrace of the Meuse river and an alluvial plain. The low terrace is situated between 30 and 45 m, on sandy soils gradually becoming siltier to the south. The alluvial plain lies some metres below the terrace and hosts the large meanders of the Meuse river, as well as numerous oxbow lakes. The region is an important passage for migrating birds.

The **coastal plain and the polders of the Scheldt** are the lowest areas in Belgium and are part of the large maritime plain stretching from Cap Blanc-Nez in France to Denmark. Altitudes generally range from 3 to 5 m above sea level, but can also be below sea level in the polders. These areas would be flooded at high tide if they were not protected by coastal dunes, or when these are missing, by an elaborated system of dikes and locks. In Belgium, the coastal plain is usually not broader than 15 km except in the Yser basin. The Scheldt polders border the left side of the maritime Scheldt, forming a vast region north of Antwerp and extending to the south well beyond Temse. The maritime Scheldt, with a mouth width of 5 km, has a complex tidal structure with a far-reaching effect inland: the tidal range exceeds 2 m in Ghent, more than 170 km upstream. These inland areas, covered by very fertile soils, are often cultivated or used as grasslands. They also have a very important value for nature, serving as resting or feeding places for water or wintering birds.

The coastal plain and the Scheldt polders are covered by tidal sediments. In fact, the entire area was gained from the sea through the construction of dikes and artificial drainage. Before the construction of dikes, sea water penetrated via tidal channels cutting through tidal flats. Typical mud flats and marshes can be found here. In direct contact with the Scheldt estuary, the 'slikke' correspond to lower, muddy areas that are flooded twice a day by the tide. Communities are typically dominated by polychaete worms and bivalve molluscs. The high biomass of invertebrates provides an important food source for waders and wildfowl. Scattered vegetation is found mainly at the limit with the 'schorre' (e.g. *Salicornia europaea*). The 'schorre', situated just above the 'slikke', are flooded during exceptional tides only. These salty meadows generally show parallel vegetation belts that correspond to a gradient of salinity tolerance of the species. Because of their extremely high biological value, especially for plants and birds, many of 'slikke' and 'schorre' areas have been granted protection status (see chapter 6, partim Flanders). In this regard, the Zwin nature reserve is one of Belgium's most important protected areas. Located on the Belgian-Dutch border, it has a surface of 125 ha on the Belgian territory and about 25 ha on the Dutch territory.

The Belgian **coast** is 65.5 km long and almost straight. It includes a continuous coastal dune system that dominates the maritime plain on one side and the foreshore on the other. This dune system, which hardly exceeds an altitude of 20 m, has a variable width: it reaches several km close to the French and Dutch borders, but rarely exceeds 200 m along most of the Belgian coastline. In some places, the mobility of the dunes is important and results in the formation of blow-out depressions often reaching the water table. The natural formation of dune ridges results in the creation of humid dune slacks (or 'pannen') that divide successive ridges. Because of their low-lying topographic position, slacks are sheltered from the wind, often seasonally flooded, and usually have a water table within 1 m of the surface. Dunes surrounding a slack have an important effect on its development because organic and inorganic materials move down into the slack. Wind erosion also transports organic matter into the slack. The range of communities found is considerable and depends on the structure of the dune system, the successional stage of the dune slack, the chemical composition of the sand and the prevailing climatic conditions. These small biodiversity oases are highly threatened by the lowering of the water table.



3

Main geomorphological units in Belgium (from DENIS 1992, courtesy of Dexia).
1. Sambre-Meuse axis, 2a. Ardenne Condroz, 2b. Marlagne, 2c. Northern Thudinie, 3a. Condroz Plateau, 3b. Southern Thudinie, 4a. Famenne, 4b. Fagne, 5. Calcareous strip, 6. Ardenne, 6a. Northern Ardenne, 6aH. Thierarche, 6aT. Theux depression, 6c. Central Ardenne, 6cLN. Northern crest line, 6cLS. Southern crest line, 6cO. Depression of the two Ourthes, 6cM. Malmedy depression, 6d. Southern Ardenne, 7. Belgian Lorraine, 7S. Florenville cuesta, 7M. Virton cuesta, 7O. Torgny cuesta, 8. Herve Plateau, 9. Vesdre Valley, 10a. Lower area of Charleroi, 10b. Anderlues Plateau, 10c. Haut Pays, 11. Haine Valley, 12. Large hilly interfluvial area, 12a. Interfluve of coastal plain and Lys Valley, 12aI. Izenberghe Plateau, 12aT. Tielt cuesta, 12aH. Hertsberge cuesta, 12aB. Beernem depression, 12aO. Oedelem cuesta, 12b. Lys-Scheldt interfluve, 12c. Scheldt-Dender interfluve, 12cW. Wetteren glacis, 12d. Dender-Zenne interfluve, 12dA. Asse cuesta, 12dB. Buggenhout glacis, 12eN. Plateau of northern Brabant, 12eS. Plateau of southern Brabant, 12eO. Okkerzeel glacis, 12f. Hainaut Plateau, 12g. Low hills of the Wet Hesbaye, 12h. Plateau of the Dry Hesbaye, 12R. Crest line of the Flemish Hills, 13a. Hageland hills, 13b. Lummen hills, 14a. Flemish Valley, 14b. Southern branch of the Flemish Valley, 14c. Eastern branch of the Flemish Valley, 14d. Halen-Schulen depression, 14e. Demer Valley, 15. Northern cuestas, 15a. Boom cuesta, 15aW. Country of Waes, 15aB. Boom area, 15aH. Heist-op-den-Berg area, 15b. Schyns-Nete depression, 15bL. Lichtaart interfluve, 15bG. Geel interfluve, 15c. Brasschaat glacis, 15d. Kempen cuesta, 16a. Kempen Plateau, 16b. Beringen-Diepenbeek glacis, 17a. Plain of the Limburgse Maas, 17b. Ledge of Gerdingen-Bocholt, 18a. Coastal plain, 18b. Scheldt polders, 19. Dune line.

The present-day intertidal zone is widest (more than 500 m) at the western limit of the Belgian coast, where the average tidal range is also the most important (4.5 m). On the eastern side, where the average tidal range is only 3.6 m, its width does not exceed 200 m. The width of the intertidal zone is not only influenced by its tidal range but also by its slope, which varies all along the coast. At some places, the intertidal zone is severely eroded. This is not only due to harbour construction works but also to natural and local cyclic phenomena. In order to fight this erosion, more than 70% of the coast is now protected by longitudinal dikes, groynes, artificial raisings and other man-made constructions. These artificial structures create new surfaces for colonisation by species typical of hard substrata, which would otherwise not be found on the natural sandy substrates prevailing in Belgian waters (see chapter 6, partim North Sea).

The Belgian marine area is part of the most southern section of the North Sea. It stretches out in front of the coast for about 100 km and has a surface of almost 3,500 km^2, representing only 0.6% of the entire North Sea surface. Its position in the Channel nevertheless gives it a strategic and economical significance at worldwide level. The sea bottom is essentially covered by sands presenting a relief of banks and channels.

3. Soil

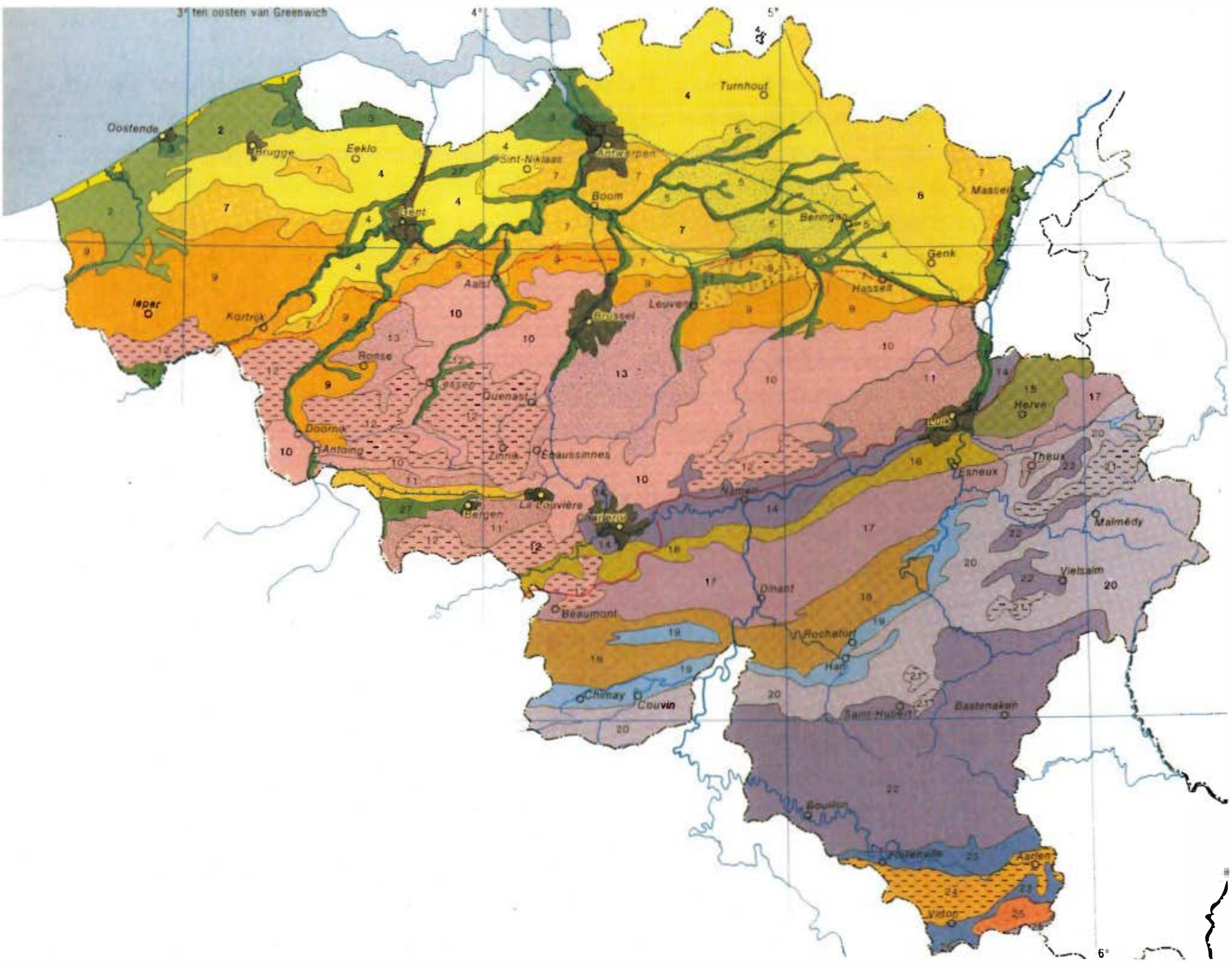
There are many definitions of the term 'soil', depending on the field of interest. Most simplified, the soil or pedosphere corresponds to the upper part of the lithosphere (all rocks and sediments) where the atmosphere (mainly precipitation, temperature and wind) interacts with the biosphere (flora, fauna, man). This subchapter focuses on soil aspects with a direct impact on the distribution of plants and animals. From this point of view, soils are regarded as an essential element among the abiotic factors in the ecosystem dynamics. Considering the depth that tree roots and some burrowing animals may reach, information is needed down to at least 2 m. The term 'soilscape' refers to the soil types, and their distribution, occurring below the surface of the landscape. Figure 3 provides the distribution of soil types in Belgium. The numbers between brackets in the text refer to this map and its legend. Published at a scale of 1:1,500,000 by the Standaard Atlas, it was derived from the soil association map (Marechal & Tavernier 1970, 1974) of the Atlas of Belgium, edited at a scale of 1:500,000.

3.1. *Major soil-geomorphic areas*

In the description of the Belgian soilscape, 5 major soil-geomorphic units can be distinguished. For more information on the topography of these units, see subchapter 2.

Lower Belgium [1] includes the coastal dunes (1), polder area (2, 3) and the sand belt of Flanders and the Kempen (4 to 7). The relief is very flat and agriculture is the dominant land use feature.

[1] Belgium is sometimes divided into three regions based on altitude: Lower Belgium (up to 100 m above sea level), Middle Belgium (between 100 and 200 m), Upper Belgium (above 200 m).



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Distribution of soil types in Belgium (Atlas Mens en Aarde, Uitgeverij De Boeck, Antwerp). Only the dominant soil types are commented.

1. Slightly calcareous sandy soils of coastal dunes. Excessively drained on the dunes, poorly drained in the dune slacks (pannen). Half of the area under natural to semi-natural colonising vegetation.

2 and 3. Clayey to clayey sandy soils of the polders, mostly slightly calcareous. Groundwater table present within a depth of 1.2 m. Under intensive agriculture, mainly as cropland, partly as meadows.

4. Acidic sandy soils of the sand belt. West of the Scheldt, agriculture and drainage since the mediaeval period. East of the Scheldt, less pronounced human activities until World War II, except around villages. Since then, increased human impact following intensive crop growth, urbanisation and industrialisation. Locally, a few heathlands and mobile dunes remain.

5. Transition between the sand belt (4) and the loess belt (9 to 13).

6. Acid sandy soils developed on relict dunes. These dunes stabilised on Pleistocene Meuse river terraces (Kempen Plateau). A few preserved heathlands. Large areas reforested with pine tree plantations.

7. As 5: transition between the sand belt (4) and the loess belt (9 to 13).

8. Shallow loess soils on Tertiary sandy clay substratum.

9. Sandy silt facies of the loess belt, with water table.

10 and 11. Loess belt soils, without water table. Under agricultural pressure for many centuries.

12. Loess belt soils, with water table. Under agricultural pressure for many centuries.

13. Association of loess and sandy soils, without water table. Developed in loess on the smooth slope and plateau positions. Under agricultural pressure for a few centuries. Developed in Tertiary sand outcrops along the valley slopes, these areas were forested most of the time but are now under intensive urbanisation pressure. At the southeastern fringe of Brussels, a 40 km^2 forested area (Sonian Forest, not represented on the map) has never been used for agricultural purposes. Grazing has always been severely restricted. This area is unique because it allows to observe the original geomorphology and soilscape of the West European loess belt before man started to clear the forest for agricultural purposes.

14. Slopes and valley bottoms of Meuse and Sambre river incisions. Very diverse soilscape due to landscape features such as valley slopes, Pleistocene terraces, Holocene alluvial plain, soil parent material and the strong human impact.

Middle Belgium is largely coinciding with the dominant loess cover (9 to 13) resting on Tertiary marine sediments that are mainly clayey or sandy and outcrop at particular landscape sites such as hill tops and west, southwest and south-facing slopes. Except along the main river valleys, the relief is mainly smoothly undulating.

Upper Belgium hosts three important soil-geomorphic components, described here from northwest to southeast.

The **Condroz-Fagne-Famenne-Herve area** with altitudes from 200 up to 350 m. This area has still some patchy areas of loess cover, but most soils are developed on a high diversity of rock types including chalk, limestone, psammite and shale. The relief is moderately undulating (15, 16, 17, 19) except for the flat Fagne-Famenne depression (18).

The **Ardenne massif** (20 to 22) with smoothly undulating plateaus intersected by deep incising valleys. Soils are dominantly derived from weathering products of acid rocks such as sandstone, shale and slate. Crop growth is restricted, mainly because of the relatively low air temperature regime inducing a too short growing season.

The **Belgian Lorraine** (23 to 25) with altitudes between 200 and 465 m and a cuesta landscape belonging to the Paris Basin. Soils are developed on a very wide variety of sediments and rocks including loess, calcareous sandstone, limestone, marl, etc.

3.2. Factors of soil formation

The diversity of present-day soil types is mainly the result of nine environmental factors, briefly commented below.

15. Herve Plateau. Loess soils with substratum of Cretaceous chalk, weathering clay and Primary shales at variable depth.
16. Northern fringe of the Condroz. Loess soils on Primary sandstone and shales. Forests in the areas with water table, cropland on the better-drained areas.
17. Condroz. Moderately rolling landscape with very diverse soil types: thin loess cover on Primary limestone and psammite at variable depth, scattered patches of deep loess soils on plateau areas with limestone substratum. Very diverse land use with cropland, meadows and forests according to slope and soil composition.
18. Fagne-Famenne depression with shallow silty and clayey soils on weathered Primary shales. Mainly forests and meadows.
19. Southern fringe of the Fagne-Famenne, or Calestienne. Shallow silty soils on limestone. Cropland on the deeper soils, forests on the shallow soils.
20. Northern half of the Ardenne massif. Silty stony soils on Primary rock substratum of shales and sandstones, mostly without water table. Forests on the slopes and where the rock occurs at shallow depth. Meadows around villages in areas with the thickest silty soils on the plateau areas.
21. Plateau peat bogs and surrounding silty soils with groundwater stagnation on the clayey weathered rock substratum (saprolite). Locally traces of periglacial (Weichsel Late Glacial) ice mounds. Some peat bogs are still open landscapes with *Sphagnum* mosses and sedges. Others were quarried up to the mid 20[th] century, or were drained and planted with coniferous trees.
22. Southern half of the Ardenne massif. Silty stony soils on Primary rock substratum of shales and slates, without groundwater. Soil distribution and land use as under 20, except some cropland towards the south.
23. Belgian Lorraine. Clayey soils with internal drainage problems on Jurassic marls. Dominantly meadows, some deciduous forests.
24. Belgian Lorraine. Soils on limestone and calcareous sandstone, without groundwater. Some loess soils on plateau areas. Dominantly under deciduous forest, some cropland.
25. Belgian Lorraine. Soils on calcareous sandstone (macigno), without groundwater. Cropland, forest and meadows.

The **soil parent material** (rocks and sediments) in Belgium is rather diverse. Three major units cover each at least 20% of the country: firstly the quartzitic sands (1, 4, 5, 6) of Lower Belgium, secondly the loess belt of Middle Belgium with dominant silty and sandy silt textures and about 15% clay (7 to13) and thirdly the silty soils on acid rocks such as siliceous sandstone, shale and slate in the Ardenne massif (20 and 22). Besides these large units, soils developed on calcareous clayey tidal flat (2, 3) and alluvial (27) sediments, on chalk (15) and marls (23), on Tertiary marine outcrops ranging from quartzitic sands to glauconic clays (in areas 4 to 13), on hard rocks such as limestone (17, 19), shale (18) and sandstone that can be micaceous (17), calcareous (24, 25), ferruginous and siliceous (25, locally 5 and 8).

Duration of the period over which the landscape is stable, or 'age' of the soil. The Belgian soilscape is rather 'young'. Soils on the coastal dune ridge (1), the polder areas (2, 3) and alluvial plains (27) are younger than 1,000 years. The end of the original Weichsel Pleniglacial and Late Glacial sand and loess deposition of North and Middle Belgium (4 to 13) dates back to 10,000-15,000 years. Since then, anthropogenic erosion and sedimentation have rejuvenated a large part of the soils in these areas. The large soilscapes developed on Tertiary (scattered in 4 to 13), Secondary (15, 23 to 26) and Primary (16 to 22) sediments and rocks were significantly renewed by Weichselian erosion processes. Anthropogenic erosion and sedimentation processes have further strongly rejuvenated those areas of the sand (4 to 7) and loess (8 to 13) belts that are since many centuries under intensive agriculture. Only in some karstic sinkholes (scattered in 17) and on part of the Ardenne plateau (20, 22), deep saprolite can be observed reflecting long lasting weathering under a tropical climate and high soil surface stability during and since the Tertiary.

During the Bolling and Allerod stadials of the Late Glacial, and during most of the Holocene, the **climate** of the country presented an excess of precipitation over evapotranspiration for forested sites. Since forests have been cleared over large areas to create meadows and cropland, the precipitation excess increased markedly. As a consequence of this recharge-discharge balance, the whole Belgian soilscape, including the coastal dune area with the lowest precipitation, is losing plant nutrients through time. Where developed on calcareous sediments, such as the Pleniglacial cover sands and loess (4 to 13), or on calcareous rocks such as the Carboniferous and Jurassic limestones (17, 23 to 26), soils become gradually decarbonated and more acid. Soils can also have an impact on the (micro)climate: the coolest temperatures of Belgium, recorded in the peat bogs (21) of the Ardenne plateau, are slightly enhanced by the intensive evaporation from these large marshy, wind-swept areas.

The **topography** plays an important role in soil variability, mainly by three observed environmental impacts. Firstly, soils on south facing slopes warm up and dry out more and faster than those facing north. Secondly, during rainy periods, dominant winds come from the southwest. Consequently, the slopes oriented in this direction receive considerably more precipitation than slopes oriented towards the northeast. This difference in soil moisture regime has an impact on the leaching of nutrients, the acidification and the depth of decarbonation. On calcareous sandstone, or on loess deposits, it is not uncommon to observe a decarbonation occurring twice as deep on the southwest facing slopes in comparison with the northeast oriented slopes. Thirdly, when the land is bare, the risk for erosion by wind or water is considerably higher on southwest facing slopes than on northeast facing ones.

Soils have a direct impact on plant growth. But **vegetation** has also an impact on soils, among others by:

- the quality of the litter input (e.g. deciduous and coniferous trees will produce different types of humus);
- the evapotranspiration of the ecosystem, influencing the amount of excess water percolating through the soil;
- the organic matter input in the soil surface horizons, increasing aggregate stability and potential for nutrient and water retention;
- the feed-back of nutrients to the surface horizons by the litter and to the deeper soil horizons by the input of substances from the roots.

One neglected impact of plants on soils is the uprooting of trees. This process increases markedly the ecosystem diversity. In Lower and Middle Belgium (4 to 13) about 10% of the soilscape has been influenced by this process down to at least 80 to 100 cm depth. Another human-induced feature is the development of heathlands due to sheep and cattle grazing since the Bronze Age. Heath vegetation accelerates soil acidification (4 to 6). A third example of anthropogenic impact by vegetation on soils is the plantation of extensive pine areas in the sand belt (4, 5) and spruce and Douglas fir in the Ardenne (20 to 22). These are responsible for an impoverishment of the soil fauna and flora and create a risk for increased release of aluminium in the groundwater with a possible impact on the river water quality.

The herbivore **fauna** has an important influence on acid soils. Consumption of the ground vegetation and straw and the input of dung and urine, decrease the carbon/nitrogen (C/N) ratio in the soil surface horizons. Besides this direct impact on the chemical soil fertility, there is also a very important effect on the physical soil fertility. Parallel to the input of dung and the lowering of the C/N ratio, an increase of the scarabid and earthworm populations is observed. In a second phase, these burrowing animals attract the presence of insectivores such as moles. All these animals drill galleries in the soils and thus favour aeration, water percolation and deep root penetration. These processes are strongly hampered in many soils that have undergone no human impact such as organic or mineral fertiliser applications or bringing grazing animals in forested sites. The most intensive and deepest faunal turbation by earthworms and moles is observed in the polder areas (2, 3), those loess soils (7 to 13) that are under pastureland and the soils on chalk (15), marl (23) and limestone.

Since centuries, North and Middle Belgium are among the densest populated areas in the world. Evidently, the impact of **man** on the soilscape is very important. Today, very few areas allow to have an idea how the soilscape would have been, if human presence had been restricted to hunters/gatherers in these areas. A few forested sites that have undergone little or no grazing activities are from this point of view unique for earth science and should be protected from further human disturbance. The Sonian Forest, situated in the loess belt at the south eastern edge of Brussels, is such an area (not represented on the map). Here, soils display the very acid and the low physical fertility conditions that the first farmers were facing some 7,000 years ago, when they made a first tentative in colonising the West European loess belt. These areas allow the measurement and the evaluation of human impact on the remaining 99% of the soilscape in North and Middle Belgium. Deep ploughing, intensive fertilisation, soil levelling and drainage, and the associated erosion and sedimentation processes have been the main activities responsible for a profound change in morphological, physical and chemical soil characteristics in Lower and Middle Belgium. In Upper Belgium, this impact has been much less important. However, it is difficult to find areas on the Ardenne plateau where shifting cultivation, drainage works or cattle grazing have been absent.

Another factor influencing soil formation is the **soil moisture regime**. Well-drained soils dominate the Belgian soilscape. When crops are grown, such soils do not have to be drained or irrigated. Despite a considerable precipitation deficit in summer, plants will not reach wilting point because of a groundwater table within rooting depth in sandy soils, or because of the water-holding capacity of the clayey or silty soils. The driest soils of the country are found in the coastal (1) and inland (scattered in 5 and 6) dune areas of Lower Belgium and on some of the Tertiary sandy outcrops (scattered in 13) of Middle Belgium. In these soils without clay or silt, the drought is enhanced by the hydrophobicity of the humus-rich surface horizon and the dense packing of the sand grains in the deeper subsurface horizons. Intensive drainage operations have considerably lowered the groundwater table in the polders (2, 3), that were once tidal flat areas, in most of the original wetlands of the cover sand area (4 to 8), where the low position and the presence of a clayey substratum below the sand cover impede good drainage, and finally in that part of the loess belt with a clayey substratum (9, 12). Some of these drainage works date back to the mediaeval period. Later, in the first decades after World War II, they became very intensive in the frame of land reclaim projects. The purpose was to facilitate the growth of winter crops and to make the land accessible to heavy engines in early spring in order to extend the growing season for summer crops.

Today, the few remaining wetland soils are scattered throughout the country. Most of them are situated in the alluvial plains (27) or dispersed in small parts of the cover sand area (mainly in 4 to 6). Most of these areas are still under threat of surrounding drainage works that locally penetrate the alluvial plains in order to grow crops. Peat soils covered originally rather extensive areas of the sandy lowlands (4 to 6) and the alluvial plains (27). The extent of these soils has dramatically decreased because of intensive peat exploitation for fuel and drainage works to enhance crop grow. The drainage process has led to an accelerated decomposition of the organic matter and a lowering of the soil surface reaching 1 to 2 cm per year. Large part of the upland peat bogs on the Ardenne plateaus (21) have also been quarried for fuel production and have been drained for coniferous tree plantations.

In Belgium, erosion processes would be almost inexistent if there was no human interference. In naturally forested sites, all precipitation water infiltrates into the soil and no surface runoff is observed. The most important 'natural' **erosion and sedimentation processes** were landslides on slopes with clayey soils (15, 23) and on scattered hills with Tertiary clay outcrops in Lower Belgium. Under 'natural' conditions, similar processes could take place in the alluvial plains (27), on the tidal flat areas (2, 3), along the coastal beach fringe (1) and along the rock cliffs of Upper Belgium where some slope debris deposition occurs. The rest of the soilscape would be completely stable since at least the beginning of the Holocene. After a first clearance of the forest for agricultural purpose by the early Neolithic farmers, some 7,000 years ago, accelerated erosion and sedimentation processes started. In the beginning, and probably up to the end of the Iron Age, the magnitude of these processes was rather limited. Even though agriculture intensified during Roman times, it is mainly since the mediaeval period that colluvial sedimentation has been observed on foot slopes and in depressions, together with alluvium sedimentation in the alluvial plains. The use of the plough that cuts, lifts and turns over the soil has certainly accelerated the erosion processes. Splash, sheet, rill and tillage erosion are the main processes taking place on croplands of the loess belt (9 to 13). Where these soils are under agricultural practice since many centuries (9 to 12), up to 30% of the soilscape may be composed of soils developed in metres thick colluvial deposits that gradually filled the depressions. In the sandy area of Lower Belgium, some aeolian erosion may happen on cropland or when overgrazing of heathland occurs.

4. Geology

Belgium has a rich geological history and it would take too long to make a detailed presentation of the geological structure of the country. This section will therefore concentrate on items relevant for biodiversity, namely the main lithological features of the major stratigraphic units.

Belgium is almost entirely made up of sedimentary rocks, showing a considerable age and composition diversity. Igneous and metamorphic rocks are much less represented. Igneous rocks appear only sporadically, such as in Lessine and Quenast, two villages in Brabant famous for their quartz diorite (or porphyry) found in old volcanic chimneys. Volcanic rocks sometimes occur between marine sediments. This is the case near Manderfeld on the Belgian-German border, where the most occidental of the recent Eifel volcanoes is found. Metamorphic rocks occur in some regions, for example in the Ardenne around Vielsalm, Bastogne and Libramont, but their metamorphic character is generally so weak that it is easy to recognise the properties of the sedimentary rocks from which they are derived.

The sedimentary rocks can be subdivided into four large stratigraphic units, corresponding to their age and structural position: the lower and upper Paleozoic folded units, the unfolded post-Paleozoic cover and the Quaternary cover.

4.1. Lower Paleozoic rocks

The rocks of the lower Paleozoic unit, the most ancient sedimentary rocks in Belgium, were deposited between 545 and 417 million years ago (Ma) following a major marine transgression. They are mostly of detrital marine origin, but some of them have a coastal or continental origin. Diagenesis and low-grade metamorphism transformed the unconsolidated sediments into coherent rocks, mostly sandstone, quartzite and shale. They were then folded and faulted during two different phases of the Caledonian orogeny, a major mountain-building episode of the lower Paleozoic era: an earlier phase took place in the Ardenne about 450-420 Ma and a later phase in the Brabant Massif about 410-380 Ma.

4.2. Upper Paleozoic rocks

The rocks of the upper Paleozoic unit were deposited between 417 and 290 Ma. They include detrital rocks but also marine limestone and continental coal. In the Ardenne, they were folded during the Variscan (or Hercynian) orogeny around 300-270 Ma and underwent low-grade metamorphism. In the northern part of the country, they are mostly lying unfolded on the southern and north-eastern edges of the Brabant basement, but they do show some faulting.

GEOCHRONOLOGY Ma					LITHOLOGY
	CENOZOIC	QUATERNARY	HOLOCENE		sand, loam, clay, peat, gravel
1,8			PLEISTOCENE		
		TERTIARY	PLIOCENE		sand
			MIOCENE		
			OLIGOCENE		clay, sand
			EOCENE		
			PALEOCENE		sand, calcarenite, marl
65	MESOZOIC	CRETACEOUS	UPPER		chalk, marl, calcarenite
			LOWER		
144		JURASSIC	MALM		
			DOGGER		
				BAJOCIAN	limestone
			LIAS		sandstone, marl
213		TRIASSIC	RHAETIAN		sand
			KEUPER		marl
					conglomerate
			MUSCHELKALK		
248			BUNTSANDSTEIN		
	PALEOZOIC	PERMIAN			
286		CARBONIFEROUS	SILESIAN	STEFANIAN	
				WESTFALIAN	shale (sandstone)
				NAMURIAN	
			DINANTIAN	VISEAN	limestone
				TOURNAISIAN	
360		DEVONIAN	UPPER	FAMENNIAN	sandstone
					shale
				FRASNIAN	limestone
			MIDDLE	GIVETIAN	limestone
				COUVINIAN	limestone, shale
			LOWER	EMSIAN	shale, slate (sandstone)
				SIEGENIAN	
408				GEDINNIAN	
438		SILURIAN			shale, slate
		ORDOVICIAN			
505				TREMADOCIAN	slate
		CAMBRIAN		REVINIAN	slate
590				DEVILLIAN	quartzite

5

The stratigraphic timescale with indication of the corresponding lithology (from DENIS 1992, courtesy of Dexia).

The Paleozoic bedrock emerged as a platform after the Variscan orogeny and is at present exposed all over Upper Belgium (south of the Sambre and Meuse axis), except in the Belgian Lorraine where it is covered by younger unfolded rocks. To the north of the Sambre and Meuse axis, the Paleozoic bedrock is uncovered only locally in the valleys of the Scheldt, Dender, Senne, Dyle and Gete.

4.3. *Post-Paleozoic cover*

The sediments of the post-Paleozoic cover date from the Mesozoic and the Tertiary. They were deposited between 225 and 1.8 Ma, and are generally of marine origin. As they have not been affected by any folding, they mostly kept their horizontal stratification and remained in a soft rock state (sand, clay, chalk). More or less coherent layers of limestone or calcareous and siliceous sandstone are inserted between them. North of the Sambre and Meuse axis, the total thickness of the post-Paleozoic cover increases gradually in a north to north-eastern direction: from 0 to 200 m in Middle Belgium, 200 to 500 m in Lower Belgium to more than 1,000 m in the north and north-eastern part of the Kempen. In the Haine Valley, the sediment deposits reach 200 to 400 m, while in the Belgian Lorraine they progressively increase from north to south, to exceed 700 m at the French border.

4.4. *The Quaternary cover*

The sediments of the Quaternary cover are very recent compared to those of the Paleozoic bedrock and post-Paleozoic cover: even though the beginning of the Quaternary has been fixed at 1.8 Ma, the sediments generally do not exceed a few tens of thousand years in Belgium. They are mostly of continental origin, except for some deposits in the coastal zone. The major part of the oldest Quaternary deposits has been removed by erosion. Only scattered remnants are found, except in the Kempen where the clay and sand deposits can be 50 m thick, and in central Belgium where an extensive loess cover dating from the Ice Age attains several metres. The thickness of the Quaternary cover is usually less than 1 m, but can reach exceptionally 30 to 40 m in some places. The Quaternary deposits are the thickest on the plateaus, gentle slopes and plains with a concave or flat relief. They are absent or discontinuous on steeper slopes. The composition of the cover is extremely variable: clay, sand, silt, peat, gravel, etc. Abrupt changes in composition are mainly due to the local topography.

The Quaternary deposits are extremely important, as they constitute almost everywhere the superficial layer in which soils were formed and on which human activities take place. The subdivision of Belgium in natural regions also reflects the origin, composition and thickness of the Quaternary cover.

5. Climate

The Belgian climate can be summarised by two annual averages calculated for the Uccle weather station, at the headquarters of the Royal Meteorological Institute: a temperature of 9.8°C and a precipitation of 802 mm. This corresponds to a mild, temperate, maritime climate with a relatively high average temperature and moderate precipitation for such a latitude (50°). The south-eastern part of the country, especially the Hautes Fagnes, displays features of a slightly more continental and tougher climate, as illustrated below.

5.1. Precipitation

The annual precipitation measured in Uccle ranges between 406 mm and 1,082 mm, with an average of 802 mm. The lowest rainfall is observed near the coast, while it increases gradually inlands towards the southeast.

The predominant factor influencing the annual precipitation is the altitude: the higher the altitude, the more abundant the rainfall. Anomalies can be explained by the general orientation of slopes in relation to the progression of the main atmospheric disturbances: the south-western border of the Ardenne is much wetter than its central and south-eastern parts, which correspond to more sheltered zones. With annual rainfall normals varying between 1,100 and 1,400 mm, the Hautes Fagnes, near the German border, and the Plateau des Tailles, near the French border, also experience higher precipitations than expected by a higher altitude only. This is also the case to a lesser extent in the northern part of the country, such as in the Kempen near Antwerp, the Country of Waes and the surroundings of Eeklo and Ghent. On the other hand, the surroundings of Tienen, the north-eastern corner of Limburg, the Hesbaye, the Condroz and the area between Sambre and Meuse are characterised by lower precipitations than expected. These variations can partly be explained by the analysis of changes in rainfall distribution throughout the year.

The times of the year with the least precipitation in Belgium are generally the end of winter and the beginning of spring. The periods with the most abundant precipitations differ from one region to another. The coastal zone experiences a simple pattern with maximum rainfall in autumn, while the most southern part of the country shows a maximum in winter. These maxima both demonstrate a maritime influence: the autumn maximum at the coast corresponds to North Sea maritime features, whereas the winter maximum in southern Belgium relates to oceanic influences (such as seen in Brest, France). Between these most distant areas, the different rainfall zones show a complex regime where an aestival rainy period appears in addition to the two peaks cited above. This feature, typical of more continental climates, may even dominate in some areas, as for example in the Hautes Fagnes.

5.2. Temperature

The average temperature from 1901 to the present day is 9.8°C in Uccle. Nearly 10°C is actually a mild temperature for a latitude of 50°: this average is similar to stations in southern England and Ireland, but much higher than what is observed on the Russian east coast (2°C in Petropavlovsk, Kamtchatka) and somewhat higher than averages from Canadian or Argentinean coastal towns of comparable latitudes (8°C in Port Hardy and Santa Cruz). The mild temperatures occurring in Belgium are related to the influence of the Gulf Stream, which tempers the air masses in winter. Particularly wet or dry years can most often be correlated to the character of their summer or autumn, whereas years with abnormal average temperatures are principally controlled by the harshness or mildness of their winter months.

Like for precipitation, the principal factor regulating the spatial distribution of average temperatures is the altitude (cooler temperatures with higher elevations). Again, the gradient does not remain constant from one month to another. The average cooling rate per 100 m of altitude is higher in winter than in summer, both for maximal and minimal temperatures. Other factors intervene besides altitude. For example, the proximity to the coast influences somewhat the maximal temperature (but not the minimal temperature); the effect of the North Sea and Zeeland can be felt up to 30-40 km inland, especially from April to August. Topography also plays a role: temperature extremes are less correlated to altitude during the summer, when stations react in function of the local site configuration and land use. Valleys are cooler during the night and warmer during the day, while urban areas are warmer both during day and night.

Table 1. Some regional characteristics of the Belgian climate. The empty boxes indicate normal values in relation to the altitude or information gaps.

Area	Annual rainfall (*)	Period of maximum rainfall	Maximum summer temperature (*)	Wind speed	Sunshine
Coastal region (40 km inland)		autumn	very low	quite high	high
Country of Waes, western Kempen	excess	summer (autumn)	low		
Inland Flanders, Middle Belgium (Hainaut, Brabant, eastern Kempen)		summer, autumn, winter	quite high		low
Liège area (Hesbaye, Condroz, Plateau of Herve)	shortage	summer (winter)			low
Sambre-Meuse axis, central Ardenne	shortage	summer, winter (minor changes)			
High plateaus of the Ardenne (above 600 m)	large excess	summer (winter)	low	quite high	
Southern Ardenne	large excess	winter			
Belgian Lorraine	shortage		quite high		high

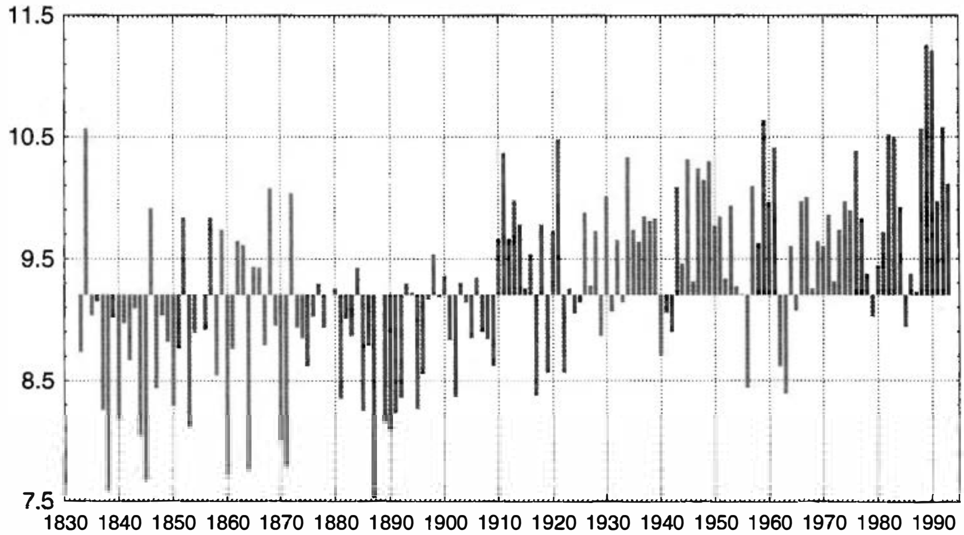
(*) Residuals from the regression in relation to altitude.

5.3. Other climatic features

Wind directions and velocities are particularly sensitive to the local environment of the recording station. As far as wind directions are concerned, it is difficult to identify specific patterns. Average wind velocities are highest at the coast and, to a lower degree, in a hinterland of about 40 km. Wind speeds are more moderate above central Belgium while they increase again further to the south, reaching another maximum on the high plateaus of the Ardenne.

Regional trends are difficult to establish for other climatic features such as the amount of sunshine, atmospheric humidity, cloud cover, mist, frost and snow cover. Some of these need complementary studies (e.g. snow) or even more adequate data collection (e.g. frost, atmospheric humidity).

Is Belgium experiencing a warming of its climate? This contemporary topic of interest must be handled with caution. Comprehensive data are available since 1833 only; moreover they may not be totally comparable as the network of observers and the recording methods evolved with time. Climatic records in Uccle show that a general warming of the climate has been observed in Belgium in the 20th century, but that there have been no unusually warm years till the end of the 1980s. It should be noted that no significant changes have been observed for the rainfall.



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Average annual temperatures (°C) measured in Uccle from 1833 to 1993 (from SNEYERS & VANDIEPENBEECK 1995, courtesy of the RMI).

Between 1971 and 1987, the annual average temperature exceeded the 10°C barrier only three times, with a maximum value of 10.5°C in 1982 and 1983. But then a particularly warm period started: since 1988, with the exception of 1996 (9.1°C), the annual average temperature always exceeded 10°C, with maximal values of 11.3°C in 1989 and 11.2°C in 1990 and 2000. 1989 was the hottest year since the beginning of observations. The average annual temperature for 1988-2001 is 10.7°C. This may support the idea of climate warming, but conclusions in this matter should however be drawn extremely carefully.

Ecosystems around the world are showing the effects of climate warming. Four types of changes are possible (ROOT *et al.* 2003): the geographical range of species may shift, the timing of events (phenology) may change, changes in morphology and behaviour may occur and genetic frequencies may shift. Examples include the migration of species towards the poles or up in elevation, the earlier arrival of migrant birds, earlier appearance of butterflies, earlier spawning in amphibians or egg laying in birds and earlier flowering of trees and plants.

These phenomena are also observed in Belgium. Climate warming could, at least partially, explain the expansion of some Mediterranean species in a northern direction, in a way that their new distribution area encompasses Belgium or a part of it. A well-documented example in Belgium is that of southern dragonflies, observed regularly in Wallonia for the past ten years (GOFFART & DE SCHAETZEN 2001). Other Mediterranean insects have been recorded in Belgium, among others Orthoptera (crickets and grasshoppers) and Hymenoptera (bees, wasps, ants, etc.). Outside the world of insects, examples are also reported among spiders (*Argiope bruennechi*) and birds (European bee-eater, *Merops apiaster*).

The increase in the number of southern species reproducing in Belgium could be seen as a positive contribution to Belgian biodiversity. However, this might be overly optimistic, as the decline of species with a more northerly distribution has also been observed. Such a rarefaction has for example been recorded for dragonfly species found in peat bogs in the Kempen and Ardenne (GOFFART & DE SCHAETZEN 2001). Moreover, as current climate changes are very rapid, many organisms are not able to change their distribution patterns as fast as dragonflies, either because of lower dispersion abilities or because of the lack of suitable relay habitats allowing an easy retreat to the north. If temperatures rise further, northern species are predicted to decline significantly as they will disappear from the southern margins of their ranges, with little opportunity to expand northwards.

6. EVOLUTION OF THE BELGIAN LANDSCAPE

6.1. A wilderness

The recent origin (on the geological time scale) of the Belgian landscape is largely the result of changing climate and vegetation patterns over time. The Quaternary has been marked by an alternation of glaciations and warmer periods, with considerable changes in the fauna and flora as a consequence. During the coldest episodes, a thick ice mantle covered most of northern Europe (Ireland, Wales, Scotland, northern England, Scandinavia) while Belgium experienced a periglacial climate, with many cold spells briefly interrupted by warmer periods. The landscape, open and apparently lacking in trees, was dominated by a steppe vegetation. The last glaciation ended about 10,000 years ago, giving place to the current interglacial period.

The gradual warming up of the climate after the last glaciation allowed the development of an almost continuous forest cover from the coast to the higher areas of the Ardenne. This cover was actually made of a series of different deciduous forest types, depending on the local soil conditions. It was interrupted only where tree growth could not take place: on emerging rocky substrates, unstable soils such as dunes, regularly flooded areas such as marshes, peat bogs, etc.

6.2. Forest clearance

The introduction of agriculture and the successful establishment of farming communities around 5,200 B.C. marked one of the most significant transformations of the landscape in northern Europe. Neolithic farmers first started clearing the forests located on the best soils, in the alluvial plains of the large river valleys, the limy plateaus and sandy areas. Later on, they progressively carried out their expansion to less fertile regions of the Ardenne and Flanders. During the Middle Ages, the uninhabited landscape still dominated over the inhabited countryside and large forest areas occupied most of the space. Between the end of the Middle Ages and the 19th century, the landscape became progressively more open, with a combination of cultivated fields, pastures and forests. The forest cover decreased substantially around towns and villages, always in need of more wood for construction and economic development.

Until the industrial revolution, and even far beyond for some areas, the traditional agro-pastoral economy resulted in well-individualised, stable and harmonious landscapes. From a biological point of view, the opening up of the primeval forest coupled to recurrent land uses led to the diversification of the fauna and flora and to their combination into original communities, often of a very high biological richness. These forest-derived secondary communities, still present nowadays, are considered as semi-natural landscapes. They include calcareous grasslands, heaths and unfertilised hay meadows (which then occupied vast areas). Secondary semi-natural forests correspond for example to oak-birch forests that replaced beech forests in the Ardenne. Forests only slightly modified by human influence, both in terms of structure and composition, are considered as sub-natural. The habitats least influenced by man, and the most natural still found in Belgium, are those of primary dunes, salt meadows, peat bogs, marshes, rocky vegetation and aquatic fringes. All these environments described as natural, sub-natural or semi-natural, in function of the level of human influence, can be considered as natural in the broad sense since their characteristics are favourable to wildlife. Obviously, the same considerations cannot be applied to intensive agricultural, urbanised and industrial environments.

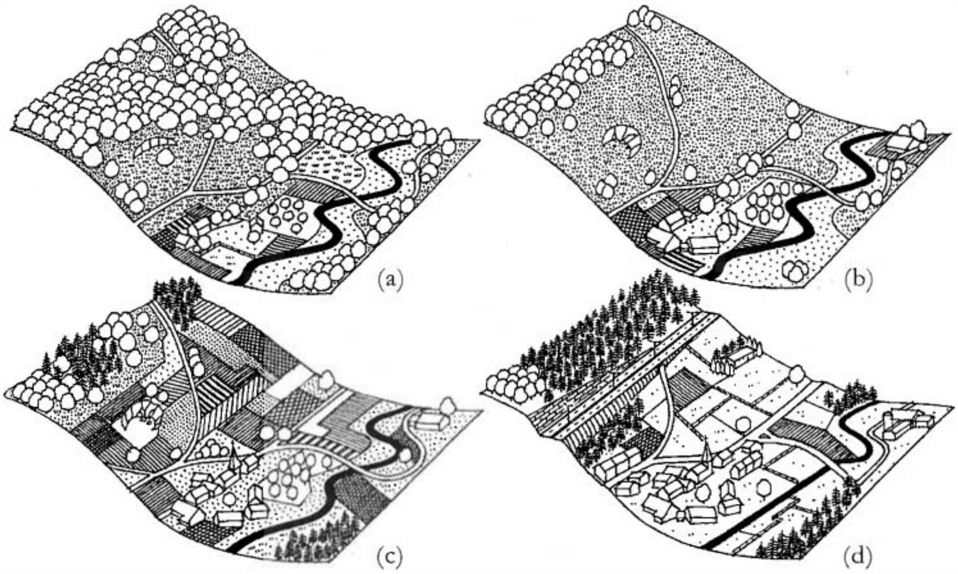
6.3. Transformation of the rural landscape

The industrial revolution led to major changes in the landscape. The country became more industrialised and urbanised. Early in the 19th century, the industrial axis of the Sambre-Meuse-Ruhr was formed, heralding the big conurbations of today. From the 1950s onwards, cities expanded and urbanisation slowly munched through the countryside. Housing developments surrounded small villages, while industrial estates spread along major roads and railways, with as a result the increased fragmentation of natural habitats. This is still the case nowadays.

Improved farming methods led to the intensification of agriculture, with increased pressure on the environment as a consequence. Until World War I, traditional agricultural practices were favourable to the development of biological and ecological elements of high value playing a decisive role in the ecological structure of the landscape. This was also the case for other traditional, sometimes semi-industrial, practices such as the exploitation of reed beds and peat extraction, which resulted in highly diversified landscapes with a well-marked regional identity and a considerable biological value. Biologically rich ecosystems developed and remained present on land marginal for agriculture (dunes, calcareous grasslands, dry and wet heathlands, marshes, peat bogs, etc.).

The industrial revolution accelerated the development of agriculture, with severe consequences for the ecological structure of the landscape. The first changes came with the increased use of fertilisers. Later on, mechanisation, an easier access to fossil energies, the modification of farming methods, the changeability of world markets, and, since the 1950s, the common agricultural policy in Europe, all contributed to the fast disappearance of traditional agriculture, the intensification of production and the levelling of landscapes. The regrouping of land parcels led to the disappearance of important landscape features such as hedges, ditches and ponds. Moreover, biologically rich marginal agricultural lands were either developed intensively through the use of fertilisers or, if their exploitation became economically unviable, set aside for afforestation (or reforestation) with exotic conifer species like Scots pine (*Pinus sylvestris*) in the Kempen and Norway spruce (*Picea abies*) in the Ardenne.

Together with urbanisation, major public works like the construction of highways and the straightening of waterways, and the increase in domestic and industrial pollution, agriculture has had disastrous effects on the survival and quality of natural habitats. This impact has been particularly severe in northern and central Belgium, prominent agricultural regions, where the ecological and agricultural characteristics of the landscape were transformed in a drastic way. In Upper Belgium, where the forest cover has always been more important, changes in the landscape affected the nature of the wooded areas, through the generalisation of plantations of exotic tree species. Here also, marginal agricultural areas underwent severe decline.



7

Evolution of a typical landscape in the Ardenne: (a) situation in the 18th century, (b) in the 19th century, (c) at the end of the 19th century, (d) today (drawing by A. FROMENT, courtesy of Dexia).

7. People and society

7.1. *Population*

With a current population estimated at 10.3 million inhabitants (2002), Belgium is a very small country at the European level. However, with 338 inhabitants/km^2, it is the second most densely populated country in the European Union after the Netherlands (465 inhabitants/km^2).

The spatial distribution of the population underlines the unequal distribution over Belgium's territory. The most densely populated areas are found in a central rectangular area between Antwerp, Leuven, Brussels and Ghent. Other areas with a high population density (more than 300 inhabitants/km^2) are found along the Sambre and Meuse axis, around Kortrijk and along the coast. At the opposite, most areas south of the Sambre and Meuse axis do not exceed 50 inhabitants/km^2.

Belgium is a heavily urbanised country. There are 17 urban areas with more than 80,000 inhabitants, which gather 60% of the population on one fourth of the territory. Five cities exceed 100,000 inhabitants: Brussels, Antwerp, Ghent, Charleroi and Liège.

7.2. *Economy*

Thanks to its central position, Belgium is at the heart of the economic activity of the European Union. Even if it hosts only 0.2% of the world's population, it is the tenth exporter of goods (3% of the world market). Regarding services, Belgium comes in eight position (3.6% of the world market). Belgium is also a major transit zone in Europe, with 20% of the EU road transport carried out by Belgian transporters and with Antwerp as the second port in Europe after Rotterdam. Belgium also beneficiates from the presence of the headquarters of European institutions in Brussels, such as the Commission, the Council of Ministers and the Parliament. Other international organisations such as NATO are also established in the capital.

In 2001, Belgium's gross domestic product (GDP) totalled 263 billion EUR, which represents 2.9% of the EU total GDP. Long-term growth calculated for the past ten years averages 2.1% a year. The economy is dominated by the service sector and, while the manufacturing industry continues to contribute about 25% of the total GDP, its share of GDP is declining while that of the service sector continues to grow. In 1999, the Belgian GDP was distributed as follows: 1.3% for agriculture, 24.7% for industry and 67.1% for services. It should not be forgotten however that most services in the private sector are closely linked to industrial activities, among others for transport, adverting, financial services, engineering and maintenance. In 1999, Belgium exported goods and services to 76.5% of its GDP, with imports amounting to 73%. The main markets for exports were the other countries of the European Union, mainly Germany, France and the Netherlands.

7.3. *Agriculture and fisheries*

Modern agriculture bears little resemblance with traditional practices. As exposed earlier, the agricultural world has undergone significant changes in the 20th century. However, even though agriculture currently occupies less than 2.5% of the active population, it remains an important economic sector not only for food supply but also because its activities extend over half the Belgian territory and shape the evolution of the rural landscape.

The major agricultural activities are arable crops and livestock production. Crops include cereals (about 500,000 ha in 2001), sugar beet (95,000 ha), potatoes (60,000 ha), rapeseed and linseed. Vegetables, fruits and flowers are other significant economic activities. Livestock production is mainly centred on cattle (both meat and milk), pig and poultry.

In 2001, there were less than 60,000 farms in Belgium while in 1970 there were 184,000. Their productivity and average area have increased, the latter reaching nearly 20 ha nowadays as compared to 8 ha in 1970. There are major differences between regions: Wallonia, with more extensive livestock production and crop cultivation, has bigger farms than Flanders, where intensive agriculture predominates (e.g. horticulture and intensive livestock rearing with no natural grazing).

Because of the limited coastline (66 km), fishing is not a major activity in Belgium. Only about 20,000 tons of fish (mostly flat fish and cod) are brought ashore by Belgian fishermen each year. Other marine products are shrimp and oysters. Zeebrugge, Ostend and Nieuwpoort are the three ports concerned by fishing activities.

8. A federal state

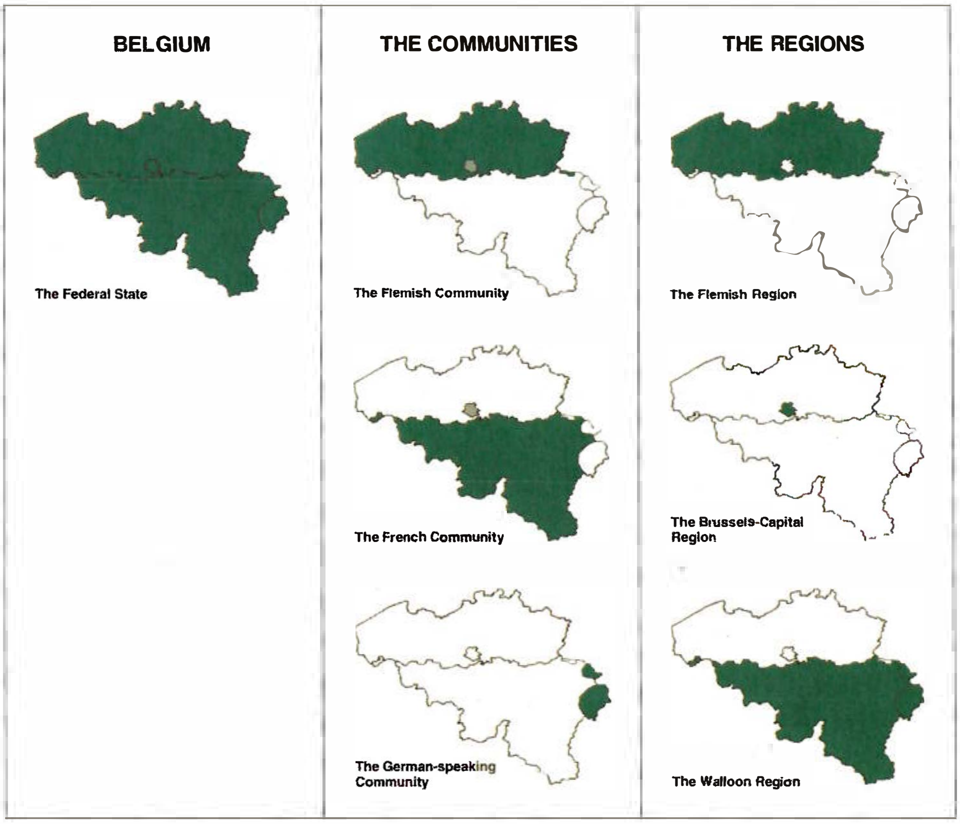
Belgium has existed in its present form since 1830, when the Southern Netherlands (now Belgium) gained their independence following a revolution that separated them from the Northern Netherlands (now the Netherlands). During 140 years, Belgium remained a unitarian state with a decentralisation of responsibilities to the provinces and municipalities. Via four successive phases of institutional reform in 1970, 1980, 1988-89 and 1993, the country evolved progressively into a federal state. A fifth reform is currently envisaged. The redistribution of the decision-making power followed two lines:

(1) The first concerned linguistics, and more broadly, everything related to culture. It gave rise to three communities, based on language and related to population groups: the Flemish-, French- and German-speaking Communities.

(2) The second main line of the state reform was inspired historically by economic concerns and led to the founding of three regions corresponding to geographical entities: the Flemish Region (or Flanders), the Brussels Capital Region and the Walloon Region (or Wallonia).

As a result, the first article of the Constitution states today: "Belgium is a federal state, which consists of communities and regions". To some extent, the Belgian regions are similar to the German 'Länder' or the Swiss cantons. The country is furthermore divided into 10 provinces and 589 municipalities. The current decision-making structure of Belgium is therefore made of several levels: the upper level comprises the federal state, the communities and the regions; the middle level is occupied by the provinces and the lower level is that of the municipalities. The provinces and municipalities act within the framework of competences at the federal, community or regional level. The federal level, regions and communities each have their own government and parliament, giving Belgium a very distinct and unusual character.

The **federal level** remains responsible for everything that falls within the sphere of the national interest: foreign affairs, defence, justice, finances, social security, important sectors of public health and domestic affairs. The regions and communities are entitled to run foreign relations themselves in those areas where they have competence. The **communities** deal with matters relating to the people composing them: culture, education, radio and television, uses of languages, welfare for individuals, etc. The **regions** have authority in territorial matters such as regional development and town planning, environment, agri-



8

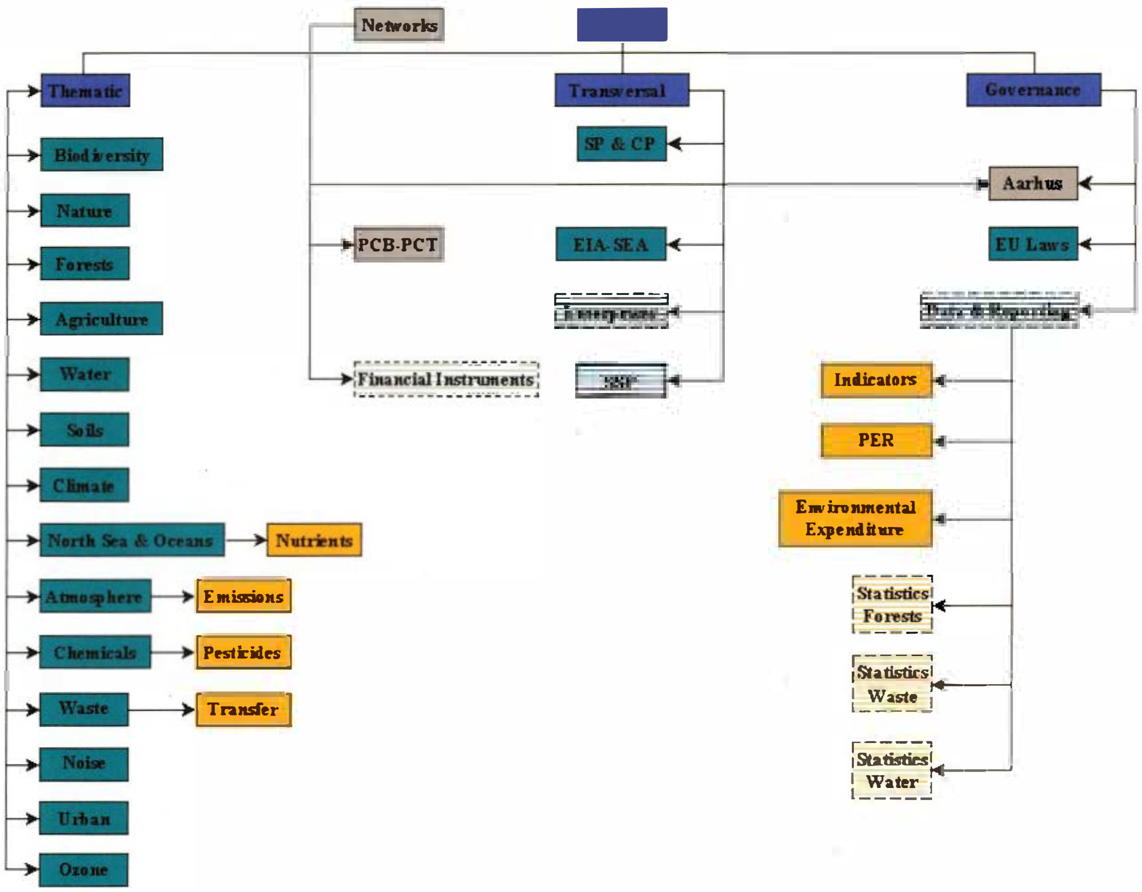
Belgium, a federal state consisting of communities and regions (drawing by H. VAN PAESSCHEN, based on a web-published map on http://www.belgium.be).

culture, rural development and nature conservation, energy, housing, water policy, employment, public works, transport, economic policy, regional aspects of banking policy and foreign trade. Implementation of nature and biodiversity conservation measures is therefore nearly entirely a regional competence.

Due to the complex organisational structure, decisions regarding international aspects of environmental policy are taken as a consensus between the different decision-making levels. The consultation process takes place through the Co-ordinating Committee for International Environmental Policy (CCIEP), which is composed of representatives of all the competent federal and regional administrations. This body functions under the high level authority of the Inter-ministerial Conference for the Environment (ICE), chaired by the Federal Minister for Environment. The main tasks of the CCIEP are to prepare for the positions of the Belgian delegations in international conferences and to organise consultation processes to establish a co-ordinated execution of international decisions and recommendations.

Several thematic steering committees operate under the authority of the CCIEP. Two of these are the steering committees 'Biodiversity Convention' and 'Nature'. The steering committee 'Biodiversity Convention' is specifically in charge of the follow-up of the

Convention on Biological Diversity (CBD). Its tasks include among others the establishment of Belgian positions and the undertaking of reporting obligations. The steering committee 'Nature' carries out the follow-up of other international agreements such as the Convention on Wetlands (Ramsar Convention), the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) and the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention). It is also in charge of the co-ordination between regions regarding the European Union Habitats and Birds Directives.



9

Organisation chart of the Co-ordinating Committee for International Environmental Policy (adapted from the original version). Green box: Steering Group; yellow box: Working Group; striped box: new situation; SP & CP: Sustainable Production & Consumption Patterns; EIA-SEA: Environment Impact Assessment / Strategic Environmental Assessment; SSP: Strategic and Structural Policy (including integration and sustainable development); PER: Pollutants Emissions Register; Aarhus: follow-up of the Convention on access to information, public participation in decision-making and access to Justice in Environmental matters; EU Laws: follow-up of the transposition process by legislative & administrative authorities in the field of environment & chemicals regulations, directives and decisions.

Acknowledgements

The authors acknowledge most sincerely the following experts for their precious contributions and suggestions: François BROUYAUX, Gaston DEMARÉE and Marc VANDIEPENBEECK (RMI), Robert FOURNEAU (ULg-CNB), Gerard GOVERS (KUL), Roger LANGOHR (RUG), Pieter LAGA and Walter DE VOS (Geological Survey of Belgium/RBINS), Jeroen REYNIERS (VLM), Martin TANGHE (ULB).

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Anne FRANKLIN
Marc PEETERS
Department of Invertebrates
Royal Belgian Institute of Natural Sciences
Rue Vautier 29
1000 Brussels

Vicky LEENTJES
Studies and Co-ordination Office
Federal Department of the Environment
Pachecolaan 19 bus 5
1010 Brussels

CHAPTER 3

PROKARYOTIC AND BOTANIC DIVERSITY

Guido RAPPÉ & Jan RAMMELOO

1. INTRODUCTION

Botanic diversity is used in its classical sense, excluding the prokaryotes. The latter are integrated as a separate paragraph in this chapter for completeness. Besides the prokaryotes, the chapter provides information on algae (with the exception of the prokaryotic blue-green algae), green plants and fungi.

Most of the information was obtained by sending out a questionnaire, based on the model for zoologists developed by Marc PEETERS and Jackie VAN GOETHEM (RBINS), to targeted experts. The answers of the completed forms were 'translated' into a summary text by the first author, under the supervision of the second author. The correspondents are acknowledged in the text.

In addition to the answers gathered via the questionnaires, information was collected by directly contacting additional researchers, or by searching Belgian or other West European literature, in some cases also grey literature. The latter category tends to become more and more important, since several main sources of information, often related to short time research, do not reach the public literature. For a number of groups, no questionnaire was returned despite further contacts. This was especially the case for algae with marine planktonic taxa and for many microfungi in general, especially plant pathogens. In these cases, we tried to estimate or describe the diversity on the basis of the literature mentioned above. Occasionally, the questionnaires were returned with data that could not directly be synthetised (e.g. amalgamated information on several taxa, former classification concepts). If the task of bringing together the information with the help of the available literature could not be done within a realistic time frame, we opted not to join any summary of knowledge on the respective taxa.

We selected basic reference texts for inclusion in the reference list. If dedicated literature on the identification or status of a taxon in Belgium was not readily available, we included the references of literature covering other (western) European countries or of a recent general textbook. References used for the description (Belgian or worldwide situation) of several taxa are grouped at the end of the chapter under 'general references and further reading'.

The authors have tried to follow present-day insights in phylogeny and systematics as much as possible, but the delimitation of the many taxonomic subdivisions presented in this chapter has also been dictated by other factors such as common scientific practice and specific Belgian expertise. This explains why flowering plants and chlorophytes are not subdivised any further. For the latter, Belgian researchers are generally specialised either as marine or continental experts. On the other hand, some groups, such as for example the taxon Laboulbeniales, which is a highly specialised group of ascomycetes relatively well known in Belgium, is treated separately. This may seem an eclectic point of view, but it offers the opportunity to illustrate the highly diverse degrees of knowledge in the matter.

In one particular case, we opted not to follow the formal hierarchic ranks and their appropriate suffixes imposed by systematics and the International Code of Botanical Nomenclature. For all groups of land plants (embryophytes), we consequently kept the suffix '-ophyta' at all distinguished levels. One would end up with too many intermediate levels (with badly known suffixes) before arriving at the angiosperms. Moreover, this choice is supported by other authors such as RAVEN *et al.* (1999). The order in which the summaries on embryophytes are placed nevertheless reflect current views on their phylogeny.

This is the first time since the beginning of the 19th century (see DE WILDEMAN & DURAND 1898-1907 with three volumes of the 'Prodrome de la flore belge') that a compilation like this is achieved in Belgium. We have brought information together on botanic biodiversity and produced a summary for all taxa on a 'best professional judgement' basis. We are pretty confident that the experts answered the questionnaires to the best of their knowledge. However, it is inevitable that this synthesis is incomplete. We would very much appreciate any comments, corrections and additions.

2. PROKARYOTIC DIVERSITY

PROKARYOTA, partim EUBACTERIA (excl. CYANOBACTERIA) and ARCHAEA (syn. ARCHAEBACTERIA) - TRUE BACTERIA and ARCHEBACTERIA
(BACTERIËN en ARCHAEBACTERIËN - BACTÉRIES et ARCHÉBACTÉRIES - BAKTERIEN und ARCHEBAKTERIEN)

Ancient life forms; simple cell structure, with few organelles: no nucleus (but DNA and RNA present), no chloroplasts (but pigments and thylakoids can be present), no mitochondria, small ribosomes for protein synthesis; bacterial cell walls contain peptidoglycan or murein; most known Archaea have a protein coat, although some do have pseudomurein; unicellular, eventually forming aggregates; Archaea originally mainly known from extreme habitats (extreme thermophiles in hot springs, extreme halophiles in hypersaline conditions, etc.), but recently proven to be more widespread; methane production in nature is the work of Archaea (methanogens); asexual reproduction.

Prokaryotes occur everywhere, sometimes in very extreme habitats, in marine, freshwater and terrestrial environment, in other organisms, as useful symbionts or parasites (pathogens), in anaerobic or aerobic conditions; anoxygenic photosynthesis by bacteria is at the basis of many food webs.

At present, approx. 6,000 species known worldwide; this number represents only 1% of the actual diversity as based on estimations in various ecosystems; a species concept in prokaryotes is not well defined, partly because a biological species definition as in Eukarya is not possible and also because of the important impact of lateral gene transfer on the composition and the organisation of the prokaryotic genome.

The questionnaire has been completed by Paul DE VOS and Anne WILLEMS (Ghent University).

Knowledge is insufficient. An estimation of the diversity in Belgium is not available and not relevant as most species are ubiquitous. The Belgian diversity will be similar to the diversity in other regions of the world with comparable conditions. A downward trend may be caused by habitat loss and an upward one by the continuous creation of new xenobiotic compounds that are targeted via a reshuffling of the bacterial genome and/or the introduction of external genomic elements. Reference literature are the globally acknowledged handbooks: 'Bergey's Manual of Systematic Bacteriology', the second edition of which is currently been undertaken, and the on-line third edition of 'The Prokaryotes' (DWORKIN 1999-2002). Belgian expertise in bacterial taxonomy is recognised worldwide. Important collections are kept in the Belgian Co-ordinated Collections of Micro-organisms, Bacteria Collection (BCCM™/LMG, http://www.belspo.be/bccm/lmg.htm).

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PROKARYOTA, partim CYANOBACTERIA, (syn. CYANOPROKARYOTA, CYANOPHYTA) - BLUE-GREEN ALGAE, CYANOPHYTES, CYANOBACTERIA

(BLAUWWIEREN, CYANOBACTERIËN - ALGUES BLEUES, CYANOPHYCÉES, CYANOBACTÉRIES - BLAUALGEN, CYANOBAKTERIEN)

Oxygen-producing photoautotrophic prokaryotic organisms with a unicellular, colonial or filamentous organisation; specialised (asexual) reproductive cells absent or present in the form of exospores, endospores or akinetes; occur virtually everywhere, in marine, freshwater and terrestrial environments, sometimes in very extreme habitats (hotsprings), also epiphytic and endophytic; two taxonomic approaches are presently coexisting: a 'botanical' one based on the morphological features (e.g. KOMAREK & ANAGNOSTIDIS 1999) and a 'bacteriological' one based on molecular characters and gene sequences (e.g. CASTENHOLZ 2001); approx. 1,700 (1,400-2,000) species worldwide.

The questionnaire has been completed by Pierre COMPÈRE (National Botanic Garden of Belgium). Additional information was received from Annick WILMOTTE (University of Liège) and Lucien HOFFMANN (Luxembourg University Centre, Grand Duchy of Luxembourg).

Approx. 300 species are known from Belgium, but this is an incomplete estimation. Knowledge is insufficient and supported by very few people. Some 15 endemics of unclear taxonomic status are described. The main geographical regions and habitats are the North Sea and estuaries, wet soils and rocks, eutrophic and polluted standing waters (but this may merely reflect the existing research). Caves and 'tufs' are especially vulnerable habitats (Symoens *et al.* 1951, Garbacki *et al.* 1999). Blue-green algae have been observed to cause toxic blooms in standing waters (Van Hoof *et al.* 1994, Wirsing *et al.* 1998, Willame & Hoffmann 1999). Mollenhauer *et al.* (1999) warn that cyanobacteria and algae may be endangered, mainly due to human influences. However, the extinction risk of microbial taxa is problematic to assess. Two partial checklists and identification keys are available: Compère (1986) for the freshwater and terrestrial habitats and Coppejans (1995, 1998) for the hard substrates within the littoral marine environment. Other marine habitats have hardly been sampled for Cyanobacteria.

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3. Synopsis of the Belgian flora

Eukaryota, partim Protoctista

The photoautotrophic representatives of the Protoctista or Protists are the so-called Algae, studied by phycologists (who also often study the photoautotrophic prokaryotic Cyanobacteria). Heterotrophic Protoctista comprise taxa formerly classified with fungi (and often still being studied by mycologists) or animals.

MYXOMYCOTA (syn. MYXOMYCETES, MYXOGASTRIA, MYCETOZOA) - TRUE SLIME MOULDS
[(PLASMODIALE) SLIJMZWAMMEN - MYXOMYCÈTES PLASMODIAUX - MYXOMYCETEN, SCHLEIMPILZE]

Heterotrophic protoctists, formerly classified with Fungi (or with animals); also known as plasmodial slime moulds or acellular slime moulds; exhibiting different life cycle stages: uninucleate cells (some biflagellate), somatic moving multinucleate plasmodium, resistant sclerotium and reproductive phase with the formation of stationary sporophores; true slime moulds are essentially terrestrial organisms, generally avoiding dry habitats, although 'blooms' have been observed in deserts after rainfall; saprobic on decaying (wooden or leavy) organic material (with among others nivicolous, corticolous and coprophilous specialists), fungivorous, bacteriovorous or in symbiosis with bacteria; no marine representatives; some 900 species worldwide.

The questionnaire has been completed by Myriam DE HAAN (independent expert, Kalmthout).

Some 300 (200-500) species are estimated to occur in Belgium. The group is moderately well known (better in the northern part of the country, i.e. Flanders), but knowledge is supported by too few specialists. A relatively recent checklist and identification keys for Flanders are available (VANDEVEN *et al.* 1996, VERMEULEN 1999). Knowledge on trends does not exist. Important collections (among others Nannenga-Bremekamp) are kept in the National Botanic Garden of Belgium.

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ACRASIOMYCOTA and DICTYOSTELIOMYCOTA - LOBOPODIAN CELLULAR SLIME MOULDS or ACRASIDS and FILOPODIAN CELLULAR SLIME MOULDS or DICTYOSTELIDS
[(CELLULAIRE) SLIJMZWAMMEN - MYXOMYCÈTES CELLULAIRES - ZELLIGE SCHLEIMPILZE]

The latter used to be seen as a class of the former, but both groups are now considered as separate phyla, probably not even closely related. They are treated together for convenience. Acrasids are found on dead plants, tree bark, dung and soil, whereas dictyostelids are typical soil organisms; both are small taxa, with 12 acrasid and 46 dictyostelid species worldwide.

No questionnaire has been returned. DE WILDEMAN & DURAND (1898-1907) mention no acrasids and two species of *Dictyostelium*. The actual status of both groups in Belgium is unclear.

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GLAUCOPHYTA (syn. GLAUCOCYSTOPHYTA)

Unicellular and colonial flagellates, with a primary endosymbiosis (cyanelles); main environment is fresh water, especially soft water habitats such as bogs; only 13 species are known worldwide.

One species has been recorded in Belgium (e.g. VAN MEEL 1944). A second species, common in well-defined habitats in the British Isles, may be found elsewhere in temperate regions, Belgium included (JOHN *et al.* 2002).

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CHLORARACHNIOPHYTA

Unicellular green-pigmented algae, derived from filose amoebae with a secondary endosymbiosis (green alga); so far, only species from temperate and tropical marine waters have been described; only 5 species are known worldwide; environmental sampling in the North Sea near Helgoland has shown the occurrence of chlorarachniophytes.

Nothing is known about the occurrence in Belgium.

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EUGLENOPHYTA (syn. EUGLENIDA) - EUGLENOPHYTES, EUGLENIDS, EUGLENOIDS, EUGLENOID FLAGELLATES

(GESELWIEREN, OOGWIERTJES - EUGLÉNIENS, EUGLÉNOÏDES - AUGENTIERCHEN)

Mainly unicellular green-pigmented flagellated algae (but also a number of non-pigmented -with colourless plastids or lacking plastids- heterotrophic taxa), originating from an ancient divergence of protists, with a secondary endosymbiosis occurring much later (green alga); chlorophyll a and b are thus the photosynthetic pigments; chloroplasts enveloped by triple membrane; pellicula has subsurface proteinaceous (usually), spirally arranged bands ('striped' pattern); typical eyespot; usually elongated form, but very plastic; asexual reproduction by closed mitosis; no sexual reproduction; lives predominantly planktonic in freshwater habitats (swamps, ditches, lakes, bogs, etc.), but also benthic and in nearshore marine or brackish mud or sand, or in marine plankton; approx. 930 species worldwide.

The questionnaire has been completed by Pierre COMPÈRE (National Botanic Garden of Belgium).

So far, 405 species are known, but knowledge is insufficient and supported by very few people. Some 50 species of doubtful taxonomic status are described as endemics. Main geographical regions and habitats are standing, or slow running, waters in the lowlands of Belgium: Pleistocene sandy region, loam plateaus, polders (but this may reflect the habitats in which phycologists were active). Nothing is known about possible trends. A partial checklist and identification key for the inland waters is available (COMPÈRE 1989).

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CRYPTOPHYTA (syn. CRYPTOMONADIDA) - CRYPTOPHYTES, CRYPTOMONADS

(CRYPTOWIEREN - CRYPTOPHYCÉES - SCHLUNDGEISSLER)

Small planktonic algae with a unicellular, rarely colonial or filamentous organisation, derived from a secondary endosymbiosis (red alga); phototrophic and heterotrophic species; showing a large spectrum of pigments: chlorophyll a and c_2, α- and β-carotenes, phycoerythrin or phycocyanin; chloroplasts surrounded by four membranes; asymmetrical cell shape, with furrow/gullet or depression; asexual reproduction by semi-closed mitosis, no sexual reproduction; occur mainly in marine and fresh water of temperate and Boreal regions; approx. 200 species worldwide.

The questionnaire has been completed by Pierre COMPÈRE, amended for the marine environment by Guido RAPPÉ (both National Botanic Garden of Belgium).

Some 50 inland species are known, with an additional estimated number of less than 10 for the purely marine environment. Knowledge is insufficient, especially as far as marine species are concerned, and is supported by very few people. From Belgium, 23 species have been described, many of doubtful taxonomic status and with a badly known distribution. Main geographical regions and habitats in Belgium are estuaries, creeks and other inland waters in the coastal zone (but this may reflect the habitats in which phycologists were active). Nothing is known about possible trends. A partial checklist and identification key for the inland waters is available (COMPÈRE 1989).

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HAPTOPHYTA (syn. PRYMNESIOPHYTA) - HAPTOPHYTES, HAPTOMONADS, COCCOLITHOPHORIDS

(HAPTOWIEREN - HAPTOPHYTES - KALKALGEN)

Unicellular (sometimes colonial), mainly nannoplanktonic, biflagellated algae, derived from a secondary endosymbiosis (red alga); pigments common to all haptophytes are chlorophyll a, c_1 and c_2, β-carotene, diatoxanthin and diadinoxanthin; chloroplasts typically surrounded by four membranes; cell shape is variable (round, flattened, elongated); scales or spines may be observed; asexual reproduction by closed, semi-closed or open mitosis, depending on the species; typical haptonema; most haptophytes are marine, being important members of the plankton and responsible for a major part of the oceanic primary production, nutrient cycles, DMS production and marine (chalky) deposits; benthic forms are insufficiently known; approx. 300 species worldwide.

No questionnaire has been returned. The text has been compiled by Guido RAPPÉ, with additional information from Pierre COMPÈRE (both National Botanic Garden of Belgium).

From inland waters and estuaries, 12 to 13 species have been mentioned in literature. A conservative estimation leads to 10 species for the area of the Belgian Continental Shelf, with another 10-15 to be expected. *Chrysochromulina* is the most diverse genus in marine waters, but identification at species level is difficult. No checklist is available. Belgian marine phytoplankton researchers mainly focus on ecology, production and nutrient cycles of the dominant bloom species. *Phaeocystis globosa* causes an important bloom in Belgian waters in spring and some years also in summer. These blooms have intensified in abundance and duration during the last decades. The ecology of *Phaeocystis* is very well studied in the Southern Bight and along the Belgian coast, among others by LANCELOT and colleagues (e.g. ROUSSEAU *et al*. 2000).

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RHODOPHYTA - RED ALGAE

(ROODWIEREN - ALGUES ROUGES - ROTALGEN)

Showing a variety of thallus organisations: unicellular, filamentous and foliose, often multibranched; derived from a primary endosymbiosis; most important photosynthetic pigments are chlorophyll a, phycoerythrin and phycocyanin; most filamentous species show typical connections between daughtercells, known as primary pit plugs; secondary pit plugs can be formed between non-sister cells or even red algae parasites and their hosts; sexual reproduction is oogamous, with coccoid (non-motile) gametes (lacking flagella); biphasic or triphasic, isomorphic or heteromorphic life history; occur mainly in a marine, much less in a freshwater environment; approx. 5,500 species worldwide.

The questionnaire has been completed by Henry ENGLEDOW (Ghent University) for the marine benthic species and amended by Guido RAPPÉ (National Botanic Garden of Belgium) to include the freshwater species.

In the marine tidal and subtidal coastal zone, 33 species are known, but a further 15 can be expected. In the non-marine environment, 20 species have been found. Knowledge is moderate to good. As most of the red algae in the temperate zone are benthic or epiphytic on other algae, the most important habitats are formed by a variety of artificial constructions in the coastal waters (harbours, groynes, piers, etc.). Many non-indigenous species can be found washed ashore on the beach. Nothing is known about possible trends, but alien species clearly are in progress, finding shelter in harbours and marinas (e.g. KERCKHOF & STEGENGA 2003). Two partial checklists and identification keys are available, COMPÈRE (1991) for the freshwater habitats and COPPEJANS (1995, 1998) for the (coastal) marine environment. Main collections are kept at the herbaria BR (National Botanic Garden of Belgium, Meise) and GENT (Ghent University).

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ALVEOLATA, partim PLASMODIOPHOROMYCETES - ENDOPARASITIC SLIME MOULDS

(PLASMODIOFOREN, PARASITAIRE SLIJMZWAMMEN - MYXOMYCÈTES PARASITAIRES - PARASITISCHE SCHLEIMPILZE)

These organisms have formerly been classified within the kingdom Fungi. Obligate endoparasites observed in vascular plants, in heterokont and streptophycean algae and in water moulds (Saprolegniales); producing multinucleate, unwalled protoplasts within the cells or hyphae of their hosts and forming biflagellate zoospores; asexual reproduction in the hostcells or hyphae; 47 known species worldwide.

No questionnaire has been returned. DE WILDEMAN & DURAND (1898-1907) mention two species, but no doubt more taxa occur in Belgium. Apparently, no synthesis of current knowledge on plasmodiophorids is available.

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ALVEOLATA, partim DINOFLAGELLATA (syn. DINOPHYTA, PYRRHOPHYTA p.p.) - DINOFLAGELLATES, DINOPHYTES

(PANTSERZWEEPHAARWIEREN, DINOFLAGELLATEN - DINOFLAGELLÉS, DINOFLAGELLATES - DINOFLAGELLATEN, PANZERGEISSLER)

Largely unicellular flagellates with two distinctive undulipodia (each of them often in a distinct furrow); autotrophic forms mainly derived from a tertiary endosymbiosis, from a variety of sources: green algae, cryptomonads, haptophytes, diatoms; a wide variety of pigments can thus be encountered (chlorophyll a and c_2, carotenes, xanthophylls, etc.), with one pigment typical for most autotrophic dinoflagellates: peridinin; chloroplasts usually surrounded by three membranes; many species with a theca, showing a multiple membrane complex forming plates, giving them an armoured appearance; some species have scales; different types of eyespots; characteristic reproductive cells are known as dinospores (zoospores) and asexual resting spores (hypnospores); vegetative cells are haploid; diploid motile zygotes (planozygotes) occur due to sexual reproduction; common in fresh and (predominantly) marine water, planktonic and benthic; symbiotic and parasitic lifestyle; approx. 4,000 species worldwide.

The questionnaire has been completed by Pierre COMPÈRE for the brackish and freshwater species, completed for the marine environment by Guido RAPPÉ (both National Botanic Garden of Belgium).

So far, 141 inland species have been recorded, with an additional estimated minimum of 60 for the purely marine environment. Knowledge is insufficient, especially as far as marine species are concerned. Forty species are described from Belgium (mainly from inland coastal waters), but were rarely seen after their original description. The most important habitats in Belgium are the marine and coastal waters: North Sea, estuaries, brackish polder creeks (e.g. CALJON 1984) and ditches, as well as the Pleistocene sandy regions (Flemish and Campine districts). Nothing is known about possible trends. A partial checklist and identification key for the inland waters is available (COMPÈRE 1989).

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HETEROKONTA (syn. STRAMENOPILES) - HETEROKONTS

(HETEROKONTEN - HÉTÉROKONTÉES - HETEROKONTEN)

Possessing two flagella that differ in length and ornamentation; group is very diverse, including oomycetes, diatoms, chrysophytes, brown algae, etc.

HETEROKONTA (syn. STRAMENOPILES), partim HETEROKONTIMYCOT(IN)A (syn. PSEUDOFUNGI)

This taxon encompasses the Oomycetes, Labyrinthulomycetes and Hyphochitriomycetes.

OOMYCETES - OOMYCETES or DOWNEY MILDEYS and WATER MOULDS

(o.a. WATERSCHIMMELS en VALSE MEELDAUWEN - OOMYCÈTES, CHAMPIGNONS AQUATIQUES p.p. - ALGENPILZE)

Include aquatic, both freshwater ('water moulds') and marine, terrestrial and parasitic, heterotrophic organisms, formerly classified within the Fungi; range from unicellular to highly branched coenocytic filamentous forms; main cell wall components are cellulose and cellulose-like polymers; asexual reproduction by biflagellated zoospores; sexual reproduction through conjugation; form thick-walled oospores; approx. 810 species worldwide.

LABYRINTHULOMYCETES - NET SLIME MOULDS

Living in marine and brackish habitats, nearshore and in estuaries, most often associated to marine angiosperms or benthic algae; at least one species is known as a parasite of bivalve molluscs; approx. 48 species worldwide.

HYPHOCHITRIOMYCETES

Occurring in marine, freshwater and terrestrial habitats; living saprobic and in soils, in nearshore waters and in estuaries; approx. 23 species worldwide.

One questionnaire comprising these three related groups has been completed by André FRAITURE (National Botanic Garden of Belgium).

Based on old literature (DE WILDEMAN & DURAND 1898-1907, VERPLANCKE 1940), approx. 100 (80-150) species, almost exclusively oomycetes, may occur. Knowledge of these groups in Belgium is poor. Some serious pathogens of important agricultural crops, e.g. the oomycete *Phytophthora*, are studied in depth. Nothing is known about trends or extinctions.

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HETEROKONTA (syn. STRAMENOPILES), partim HETEROKONTOPHYTA (syn. OCHROPHYTA, CHROMOPHYTA p.p.)

All autotrophic Heterokonta are the result of a secondary endosymbiosis (red alga); photosynthetic pigments: chlorophyll a and c (in one or more forms c_1, c_2 or c_3), β-carotene, fucoxanthin or vaucheriaxanthin; chloroplast surrounded by four membranes; many eyespots can be present.

HETEROKONTOPHYTA, partim CHRYSOPHYCEAE s.s. and *incertae sedis* - CHRYSOPHYCEANS, GOLDEN(-BROWN) ALGAE

(GOUDWIEREN - CHRYSOPHYCÉES - GOLDBRAUNE GEISSELALGEN, GOLDALGEN)

Chrysophytes used to be a large concept, including xanthophytes and diatoms, next to the chrysophyceans. The latter used to include haptophytes, synurids, silicoflagellates, etc., but has been narrowed down considerably the last two decades (KRISTIANSEN & PREISIG 2001). The chrysophyceans *sensu stricto* are small planktonic organisms, with a unicellular, colonial or filamentous thallus organisation; derived, like other phototrophic heterokonts, from a secondary endosymbiosis (red alga); major brown pigment is fucoxanthin; thallus consists of naked cells or cells covered with (sometimes silicified) scales; some species with a cellulose or chitin lorica; Chrysophyceae, like Synurophyceae, form silica-walled resting stages (stomatocysts) by (isogamous) sexual or asexual reproduction; cell shape often round or pyriform; mainly living in inland waters, approx. 890 species worldwide; to this number can be added, for reasons of convenience, another 100 chrysophyte species *incertae sedis*, but not Chrysophyceae s.s. following KRISTIANSEN & PREISIG (2001).

The questionnaire has been completed by Pierre COMPÈRE, amended for the marine environment and the new taxonomic concepts within chrysophytes and allies by Guido RAPPÉ (both National Botanic Garden of Belgium).

A total of 175 non-marine species are mentioned in the literature. For the marine environment, a species number of 10 is roughly estimated. Also mentioned here, for reasons of convenience, are 9 chrysophyte species *incertae sedis*, but not Chrysophyceae s.s. following KRISTIANSEN & PREISIG (2001). Several species have been described from Belgian inland waters, many of doubtful taxonomic status and with a badly known distribution. Knowledge is moderate to insufficient and supported by very few people, especially as far as marine species are concerned. Main geographical regions and habitats are the coastal zone and Lower Belgium. Nothing is known about possible trends. No checklist is available.

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TOMAS, C.R. (ed.), 1993. Marine phytoplankton: a guide to naked flagellates and coccolithophorids. Academic Press, London: 263 pp.

HETEROKONTOPHYTA, partim SYNUROPHYCEAE

Small planktonic organisms, with a unicellular thallus organisation, often forming globular or chain-like colonies; cells or colonies are covered with siliceous scales, sometimes bearing silica bristles; derived, like other phototrophic heterokonts, from a secondary endosymbiosis (red alga); main reasons to separate them from the chrysophyceans are their lack of chlorophyll c and differences in flagella root systems; Synurophyceae, like the Chrysophyceae, form silica-walled resting stages (stomatocysts) by (isogamous) sexual or asexual reproduction; almost entirely restricted to fresh water, with some species penetrating brackish water; 151 species are recognised worldwide, 121 of which are attributed to the genus *Mallomonas*.

No separate questionnaire was received. The text was compiled from information supplied by Pierre COMPÈRE and from the literature by Guido RAPPÉ (both National Botanic Garden of Belgium).

In Belgian literature, 63 species are mentioned, 11 of which belong to *Synura* and 50 to *Mallomonas*. No doubt several of these have to be synonymised. Some species have been described from Belgian waters and possess a doubtful taxonomic status and a badly known distribution. Knowledge is moderate to insufficient, supported by few people. Main geographical regions and habitats are primarily located in Lower Belgium, but this is possibly biased by the distribution of the sampling effort. Nothing is known about possible trends. No checklist is available.

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HETEROKONTOPHYTA, partim BACILLARIOPHYCEAE - DIATOMS

(DIATOMEEËN, KIEZELWIEREN - DIATOMÉES - DIATOMEEN, KIESELALGEN)

Unicellular, solitary or colonial organisms, with a characteristic two-valved silica skeleton (frustule); main xanthophyll is fucoxanthin; diploid vegetative cells, with gametes produced by meiosis; centric diatoms are oogamous, pinnate forms isogamous; zygote develops into a large auxospore; auxospore formation is also possible by autogamy or apogamy; environment very broad, encompassing marine, freshwater, brackish water, planktonic, benthic, epiphytic, epizoic habitats, etc.; approx. 12,000 species worldwide, but estimations vary (up to millions).

The questionnaire has been completed by Koen SABBE (Ghent University) and Pierre COMPÈRE (National Botanic Garden of Belgium), with additional information from Luc DENYS (Antwerp University).

Approx. 1,600 non-marine (reasonable estimation) and 1,000 marine (very rough estimation) species estimated from Belgium. Several were described from Belgian inland waters. Knowledge is moderate to insufficient, especially as far as marine species are concerned. Main geographical regions and habitats in Belgium are the North Sea and estuaries, brackish waters and oligotrophic to mesotrophic standing waters. The increasing number of species is due to recently intensified research. No recent checklist is available, the latest one is that of De Wildeman & Durand (1898-1907), but many partial checklists have been drawn from larger research projets (e.g. Denys 1991, Denys *et al.* 2000, Descy 1983, Fabri & Leclercq 1984). Diatoms have been used in studies on the water quality of lotic systems (Descy & Empain 1981), applying the Diatom Biological Index (IBD, Prygiel & Coste 2000), or as an instrument to typify lentic freshwater habitats (Denys 1997). An identification key to freshwater genera is available on the Internet (Compère 2001). The famous collection Van Heurck will soon be transferred from the facilities of the Antwerp Zoo to BR (herbarium National Botanic Garden of Belgium, Meise). Many small but fine collections are managed by research groups of the universities of Antwerp, Ghent, Liège and Namur.

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HETEROKONTOPHYTA, partim PELAGOPHYCEAE

Small group of planktonic algae with unicellular (coccoid, monadoid or palmelloid) or filamentous thallus organisation; derived, like other heterokonts, from a secondary endosymbiosis (red alga); exclusively marine, possibly entering brackish estuaries; this class was only established in 1993; approx. 12 species have been described worldwide.

No questionnaire was returned. In the Belgian literature, one species is mentioned, with a further two expected. Knowledge is insufficient. The coastal habitats are the main geographical region. Nothing is known about possible trends.

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HETEROKONTOPHYTA, partim DICTYOCHOPHYCEAE

Class includes silicoflagellates, pedinellids and rhizochromulinids; silicoflagellates are unicellular, planktonic and marine, living mostly in temperate surface waters and having a siliceous skeleton; pedinellids are unicellular, with the second undulipodium internally; main xanthophyll is fucoxanthin; occur in both marine and freshwater environments; *Rhizochromulina* is a marine amoeboid species; 25 to 27 species are recognised worldwide for the three groups together.

No separate questionnaire has been received. Text compiled by Guido RAPPÉ, based on information provided by Pierre COMPÈRE (both National Botanic Garden of Belgium) and on the situation elsewhere in the southern North Sea (NOVARINO *et al*. 1997, AQUASENSE 2000).

The literature mentions two silicoflagellates and five pedinellids, with one forma. One newly described pedinellid is doubtful. Very little is known about their status in Belgium. From the available data, brackish water seems to be the major habitat in Belgium. No knowledge on possible trends or threats exists, apart from the general situation of the mentioned habitat.

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HETEROKONTOPHYTA, partim RAPHIDOPHYCEAE (syn. CHLOROMONADIDA)

Relatively large (30-80 m) unicellular photoautotrophic flagellates; naked cells, no cell wall or skeletal elements; marine species with fucoxanthin and violaxanthin, freshwater species with vaucheriaxanthin instead of fucoxanthin; no photoreceptor system; no sexual reproduction known; occur in marine and freshwater environment; 28 species known worldwide.

No questionnaire was returned. Text compiled by Guido RAPPÉ (National Botanic Garden of Belgium).

Three non-marine species are mentioned from Belgium. In the southern North Sea, at least five species have been observed (e.g. AQUASENSE 2000, KOEMAN *et al.* 2002). These are expected to be present in the Belgian marine waters too. Main geographical regions and habitats probably are the North Sea, estuaries and inland standing (acid) waters. Knowledge is poor. Nothing is known about any trends in species composition or populations. A partial checklist and identification key for the inland waters are available (COMPÈRE 1989).

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HETEROKONTOPHYTA, partim EUSTIGMATOPHYCEAE

Small unicellular, coccoid algae; derived, like other phototrophic heterokonts, from a secondary endosymbiosis (red alga); fucoxanthin and chlorophyll c are lacking; major brown pigments are violaxanthin and vaucheriaxanthin; show typical red body, which function is unknown; reproduction by the formation of autospores or sometimes by zoospores; cell shape often round or ovoid; mostly in fresh water or in soil, but marine forms exist; approx. 20 species worldwide.

No questionnaire was returned. The text was compiled by Guido RAPPÉ, on the basis of information from Pierre COMPÈRE (both National Botanic Garden of Belgium) and the literature.

Seven species are mentioned in the literature, of which possibly half have to be synonymised. Knowledge is insufficient and supported by very few people. Nothing is known about possible trends. No checklist is available.

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HETEROKONTOPHYTA, partim TRIBOPHYCEAE (syn. XANTHOPHYCEAE) - YELLOW-GREEN ALGAE, XANTHOPHYTES

(GEELGROENE WIEREN - XANTHOPHYCÉES - GELBGRÜNE ALGEN, GELBGRÜNALGEN)

Unicellular photoautotrophic flagellates, filamentous and siphonaceous coenocytic, rarely coccoid, palmelloid or amoeboid; greenish to greenish-yellow colour due to the lack of fucoxanthin, which is normally widely present among Heterokontophyta; instead, vaucheriaxanthin is the common xanthophyll; asexual reproduction by motile zoospore or non-motile aplanospore; sexual reproduction by oogamy only occurs in *Vaucheria*; xanthophytes primarily live in terrestrial habitats (wet soil) and in fresh and brackish water; approx. 600 species worldwide, many of which are rare.

The questionnaire has been completed by Pierre COMPÈRE and adapted to current taxonomic concepts within chrysophytes and allies by Guido RAPPÉ (both National Botanic Garden of Belgium).

Some 105 inland species are mentioned in literature. Knowledge is moderate. Some species have been newly described from Belgium, but they are often of doubtful taxonomic status. Most obvious species belong to the genus *Vaucheria*, forming green mats on regularly inundated muddy soils, inhabited and grazed by a typical community. The most important habitats in Belgium are the coastal inland fresh and brackish waters (polder creeks and ditches) and the estuarine part of lowland rivers. Vulnerable habitats are estuaries and other brackish waters. Nothing is known about possible trends. Identification and reference literature was only developed by foreign authors (SIMONS 1977, ETTL 1978, RIETH 1980, BOURRELLY 1981, CHRISTENSEN 1987, JOHN *et al.* 2002). No checklist is available.

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HETEROKONTOPHYTA, partim PHAEOPHYCEAE (syn. FUCOPHYCEAE) - BROWN ALGAE

(BRUINWIEREN - ALGUES BRUNES - BRAUNALGEN)

Multicellular photoautotrophic benthic organisms; small filamentous to giant thalloid organisation; many have root-like holdfast systems, stem-like stipes and leaf-like blades; next to the green pigment chlorophyll a, the main xanthophyll (brown pigment) is fucoxanthin; sexual reproduction mostly by oogamy, but isogamy and anisogamy occur; also asexual zoospores; isomorphic or heteromorphic alteration of generations; occur almost exclusively in marine waters; approx. 1,700 species worldwide.

The questionnaire has been completed by Henry ENGLEDOW (Ghent University) for the marine species, with additional information received from Pierre COMPÈRE (National Botanic Garden of Belgium) on the freshwater species.

In the marine tidal and subtidal coastal zone, 28 species are known, but a further 12 could be expected. Only one species, *Pleurocladia lacustris*, is found in inland waters. Knowledge is moderate to good. The large brown algae need a hard substratum to attach to. Others live epiphytic on the larger species. Along the sandy coast of Belgium, the most important habitats are artificial, in the form of a variety of constructions in the coastal waters (harbours, groynes, piers, etc.). Non-indigenous species from rocky shores to the west (English Channel) can be found in huge quantities, washed ashore on the beach. Alien species are clearly in progress, finding shelter in harbours and marinas. Nothing is known about possible trends, but the most conspicuous species, the laminarian *Laminaria saccharina*, disappeared from its sole locality. A checklist and identification key are available (COPPEJANS 1995, 1998). Main collections are kept at the herbaria BR (National Botanic Garden of Belgium, Meise) and GENT (Ghent University).

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Halidrys siliquosa (Phaeophyta), a brown seaweed regularly washed ashore, but not a Belgian native species (© National Botanic Garden of Belgium, drawing by E. COPPEJANS).

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HETEROKONTOPHYTA, remaining classes

On the other -most often very recently described or recognised- classes of Heterokontophyta, i.e. the freshwater Phaeothamniophyceae (1998) and the marine Chrysomerophyceae (1995), Bolidophyceae (1999) and Pinguiophyceae (2002), no questionnaire has been received. The first three may be expected to occur in Belgium, while this is far less probable for the picoplanktonic and oceanic latter class. On the other hand, picoplanktonic exploration has hardly started. Bolidophyceans e.g. proved to be an important part of the diversity in environmental sampling in the North Sea near Helgoland, Germany (VALENTIN *et al.* 2001). It is very improbable that the group is absent in Belgian marine waters. Apparently, no synthesis of current knowledge on their status in Belgium exists.

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EUKARYOTA, partim CHLOROBIO(N)TA (syn. VIRIDIPLANTAE) - GREEN PLANTS

Only the green pigments chlorophyll a and b are present, derived from a primary endosymbiosis; storage of carbohydrates usually in the form of starch; two anterior whiplash flagella (sometimes modified or lost); two groups: chlorophytes and streptophytes.

CHLOROPHYTA - GREEN ALGAE, CHLOROPHYTES

(GROENWIEREN - ALGUES VERTES - GRÜNALGEN)

Include the classes Prasinophyceae, Chlorophyceae, Trebouxiophyceae and Ulvophyceae; photoautotrophic unicellular, colonial or multicellular organisms, derived from a primary endosymbiosis, with very diverse thallus organisation: monadoid, palmelloid, colonial, coccoid, sarcinoid, trichoid, thalloid and coenocytic forms; a phycoplast is formed during cell division; the spindle does not last during closed mitosis; sexual reproduction usually by flagellated gametes (iso-, aniso- and oogamy), asexual reproduction usually by zoospores; environment mainly fresh water, although Ulvophyceae are almost exclusively marine; also terrestrial, epiphytic and in association with lichens; approx. 12,000 species worldwide.

The questionnaire has been completed by Pierre COMPÈRE (National Botanic Garden of Belgium) for the freshwater species and by Henry ENGLEDOW (Ghent University) for the marine benthic macro-algae. Additional information on the marine plankton has been gathered by Guido RAPPÉ (National Botanic Garden of Belgium).

Approx. 860 non-marine species have been recorded, with numerous species and subspecies described from Belgium, whose taxonomic status is unclear nowadays. So far, 37 marine benthic species (mainly Ulvophyceae) were observed, with another 13 to be expected. Chlorophytes are uncommon in the marine plankton, with six species mentioned in recent Dutch monitoring reports (AQUASENSE 2000, KOEMAN *et al.* 2002). All of these belong to the Prasinophyceae. Knowledge is moderate, supported by very few people, and poor for the marine plankton. Nothing is known about possible trends. Main geographical regions and habitats are the coastal marine and inland waters, inland running and standing waters and, for the benthic marine species, artificial constructions. Oligotrophic and mesotrophic waters are the most vulnerable habitats. A partial checklist and identification keys for the marine benthic species are available (COPPEJANS 1995, 1998). At the National Botanic Garden of Belgium, an unpublished list is kept for the inland species. Published records are dispersed, sometimes presenting species lists for a particular area (e.g. SYMOENS 1960). Main collections are managed by the herbaria BR (National Botanic Garden of Belgium, Meise) and, especially for the marine species, GENT (Ghent University).

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Streptophyta

The Streptophyta include the land plants and the remainder of what was formerly called the 'green' algae. The streptophycean green algae are sometimes grouped together and referred to as 'Charophyta' (charophytes) in older literature, but this should be avoided because this term is also used in a narrowed sense to designate the stoneworts only. The terms 'charophycean green algae' or 'charophyceans' do not take away the confusion (Graham & Wilcox 2000) and are only practical in a strictly phycological environment. Although professional botanists may be split up in an algal and a land plants clade (and a fungal clade for that matter), one should be aware that nature is not that simple and that land plants have algal ancestors more related to them then to other algae.

Algal representatives of the streptophytes are unicellular or multicellular; thallus organisation is mainly monadoid, coccoid, sarcinoid or trichoid; land plants have a more elaborate structure; cell division with formation of a phragmoplast; permanent spindle during open or halfopen mitosis.

Streptophyta, partim Zygnematophyceae (syn. Conjugatophyceae) - zygnemataleans, zygnematophyceans

(Jukwieren, Voegwieren - Zygnématophycées - Jochalgen, Konjugaten)

Unicellular coccoid, colonial pseudofilamentous and multicellular unbranched filamentous forms; no flagellated cells; reproduction by 'conjugation' between two amoeboid gametes; half-open mitosis; exclusively non-marine species, very few in brackish water; approx. 4,600 species worldwide.

The questionnaire has been completed by Pierre Compère (National Botanic Garden of Belgium).

Approx. 740 species have been recorded, with numerous species and subspecies described from Belgium, whose taxonomic status is unclear nowadays. Desmids are the most important group. Knowledge is moderate, supported by few people. Main geographical regions are the Pleistocene sandy lowlands (Flemish and Campine district), the

Ardenne (particularly the Haute Ardenne) and the Gaume. Oligotrophic and mesotrophic standing waters (bogs, fens) and non-polluted brooks and brooklets are the main, and at the same time most vulnerable, habitats. An identification key for the desmids has been published (COMPÈRE 2001). Little is quantified about possible trends, but a decrease in diversity is suspected in the vulnerable habitats mentioned above. Main collections are kept at the herbaria BR (National Botanic Garden of Belgium, Meise).

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STREPTOPHYTA, partim CHAROPHYCEAE - CHAROPHYTES, CHARALEANS

(KRANSWIEREN - CHARACÉES - ARMLEUCHTERALGEN)

Highly developed multicellular thalloid forms, with a typical nodal and internodal organisation and whorled branching; asexual reproduction by adventitious development of new thalli from rizoids or nodal complexes, also by formation of bulbils; sexual reproduction by oogamy; their natural environment is fresh water, with very few species in brackish water and none in the marine environment; up to 450 species worldwide, though some authors consider many taxa conspecific.

The questionnaire has been completed by Pierre COMPÈRE (National Botanic Garden of Belgium).

Twenty-nine species are known from Belgium. Knowledge is sufficient to good, supported by a working group. Some species tend to become rare. The main geographical regions are the Pleistocene lowland sands (Flemish and Campine districts), the loamy plateau (Brabantine district), the coastal inland waters and the Meuse district. Oligotrophic and mesotrophic non-polluted waters are the most vulnerable habitats. A checklist, identification key and distribution maps are available (COMPÈRE 1992, BRUINSMA *et al.* 1998). Main collections are kept at the herbaria BR (National Botanic Garden of Belgium, Meise), GENT (Ghent University) and LG (University of Liège).

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STREPTOPHYTA, partim KLEBSORMIDIOPHYCEAE

Non-branching filamentous organisation, with cells in one row; asexual reproduction by formation of a single zoospore per cell; mainly in standing and running fresh water; also on banks, terrestrial and epiphytic; approx. 17 species worldwide.

No questionnaire was returned. Text compiled by Guido RAPPÉ, based on literature and additional information from Pierre COMPÈRE (both National Botanic Garden of Belgium).

Seven or eight species have been recorded in Belgium. Main geographical regions and habitats are the higher altitudes, but this may be merely a reflection of the distribution of explorations. Oligotrophic and mesotrophic waters are the most frequent habitats. Knowledge is poor to moderate, supported by very few people. Nothing is known about possible trends. A thorough study of the genus *Klebsormidium* in Europe was carried out by LOKHORST (1996), who also gives a key in SIMONS *et al.* (1999).

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STREPTOPHYTA, partim COLEOCHAETOPHYCEAE - COLEOCHAETALEANS

Branching filamentous organisation, forming a two-dimensional, disc-like (one cell thick) or three-dimensional thallus; typically sheated hairs; asexual reproduction by formation of a single zoospore per cell; sexual reproduction by a kind of oogamy; mainly epiphytic or epilithic in fresh water; also terrestrial and epiphytic on banks; approx. 19 species worldwide.

No questionnaire was returned. Text compiled by Guido RAPPÉ, based on literature and additional information from Pierre COMPÈRE (both National Botanic Garden of Belgium).

Six or seven species have been recorded in Belgium, five of which belong to the *Coleochaete* and one or two to the *Chaetosphaeridium* (probably synonymous). Main geographical regions and habitats are the lower altitudes, mainly on sandy substrates. Oligotrophic and mesotrophic waters are the most frequent habitats. Knowledge is poor to moderate, supported by very few people. Nothing is known about possible trends. An identification key for the Dutch species is given by SIMONS *et al.* (1999).

References and further reading

See under 'General references and further reading' at the end of the chapter.

STREPTOPHYTA, partim EMBRYOPHYT(IN)A - LAND PLANTS
(LANDPLANTEN - EMBRYOPHYTES - ECHTE LANDPFLANZEN)

The basal taxa of non-algal green plants are informally grouped together under the vernacular or paraphyletic name 'bryophytes' (mossen - bryophytes - Moospflanzen). They are usually divided in three subgroups: liverworts, hornworts and mosses. They are small flat or leafy plants, which most often, but not exclusively, grow in moist conditions in temperate and tropical environments.

In many respects, the 'bryophytes' are intermediate between streptophycean green algae and the vascular plants. Together with the latter, they form the embryophytes and share a number of characteristics that distinguish them from the other Streptophyta. They have male and female gametangia, called antheridia and archegonia respectively, with a protective, sterile 'jacket' layer. The zygote and the developing multicellular embryo (or young sporophyte) are retained within the archegonium or the female gametophyte. The multicellular diploid sporophyte allows an increased number of meioses and thus the production of an increased number of spores. The thick wall of the spores contains sporopollenin, which resists decay and drying. The epidermal cells are coated with a waxy protective layer: the cuticle. All these are adaptations to life on land.

Bryophytes lack the true vascular tissues xylem and phloem of the vascular plants. Their cell walls are never lignified. Bryophytes and vascular plants both exhibit alternating heteromorphic, gametophytic and sporophytic generations.

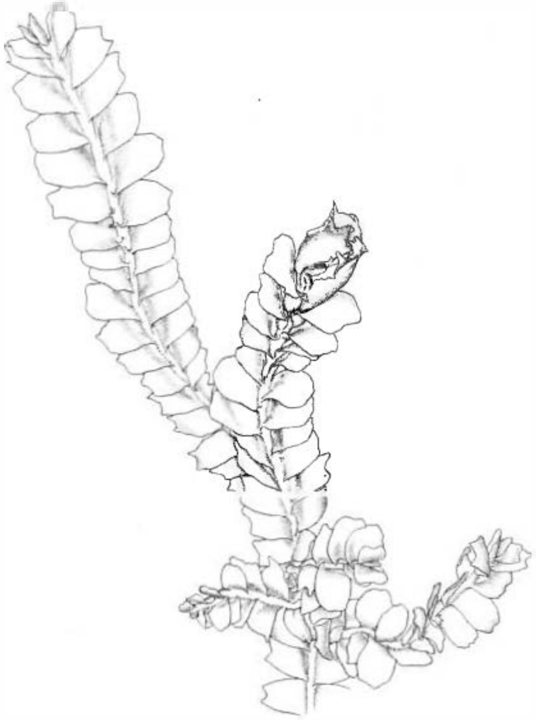
In bryophytes, the gametophyte is dominant and free-living, with the unbranched sporophyte being small and bearing only a single sporangium. It is attached to, and nutritionally dependent upon, the gametophyte.

HEPATOPHYTA (syn. MARCHANTIOPHYTA) - LIVERWORTS
(LEVERMOSSEN - HÉPATIQUES - LEBERMOOSE)

Usually divided into thalloid and leafy species; gametophyte is dominant and free-living; possessing unicellular rhizoids; most cells have numerous chloroplasts; many produce gemmae; some have a protonema stage; most species store lipids in a special organelle, the oil body; growth from an apical meristem; sporophyte lacks stomata; spores (and gemmae) for dispersal; approx. 5,500 (5,000-6,000) species worldwide.

The questionnaire has been completed by Herman STIEPERAERE and André SOTIAUX (National Botanic Garden of Belgium).

The Belgian list comprises 171 species. Most important geographical regions are the Ardenne, the Meuse district and the Gaume. Main threat is habitat loss. Knowledge is good. The total species number is more or less constant since vanishing species are compensated by new discoveries. In the near future, nine species are threatened with disappearance. VANDEN BERGHEN (1979, 1981) has published an identification key to the inland species. SCHUMACKER (1985) has edited a national distribution atlas. VANDERPOORTEN (1997) and SOTIAUX & VANDERPOORTEN (2001) have published regional distribution data, offering a view on the dynamics of the bryoflora in a limited area. A recent checklist is available (SOTIAUX & VANDERPOORTEN 2002), with an even more recent addition (SOTIAUX *et al.* 2003). Main collections are kept at the herbaria BR (National Botanic Garden of Belgium, Meise), LG (University of Liège) and CMV (Centre Marie-Victorin, Vierves-sur-Viroin).



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Lophocolea heterophylla (Hepatophyta), a common liverwort on decaying trees (© National Botanic Garden of Belgium, drawing by O. VAN DE KERCKHOVE).

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ANTHOCEROPHYTA - HORNWORTS

(HAUWMOSSEN - ANTHOCÉROTES - HORNMOOSE)

Dominant and free-living gametophyte; thalloid of many species looking rosette-like; elongated sporophyte splits in mature stage; unicellular rhizoids; most cells have a single chloroplast; sporophyte with stomata; no specialised conducting tissues; spores for dispersal; small group with approx. 120 (100-150) species worldwide.

The questionnaire has been completed by Herman STIEPERAERE and André SOTIAUX (National Botanic Garden of Belgium).

Five species have been recorded. Most important geographical region is the Pleistocene sandy lowland (Flemish and Campine district). Habitat loss forms the main threat. The species have a preference for bear moist soils, where they act as pioneers; for example, several new discoveries have been made in abandoned agricultural fields under nature management. A fifth species has recently been recognised as new to the Belgian flora (HEYLEN *et al.* 2001). Knowledge is good. VANDEN BERGHEN (1979, 1981) published an identification key for inland species. SCHUMACKER (1985) has edited a national distribution atlas, while VANDERPOORTEN (1997) and SOTIAUX & VANDERPOORTEN (2001) published regional distribution data. A recent checklist is available (SOTIAUX & VANDERPOORTEN 2002). Main collections are kept at the herbaria BR (National Botanic Garden of Belgium, Meise), LG (University of Liège) and CMV (Centre Marie-Victorin, Vierves-sur-Viroin).

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BRYOPHYTA - MOSSES

(BLADMOSSEN - MOUSSES - LAUBMOOSE)

A huge number of organisms have been called 'mosses', but the organisms in the present group are the 'common' mosses. Subdivision is subject to discussion, but three classes are generally accepted: the Sphagnidae or peat mosses, the Andreaeidae or granite mosses and the Bryidae or 'true' mosses.

Dominant and free-living gametophyte; rhizoids are multicellular; most cells have numerous chloroplasts; several species produce gemmae; growth from an apical meristem in the Bryidae; protonema stage grows by a marginal meristem followed by growth from an apical meristem in the Sphagnidae; some species have non-lignified conductive tissue for water transport; sporophyte has stomata, forming spores (and gemmae) for dispersal; terrestrial, epiphytic and a few aquatic species; approx. 9,500 (7,500-12,500) species worldwide.

The questionnaire has been completed by Herman STIEPERAERE and André SOTIAUX (National Botanic Garden of Belgium).

So far, 557 species have been recorded. Another 20 are expected. The total number increased with 10% since 1985, due to dedicated research. The real trend is probably the reverse, as a result of habitat loss, drainage, intensive agriculture and atmospheric deposition. The most important geographical regions are the higher altitudes [Ardenne (incl. Haute Ardenne), Meuse district], followed by the Gaume and Middle (Brabantine district), and Lower Belgium (the Pleistocene sandy region). Rocks, rocky outcrops and calcareous fen are very important habitats for the survival of special taxa. Knowledge is good. Some alien species are rapidly spreading (STIEPERAERE 1994, STIE-

PERAERE & JACQUES 1996). The exploration of the urban environment has yielded interesting discoveries during the last decade (STIEPERAERE & HOFFMANN 1993, ZWAENEPOEL *et al.* 1994, VANDERPOORTEN 1997, DURWAEL & LOCK 2000). The bio-indicating role of bryophytes for the water quality in Belgian rivers has been studied by EMPAIN (1973, 1974) and, more recently, VANDERPOORTEN & EMPAIN (1999). Regional distribution atlases have been published by VANDERPOORTEN (1997) and SOTIAUX & VANDERPOORTEN (2001), the latter offering an illustration of the dynamics (disappearance, expansion) of the bryoflora on a local scale. A recent checklist is available (SOTIAUX & VANDERPOORTEN 2002). Main collections are kept at the herbaria BR (National Botanic Garden of Belgium, Meise), LG (University of Liège) and CMV (Centre Marie-Victorin, Vierves-sur-Viroin).

3

Campylopus introflexus (Bryophyta), an established alien moss (© National Botanic Garden of Belgium, drawing by O. VAN DE KERCKHOVE).

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EUTRACHEOPHYTA - VASCULAR PLANTS

(VAATPLANTEN - PLANTES VASCULAIRES - GEFÄSSPFLANZEN)

In vascular plants, the sporophyte is the dominant generation and the gametophyte greatly reduced: the sporophyte is free-living, branched and bearing many sporangia; include a number of seedless vascular plant groups and the seed plants; habitus differentiated in roots, stems and leaves; vascular tissues present; secondary growth confined to the seed plants; spores or seeds for dispersal.

'PTERIDOPHYTA' - SEEDLESS VASCULAR PLANTS

(VARENPLANTEN - PTERIDOPHYTES - FARNPLANZEN)

A vernacular (paraphyletic) name for the following groups of non seed-forming vascular plants.

LYCOPHYTA - LYCOPHYTES

(LYCOFIETEN - LYCOPHYTES)

Some species are more or less dichotomously branched; stem of most species protostele or modified protostele; leaves microphylls; sporangia on or in the axills of sporophylls; Lycopodiaceae (clubmosses - wolfsklauwen - lycopodes - Bärlappe) homosporous, Selaginellaceae (lesser clubmoss - mosvarens - sélaginelles - Moosfarne) and Isoetaceae (quillworts - biesvarens - isoètes - Brachsenkraut) heterosporous; spores for dispersal; terrestrial and aquatic species; approx. 1,000 species worldwide.

The questionnaire has been completed by Ronald VIANE (Ghent University).

A total of 11 (nine according to some authors who consider *Diphasiastrum issleri* and *D. zeilleri* as hybrids) species have been recorded, with another one to be expected and one non-native. Of these, nine species (or seven, see above) belong to the Lycopodiaceae, one to the Selaginellaceae and one to the Isoetaceae. *Isoetes lacustris* occurs near the Belgian border. Numbers have decreased since 1905, mainly due to habitat loss. Most important geographical regions are the higher altitudes (Haute Ardenne, Ardenne) and the Pleistocene sandy region (Flemish and Campine district). The Hautes Fagnes was the sole region where *Selaginella helvetica* (single observation), and the now extinct *Diphasiastrum issleri* and *Diphasiastrum complanatum*, were found. The other *Diphasiastrum* species, except *D. tristachyum*, have disappeared too. *Selaginella kraussiana* is known as an escape that can overwinter. Isoetaceae only occur in oligotrophic standing waters of the Pleistocene sandy region, which are not used for recreation. Some Lycopodiaceae are under pressure due to *Picea* and *Pinus* plantations. All habitats suffer from atmospheric deposition. Knowledge is good. An identification key is available in the flora of Belgium and neighbouring regions (LAMBINON *et al.* 1998, 2003). The Plant Atlas (VAN ROMPAEY & DELVOSALLE 1979) gives distribution maps for all species. Main collections are kept at the herbaria BR (National Botanic Garden of Belgium, Meise), BM (Natural History Museum, London) and LG (University of Liège).

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SPHENOPHYTA - HORSETAILS

(PAARDESTAARTEN - PRÊLES - SCHACHTELHALME)

Only one recent genus: *Equisetum*; not dichotomously branched; stems eustele-like siphonostele; leaves scale-like macrophylls/megaphylls; sporangia on sporophores in strobili at the apex of the stem; homosporous; dispersal by formation of spores; terrestrial and semi-aquatic species; only 15 species worldwide.

The questionnaire has been completed by Ronald VIANE (Ghent University).

Seven species have been recorded, with an additional one to be expected. Species number remains constant, but wetland species show some decline. *Equisetum variegatum*, primarily found in dune slacks, has shown a strong decline. For the group as a whole, all geographical regions are important, with the coastal dunes especially important for *E. variegatum* and the loam plateau and Gaume for *E. telmateia*. Knowledge is good. An identification key is available in the flora of Belgium and neighbouring regions (LAMBINON *et al.* 1998, 2003). The Plant Atlas (VAN ROMPAEY & DELVOSALLE 1979) gives distribution maps for all species. Main collections are kept at the herbaria BR (National Botanic Garden of Belgium, Meise), GENT (Ghent University) and LG (University of Liège).

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PTEROPHYTA - FERNS

(VARENS - FOUGÈRES - FARNE)

Not dichotomously branched; stems in some a protostele, in others siphonostele or more complex types; leaves megaphylls; sporangia on sporophylls, sometimes clustered in sori; all homosporous, except the heterosporous 'waterferns' Marsileales and Salviniales; spores for dispersal; terrestrial, rarely aquatic species; approx. 11,000 species worldwide.

4

Botrychium lunaria (Pterophyta), a threatened fern of nutrient-poor soils (© National Botanic Garden of Belgium, drawing by A. CLEUTER).

The questionnaire has been completed by Ronald VIANE (Ghent University).

So far, 42 species have been recorded, although some doubt exists on the true native status of *Botrychium simplex* (possible, but maybe erroneous herbarium label), *Matteuccia struthiopteris* (almost certainly native), *Salvinia natans* (doubtful) and *Azolla filiculoides* (extinct and re-established). Another four species could be expected. *Asplenium* is the most numerous genus with eight species. Numbers have decreased since 1950 with 10% to 12%, or four or five species, mainly due to habitat loss. The most important geographical regions are the higher altitudes (Ardenne, Meuse district), followed by the Gaume and Middle (Brabantine district) and Lower Belgium (the Pleistocene sandy region). In Lower Belgium, old walls, quays and graveyards in historic cities are important habitats for ferns (JADEM 1975, VAN LANDUYT & HEYNEMAN 1999). Knowledge is good. An identification key is available in the flora of Belgium and neighbouring regions (LAMBINON *et al.* 1998, 2003). The Plant Atlas (VAN ROMPAEY & DELVOSALLE 1979) gives distribution maps for almost all species. Main collections are kept at the herbaria BR (National Botanic Garden of Belgium, Meise), GENT (Ghent University) and LG (University of Liège).

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SPERMATOPHYTA - SEED PLANTS

(ZAADPLANTEN - SPERMATOPHYTES - SAMENPFLANZEN)

Seed plants form seeds for dispersal; a seed consists of a seed coat (integuments), an embryo and stored food; it develops from an ovule that consists of the megasporangium, the single retained megaspore in it and one or two integuments; male gametophytes develop inside pollen grains; antheridia are lacking; five divisions with living representatives, two of which occur in Belgium: the Pinophyta (syn. Coniferophyta) or conifers and the Angiospermae (syn. Anthophyta) or flowering plants.

PINOPHYTA (syn. CONIFEROPHYTA) - CONIFERS

(NAALDBOMEN, CONIFEREN - CONIFÈRES - NADELHÖLZER, GABELNERVIGE NACKTSAMER)

Together with the three divisions lacking in Belgium commonly grouped as gymnosperms; ovules exposed on the surface of megasporophylls; fertilisation of egg cell by one sperm of male gametophyte; stored food in seed is provided by female gametophyte; approx. 630 species worldwide.

Only two species are considered indigenous: *Juniperus communis* and *Taxus baccata*, with conflicting opinions on the true nature of a few stands of *Pinus sylvestris*. The latter is often planted in sylviculture, as other *Pinus* species are and, primarily, *Picea abies* (for the former coal mining industry and for wood production). Many individual localities of *Taxus baccata* and *Pinus sylvestris* are debated on their indigenous status. A lot of species are also used in horticulture, with as a result some garden escapes rarely found in the wild. Knowledge is good. An identification key is available in the flora of Belgium and neighbouring regions (LAMBINON *et al*. 1998, 2003). The Plant Atlas (VAN ROMPAEY & DELVOSALLE 1979) gives distribution maps for the species, except for *Pinus sylvestris*. Main collections are kept at the herbaria BR (National Botanic Garden of Belgium, Meise), GENT (Ghent University) and LG (University of Liège).

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ANGIOSPERMAE (syn. ANTHOPHYTA) - FLOWERING PLANTS

(BLOEMPLANTEN, ANGIOSPERMEN - ANGIOSPERMES, PLANTES À FLEURS - BEDECKTSAMER, BLÜTENPFLANZEN)

Flowerlike reproductive structures; ovules enclosed by carpels often differentiated to form an ovary; stamens derived from microphylls, with anthers bearing two pairs of pollensacs; fertilisation of egg cell by one sperm of male gametophyte; stored food in seed provided by the second fertilisation between second sperm and polar nuclei (double fertilisation); fruits contain mature ovaries, with mature seeds; approx. 230,000 (222,700-258,700) known species worldwide.

Questionnaire completed by Leo VANHECKE (National Botanic Garden of Belgium).

Approx. 1,350 (1,250-1,430) species are considered 'indigenous' (including some species naturalised since a long time). This figure also varies with the taxonomic status given to the taxa in apomictic genera such as *Taraxacum*, *Hieracium*, *Rubus*, *Alchemilla*, etc. One taxon on the level of variety is endemic: *Sempervivum funckii* var. *aqualiense* (but some authors consider it to be a triple hybrid). Another taxon, *Bromus bromoideus*, almost exclusively restricted to Belgium, has not been seen since 1935 (TOURNAY 1968). The territory is divided in a number of geographical regions, called plant districts, each of them with its own characteristic flora. VAN LANDUYT *et al*. (2000) published a report on the botanic quality of habitats, based on combinations of vascular plant indicator species. Main reason for important decline is habitat loss. Remainders of the habitats suffer from fragmentation, overdressing, drainage, atmospheric nutrient deposition, eutrophication and pollution in general. Nutrient-poor soils and waters are not adequately protected. Heaths, bogs, fens (including calcareous fens), chalky grasslands and weed communities, and coastal habitats such as strandlines (trampling and beach cleaning), salt marshes, dune slacks and grasslands, are among the most vulnerable.

This is by far the best known group in the plant kingdom and Belgium is no exception to this statement. New species added to the flora during the last quarter of the 20th century are mainly the result of dedicated research in difficult groups such as bramble, some genera of orchids (BOURNÉRIAS 1998, TYTECA 2003) or neglected groups like thalassochorous species (RAPPÉ 1996) and indigenous trees and shrubs (MAES 1997, 2002). An important trend is the rapid spread of alien species due to increased human transport activity or deliberate introduction (LAMBINON 1997). In some spectacular cases, existing communities are invaded, dominated or completely replaced by naturalised -or naturalising- species (e.g. HOSTE & VERLOOVE 2001), probably causing irreversible changes in our wild flora at a speed never seen before. Another human-induced phenomenon is the inland spread of certain coastal species, due to the use of deicing agents on the main traffic axes in winter (RAPPÉ 2000). A recent report on the subject of alien species in the wild in Flanders presents a checklist of taxa almost as long as the indigenous list (VERLOOVE 2002).

A (now dated) checklist has been published by STIEPERAERE & FRANSEN (1982). DELVOSALLE *et al*. (1969) and VANHECKE (1985) have drawn a list of threatened species. An identification key is available in the flora of Belgium and neighbouring regions (LAMBINON *et al*. 1998, 2003). The Plant Atlas (VAN ROMPAEY & DELVOSALLE 1979) gives distribution maps for the indigenous species. For the northern part of the country, Flanders, a red list of endangered species has recently been published as an appendix to VAN LANDUYT *et al.* (1999). A synthesis of trends and threats at province level is presented by BERTEN & GORA (2002). Also in Flanders, a register with ecological indicator values for the inland vascular flora is available on cd-rom (BIESBROUCK *et al.* 2001). A document established through a similar approach, but restricted to woodland plants, is published for the southern part of the country (DULIÈRE *et al.* 1996). Main collections are kept at the herbaria BR (National Botanic Garden of Belgium, Meise), GENT (Ghent University) and LG (University of Liège).

5

Viscum album (Angiospermae), a flowering half-parasite (© National Botanic Garden of Belgium, drawing by G. VAN ASSCHE).

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EUMYCOTA - TRUE FUNGI

[(ECHTE) ZWAMMEN - CHAMPIGNONS - ECHTE PILZE]

The true fungi are mostly terrestrial, heterotrophic organisms; cells have a cell wall containing chitin; although unicellular forms exist (= yeasts), most are filamentous; fungal filaments are called hyphae, the whole packing and network of hyphae being called a mycelium; hyphae with (septate) or without crosswalls (aseptate, coenocytic); densely packed hyphae (mycelium) in many cases form the 'fruiting' bodies called mushrooms, toadstools, puffballs, etc.

'CHYTRIDIOMYCOTA' (syn. ARCHEMYCOTA) - CHYTRIDS

(- CHYTRIDES - FLAGELLATENPILZE)

Recently, strong evidence has been put forward that this is a paraphyletic group (BARR 2001, SCHÜSSLER *et al.* 2001). Aseptate or coenocytic hyphae; reproduce asexually by forming zoospores; sexual reproduction is unknown or doubtful in most species; oogamous reproduction (oospores) is however known in the Monoblepharidales; inhabitants of soil, fresh water and estuaries; most live saprobic, but pathogens of plants (*Synchytrium*, *Olpidium*, vector of plant pathogenic viruses), other fungi and animals are known; approx. 914 species worldwide, e.g. many 'water moulds', Allomyces, etc.

The questionnaire has been completed by André FRAITURE (National Botanic Garden of Belgium).

A list with 57 species has been published at the end of the 19^{th} century (DE WILDEMAN & DURAND 1898-1907). This group is poorly known in Belgium.

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'ZYGOMYCOTA' (incl. GLOMEROMYCOTA) - ZYGOMYCETES

(JUKZWAMMEN, WIERZWAMMEN - ZYGOMYCÈTES - JOCHPILZE)

The ecologically and economically important arbuscular mycorrhizal (AM) fungi, crucial in the ecology and physiology of land plants, together with Geosiphon pyriformis, an endocytobiotic fungus, have recently been separated from the Zygomycota and put in a phylum of their own: the Glomeromycota (SCHÜSSLER *et al.* 2001). *As the major part of the latter used to be classified within the class Zygomycetes, both phyla are still treated together here. Moreover, there is strong evidence that the remainder of the Zygomycota, i.e. excluding the Glomeromycota, is in fact a paraphyletic group* (SCHÜSSLER *et al.*, op.cit.).

Aseptate or coenocytic hyphae; reproduce asexually by forming non-motile spores or sexually by the zygospore formed in the zygosporangium; most are commonly known as moulds (schimmels - moisissures - Verschimmeln) but this is a general term that designates any fungus without a fruiting body; species of the class Zygomycetes live on a variety of substrates: soil, dung, plants, mushrooms, animals (including man and his food), as saprobes or parasites; some are mycorrhizal; species of the class Trichomycetes (about 230 species worldwide) are obligate symbionts, mostly commensals, but a few are parasites within the digestive tract of arthropods; approx. 1,090 species worldwide.

No questionnaire has been returned.

VANDEVEN *et al.* (1996) mention only 15 species, but this figure is irrelevant, merely being the number of taxa observed during fieldwork focused on macrofungi. THOEN (1988) mentions four species of *Endogone* (now in Glomeromycota). Apparently, no synthesis of knowledge on Zygomycota and Glomeromycota is available in Belgium. Important collections of economically or medically important species and strains are kept in the Belgian Co-ordinated Collections of Micro-organisms, (Agro-)industrial Fungi & Yeasts Collection (BCCM^{TM}/MUCL, http://www.belspo.be/bccm/mucl.htm) and Biomedical Fungi & Yeasts Collection (BCCM^{TM}/IHEM, http://www.belspo.be/bccm/ihem.htm).

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ASCOMYCOTA (excl. LABOULBENIALES and LICHENISED ASCOMYCETES) - ASCOMYCETES

(ZAKJESZWAMMEN - ASCOMYCÈTES - SCHLAUCHPILZE)

Septate hyphae; sexual spores (ascospores) are formed in a typical ascus (sac fungi); ascocarp present or absent; diversity of forms and life strategies is large: e.g. powdery mildew, Dutch elm disease, morels, truffles, beer yeast; many species exhibit an additional asexual reproduction process by the formation of conidia (see Deuteromycetes) or by having a yeast phase (mostly unicellular); occur on a large variety of substrates as saprobes, parasites and predators: soil, dung, in bark, wood, leaves, associated to algae in lichens (treated separately lower), even in marine habitats; many are associated with particular plant species; Ascomycetes all in: approx. 32,800 species worldwide; excluding the groups mentioned in the above title (they are treated separately below): approx. 17,400 species.

The questionnaire, restricted to the Pezizales, Elaphomycetales, Helotiales, Rhytismatales, Ostropales, Erysiphales, Taphrinales, Sphaeriales, Clavicipitales, Diaporthales, Hypocreales, Sordariales, Xylariales and Dothideales, has been completed by Bernard DECLERCQ (independent expert, Wachtebeke).

Approx. 2,000 (between 1,800-2,200) species are known from Belgium, but this estimation is not complete since some taxa are not taken into consideration, including among others the yeast *Dekkera bruxellensis* (involved in the spontaneous fermentation that yields the lambic and gueuze beers, typical for the vicinity of Brussels). In fact, this figure should be compared with an adjusted worldwide total, restricted to the orders mentioned above, i.e. 8,500 species. Knowledge is fairly good, but supported by very few people. Roughly estimated, some hundreds additional species are to be expected on the territory, based on the situation in neighbouring countries. The highest diversity is found in the southern part of the country: Ardenne (incl. Haute Ardenne), Gaume, river Meuse valley and tributaries.

Saprobic species on endangered plants and hydrophilic species (water quality) are especially vulnerable. A partial checklist is available (VANDEVEN *et al.* 1996). A Red List of some macrofungal taxa, including information on a number of trends, is available for the northern part of the country (WALLEYN & VERBEKEN 1999). Two sets of distribution maps of macrofungi (incl. Basidiomycota) have been published (HEINEMANN & THOEN 1981, FRAITURE *et al.* 1995). The herbaria at the National Botanic Garden of Belgium (BR), Ghent University (GENT) and University of Liège (LG) harbour the largest collections. Important collections of economically or medically important species and strains are managed by the Belgian Co-ordinated Collections of Micro-organisms, (Agro-)industrial Fungi & Yeasts Collection (BCCM™/MUCL, http://www.belspo.be/bccm/mucl.htm) and Biomedical Fungi & Yeasts Collection (BCCM™/IHEM, http://www.belspo.be/bccm/ihem.htm).

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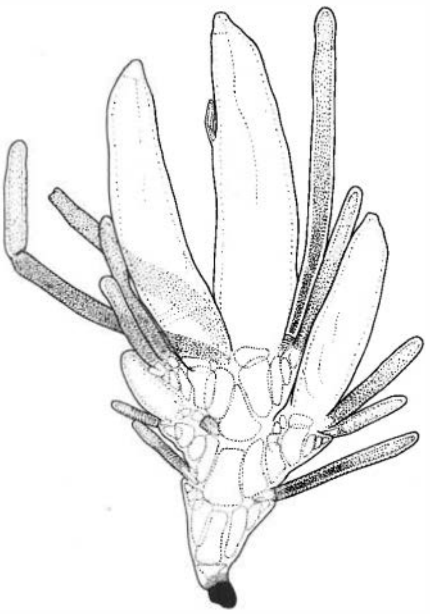
ASCOMYCOTA, partim LABOULBENIALES

Group of highly specialised ascomycetes, forming obligate associations with arthropods (insects, mites, few millipedes); mycelium is lacking in many species, the thallus being derived from enlargement and subsequent cell divisions of the two-celled ascospore; approx. 1,900 species worldwide.

The questionnaire has been completed by André DE KESEL (National Botanic Garden of Belgium).

So far, 100 species have been recorded in Belgium, almost exclusively on beetles (Insecta, Coleoptera). Half of these species belong to the genus *Laboulbenia* (DE KESEL 1998). The group is poorly studied, but relatively well known in Belgium. Another 100 species can be expected, on other arthropods. Two recently described species are, for the time being, only known from Belgium: *Phaulomyces simplocariae* and *Laboulbenia hyalopoda*. A checklist (DE KESEL & RAMMELOO 1992) and (unpublished) flora (DE KESEL 1997) exist. Partial results of the latter (identification keys for the genera *Laboulbenia* and *Rhachomyces* and for the species on cockroaches) have been published (DE KESEL 1998, 2001, 2002).



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Peyritschiella heinemanniana (Laboulbeniales), a staphylinid beetle parasite newly described from Belgium (© National Botanic Garden of Belgium, drawing by O. VAN DE KERCKHOVE).

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'LICHENES' - LICHENS

(KORSTMOSSEN - LICHENS - FLECHTEN)

A lichen is a mutualistic symbiotic association between a fungal partner (the mycobiont) and an algal partner (the phycobiont or photobiont); alga can be filamentous, unicellular eukaryotic or prokaryotic (Cyanobacteria); lichens are named after the fungus, which is, however, never occurring as a free-living organism (in contradiction to the alga); most of the lichen-forming fungi belong to the Ascomycota, a minority to the Basidiomycota or anamorphic fungi; approx. 13,500 species worldwide. *Included here are some other fungi that are usually studied by lichenologists.*

No questionnaire has been returned. The following information has been compiled from the literature by Guido RAPPÉ (National Botanic Garden of Belgium).

This element of the flora is reasonably well known. A total of 977 taxa are concerned: 832 lichens, 19 lichenicolous lichens, 109 lichenicolous fungi, 4 doubtfully lichenised fungi and 13 non-lichenised fungi. Some 200 dubious taxa have been mentioned for the country, but not accepted. Twenty-five taxa have been originally described from Belgium, of which only 16 are accepted (11 lichens, five lichenicolous fungi). Forty-eight lichens and one lichenicolous fungus are considered extinct. The majority of these were only known from one locality. Local lichen deserts occur in areas of major air pollution (big cities, harbours with associated heavy industry, etc.). Because the quality of the air (SO_2 load) is recently evolving in the good direction, some species clearly show recovery. Nitrophilous species also are doing well during the last decades, due to atmospheric deposition. The urban environment can harbour interesting species on stone artifacts, such as in old graveyards, with their variety in used materials (e.g. ZWAENEPOEL *et al.* 1994). A checklist for Belgium, Luxembourg and northern France has recently been published (DIEDERICH & SÉRUSIAUX 2000). Recent identification literature is of foreign origin: POELT & VEZDA (1977, 1981), PURVIS *et al.* (1992), WIRTH (1987), APTROOT & VAN HERK (1994). A key to the Belgian macrolichens is in preparation.

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Basidiomycota

Basidiomycota have dikaryotic, septate hyphae, often with a dolipore (no pore in some Ustilaginomycetes); hyphae form clamp connections (associated with mitosis); multilayered cell wall; sexual basidiospores formed on a basidium; asexual reproduction by conidial formation (fragmentation, budding), some species also having a yeast phase; sexually or asexually formed ballistospores; three classes: Basidiomycetes s.s., Urediniomycetes (mainly the rusts) and Ustilaginomycetes (mainly the smuts).

Basidiomycota, partim Basidiomycetes s.s. (syn. Hymenomycetes s.l.) - basidiomycetes

(Buisjeszwammen - Basidiomycètes - Ständerpilze)

Basidia are arranged on a distinct exposed fertile layer, the hymenium, in the 'Hymenomycetes s.s.' (mushrooms, coral fungi, polypores, chantarelles, etc.), and formed in a gleba inside the basidiocarp in the 'Gasteromycetes' (puffbals, earth stars, stinkhorns, etc.); traditional classification is being reshuffled by detailed microscopic studies and molecular evidence, redefining or leaving concepts like Hymenomycetes, Gasteromycetes, Aphyllophorales, Agaricales, etc.; other groups are Tremellomycetidae, 'jelly fungi', etc.; the class Basidiomycetes roughly corresponds to the 'macrofungi' in the phylum Basidiomycota; Basidiomycetes are mainly terrestrial organisms; many are important ectomycorrhizal species; approx. 20,400 species worldwide.

A questionnaire for the macrospecies has been completed by André Fraiture (National Botanic Garden of Belgium).

The species number of the basidiomycete macrofungi in Belgium is estimated at 2,910 (2570-3350) with another 300 to be expected. Most numerous taxa are Agaricales s.l. (approx. 2,100, including Boletales, Russulales, Cantharellales) and 'Aphyllophorales' (approx. 600). Outdated checklist in De Wildeman & Durand (1898-1907), incomplete checklist in Vandeven *et al.* (1996). Declining in numbers. Basidiomycetes are present in all natural regions, with the highest diversity in the southern part of the country, the lowest on the Holocene deposits. Mycosociology has a strong tradition in the south and has been studied extensively in the forests (Heinemann & Darimont 1956, Darimont 1975, Thoen 1977, Fraiture 2003). Information on trends is included in a Red List discussing the status of some macrofungal taxa in the northern part of the country (Walleyn & Verbeken 1999). Two sets of distribution maps of macrofungi (including Ascomycota) have been published (Heinemann & Thoen 1981, Fraiture *et al.* 1995). The herbaria at the National Botanic Garden of Belgium (BR), Ghent University (GENT) and University of Liège (LG) harbour the largest collections.

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7

Suillus luteus (Basidiomycota), a mushroom (© National Botanic Garden of Belgium, drawing by O. VAN DE KERCKHOVE).

Basidiomycota, partim Urediniomycetes - rusts

(ROESTZWAMMEN - ROUILLES, URÉDINÉES - ROSTPILZE)

Mycelia generally intercellular; complex life cycle, with up to five spore states; a vast majority of species are obligate parasites on seed plants and ferns, frequently causing major diseases; 8,057 species worldwide, 6,929 of which belong to the order Uredinales.

Data collated from the literature by Guido RAPPÉ (National Botanic Garden of Belgium).

DE WILDEMAN & DURAND (1898-1907) mention 189 species. VANDEVEN *et al.* (1996) include 126 taxa, many with the rank of forma or varietas, of which 44 to 75 are not in the previous list. This leads to a provisional total ranging between 233 and 264 species. The actual status of this group in Belgium is unclear.

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Basidiomycota, partim Ustilaginomycetes - smuts

(BRANDZWAMMEN - CHARBONS, USTILAGINÉES - BRANDPILZE)

Thick-walled probasidia (ustilospores); non-septate or transversely septate promycelia; septa with or without pores; life cycle with a saprobic haploid phase and a parasitic dikaryophase; host-specific endophytes, parasitic on flowering plants (mainly Poaceae and Cyperaceae); important diseases of cereal crops; 1,464 species worldwide, at least half of which belong to the order Ustilaginales.

Data collated from the literature by Guido RAPPÉ (National Botanic Garden of Belgium).

DE WILDEMAN & DURAND (1898-1907) mention 48 species. VANDEVEN *et al.* (1996) include 17 species, of which 7 to 8 are not in the previous list, bringing the provisional total to 55-56. Apparently, no recent synthesis of knowledge on this 'micro-fungi' group in Belgium is available.

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'DEUTEROMYCETES' (syn. DEUTEROMYCOTINA, FUNGI IMPERFECTI) -
DEUTEROMYCETES, ANAMORPHIC FUNGI
(DEUTEROMYCETEN - DEUTÉROMYCÈTES, CHAMPIGNONS IMPARFAITS - DEUTEROMYCETEN)

Artificial gathering of fungi without known sexual cycle (hence 'anamorphic fungi' or 'asexual fungi'); most of them belong to the ascomycetes, with others allied to the basidiomycetes or zygomycetes; lichenicolous Deuteromycetes are considered under 'Lichenes' (see before); molecular methods can help solve their taxonomic positions; some are common medically important species; as mycological knowledge advances (discovery of sexual stages), this list of asexual forms tends to get shorter, compensated however by discoveries of new deuteromycetes; in the case of separately named sexual and asexual morphs, the name of the sexual morph is preserved; approx. 16,200 species worldwide.

In the list of VANDEVEN *et al.* (1996), 268 species are included. To 46 of these, a teleomorph is attributed, in fact expelling them from this gathering of anamorphic fungi. Apparently, no synthesis of knowledge is available for the Belgian species. The herbarium at the Mycothèque de l'Université de Louvain (MUCL) houses a large collection. Important collections of economically or medically important species and strains are kept in the Belgian Co-ordinated Collections of Micro-organisms, (Agro-)industrial Fungi & Yeasts Collection (BCCM™/MUCL, http://www.belspo.be/bccm/mucl.htm) and Biomedical Fungi & Yeasts Collection (BCCM™/IHEM, http://www.belspo.be/bccm/ihem.htm).

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4. CONCLUSIONS

A little more than 13,500 species of fungi, algae and plants have so far been recorded in our country. Between 3,500 and 5,200 additional species are expected, which means that not less than 19% to 28% of our flora is still unknown.

Only the vascular plants (flora and distribution atlas) and, to a lesser extent, the bryophytes (checklist and regional distribution atlases) and lichens (checklist, identification key in preparation) can be considered as well known taxonomic groups. All other groups are moderately to badly known, some are even poorly or not studied at all. This is particularly the case for micro-organisms from soil and marine environments, as well as for parasitic and pathogenic agents of non-commercial hosts: bacteria, archea, marine phytoplankton,

Table 1. Overview of the Prokaryotic and botanic biodiversity in Belgium and the world. For Belgium, recorded and expected (= recorded + additional expected species) species numbers are given. The last column indicates the worldwide number of described species per taxon. [+: present; +?: probably present; xx ?: rough estimate; ?: not known (more precisely)]

Taxon/Group	Recorded	Expected	Described
Prokaryotes:			
– Eubacteria (excl. Cyanobacteria) and Archaea	< 6,000	< 6,000	6,000
– Cyanobacteria	300	400 ?	1,700
Eukaryotes:			
– Myxomycota	300	400	900
– Acrasiomycota	?	?	12
– Dictyosteliomycota	2	> 2	46
– Glaucophyta	1	2	13
– Chlorarachniophyta	0	+?	5
– Euglenophyta	< 405	400	930
– Cryptophyta	< 60	60 ?	200
– Haptophyta	22	40	300
– Rhodophyta	53	68	5,500
– Alveolata:			
– – Plasmodiophoromycetes	2	> 2	47
– – Dinoflagellata	200 ?	250	4,000
– Heterokonta:			
– – Oomycetes			810
– – Labyrinthulomycetes			48
– – Hyphochitriomycetes			23
– – The above three groups together	100 ?	150	880
– – Chrysophyceae	185	185	890
– – Heterokontophyta *incertae sedis*	9	9	100
– – Synurophyceae	< 63	60	151
– – Bolidophyceae	0	+?	2
– – Bacillariophyceae	1,600	2,600	12,000
– – Pelagophyceae	1	3	12
– – Dictyochophyceae	7	9	25-27
– – Chrysomerophyceae	0	+?	7-8
– – Pinguiophyceae	0	0	5
– – Raphidophyceae	3	8	28
– – Eustigmatophyceae	< 7	7	20
– – Tribophyceae	105	110	600
– – Phaeophyceae	29	41	1,700
– – Phaeothamniophyceae	0	+?	26
– Chlorophyta	< 900	950	12,000
– Streptophyta:			
– – Zygnematophyceae	< 740	750	4,600
– – Charophyceae	29	30	< 450
– – Klebsormidiophyceae	7	8	17
– – Coleochaetophyceae	6	7	19
– – Embryophyta:			
– – – Hepatophyta	171	185	5,500
– – – Anthocerophyta	5	5	120
– – – Bryophyta	557	577	9,500
– – – Lycophyta	11	12	1,000
– – – Sphenophyta	7	8	15
– – – Pterophyta	42	46	11,000
– – – Pinophyta	2	2-3	630
– – – Angiospermae	1,350	> 1,350 ?	230,000
– Eumycota:			
– – 'Chytridiomycota'	57	150 ?	914
– – 'Zygomycota' and Glomeromycota	+	200-400 ?	1,090
– – Ascomycota:			
– – – Ascomycota (excl. Laboulbeniales and lichenised ascomycetes)	> 2,000	2,500	17,400
– – – Laboulbeniales	100	200	1,900
– – – Lichenised and lichenicolous fungi	977	1,000	13,500
– – Basidiomycota:			29,950
– – – Basidiomycetes (macrofungi only)	2,910	3,200	20,400

zygomycetes, glomeromycetes and other microfungi or pseudofungi (slime moulds, alveolates, heterokonts). In many cases, the knowledge is out of date, going back a century or more. This leads to the conclusion that the knowledge of the Belgian botanic diversity is fragmentary and that many taxa have an uncertain taxonomic status.

Taxonomic research is thus far from achieved. On the one hand, there is the lack of knowledge on an important part of the Belgian flora. On the other hand, the few existing overview papers, even the recent ones, need to be updated with the most recent information. For example, a flora on the marine benthic macro-algae exists, but a recent survey of groynes and other hard substrates on the Belgian coast revealed many additions to the list (pers. comm. H. ENGLEDOW).

Another point of concern is the fast spread and the important number of alien botanic species. For example, the list of alien flowering plants observed in the wild in Flanders is almost as long as the indigenous list! Because the ecological consequences of this phenomenon are unknown and probably mainly unpredictable, monitoring and early warning systems become of crucial importance.

Tackling the lack of knowledge, keeping track of the settling of alien species, making information easily available, and this by the preparation of checklists, reference works and reviews, and by the follow up of the literature, are clearly important as well as huge tasks for botanic researchers. In many cases, this work is supported by accomplished naturalists. Strengthening taxonomy as an important basic scientific discipline should be the subject of an urgent and dedicated initiative by the federal and community governments.

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Guido RAPPÉ
Jan RAMMELOO
National Botanic Garden of Belgium
Domein van Bouchout
1860 Meise

CHAPTER 4

ZOOLOGICAL DIVERSITY

Marc PEETERS & Jackie VAN GOETHEM

1. INTRODUCTION

An exhaustive inventory or overview of the Belgian fauna does not exist to date. The works of LAMEERE (1895, 1900) 'Manuel de la Faune de Belgique', and MAITLAND (1897) 'Prodrome de la Faune des Pays-Bas et de Belgique', have the merit to be the first and only initiatives, but they are incomplete and largely outdated.

In comparison with the series published in adjacent countries, e.g. 'Synopses of the British Fauna', 'Nederlandse Fauna', 'Faune de France', 'Wetenschappelijke Mededelingen van de Koninklijke Nederlandse Natuurhistorische Vereniging', no overview series is running on the Belgian fauna. There was however a good impulse by the 'Faune de Belgique' starting with the publication of POLL (1947) on marine fishes. Unfortunately, only eleven issues appeared, the last one on the beetle family Elateridae (JEUNIAUX 1996).

Data on zoological diversity in Belgium are therefore incomplete, scattered or unavailable. This chapter draws on information directly provided by experts to present an overview of faunal groups observed or expected in Belgium.

2. METHODS

In 1998, the authors developed a questionnaire to investigate the Belgian zoological diversity, based on the one created by KRIKKEN and KOOMEN (Naturalis, Leiden). After a first consultation round within the Royal Belgian Institute of Natural Sciences, the questionnaire was sent to selected Belgian experts in other research institutions, universities, nature associations, etc. If no Belgian expert could be identified for a target group, the questionnaire was sent to experts in neighbouring countries or even to specialists worldwide.

During the inquiry, held from end 1998 to mid 2002, 316 questionnaires were returned, of which 194 were completed by Belgian experts and 122 by foreign specialists. The information gathered via these questionnaires forms the basis for the assessment of the faunal groups. These data were completed by literature and collection information, as well as by personal communications. For groups without questionnaire response, a literature or collection study was conducted.

Additional information was also gathered and checked from websites such as the 'European Register of Marine Species' (ERMS, http://erms.biol.soton.ac.uk), the 'North East Atlantic Taxa' (NEAT, http://www.tmbl.gu.se/libdb/taxon/taxa.html), the 'Integrated Taxonomic Information System' (ITIS, http://sis.agr.gc.ca/pls/itisca/taxaget), the 'Insect Identification and Natural History' site (http://entomology.unl.edu/lgh/insectid/), and from numerous scientific websites focusing on one or more faunal subgroups.

3. Description

This chapter does not present a complete hierarchical system. Taxa are discussed if occurring or expected in Belgium. Phyla are listed following Margulis & Schwartz (1998), with some minor changes. Small phyla are treated as a whole, while large ones are subdivided.

Each faunal taxon present or expected in Belgium is described as follows:

- scientific name followed by English, Dutch, French and German vernacular names;
- brief general description of the taxon with emphasis on morphological, ecological and distributional aspects, and the number of species worldwide (in few cases the fossil record is also mentioned);
- information source(s);
- knowledge on and, if available, state of the art of the taxon in Belgium (number of observed and expected species, state of knowledge, information on collection(s), trends, threats, alien species, geographical species richness, etc.); for poorly known groups, species numbers of adjacent countries are presented, when available;
- references and further reading with a focus on synoptical publications for Belgium and/or neighbouring countries; however, the aim was not to obtain an exhaustive enumeration of all the references in relation to the taxon dealt with; references used for the description (Belgian and worldwide situation) of several taxa are grouped at the end of the chapter under 'general references and further reading'.

This chapter does not pretend to be exhaustive or completely up-to-date. Any reader who should notice missing information is welcome to contact the authors, as this will contribute to elaborate an increasingly complete picture of the Belgian fauna.

4. Synopsis of the Belgian fauna

Protozoa - protozoans

(oerdieren, protozoën - protozoaires - Urtiere, Protozoen)

Single-celled eukaryotic organisms, feeding heterotrophically and exhibiting diverse motility mechanisms (pseudopodia, flagella, cilia, etc.); most abundant eukaryotic organisms in the world in terms of numbers and biomass; of major importance as consumers of bacteria and as parasites and symbionts of animals and plants; some are responsible for the contamination of water, others contribute to the fertility of soils; the Protozoa is an extremely diverse group for which numerous classifications have been developed over time according to very divergent views on its phylogeny; ca. 40,000 living species described; guesstimates for the total number of living species worldwide range from more than 100,000 to a multiple of this number.

Questionnaire completed by Johan De Jonckheere (Scientific Institute of Public Health).

Few overviews of Belgian species exist. Obviously, our knowledge of this group is very poor and even a very rough estimate of the expected number of Belgian protozoan species is simply impossible. Only some subgroups, genera or species, often of medical, veterinary, pharmaceutical or economical interest, are or have been studied. Most of the few laboratories in Belgium involved in Protozoa are specialised in tropical diseases or in ecological research. Representatives of this group are present in all aquatic and terrestrial habitats occurring as free-living forms, symbionts, commensals or parasites. An example of a representative collection is the 'Culture Collection of Algae and Protozoa' which is the longest established of the world's major protistan service culture collections (CCAP, http://www.ife.ac.uk/ccap). It holds over 2,000 strains of algae and protozoans. All protozoans and freshwater algae are kept at the Centre for Ecology and Hydrology (CEH), Windermere, England. The remaining part is managed by the Dunstaffnage Marine Laboratory (DML), Scotland. Another collection is the Protistology Collection of the 'American Tissue Culture Collection' (ATCC, http://www.atcc.org), based in Manassas, Virginia.

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Data were gathered via questionnaire, literature and personal communications on taxa of the following phyla. Even more than for metazoans, the texts on protozoans must be seen as a first impulse towards a more complete picture of this group in Belgium. The classification hereafter follows MARGULIS *et al.* (1990), *with some minor changes.*

RHIZOPODA (SARCODINA) - AMOEBOID PROTOZOANS

(NAAKTE en GESCHAALDE AMOEBEN - RHIZOPODES - WURZELFÜSSLER und TESTACEEN)

Probably the largest protozoan phylum; unicellular organisms moving and capturing food by means of pseudopods; most Rhizopoda are free-living, others are parasitic (*Entamoeba histolytica* causing some forms of amoebic dysentery); reproduce asexually by cell division or sexually by meiosis and the production of haploid gametes, followed by fusion of gametes and the formation of zygotes; include the naked forms (amoebas) and forms with perforated shells; a few thousand living species known world-wide.

Questionnaires completed by † Didier CHARDEZ (Gembloux Agricultural University) on the Thecamoebidae, by Peter WEEKERS (Ghent University) on the genera *Acanthamoeba* and *Hartmannella* and by Johan DE JONCKHEERE (Scientific Institute of Public Health) on the pathogenic *Acanthamoeba*. Text completed with data from the literature.

Of the 60 species listed in his contribution on the Rhizopoda, DE SAEDELEER (1934) only mentions Belgian locations for 35 of them. It is unclear whether the 25 other species were also found in our country. An overview of the Rhizopoda species recorded in Belgium until the 1950s, with bibliographic references, is published by VAN OYE (1948, 1956). He lists 164 species mainly belonging to the genera *Amoeba, Arcella, Difflugia, Euglypha* and *Nebela.*

Later, 280 species, 95 varieties and 20 forms of Thecamoebidae or testate amoebae have been recorded (CHARDEZ 1987, with partial species list). In this number are included the taxa found in the following habitats: fresh water, soil, mosses, ferns, lichens, rhizosphere and the supralittoral mesopsammon. Information on other terrestrial habitats and the marine environment is not known to us. Taxonomic knowledge of the Thecamoebidae is moderate. A representative collection is managed by the Gembloux Agricultural University. The species number is increasing, not only because of an intensification of sampling and research, but also because of the restoration of some habitats and the decrease of desiccation. Middle Belgium, the Hautes Fagnes and the Belgian Lorraine show the highest species richness. Ecologically, the highest diversity is found in stagnant freshwater and terrestrial habitats.

The number of observed and expected species of *Acanthamoeba* and *Hartmannella* in Belgium is unknown, among others because of the cosmopolitan feature of these organisms. A global list can be found in SLEIGH (1985). General identification keys are provided in PAGE (1983, 1988), SIEMENSMA (1987) and PAGE & SIEMENSMA (1991). Taxonomic knowledge is poor. Ecologically, the highest species richness is found in the terrestrial environment, followed by, in decreasing order of richness, stagnant fresh water, the marine environment and running fresh water. Some occur as symbionts or parasites of animals and plants. A few are human pathogens. DE JONCKHEERE investigates the occurrence of pathogenic *Acanthamoeba* spp. in natural, man-made (e.g. pools, fish farms) and thermally polluted water systems.

Based on samples from the Belgian marine waters, KUFFERATH (1952) described four new species of Amoebidae: *Amoeba ostendensis*, *A. hostilis*, *A. placida* and *Rhizophidium lyngbyae*. He did not mention how many species of this family are known or expected in Belgium. The number of *Psalteriomonas* and *Lyromonas* spp. in Belgium is unknown. Only two species have been described so far: *Psalteriomonas lanterna* and *Lyromonas vulgaris* (BROERS *et al.* 1990, BROERS *et al.* 1993). Both are occurring in the anaerobic bottom layer of freshwater ponds. SIEMENSMA (1987) lists 67 Gymnamoebia spp. found in Dutch freshwater systems. There is no expert in Belgium able to identify species. Taxonomic knowledge of amoeboid protozoans in Belgium is very poor.

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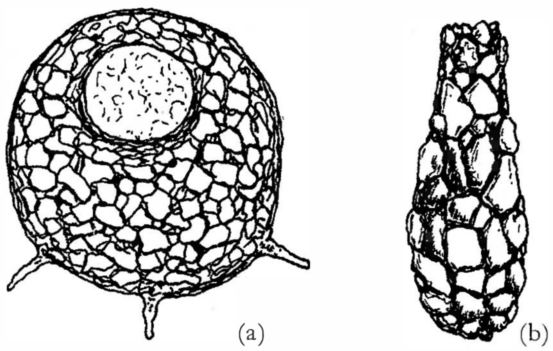

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Tests of two species of Thecamoebidae observed in Belgium: (a) *Centropyxis aculeata* and (b) *Difflugia linearis* (drawings by D. CHARDEZ, courtesy of M. HEUSCHEN and the Gembloux Agricultural University).

The phylum MYXOZOA*, formerly assigned to the Protozoa, has been transferred to the Metazoa following recent research, and is discussed there.*

ZOOMASTIGINA (ZOOMASTIGOPHORA) - ZOOFLAGELLATES or FLAGELLATED PROTOZOA

(ZOÖFLAGELLATEN - ZOOFLAGELLÉS - ZOOFLAGELLATEN)

Free-living, symbiotic or parasitic protozoans with one or more whip-like flagella; in freshwater and marine environments; feed by absorbing organic molecules from the surrounding medium or engulf prey by phagocytosis; reproduction by binary or multiple fission, sexual processes unconfirmed; most live as solitary cells, some form colonies; some have pseudopodia besides flagella; an example of a symbiont is the zooflagellate living in the gut of termites where it digests cellulose; an example of a parasite is *Trypanosoma gambiense*, which causes African sleeping sickness; very rough guesstimate: 4,000 living species worldwide.

Questionnaire completed by Johan DE JONCKHEERE (Scientific Institute of Public Health) on the pathogenic *Naegleria*. Additional information from literature.

Specimens of this group seem to be studied mainly incidentally during ecological or health-related studies. DE JONCKHEERE investigates the occurrence of pathogenic *Naegleria* spp. in natural, man-made (e.g. pools, fish farms) and thermally polluted water systems.

In addition to diatoms, dinoflagellates, Chrysophyceae, Xanthophyceae, Euglenophyceae, etc., CONRAD & KUFFERATH (1954) list 41 'zooflagellate' spp. from brackish water habitats near Lilloo. Most of the genera cited, e.g. *Bodo*, *Monosiga*, *Tetramitus*, are classified within the Zoomastigina by MARGULIS *et al*. (1990). KUFFERATH (1952) describes one new species of

Rhizomastigina from Belgium, but it is unclear whether this taxon (still) belongs to the Zoomastigina, and if yes, under what name. SCHOUTEDEN (1905) and NEALE ELLIS (1929) mention some Choanoflagellata from adjacent areas.

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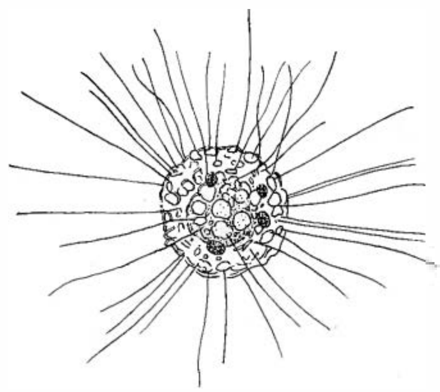
ACTINOPODA - ACTINOPOD PROTOZOANS

Free-living protozoans with stiffened pseudopodia, called actinopoda, used for locomotion and food trapping; shells made of silica; locomotion via rolling is achieved through lengthening and shortening of the axopodia by assembly and disassembly of the microtubule core of the axopod; containing two major classes: the Heliozoa or heliozoans (zonnediertjes - héliozoaires - Sonnentierchen), mainly living in fresh water but also present in the marine environment, and the Radiolaria or radiolarians (straaldiertjes, radiolariën - radiolaires - Straltierchen, Radiolarien), which are mainly marine planktonic organisms; ca. 180 living heliozoan species as well as 4,100 living and almost 7,600 fossil radiolarian species have been recorded worldwide.

No questionnaire has been completed.

KUFFERATH (1952) lists 20 Heliozoa species, three of them new for science, from Belgian marine waters and the Sluice dock in Ostend. In 1950, the same author reported on one radiolarian from the mouth of the Scheldt. No studies on the Belgian freshwater fauna are known to us. SIEMENSMA (1981) recorded 46 Heliozoa species in Dutch freshwater systems. Given the proximity of the study area and the often wide distribution of the species, most of them are (or were) probably also present in Belgium. The optimal environment for Heliozoa species is shallow, clear, oxygen-rich fresh water with much vegetation. Only two species were found on riverbank plants of heavily polluted waters. Obviously, this entire phylum is very poorly studied in Belgium.



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Actinosphaerium portuum, a new heliozoan species described by KUFFERATH in 1952 from the southern part of the North Sea. Body diameter is 30 µm, while the fine, radiant pseudopodia can reach 40 µm (from KUFFERATH 1952, © RBINS).

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CILIOPHORA - CILIATES OF CILIATED PROTOZOANS

(TRILHAARDIERTJES, WIMPERDIERTJES - CILIÉS, CILIOPHORES - WIMPERTIERCHEN)

Cell body covered with cilia; nucleus differentiated into macro- and micronucleus; free-living in freshwater and marine environments; feed on bacteria or algae; although ciliates typically reproduce asexually, they also exchange genetic information via conjugation; taxon includes the slipper-shaped paramecium and the trumpet-shaped stentor; Suctoria are sessile ciliates that suck out the protoplasm of their prey through tentacles; opinions about the worldwide ciliate species diversity are very divergent: B.J. FINLAY (Centre for Ecology and Hydrology, Windermere) states that ciliate species have a cosmopolitan distribution and that almost all species (ca. 3,000) have been described; W. FOISSNER (University of Salzburg) contests this hypothesis and thinks the total species number of Ciliophora is approximately a tenfold of it.

Main information provided by Jeroen VAN WICHELEN (Ghent University). Questionnaires completed by †Didier CHARDEZ (Gembloux Agricultural University) and Ilse HAMELS (Ghent University) on the Ciliophora in general and by Eric HOCHBERG (Santa Barbara Museum of Natural History) on the Opalinopsidae. Additional information from the literature.

Although this taxon seems to be the 'best' known protozoan phylum in our country, taxonomic knowledge is poor and no representative collection could be identified. A catalogue of the Belgian Ciliophora, following sampling of different lakes, ponds, ditches, rivers, brooks, lichens, mosses, ferns and soils, is published by CHARDEZ (1987) and contains ca. 250 species. VAN WICHELEN *et al.* (2002) studied the Flemish lakes and found 135 taxa out of which 90 species could be identified. Next to the free-living species, some ciliates occur as symbionts and commensals of mainly fishes and as parasites of cephalopods, crustaceans, fishes and amphibians. The interstitial marine and brackish water ciliates have only been studied ecologically. It is obvious that Belgian marine waters and some terrestrial habitats are poorly studied or not at all from a taxonomic point of view. Other problems are the often obsolete descriptions of Belgian species, the high number of synonyms and, more fundamentally, the species concept which is difficult to apply to these organisms. Nevertheless, since 1950, the species number has increased because of research intensification and probably introductions.

Opalinopsidae or apostome ciliates are parasites of cephalopods and crustaceans. So far, no species have been recorded in Belgian marine waters, but four or five are expected based on host-parasite relationships. Taxonomic knowledge is obviously very poor and a Belgian expert could not be identified. A European species list can be found in HOCHBERG (1990). Representative collections are present in the Santa Barbara Museum of Natural History and the Muséum d'Histoire Naturelle of Geneva.

KUFFERATH (1950) lists 16 species of Tintinnidae, of which 6 are new to science, from the Belgian marine waters. Because of taxonomic uncertainty and changing classification, it is unclear how many species of this family really occur.

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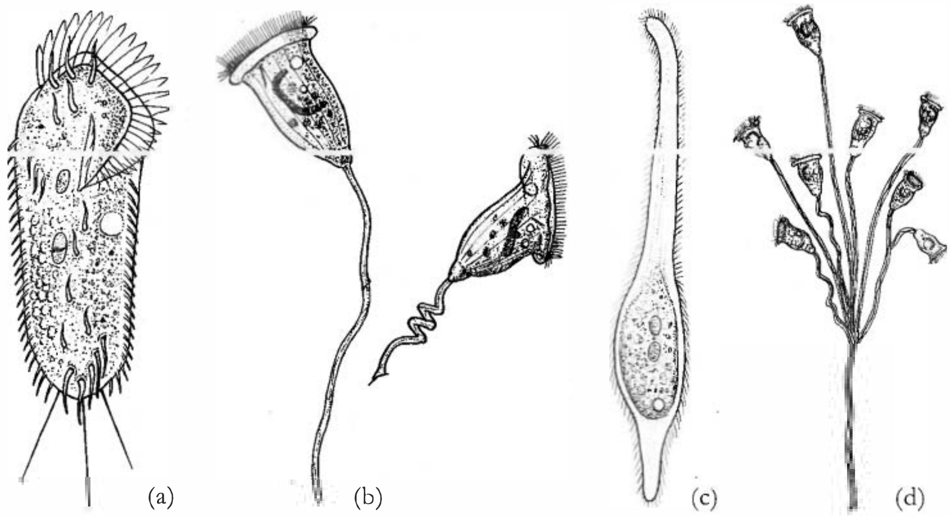

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Four ciliate species occurring in Belgium: (a) *Stylonichia mytilus*, (b) *Vorticella nebulifera*, (c) *Litonotus anser* and (d) *Carchesium polypinum* (drawings by D. CHARDEZ, courtesy of M. HEUSCHEN and the Gembloux Agricultural University).

GRANULORETICULOSA

Phylum almost entirely consisting of the Class Foraminifera or foraminifers, foraminiferids (foraminiferen - foraminifères - Foraminiferen); possessing hard parts in the form of tests (or shells), composed of organic matter reinforced with sand or calcium carbonate, and granular, reticulose pseudopodia; shell consisting of one or more chambers; among the most abundant, diverse and widely distributed protists in the oceans playing a significant role in food webs; mostly benthic, some are planktonic; length ranging from 100 µm to ca. 10 cm (*Nummulites* spp.); feed on organic molecules, bacteria, diatoms, other single-celled phytoplankton and even small animals such as copepods; mineralised shells of Foraminifera preserve a record of ocean chemical properties useful for evolutionary, paleobiological and geochemical analysis of global environmental change; to date, 3,620 genera and ca. 60,000 species, of which ca. 4,000 recent species, have been described; fossil record of Foraminifera dates back to more than 550 million years ago.

Information from literature, completed by personal communications of Pieter LAGA (Geological Survey of Belgium), Herman HOOYBERGHS (KUL) and Stefan REVETS (RBINS).

CUSHMAN (1949) lists 128 species and subspecies (this includes recent and subrecent forms) based on the study of bottom samples from the Belgian marine waters. He notes that the samples are characterised by a considerable number of Cretaceous specimens and the occasional presence of Tertiary ones. In adjacent areas, MURRAY (1979) found 63 brackish and nearshore species in British waters.

Much more research activities are or have been undertaken in relation to fossil Foraminifera in Belgium: Tertiary foraminifers are studied at the Catholic University of Leuven (H. HOOYBERGHS, †F. DE MEUTER and former colleagues). More specifically, Oligocene forms are the subject of a Ph.D. at the Royal Belgian Institute of Natural Sciences (E. DE MAN). Cretaceous and Paleocene foraminifers are investigated by F. ROBASZYNSKI and T. MOORKENS, both retired but still doing research. L. HANCE, guest professor at the UCL, and his Ph.D. researcher F.-X. DEVUYST, study the foraminifers of the Paleozoicum, which were also the main research involvement of the late R. CONIL (UCL). Furthermore, the existence of doctoral papers on Foraminifera of P. LAGA (Pliocene), F. DE MEUTER (Miocene), J. BACCAERT (large Foraminifera), W. WILLEMS (Ypresian) and T. MOORKENS (Paleocene) was brought to our attention.

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(References and further reading on fossil Foraminifera in Belgium are not included because the current publication focuses on present-day biodiversity.)

APICOMPLEXA (SPOROZOA) - APICOMPLEXANS or NON-MOTILE PARASITIC PROTOZOANS (SPOROZOANS)

(SPORENDIERTJES - APICOMPLEXANS, APICOMPLEXÉS, SPOROZOAIRES - SPOROZOEN, SPORENTIERCHEN)

Probably the largest and best-known taxon of parasitic protozoans; unicellular organisms possessing an apical complex of microtubules; many apicomplexans are bloodstream parasites with complex life cycles, and both asexual and sexual reproduction; they infect vertebrates, causing serious illnesses (e.g. species of the genus *Plasmodium* cause malaria, others cause coccidiosis, toxoplasmosis, etc.), and invertebrates (some apicomplexans may be useful for man in controlling populations of pest insects); ca. 5,000 described species worldwide, but a multiple of this number still to be discovered.

Questionnaire on the Aggregatidae completed by Eric HOCHBERG (Santa Barbara Museum of Natural History).

Species of Aggregatidae parasitise crustaceans and cephalopods. None have been recorded in Belgian marine waters so far, but 4 to 8 species are expected based on host-parasite relationships. A list of European species can be found in HOCHBERG (1990). Taxonomic knowledge of this group is very poor and no Belgian expert could be identified.

Representative collections are managed by the Santa Barbara Museum of Natural History and the University of Vigo.

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METAZOA - METAZOANS or MULTICELLULAR ANIMALS

(VEELCELLIGE DIEREN, MEERCELLIGE DIEREN - MÉTAZOAIRES - MEHRZELLIGEN TIERE, VIELZELLIGEN TIERE)

Multicellular, heterotrophic, diploid organisms with development proceeding via a blastula; include all faunal groups from Porifera to Mammalia.

PORIFERA - SPONGES

(SPONZEN - ÉPONGES - SCHWÄMME)

Multicellular animals without tissues and organs; numerous microscopic ostia by which water enters the canal system through the body and one or a few oscula from which water exits; physiological functions by individual cells; no nervous, muscular or hormonal systems; adults sessile; larvae ciliated and free-swimming; most species are dioecious; the vast majority are marine, ca. 100 species live in fresh water; more than 7,000 living species described worldwide; a considerable number of additional species is expected.

Questionnaire completed by Philippe WILLENZ (Royal Belgian Institute of Natural Sciences).

Five freshwater and ca. 27 marine species have been recorded. Given the fact that hard substrates are crucial for the settling of sponges, the relative high number of marine species seems to contrast somewhat with the rarity of natural hard substrates. Man-made constructions are probably the major explanation for this. Furthermore, it is most unlikely that all the recorded species still occur in the Belgian marine waters. For the freshwater habitat and specifically the more diverse running waters (RASMONT 1957), Lower and Middle Belgium show the highest species richness (RICHELLE-MAURER *et al.* 1994). *Trochospongilla horrida* was first reported in Belgium in 1994 while the other freshwater species were observed much earlier.

Taxonomic knowledge of the Porifera in Belgium is moderate, and information on actual trends like spreading or regression is not available. RICHELLE-MAURER *et al.* (1994) propose the use of sponges as bio-indicators for the detection of heavy metals in the environment.

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MYXOZOA - MYXOZOANS

(MYXOZOËN - MYXOZOAIRES - MYXOZOEN)

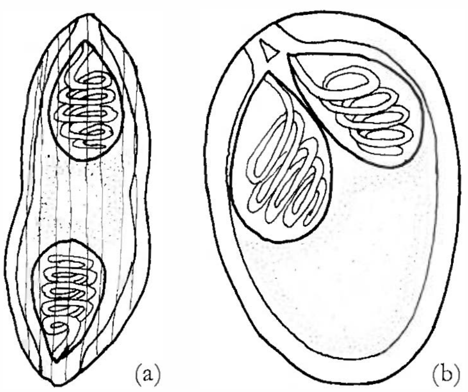
Myxozoans have traditionally been classified within the Protozoa. Recent investigations (SMOTHERS *et al.* 1994) *show that it is a metazoan group, possibly related to the Cnidaria* (pers. comm. E. KARLSBAKK). *Some experts consider the Myxozoa as a highly derived group of cnidarians.*

Spore producing parasites of fishes, amphibians and reptiles, and also of annelids and bryozoans; present in host species living in marine as well as in freshwater habitats; ca. 1,400 described species worldwide; a total species number between 3,000 and 5,000 is expected.

Questionnaire completed by Egil KARLSBAKK (University of Bergen) for the marine species and by Steven FEIST (Centre for Environment, Fisheries and Aquaculture Science, Weymought) for the freshwater species.

At least 49 species could occur in Belgian marine waters following species observations in adjacent waters and host-parasite relationships. Furthermore, some 20 additional species, among others exotic myxozoans carried by introduced or vagrant fish species, are expected in our marine zone. These numbers together would result in a total of ca. 70 species of Myxozoa in Belgian marine waters. A partial list of European marine Myxozoa can be found on the website 'European register of marine species' (ERMS). Some ten freshwater species were recorded, while not fewer than 50 additional ones are expected (SHULMAN 1966).

The highest species richness is expected in marine and running freshwater habitats. Stagnant freshwater bodies show a lower species richness. For Belgium and the neighbouring countries, it is obvious that taxonomic knowledge of this group is very poor. Moreover, no Belgian expert could be identified for this group.



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Examples of Myxozoa parasitising fishes in Belgian waters: (a) *Myxidium rhodei* LÉGER, 1905 from the kidney of roach (*Rutilus rutilus*); (b) *Myxobolus cyprini* DOFLEIN, 1898 from the musculature of chub (*Leuciscus cephalus*) (drawings by M. LONGSHAW).

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CNIDARIA - CNIDARIANS

(NETELDIEREN - CNIDAIRES - NESSELTIERE)

Metazoans with two basic body forms (polyp and medusa); ectodermal and gastrodermal epithelia, separated by mesogloea; nerve net acting as nervous system; cnidae used in predation and defence; mostly carnivorous, although, in some species, nutrition is supplemented by dissolved organic material and photosynthesising endosymbionts; phylum contains four major classes: the Anthozoa (sea anemones, corals, etc.), Hydrozoa (hydras), Cubozoa (sea wasps) and Scyphozoa (jellyfish); all species are aquatic, most are marine; size of adult individuals range from less than 1 mm to 70 m long; ca. 9,000 living species described worldwide.

Basic information on the marine species was provided by Francis KERCKHOF (Marine Ecosystem Management / RBINS). Questionnaires were completed by Bregje BEYST and Ann DEWICKE (Ghent University) for the marine species, and by Jean BOUILLON (Free University of Brussels) for the brackish and freshwater species.

Some 90 marine species have been recorded (LELOUP 1952), but many listed species are probably not living in Belgian waters as they were found cast ashore or because they belong to the so-called trawler fauna brought in by fishermen from their fishery grounds. However, based on comparable data from the Netherlands (more than 130 species) and Sweden (210 species), and given the fact that the sampling methods used by Belgian scientists during their monitoring campaigns of the past decades were not specifically aimed at cnidarians, many additional species can be expected as already observed by MASSIN *et al.* (2002). Another example: recent research of specific habitats such as the Sluice dock in Ostend and the groynes on the Belgian beaches revealed the presence of the sea anemones *Haliplanella lineata* (KERCKHOF, unpublished) and *Sagartia elegans* (FAASSE & DE BLAUWE 2003).

Eight brackish and freshwater species (LELOUP 1952) have been observed, four of which belong to the genus *Hydra*. Based on species observations in similar habitats outside Belgium, at least three additional species are expected (VERVOORT 1946). Upper Belgium shows the highest species richness. The number of freshwater species is increasing because of the immigration and introduction of at least three species since 1900. For the non-marine species of this group, no scientific expert able to identify organisms to the species level could be identified. Taxonomic knowledge of this group in Belgium is very poor for the marine as well as for the brackish and freshwater habitats.

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CTENOPHORA - CTENOPHORES or COMB JELLIES

(RIBKWALLEN, KAMKWALLEN - CTÉNOPHORES, CTÉNAIRES - RIPPENQUALLEN)

Diploblastic metazoans with biradial symmetry; basic body form is ovoid, typically around 1 cm; most species are planktonic; locomotion by rows of comb plates (fused cilia); nerve net acting as nervous system; no respiratory, circulatory or excretory system; adhesive colloblasts; sexual reproduction, mostly hermaphroditic; ctenophores are all predatory, although nutrition in some species is supplemented by photosynthetic algae; all species are marine, occurring from the surface waters to at least 3,000 m; about 100 described species worldwide, but many unknown species probably exist in deep waters.

Questionnaire completed by Bregje BEYST and Ann DEWICKE (Ghent University).

At least two species are present in Belgian marine waters. *Pleurobrachia pileus*, representing the class Tentaculata, is very common along the coast. *Beroe gracilis*, up to 1982 erroneously identified (KERCKHOF 1982) as *Beroe cucumis*, belongs to the class Nuda and feeds on *P. pileus*. Recently, *Bolinopsis infundibulum* and *Beroe cucumis* have been observed along the Dutch coast (HOLSTEIJN 2002), although these species normally occur more to the north. If they continue to expand their distribution area in southern direction, they could appear in Belgian marine waters in the near future. Since fixation of ctenophores is often difficult, the identification of specimens and the set up of a representative collection is problematic.

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PLATYHELMINTHES - FLATWORMS

(PLATWORMEN - VERS PLATS - PLATTWÜRMER)

Phylum with the simplest structure of the bilaterally symmetrical and triploblastic animals; body flattened dorsoventrally; acoelomate; includes the Turbellaria, Trematoda, Monogenea and Cestoda.

TURBELLARIA - TURBELLARIANS or FREE-LIVING FLATWORMS

(TRILHAARWORMEN, VRIJLEVENDE PLATWORMEN - TURBELLARIÉS, VERS PLATS LIBRES - STRUDELWÜRMER)

Ciliated, mostly free-living flatworms; some taxa are parasitic or symbiotic; most species are predators or scavengers; hermaphrodites with complex reproduction system and internal fertilisation, some also reproduce by fission; they inhabit marine, freshwater, benthic, periphyton and moist terrestrial systems; most species are relatively small (0.5 to 5 mm); ca. 8,000 species have been described worldwide while the expected species number ranges from 15,000 to 20,000.

Data provided by Ernest SCHOCKAERT (Limburg University Centre).

The estimated number of known marine and brackish water species in Belgium is 400. Given the fact that new species, some even unknown to science, are still discovered in our coastal and marine zone, the real number of species will be higher. A partial species list is presented in SCHOCKAERT *et al.* (1989).

The freshwater fauna is almost completely unknown. At least 50 species are expected. All known Belgian turbellarian species are free-living. An example of a recent introduction is the Ponto-Caspian invader *Dendrocoelum romanodanubiale* in the Albert Canal (pers. comm. T. VERCAUTEREN).

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TREMATODA - TREMATODES or FLUKES

(ZUIGWORMEN - TRÉMATODES, VERS INTESTINAUX - SAUGWÜRMER)

Most are endoparasitic and have two to four hosts in the life cycle; usually two holdfast organs without hooks: an anterior oral sucker surrounding the mouth and a ventral sucker; adults occur in the definitive host, normally a vertebrate; most species have a molluscan intermediate host; the flukes of the subclass Aspidobothrea have a single host in the life cycle and some are ectoparasitic; 15,000 to 18,000 digenean (Trematoda s.s., excl. Monogenea) species have been recorded worldwide.

Questionnaire completed by David GIBSON (The Natural History Museum, London). Additional data from collection archives, unpublished observations and personal communications.

A preliminary list of 103 species is compiled based on the collections of the Royal Belgian Institute of Natural Sciences and the Zoological Museum of the University of Liège, on grey literature and on communications from the Prince Leopold Institute of Tropical Medicine, the Institute for Forestry and Game Management, the Ghent University, the Sea Fisheries Department, the Scientific Institute of Public Health and the Marine Ecosystem Management Department of the RBINS. No published overview of this taxon is available. The total number of trematode species in Belgium is estimated at 325, based on the fauna in the neighbouring countries and information contained in the host-parasite database managed by The Natural History Museum in London.

As it is often the case for parasitic taxa, taxonomic and faunal studies concerning the Trematoda are scarce and only some species of medical, pharmaceutical or veterinary interest are studied (e.g. *Fasciola hepatica* and *Schistosoma* spp.). Most species occur as fish parasites. Main collections in relation to the Belgian fauna are housed in the Royal Belgian Institute of Natural Sciences and the Zoological Museum of the University of Liège. Few specimens are present in the medical and veterinary departments of universities and other scientific institutes. In the Netherlands, 100 species are observed hitherto, but not less than 500 additional species are expected. In the United Kingdom, 400 trematode species have been recorded and a considerable number of additional species is expected.

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MONOGENEA - MONOGENEANS or MONOGENETIC FLUKES

(ECTOPARASITAIRE PLATWORMEN, UITWENDIGE ZUIGWORMEN - VERS MONOGÈNES - MONOGENE SAUGWÜRMER)

Monogenea are often placed in the class Trematoda. They are treated apart here to obtain a more detailed presentation. Hermaphroditic, ectoparasitic flatworms mostly found on the gills or skin, or in the nose, mouth, etc. of fish, amphibians and reptiles, some on mammals, crustaceans and cephalopods; direct life cycle: free-swimming larva attaches to a new host and grows into an adult worm; found in freshwater and marine habitats; adults most often less than 10 mm in length; adhesive structures at both ends of the worm; mouth sometimes encircled by a sucker; the posterior adhesive structure, the opisthaptor, is a complex of suckers, suckerlets, hooks, anchors, etc.; can cause serious problems for example in aquarium or hatchery; 7,000 to 8,000 described monogenean species worldwide, while a total of more than 20,000 is expected.

One of the most significant radiations of platyhelminth fish parasites is demonstrated within the monogenean 'supergenera' *Dactylogyrus* and *Gyrodactylus*. More than 400 *Gyrodactylus* species have been described at present, but the estimated species number is about 20,000 (BAKKE *et al.* 2002). Gyrodactylids display the widest host range of any monogenean family (they are found on 19 orders of bony fishes), encompassing both highly specific and generalist species. The combination of viviparity, progenesis and protogyny is unique in the animal kingdom. Advanced progenesis allows the first-born daughter to be produced within 24 hours after her parents' birth. This may result in an explosive population growth, especially when transmission is favoured under aquacultural conditions. The population dynamics resemble those of microparasites rather than those of typical helminth macroparasites (CABLE & HARRIS 2002).

Information provided by Tine HUYSE (Catholic University of Leuven), with additional data from David GIBSON (The Natural History Museum, London).

So far, 21 species have been recorded in Belgium, but the presence of 300 to 500 species of this poorly studied and species-rich taxon is expected. All species in Belgian waters occur as ectoparasites on the gills, skin and fins of marine and freshwater fish. The knowledge of this group in Belgium is poor. A representative collection does not exist although a few specimens are present in the Royal Belgian Institute of Natural Sciences and in some university collections. A larger collection is housed by the natural history museums of London and Stockholm.

The genus *Gyrodactylus* is one of the largest within the Monogenea. A first study on *Gyrodactylus* spp. parasitising marine fishes in the North Sea revealed the presence of six new species, of which two are hitherto described (GEETS *et al.* 1998, HUYSE & VOLCKAERT 2002).

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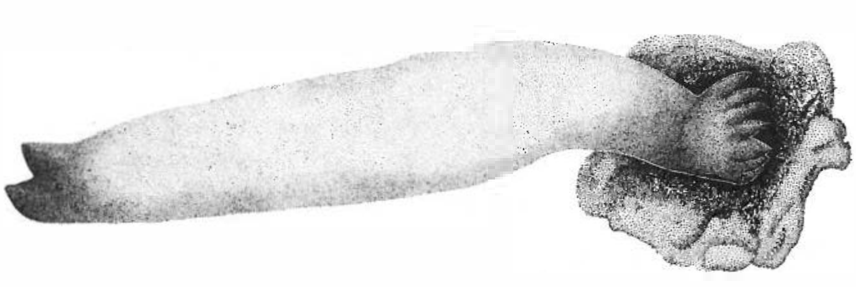

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The monogenean *Gyrodactylus branchialis*. The parasitising specificity of monogeneans is illustrated by the fact that this species, for example, only occurs on the gills of the common goby (*Pomatoschistus microps*). Length: 130-150 µm (drawing by H. VAN PAESSCHEN, based on photographs by T. HUYSE).

CESTODA - TAPEWORMS

(LINTWORMEN - CESTODES - BANDWÜRMER)

Adults occurring as elongated and flattened endoparasites in the intestines of vertebrates, involving at least two hosts of different species; usually one or more larval stages either in vertebrates or invertebrates; no mouth nor digestive organ present; head, with an attachment organ (scolex), followed by a series of body units (proglottids); no epidermis but covered with a thick cuticle; length ranges from less than 10 mm to more than 30 m; 5,000 species are known worldwide.

Questionnaire completed by David GIBSON (The Natural History Museum, London). Additional data from collection archives, unpublished observations and personal communications.

The number of observed species in our country is unknown, because only species with special interest to human and animal health are studied. A preliminary list of 144 species is compiled based on the collections of the Royal Belgian Institute of Natural Sciences and the Zoological Museum of the University of Liège, on grey literature and on communications from the Prince Leopold Institute of Tropical Medicine, the Institute for Forestry and Game Management, the Ghent University, the Sea Fisheries Department, the Scientific Institute of Public Health and the Marine Ecosystem Management Department of the RBINS. No published overview of this taxon is available. At least 250 tapeworm species are expected to occur in Belgium, based on figures of the host-parasite database at The Natural History Museum in London.

The expected species number of 250 is probably an underestimation since more than 500 species and subspecies are mentioned in an anonymous, dateless manuscript titled 'Cestodes belges - Catalogue alphabétique', found in the archives of the Royal Belgian Institute of Natural Sciences. This manuscript, possibly based on somewhat obsolete systematics and probably containing synonyms and doubtful observations, needs further investigation, and may not (yet) be used as a reference for the number of tapeworm species in Belgium. Main collections in relation to the Belgian fauna are housed in the Royal Belgian Institute of Natural Sciences and the Zoological Museum of the University of Liège. A few specimens are present in the medical and veterinary departments of universities and other scientific institutes. In the Netherlands, 80 species have been recorded and more than 400 additional species are expected.

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GNATHOSTOMULIDA - GNATHOSTOMULIDS or JAW WORMS

(KAAKWORMEN - GNATHOSTOMULIDES - KIEFERMÄULCHEN, KIEFERMÜNDCHEN)

Quite recently described phylum (1956); bilaterally symmetrical, unsegmented marine worms mainly occurring in interstitial habitats, on algae and plants or in the black, anaerobic layer produced by sulfur-metabolising bacteria; jaw worms are small (less than 1 mm) and transparent; hermaphrodites; feeding on bacteria, protists and fungi; 80 species described worldwide, at least 170 additional species expected.

Questionnaires completed by Martin SORENSEN and Reinhardt KRISTENSEN (University of Copenhagen), Wolfgang STERRER (Bermuda Natural History Museum) and Alessandra FALLENI (University of Pisa).

So far, no jaw worms have been recorded from Belgian marine waters. Not because the group is poorly represented, but because Gnathostomulida have not been investigated yet in the Belgian part of the North Sea. SORENSEN and KRISTENSEN state that the Belgian waters contain several species and probably also some undescribed taxa because this group is only well investigated in the Western Atlantic. The expected number of gnathostomulid species in Belgian waters ranges from 9 to 22. For this group, no specialist could be identified in our country and taxonomic knowledge is obviously lacking.

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'MESOZOA - MESOZOANS'

(WEINIGCELLIGEN, MIDDENDIEREN - MÉSOZOAIRES - MITTELTIERE)

Probably have the simplest structure of any metazoan form. Until recently, the phylum Mesozoa was subdivided in two classes: Dicyemida (or Rhombozoa) and Orthonectida. New insights elevated both classes to the rank of phylum, outdating the name Mesozoa.

Common characteristics for Dicyemida and Orthonectida: minute, parasitic vermiform animals generally consisting of 20 to 30 cells; lacking circulatory, respiratory, digestive and nervous systems; asexual and sexual reproduction; size ranges from less than 1 to 7 mm.

DICYEMIDA ('RHOMBOZOA') - DICYEMIDS ('RHOMBOZOANS')

(DICYEMIDEN - DICYÉMIDES - DICYEMIDEN)

Specific characteristics: often only one axial cell (through long axis of the body), surrounded by a single, ciliated cell layer (somatoderm); axial cell(s) involved in reproduction, not in digestion; two types of larva; parasitic in the kidneys of bottom-dwelling cephalopods; more than 200 known species worldwide.

Questionnaire completed by Eric HOCHBERG (Santa Barbara Museum of Natural History).

No dicyemid species from Belgian waters have been recorded although three to more than 15 species are expected based on host-parasite associations and species lists for Europe (HOCHBERG 1990). For example, *Sepia officinalis* and *Octopus vulgaris*, only two of the common cephalopod species in Belgian marine waters, can each be parasitised by a different set of four dicyemid species. Representative collections with species occurring in Belgium are housed in the 'Muséum d'Histoire Naturelle' in Geneva (Switzerland) and the

Santa Barbara Museum of Natural History (California, USA). The status of this group is indissolubly related to the trends displayed by their hosts, i.c. cephalopods.

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ORTHONECTIDA - ORTHONECTIDS

(ORTHONECTIDEN - ORTHONECTIDES - ORTHONECTIDEN)

Specific characteristics: free-swimming adults; sexual reproduction results in ciliated larvae entering the body of suitable hosts (Platyhelminthes, Nemertea, Annelida, Mollusca, Echinodermata and Tunicata), where they grow to form a multinucleate plasmodium of less than 1 mm; less benign than dicyemids since they may affect host reproduction; ca. 22 species described worldwide; undoubtedly, there are many undescribed species as these organisms are very small parasites and the percentage incidence in a particular host species is often very low.

Questionnaire completed by Eugene KOZLOFF (University of Washington).

So far, no orthonectids seem to have been reported from Belgium. Based on host-parasite relationships for hosts also known from Belgian marine waters, at least six described (KOZLOFF 1992, 1993), and some undescribed species, are expected. The tidal and subtidal zones are expected to show the highest species richness. Taxonomic knowledge of this group in Belgium is totally lacking, in contrast with for example France, where it is considered to be good. No expert nor representative collection could be identified in Belgium.

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NEMERTEA - RIBBON WORMS or NEMERTEANS

(SNOERWORMEN - NÉMERTIENS, NÉMERTES - SCHNURWÜRMER)

Bilaterally symmetrical, usually cylindrical, unsegmented worms with eversible proboscis which is sometimes used for gripping or burrowing; body length ranging from 0.5 mm to 30 m; almost all marine (some as symbionts/commensals in gill chambers of crustacean decapods or mantle cavity of molluscs), a few occur in freshwater or moist terrestrial habitats; external fertilisation, some are viviparous; mainly carnivorous; almost 1,200 species described worldwide.

Questionnaire completed by Ray GIBSON (Liverpool John Moores University).

Ten species are reported from the Belgian marine waters (P.J. VAN BENEDEN 1861, E. VAN BENEDEN 1883). More recent observations are lacking. A new and comprehensive survey is needed and would probably double or triple the species number. The species occurring in Belgian waters can be found in the species list of the United Kingdom (GIBSON 1995). No expert able to identify organisms to the species level, neither a representative collection, could be identified in Belgium. Obviously, this group is poorly known in our country.

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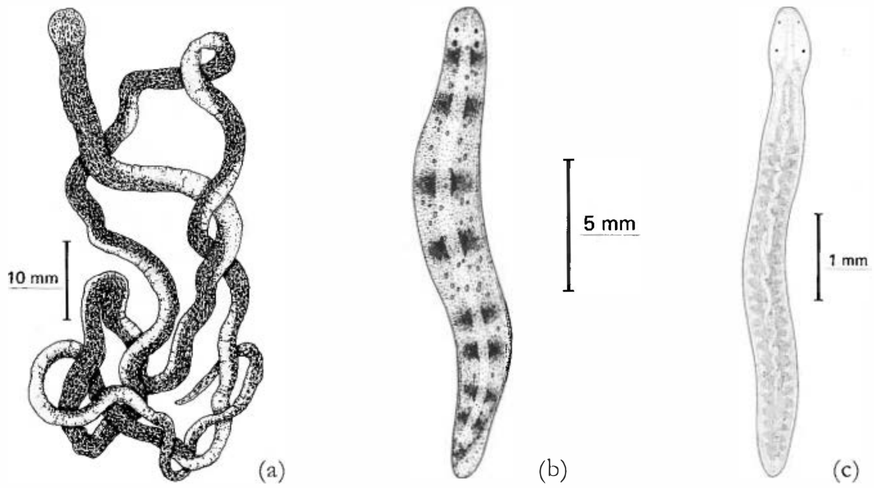

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Examples of ribbon worms observed in Belgian marine waters: (a) *Emplectonema neesii*, (b) *Oerstedia dorsalis* and (c) *Tetrastemma flavidum*. The first two were recorded by P.J. VAN BENEDEN, the latter by E. VAN BENEDEN (from GIBSON 1982, courtesy of Cambridge University Press).

NEMATODA - NEMATODES

(NEMATODEN, SPOELWORMEN, RONDWORMEN - NÉMATODES - FADENWÜRMER, NEMATODEN)

Spindle or thread-like body shape, round upon cross section and with bilateral symmetry; crawling or swimming with undulating movements; post-embryonic development is characterised by four moults; nematodes show a wide range of life histories from entirely free-living to parasitic in plants and animals; as parasites, some species belong to the most serious pest organisms to mankind (e.g. causing filariasis); nematodes can be found in any habitat but depend on moisture for their locomotion and active life; most can survive periods of drought (cryptobiosis, quienscence); feeding on bacteria or algae, omnivorous or predacious on nematodes and other small invertebrates; body length from less than 0.1 mm to 9 m; ca. 25,000 species described; the estimated total number of nematode species would be between 100,000 and 1,000,000 species.

Questionnaire completed by Wilfrida DECRAEMER (Royal Belgian Institute of Natural Sciences).

COOMANS (1989) lists 519 free-living species. More than half of these are present in the marine environment. A species list of nematodes of the Belgian Continental Shelf recorded between 1970 and 1998 can be found in CATTRIJSSE & VINCX (2001). During the last decades, the number of species increased because of research intensification. BERT (2002), for example, next to removing 6 species from COOMANS's list because of synonymy, added 27 species of Tylenchida new for the Belgian fauna.

A considerable number of additional species is expected (total nematode fauna roughly estimated at 2,500 species in Belgium) because of some knowledge gaps in relation to freshwater habitats, moorland and deciduous forests, and based on the figures of the Netherlands (1,700 species observed, ca. 2,500 expected; both figures excluding the nematodes parasitising vertebrates). Although a lot of research was and is being done on nematodes as animal parasites, no inventory of species parasitising vertebrates seems to be available for Belgium. Five parasitic species are commonly found in harbour porpoises stranded or bycaught in Belgium (DEBACKER *et al.* 2002, JAUNIAUX *et al.* 2002).

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NEMATOMORPHA - HORSEHAIR WORMS

(PAARDENHAARWORMEN - NÉMATOMORPHES - SAITENWÜRMER)

Long and slender body, covered with a thin white, creamy yellow, brown or dark cuticle, adorned in Nectonematoidea; juveniles of the Gordioidea are endoparasitic in aquatic and terrestrial arthropods (particularly crickets, grasshoppers and beetles); juveniles of the Nectonematoidea are parasites of hermit crabs, true crabs and shrimps; adults do not feed and are free-living, mainly occurring in fresh water and damp soil (Gordioidea) or found swimming in the pelagic zone of the Atlantic, North Pacific and Indian Oceans, and in the Mediterranean Sea (Nectonematoidea); locomotion via body undulations as in nematodes; internal fertilisation; length of adults up to 1 m; 320 species of Gordioidea and four species of Nectonematoidea described; at least 70 additional species expected.

Questionnaire completed by Andreas SCHMIDT-RHAESA (University of Bielefeld).

The Belgian nematomorph fauna was only once subject to an investigation. SCHUURMANS STEKHOVEN published a list of 12 species in 1943. Since then, no studies, publications or observations seem to be available. At least five additional species are expected. A representative collection, on which SCHUURMANS STEKHOVEN based his publication, is present in the Royal Belgian Institute of Natural Sciences. Three species, *Gordius heinzei*, *G. longareolatus* and *Gordionus divergens* are, until now, only known from Belgium. Small water bodies, including temporary ones, are essential for the survival of horsehair worms (SCHMIDT-RHAESA 1997).

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ACANTHOCEPHALA - SPINY-HEADED OR THORNY-HEADED WORMS

(HAAKWORMEN, STEKELSNUITWORMEN - ACANTHOCÉPHALES - HAKENWÜRMER)

Obligate intestinal parasites of vertebrates; larval development in intermediate arthropod host; body unsegmented, laterally flattened or cylindrical, usually gently curved; no mouth nor intestine (food uptake through tegument); from less than 2 mm up to 70 cm, most species shorter than 10 mm; ca. 1,150 species described, but it is likely that the majority of spiny-headed worm species are as yet unknown to science.

Questionnaire completed by Matthew WAYLAND (The Natural History Museum, London).

At least three species, *Acanthocephalus anguillae*, *A. lucii* and *Neoechinorhynchus rutili*, have been observed (VAN DAMME 1985, SCHABUSS *et al.* 1997). Based on data from the host-parasite database of The Natural History Museum and on GOLVAN (1994), at least nine other species will certainly occur and 13 additional ones can be expected. Representatives of most of the species observed and expected in Belgium are housed in the helminth collection of The Natural History Museum in London. Since the survival of these species is entirely dependent on the survival of their intermediate and definitive hosts, possible trends are directly linked to the status of the parasitised taxa. Aquatic habitats (both freshwater and marine) are especially important for the survival of spiny-headed worms occurring in Belgium, because the majority of them use aquatic intermediate hosts and many also have aquatic definitive hosts.

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ROTIFERA - ROTIFERS

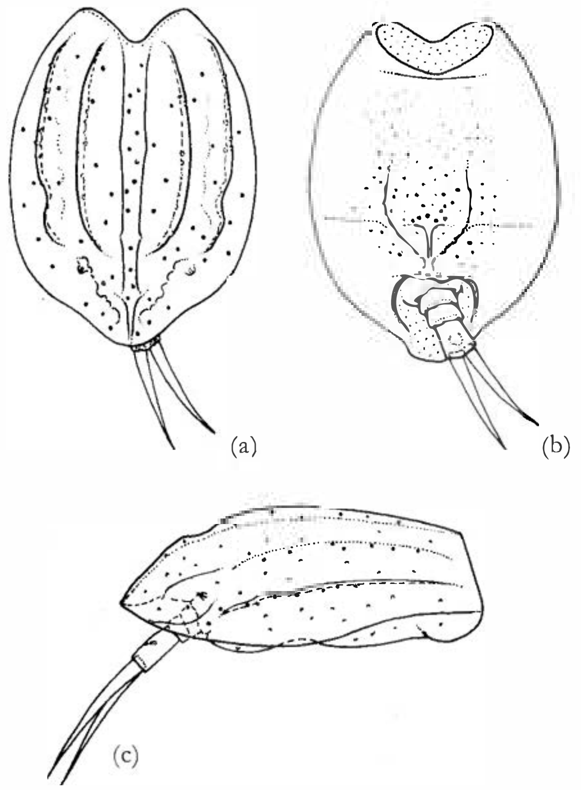
(RADERDIERTJES - ROTIFÈRES, PORTES-ROUES - RÄDERTIERE)

Transparent organisms with anterior ciliated corona and complex masticatory apparatus; size from 50 µm to 2 mm; occur in great numbers in freshwater lakes and ponds; few brackish or marine species; some inhabit soils or bryophytes, but need a film of moisture; mainly free-living predators, using the corona for locomotion; the few sessile ones attach by foot; some species are parasites of Oligochaeta; parthenogenetic reproduction (Bdelloidea) or with alternating parthenogenetic and sexual periods (Monogononta); since rotifers can tolerate adverse environmental conditions (for example drying or freezing), they can colonise temporary pools and polar regions; ca. 1,800 valid species are recognised but many more are expected.

Questionnaire completed by Hendrik SEGERS (Belgian Biodiversity Platform).

Some 300 species are recorded and many hundreds are expected (1,200 species are expected in the Netherlands). Partial species lists can be found in DE RIDDER (1989, 1991). Representative collections are housed in the Royal Belgian Institute of Natural Sciences and the universities of Ghent and Antwerp. For Europe, taxonomic knowledge of Rotifera is highest in Belgium and Germany.

The number of species is rising because of increasing research. Some five species were first described from Belgium and have not (yet) been observed in other countries. Since 1990, 43 new species for the Belgian fauna have been recorded, including several species new to science. If the factor 'increasing knowledge' is not considered, the number of species is probably decreasing because of acidification and manuring. Geographically, the species diversity is highest in Lower Belgium (incl. the Kempen), followed by, in decreasing order of richness, Upper Belgium with the Hautes Fagnes, the coastal area, the Belgian Lorraine and Middle Belgium with the Sonian Forest. The lowest species richness is found in the tidal zone. Concerning the ecological richness, most Belgian species occur in stagnant fresh water, followed by the interstitial environment (in fresh water as well as in brackish and marine waters), the terrestrial habitats and finally the non-interstitial marine zone. Dune pools are an example of a habitat with a crucial importance for the survival of some particular Belgian taxa (SEGERS 1998). An example of an introduced species is *Keratella* *americana*; the arrival of the non-indigenous species *Kellicottia bostoniensis* is expected. Occasional intruders during warm summers are *Brachionus variabilis* and *Keratella tropica*.



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(a) Dorsal, (b) ventral and (c) lateral view of *Lepadella deridderae*, a rotifer discovered in Belgium in 1996. The species was found in a temporary pond in an unmown, old-stabilised wet dip in the 'Westhoek' nature reserve, De Panne (from SEGERS *et al*. 1996, courtesy of the Royal Belgian Zoological Society).

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CYCLIOPHORA - CYCLIOPHORANS

(LIPKLEVERS - CYCLIOPHORES - CYCLIOPHOREN)

Phylum described in 1995, showing affinities to Rotifera; commensals or symbionts found on common and Norwegian lobsters among others in the North Sea; bilaterally symmetrical body with distinct head and trunk; mouth surrounded by a circle of cilia used in feeding; both sexual and asexual reproduction; adult stage ca. 350 µm long; so far, only three species are known worldwide.

Data provided by Reinhardt KRISTENSEN (University of Copenhagen).

So far, there has been no firm record of cycliophoran species, but *Symbion pandora* is expected to be present on Norwegian lobsters in Belgian marine waters and one more, still undescribed, *Symbion* sp. could occur. Representatives of this group have been collected off the coasts of Denmark, Sweden, the Faroe Islands, Italy and in the western part of the Atlantic Ocean.

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KINORHYNCHA - KINORHYNCHS or MUDDRAGONS

(SLURFWORMEN - KINORHYNQUES - HAKENRÜSSLER)

Small (about 1 to 5 mm long but most are shorter than 2 mm), spiny, segmented 'Pseudocoelia'; body flattened ventrally and domed dorsally; eversible head or introvert with scalids; separate sexes, presumably internal fertilisation; free-living, marine organisms in sediments from the intertidal to abyssal depths; some have been found in association with other invertebrates or aquatic plants; ca. 150 species described.

Questionnaires completed by Martin SORENSEN and Reinhardt KRISTENSEN (University of Copenhagen), and Birger NEUHAUS (Museum of Natural History, Berlin).

The only published record of kinorhynchs from the Belgian coast can be found in GREEFF (1869) who mentions five species found in the vicinity of Ostend and Nieuwpoort (HUYS & COOMANS 1989, with species list). Because of taxonomic uncertainty and the fact that some determinations were based on immature stages, it is unclear how many valid species have been observed. Consulted experts suspect that the real number of species found by GREEFF ranges from two to four. The occurrence of 15 to 20 additional species is expected.

A collection is present at the Royal Belgian Institute of Natural Sciences. Specimens of some kinorhynch representatives observed or expected in the Belgian marine waters are housed in the collections of the Smithsonian Institution (Washington). Taxonomic knowledge of this group is totally lacking. Several species of Kinorhyncha are definitely present in Belgian waters, but a thorough investigation has never been achieved.

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PRIAPULA - PRIAPULANS

(PRIAPULIDEN - PRIAPULIENS - RÜSSELWÜRMER)

Unsegmented marine worms showing a mixture of bilateral and radial symmetry; retractile introvert (= presoma) with scalids acts as a locomotion and feeding organ; separate sexes, hermaphroditic individuals rarely occur; fertilisation internal or external; free-living in marine littoral sediments worldwide; size ranges from 0,5 mm to 30 cm; 17 species known worldwide; the group reflects a long history: fossils similar to modern forms are common in the Cambrian Burgess Shale deposits of Canada (making them the so-called 'longest-existing living fossils' among Metazoa).

Questionnaire completed by Volker STORCH (University of Heidelberg).

So far, no records of Priapula exist. Based on the distribution in adjacent waters, one species, *Priapulus caudatus*, is almost certainly present in Belgian waters. Two other species, *Halicryptus spinulosus* and *Tubiluchus* sp. may also occur. Specimens of these species are present in the collection of the Smithsonian Institution (Washington). Undisturbed marine sediments (sand, soft bottom) are essential for the survival of priapulan species.

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GASTROTRICHA - GASTROTRICHS

(BUIKHAARWORMEN, GASTROTRICHEN - GASTROTRICHES - BAUCHHÄRLINGE)

Dorsoventrally flattened worms with two or more adhesive tubes; hermaphroditic or parthenogenetic reproduction; common in the benthic fauna of marine and freshwater habitats, living in sediments or among filaments of plants, some are planktonic; easily overlooked because average length is 0.5 mm (from 0.1 to 4 mm); locomotion by ventral cilia; ca. 450 living species described, many more to be expected.

Questionnaire completed by Philippe JOUK (Royal Zoological Society of Antwerp), with the contribution of William and Margaret HUMMON (Ohio University).

During a one-off investigation, part of a broad study of the meiofauna along the Belgian coast, 37 species were recorded (JOUK *et al.* 1992, with species list). Twenty species were observed in the eulittoral zone, 13 in the sublittoral zone and four occurred in both. Although only a few sites were investigated, the Belgian coast can be considered as one of the best known in the world for this group. For comparison, only 20 species are recorded from the coast of the Netherlands, where 150 species (in marine and freshwater systems) are expected. Taxonomic knowledge is considered to be moderate, but a Belgian expert able to identify organisms to the species level could not be found. Until now, no freshwater species are known from Belgium although ten or more are expected. In the Netherlands, seven freshwater species have been recorded so far.

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LORICIFERA - LORICIFERANS

Phylum described in 1983; bilateral, unsegmented, small (less than 400 µm) species with a body divided into a head, neck and thorax retractable into the abdomen; lorica of six cuticular plates covers abdomen; head houses an introvert with a ring of eight stylets surrounding its base, and a mouth at its apex; distributed worldwide in the marine interstitial environment; only 25 species have been described hitherto but at least 100 additional ones have been found and are waiting for description; hundreds of species are expected to be discovered in the deep sea.

Data provided by Reinhardt KRISTENSEN (University of Copenhagen).

To date, no Loricifera have been observed in the Belgian marine waters. Some six species are expected: *Nanaloricus mysticus* will almost surely be present, while *N. khaitatus*, *Rugiloricus caroliensis* and three new species, *Nanaloricus* sp.n., *Rugiloricus* sp.n. and *Pliciloricus* sp.n. should occur. Species of the genera *Rugiloricus* and *Pliciloricus* are often observed in habitats ranging from fine sands to mud, which are sediment types common in Belgian marine waters.

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ENTOPROCTA or KAMPTOZOA - ENTOPROCTS

(KELKWORMEN - ENTOPROCTES, KAMPTOZOAIRES - KELCHWÜRMER, KAMPTOZOEN)

Small (0.5-5 mm), sessile filter-feeders, many of which are colonial; the few solitary forms are often associated with sponges, bryozoans, polychaetes and sipunculids; visceral mass housed within a cup-shaped calyx on a supporting stalk; in colonial forms, the individuals or zooids are united, generally by a stolon; ring of tentacles used in feeding; almost all species are marine, one genus in fresh water; differ from the superficially resembling Ectoprocta among others by the position of the anal opening within the ring of tentacles; ca. 150 species described but a total number of up to 300 species is expected worldwide.

Questionnaire completed by Peter EMSCHERMANN (University of Freiburg).

Some ten species have been recorded (various publications), all of them are marine, with the exception of the freshwater species *Urnatella gracilis*. Up to ten additional species are expected. Taxonomic knowledge of this group is poor and no scientist able to identify organisms to the species level was found. Representative collections, holding the majority of the Entoprocta species observed and expected in Belgium, are housed in The Natural History Museum in London and the Zoological Museum in Copenhagen.

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ARACHNIDA - ARACHNIDS

(SPINACHTIGEN - ARACHNIDES - SPINNENTIERE)

Large and very diverse group of arthropods with body consisting of two parts: cephalothorax and abdomen; cephalothorax (fusion of head and thorax) bears six pairs of appendages: one pair of chelicerae, one pair of pedipalps and four pairs of legs; respiration via tracheae or book lungs, cutaneous in many small forms; includes the orders Amblypigi, Palpigradi, Ricinulei, Scorpiones, Solifugae, Uropygi, Araneae, Pseudoscorpiones, Opiliones and Acari, only the last four being indigenous in Belgium (several findings of introduced scorpions are recorded, LONEUX 2002).

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ARANEAE - SPIDERS

(SPINNEN - ARAIGNÉES - (WEB)SPINNEN, ARANEEN)

Major and worldwide distributed group of carnivorous and almost exclusively terrestrial arthropods with size ranging from 0.37 mm to over 110 mm; show great diversity of form and habitat; broad prosoma carrying cheliceral fangs with poison glands, used to paralyse prey; most species with eight eyes; prosoma attached to opisthosoma by a narrow pedicel; opisthosoma contains book lungs and/or tracheae, silk-producing glands and spinnerets; nearly 3,500 genera encompassing almost 40,000 described species.

Questionnaire completed by Léon BAERT (Royal Belgian Institute of Natural Sciences).

So far, 679 species of spiders have been recorded (BOSMANS & VANUYTVEN 2001, KEKENBOSCH *et al.* 1977, MAELFAIT *et al.* 1998, all three with species list), 254 of which belong to the family Linyphiidae (sheet-web weavers). Taxonomic knowledge of this group in Belgium is very good and a representative collection is housed in the Royal Belgian Institute of Natural Sciences. Since 1955, the species number has increased with 270 species (= 30%) thanks to the intensification of sampling and inventories. The region with the highest number of species is the Lorraine, followed by Upper Belgium, Lower Belgium, the coastal zone and the Hautes Fagnes.

Destruction and desiccation of habitats are the most important threats for spider species in Belgium. At present, only about half of the species recorded in Belgium is safe or at low risk. In Flanders, spider biodiversity is most heavily threatened in oligotrophic grasslands, deciduous forests, heathland and various wetland habitats. These are the habitat types prior attention should be directed to by nature conservation policy makers (MAELFAIT *et al.* 1998). Four species of the family Pholcidae have been recorded as alien species, two of which (*Holocnemus pluchei* and *Crossopriza lyoni*) established viable populations in the proximity of the port of Antwerp (VAN KEER & VAN KEER 2001).

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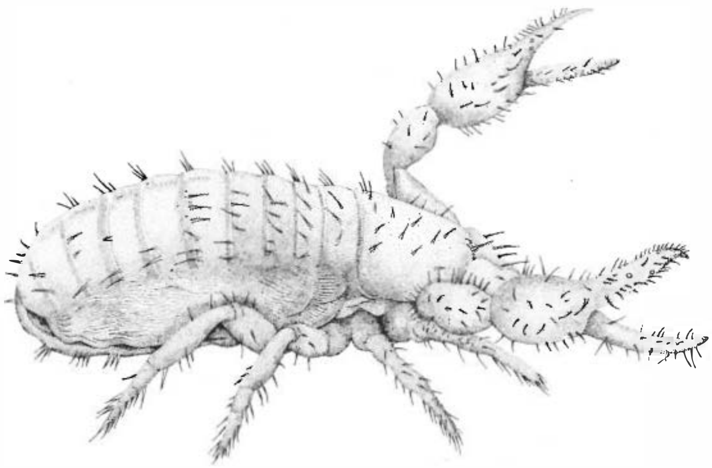

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In 1995, the pseudoscorpion *Microbisium brevifemoratum* (ELLINGSEN, 1903) was found for the first time in Belgium (nature reserve 'De Liereman', Province of Antwerp). The species lives in wet, acid biotopes with *Sphagnum* and occurs in North and Central Europe. Length: ca. 2 mm (drawing by H. VAN PAESSCHEN, based on photographs by H. HENDERICKX).

PSEUDOSCORPIONES - FALSE SCORPIONS or PSEUDOSCORPIONS

(PSEUDOSCHORPIOENEN, BASTAARDSCHORPIOENEN - PSEUDOSCORPIONS, FAUX-SCORPIONS - PSEUDOSKORPIONE, AFTERSKORPIONE)

Small (1 to 5 mm long) arachnids with greatly enlarged and chelate pedipalps giving them a superficial appearance of a true scorpion deprived of the post-abdomen and sting; occurring in leaf litter and under bark on all continents, predating on other small animals; some 434 genera encompassing over 3,000 described species worldwide, but far more species are expected.

Questionnaire completed by Hans HENDERICKX (independent researcher, Mol).

Twenty-two species are listed in HENDERICKX (1999). Two additional species for Belgium have been discovered since then: *Chernes hahni* (HENDERICKX & VETS 1999) and *Neobisium sylvaticum* (HENDERICKX, in press). Up to 5 additional species are expected, based on the observed fauna in neighbouring countries. Taxonomic knowledge of this group in Belgium is considered to be moderate. The joint collection of HENDERICKX and VETS forms a representative collection of species occurring in Belgium. Some pseudoscorpions occur as symbionts: *Lasiochernes pilosus* with the mole (*Talpa europaea*) and *Chernes vicinus* with the ant *Lasius fuliginosus*. Bird nests in hollow trees, dead and overmature trees in ancient woodland and *Sphagnum* moors are essential habitats for the Belgian pseudoscorpion fauna.

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OPILIONES - HARVESTMEN or OPILIONIDS

(HOOIWAGENS - FAUCHEURS - WEBERKNECHTE)

Arachnids characterised by long legs with multi-jointed, flexible tarsi, making them agile climbers and fast runners; compared to the Araneae, prosoma and opisthosoma are broadly joined; bulbous body shape; prosomal carapace protrudes as a tubercle, with one eye on each side; living in tropical to temperate areas worldwide, in vegetation, leaf litter and caves; body size ranges between 5 and 10 mm; feeding on small prey; ca. 650 genera and 2,400 species described worldwide; a total of 3,500 to 5,000 species is expected.

Questionnaire completed by Luc VANHERCKE (independent expert, Ghent).

Twenty-six species have been recorded, 19 of which belong to the family Phalangiidae (daddy long-leg spiders). At least four additional species are expected. A species list, together with other data on the Belgian opilionid fauna, is available on http://www.elve.net/opilio. This group is considered to be taxonomically well known in Belgium. A representative collection is housed in the Royal Belgian Institute of Natural Sciences. Regarding the habitats, caves and trees were not or poorly studied until now and future campaigns should have special attention for them.

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ACARI - MITES and TICKS

(MIJTEN en TEKEN - ACARIENS - MILBEN, ACARIDEN)

Diverse assemblage of small arachnids characterised by the mouth region consisting of cheliceral and pedipalpal segments, movable and terminal (gnathosoma), and by having lost external signs of segmentation with few exceptions; mites are usually less than 1 mm long, while ticks are generally much larger; all ticks are parasitic throughout their life cycle, feeding on the blood of reptiles, birds or mammals; like ticks, many mites parasitise terrestrial vertebrates, but they also parasitise invertebrates, while some prey on invertebrates or feed on plants, mushrooms, bacteria, algae or decomposing organic matter; ca. 30,000 species are described worldwide, while a total of 500,000 species is expected.

Questionnaire completed by Georges WAUTHY, with the contribution of Alexander FAIN (both Royal Belgian Institute of Natural Sciences). Additional information from Philippe LEBRUN (Catholic University of Louvain).

Some 970 species have been observed: 175 parasitic species subdivided in 75 species, of which 15 ticks (FAIN 1990), parasitising vertebrates, and 100 species parasitising invertebrates (COOREMAN 1963, FAIN *et al.* 1995); ca. 550 species living in the soil (ANDRÉ *et al.* 2002, LEBRUN *et al.* 1989, WAUTHY 1994); ca. 120 species occurring on trees and rocks (ANDRÉ 1986); ca. 30 cavernicolous species (pers. comm. X. DUCARME); 34 species occurring in houses (pers. comm. D. GRIDELET-DE SAINT-GEORGES); ca. 50 species living in food and agricultural products (pers. comm. D. GRIDELET-DE SAINT-GEORGES) and ca. 15 aquatic species (DEWEZ & WAUTHY 1981). Up to 250 additional species, ca. 100 parasitic ones, 100 occurring in soils and 50 living in food and agricultural products, are expected.

Taxonomic knowledge of this group in Belgium is considered to be moderate to good but information on trends is not available. Major collections are present in the Royal Belgian Institute of Natural Sciences. The FAIN collection, among others including a representative tick collection for the Belgian fauna, focuses mainly on parasitic species and contains ca. 3,000 holotypes and paratypes. Free-living species are mainly kept in the COOREMAN and LIONS collections, among others containing around 20 holotypes. Other smaller collections exist and contain altogether some ten holotypes.

Geographically, the highest species diversity is found in Upper Belgium (with the Hautes Fagnes) followed by, in decreasing order of species richness, the Lorraine region, Middle Belgium (with the Sonian Forest), Lower Belgium and finally the coastal, tidal and marine zones (LEBRUN *et al.* 1989). More than half of the recorded species is present as free-living organisms in terrestrial habitats. Other species occur as parasites of vertebrates, as commensals of birds or are present in the aquatic environment. Up to 150 different species and 100,000 individuals can be found on 1 m^2 of soil organic layer in deciduous forests (LEBRUN 1971).

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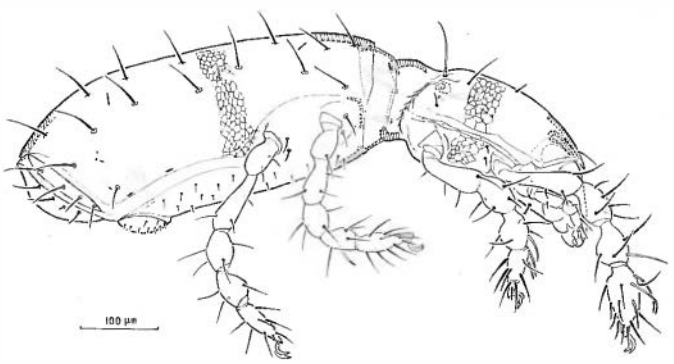

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Adult female of *Eulohmannia ribagai* BERLESE, 1910. This is an example of a hypogeic oribatid mite occurring in Belgium and featuring a remarkable articular zone between the anterior and posterior parts of the body. This articulation enhances the agility of the species to move through slits and pores. Surface reticulation shown at two places (from LEBRUN & WAUTHY 1981).

PYCNOGONIDA - SEA SPIDERS

(ZEESPINNEN - PYCNOGONIDÉS - ASSELSPINNEN, SEESPINNEN)

As their names Pycnogonida or Pantopoda suggest, legs are their dominant feature: most of the species have four pairs of long legs, though some have five or six pairs; the males of some species have an extra pair of legs to collect and brood the eggs; most pycnogonids are small, only a few mm, while some species are much larger and gigantism occur; common in all oceans, especially cold ones; ca. 1,000 described species worldwide; feeding on the soft parts of sponges, hydroids, soft corals, anemones, ectoprocts and clams.

Questionnaire completed by Ann DEWICKE and Bregje BEYST (Ghent University).

Fourteen species have been recorded. GILTAY (1928) suggested 12 species for Belgium, based on the pycnogonid specimens present in the collection of the Royal Belgian Institute of Natural Sciences. Since then, new field information on the species in Belgian waters was lacking, and only the presence of *Pycnogonum littorale* was noted in some publications. Since 1993, intensive sampling has been performed by researchers from the Ghent University. As a result, ten of the 12 species suggested by GILTAY were found again and two new species for the Belgian fauna were discovered. Despite this, taxonomic knowledge of this group in Belgium is poor. Representative collections are present at the Ghent University and the Royal Belgian Institute of Natural Sciences.

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HEXAPODA - HEXAPODS

(ZESPOTIGEN - HEXAPODES - SECHSFÜßER)

Arthropods with body consisting of three parts: head (six segments), thorax (three segments) and abdomen (max. 12 segments); head usually with eyes, antennae, mandibula and maxillae; thorax with three pairs of legs; subdivided in Apterygota (wingless forms, Ametabola: have no metamorphosis) and Pterygota or Insecta (winged forms, Eumetabola: with metamorphosis).

APTERYGOTA - PRIMITIVE WINGLESS HEXAPODS or APTERYGOTES

(ONGEVLEUGELDE ZESPOTIGEN, OERINSECTEN - APTERYGOTES - URINSEKTEN, FLÜGELLOSE SECHSFÜßER)

Wingless hexapods without metamorphosis (Ametabola); include the Protura, Diplura, Collembola and Thysanura.

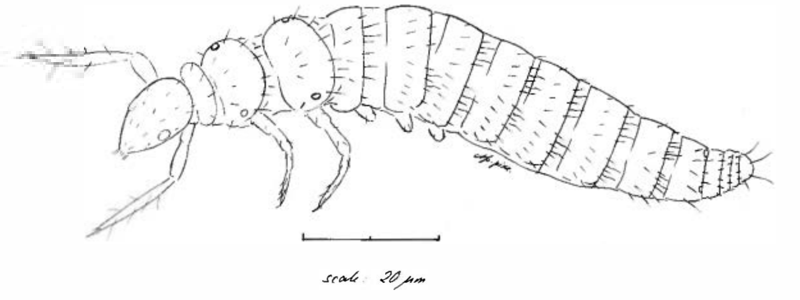
PROTURA - PROTURANS

(PROTUREN - PROTURES, PROTOURES - BEINTASTLER, PROTUREN)

Small (0.5 to 2.5 mm long), entognathous hexapods which inhabit soil and leaf litter in all parts of the world, preferring moist organic soils; not discovered until 1907; no eyes, no or very reduced antennae, no cerci, three pairs of thoracic limbs and limb-like abdominal appendages; more than 660 species described worldwide, but this would only be about 10% of the total number of Protura species.

Questionnaire completed by Andrzej SZEPTYCKI (Institute of Systematics and Evolution of Animals, Poland).

Five species have been recorded (LERUTH 1939, with species list) while 40 to 50 species are expected based on observations in neighbouring countries, mainly the Grand Duchy of Luxembourg, where 32 species were recorded and some more are expected (SZEPTYCKI *et al.* 2002). Other features observed in adjacent areas are the co-existing of up to eight different species within 1 dm^3 of soil and the occurrence of 5,000 to 140,000 individuals of the same species on a surface of 1 m^2. Taxonomic knowledge of this terrestrial group is very poor and no Belgian expert, nor a representative collection, could be identified. A thorough investigation of soil habitats, with exception of extremely wet as well as intensely cultivated soils, is needed for a better knowledge of this group in Belgium.



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Eosentomon sp. collected in the Grand Duchy of Luxembourg. A recent study of the Protura fauna of this neighbouring country revealed among others five new *Eosentomon* spp. (drawing by A. SZEPTYCKI).

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DIPLURA - DIPLURANS

(TWEESTAARTEN - DIPLOURES - DOPPELSCHWÄNZE, DIPLUREN)

Small to medium sized, mostly white, entognathous hexapods inhabiting soil and leaf litter and occurring all over the world; no eyes; possessing many segmented antennae, an abdomen with styles and exsertile vesicles, and variably formed, paired cerci; ca. 800 species known worldwide.

Questionnaire completed by Bruno CONDÉ (University Henri Poincaré, Nancy).

Two or three species have been observed (LERUTH 1939, CONDÉ 1956) while a number of seven to ten species is expected, mainly based on observations in France where taxonomic knowledge of this group is good. For Belgium and other neighbouring countries, this knowledge is very poor and no Belgian expert, nor a representative collection, could be identified. A thorough and sustained investigation of caves and soils is needed.

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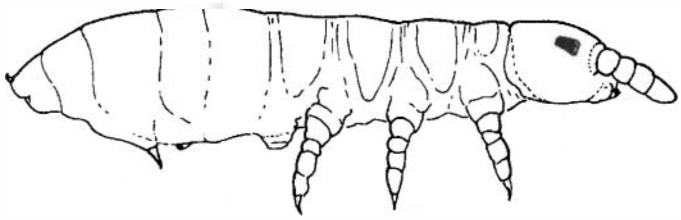
COLLEMBOLA - SPRINGTAILS or COLLEMBOLANS

(SPRINGSTAARTEN - COLLEMBOLES - SPRINGSCHWÄNZE)

Small to minute entognathous hexapods common in leaf litter and other humid microclimates; occurring all over the world, even in the deserts of Australia and on Antarctica (able to survive temperatures below – 60°C); eyes occur as simple ocelli or are absent; possessing a ventral tube enabling the absorption of moisture and a furca which is a forked, springing organ; springtails have been around for at least 400 million years; most species feed on fungi, bacteria, algae or various plant material, some are carnivorous on nematodes or other collembolans; more than 6,000 species described worldwide, and some experts estimate a real species number of 50,000.

Questionnaire completed by Wim JACOBS, Frans JANSSENS (both RUCA, University of Antwerp) and Luc DE BRUYN (Institute of Nature Conservation).

So far, 130 species have been observed (http://wcc.ruca.ua.ac.be/Evolutionary-Biology/coll, with partial species list). Some 120 additional species are expected mainly relying on the Collembola fauna observed in the Netherlands. Taxonomic knowledge of this group in Belgium is moderate and a representative collection is housed in the University of Antwerp (RUCA), while another collection is managed by the Royal Entomological Society of Antwerp. Caves are identified as crucial habitats for the survival of various populations and species of Collembola in Belgium.



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The xerophyl springtail *Xenylla maritima* (TULLBERG, 1869) was observed for the first time in Belgium in 2002. It shows a marked preference for dunes, and occurs also on tree trunks or in the litter of coniferous trees. Length: 1.4 mm (from FJELLBERG 1998, published by Brill, Leiden).

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THYSANURA - SILVERFISH and FIREBRATS

(ZILVERVISJES - THYSANOURES - BORSTENSCHWÄNZE)

Hexapods with ectognathous mouth parts and reduced compound eyes; antennae consisting of 30 or more segments; the abdomen ends in three caudal filaments: two cerci and a telson; occur in leaf litter or under bark or stones, mostly feeding on plant and fungal material; some species are found in houses; ca. 250 species worldwide.

Questionnaire completed by Koen LOCK (Ghent University). Additional information from Frans JANSSENS (RUCA, University of Antwerp) and Peter DE BATIST (Royal Entomological Society of Antwerp).

Five species, of which two cavernicolous (TERCAFS 1960), are listed in LOCK (2001) and RAPPÉ (1989). *Lepisma saccharina* was introduced before 1900. One or two additional species are expected based on their occurrence in neighbouring countries. Taxonomic knowledge of this group in Belgium is moderate and one expert was identified. A representative collection is housed in the Royal Belgian Institute of Natural Sciences. The highest diversity is found in the Belgian Lorraine, followed by Upper Belgium, the Hautes Fagnes and Middle Belgium, while the western part of the country shows a lower diversity.

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INSECTA (PTERYGOTA) - INSECTS (PTERYGOTES)

(INSECTEN - INSECTES - INSEKTEN)

Hexapods usually having two pairs of wings, one on the second and one on the third thoracic segment; subdivided in Exopterygota (Hemimetabola) and Endopterygota (Holometabola); in the Exopterygota, the wings develop outside the body and there is an incomplete metamorphosis without a pupal stage; in the Endopterygota, the wings develop inside the body and the metamorphosis to adult form is elaborate, involving a pupal stage; with around one million described species, and a multiple of this number still to be discovered, insects are by far the most species-rich, and evolutionary the most successful, faunal group on earth.

EPHEMEROPTERA - MAYFLIES

(EENDAGSVLIEGEN, HAFTEN - ÉPHÉMÉROPTÈRES, ÉPHÉMÈRES - EINTAGSFLIEGEN, HAFTE)

Common exopterygotes found in almost all freshwater habitats, as well as in some brackish ones; aquatic larval stage; most subadult and adult mayflies have two pairs of wings, the second pair being considerably smaller than the first one; wings can not be folded; only insect order having a subimago (last non-adult life stage) with wings; possessing two long cerci and usually a long median caudal filament at the end of the abdomen; in many species, adults live only for one or two days, while in others the adult life span may be as short as two hours or as long as 14 days; mayflies date from the Carboniferous and Permian times and are the oldest of the extant winged insects; ca. 2,100 described species worldwide.

Questionnaire completed by Hendrik GYSELS (Ghent University).

In STROOT & MOL (1989), 65 species are listed. This high number is possibly a slight overestimation of the real species number because of uncertainties of nomenclature and systematics. Based on the Ephemeroptera fauna observed in the Netherlands (MOL 1985a, 1985b), some species not mentioned in STROOT & MOL (1989) are expected. Taxonomic knowledge of this group in Belgium is moderate and a representative collection is managed by the Royal Belgian Institute of Natural Sciences. Another collection of importance is housed in the Zoological Laboratory of the University of Utrecht. Because of habitat destruction, drying out of the land, acidification, manuring and pollution, at least ten species are expected to disappear from Belgium in the next decades if present trends are maintained. The highest species richness is found in Upper Belgium, followed by the Belgian Lorraine, the Hautes Fagnes, and Lower and Middle Belgium. Oxygen-rich, unpolluted freshwater habitats are of paramount importance for the survival of most Ephemeroptera species.

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ODONATA - DRAGONFLIES and DAMSELFLIES

(LIBELLEN en WATERJUFFERS - LIBELLULES - LIBELLEN)

Relatively large exopterygotes with transparent, many-veined wings, massive compound eyes and biting mouth parts; wings can not be folded; highest diversity in tropical and subtropical regions; aquatic larval stage; adults and larvae are aggressive carnivores preying mostly on other insects; very ancient order of insects: fossil record dates back to more than 300 million years; fossil record shows that Odonata or their relatives are the largest flying insects; one species, *Meganeura monyi*, had a wingspan up to 75 cm; ca. 5,300 species described worldwide, while a real species number of 10,000 is expected.

Questionnaires completed by Geert DE KNIJF (Institute of Nature Conservation), Henri DUMONT (Ghent University) and Philippe GOFFART (Catholic University of Louvain).

So far, 69 species have been observed (MICHIELS *et al.* 1986, DE KNIJF & ANSELIN 1996, http://www.gomphus.be) and one additional species is expected (BOS & WASSCHER 1997). With 20 to 30 Belgian Odonata experts and more than 250 collaborators, the taxonomy and distribution of this group in Belgium are very well known. A representative collection is housed in the Royal Belgian Institute of Natural Sciences. Smaller collections can be found at the Centre de Recherche de la Nature, des Forêts et du Bois (Gembloux) and in most universities. The highest diversity is found in the north-eastern part of Belgium, followed by the Belgian Lorraine (DE KNIJF & ANSELIN 2001, DE KNIJF *et al.* 2002). The number of species remains approximately the same, but the number of populations is decreasing for some species and increasing for others.

Most important threats for the Belgian Odonata fauna are the destruction of habitats, water pollution, acidification and manuring. If present trends are maintained, one or two species could disappear from Belgium in the next decade, and two additional ones during the following ten years. A red list for Flanders (DE KNIJF & ANSELIN 1996) indicates the disappearance of seven species. The red list status and other useful data of Odonata species occurring in the Walloon

Region can be consulted at http://mrw.wallonie.be/cgi/dgrne/sibw/sibw.esp.list2.pl?VAR=Libellules.

Up to 48 different species can be found within one UTM area of 5 km by 5 km (DE KNIJF *et al.* 2002). Crucial habitats for the conservation of Odonata species are, in decreasing order of importance: (1) mesotrophic and natural eutrophic ponds, peat bogs and marshes, (2) oligotrophic peat moors and fens, and (3) oxygen-rich running waters (DE KNIJF & ANSELIN 1996). Some Mediterranean species are observed on a more or less frequent basis, but none of these are considered as established alien species (yet).

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PLECOPTERA - STONEFLIES

(STEENVLIEGEN - PLÉCOPTÈRES - STEINFLIEGEN)

Ancient order (known since the Permian) of small to medium-sized exopterygotes with weak (biting) mouth parts and generally two long, threadlike cerci; aquatic larvae mostly living in cooler waters, used as indicators of water quality because of their sensitivity to pollution; many species with restricted distribution; adults have large foldable wings or reduced wings; ca. 2,000 described species worldwide.

Questionnaire completed by Thierry VERCAUTEREN (Provincial Institute for Hygiene, Antwerp).

Following AUBERT (1956, 1957, both with species list), 48 species (of which 16 belong to the Nemouridae) have been observed frequently or sporadically. Some ten additional species are to be found (AUBERT 1956). This group is considered to be taxonomically well known in Belgium, but a recent synoptical publication for Belgium and adjacent areas is not available. Consequently, identifications are often based on incomplete and somewhat older keys. Furthermore, although stoneflies (mainly the larvae) are regularly collected in the frame of water quality assessment, identifications at the species level are rarely performed (not needed for biotic index) or are seldom published if achieved. A collection is housed in the Royal Belgian Institute of Natural Sciences. Factors endangering stonefly populations are pollution, habitat destruction, acidification and eutrophication. The highest Plecoptera diversity is found in Upper Belgium, followed by Middle Belgium (with the Sonian Forest) and the Hautes Fagnes, the Belgian Lorraine, and Lower Belgium with the Kempen (AUBERT 1956).

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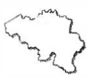
BLATTODEA - COCKROACHES

(KAKKERLAKKEN - BLATTES, CAFARDS - SCHABEN(ARTIGE), KAKERLAKEN)

Dorsoventrally flattened, omnivorous exopterygotes with somewhat hardened forewings and expansive hindwings; wings often reduced or absent; eggs are deposited or carried in ootheca; most cockroaches have a tropical habitat; many Blattodea are forest floor species though some are cave dwellers, semi-aquatic, burrowing, wood boring or even housing in the nests of social insects; some cosmopolitan pest species are associated with human habitations; present for at least 250 million years and it is thought that in the late Carboniferous, cockroaches, in terms of numbers of individuals, outnumbered all other flying insects; ca. 3,500 species worldwide, of which less than 1% have a pest status.

Questionnaire completed by Hendrik DEVRIESE (scientific associate, Royal Belgian Institute of Natural Sciences).



Based on DEVRIESE (1991) and KRUSEMAN (1979), both with species list, four indigenous species have been recorded. No additional ones are expected. Furthermore, four introduced species established viable populations in homes and warehouses. This terrestrial group is taxonomically well known in Belgium and representative collections are housed in the Royal Belgian Institute of Natural Sciences and the Gembloux Agricultural University. The increasing number of introduced individuals is due to the intensification of trade and transport. The highest diversity is found in Middle Belgium with the Sonian Forest, followed by Upper and Lower Belgium (with the Kempen) and the Belgian Lorraine. The coastal area and Hautes Fagnes show a lower diversity (DEVRIESE 1991, GOETGHEBUER 1953).

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MANTODEA - MANTIDS

(BIDSPRINKHANEN - MANTES - FANGSCHRECKEN)

Raptorially predatory, mostly medium-sized exopterygotes with very mobile head and large compound eyes; occurring throughout the tropics and in many sunny temperate zones; eggs are deposited in large, foamy ootheca; all species are carnivorous and prey on insects and spiders; powerful forelegs and jaws to catch and eat their prey; in some species, the female eat the male during copulation; about 2,000 described species worldwide.

Information provided by Hendrik DEVRIESE (scientific associate, Royal Belgian Institute of Natural Sciences), Jean-Yves BAUGNÉE (Observatory of Fauna, Flora and Habitats) and Jean-Paul JACOB (Centre de Recherche de la Nature, des Forêts et du Bois, Gembloux).

One species, *Mantis religiosa*, is known from the southernmost part of the Province of Luxembourg [mainly Torgny (Rouvroy) - natural reserve 'Raymond Mayné', and surrounding area]. The most recent published observation seems to go back to 1968 (PARENT 1976). The species is protected in the Walloon Region (AERW of 9 July 1987) and is listed in annex IIb (species placed under strict protection) of the Walloon Decree of 6 December 2001 in relation to the conservation of Natura 2000 sites as well as the faunal and floral wildlife. The present status of *M. religiosa* in Belgium is uncertain.

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ORTHOPTERA - GRASSHOPPERS, LOCUSTS and CRICKETS

(SPRINKHANEN en KREKELS, RECHTVLEUGELIGEN - CRIQUETS, SAUTERELLES et GRILLONS ou ORTHOPTÈRES - HEUSCHRECKEN)

Relatively large, mostly plant-feeding exopterygotes with hardened forewings, hind legs usually modified as jumping legs and powerful biting mouth parts; males can produce sounds via forewings or through interaction of forewings and hind legs; wings are sometimes reduced; some species are parthenogenetic; ca. 20,000 species known worldwide, many more to be discovered.

Questionnaire completed by Hendrik DEVRIESE (scientific associate, Royal Belgian Institute of Natural Sciences).

So far, 51 species have been registered in Belgium: 18 Tettigonioidea, 5 Grylloidea, 5 Tetrigoidea and 23 Acridoidea (DECLEER *et al.* 2000, with species enumeration and preliminary red list). Five species have not been observed anymore since 1960. Some five additional species are expected (KLEUKERS *et al.* 1997). This group is taxonomically well known in Belgium and there are a lot of experts able to identify specimens to the species level. A representative collection can be found in the Royal Belgian Institute of Natural Sciences. Another collection is housed in the Gembloux Agricultural University. The highest species diversity is found in Upper Belgium (excl. the Hautes Fagnes), followed by, in decreasing order of diversity, the Belgian Lorraine, Lower Belgium with the Kempen, Middle Belgium with the Sonian Forest, the coastal area and the Hautes Fagnes (DECLEER *et al.* 2000). If present tendencies persist, three to five species of Orthoptera will disappear from Belgium because of habitat destruction, drying out of the land, acidification and manuring (DECLEER *et al.* 2000).

Important habitats for the preservation of Orthoptera species are dry and wet grasslands, dunes, rocks and peat areas (KLEUKERS *et al.* 1997, MARSHALL & HAES 1988, INGRISCH & KÖHLER 1998). On a population level, up to 15 species per ha and more than 40 individuals per m^2 can be found (INGRISCH & KÖHLER 1998). Taking 1900 as reference, five species have been introduced: *Acheta domesticus* (house cricket, introduced more than two centuries ago), *Tachycines asynamorus* (greenhouse camel-cricket), *Meconema meridionale* (southern oak bush-cricket, imported specimens are able to establish viable populations in urban environments), *Anacridium aegyptium* (Egyptian grasshopper) and *Gryllomorpha dalmatina*.

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DERMAPTERA - EARWIGS

(OORWORMEN - PERCE-OREILLES, DERMAPTÈRES - OHRWÜRMER)

Oblong exopterygotes with biting and chewing mouth parts as well as shortened and hardened forewings; hindwings semicircular, often reduced; abdomen carries cerci as terminal forceps, used among others in self defence and capturing of prey; females exhibit maternal care in relation to eggs and early instar nymphs; earwigs are omnivorous, feeding on dead plant material and dead or slow invertebrates; very few species are commensals or ectoparasites of mammals; ca. 1,900 described species worldwide.

Questionnaire completed by Hendrik DEVRIESE (scientific associate, Royal Belgian Institute of Natural Sciences).

Four species have been observed (DE SELYS-LONGCHAMPS 1888, with species list). One additional species is expected (ALBOUY & CAUSSANEL 1990). This group is taxonomically well known although a synoptical overview of recent observations does not exist. A representative collection is housed in the Royal Belgian Institute of Natural Sciences. Upper (excl. the Hautes Fagnes) and Middle Belgium show the highest diversity, followed by Lower Belgium, the Hautes Fagnes, the Belgian Lorraine and the coastal area (DE SELYS-LONGCHAMPS 1888).

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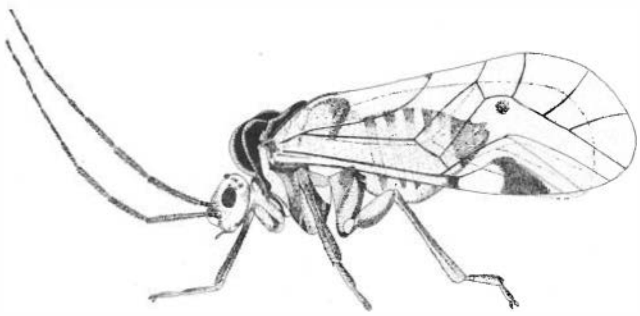
PSOCOPTERA - BOOK- and BARKLICE or PSOCIDS

(HOUTLUIZEN, STOFLUIZEN, BOEKLUIZEN - PSOCOPTÈRES, PSOQUES - STAUBLÄUSE, RINDENLÄUSE)

Small (0.5 to 5 mm) exopterygotes with asymmetrical, biting mouth parts; some possess delicate membranous wings, others are wingless; some species live in man-made constructions and can be pests of stored products like books, museum specimens, etc., though the majority live on trees; fossil record goes back to the Permian; 3,000 (most sources) to 4,000 described species worldwide.

Questionnaire completed by Nico SCHNEIDER (scientific associate, Luxembourg National Museum of Natural History).

Seventy-three species have been observed (LIENHARD 1998, with species list). Some nine additional species are expected based on LIENHARD (1998) and the presence of some of these species in the Grand Duchy of Luxembourg. Although this group is taxonomically well known in Belgium, no expert able to identify organisms to the species level was found in our country. A major collection is present at the Royal Belgian Institute of Natural Sciences. Another collection is housed in the Gembloux Agricultural University. Because of increased fieldwork, the species number augmented significantly from 40 species in 1926 (BALL), over 63 in 1979 (SCHNEIDER) to reach the actual number of 73. If the factor 'increase of the faunal knowledge' is not considered, the species number stays about the same. Although data concerning the geographical species richness are not available,



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Amphigerontia contaminata (STEPHENS, 1836), a hygrophilous psocid occurring abundantly on the bark of deciduous trees and conifers. Length: 3-4 mm (drawing by N. SCHNEIDER).

Upper and Middle Belgium are expected to show the highest Psocoptera diversity. At least three species have been introduced since 1900: *Psoquilla marginepunctata*, *Dorypteryx domestica* and *D. longipennis*.

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ANOPLURA - SUCKING LICE

(ZUIGENDE LUIZEN - ANOPLOURES, POUX VRAIS ou SUCEURS - ECHTE LÄUSE, SÄUGENDE LÄUSE)

Dorsoventrally flattened, ectoparasitic exopterygotes sucking blood of mammals and possessing short stout legs ending in a single large curved claw; wingless; generally blind although some possess photosensitive areas; sucking lice are extremely host specific with a particular lice species being found on only one host species; lifespan and development time are related to temperature and humidity; ca. 400 species described worldwide.

Questionnaire completed by Roland LIBOIS (University of Liège).

Fifteen species have been observed in Belgium (COOREMAN 1952, VAN DEN BROEK 1977), while about 13 more are expected based on the Anoplura fauna in neighbouring countries and the presence of their host species in Belgium. Taxonomic knowledge of this group in Belgium is poor. A collection is housed in the Royal Belgian Institute of Natural Sciences. At the population level, one or two Anoplura species and more than 100 specimens can occur per host individual.

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'MALLOPHAGA - CHEWING or BITING LICE'

(BIJTENDE LUIZEN - MALLOPHAGES, POUX BROYEURS - LÄUSLINGE, BEISSLÄUSE)

The term 'Mallophaga' is considered to have no taxonomic value, but is still used for descriptive purposes when referring collectively to the Amblycera, Ischnocera and Rhyncophthirina. Dorsoventrally flattened, wingless ectoparasites of mainly birds and some mammal species; biting mouth parts; reduced or no eyes; most species feed on fragments of hair and feathers, some on blood; some species have a symbiotic relationship with bacteria; highly host specific; 4,300 species and subspecies described worldwide.

Information provided by Ronald HELLENTHAL (University of Notre Dame, Indiana), Roger PRICE (University of Minnesota) and Ricardo PALMA (Museum of New Zealand). Additional collection information.

Based on the 'Mallophaga' collection assembled by J. COOREMAN and integrated in the entomological collection of the Royal Belgian Institute of Natural Sciences, a preliminary list with 124 species was compiled for Belgium. Via host-parasite associations using the Belgian list of mammal and bird species, it was found that not less than 873 species and 23 subspecies of chewing lice could occur in Belgium. A document containing the list of expected chewing lice species in Belgium (associated with their host species) is available at the CBD-National Focal Point, RBINS. Although this high number is maybe an over-estimation of the real number, because of the used deduction method and in comparison with the 425 'Mallophaga' species in the United Kingdom (SIMS *et al.* 1988), it illustrates the diversity of this very poorly known faunal group. Chewing lice are expected to parasitise about 26% of the mammal species and 74% of the bird species in our country.

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HETEROPTERA - TRUE BUGS

(WANTSEN - HÉTÉROPTÈRES, PUNAISES - WANZEN)

Often flattened exopterygotes with elongated, piercing-sucking mouth parts; at rest, wings lie flat over the abdomen; forewing often subdivided into thickened, coriaceous basal and membranous distal region; true bugs are adapted to a broad range of habitats and include terrestrial, freshwater and marine groups; feeding on plant or animal material; some species are blood sucking disease vectors; ca. 62,000 species described worldwide.

Questionnaire completed by Michel DETHIER (Gembloux Agricultural University). Additional information provided by Jean-Yves BAUGNÉE (Observatory of the Fauna, Flora and Habitats).

To date, 620 species are known from Belgium (BAUGNÉE *et al.*, in prep.) and some 30 additional ones are expected. Since BOSMANS & MERCKEN (1989), the species number has increased by 97 species. Heteroptera are relatively well known in Belgium but a complete cartography is only developed for the aquatic species. This led to the first red list ever on invertebrates in Flanders (BOSMANS 1994, with additions on cd-rom, see BONTE *et al.* 2001). Five to ten Belgian experts are able to identify specimens to the species level. Representative collections for the Belgian fauna are housed in the Royal Belgian Institute of Natural Sciences and the Gembloux Agricultural University. Other (smaller) collections have been developed by experts or within universities.

The terrestrial environment shows the highest species richness, followed by stagnant and running freshwater habitats. Most important threats for the true bugs are the destruction and fragmentation of habitats and the drying out of the land. The highest species richness is found in the Belgian Lorraine, the Fagne-Famenne Calestienne, the Meuse valley and the

Kempen. Habitats with an essential importance for the preservation of Heteroptera species are dry grasslands, mowed fields, wet pastures with pools, fallow lands, dunes, heathlands, etc.

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AUCHENORRHYNCHA - HOPPERS and CICADAS

(CICADEN - AUCHÉNORRHYNQUES, CIGALES - ZIKADEN)

Exopterygotes with elongated, piercing-sucking mouth parts and often entirely hardened forewings; at rest, wings are held over the body like a tent; most species possess capacity to jump; larvae sometimes occur in a foamy substance or in the soil; feeding on plant material; ca. 35,000 species described worldwide but a real species number of 100,000 is expected (some authors even mention 1,000,000).

Questionnaires completed by Jean-Yves Baugnée (Observatory of the Fauna, Flora and Habitats) and Jan Van Stalle (scientific associate, Royal Belgian Institute of Natural Sciences).

At present, 393 species are known in Belgium, while the occurrence of 15 other species is considered to be doubtful (Van Stalle 1989; Baugnée, in prep.). This species number means an increase of more than 150 species in comparison with the species total published in 1951 (SYNAVE 1951a, 1951b). Based on BAUGNÉE (in prep.) and the checklists of adjacent areas, 30 to 60 additional species are expected. A better knowledge of this group in Belgium is needed and could be achieved through additional fieldwork and revisions of the existing collections at the Royal Belgian Institute of Natural Sciences and the Gembloux Agricultural University.

Most Auchenorrhyncha species in Belgium are terrestrial. Others occur in freshwater or marine habitats or as symbionts, parasites or commensals. The highest species richness is found in the Belgian Lorraine, followed by the rest of the territory, including the coastal zone. Only the tidal area clearly shows a lower diversity. Calcareous grasslands, heaths, dunes, marshes and broad-leaved forests are some of the essential habitats for the conservation of hoppers and cicadas in Belgium.

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PSYLLOIDEA - JUMPING PLANT LICE or PSYLLIDS

(BLADVLOOIEN - PSYLLES, FAUX PUCERONS - BLATTFLÖHE)

Small plant-feeding Sternorrhyncha with specially developed legs for jumping; exopterygotes; although adults have two pairs of wings with reduced venation, they are weak flyers; adults and nymphs feed by sucking sap of plants, thereby often injecting toxic saliva causing plant galling, malformations or necroses; some species transmit plant diseases; more than 2,000 species described worldwide.

Questionnaires completed by Jean-Yves BAUGNÉE (Observatory of the Fauna, Flora and Habitats), Ian HODKINSON (Liverpool John Moores University) and Pavel LAUTERER (Moravian Museum, Brno).

About 64 species have been recorded for Belgium (BAUGNÉE *et al.* 2002, with species list). Some 15 additional species are expected. This group is poorly known in Belgium. Next to the checklist of BAUGNÉE *et al.* (2002), the most recent catalogues are those of LETHIERRY (1892) and LAMEERE (1900), with respectively 20 and 18 species enumerated. New explorations in all parts of the country are needed to obtain a more complete picture of the distribution and actual frequence of the species. Collections are present in the Royal Belgian Institute of Natural Sciences and the Agricultural Research Centre of Gembloux.

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ALEYRODIDEA - WHITEFLIES

(WITTE VLIEGEN - MOUCHES BLANCHES, ALEURODES DES SERRES - MOTTENLÄUSE, WEISSE FLIEGEN)

Minute (2 to 3 mm), moth-like Sternorrhyncha feeding on plant material; exopterygotes; body and wings covered with white substance; hindwings nearly as large as forewings; except for the first stage, larvae possess neither legs nor antennae, and live attached to the food plant; about 1,200 species worldwide.

Information provided by Jon MARTIN (The Natural History Museum, London).

Following MARTIN *et al.* (2000), the whitefly fauna of Europe and the Mediterranean Basin comprises 56 species. Seven of them have been observed in Belgium (mostly old observations) or are occurring throughout Europe and at least six other species are expected in Belgium. Knowledge of this group in Belgium is clearly very poor and field surveys are needed to remedy. Neither a Belgian specialist of whiteflies, nor a representative collection, could be identified.

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ADELGIDAE and PHYLLOXERIDAE - OVIPAROUS APHIDS or CONIFER APHIDS and PHYLLOXERA

(SPARRENGALLUIZEN en DWERGLUIZEN - PUCERONS ADELGINES, PUCERONS DES ÉCORCES et PHYLLOXÈRES - TANNENGALLÄUSE und ZWERGLÄUSE)

'Adelgoidea' is often used to refer collectively to these two families. Often classified within the Aphidoidea among others because of the similar morphology; exopterygotes feeding on woody plants; serious grape pests; ca. 150 species estimated worldwide.

Questionnaire completed by Andrea BINAZZI (Experimental Institute for Agricultural Zoology, Firenze) with the contribution of Georges REMAUDIÈRE (Muséum National d'Histoire Naturelle, Paris).

Four species have been registered (NEF 1984). Based on their presence in neighbouring countries (and the presence of their host plants in Belgium), nine other species occur almost certainly in Belgium, which brings the total up to 13 species. In addition to these, nine other species could occur based on the presence of introduced host conifers (such as *Pinus strobus*, *Picea orientalis*, etc.). This group is poorly known in Belgium. Reference collections are housed in The Natural History Museum in London and in the Experimental Institute for Agricultural Zoology in Firenze.

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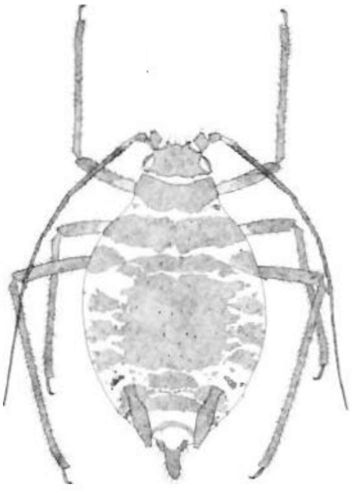
APHIDOIDEA - PLANT LICE or APHIDS

(BLADLUIZEN - PUCERONS, APHIDES - BLATTLÄUSE)

Small (1-5 mm), soft-bodied Sternorrhyncha occurring predominantly in the northern temperate regions of the world; exopterygotes often found feeding together in large clusters on their host plants; complex life cycle including both parthenogenetic and sexual reproduction as well as the production of eggs or living young depending upon the cycle; adults include winged and wingless forms; possessing two prominent structures on the abdomen called cornicles or siphunculi that excrete warning pheromones; most produce saccharine anal secretions (honeydew); ca. 4,700 species worldwide, of which ca. 250 are serious pests.

Questionnaire completed by Juan Manuel NIETO NAFRÍA, Nicolás PÉREZ HIDALGO (both University of León) and Guy LATTEUR (Agricultural Research Centre).

So far, 371 Aphididae species have been recorded in Belgium (NIETO NAFRÍA *et al*. 1999). Since 1996, the species number has augmented with as much as 125 species (34.5%). Roughly estimated, a total species number of around 500 is expected for Belgium, based on the plant lice faunas of other European countries (NIETO NAFRÍA & MIER DURANTE 1999, PATTI & BARBAGALLO 1998). This group is taxonomically relatively well known in Belgium. Information on trends is not available. Representative collections are present at the Agricultural Research Centre and the University of León. Some 16 species are considered to have been introduced; they mainly occur in greenhouses.



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Wingless viviparous female of *Hyperomyzus (Hyperomyzella) rhinanthi* (Schouteden, 1903). The aphid shows host alternation between *Ribes rubrum* and *Rhinanthus* spp. and is widespread in Europe. Length: 2.6 mm (drawing by Nicolás Pérez Hidalgo).

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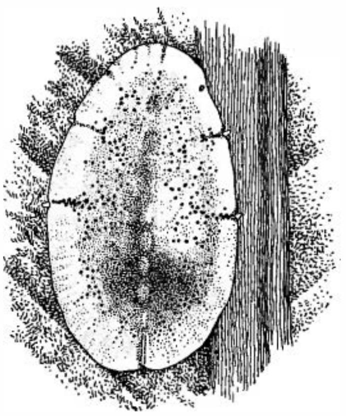
Coccoidea - scale insects and mealybugs

(Schildluizen - Cochenilles - Schildläuse)

Sternorrhyncha with modified body shape adapted to their plant-sucking way of life; exopterygotes; adult females are wingless, bag-like and possess reduced or no legs; males usually have two pairs of wings and possess a distinct head, thorax and abdomen; first instars are mobile and contribute largely to the dispersal of the population; other immature instars generally sessile; some scale insects are serious plant pests, others are beneficial (a.o. through the production of wax; some are used for controlling noxious weeds); probably more than 7,600 species worldwide.



14

Coccus hesperidum is a common scale insect in southern Europe that cannot survive in the wild at our latitude. In Belgium, it often occurs in greenhouses and houses. This polyphagous species can among others be found on agave, oleander, apple and citrus. Adult length: 1.5-4 mm; width: 1-2.5 mm (from Borchsenius 1957).

Questionnaire completed by Maurice Jansen (Plant Protection Service, Wageningen).

So far, 27 species have been recorded: 19 in the wild and 8 in greenhouses (Kosztarab & Kozar 1988 combined with non-published data of the Netherlands Plant Protection Service). Based on figures and tendencies observed in the Netherlands, the United Kingdom and Central Europe, a total species number of 100 to 125 is expected in the field complemented by ca. 50 species in greenhouses. The knowledge of this group in Belgium is poor. No expert could be identified in Belgium. Species number increases because of plant trade and the introduction of plants by individuals after a holiday abroad. On the other hand, some five species will probably disappear from Belgium in the following decades owing to the drying out of marshes and related habitats, and/or a shift of their distribution area. The Hautes Fagnes and the coastal zones show the highest species richness while the rest of Belgium shows a somewhat lower diversity.

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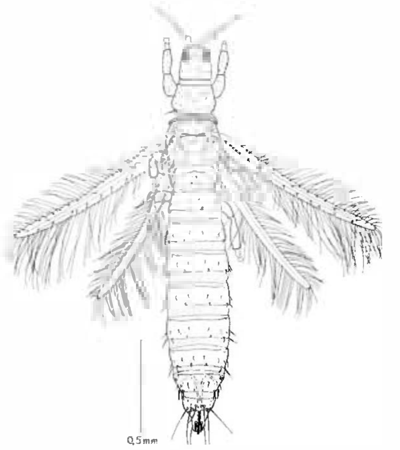
THYSANOPTERA - THRIPS

(TRIPSEN - THRIPS, THYSANOPTÈRES - FRANSENFLÜGLER, THRIPSE)

Small (0.5-1.5 mm), flattened exopterygotes; wings, if present, are very narrow, with a fringe of long hairs; some are predaceous, but many feed by sucking plant juice and are agricultural pests; oldest fossil thrips seem to date back to the Permian; ca. 5,000 species described worldwide.

Information provided by Richard ZUR STRASSEN (University of Frankfurt) and Bert VIERBERGEN (Plant Protection Service, Wageningen).

Less than 20 species, almost half of which have been introduced, are known from Belgium. It seems that only some species with a (possible) pest status in greenhouses have been observed. Among others based on the number of species in the Netherlands (148), UK (180), Germany (225), France (250) and Denmark (103), B. VIERBERGEN estimates the number of Thysanoptera species in Belgium to be at least 110. Knowledge of this group in Belgium is very poor. No Belgian expert could be identified. The most complete collection at the European level is housed in the Senckenberg Institute in Frankfurt am Main. Another collection is kept by The Natural History Museum in London. For the thrips possibly occurring in Belgium, the collection of the Plant Protection Service in Wageningen can be consulted.



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Limothrips cerealium HALIDAY, 1836 is one of the many expected but not yet observed thrips in Belgium. Its presence in the Netherlands, France, Germany and the United Kingdom was ascertained a long time ago (from ZUR STRASSEN 1972).

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NEUROPTERA (PLANIPENNIA) - LACEWINGS, ANT LIONS

(NETVLEUGELIGEN - NÉVROPTÈRES - ECHTE NETZFLÜGLER, NEUROPTEREN)

Endopterygotes with two pairs of large, highly veined, subequal wings; eggs often deposited on stalks; larvae possess sucking jaws and are predating on ants, aphids, mites or freshwater sponges; almost 5,000 described species worldwide.

See below under Raphidioptera.

MEGALOPTERA - ALDER FLIES, DOBSON FLIES, FISH FLIES

(ELZENVLIEGEN - MÉGALOPTÈRES - GROSSFLÜGLER, SCHLAMMFLIEGEN)

Minute to very large, primitive endopterygotes with aquatic larvae predating on insects, annelids, crustaceans and molluscs; large membranous wings (up to 16 cm wing span); adults are fluid feeders, some eat soft-bodied prey; formerly classified within the Neuroptera; ca. 300 extant species worldwide.

See below under Raphidioptera.

RAPHIDIOPTERA - SNAKE FLIES

(KAMEELHALSVLIEGEN - RAPHIDIOPTÈRES, MOUCHES SERPENTS - KAMELHALSFLIEGEN)

Endopterygotes with an elongated pronotum giving a snake-like appearance; terrestrial, predaceous larvae mostly feeding on aphids; females possess an elongated ovipositor; elongated, highly veined wings; formerly classified within the Neuroptera; ca. 150 described species worldwide.

Questionnaires on Neuroptera, Megaloptera and Raphidioptera were completed by Colin PLANT (consultant entomologist, United Kingdom).

Neuroptera, Megaloptera and Raphidioptera are discussed together.
So far, 37 Neuroptera, two Megaloptera and four Raphidioptera species have been recorded in Belgium. Based on the available European data, at least five additional species of Neuroptera are expected. Knowledge of these groups is very poor: Belgium is perhaps the poorest recorded country in western Europe for these taxa. No Belgian expert has been identified. These groups are mainly terrestrial, although the larvae of some species occur in fresh water. The larvae of three species live in close relation with freshwater sponges. Arboreal habitats are essential for the preservation of the species.

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MECOPTERA - SCORPION FLIES

(SCHORPIOENVLIEGEN - MÉCOPTÈRES - SCHNABELFLIEGEN, SKORPIONSFLIEGEN)

Small to medium, fragile endopterygotes with the head drawn out as a downward pointing rostrum; in some species, the last segment of the males is modified into pincers and held upright, giving them a scorpion-like appearance; chewing mouth parts; two pairs of similar narrow wings carried horizontally when at rest; larvae aquatic or terrestrial; among the oldest of the holometabolous insects (fossil record goes back to the lower Permian); ca. 550 described species worldwide.

Questionnaire completed by Robert GÜSTEN (Nature History Museum Mainz). Additional information from Victor NAVEAU (Royal Entomological Society of Antwerp) and Wolfgang DOROW (Senckenberg Research Institute).

Seven or eight species are known from Belgium (DE SELYS-LONGCHAMPS 1888, BERLAND 1962). It is still unclear whether *Panorpa communis* and *P. vulgaris* are distinct species. *Bittacus italicus* and *B. hageni*, mainly Mediterranean species, have been very rarely recorded in Belgium and the few observations of *B. hageni* may in fact pertain to *B. italicus*. No additional species are expected. One or two species are threatened in Belgium. Especially humid riverine forests are essential for the preservation of scorpion flies (HOFFMANN 1966).

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SIPHONAPTERA - FLEAS

(VLOOIEN - PUCES - FLÖHE)

Minute to small, laterally compressed, wingless endopterygotes often with legs modified for jumping; sucking-piercing mouth parts; legless larvae scavenge in nest material of host; transmitter of several important diseases, e.g. bubonic plague and typhus fever; ectoparasites on mammals and birds; ca. 2,400 species worldwide.

Questionnaire completed by Roland LIBOIS (University of Liège).

So far, 43 species have been observed (COOREMAN 1950, non-published list by LIBOIS). Based on SMIT (1967) and BEAUCOURNU & LAUNAY (1990), eight additional species could occur in Belgium. Species of this group are relatively well known except for their chorology. A representative collection is housed in the Royal Belgian Institute of Natural Sciences. Another collection is managed by the University of Liège. Since 1950, the species number has increased by six. As parasites of micro-mammalia (rodents and insectivores), the trends shown by the Siphonaptera are similar to those of their host species. For instance, *Rhinolophopsylla unipectinata* could disappear from Belgium during the following decades because of the regression of *Rhinolophus* species. For the same reason, Chiroptera nurseries and underground cavities are essential for the survival of some Siphonaptera species in Belgium.

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COLEOPTERA - BEETLES

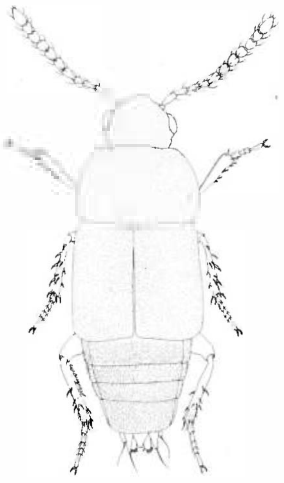
(KEVERS - COLÉOPTÈRES - KÄFER)

Endopterygotes with hardened forewings (elytra) and membranous hindwings, often reduced or absent; biting mouth parts; complete metamorphosis; successful in almost all terrestrial and freshwater ecosystems; most lifestyles present (herbivores, predators, detritivores, parasites); some are important biological control agents, others are serious agricultural pests; largest and most diverse order with 166 families and ca. 370,000 described species worldwide; a multiple of this number still has to be discovered.

Information provided by diverse experts in relation to specific families (see table 1) was compiled and completed by literature data and with the help of Didier DRUGMAND (Royal Belgian Institute of Natural Sciences).

Approximately 4,500 species (a very rough estimate) have been recorded in Belgium. Between 100 and 500 additional species are expected based on the numbers in neighbouring countries (ca. 4,200 species recorded in the Netherlands and ca. 300 additional species expected). A general overview of this group is not available, although initiatives in this context were launched several times. Experts with a synoptical knowledge of the Belgian Coleoptera could not be identified.

The species-richest families are: Staphylinidae (1030), Curculionidae (estimated between 500 and 700), Carabidae including Cicindelidae (402), Chrysomelidae (334), Dytiscidae (117 observed, ten additional ones expected), Scarabaeoidea (superfamily: 123), Cerambycidae (122), Elateridae (94), Scolytidae (76), Coccinellidae (61) and Pselaphidae (52).



16

Tachinus flavolimbatus, a new staphylinid for the Belgian fauna. The first Belgian observation was made in 2002 in the Ruhrbush forest reserve (Butgenbach, Province of Liège). It is the most northeastern record of this Mediterranean species. Length: 2-3 mm (drawing by M. LECLERCQ).

Smaller families are the Anobiidae (43), Tenebrionidae (35), Buprestidae (30), Haliplidae (19), Ptinidae (16), Bruchidae (15), Gyrinidae (9), Lucanidae (5), Trogidae (4). The Urodontidae, Bostrichidae, Lycidae and Lampyridae each have three species in Belgium. Biphyllidae, Lymexylidae and Noteridae are limited to two Belgian species each. The Hygrobiidae, Platypodidae, Homalisidae, Drilidae, Microsporidae and Phloiophilidae are each represented by one species in Belgium. No species number could be found for several families. An example of a recent observation of an aquatic beetle new to the Belgian fauna is *Oulimnius rivularis*, observed in Edegem (Province of Antwerp) in 2001 (pers. comm. T. VERCAUTEREN). Another example is *Tachinus flavolimbatus* (figure 16).

Data gathered via the questionnaire show a clear and alarming regression in native species numbers and population numbers and sizes for almost all families (see table 1 for more detailed information on the threats, important habitats for conservation, etc.). Many species have been introduced over the past few hundreds of years. Perhaps the most recent example is *Harmonia axyridis* (Coccinellidae), introduced as control agent of aphids and originating from Asia. The most important Belgian Coleoptera collection is housed in the Royal Belgian Institute of Natural Sciences. Smaller collections can be found in the Zoological Museum of the University of Liège, the Free University of Brussels, the Ghent University, the Gembloux Agricultural University and the 'Cercle des Entomologistes Liégeois'. There are also several well-established private collections.

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Table 1. Evaluation of some coleopteran families in Belgium. Information from Jean-Yves BAUGNÉE (OFFH), Etienne BRANQUART (CRNFB), Roger CAMMAERTS (ULB), Georges COULON (RBINS), Raphaël DE COCK (UIA), Konjev DESENDER (RBINS), Claude DOPAGNE (Bolland), Didier DRUGMAND (RBINS), Guy HAGHEBAERT (RBINS), Geoffrey MIESSEN (Malmedy), Peter VERDYCK (RBINS), Veerle VERSTEIRT (RBINS) and the Coccinula working group. [(*): for some families, one or more vernacular names could not been found; n.m.: not mentioned]

Family (*)	Observed species	Additional expected species	Taxonomic knowledge	Main collection(s)	Trend	Threatened number	Threats	Geographical species richness	Important habitats for conservation
Anobiidae (furniture or death-watch beetles - klopkevers - vrillettes - Nagekäfer)	43	0	moderate	RBINS	status quo	n.m.	n.m.	Lower Belgium > Middle Belgium > Upper Belgium	presence of dead wood
Bostrichidae (bostrichids - schorskevers - bostrichidés - Holzbohrkäfer)	3	0	good	RBINS	status quo	n.m.	n.m.	Lower Belgium > Upper Belgium > Middle Belgium	n.m.
Carabidae, incl. Cicindelidae (ground and tiger beetles - loopkevers en zandloopkevers - coléoptères carabiques - Laufkäfer)	402	0	good	RBINS	negative	50% vulnerable or threatened	habitat destruction and fragmentation, acidification, manuring, pollution	highest in Belgian Lorraine and coastal area	dune habitats, old forests, heaths, peat areas, river banks, salt marshes
Cerambycidae (longhorn or longicorn beetles - boktorren - longicornes, cerambycidés - Bockkäfer)	122	unknown	moderate to good	RBINS	unknown	unknown	removing of dead wood, forest clearance	Upper Belgium > Middle Belgium (Flanders poorly investigated)	(old) forests with dead wood
Chrysomelidae (chrysomelid or leaf beetles - bladkevers of bladhaantjes - chrysomèles - Blatterkäfer)	334	10-25	moderate to good	RBINS	unknown	unknown	unknown	Middle Belgium > Lower Belgium > Belgian Lorraine	areas with high plant diversity

Family (*)	Observed species	Additional expected species	Taxonomic knowledge	Main collection(s)	Trend	Threatened number	Threats	Geographical species richness	Important habitats for conservation
Coccinellidae (lady or ladybird beetles - lieveheersbeestjes - coccinellidés, coccinelles - Marienkäfer)	61	2	good for typical ladybird beetles, bad to moderate for other subfamilies	RBINS, FUSAGx	status quo	⩾ 6 spp. threatened	habitat destruction, drying out of the land, alien species	highest in Kempen, Belgian Lorraine, Hautes Fagnes, Fagne-Famenne and some areas in Middle Belgium	dry and wet heathland, moors, marshes, fens, fallows, deciduous and mixed forests, parks
Dytiscidae (predaceous water or diving beetles - waterroofkevers - dytiques - Schwimmkäfer)	117	10	moderate	RBINS	negative	12 spp. not found since 1950, 5 spp. threatened, 22 spp. vulnerable	habitat destruction, pollution, drying out of the land, acidification and manuring	Middle Belgium > Lower Belgium > coastal zone and Hautes Fagnes > Upper Belgium > Belgian Lorraine	small water bodies, pools, ditches
Elateridae (click beetles - kniptorren - taupins, elateridés - Schnellkäfer)	94 known, 81 found at present	0	good	RBINS, FUSAGx, ULg, private collections	negative	mainly xylophagous spp. are threatened (near disappearance in Belgium), others more abundant (e.g. pest spp.)	habitat destruction, isolation of woodland, dead wood removal	Upper Belgium and Belgian Lorraine > Middle Belgium > Lower Belgium	dead wood, old forests, hollow trees
Lampyridae (glow-worms, fireflies - glimwormen, vuurvliegen - ver luisants, lucioles - Glümwürmchen)	3	1	good	RBINS, RMCA	status quo	population number and size decrease	habitat destruction, drying out of the land, pollution, pesticides	Middle Belgium > Upper Belgium > Lower Belgium > Belgian Lorraine > tidal area > Hautes Fagnes	forests, sunken roads, areas with less light pollution
Lymexylidae (lymexyloids - (scheeps)werfkevers - lyméxylonidés - Werftkäfer)	2	0	good	RBINS, FUSAGx	status quo	n.m.	n.m.	Middle Belgium > Belgian Lorraine > Upper Belgium	forests with dead wood

Family [*]	Observed species	Additional expected species	Taxonomic knowledge	Main collection(s)	Trend	Threatened number	Threats	Geographical species richness	Important habitats for conservation
Pselaphidae (short-winged mold beetles - dwergkevers - psélaphides - Palpenkäfer)	52	10-13	good	RBINS, private collections	status quo	under investigation	habitat destruction, drying out of the land	Upper Belgium > Middle Belgium > Belgian Lorraine	dry calcareous grasslands, old deciduous forests, wet areas incl. salt marshes, river banks, karst areas
Ptinidae (ptinids - diefkevers - ptinidés - Diebskäfer)	16	± 5	good	RBINS, FES, private collections	status quo	n.m.	n.m.	Belgian Lorraine > Upper Belgium > Middle Belgium	n.m.
Scarabaeoidea (superfamily) (lamellicorn or coprophagous beetles - bladsprietigen - scaraboïdes - Blatthornkäfer)	123	10	good	RBINS, private collections	negative	26 spp. disappeared since 1950, 40 spp. threatened	pollution, alteration of agro-pastoral methods, veterinary antibiotics	Middle Belgium > Lower Belgium > Belgian Lorraine	sandy and coastal biotopes, slopes not accessible with machinery
Scolytidae (bark beetles - schorskevers - scolytes - Borkenkäfer)	76	20	good	RBINS, FUSAGx	unknown	unknown	removal of dead wood	Middle Belgium > Upper Belgium > Belgian Lorraine	forested areas, presence of dead or dying wood
Staphylinidae (rove beetles - kortschildkevers - staphylins - Kurzflügler)	1030	50	good	RBINS, MNHN, NHM, Humbold Univ. Berlin	negative	under investigation	habitat destruction, pollution, drying out of the land	Brabantine district > Mosan district > Flanders district > Kempen and Ardenne district > maritime and Lorraine district	dry calcareous grasslands, peat soils, deciduous forest, wet areas

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STREPSIPTERA - TWISTED-WING INSECTS, STYLOPIDS or STREPSIPTERANS

(WAAIERVLEUGELIGEN - STREPSIPTÈRES - FÄCHERFLÜGLER)

Small endopterygotes with strong sexual dimorphism; females without wings, eyes and antennae; free-living males with enlarged hindwings and reduced forewings (halteres); females parasitising bees, wasps and other insects; ca. 560 species worldwide.

Questionnaire completed by Guy HAGHEBAERT (scientific associate, Royal Belgian Institute of Natural Sciences).

Five species have been recorded (HAGHEBAERT 1993, with species list). Some five additional species could be expected (KINZELBACH 1969). The knowledge of this group in Belgium is poor and information on trends is not available. A collection is present in the Royal Belgian Institute of Natural Sciences. Most species are found in the coastal area (above the high-water mark), followed by, in decreasing order of richness, Upper Belgium and Middle Belgium with the Sonian Forest (PASTEELS 1949, HAGHEBAERT 1993). Stylopids occur as terrestrial free-living organisms or as parasites of Hymenoptera and Homoptera. Consequently, appropriate habitats for these two insect groups are also very important for the survival of Strepsiptera.

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DIPTERA - TRUE FLIES or FLIES and MOSQUITOES

(TWEEVLEUGELIGEN, VLIEGEN en MUGGEN - DIPTÈRES, MOUCHES et MOUSTIQUES - ZWEIFLÜGLER, FLIEGEN und MÜCKEN)

Endopterygotes with well-developed forewings and hindwings reduced to club-shaped halteres (organs of balance); compound eyes large; piercing, sucking or sponging mouth parts; legless larvae; some are vectors of diseases for livestock and humans; diverse order with many different ecological roles in larval as well as adult stage; guesstimates range from 120,000 to more than 150,000 described species worldwide; a multiple of these numbers to be discovered.

Questionnaire completed by Patrick GROOTAERT (Royal Belgian Institute of Natural Sciences).

In GROOTAERT *et al.* (1991), 4,474 species are listed. Mainly thanks to a better faunal knowledge, but also because of the appearance of Mediterranean species, the species number is increasing. Based on the Diptera fauna of the United Kingdom, around 2,200 additional species are expected (CHANDLER 1998). This group is moderately known in Belgium; a representative collection is housed in the Royal Belgian Institute of Natural Sciences. Next to the terrestrial environment, containing by far the highest number of Diptera species in Belgium, an important part of the true flies fauna is related to stagnant and running freshwater habitats. Furthermore, some species occur as parasites or commensals (GROOTAERT *et al.* 1991). Fragmentation and habitat destruction are identified as the biggest threats for this group. The highest species richness is found in Upper Belgium (excl. the Hautes Fagnes). A somewhat lower diversity is found in the Belgian Lorraine, the Hautes Fagnes and Middle Belgium. In Lower Belgium, the species richness is further decreasing towards the proximity of the North Sea (GROOTAERT *et al.* 1991).

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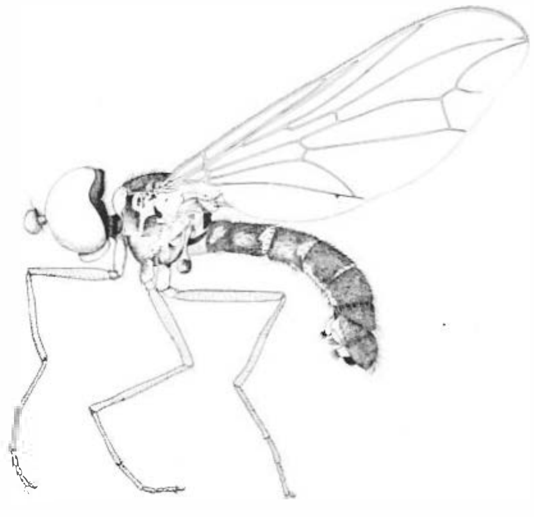

17

Nephrocerus lapponicus, one of the three species of this Pipunculidae genus occurring in Belgium. Body length: 7.3-7.8 mm; wing length: 7.0-8.6 mm (from GROOTAERT & DE MEYER 1986).

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Table 2. Evaluation of some dipteran families in Belgium. Information from Luc De Bruyn (IN), Marc De Meyer (RMCA), Kris Decleer (IN), Boudewijn Goddeeris (RBINS), Patrick Grootaert (RBINS), Marcel Leclercq (Beyne-Heusay), Jacques Petit (Bassenge), Jan Scheirs (RUCA), Guy Tomasovic (FUSAGx). See Grootaert *et al.* (1991) for more information on these and other dipteran families. [(*): for some families, one or more vernacular names could not been found; (1): cause animal and human myasis; (2): used as biological control agents of Trematoda infesting humans and animals; n.m.: not mentioned]

Family (*)	Observed species	Additional expected species	Taxonomic knowledge	Main collection(s)	Trend	Threatened number	Threats	Geographical species richness	Important habitats for conservation
Agromyzidae (leafminer flies - mineervliegen - mouches mineuses - Minierfliegen)	173	300-500	insufficient	private collection	unknown	unknown	unknown	unknown	unknown
Asilidae (robber flies - roofvliegen - asilides - Raubfliegen)	50	n.m.	moderate	RBINS, FUSAGx	negative	19 spp. threatened	habitat destruction	Upper Belgium > Belgian Lorraine > Middle Belgium > Hautes Fagnes > Lower Belgium > coastal zone	sandy or open mesobrometum environments, old forests and edges
Bibionidae (St Mark's, march or fever flies - maartse of zwarte vliegen - bibionidés, mouches de St Marc - Märzfliegen, Haarmücken)	18	1	moderate	RBINS, FUSAGx	negative	3 spp. disappeared, 8 spp. threatened	habitat destruction, acidification, manuring, pollution	Middle Belgium and Belgian Lorraine > Upper Belgium > Lower Belgium > Hautes Fagnes	grasslands and open spaces in the forest environment
Chironomidae (midges - dansmuggen, vedermuggen - chironomides - Zuckmücken)	352	150	moderate	RBINS	negative	unknown	water pollution, habitat destruction	unknown	freshwater and semi-aquatic habitats
Chloropidae (grass or frit flies - halmvliegen - mouches des chaumes - Halmfliegen, Gelbkopffliegen)	113	> 10	moderate	RBINS	positive due to knowledge increase	n.m.	n.m.	± equal richness throughout the country, coastal zone with lower richness	habitats with Poaceae, Cyperaceae, Juncaceae and or Juncaginaceae

Family [*]	Observed species	Additional expected species	Taxonomic knowledge	Main collection(s)	Trend	Threatened number	Threats	Geographical species richness	Important habitats for conservation
Conopidae (thick-headed flies - blaaskopvliegen - conopides - Blasenkopffliegen)	34	4	moderate	RBINS	unknown	unknown	unknown	Upper Belgium, Belgian Lorraine and Montagne Saint-Pierre > Hautes Fagnes, Lower and Middle Belgium > coastal zone	xerothermic grasslands, fallow land, *Calluna* heathland
Empididae (dance flies - dansvliegen - empidides - Tanzfliegen)	175	10	moderate to good	RBINS, FUSAGx, ULg	status quo	9 spp. threatened	fragmentation	Middle and Upper Belgium and Belgian Lorraine > Hautes Fagnes > Lower Belgium and coastal zone	*spp. show high habitat-specificity and are good indicators for site quality assessment*
Gasterophilidae [1] (horse bot flies - maagvliegen - gastérophiles - Magenfliegen, Magendasseln)	3	3	good	private collection, FUSAGx	negative	unknown	prophylactic measures of breeders and veterinary services	highest in Upper Belgium, Hautes Fagnes, mammal breeding zones and forests	n.m.
Hippoboscidae (louse flies - luisvliegen - hippoboscides - Lausfliegen)	10	'some'	moderate	RBINS NHM	following trends of mammals and birds (Hippoboscidae are obligate ectoparasites of these groups)	unknown	hunting, poaching, pollution	n.m.	n.m.
Hybotidae (dance flies - dansvliegen - hybotides - Tanzfliegen)	165	10	moderate to good	RBINS, FUSAGx, ULg	status quo	10 spp. threatened	fragmentation	Middle and Upper Belgium and Belgian Lorraine > Hautes Fagnes > coastal zone and Lower Belgium	*spp. show high habitat-specificity and are good indicators for site quality assessment*
Hypodermatidae [1] (warble flies - hypodermes, mouches du varon - Hautdasseln)	3	0	good	private collection, FUSAGx	negative	unknown	prophylactic measures of breeders and veterinary services	highest in Upper Belgium, Hautes Fagnes, mammal breeding zones and forests	n.m.

Family [*]	Observed species	Additional expected species	Taxonomic knowledge	Main collection(s)	Trend	Threatened number	Threats	Geographical species richness	Important habitats for conservation
Oestridae [1] (bot flies - horzels - oestres - Dasselfliegen)	4	0	good	private collection, FUSAGx	negative	unknown	prophylactic measures of breeders and veterinary services	highest in Upper Belgium, Hautes Fagnes, mammal breeding zones and forests	n.m.
Pipunculidae (big-headed flies - grootoogvliegen, oogkopvliegen - pipunculides - Augenfliegen)	79	10-15	good	RBINS	unknown	unknown	unknown	Middle Belgium > Upper Belgium > Lower Belgium > Hautes Fagnes > Belgian Lorraine > coastal zone	calcareous grasslands, boreomontane habitats
Sciomyzidae [2] (snail-killing or marsh flies - slakkendodende vliegen - sciomyzides, mouches malacophages - Schneckenfliegen, Hornfliegen)	66	n.m.	good but probably incomplete	RBINS FUSAGx, private collection	unknown	unknown	habitat destruction, drying, pollution	considerable richness throughout Belgium with exception of Hautes Fagnes and coastal zone	marshy aquatic environments
Syrphidae (hover flies - zweefvliegen - syrphides - Schwebfliegen)	322	5	moderate to good	RBINS ULg	negative	> 50 spp. threatened	habitat destruction, lack of adequate habitat management	highest richness in Upper Belgium	old woodlands, wetlands, wet heathlands, semi-natural grasslands and dunes
Tabanidae (horse and deer flies - dazen - taons, tabanides - Bremsen)	39	1-2	good	private collection, FUSAGx	status quo	unknown	habitat destruction, drying out of the land, pollution	highest in Lower Belgium, Hautes Fagnes and Lorraine	marshes and lakes
Tephritidae (fruit flies - boorvliegen - téphritides, mouches des fruits - Fruchtfliegen, Bohrfliegen)	67	n.m.	moderate	FUSAGx, private collection	unknown	unknown	pesticides and insecticides, habitat destruction, acidification and manuring	considerable richness throughout Belgium with exception of Hautes Fagnes and coastal zone (larvae parasitises phanerogams)	habitats with wild or cultivated flora

TRICHOPTERA - CADDISFLIES

(KOKERJUFFERS, SCHIETMOTTEN - TRICHOPTÈRES - KÖCHERFLIEGEN)

Small to medium, brownish or grayish, moth-like endopterygotes; two pairs of membranous wings with silky hairs; larvae aquatic, most species building specific cases, nets or tubes; primarily important as fish food; often used as biological indicators for water quality assessment; about 7,000 described species worldwide.

Questionnaires completed by Thierry VERCAUTEREN (Provincial Institute for Hygiene, Antwerp) and Alain DOHET (Public Research Centre Gabriel Lippmann, Luxembourg).

Mainly based on research activities of Philippe STROOT, 202 species are registered (STROOT 1984-1987, STROOT & NEVEN 1989, some with species list). Some 20 to 25 additional species could be found (STROOT 1987, 1989). Except for the larval stages of some subgroups, the caddisflies are well known in Belgium. A representative collection is managed by the Royal Belgian Institute of Natural Sciences. Another, somewhat smaller, collection is housed in the Zoological Institute of the University of Liège. Thanks to the intensification of research activities, the species number has increased with 36 species since 1950. The highest species richness is found in Upper Belgium (including the Hautes Fagnes, containing some species not occurring elsewhere in Belgium), followed by, in decreasing order of diversity, Middle Belgium, Lower Belgium and the Belgian Lorraine (STROOT 1987). Nineteen species are clearly in regression (STROOT & DEPIEREUX 1989) because of habitat destruction, pollution, desiccation, clearing of river banks, acidification and eutrophication. The potamic environment, river sources, old river branches, temporal water bodies, marshes, peat bogs and floodable areas are some of the habitats identified as very important for the conservation and survival of many caddisfly species in Belgium.

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Lepidoptera - butterflies and moths

(Vlinders en motten - papillons et phalènes - Schmetterlinge)

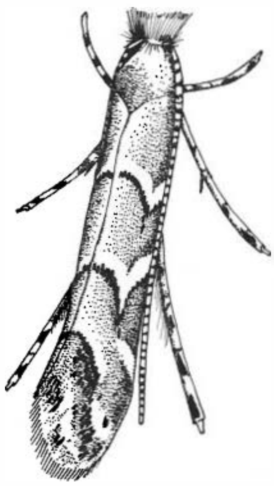
Very small to largest (by wing span) endopterygotes with two pairs of membranous wings, covered with overlapping colourful (as is the rest of the body) scales; compound eyes well developed; mouth parts of most species modified in a long, coiled proboscis for sucking; larvae (caterpillars) with chewing mouth parts; generally phytophagous, sometimes significant crop pests; a few feed on clothes or stored food products; one of the largest insect orders with ca. 127 families and 165,000 known species worldwide; the real total of extant species is expected to be much higher.

Questionnaires completed by Willy De Prins (scientific associate, Royal Museum of Central-Africa) for the Lepidoptera and by Dirk Maes (Institute of Nature Conservation) in collaboration with Hans Van Dyck (University of Antwerp) and Philippe Goffart (Catholic University of Louvain) for the Rhopalocera.

In De Prins (1998), 2,405 species, belonging to 71 families, are listed. Since then, 18 new species have been found (various articles in 'Phegea'). At least 100 additional species are expected based on Kuchlein (1993). The group is taxonomically well known in Belgium and a considerable number of experts able to identify Lepidoptera (especially the Rhopalocera) to the species level are studying and monitoring these species. A representative collection is housed in the Royal Belgian Institute of Natural Sciences. Another collection is developed by the Flemish Entomological Society and housed in the University of Antwerp (RUCA). In average, two or three new species for the Belgian fauna are discovered each year. Unfortunately, if present trends continue, some ten Lepidoptera species are expected to disappear from Belgium each year because of habitat destruction, drying out of the land, acidification, manuring and pollution.

The highest species richness is found in zones with calcareous habitats, followed by, in decreasing order of diversity, the Belgian Lorraine, Middle Belgium with the Sonian Forest, Upper Belgium, Lower Belgium with the Kempen, the Hautes Fagnes and the coastal and tidal area. Dry calcareous slopes, peat moors and fen meadows (= wet, nutrient-poor grasslands) were identified as important habitats for the conservation of specific or scarce populations. Since 1900, some 20 species were introduced and mainly observed in the proximity of railway stations or the harbour of Antwerp.

Regarding the Rhopalocera, 111 species have been recorded and no additional species are expected. This group is very well known and monitored in Belgium; collections are housed in the Gembloux Agricultural University, the Royal Belgian Institute of Natural Sciences, the Royal Zoological Society of Antwerp and the Ghent University. Since 1980, 16 species (14%) have disappeared in Belgium (Van Swaay *et al.* 1997a). Red lists for the Flemish (http://www.instnat.be/content/page.asp?pid=FAU_VL_Rode_Lijst) and the Walloon Region (http://mrw.wallonie.be/dgrne/sibw/especes/ecologie/papillons/ISB_SURWAL/liste_rouge.htm) are available. The highest diversity is found in the Belgian Lorraine, followed by the Viroin valley and Upper Belgium with the Hautes Fagnes (Goffart *et al.* 1992). Important habitats for butterflies are wet and dry poor grasslands, peat areas, calcareous grasslands, marshes and wet heathlands (Maes & Van Dyck 1999, Goffart



18

Cameraria ohridella DESCHKA & DIMIC, 1986, in resting position. Although the first observation in Belgium of this leafmining species, originating from Central Europe, was made only recently in Tervuren (1999), the species has already spread over the whole Belgian territory. Wing span: 6-8 mm (drawing by W. DE PRINS).

et al. 1992). About 20 rhopaloceran species are legally protected, some only in Flanders or in Wallonia, others in both regions.

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HYMENOPTERA - BEES, ANTS, WASPS and SAWFLIES

(VLIESVLEUGELIGEN - HYMÉNOPTÈRES - HAUTFLÜGLER, HYMENOPTEREN)

Minute to large endopterygotes with highly variable mouth parts; two pairs of membranous wings coupled by hamuli, some species wingless; larvae usually legless with distinct head or caterpillar-like; females with ovipositor modified for inserting eggs into tissue or transformed into a stinger; important pollinators and biological control agents, few pest or nuisance species; based on the complexity and diversity of their biology, Hymenoptera are often considered to be the most advanced insect group; 198,000 described species worldwide, while a multiple of this number still has to be discovered.

Questionnaire completed by Alain PAULY (Gembloux Agricultural University) and Jean-Luc BOEVÉ (Royal Belgian Institute of Natural Sciences).

Probably the most species-rich animal group in Belgium. The total number of species is estimated at least at 7,200 based on the following recorded numbers and guesstimates for the different subgroups: Symphyta 462 (recorded number, see MAGIS 1994); Aculeata 837 (recorded number, see PAULY 1999); Ichneumonoidea ± 3,300; Cynipoidea ± 190; Proctotrupoidea ± 343; Platygastroidea ± 252; Ceraphronoidea ± 87; Chalcidoidea ± 1,800; Mymarommatoidea 1. Of the estimated number of species, only less than half have been recorded or identified in collections.

Table 3. Evaluation of some hymenopteran families in Belgium. Information from Yvan BARBIER (UMH), Johan BILLEN (KUL), Wouter DEKONINCK (RBINS), Jean LECLERCQ (Jupille), Sébastien PATINY (FUSAGx), Pierre RASMONT (UMH), Camille THIRION (Flémalle), Raymond WAHIS (Chaudfontaine). [(*): for some families, one or more vernacular names could not been found; n.m.: not mentioned]

Family (*)	Observed species	Expected additional species	Taxonomic knowledge	Main collection(s)	Trend	Threatened number	Threats	Geographical species richness	Important habitats for conservation
Andrenidae (andrenid bees - andrenides - Sandbienen)	84	20	moderate	Oberösterreiches Landes Museum Linz, FUSAGx, Naturalis, NHM	negative	n.m.	modification of agricultural practices	higher in Lorraine, Hautes Fagnes, Middle and Upper Belgium	parcels with high floral diversity
Apoidea (superfamily) (bees - bijen - abeilles - Bienen)	376	0	good	FUSAGx, UMH, RBINS	status quo	some species in expansion, others in regression	n.m.	high throughout country, lower richness in Hautes Fagnes and coastal zone	n.m.
Chrysididae (gold wasps - goudwespen - chrysides - Goldwespen)	49	0	good	FUSAGx, RBINS, private collection	negative	9 spp. disappeared since 1950, 5-10 spp. threatened	habitat destruction	highest in Lower and Middle Belgium and on Montagne St-Pierre	heathlands, old hedges, forest edges, ecologically managed diverse gardens
Eumenidae (eumenid wasps - euménides - solitären Faltenwespen)	41	0	good	FUSAGx, RBINS	status quo	n.m.	n.m.	highest in Belgian Lorraine and Lower and Middle Belgium	sandy or calcareous open landscapes, old hedges, forest edges
Formicidae (ants - mieren - fourmis - Ameisen)	75	5	good	RBINS, Natuurhistorisch Museum Maastricht	negative	15 spp.	habitat destruction, pollution	Lower Belgium > Hautes Fagnes > Ardenne > Middle Belgium	sandy areas, heathlands, calcareous soils, forests

Family (*)	Observed species	Expected additional species	Taxonomic knowledge	Main collection(s)	Trend	Threatened number	Threats	Geographical species richness	Important habitats for conservation
Ichneumonidae (ichneumon wasps, ichneumonids - sluipwespen - ichneumonides - Schlupfwespen)	300	500-1500	insufficient to moderate	RBINS, FUSAGx	status quo	± 20 spp.	disappearing Lepidoptera (host-specific relation)	throughout country, even in urban areas	mixed forests, fallow land, gardens, natural (river) banks, slopes, heathland
Pompilidae (spider wasps - spinnendoders - pompiles - Wegwespen)	70	0	good	FUSAGx, RBINS, private collection	positive (new spp. found)	n.m.	n.m.	Calestienne > Belgian Lorraine and Upper Belgium > Kempen and Middle Belgium > coastal zone	fallow land, reed-beds besides lakes, xerothermic calcareous grasslands
Sphecidae (sphecid wasps - graafwespen - sphécides - Grabwespen)	170	0	good	FUSAGx, RBINS	status quo	n.m.	n.m.	high throughout country, lower richness in Hautes Fagnes and coastal zone	sandy or calcareous open areas, old hedges, forest edges, ecologically managed diverse gardens
Vespidae (wasps - wespen - guêpes - Wespen)	15	0	good	FUSAGx, RBINS	positive (2 new spp. since 1995: due to temp. rise?)	n.m.	n.m.	highest in Belgian Lorraine and Middle and Upper Belgium	some taxa related to thermophilous biotopes, most have no strict preference

In neighbouring countries, the Hymenoptera fauna is estimated as follows: ca. 7,500 species in the Netherlands, more than 8,000 in France and around 7,000 in the United Kingdom. In Germany, 8,896 species have been recorded hitherto (Dathe *et al.* 2001).

This group is moderately known in Belgium. Nowadays, some 15 Belgian hymenopterologists are contributing to this knowledge. In general, the highest species diversity is found in the Belgian Lorraine, followed by, in decreasing order of richness, Lower Belgium with the Kempen, Middle Belgium with the Sonian Forest and finally Upper Belgium. For some groups (Symphyta, Formicidae) however, Upper Belgium shows the highest richness. The Aculeata show the highest richness on Cretaceous grounds of the Montagne Saint-Pierre and the lower valley of the Geer.

Collections are present in the Royal Belgian Institute of Natural Sciences and the Gembloux Agricultural University. If current trends continue, 25 to 50% (depending on the group) of the species are or could become extinct, threatened, etc. (Rasmont *et al.* 1993). Sand quarries, coastal dunes, heather moors, calcareous grasslands and forest edges are some of the habitats identified as crucial for the Aculeata (Day 1991). For other subgroups, important habitats for conservation are the wet environments (Symphyta, Chalcidoidea) and forests (Ichneumonoidea, Chalcidoidea, Proctotrupoidea).

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Myriapoda - myriapods

(Myriapoden - Myriapodes - Myriapoden)

Terrestrial arthropods with elongated body and variable number of somites; mostly living in moist environments; fossil record goes back to the Cambrian; include Chilopoda, Symphyla, Diplopoda and Pauropoda.

CHILOPODA - CENTIPEDES

(DUIZENDPOTEN - MILLEPATTES - HUNDERTFÜSSER)

Terrestrial arthropods with unfused trunk segments, all but the last two with a pair of legs; number of legs varies from 15 to 181 pairs; first pair modified as large poison fangs; most species are nocturnal predators, well adapted to chase insects and other small prey; in many species, the female cares for the eggs and young in underground burrows; ca. 3,000 species described worldwide.

Questionnaires completed by Koen LOCK (Ghent University) and Richard KIME (Royal Belgian Institute of Natural Sciences).

Thirty-one species have been recorded (LOCK 2001a, LOCK 2001b). Based on data from the Netherlands, France, Germany and the United Kingdom, 10 to 20 additional species are expected. Since 1950, the species number augmented with nine species, thanks to an increase of the faunal knowledge. A representative collection is housed in the Royal Belgian Institute of Natural Sciences. The highest species richness is found in the Calestienne, followed by the somewhat less diverse Hautes Fagnes and Lorraine. Although Lower and Middle Belgium are characterised by a rather poor fauna, an important number of species have been observed here because most research took place in these parts of Belgium (LOCK 2001b). The Hautes Fagnes are of special importance to the centipedes among others because of the occurrence of three particular varieties or subspecies: *Lithobius microps exarmatus*, *L. tricuspis mononyx* and a variety of *L. forficatus*.

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SYMPHYLA - SYMPHYLANS

(DWERGPOTIGEN - SYMPHYLES - ZWERGFÜSSER)

Small (less than 1 cm), mainly white and blind myriapods; trunk with 14 segments, first 12 each with a pair of legs; penultimate segment with a pair of cerci; generally confined to moist areas; feeding on living or rotting vegetation; between 200 and 500 known species worldwide.

Questionnaire completed by Christian DÜKER (State Museum of Natural History, Görlitz).

At least five species have been recorded (various articles). Twenty additional species are expected based on the symphylans present in France, Germany and the Grand Duchy of Luxembourg. Taxonomic knowledge of this group is very poor and no representative collection nor an expert able to identify organisms to the species level were found in Belgium.

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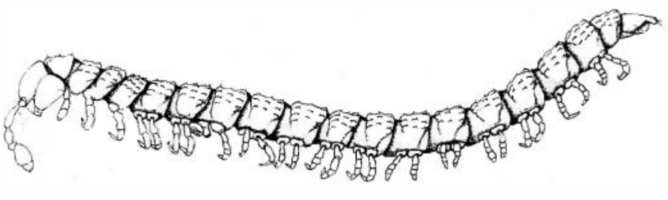
DIPLOPODA - MILLIPEDES

(MILJOENPOTEN - DIPLOPODES, MILLEPATTES - DOPPELFÜSSER, TAUSENDFÜSSER)

Most diverse group of myriapods characterised by the fusion of most trunk segments in pairs to form diplosegments, each with two pairs of legs; generally restricted to moist areas under logs and stones, and in leaf litter; mainly feeding on decaying vegetation; when disturbed, some species, called pill millipedes, curl up like pill bugs, while others spray or secrete toxic or irritating defensive substances; ca. 10,000 species described, while a total of up to 80,000 species is expected worldwide.

Questionnaire completed by Richard KIME (Royal Belgian Institute of Natural Sciences).

Fifty species have been recorded (unpublished species list). Less than ten additional ones are expected, based on the millipede species registered in neighbouring countries. Taxonomic knowledge of this group is good; a representative collection is housed in the Royal Belgian Institute of Natural Sciences. Since 1962, the species number has augmented by seven species thanks to an increase of the faunal knowledge. The highest diversity is found in Middle Belgium, followed by, in decreasing order of species richness, Upper Belgium and the Lorraine. Forests, and mainly the semi-natural ones, are of essential importance for the conservation of the millipede fauna. At the population level, up to 15 co-existing species were observed within 100 m^2 (KIME & WAUTHY 1984) and a maximum of 700 individuals were found within 1 m^2 (KIME 1992).



19

Until 25 years ago, very few records of the small diplopod *Macrosternodesmus palicola* in Belgium and adjacent countries existed. Recent fieldwork revealed the species to be widespread in calcareous localities (from BLOWER 1985, courtesy of The Linnean Society and The Estuarine and Coastal Sciences Association).

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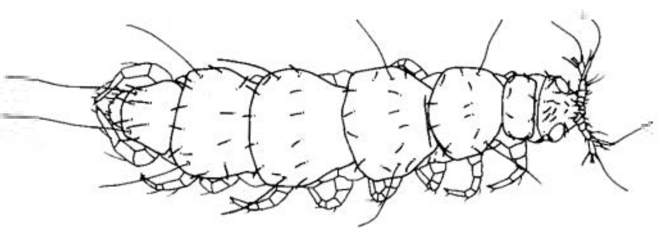
PAUROPODA - PAUROPODS

(PAUROPODEN, WEINIGPOTIGEN - PAUROPODES - WENIGFÜSSER, ZWERGTAUSENDFÜSSER)

Small (less than 2 mm), generally colourless, and thus largely unnoticed myriapods with a pair of legs on all 11 or 12 trunk segments, except on the first and last ones; frequently abundant in leaf litter and soil (up to 5 million individuals per ha); feeding on dead plant and animal matter, and on fungi; ca. 700 known species worldwide.

Questionnaires completed by Yasunori HAGINO (Natural History Museum and Institute, Chiba, Japan) and Walter HÜTHER (independent expert, Germany), with the contribution of Ulf SCHELLER (independent expert, Sweden).

Eleven species have been recorded (REMY 1940, with species list). Based on their presence in neighbouring and Central European countries, 11 to 25 additional species may occur. Taxonomic knowledge is considered to be poor to moderate. No Belgian expert able to identify organisms to the species level was found. A representative collection (REMY collection) is housed in the 'Muséum National d'Histoire Naturelle', Paris.



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Stylopauropus (*S.*) *pedunculatus* (LUBBOCK, 1867) is one of the most widely distributed pauropod species, occurring in Europe, Africa, Asia, North America and Australia. This soil dweller, living in leaf litter, under stones and logged wood, has a body length of around 1.5 mm (drawing by Y. HAGINO).

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CRUSTACEA - CRUSTACEANS

(SCHAALDIEREN, KREEFTACHTIGEN - CRUSTACÉS - KREBSTIERE)

Mostly aquatic arthropods with gills; body with dorsal carapace; appendages biramous and modified for collecting food, swimming, walking, respiration and reproduction; sexes usually separate; development with nauplius stage; most are free-living, some sessile and a few parasitic; fossil record dates back to the Cambrian; ca. 40,000 species known worldwide.

CLADOCERA - WATER FLEAS

(WATERVLOOIEN - PUCES D'EAU - WASSERFLÖHE)

Relatively primitive crustaceans with completely enclosed body by an uncalcified shell (or carapace) and with five or six trunk limbs used for feeding and respiration; post-abdomen has a series of denticles along the dorsal margin, lateral setae and a terminal pair of claws; making up a large portion of freshwater zooplankton; one of the secrets for their success is the mode of reproduction; when conditions are good, the females parthenogenetically produce more females every two or three days; when environmental conditions become adverse, these females produce sexually active males and females which together produce fertilised eggs called ephippia; these are extremely resistant to cold and drying and can be transported to new habitats by wind or in mud that clings to other animals; global number of observed species for this group range from 500 to 600; this number will increase considerably in the near future because of ongoing order reviews and a quickly evolving group taxonomy.

Questionnaire completed by Henri DUMONT (Ghent University).

Eighty species have been observed, four of which are considered as introductions. Up to five additional species are expected, mainly in the southern part of the country. Since DUMONT's species list (1989), six additional species (*Alona rustica*, *Eurycercus glacialis*, *Bythotrephes longimanus*, *Moina micrura*, *M. weismanni* and *Simocephalus serrulatus*) were discovered (synthesis on additional species in FORRÓ *et al*. 2003). Lower Belgium, including the Kempen, shows the highest species diversity. No significant increase or decrease in species number occurred during the last decades. Taxonomic expertise of this group is considered to be good and some six to eight Belgian experts able to identify organisms to the species level were identified. A representative collection is managed by the Ghent University.

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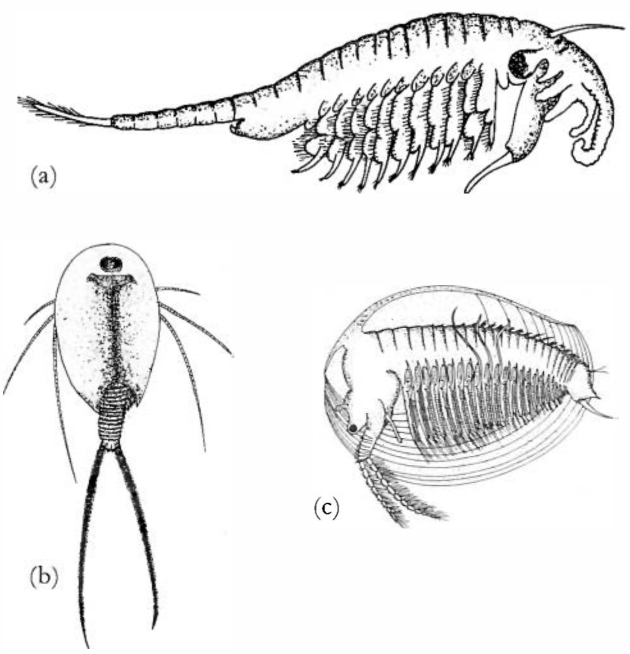
'PHYLLOPODA - PHYLLOPODS, LARGE BRANCHIOPODS or LEAF-FOOTED CRUSTACEANS'

(KIEUWPOOTKREEFTEN - GRANDS BRANCHIOPODES - BLATTFUSSKREBSE, URZEITKREBSE)

The term 'Phyllopoda' is considered to have no taxonomic value, but is still used for descriptive purposes when referring collectively to the Anostraca, Notostraca and Conchostraca. Large and diverse group of relatively primitive crustaceans; flattened and leaf-like limbs on the thorax used for respiration, locomotion and feeding; abdominal limbs are generally reduced in number or lacking; dormant embryos able to survive extremely unfavourable circumstances are produced during adverse periods; ca. 410 species described worldwide, many more to be discovered.

Questionnaire completed by Luc BRENDONCK (Catholic University of Leuven).

Seven species have been recorded (BRENDONCK 1989) and two additional ones are expected (HÖDL & RIEDER 1993). However, except for the recent finding of an introduced conchostracan species (*Leptestheria dahalacensis*), which seems to have vanished in the meantime, and the observation of a population of *Chirocephalus diaphanus*, destroyed shortly afterwards because of the hardening of the location, no phyllopods have been collected since 1959. This group is considered to be taxonomically well known in Belgium and collections are housed in the Royal Belgian Institute of Natural Sciences and the Zoological Museum of the University of Liège. Middle Belgium shows the highest species richness, followed by Lower Belgium and the Hautes Fagnes (BRENDONCK 1989, LONEUX & THIERY 1998). Habitats essential for the survival of these species are temporary pools, loam pits and ditches (BRENDONCK 1989).



21

Examples of (a) an anostracan, *Chirocephalus diaphanus*, (b) a notostracan, *Triops cancriformis*, and (c) a conchostracan, *Limnadia lenticularis*. These three species were once present in Belgium but their present status is unknown (drawings by L. BRENDONCK).

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OSTRACODA - OSTRACODS

(MOSSELKREEFTEN, OSTRACODEN - OSTRACODES - MUSCHELKREBSE, OSTRACODEN)

Oligomeric aquatic crustaceans fully enclosed in a calcified bivalved carapace; most are less than 1 mm in carapace length; locomotion by swimming or by crawling over the substratum; widely distributed in all aquatic environments; fossil record is expected to go back to the Ordovician; ostracods are of proven value for interpreting geologic age, depth, salinity and other parameters of sedimentary rocks; 9,000 living species worldwide and many more to be discovered.

Questionnaire completed by Karel WOUTERS (Royal Belgian Institute of Natural Sciences).

Following WOUTERS (1989) and MEISCH *et al.* (1990), both with partial species lists, and ATHERSUCH *et al.* (1989), 76 freshwater and 29 marine species have been observed. Up to 60 additional species are expected (ATHERSUCH *et al.* 1989, MEISCH 2000).

For Belgium and the neighbouring countries, taxonomic knowledge of this group is considered to be moderate. The highest species richness in Belgium is found in the marine zone, followed by the creek area and Lower Belgium. Middle and Upper Belgium and the Lorraine seem to be characterised by a lower species diversity, but this may be due to a lower sampling effort. A representative collection is housed in the Royal Belgian Institute of Natural Sciences.

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COPEPODA - COPEPODS

(ROEIPOOTKREEFTEN - COPÉPODES - RUDERFÜSSKREBSE)

Maxillopodan crustaceans characterised by the presence of a head shield and the absence of a carapace and abdominal appendages; often possessing a single median eye; size ranging from 0.5 to 10 mm (a few exceptions are up to 30 cm long); occupying a wide range of aquatic and semi-aquatic habitats from the deepest part of the ocean up to 5,000 m above sea level in the Himalaya; some orders are parasitic on, or live in association with, a wide range of fishes and invertebrates; free-living forms are suspension feeders or predators; harpacticoids occur also as scavengers, algal grazers, etc.; ca. 13,000 species described, but this is considered to be only 10% of the total species number worldwide.

Questionnaire completed by Frank FIERS (Royal Belgian Institute of Natural Sciences).

Since these organisms are mainly studied in relation to their ecological niche, this overview of Belgian species will be subdivided into four categories: freshwater and semi-aquatic forms, marine benthic forms, marine pelagic forms, and parasitic and commensal forms.

So far, 84 species have been recorded in the freshwater and semi-aquatic environments (LINDBERG 1950, DUMONT 1989, FIERS & GHENNE 2000, ALEKSEEV *et al.* 2002, FORRÓ *et al.* 2003, all with partial species list). At least 15 additional species are expected as a result of several ongoing studies and revisions. Since 1950, the freshwater species number has augmented with 52%, or 42 species, as a result of increasing faunal knowledge. Upper Belgium, although less studied, shows the highest species diversity, followed by Middle Belgium and the Lorraine. Karst habitats and the interstitial environment of rivers are essential for the freshwater and semi-aquatic copepod fauna. Taxonomic knowledge of this group is considered to be moderate and two Belgian scientists are currently able to identify organisms to the species level. When neighbouring countries are included, the number of experts rises to ten. Representative collections are managed by the Royal Belgian Institute of Natural Sciences and the Ghent University.

Approximately 180 marine benthic species have been observed (HERMAN 1989, with partial species list). A considerable number of additional species can be expected based on the 515 species reported from the entire North Sea. As for the freshwater forms, two Belgian scientists are currently able to identify organisms to the species level and the expert number increases to almost ten when neighbouring countries are included. Apart from the North Sea, the tidal zone and estuarine areas show a considerable species richness, following investigations in neighbouring countries.

Fifteen marine pelagic species have been recorded (M'HARZI *et al.* 1998 with partial species list) and about 20 additional species are expected. Taxonomic knowledge of this subgroup is good and one Belgian scientist is currently able to identify organisms to the species level, together with the ca. ten experts in the neighbouring countries.

No real inventories of the parasitic and commensal copepod species in Belgium exist. Dozens of species are expected based on KABATA (1992) and GOTTO (1993). While no Belgian expert is able to identify parasitic and commensal copepods to the species level, up to ten European scientists do possess this expertise. For the parasitic and commensal species, as well as for the marine benthic and pelagic ones, no (representative) collection could be identified.

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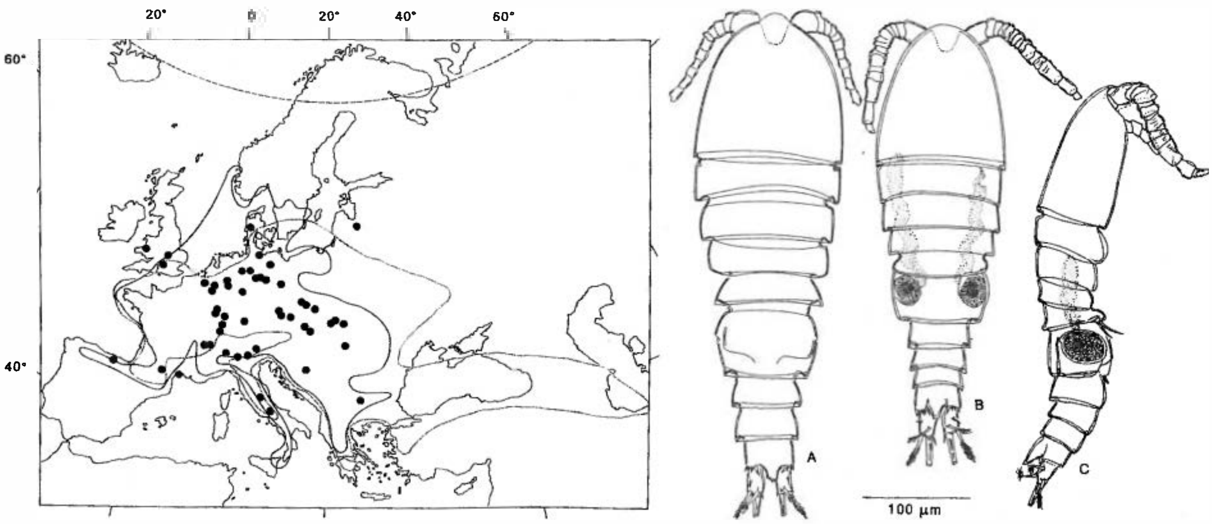

22

The minute, stygobiont cyclopoid *Graeteriella unisetigera* (GRAETER, 1908) belongs to the cryptozoic fauna in leaf litter (FIERS & GHENNE 2000). The distribution of this species in Europe shows a remarkable coincidence with the extension range of the beech (*Fagus sylvatica*). (a) Adult female, in dorsal view; (b) adult male, in dorsal view; (c) adult male, in lateral view (drawing by H. VAN PAESSCHEN).

BRANCHIURA - BRANCHIURANS or FISH LICE

(VISLUIZEN - BRANCHIOURES, POUX DE POISSONS - KIEMENSCHWANZKREBSE)

Highly specialised ectoparasitic crustaceans with paired compound eyes and 1-3 median simple eyes; living on marine and freshwater fish; attaching to host by maxillae, modified into suckers or grasping claws; flattened oval body and carapace provide streamlining to prevent detachment from swimming host; ca. 130 described species world-wide.

Personal communications by Geoff BOXSHALL (The Natural History Museum, London) and Geoffrey FRYER (Windermere, Cumbria).

In the freshwater environment, one species was recorded and two additional ones are expected. Only the genus *Argulus* has European representatives. The most widely distributed European species, *Argulus foliaceus*, is present in Belgium. Another common European species is *A. coregoni*, but, to our knowledge, it has not (yet) been observed in Belgium. It is unclear whether *A. japonicus*, which was introduced in Europe and shows a preference for fish monocultures (VAN DAMME 1985), has been observed in Belgium yet. If not, it is highly expected. Information on the possible presence of marine fish lice in Belgian waters is not available.

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TANTULOCARIDA - TANTULOCARIDS

Ectoparasitic marine crustaceans with highly modified body, consisting of a sacciform, unsegmented thorax and strongly reduced abdomen; both biramous and uniramous appendages present; parasitic on crustaceans, especially the deep-water forms; ca. 25 species described worldwide, but many more expected among others given the recent description (1983) of the taxon.

Personal communication by Geoff BOXSHALL (The Natural History Museum, London).

No species recorded but one to three species expected based on observations in adjacent waters. Specimens of the expected species are present in the Crustacea collection managed by The Natural History Museum in London.

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CIRRIPEDIA - CIRRIPEDS or BARNACLES
(RANKPOTIGEN - CIRRIPÈDES - RANKENFÜSSER, CIRRIPEDIEN)

Sessile, marine, filter-feeding crustaceans that live attached to rocks, floating objects, ships or animals; some are boring in calcareous substrates while others are parasitic; in the Thoracica, the most important and well-known group, the mantle is usually covered with calcareous plates; pedunculate barnacles are living attached by a tough, fleshy stalk, called peduncle (e.g. *Lepas*); in sessile barnacles (e.g. *Balanus*, *Verruca*), the stalk is reduced to a flattened basis and the calcareous plates completely surround the body; movable valves at the top can be opened to allow filter-feeding; parasitic and boring species are not covered with plates and show a reduced morphology; generally, thoracican barnacles, unlike the major part of the other crustaceans, are hermaphroditic; most boring and parasitic barnacles are dioecious; cross-fertilisation of their neighbours is generally the rule; ca. 800 species described worldwide.

Questionnaire completed by Francis KERCKHOF (Marine Ecosystem Management / RBINS).

Between 1830 and present, 28 species have been reported for the Belgian waters. Not all of them can be regarded as belonging to the Belgian fauna. Especially earlier workers often mentioned species brought in by fishermen, originating from remote fisheries. Other species have been found only occasionally (e.g. *Balanus reticulatus*, *B. trigonus*), but until now their establishment and permanent presence has not been observed. Yet other species can be regarded as vagrants. They reach the Belgian marine waters attached to floating objects, often with a southern origin (e.g. most Lepadomorpha, *Solidobalanus fallax*), or attached to stranded leatherback turtles (*Stomatolepas elegans*). They occur irregularly in Belgian waters where they are able to survive for some time.

Hence, at this moment, only 13 species are considered as belonging to the Belgian fauna. The Thoracica are dominantly present with ten species (8 Balanomorpha, 1 Lepadomorpha and 1 Verrucomorpha). A partial species list of this order can be found in VAN FRAUSUM 1989. The parasitic Rhizocephala are represented by two species (*Peltogaster paguri* and *Sacculina carcini*) and the boring Acrothoracica by one (*Trypetesa lampas*). Based on the recorded species in adjacent waters, recent studies (KERCKHOF & CATTRIJSSE 2001), the worldwide expansion of mainly Balanomorpha species and in-depth studies of the poorly investigated (parasitic) subgroups, three or four additional barnacle species are expected.

Introduced species, all Balanomorpha, play an important role in the Belgian barnacle fauna. Of the eight species belonging to the Belgian fauna, six are introduced through fouling or ballast water, and the expansion of the distribution area of some species normally occurring in more southern and warmer waters. *Elminius modestus*, for example, was originally native to New Zealand and Australia, but reached the groynes and piers of the Belgian coast via harbours in south-east England, and has now become the most common barnacle species of the Belgian fauna. Another example is *Balanus amphitrite*. This species, typical for warmer waters, is now very common in the harbour of Ostend and present on buoys and groynes. As hard substrata are important for the settlement of barnacles, the overall creation of artificial habitats, such as groynes and especially harbour installations, added to the success of the Balanomorpha.

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NEBALIACEA - NEBALIACEANS

(NEBALIA'S - NÉBALIES - MITTELKREBSE)

Small, marine, mud-dwelling crustaceans characterised by a large bivalved carapace, consisting of two halves joined by an adductor muscle, a rostral plate covering the head and a caudal furca or tail; suspension feeding on bottom sediments; ca. 20 species described worldwide.

Questionnaire completed by Jan MEES (Flanders Marine Institute) with the contribution of Ann DEWICKE and Bregje BEYST (both Ghent University).

Only one species, *Nebalia bipes*, is present in the Belgian part of the North Sea. This species, with a maximum length of 12 mm, occurs in coastal areas throughout the North Atlantic. No additional species are expected.

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BATHYNELLACEA - BATHYNELLACEANS

(FONTEINKREEFTEN - BATHYNELLACÉS - BRUNNENKREBSE)

Blind, elongated crustaceans with seven or eight pairs of legs (peraeopods), typically occurring interstitially in fresh water (exception made for one species living secondary in polyhaline conditions); length ranging from 0.5 to 3.5 mm; no carapace; thorax and abdomen differentiated; eight free thoracic segments, five pleomeric segments and a pleotelson (14 body segments); uropods well developed; occurring worldwide; Bathynellacea and Anaspidacea together form the Syncarida of which about 160 species are known worldwide.

Personal communication by Véronique GHENNE and Frank FIERS (both Royal Belgian Institute of Natural Sciences).

One species, *Antrobathynella stammeri* (JAKOBI, 1954), was discovered in August 2002 in the hyporheic of a small tributary of the river Meuse, where it occurs abundantly. A second population was found in November of the same year. The taxon Bathynellacea was expected to be present in Belgium, which is now confirmed. The specimens are deposited in the collections of the Royal Belgian Institute of Natural Sciences. One or two additional species are expected.

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STOMATOPODA - MANTIS SHRIMPS

(BIDSPRINKHAANKREEFTEN - STOMATOPODES - HEUSCHRECKENKREBSE, MAULFUSSKREBSE)

Marine, generally large (2-30 cm), raptorial carnivorous crustaceans typically occurring in shallow tropical or subtropical seas; living in individual burrows or in cracks or crevices from which they emerge to attack passing organisms; second thoracic limbs are specialised either to hold swimming prey (e.g. fish, prawns) or to club and crack shells or exoskeletons (e.g. molluscs, crabs); ca. 400 species described worldwide.

Questionnaire completed by Cees HOF (University of Bristol).

No species were recorded in Belgian waters until now, but one to three species are expected based on the occurrence of stomatopod larvae in the southern part of the North Sea and the Channel, the presence of adult specimens of *Platysquilla eusebia* along the Atlantic coast of France and of *Rissoides desmaresti*, which is now considered to belong to the British native fauna, before the coasts of England, Wales and the Netherlands. While taxonomic knowledge of this group in the neighbouring countries is good, no Belgian scientist with stomatopod expertise could be identified.

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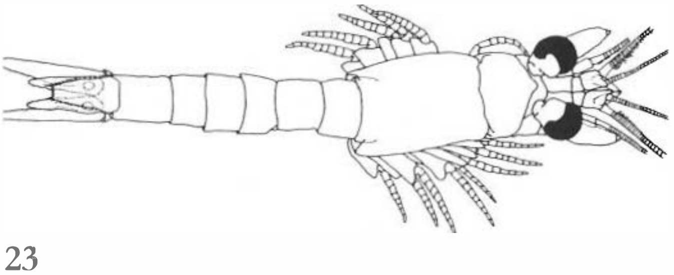
MYSIDACEA - MYSIDS or OPOSSUM SHRIMPS
(AASGARNALEN - MYSIDACÉS - SPALTFUSSKREBSE, SCHWEBGARNELEN)

Generally small and often extremely numerous crustaceans with well-developed carapace and stalked compound eyes; most species live in or on the substratum or swim in the shallow waters above; many mysids are filter-feeders, except for some scavenging benthic forms and species preying on zooplankton; female mysids have a large brood pouch in which the developing stages are retained before being released as juveniles; 1,022 species described worldwide.

Questionnaire completed by Jan MEES (Flanders Marine Institute).

So far, 19 species have been observed and up to six additional ones (TATTERSALL & TATTERSALL 1951) are expected. Apart from the North Sea, mysids are also present in the tidal zone, in brackish water pools and estuaries. Especially in the turbid brackish water zone of estuaries, extremely high densities of mysids are noted (MEES *et al.* 1993). Up to 1,000 individuals of *Neomysis integer* were found on 1 m^2 in brackish water pools. Taxonomic expertise of this group is good; a representative collection is housed in the Ghent University. Brackish water systems are of essential importance for *N. integer*.

In October 1999, in a brackish pond, the Ponto-Caspian invader *Hemimysis anomala* was observed for the first time in Belgium (VERSLYCKE *et al.* 2000), and in 2000 and 2001, the species was collected in the Meuse (VANDEN BOSSCHE 2002). Its invasion could have dramatic effects on the zooplankton composition and abundance, given its strong preference for cladocerans over copepods as prey. Further research is needed to demonstrate the impact of this invader on local ecosystems.



23

Hemimysis anomala (SARS, 1907), a species of Mysidacea initially only known from the Caspian and Black Sea. In October 1999, it was collected for the first time in Belgium. It was found in a brackish remainder pond, connected to the Westerschelde estuary via a sluice (from VERSLYCKE *et al.* 2000, courtesy of the Royal Belgian Society for Zoology).

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CUMACEA - CUMACEANS

(ZEEKOMMA'S - CUMACÉS - CUMACEEN)

Marine crustaceans occurring worldwide in predominantly benthic habitats; body length up to 35 mm; burrowing or constructing tubes in the sediment; feeding on organic matter in sediment or filter-feeding; swimming via anterior thoracic limbs, burrowing via posterior ones; they may periodically emerge from the sediment and gather in the water column in what are thought to be mating swarms; females incubate the eggs in a brood pouch; ca. 1,200 species worldwide.

Questionnaires completed by Ute MÜHLENHARDT-SIEGEL (Zoological Institute and Zoological Museum, Hamburg) and Jan MEES (Flanders Marine Institute), with the contribution of Ann DEWICKE and Bregje BEYST (both Ghent University).

So far, 12 species have been recorded. At least three and up to 15 additional species are expected, based on the cumacean fauna observed along the French and British coasts. *Pseudocuma gilsoni* is described from Belgian marine waters. The most important European collections on cumaceans are housed in the natural history or zoological museums of London, Paris and Copenhagen. This group is taxonomically well known in western Europe.

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TANAIDACEA - TANAIDACEANS or TANAIDS

(SCHAARPISSEBEDDEN - TANAIDACÉS - SCHEERENASSELN)

Marine crustaceans living in mucous tubes or burrows in muddy sediments beneath shallow waters; body length ranging from 0.5 to 20 mm; poor swimming and crawling abilities; some tanaidaceans secrete a thread or 'life line', facilitating return to the burrow or tube; some species are filter-feeders, but most are raptorial; sex change is common in this group: in many species, individuals begin life as females and breed once or more before molting to become functional males; females possessing a marsupial brood pouch; ca. 850 species described worldwide.

Questionnaires completed by Graham BIRD (independent expert, United Kingdom) and Marco FAASSE (independent expert, the Netherlands).

Three species have been recorded (two in HOLTHUIS 1950, one in VANOSMAEL *et al.* 1982) and nine additional species could occur based on their presence in adjacent French, Dutch and British waters. However, the species richness is expected to be relatively low because of the predominance of sandy or muddy substrates and the lack of influence from either warmer Lusitanean or colder Norwegian waters. At present, there seems to be no Belgian expert able to identify organisms to the species level. Representative collections for the European tanaidacean fauna are housed by The Natural History Museum in London and the Zoological Museum in Copenhagen.

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ISOPODA - ISOPODS

(PISSEBEDDEN - ISOPODES, CLOPORTES - ASSELN)

Dorsoventrally flattened crustaceans without carapace; body length from 0.5 to 500 mm (*Bathynomus giganteus*), although most species are less than 20 mm long; worldwide distribution and present in marine, freshwater and terrestrial habitats; varying feeding habits: isopods are predators, herbivores, saprovores or parasites; most have strong biting and chewing mouth parts, but parasitic forms are often adapted to suck the body fluids of their hosts; females incubate the eggs in a brood pouch; the fossil record, although limited, suggests that this group dates back to, at least, the Carboniferous; ca. 10,000 species worldwide.

Questionnaires completed by Karel WOUTERS (Royal Belgian Institute of Natural Sciences) for the terrestrial species and by Guido RAPPÉ (National Botanic Garden of Belgium) for the marine and brackish water species. Frank FIERS (Royal Belgian Institute of Natural Sciences) provided information on the freshwater species.

Thirty-three terrestrial species have been recorded (WOUTERS *et al.* 2000, with checklist of 30 species, one subspecies and one species of which the record is doubtful; LOCK & VANACKER 1999, LOCK & DURWAEL 2000 and LOCK 2001). Five species can be qualified as alien species. A cartography showing the distributional records of 30 terrestrial isopod species in Belgium is available in WOUTERS *et al.* (2000). The highest species richness is found in calcareous areas. Six additional species are expected following BERG & WIJNHOVEN (1997). The terrestrial isopods are taxonomically well known and a representative collection, including the marine and brackish water forms, is housed in the Royal Belgian Institute of Natural Sciences.

In the marine and brackish water environment, 31 species are recorded (RAPPÉ 1989, with species list) while 10 to 15 additional species may occur (GLAÇON 1977, HUWAE 1977). The highest species richness is found in the North Sea, followed by the tidal zone and the coastal area. The species *Prodajus ostendensis*, living parasitically on the mysid *Gastrosaccus spinifer*, is described from Belgian marine waters. If present trends persist, two marine species will have disappeared from Belgium during the following decades. The conservation of the brackish water environment is essential for the survival of some species.

Four freshwater species, two epigean and two hypogean, are known to occur in Belgium. Additional hypogean species might be present. *Proasellus hermallensis*, described from gravel beds of the river Meuse, is apparently endemic in the Meuse basin with four published localities in Belgium and one in the Netherlands (HENRY 1974).

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AMPHIPODA - AMPHIPODS

(VLOKREEFTEN - AMPHIPODES, PUCES DE PLAGE ou DE RIVAGE - FLOHKREBSE)

Laterally compressed malacostracan crustaceans with worldwide distribution; length usually ranging from 1 to 30 mm, with a few larger species; maximum length record: 340 mm; mostly marine, but a significant number of freshwater species and some semi-terrestrial and terrestrial ones occur; most amphipods are benthic, with free-swimming, crawling, burrowing, nestling, tubiculous and commensal forms; about 5% are pelagic; only a few species are parasitic; feeding modes are diversified: some are predators or scavengers, but detritivorous, grazing and filter-feeding forms are also well represented; as in the isopods, the eggs are incubated in a thoracic brood pouch; at least 7,500 species described worldwide.

Questionnaire completed by Claude DE BROYER (Royal Belgian Institute of Natural Sciences) with the contribution of Jan VANAVERBEKE (Ghent University). Additional notes provided by Marco FAASSE (independent expert, the Netherlands).

Following an unpublished checklist and database, 126 species have been recorded, subdivided in 100 marine and brackish water, ten subterranean, six freshwater, eight semi-terrestrial and at least two species found as ectoparasite or commensal on cetaceans stranded in Belgium (HAELTERS 2001). Following their occurrence in adjacent parts of the North Sea and on the invasive character of some freshwater amphipods, up to 120 additional species can be expected. Taxonomic knowledge of this group is moderate to good and a representative collection is housed in the Royal Belgian Institute of Natural Sciences. During the last decades, the number of recorded species increased slightly because of the further improvement of the faunal knowledge and the invasion of some species mainly coming from neighbouring countries.

Gammarus tigrinus and *Crangonyx pseudogracilis*, both originating from North America, and the Ponto-Caspian *Dikerogammarus villosus* (killer shrimp) and *Corophium curvispinum*, have been found rather recently in freshwater systems in Belgium. The southern European *Echinogammarus berilloni* (oldest observation dates back to 1925) and the Mediterranean and Ponto-Caspian *Orchestia cavimana* (around 1900) arrived earlier (VERCAUTEREN & WOUTERS 1999, VANDEN BOSSCHE 2002, WOUTERS 2002). *Caprella mutica*, originating from the West Pacific, was discovered in our coastal waters (FAASSE & KERCKHOF, in prep.). For Belgium, the highest species richness is found in the marine waters, followed, in decreasing order of amphipod diversity, by the freshwater fauna of Upper and Middle Belgium with the Sonian Forest. The conservation of subterranean waters of good quality is essential for stygobiont amphipods.

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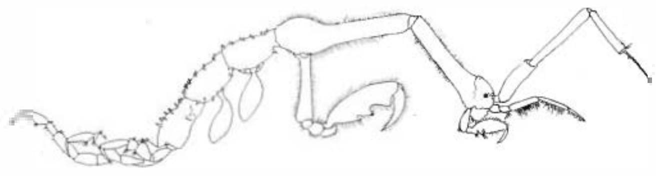

24

The caprellid amphipod *Caprella mutica* SCHURIN, 1935, a west Pacific species, recently discovered in Belgian and Dutch coastal waters (drawing by R. VAN OUTRYVE).

EUPHAUSIACEA - EUPHAUSIDS

(LICHTGARNALEN, KRILL - EUPHAUSIACÉS - LEUCHTKREBSE)

Marine, pelagic, shrimp-like crustaceans with shallow carapace, ranging from 40 to 150 mm in length; species often have wide longitudinal but restricted latitudinal distributions; sometimes exceedingly numerous, forming dense swarms; major food source for predators (e.g. fish, squid) and macro filter-feeders (e.g. baleen whales); are of increasing economic importance to humans; about 90 species described worldwide.

Questionnaire completed by Jan MEES (Flanders Marine Institute), with the contribution of Ann DEWICKE and Bregje BEYST (both Ghent University).

Only one species, *Nyctiphanes couchi*, has been recorded in Belgian marine waters. This species mainly occurs during winter but never displays high densities and thus cannot be regarded as an important food source for higher trophic levels. Based on MAUCHLINE (1984), no additional species are expected.

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DECAPODA - DECAPODS

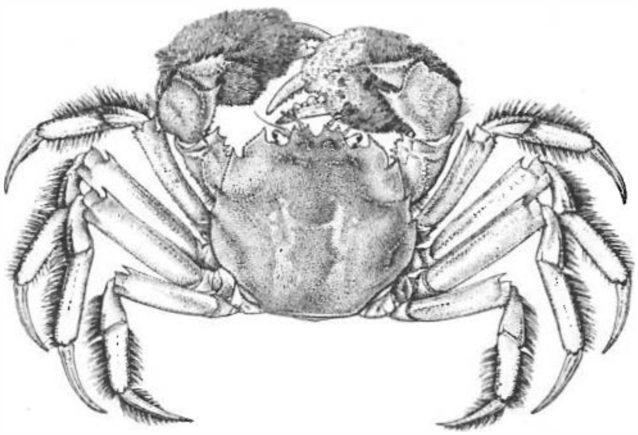
(GARNALEN, KRABBEN en KREEFTEN, TIENPOOTKREEFTEN - DÉCAPODES - ZEHNFUSSKREBSE)

Major and most conspicuous group of malacostracan Crustacea including crabs, lobsters, crayfish, hermit crabs (suborder Reptantia) and prawns (suborders Dendrobranchiata, Stenopodidea, Caridea, Eukyphida and Euzygida); possessing large carapace which covers head and thorax, and encloses gills; first three pairs of thoracic limbs are specialised for food handling; in all decapod species, the females brood the eggs, with the exception of the dendrobranch prawns which shed the eggs into the water; ca. 10,000 species are known worldwide.

Questionnaire completed by Cédric D'UDEKEM D'ACOZ (scientific associate, Royal Belgian Institute of Natural Sciences).

So far, 60 species have been recorded and 12 additional ones are expected. Both numbers are based on the collection '*Exploration de la Mer*' (assembled by G. GILSON 1899-1939 and housed in the Royal Belgian Institute of Natural Sciences), ADEMA (1991) and several small publications. Other collections are kept by the Zoological Museum of the University of Liège and the North Sea Aquarium in Ostend. The species number has augmented with six species since 1950 because of an increase of the faunal knowledge and the introduction of alien species. The highest species richness is found in the North Sea, followed by the tidal zone and Upper Belgium. Habitats with an essential importance for decapod species are running waters (GERARD 1986).

Since 1900, eight alien species have established more or less stable populations in Belgian waters. One example is the freshwater crayfish *Orconectes limosus*, originating from the eastern part of the USA, which is now by far the most common crayfish in Belgium. It is very resistant to pollution and a vector of the crayfish plague, which has a dramatic impact on European species. If present trends persist, the native species *Astacus astacus* will disappear from Belgium because of the crayfish plague, the competition with exotic species and the pollution and destruction of habitats (GERARD 1986). Other freshwater invaders are the southern European *Atyaephyra desmaresti* (probably first recorded in Belgium in 1895), the Turkish or narrow-clawed crayfish *Astacus leptodactylus*, the North American signal crayfish *Pacifastacus leniusculus*, the blue crab *Callinectes sapidus* (first Belgian record: 1981), the dwarf crab *Rhithropanopeus harrisii* (first Belgian record: 1985) and the Chinese mitten crab *Eriocheir sinensis* (first Belgian record: 1933) (WOUTERS 2002). Furthermore, Asian shore crabs of the genus *Hemigrapsus* are rapidly spreading along the European coasts, with a quickly expanding population in the southern part of the Dutch marine waters (D'UDEKEM D'ACOZ & FAASSE 2002, BRETON *et al*. 2002). In the near future, they can be expected in Belgian waters, with a possible negative impact on the native marine and estuarine fauna and flora.



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Male specimen of the Chinese mitten crab *Eriocheir sinensis* H. MILNE EDWARDS, 1854 (carapace width: 8 cm). This species was observed for the first time in Belgium in 1933. Until the early 1950s, it was a common to very common species in estuarine and inland waters; afterwards it disappeared almost entirely. Since the 1980s, it has gradually reappeared along the coast and in the basins of the rivers Yser and Scheldt, even in lowland canals, smaller rivers and isolated ponds (drawing by V. LECLERCQ, © RBINS).

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PENTASTOMIDA - TONGUE WORMS or PENTASTOMIDS

(TONGWORMEN - PENTASTOMIDES - ZUNGENWÜRMER, PENTASTOMIDEN)

– Small group of vermiform parasites with unsegmented body, ringed externally and legless; living in the respiratory tracts of reptiles and also some mammals and birds; body highly reduced, up to 15 cm long, males are usually much smaller; mouth lies between two pairs of retractable claws used to cling to the respiratory epithelium; several species occasionally infect the human nasal passages, but usually without causing symptoms; ca. 110 species worldwide.

Questionnaire completed by John RILEY (University of Dundee).

No Belgian pentastomid records are known to us, although at least three species are expected to occur. *Reighardia sternae*, a parasite occurring in the air sacs of seagulls, was recorded among others in the Netherlands and will almost certainly occur in

Belgium. *Reighardia lomviae* is found in the air sacs of guillemots (*Uria aalge*) and puffins (*Fratercula arctica*) and is also expected to occur. Adults of *Linguatula serrata* parasitise the nasal sinuses of foxes (*Vulpes vulpes*) and possibly domestic dogs (*Canis familiaris*), while intermediate stages are found in grazing animals such as rabbits, hares and sheep. This species is also expected to occur although it will probably be less common than the two bird-parasitising species. No Belgian expert able to identify organisms to the species level was found and taxonomic knowledge is lacking.

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ANNELIDA - SEGMENTED WORMS or ANNELIDS

(RINGWORMEN, GELEDE WORMEN - ANNELIDES, VERS ANNELÉS - RINGELWÜRMER)

Segmented, coelomate worms with a body wall consisting of both circular and longitudinal muscle fibres; transparent, moist cuticle covers body; all annelids except leeches have chitinous hair-like structures, called setae; fossil record goes back to the Cambrian, maybe to the Precambrian; include the Polychaeta, 'Archiannelida', Hirudinea and Oligochaeta.

POLYCHAETA - BRISTLE WORMS or POLYCHAETES

(BORSTELWORMEN, VEELBORSTELIGEN - POLYCHÈTES - VIELBORSTER, BORSTENWÜRMER)

By far the most extensive class of annelids; inside and outside segmentation; possessing parapodia and numerous setae; present in every marine habitat, uncommon in fresh water, some are parasitic; polychaetes are a dominant component of the macrobenthos of many marine habitats, and in some areas they dominate the biomass; most polychaetes are burrowers in sand or mud (sand worms, tube worms), with appendages for feeding; other bristle worms are errant and tend to have well-developed eyes and sensory appendages; finally, some polychaetes have a permanently pelagic existence and often predate on plankton; ca. 9,000 species described worldwide, at least 10,000 additional species to be expected.

Questionnaire completed by Markus BÖGGEMANN (Johann Wolfgang Goethe University, Frankfurt). Additional information from Ingrid KRÖNCKE (Research Institute Senckenberg) and Jan GOVAERE (Royal Belgian Institute of Natural Sciences).

Based on HARTMANN-SCHRÖDER (1996), and BÖGGEMANN (1998), some 450 species are expected. The vast majority occur in the marine zone, although a few species are expected in brackish water, and most species live in or on the sediment. The number of recorded species is uncertain and probably lies between 200 and 250 (pers. comm. J. GOVAERE). There is a lack of published overviews on the Belgian polychaetes. Up to 1995, some 160 species were recorded in the Netherlands. Only one expert able to identify organisms to the species level could currently be identified in Belgium. Since 1970, the number of recorded species in western Europe has increased by some 30%. There seems to begin a trend of intruding species from warmer waters. The Ponto-Caspian *Hypania invalida* is an example of a recent introduction. It was first recorded in the Meuse in 2000 (VANDEN BOSSCHE 2002) and seems to have already reached Antwerp via the Albert Canal (pers. comm. T. VERCAUTEREN).

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'ARCHIANNELIDA - ARCHIANNELIDS'

(ARCHIANNELIDEN - ARCHIANNELIDES - URRINGELWÜRMER)

This category was created for a group of generally minute annelids, presumed to be primitive because of their simple body structure. This simple morphology is now regarded as secondary and related to the interstitial habitat of the animals. Most archiannelidan families, and the ca. 50 encompassed species, are to be transferred to the Polychaeta and the category 'Archiannelida' should be eliminated (WESTHEIDE 1990). *For additional general features, see under Polychaeta.*

Questionnaire completed by Wilfried WESTHEIDE (University of Osnabrück).

As for the Polychaeta, the number of recorded species of this group in Belgium is uncertain (but probably very low) because of fragmented data (eight species recorded in the Netherlands). Some 20 species should occur based on WESTHEIDE (1990, with species list), while up to five additional species could be expected. All species belong to the interstitial marine meiofauna. Species of the families Nerillidae and Protodrilidae probably dominate this group in Belgium. Habitats with essential importance for the survival of these species are sandy intertidal and subtidal areas, especially the coarse sand areas without much detritus.

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HIRUDINEA - LEECHES

(BLOEDZUIGERS - SANGSUES, HIRUDINÉES - BLUTEGEL, HIRUDINEEN)

Blood-sucking, hermaphroditic annelids possessing chitinous jaws, a cocoon-secreting clitellum and a fixed number of somites; body usually flattened dorso-ventrally, lacking setae, parapodia or tentacles; usually with anterior and posterior suckers for attachment to host and locomotion; predators, ectoparasites or scavengers; usually occurring in fresh water, some species in the marine or terrestrial environment; ca. 500 described species worldwide.

Questionnaires completed by Eike NEUBERT (Forschungsinstitut und Naturmuseum Senckenberg) and Wilfrida DECRAEMER (Royal Belgian Institute of Natural Sciences).

Nineteen species have been recorded, two of which were found on imported marine fish species (VERRIEST 1950, DE PAUW & VERRIEST 1963, MAQUET 1985). Additionally, one marine species for Belgium is mentioned in NEUBERT & NESEMANN (1999). Some more species are expected following their presence in neighbouring countries. Information on general trends is not available. The well-known *Hirudo medicinalis* has become rare (MAQUET 1985), although this author adds that more sampling of freshwater bodies is required. It is the only vermiform species protected by the Bern Convention. In general, taxonomic knowledge of this group in Belgium is considered insufficient, similar to most parts of Europe, and it would be recommended to build a Hirudinea collection covering all types of freshwater systems (pers. comm. E. NEUBERT). A number of leech species occurring in Belgium are part of the collections of the natural history museums of Budapest, London and Senckenberg. Habitats essential for the survival of leeches are fast running waters characterised by natural conditions and potamic biotopes with natural shore conditions.

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OLIGOCHAETA - EARTHWORMS and AQUATIC OLIGOCHAETES

(REGENWORMEN en ZOETWATERBORSTELWORMEN, WEINIGBORSTELIGEN - VERS DE TERRE et OLIGOCHÈTES AQUATIQUES - WENIGBORSTER)

Recently, Oligochaeta and Hirudinea have been joined in the taxon Clitellata (MARTIN 2001). Hermaphroditic annelids with inside and outside segmentation; possessing a clitellum and few setae, but no parapodia; new segments added throughout life; two-third of the species are earthworms (terrestrial species usually burrow in moist soils); many species in fresh water, a few hundred in the marine environment, some are parasitic; ca. 6,000 described species worldwide.

Questionnaires completed by Guy JOSENS (Université Libre de Bruxelles) for the terrestrial species and by Patrick MARTIN (Royal Belgian Institute of Natural Sciences) for the aquatic species.

Up to 1999, 52 species were recorded in the marine and freshwater environments (MARTENS 1989, MARTIN 1992, both with partial species list). In June 2000, a new species for the Belgian fauna, *Vejdovskyella comata*, was found in a small lake in Vosselaar, Province of Antwerp (VERCAUTEREN *et al.* 2001). The aquatic fauna is dominated by the families Naididae (27 species) and Tubificidae (17 species). Some 20 additional species are expected, based on the oligochaete fauna of the Netherlands (MOL 1984). Taxonomic knowledge of the aquatic oligochaetes is considered to be moderate, and a representative collection on the Belgian species and information on trends are lacking. For the aquatic species, the highest richness is found in Middle and Upper Belgium (excl. the Hautes Fagnes) and the Lorraine, while Lower Belgium and the Hautes Fagnes show a lower diversity. Few species have been recorded in the Belgian marine waters.

In the terrestrial habitats, 33 species have been recorded (BOUCHÉ 1978, TÉTRY 1940, both with partial species list), of which nine belong to the Enchytraeidae, a family with terrestrial, aquatic and amphibian species. The subspecies *Lumbricus castaneus rubelloides* is only known in Belgium. At least six additional species are expected based on their presence in neighbouring countries. The terrestrial oligochaete fauna is relatively well known, but information on trends is not available because of the lack of historical data. The species richness is linked to the soil and humus type and the oligotrophic forest soil is identified as a crucial habitat for earthworm species. Three introduced species were found in Brussels and at least one additional species, used in lumbriculture, would be able to survive in natural conditions. As well as for the aquatic species, a representative collection of the terrestrial species present in Belgium is not available.

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SIPUNCULA - PEANUT WORMS

(SPUITWORMEN, PINDAWORMEN - SIPUNCULIENS - SPRITZWÜRMER)

Bilaterally symmetrical, unsegmented marine worms possessing a retractile anterior body part, called introvert, with tentacles; adults usually sessile, often burrowed in sediment or coral; length up to 1 m; present at all depths from intertidal to abyssal; different feeding methods are used in different habitats; ca. 300 described species worldwide and additional ones expected.

Questionnaires completed by José SAIZ SALINAS (University of the Basque Countr

Bilbao), Peter GIBBS (UK Marine Biological Association) and Edward CUTLER (Harvard University, Cambridge).

So far, three species have been recorded (WESENBERG-LUND 1933). Some nine additional species are expected following their distribution in the Atlantic, among others along the coasts of France, Germany and England. In Belgium, taxonomic expertise of this group is very poor and no expert able to identify organisms to the species level could be identified. Specimens of the three observed as well as of three of the expected species are present in the collection of the Royal Belgian Institute of Natural Sciences. Specimens of these and other sipunculan species possibly occurring in Belgian waters are present in the collections of the 'Musée National d'Histoire Naturelle', Paris.

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ECHIURA - SPOON WORMS

(SLURFWORMEN, STERWORMEN - ÉCHIURIDÉS, ÉCHIURES - RÜSSELWÜRMER, IGELWÜRMER)

Unsegmented marine worms with smooth or warty body, sometimes with setae; general body shape cylindrical or ovoid with typical, flattened or grooved, proboscis, which is highly extensile (up to 1-2 m for spoon worms with body size of 40 cm); adults sessile, burrowed in sediments or living in abandoned shells or in rubble; present at all depths from intertidal to abyssal; ca. 140 species described worldwide.

Questionnaire completed by José SAIZ SALINAS (University of the Basque Country, Bilbao).

One species, *Echiurus echiurus*, has been recorded (WESENBERG-LUND 1933) and three additional ones are expected (SAIZ SALINAS 1987). In Belgium, knowledge of this group is very poor, information on trends is not available and no scientist able to identify organisms to the species level could be identified. In the neighbouring countries, collections of spoon worms with species occurring in the Belgian marine waters are housed in the natural history museums of London and Paris.

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MOLLUSCA - MOLLUSCS

(WEEKDIEREN, MOLLUSKEN - MOLLUSQUES - WEICHTIEREN)

Highly successful phylum; unique rasping organ called radula; ventral muscular foot; fleshy mantle which surrounds the soft parts, encloses the mantle cavity, secretes the calcareous shell and forms the siphons; respiration by ctenidia (molluscan gills) or by diffusion through the skin, often via specialised epithelium in the mantle cavity; reproduction gonochoristic or hermaphroditic; very old group with continuous fossil record since the Cambrian; most species are marine, only two classes (Gastropoda and Bivalvia) also with freshwater species; only the Gastropoda invaded land; adult size ranging from 0.35 mm (Gastropoda: Omalogyridae) up to 22 m (Cephalopoda: Architeuthidae); number of described species worldwide is often underestimated; recent estimates range in the order of 95,000-108,000 species; ca. 200,000 is a realistic figure of currently living species; generally eight classes recognised of which five present in Belgium: Polyplacophora, Gastropoda, Bivalvia, Scaphopoda and Cephalopoda, totalising ca. 320 species; species of the classes Caudofoveata and Solenogastres could be expected in the Belgian marine waters (pers. comm. L. VON SALVINI-PLAWEN).

A database with historical and recent mollusc records and a major reference collection of the terrestrial, freshwater, marine and brackish water species occurring in Belgium are present in the Royal Belgian Institute of Natural Sciences. Many private collections of varying importance exist.

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POLYPLACOPHORA - CHITONS

(KEVERSLAKKEN - CHITONS, POLYPLACOPHORES - KÄFERSCHNECKEN)

Distinct group of elongated, bilaterally symmetrical marine molluscs characterised by a mantle bearing eight transverse, articulating plates and calcareous or chitinous spicules or bristles; most species are intertidal grazing herbivores; a flattened foot clamps the animal firmly to the hard substratum; when disturbed, the foot and mantle edge create suction, making it hard to dislodge the animal; so far, 890 species have been described worldwide, the real number could be the double of this.

Questionnaire completed by Richard VAN BELLE (Royal Belgian Institute of Natural Sciences). Additional information by Bruno ANSEEUW and Yves TERRYN (both scientific associates to the RBINS).

Six species recorded (BACKELJAU 1986), all but one are considered to be c
sional introductions. Only *Leptochiton asellus* seems native in the Belgian n

waters. Specimens of *Lepidochitona cinerea* are occasionally found. *Acanthochitona communis* and *A. crinita* are probably accidental introductions through the import of mussel and oyster spat. Taxonomic knowledge of this group is very good. Three naturalists follow in the footsteps of E. LELOUP in studying this group worldwide. Chiton species occurring in Belgian and adjacent waters are present in the collection of the Royal Belgian Institute of Natural Sciences of which the R. VAN BELLE collection is part.

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GASTROPODA - SNAILS and SLUGS

(SLAKKEN en NAAKTSLAKKEN - LIMAÇONS et LIMACES, GASTÉROPODES, GASTROPODES - SCHNECKEN und NACKTSCHNECKEN)

The largest and most diverse molluscan class, being present in nearly all aquatic and terrestrial environments; basically bilaterally symmetrical, but by torsion the visceral mass has become asymmetrical; radula very diverse with up to 100,000 teeth in some taxa; typically possess one, mostly coiled shell, although it is reduced in some groups and even absent in many marine and terrestrial species (slugs); foot is usually prominent and used for crawling, is greatly reduced in sedentary forms but enlarged in burrowers; an operculum is carried on the postero-dorsal surface of the foot in many marine, few terrestrial/freshwater species; many pulmonates and opisthobranchs display complex mating behavior; between 80,000-90,000 species described worldwide; at least equally more to be discovered, especially in terrestrial habitats.

Questionnaire completed by Thierry BACKELJAU (Royal Belgian Institute of Natural Sciences) for the marine species, by Rose SABLON (id.) for the brackish and freshwater species and by Harry VAN LOEN (id.) for the terrestrial species. Additional information by Jackie VAN GOETHEM (id.).

Some 120 species are present in the terrestrial environment (VAN GOETHEM 1989), 29 of which belong to two families: Hygromiidae and Helicidae. Some 10 alien species can be expected, even a few native ones also to be discovered. Middle Belgium, especially the Condroz and the Fagne-Famenne region, shows the highest species richness, followed by the Lorraine region, Upper Belgium, Lower Belgium and the coastal area (MARQUET 1982). Taking 1950 as a baseline, some 50 terrestrial species show a severe decline in Belgium (MARQUET *et al.* 1987, VAN GOETHEM *et al.* 1987) because of the destruction and drying out of habitats, fragmentation, acidification and eutrophication. If present trends persist, minimum 10% of the current species richness in terrestrial habitats is expected to disappear from Belgium during the following decades. Since 1900, 12 species have been introduced. The appearance of alien species has been recorded in detail since the 1960s (e.g. *Boettgerilla pallens*, *Deroceras caruanae*, *Arion lusitanicus*). Habitats important for the survival of stenoecious species are marshy areas, river banks, dunes and calcareous grasslands (ANTEUNIS 1956, MARQUET 1982).

Sixty freshwater species are recorded (VAN GOETHEM 1989) and some ten additional ones are expected. Almost 20 freshwater species have been introduced since 1900. The species richness of the freshwater fauna is highest in Middle Belgium, followed by Lower Belgium and Upper Belgium. Stagnant fresh water shows a higher species richness than running waters. These two ecosystem types hold clearly distinct faunas. For the recently studied sites, the species number seems to stay about the same when comparison is made with historical data. Shallow ditches bordering pastures and arable fields, and small temporary pools are identified as important habitats for the conservation of some particular species.

Some 40 gastropod species form stable populations in the marine and brackish habitats (BACKELJAU 1986, with species list) and a rough estimation of ten additional species is suggested. Since newly settling species and vanishing ones seem to compensate each other, the species number in the Belgian marine waters remains about the same. Habitats with special importance for the marine gastropod fauna are groynes, piers and ship wrecks, as well as the scarce and highly threatened brackish water habitats. Man-made constructions have enriched the marine, littoral mollusc fauna, which otherwise would mostly comprise soft substratum species. A striking example of an introduced species with a stable population is *Crepidula fornicata* (slipper limpet). A recent survey of the fauna on buoys in Belgian marine waters revealed several species new to the country's fauna such as *Pusillina inconspicua*, *Crisilla semistriata* and *Odostomia plicata* (KERCKHOF, in prep.). One species, *Nucella lapillus* (dog whelk), became extinct because of the presence of the antifouling agent tributyltin (TBT) in the environment (KERCKHOF 1988).

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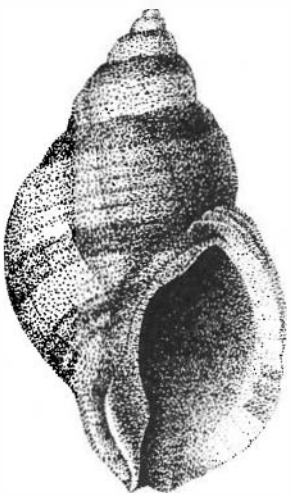

26

Nucella lapillus (LINNAEUS, 1758), dog whelk or Atlantic dogwinkle. Solid shell, up to 35 mm in length, very variable in colour. On rocky shores, groynes and pier piles. Feeds on barnacles and mussels. Atlantic coast from Norway to N. Africa and east coast of N. America. Seems to have disappeared in Belgium due to chemical pollution, in particular TBT antifouling paints (drawing by DE WESPIN, © RBINS).

BIVALVIA - BIVALVES

(TWEEKLEPPIGEN - BIVALVES - MUSCHELN)

Molluscs possessing a shell with two valves, articulated dorsally by a shell hinge complex (typically containing a ligament and cardinal and lateral teeth); most of the species are filter-feeding; gills generally well developed and plate-like; body strongly compressed laterally, lacking tentacles, eyes (except for scallops and some others) and radula; inhalant and exhalant siphons present; foot well developed in species that burrow in sand or mud, but reduced, vestigial or absent in attached forms; other methods of locomotion are creeping, swimming, climbing and boring; between 12,000 and 15,000 species described worldwide.

Questionnaires completed by Thierry BACKELJAU (Royal Belgian Institute of Natural Sciences) for the marine species and by Rose SABLON (id.) for the brackish and freshwater species.

Forty brackish and freshwater species have been recorded (VAN GOETHEM 1989, with species list) and at least five additional ones are expected. The freshwater bivalve fauna is well known but information on trends is lacking. Lower, Middle and Upper Belgium have an equal and high species richness, followed by the tidal and coastal zones and the Belgian Lorraine (ADAM 1960). Stagnant and running waters have an equally high but distinctly composed faunal richness. The conservation of relatively pure and non-calciferous rivers (e.g. for *Margaritifera margaritifera*), mainly in Upper Belgium, and of non-polluted small pools, particularly in agricultural areas, is of significant importance for the survival of many bivalve species. Freshwater clams from the families Unionidae and Margaritiferidae release larvae, called glochidium, that need attachment to certain fish species in order to parasitise for several weeks. This facilitates dispersal of the species. *Dreissena polymorpha, Corbicula fluminea* and *C. fluminalis* are examples of alien species invading freshwater habitats, including cooling, pumping and/or cleaning installations, causing significant economic impact. Recently, two exotic species of the genus *Anodonta* have been found in ponds in Flanders.

Approximately 30 bivalve species form stable populations in the Belgian marine waters and some ten additional species are also expected to be established or in process to do so (BACKELJAU 1986, with species list). As well as for the marine gastropods, the species number remains more or less constant because of compensating numbers of vanishing species and new settlings. Habitats with special importance are groynes, piers and ship wrecks, as well as the scarce and highly threatened brackish water habitats. Some examples of alien species that established stable populations are *Petricola pholadiformis* (American piddock or false angel wing) and *Ensis directus* (= *E. americanus*) (American jack-knife clam, SEVERIJNS 2002). On the other hand, the recent occurrence of *Lutraria lutraria* along the Belgian coast (VAN HAELEN & KERCKHOF 2003) is an example of a species native to the northwestern European fauna that has recently colonised Belgian marine waters.

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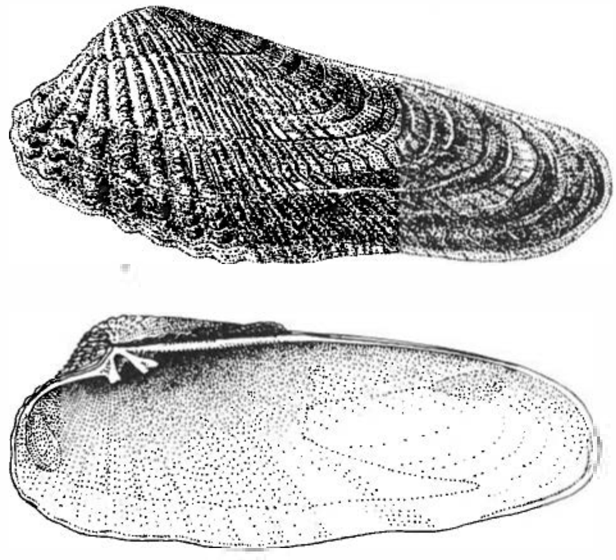

27

Petricola pholadiformis LAMARCK, 1818, American piddock. Thin, elongate shell, up to 65 mm in length, sculptured by numerous concentric lines crossed by more than 40 radiating ribs. Mechanical borer into clay and limestone, occurring from midtide level to low water. This exotic species was introduced from America around 1890 in the British Isles with American oysters, and, from there, colonised several N. European countries. In Belgium, it almost completely displaced the native piddock *Barnea candida* (drawing by J. VAN MELDEREN-SERGYSELS, © RBINS).

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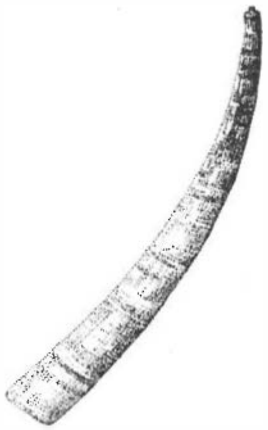
SCAPHOPODA - SCAPHOPODS, (ELEPHANT) TUSK SHELLS or TOOTH SHELLS

(OLIFANTSTANDEN, STOOTTANDEN, TANDSCHELPEN - DENTALES, SCAPHOPODES, DENTS MARINES - RÖHRENSCHALER, GRABFÜSSER)

Infaunal marine molluscs possessing a one-piece tubular shell open at both ends; reduced head without eyes, with radula; numerous (30-300) tentacle-like structures called captacula surround mouth and serve to capture prey; feed on a wide range of interstitial organisms; cylindrical foot for burrowing, water movement (respiration) and expelling gametes (spawning); ca. 600 species described worldwide.

Questionnaire completed by Thierry BACKELJAU (Royal Belgian Institute of Natural Sciences).

Two species, *Dentalium entalis* and *D. vulgare*, have been recorded (BACKELJAU 1986). *D. entalis* is only known from empty shells. Some living specimens of *D. vulgare*, probably imported through fishery activities, were observed at the Belgian coast. No additional species are expected. Taxonomic knowledge of this group is good, but information on trends is completely lacking. Shells of both species are present in the mollusc collection of the Royal Belgian Institute of Natural Sciences.



28

Dentalium vulgare (DA COSTA, 1778), common tusk. Shell up to 45 mm. As for *D. entalis*, the other scaphopod species recorded from Belgian marine waters, there is no evidence of stable populations (drawing by J. VAN MELDEREN-SERGYSELS, CORBINS).

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CEPHALOPODA - CEPHALOPODS or SQUIDS and OCTOPUSES

(INKTVISSEN - CÉPHALOPODES - KOPFFÜSSER, TINTENFISCHE)

Primarily swimming marine molluscs possessing two strong chitinous jaws and a radula; they include cuttlefish, squids, octopods and nautiluses as well as several important fossil groups like the ammonoids, nautiloids and belemnoids; shell usually with numerous chambers, but is most commonly internalised and reduced in living forms; absent in octopuses; mostly carnivorous; prehensile, muscular tentacles with suckers surround the mouth and assist in food capture, mating and locomotion; species of the genus *Nautilus* have 80-90 arms without suckers; most species are active swimmers, using reverse jet propulsion; escape response by producing an 'ink' cloud; copulation is often preceded by complex courtship which sometimes involve rapid attractant and warning colour changes in the skin; giant squids measure up to 22 m; ca. 900 species worldwide, several hundreds to be discovered.

Questionnaires completed by Thierry BACKELJAU (Royal Belgian Institute of Natural Sciences) and Uwe PIATKOWSKI (Institut für Meereskunde, Kiel).

Eight species have been recorded (BACKELJAU 1986, with species list) and five to nine additional species are expected (BACKELJAU 1986, SEAWARD 1990). Taxonomic knowledge of this group is good. W. ADAM (1909-1988) developed leading expertise during his long career at the Royal Belgian Institute of Natural Sciences. Information on trends in cephalopod occurrence is not available because of the scarcity and discontinuity of data. Representative collections are housed in the Royal Belgian Institute of Natural Sciences and in the natural history museums of London, Paris, Copenhagen and Hamburg.

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TARDIGRADA - WATER BEARS or TARDIGRADES

(BEERDIERTJES, MOSBEERTJES - TARDIGRADES - BÄRTIERCHEN)

Very small (body length from 0.1-0.5 mm, some species up to 1.7 mm), bilaterally symmetrical coelomates with four pairs of short, claw-bearing legs and a complex buccal apparatus for sucking liquid food; worldwide distribution, at elevations ranging from the Himalaya to the ocean abyss; slow creeping; mainly occurring in freshwater ponds and in water film on mosses, liverworts, etc., or in forest litter; other species interstitial in marine sediment or among shore algae; few species ectoparasitic on sea cucumbers, crustaceans and molluscs; many species use anabiosis and cryptobiosis when conditions are unfavourable, being able to survive temperatures near absolute zero (-270°C) and as high as 150°C; ca. 800 described species worldwide and many more to be expected.

Questionnaire completed by Willem DE SMET (RUCA, University of Antwerp).

Forty-five species have been recorded (HASPESLAGH 1989, VAN ROMPU & DE SMET 1995, 1998, all with partial species lists). Since 1958, the species number has augmented with 29 species thanks to an increase of the faunal knowledge. Some 100 additional species are expected based on DASTYCH (1988), SÉMÉRIA (1994) and MC INNES (1994). Taxonomic knowledge of this group is poor to moderate. No representative collection of species present in Belgium could be identified. For Belgium, the highest diversity is found in the terrestrial environment followed by, in decreasing order of species richness, running and stagnant fresh water and the marine environment.

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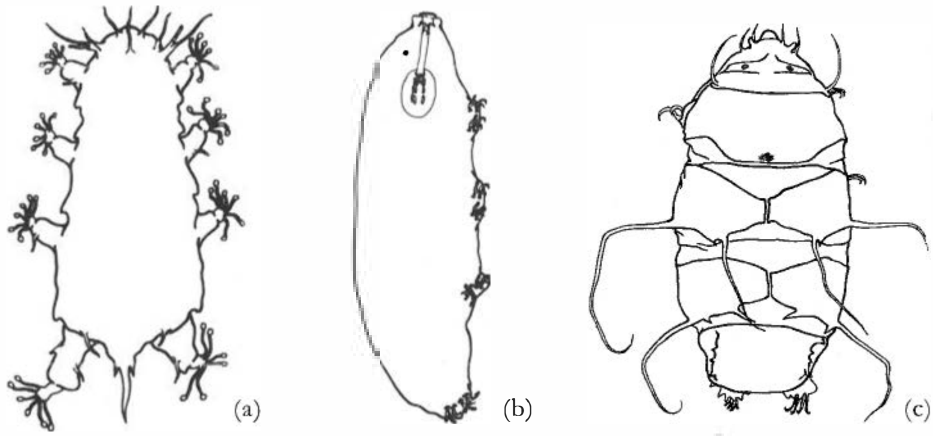

29

(a) A marine heterotardigrade, *Batillipes littoralis* (length: 180-230 µm), (b) a limno-eutardigrade, *Amphibolus weglarskae* (500-600 µm), and (c) a limno-terrestrial heterotardigrade, *Testechiniscus spitsbergensis* (170-500 µm), all three occurring in Belgium (drawings by E. VAN ROMPU).

ECTOPROCTA, BRYOZOA - MOSS ANIMALS, ECTOPROCTS or BRYOZOANS
(MOSDIERTJES - ECTOPROCTES, BRYOZOAIRES - MOOSTIERCHEN, EKTOPROKTE, BRYOZOEN)

Individually minute (less than 1.2 mm long) animals cloning themselves to form sessile colonies with a wide range of structures; all ectoproct colonies start as a single, sexually produced individual called ancestrula, which buds repeatedly to form a colony of interconnected genetic replicates; most species are marine but the class Phylactolaemata occurs exclusively in fresh water; feeding via lophophore; ectoproct fossils have been dated back as far as the early Ordovician; ca. 5,700 species recorded worldwide, of which 65 to 70 in fresh water.

Questionnaires completed by Jean-Loup D'HONDT (Muséum National d'Histoire Naturelle, Paris) for the whole Belgian ectoproct fauna, and by Gaby GEIMER and Jos MASSARD (Luxembourg University Centre) specifically for the freshwater species. Additional information on the marine Bryozoa from Hans DE BLAUWE (Strandwerkgroep).

Fifty species, 41 in marine and nine in freshwater habitats, have been recorded (LOPPENS 1948, with partial species list, LACOURT 1949, GEIMER & MASSARD 1986). Some 40 to 50 additional species, of which two or three in fresh water, are expected based on the ectoproct faunas of the United Kingdom, France and the Netherlands. During recent investigations, DE BLAUWE (pers. comm.) found 20 species living attached to substrate in Belgian marine waters and some 80 species washed up, mostly originating from the Channel. A major gap in Ectoprocta research is the sublittoral environment, where ship wrecks, gravel soils, stones and shell (grit) banks probably yield a rich and surprising bryozoan fauna.

Examples of alien species are *Tricellaria inopinata*, originating from the North Pacific Ocean, and *Bugula simplex*, first described from the Adriatic Sea. Both species were found in harbours and marinas, suggesting introduction by man (DE BLAUWE & FAASSE 2001). Taxonomic knowledge of Ectoprocta is considered to be moderate and collections holding species occurring in Belgium are housed in the natural history museums of Paris, London and Leiden. Based on his personal collection from Zeeland, Belgium and France, H. DE BLAUWE is preparing a reference collection to be deposited in the Royal Belgian Institute of Natural Sciences.

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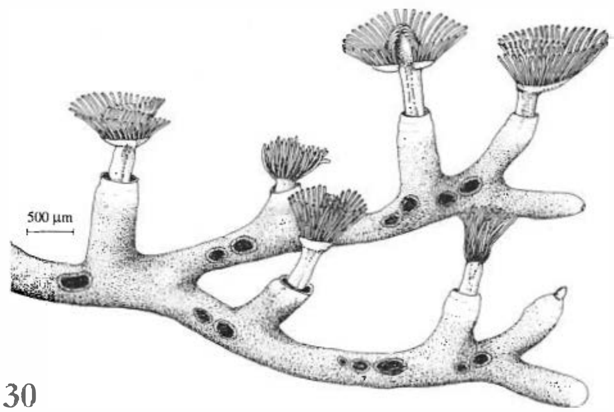


30

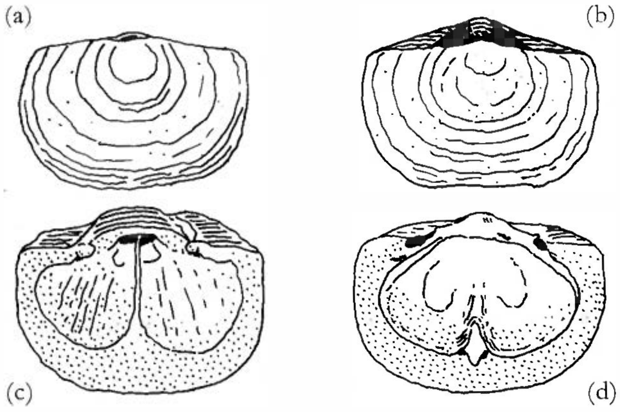
Part of a colony of *Plumatella repens* (L., 1758), the most common freshwater bryozoan in Europe, occurring in stagnant and running freshwater habitats in Belgium (from GEIMER & MASSARD 1986).

BRACHIOPODA - LAMP SHELLS or BRACHIOPODS

(BRACHIOPODEN, ARMPOTIGEN - BRACHIOPODES - ARMFÜSSER, LOCHMUSCHELN)

Sedentary or sessile, marine coelomates enclosed by bivalved shell with dorsal and ventral valves (usually unequal in size), opened and closed by antagonistic muscles; large and complex lophophore within the shell; anchorage (and movement) via pedicle; length from 1 mm to more than 9 cm; occurring at all depths from intertidal to abyssal; fossils of Brachiopoda are known from the Cambrian and the group was very abundant throughout the Paleozoic era; ca. 350 living species described worldwide; more than 15,000 fossil species known.

Questionnaire completed by Alan LOGAN (University of New Brunswick). Additional data from Francis KERCKHOF (Marine Ecosystem Management / RBINS) and Gordon CURRY (University of Glasgow).



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Argyrotheca cistellula (SEARLES-WOOD, 1841), a very small brachiopod (ca. 1 mm) often occurring on pebbles in shallow waters, together with *Gwynia capsula*. So far, only remains of specimens have been observed in Belgian waters. (a-b) Ventral and dorsal views of exterior, (c) interior of ventral valve showing dentition and median septum, (d) interior of dorsal valve showing loop and median septum (drawings by A. LOGAN).

Empty shells of two species, *Gwynia capsula* and *Argyrotheca cistellula*, were found in sediment samples taken at the Flemish Banks (pers. comm. F. KERCKHOF). Since living specimens have not been found until now, these shells are for the time being considered to be washed up subfossil brachiopods. Because both species are rather small (1.5 to 3 mm), they are easily overlooked. In addition to these, three other species may occur (BRUNTON & CURRY 1979), although natural hard substrate necessary for anchorage is scarce. Taxonomic knowledge of this group is very poor. A representative collection is present at The Natural History Museum in London.

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PHORONIDA - PHORONIDS

(HOEFIJZERWORMEN - PHORONIDIENS - HUFEISENWÜRMER)

Sedentary marine vermiforms, inhabiting secreted chitinous tubes, in shallow seas; most are infaunal dwellers in soft sediments, others have their tubes cemented to hard substrates; all species feed by extending an anterior lophophore into the water (filter-feeders); length from 1 mm to 50 cm (mostly less than 10 cm); ancestral phoronids are assumed to have been free-living worms; ca. 14 known living species worldwide.

Questionnaire completed by Christian EMIG (Marseille Oceanology Center).

One species, *Phoronis hippocrepia*, is known from the coastal waters off Ostend (EMIG 1979). It is unclear if additional species may occur. In the Netherlands, three additional species are expected next to the observed *P. hippocrepia*. Four phoronid species are present along the German coasts. For Belgium, taxonomic knowledge of this group is very poor and no expert able to identify specimens to the species level was found.

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CHAETOGNATHA - ARROW WORMS or CHAETOGNATHS

(PIJLWORMEN - CHÉTOGNATHES, VERS FLÈCHES - PFEILWÜRMER)

Marine, planktonic, hermaphroditic predators looking like tiny transparent arrows; length of adults ranges from 0.5 to 12 cm; mouth surrounded by bristles, used for catching and holding prey; occurring in high concentrations during certain periods; feeding on small planktonic organisms, from diatoms to juvenile fish; highly sensitive to changes in salinity and temperature; ca. 110 species described worldwide.

Questionnaires completed by Jan MEES (Flanders Marine Institute) with the contribution of Ann DEWICKE and Bregje BEYST (both Ghent University), and by Jean-Paul CASANOVA (University of Provence).

Two species, *Sagitta elegans* and *S. setosa*, have been recorded. Both can be abundant at certain times of the year. No additional species are expected. For Belgium and the neighbouring countries, taxonomic knowledge of arrow worms is good. No representative collection could be identified.

32

Sagitta setosa MÜLLER, 1847, one of the two species of Chaetognatha recorded in Belgian marine waters. Neritic, typically inhabiting shallow waters and having a maximum body length of 14 mm (from PIERROT-BULTS & CHIDGEY 1988, courtesy of The Linnean Society and The Estuarine and Coastal Sciences Association).

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HEMICHORDATA - ACORN WORMS or HEMICHORDATES

(EIKELWORMEN, KRAAGDRAGERS - HÉMICORDÉS, HÉMICHORDÉS - KRAGENTIERE, HEMICHORDATEN)

Marine, benthic coelomates with buccal diverticulum, dorsal nerve cord and pharyngeal slits, but without notochord; there are two classes: the very obscure and poorly studied Pterobranchia which are sessile, tiny (usually less than 1 cm) and dwell in deep water, while the well-known Enteropneusta (length ranges from 2.5 cm to 2.5 m) usually burrow in the sandy intertidal zone of temperate waters; ca. 96 described species worldwide.

Questionnaires completed by Cyril BURDON-JONES (Queensland Museum, Australia) and by Elis KNIGHT-JONES (University of Swansea).

No species have been recorded. At least two are expected among others based on HAYWARD & RYLAND (1990). In the Netherlands, *Protoglossus koehleri* was observed while *Rhabdopleura normani* is expected. Other species which might occur in Belgian waters are *R. compacta*, *Saccoglossus pygmaeus*, *S. horsti*, *Glossobalanus sarniensis* and *G. marginatus*. Larvae of these last two species are common in the North Sea plankton. Taxonomic knowledge of this group is clearly insufficient and a Belgian scientist able to identify organisms to the species level was not found. Representative collections are housed in The Natural History Museum in London and the Zoological Museum in Copenhagen.

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ECHINODERMATA - ECHINODERMS

(STEKELHUIDIGEN - ÉCHINODERMES - STACHELHÄUTER)

Marine, radially symmetrical, pentamerous coelomates with complex hydraulic system of tubes called water vascular system; many forms move via tube feet (podia); internal calcareous skeleton will generally develop; length ranges from 2 cm to 2 m; six extant classes: Asteroidea (sea stars or starfish), Ophiuroidea (brittle stars), Echinoidea (sea urchins), Holothuroidea (sea cucumbers), Crinoidea (feather stars) and Concentricycloidea (sea daisies); 8,000 described species worldwide, from tidal to abyssal zones.

Questionnaire completed by Claude MASSIN (Royal Belgian Institute of Natural Sciences).

Fifteen species have been recorded: four species of sea cucumbers, four sea urchins, three sea stars and four brittle stars (MASSIN & DE RIDDER 1989, with species list). Five to seven additional species are expected, based on GLAÇON (1977) and WOLF (1975). The echinoderm fauna of the Belgian Continental Shelf (BCS) is less rich than the one in adjacent waters, possibly because of the lower variety of habitats. Taxonomic expertise of this group is very good. A representative collection is present at the Royal Belgian Institute of Natural Sciences.

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CHORDATA - CHORDATES

(CHORDADIEREN, CHORDATEN - CHORDÉS, CORDÉS - CHORDATIERE, CHORDATEN)

Bilaterally symmetrical, coelomate deuterostomes with a living endoskeleton; notochord (rodlike) present at some stages in life cycle; a dorsal tubular nerve cord and pharyngeal gill slits which both may alter or disappear in later stages of life cycle; include Tunicata, Cephalochordata and Vertebrata.

TUNICATA (UROCHORDATA) - TUNICATES

(MANTELDIEREN, ZAKPIJPEN - TUNICIERS, UROCORDÉS - MANTELTIERE, TUNIKATEN)

Marine, filter-feeding animals with sac-like tunics surrounding the body; showing affinities to other chordates only in juvenile stage; generally from 1 mm to 4 cm, some giant species up to 60 cm; poorly represented in fossil record (no hard parts); three classes: Ascidiacea (sea squirts), containing more than 90% of all urochordate species, Copelata or Appendicularia (larvaceans) and Thaliacea (salps); Ascidiacea are benthic, sessile, globular or tubular animals with incurrent and excurrent siphons; single, social or compound individuals; Copelata and Thaliacea are small planktonic animals, barrel-shaped (Thaliacea) or with neotenous characteristics (Copelata); between 1,250 and 2,000 species described, while a total species number of 3,000 is expected worldwide.

Questionnaire completed by Jean GODEAUX (University of Liège), with the contribution of Francis KERCKHOF (Marine Ecosystem Management / RBINS) and Claude MONNIOT (Muséum National d'Histoire Naturelle, Paris).

Sixteen sea squirt and two larvacean species have been recorded. Three more ascidian species seem to occur, following recent observations at the Sluice dock in Ostend (pers. comm. F. KERCKHOF). Records of three other ascidian species, present in the collections or mentioned in literature, have an uncertain status. Studies on the Belgian Tunicata are scarce and outdated. For example, there are as good as no recent data or observations on the seven species of Molgulidae, an ascidian family with representatives able to settle in sandy substrates, mentioned in DAMAS (1905) and collected from 1884 to 1886. A thorough investigation of harbour environments and hard substrata such as the mole of Zeebrugge or ship wrecks, is expected to yield a considerable amount of additional information and maybe new species for the Belgian fauna. Representative collections are housed in the Zoological Institute of the University of Liège, the Royal Belgian Institute of Natural Sciences, the marine stations in Roscoff and Wimereux, and the 'Musée National d'Histoire Naturelle' in Paris. *Styela clava* is an example of a recently introduced species.

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CEPHALOCHORDATA - LANCELETS

(LANCETVISJES - CÉPHALOCORDÉS - CEPHALOCHORDATEN)

Slim, fish-like animals rarely exceeding 5 cm in length; some features are intermediate between those of invertebrates and vertebrates; represented in the extant fauna only by two genera: *Branchiostoma* (formerly *Amphioxus*) and *Asymmetron*; cosmopolitan in shallow marine and brackish water, often burrowed in clean sands; between 20 and 30 species described worldwide.

Information provided by Jean GODEAUX (University of Liège) and Francis KERCKHOF (Marine Ecosystem Management / RBINS).

One species, *Branchiostoma lanceolatum*, is present (POLL 1947). Larvae have been found in planktonic samples taken from 1970 to 1975 in the frame of the development of the North Sea mathematical model. The species is common in the coarse sandy sediments of the sand banks in Belgian marine waters, e.g. the Kwinte Bank and the Noord Hinder Bank. No additional species are expected. No targeted research on this group/species has taken place in the Belgian part of the North Sea. Specimens are stored in the Royal Belgian Institute of Natural Sciences, the Zoological Institute of the University of Liège and in some other university collections.

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VERTEBRATA or CRANIATA - VERTEBRATES or CRANIATES

(GEWERVELDEN - VERTÉBRÉS - WIRBELTIERE)

Animals with a brain case (cranium) and a spinal column of vertebrae which forms the skeletal axis of the body; cartilaginous or bony endoskeleton; integument (consisting of an epidermis and an inner dermis) often modified to produce hair, scales, feathers, horn, etc.; fossil record is thought to go back to the Upper Cambrian; from about 1 cm to 34 m; ca. 55,000 species known worldwide; several thousands more expected, especially fishes.

HYPEROARTIA and HYPEROTRETI (AGNATHA) - CYCLOSTOMES or JAWLESS FISHES or LAMPREYS and HAGFISHES

(KAAKLOZE VISSEN, RONDBEKKEN - AGNATHES - KIEFERLOSE)

Since the taxa Agnatha and Cyclostomata are considered to be paraphyletic, their taxon names are not used anymore. They are discussed together for convenience.

Fishlike, jawless vertebrates without paired appendages; extant species have no scales; notochord persist in adult forms; lampreys attach themselves to fishes or invertebrates with a sucker-like structure which surrounds the mouth, feeding on blood and tissue; hagfishes have a terminal mouth with sensory barbels and scavenge carcasses of fishes and larger invertebrates or actively prey on smaller invertebrates; fossil history goes back to the late Cambrian; mainly marine; ca. 84 living species described worldwide.

Information gathered from literature (VANDELANNOOTE *et al.* 1998, PHILIPPART 1998). Information on the marine forms was provided by Jan HAELTERS (Marine Ecosystem Management / RBINS).

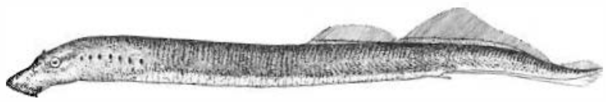
Three species are present in Belgian waters. The brook lamprey (*Lampetra planeri*) is occurring in Flanders and Wallonia, but is clearly in regression: the species disappeared from many rivers and subbasins, which is probably mainly due to the declined water quality and changes of the structural integrity of rivers and brooks, as well as to the low genetic diversity of small isolated populations.

The lampern or river lamprey (*Lampetra fluviatilis*) was last observed in the Walloon Region in 1964 and seems to be extinct there, although recent observations have been made in the

Grand Duchy of Luxembourg and in parts of the Meuse situated in the Netherlands, both near the Belgian border. In Flanders, the river lamprey is only abundant in the Lower Scheldt. In addition to the threats mentioned for the brook lamprey, the strong regression of the river lamprey is mainly due to migration barriers caused by pollution in some basins and structural changes in others. Together with other measures, removing and/or bypassing migration barriers could accelerate the recovery of populations.

The sea lamprey (*Petromyzon marinus*) is considered to be extinct in Wallonia and Flanders, although a single specimen was recently caught in the river Scheldt. The sea and river lamprey both occur at sea, but they have become uncommon in the Belgian marine waters mainly because of pollution and river construction works.

All three species are protected by the Bern Convention and the EU Habitats Directive. At the regional level, the sea and river lamprey are protected by the Walloon Regional Executive Order of 24 November 1988 in Wallonia while the Flemish Executive Decree of 20 May 1992 protects the brook, river and sea lamprey in Flanders. Sea and river lamprey are protected in marine waters (Royal Decree of 21 December 2001).



33

Male individual of the river lamprey. This species is in strong regression, as are the brook and sea lampreys (drawing by L.S. BERG in POLL 1947).

References and further reading

See under Teleostomi.

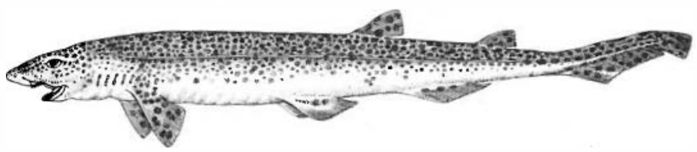
CHONDRICHTHYES - CARTILAGINOUS FISHES

(KRAAKBEENVISSEN - POISSONS CARTILAGINEUX, CHONDRICHTHYENS - KNORPELFISCHE)

Fishes with fins, jaws and a cartilaginous skeleton; placoid scales usually cover the skin; no swim bladder or lung; male with pelvic claspers for sperm transfer; teeth not fused to jaws and replaced continually; two subclasses: the Elasmobranchii (sharks and rays) with ca. 815 described species and the Holocephali (chimaeras) with 31 described species worldwide.

Questionnaires completed by Philip VAS (independent expert, United Kingdom) and by Jan HAELTERS (Marine Ecosystem Management / RBINS).

Twenty-two species have been recorded, but all are, or have become, uncommon or rare. Some are only known as very rare vagrants. Once common, the piked dogfish (*Squalus acanthias*), angelshark (*Squatina squatina*) and common skate (*Raja batis*) are now extremely rare or have disappeared completely from Belgian waters. The lesser spotted dogfish (*Scyliorhinus canicula*), starry smooth hound (*Mustelus asterias*) and thornback ray (*Raja clavata*) are still the most common elasmo-



34

The lesser spotted dogfish, *Scyliorhinus canicula*, is still one of the most common elasmobranch species in Belgian marine waters, although the number of specimens is also decreasing. Its length ranges from 40 to 70 cm, although exceptionally individuals can reach 1 m (drawing by C.L. BONAPARTE in POLL 1947).

branch species, but their abundance decreased significantly by overfishing, not only in Belgian marine waters, but in the southern North Sea in general. Chimaeras are not present in Belgian waters.

References and further reading

See under Teleostomi.

TELEOSTOMI (OSTEICHTHYES) - BONY FISHES

(BEENVISSEN - POISSONS OSSEUX, OSTÉICHTHYENS - KNOCHENFISCHE)

Fishes with fins, generally scaly skins, jaws and a bony skeleton; usually with air sacs that function either as lungs or as swim bladders for buoyancy; only the subclass Actinopterygii (ray-finned fishes) occurs in our region, consisting of the Chondrostei (sturgeons and paddlefishes), and the Neopterygii (formed by the paraphyletic Holostei and the Teleostei, the major superorder of the Osteichthyes and the dominant fish taxon since the Cretaceous); ca. 27,000 living species are known worldwide (http://www.FishBase.org), while guesstimates of the total number of species and subspecies reach 50,000 and more.

Questionnaires completed by Filip VOLCKAERT (Catholic University of Leuven) for the Belgian fish fauna in general, by Jan HAELTERS (Marine Ecosystem Management / RBINS) for the marine species and by Rudi YSEBOODT (UIA, University of Antwerp) for the freshwater species in Flanders. Jean-Claude PHILLIPART (University of Liège) provided data on the freshwater fish fauna of Wallonia. Additional information by Boudewijn GODDEERIS (Royal Belgian Institute of Natural Sciences).

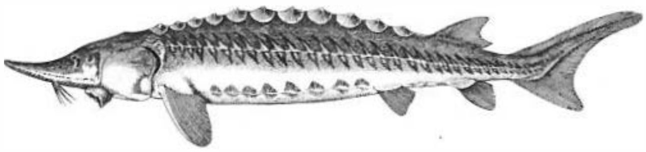
Almost 120 species have been recorded in Belgian marine waters (POLL 1947, RAPPÉ & ENEMAN 1988, unpublished list by J. HAELTERS), but this figure includes more than 30 species which can be considered as vagrants or species which are, or have become, extremely rare. Many species have declined significantly because of overfishing, pollution and the destruction of habitats. Especially diadromous fishes have become rare or even extinct because of the destruction of estuarine or riverine habitats. Dozens of other marine species can be expected as vagrants (NIJSSEN & DE GROOT 1987, WHEELER 1969, WHITEHEAD *et al.* 1984-86). For information on the marine species protected by legislation, see HAELTERS & KERCKHOF (2002).

In Flanders, 83 bony fish species were registered in rivers, streams and brooks (BELPAIRE 2002). This species number can be subdivided in 19 introduced species (23%), 20 marine and brackish water species temporarily migrating to brackish or fresh water (24%), and 44 freshwater species (53%). Of the latter, 20% have disappeared from Flemish waters, 60% are threatened and only 20%, which constitutes only 9 species out of 44, are doing relatively well at the moment. Up to ten additional species can be expected based on MAITLAND (1978), MAITLAND & CAMPBELL (1992) and DE NIE (1996). Between 1950 and 1990, the species number in Flanders declined because of habitat destruction, water depletion, acidification, eutrophication and chemical pollution. Since 1990 however, this trend seems to be reversed and there seems to be an increase of the species number, because of recent introductions of non-native species, e.g. topmouth gudgeon (*Pseudorasbora parva*), fathead minnow (*Pimephales promelas*), asp (*Aspius aspius*), sturgeon species (*Acipenser* spp.), etc. But also as a result of increasing water quality in the lower Sea Scheldt and other major watercourses. Unfortunately, the conditions in smaller watercourses and standing waters are not improving or even getting worse. For the Flemish Region, a red list can be consulted at http://www.instnat.be/Soorten/Vissen/rode_lijst.htm.

In Wallonia, the fish fauna consists of 52 species, 41 of which are considered to be indigenous. Sixteen species (39%) of this indigenous fish fauna disappeared or are rare or threatened, while 15 species (37%) are vulnerable, giving a total of 31 species (76%) with critical status. The richest fish biodiversity in the Walloon Region is located in the Meuse and Rhine basin and to a lesser extent in the Scheldt basin, containing some of the rare species (PHILIPPART 1998).

The burbot (*Lota lota*) became extinct in Belgium in the period 1950-1960. Other examples of extinct species in Belgium are: the Atlantic salmon (*Salmo salar*), common sturgeon (*Acipenser sturio*), twaite shad (*Alosa fallax*) and allis shad (*A. alosa*). Another major problem is the disappearance of the original genetic material of a lot of native fish species caused by the stocking of our waterbodies with exotic individuals for angling purposes. One example is the import of bitterling (*Rhodeus sericeus*) from Hungary.

Major collections are kept in the Royal Belgian Institute of Natural Sciences, the Zoological Museum of the University of Liège and the University of Namur. Smaller collections can be found in other universities and scientific institutions.



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The sturgeon (*Acipenser sturio*), an anadromc fish species, was already very rare in Belgian marine waters some 50 years ago and seems to be almost extinct now. Sporadically, a sturgeon is caught by Belgian fishermen, but these may be individuals of an introduced stock. The sturgeon is protected by the Royal Decree of 21 December 2001 concerning the protection of species in marine areas under Belgian jurisdiction (drawing by C.L. BONAPARTE in POLL 1947).

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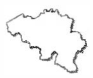
AMPHIBIA - AMPHIBIANS

(AMFIBIEËN - BATRACIENS, AMPHIBIENS - LURCHE, AMPHIBIEN)

Vertebrates with naked skin; aquatic larval stadium; respiration by gills, integument and/or lungs; two pairs of sometimes reduced lateral appendages for walking and swimming; include frogs, toads, newts, salamanders and caecilians; more than 4,800 described species worldwide, possibly another 1,000 species to be expected.

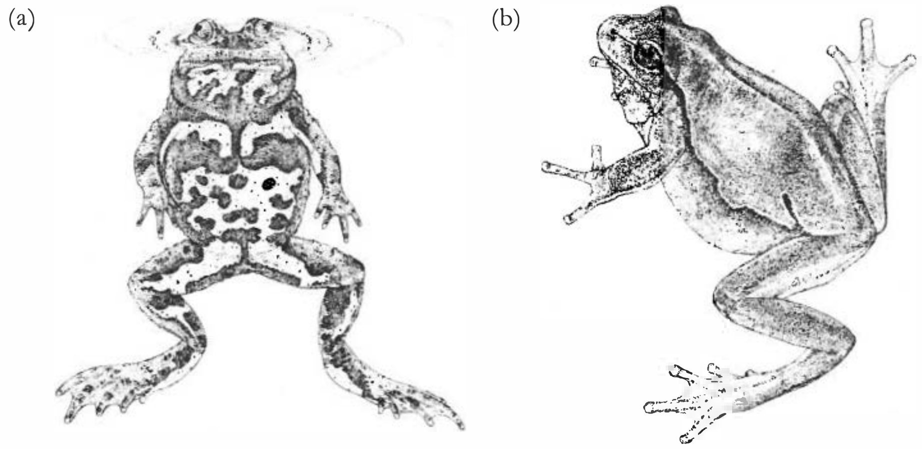
Questionnaire completed by Boudewijn GODDEERIS (Royal Belgian Institute of Natural Sciences).



Sixteen native species have been recorded (BAUWENS & CLAUS 1996, PERCSY *et al.* 1997, both with species list): six frog species, five toads and five salamanders and newts. One additional species, the parsley frog (*Pelodytes punctatus*), may be expected (PARENT 1983, PERCSY *et al.* 1997). Since 1981, one species, the yellow-bellied toad (*Bombina variegata*), has disappeared from Belgium (BAUWENS & CLAUS 1996, PERCSY *et al.* 1997) and the number of individuals of most species is decreasing, because of habitat destruction and fragmentation, isolation of populations, use of pesticides, acidification, manuring, water pollution and climate change. As a result, most of the species are rare or threatened. Only five amphibian species do not show a strong negative trend in Belgium: edible frog (*Rana esculenta* synklepton), common frog (*R. temporaria*), common toad (*Bufo bufo*), common newt (*Triturus vulgaris*) and Alpine newt (*T. alpestris*).

Following BAUWENS & CLAUS (1996) and PERCSY *et al.* (1997), the highest species richness is found in Upper Belgium and the Kempen, followed by the coastal zone (area beyond the tidal range). Essential for the conservation of amphibians are pools with species-specific adjacent terrestrial habitat. All species are protected by law. More conservation measures are needed outside the protected areas. In Flanders, specific conservation programmes have been developed for the common tree frog (*Hyla arborea*) and the common midwife toad (*Alytes obstetricans*) (VERVOORT 1994, VERVOORT & GODDEERIS 1996). Red lists are available for Flanders (http://www.instnat.be/content/page.asp?pid=ROL_staartpagina) and Wallonia (http://mrw.wallonie.be/cgi/dgrne/sibw/sibw.esp.list2.pl?VAR=Amphibiens).

Taxonomic knowledge of this group in Belgium is good and databases are managed by the Institute of Nature Conservation and by 'Hyla', a working group of the naturalist



36

(a) The yellow-bellied toad (*Bombina variegata*) disappeared entirely from our country, probably due to the combination of habitat destruction and fragmentation with climate factors. Individuals of this species were last observed in the early 1980s. (b) The common tree frog (*Hyla arborea*) is particularly threatened following habitat destruction and fragmentation. Reproductive populations are reduced to six only in Flanders and are absent in Wallonia (drawings by E. DELAYE in collaboration with B. GODDEERIS, © RBINS).

association 'Natuurpunt', for the Flemish Region, and by 'Raînne', the herpetologist working group of 'Aves', for the Walloon Region. A reference collection is housed in the Royal Belgian Institute of Natural Sciences.

The garden-pond craze in the last decades has led to massive introduction of non-native amphibians. Several introduced frog species have developed reproductive populations in Belgium (PARENT 1997, JOORIS 2002, KOK *et al*. 2002, PERCSY & PERCSY 2002): the marsh frog (*Rana ridibunda*), Iberian water frog (*Rana perezi*), Levant water frog (*Rana bedriagae*) and American bullfrog (*Rana catesbeiana*).

References and further reading

See under Reptilia.

REPTILIA - REPTILES

(REPTIELEN, KRUIPDIEREN - REPTILES - KRIECHTIERE, REPTILIEN)

Tetrapod vertebrates although legs may be strongly reduced or absent; skin covered with horny scales; breathing through lungs; no larval stages; include snakes, lizards, sphenodonts, turtles, crocodilians and amphisbaenians; ca. 8,000 species known worldwide, possibly between 1,000 and 1,500 more to be expected.

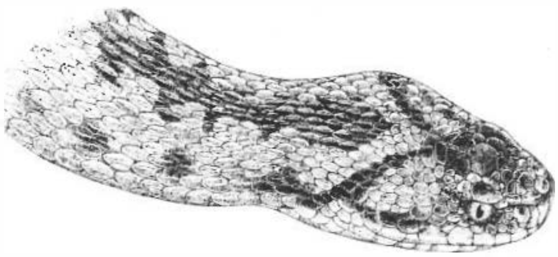
Questionnaire completed by Boudewijn GODDEERIS (Royal Belgian Institute of Natural Sciences).

Seven native species have been observed (three snake species, three lizards and the slow worm) and no additional species are expected (BAUWENS & CLAUS 1996, PERCSY *et al*. 1997, both with species list). As a result of the disappearance of terrestrial biotopes and the fragmentation of the landscape because of the expanding road system, the number of individuals of all species is declining, entailing the rare or threatened status for most species. The highest species richness is found in Upper Belgium. Heaths and calcareous grasslands are considered to be essential habitats for the survival of reptiles in Belgium (BAUWENS & CLAUS 1996, PERCSY *et al.* 1997). All reptiles are protected by law, but, as well as for amphibians, more conservation measures are needed outside protected areas. For the adder (*Vipera berus*), a species protection plan has been developed (BAUWENS *et al.* 1995).

Like the amphibians, reptiles are taxonomically well known in Belgium. Databases are managed by the Institute of Nature Conservation, 'Hyla' ('Natuurpunt') and 'Raînne' ('Aves'). Red lists are available in Flanders (http://www.instnat.be/content/page.asp?pid=ROL_staartpagina) and Wallonia (http://mrw.wallonie.be/cgi/dgrne/sibw/sibw.esp.list2.pl?VAR=Reptiles).

The introduction of various turtles for the pet-trade and the subsequent release of oversized individuals in ponds has led to the proliferation of non-reproductive populations of these long-living species, i.e. the European pond terrapin (*Emys orbicularis*) and the red-eared terrapin (*Trachemys scripta elegans*). These species cannot reproduce in Belgium because of the low summer temperatures (JOORIS 2002).

In the Belgian part of the North Sea, three sea turtle species, the loggerhead (*Caretta caretta*), green turtle (*Chelonia mydas*) and leathery turtle (*Dermochelys coriacea*), very rarely occur as vagrants. A database on strandings and sightings of marine turtles is kept by the Marine Ecosystem Management Department of the Royal Belgian Institute of Natural Sciences.



37

The adder (*Vipera berus*) reaches a maximum length of 60 to 70 cm and is typically found in heath- and moorland but also in railway embankments, rough grassland and scrub (drawing by E. DELAYE in collaboration with B. GODDEERIS, © RBINS).

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AVES - BIRDS

(VOGELS - OISEAUX - VÖGEL)

Tetrapod vertebrates with feathers and bill; fore-limbs modified as wings (vestigial in a few species), hind-limbs used for walking or swimming; scales on feet only (on tarsometatarsus and in some species also on lower part of tibiotarsus; some species on the contrary have a feathered metatarsus); breathing through lungs; young altricial or precocial, according to ecological strategy of the species; ca. 9,800 species described worldwide but a little more than 10,000 expected, especially when refining systematics.

Questionnaire completed by Gunter DE SMET (Royal Belgian Institute of Natural Sciences).

Since 1800, 424 species have been recorded in Belgium according to the guidelines for assigning species rank by HELBIG *et al.* (2002), 406 of which belong to category A, i.e. observed at least once in the wild between 1950 and 2002. The other 18 species were recorded between 1800 and 1949, but have not been observed since. Until 1966, the official Belgian birdlist was based on decisions of the Commission of the Belgian Avifauna. Since 1967, the Belgian Avifaunal Homologation Committee (BAHC) and the Homologation Commission (CH) have taken the relay. The resulting species list is available at http://www.bahc.be/documents.htm (Belgian birdlist).

For breeding birds, the highest species richness is found in Lower Belgium (particularly in the coastal area including the polders and in the Kempen), followed by, in decreasing order of richness, Middle Belgium (including the Sonian Forest), Upper Belgium, the Lorraine, the Hautes Fagnes, the tidal range and the North Sea. Habitats considered of essential importance for the survival of certain species or populations are among others wetlands, deciduous forests, heaths and small-scale landscape elements.

Since 1950, the total number of species has increased from 334 to 424 species, which is an addition of 90 species (26.9%). The number of breeding bird species has augmented by 24.3% from 144 (in 1950) to 179 species (in 1999). The increase of the general species number is mainly due to the intensification of observations, most of the additions being vagrants. The high number of breeding birds reached in 1999 is partly due to species which take advantage of temporarily favourable conditions for settling. Striking examples are the (temporary) breeding success of duck, gulls, terns and wader species in the proximity of harbour infrastructures and activities, and the high numbers of great cormorant (*Phalacrocorax carbo*), grey heron (*Ardea cinerea*), grebes and duck species linked to eutrophication and the resulting enhanced availability of whitebait. Worryingly, some of our commonest breeding birds, most noticeably the house sparrow (*Passer domesticus*), show a steep decline in numbers. On the positive side, some former breeding birds have recolonised the country successfully. Peregrine falcons (*Falco peregrinus*) took advantage of nestboxes and are now preferring buildings to traditional nesting sites in quarries. Successful reintroduction schemes of white storks (*Ciconia ciconia*) in Belgium, the Netherlands and other countries have favoured occasional nesting of the species in Flanders and Wallonia. In general, the increase in the number of breeding birds is mainly due to the following: range extension of breeding birds from abroad, large-scale infrastructure works (e.g. harbour of Zeebrugge), hunting restrictions (positive effect mainly on ducks, birds of prey, large species), long-term results of forestry practices, side-effects of pollution (e.g. eutrophication), reintroduction of formerly occurring breeding birds and climate change.

The disappearance of specific habitats and small-scale landscape elements, the fragmentation of habitats and the intensification of agriculture have led to the disappearance from Belgium of species like the black tern (*Chlidonias niger*), hoopoe (*Upupa epops*) and ortolan bunting (*Emberiza hortulana*). At least 20 other breeding bird species are highly threatened. For Flanders, a preliminary red list can be found at (http://www.instnat.be/content/page.asp?pid=ROL_staartpagina). A proposal of a red list for the Brussels Region is available at http://www.aves.be/Surbru-Chapitre-6.html#Heading40. The red list status of, and other useful data on, birds occurring in the Walloon Region can be found at http://mrw.wallonie.be/cgi/dgrne/sibw/sibw.esp.list2.pl?VAR=Oiseaux.

Not included in the total number of 424 species are some 20 species of dubious origin (e.g. white pelican, *Pelecanus onocrotalus* and greater flamingo, *Phoenicopterus roseus*) and not less than 173 species which occur in the wild only as escapes from captivity (e.g. budgerigar, *Melopsittacus undulatus*, and canary, *Serinus canaria*). Eight introduced species are considered as aliens with self-supporting breeding populations: Canada goose (*Branta canadensis*), Egyptian goose (*Alopochen aegyptiacus*), upland goose (*Chloephaga picta*), mandarin duck (*Aix galericulata*), ring-necked pheasant (*Phasianus colchicus*), feral pigeon (*Columbia livia*), ring-necked parakeet (*Psittacula krameri*) and monk parakeet (*Myiopsitta monachus*). The red grouse (*Lagopus lagopus*) was formerly also breeding, but its introduced population is now extinct.

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MAMMALIA - MAMMALS

(ZOOGDIEREN - MAMMIFÈRES - SÄUGETIERE)

Tetrapod vertebrates with, in some species, forelimbs modified as wings or flippers; hairy skin, neither scales nor feathers; females possess mammary glands; breathing via lungs; no larval stages; a total of 4,629 described species worldwide, some hundreds more to be discovered.

Questionnaires completed by Roland LIBOIS (University of Liège) and Georges LENGLET (Royal Belgian Institute of Natural Sciences) for the non-marine mammals, by Jan HAELTERS (Marine Ecosystem Management / RBINS) for the marine mammals and by Jacques FAIRON (Royal Belgian Institute of Natural Sciences) for the bats.

Sixty-eight non-marine and five marine mammal species are considered to belong to the Belgian fauna. Neither domestic animals and pets, nor man, are included in these figures. The 68 non-marine species can be subdivided in 9 Insectivora, 18 Chiroptera, 2 Lagomorpha, 5 Artiodactyla, 14 Carnivora and 20 Rodentia (FRECHKOP 1958, LIBOIS 1982, CRIEL *et al.* 1994, 1997).

One species, the wolf (*Canis lupus*), is extinct in Belgium and 22 other species are considered to be threatened in Flanders (CRIEL *et al.* 1994, red list for mammals in Flanders). For the southern part of the country, a red list can be found on the 'Système d'Information sur la Biodiversité en Wallonie' (SIBW) http://mrw.wallonie.be/dgrne/sibw/especes/eew/eew93/mammifer.html. A text on the status of mammals in the Brussels Capital Region is available at http://www.naturalsciences.be/cb/documents/regions/brussels/bru_mammals/brussels_mammals.htm.

Based on the European mammals atlas, two additional species are expected in Belgium: the water vole (*Arvicola sapidus*) and the lynx (*Lynx lynx*). The mammal species number stays more or less the same due to two opposite factors, balancing each other: the (re-)introduction or invasion of species on one side and the destruction and fragmentation of habitats leading to disappearance and threatened species on the other side. Due to this, the numbers of individuals of some species are declining. Examples are the dramatic regression of the greater and lesser horseshoe bat (*Rhinolophus ferrumequinum* and *R. hipposideros*). The highest species richness is found in Upper Belgium (excl. the Hautes fagnes), followed by, in decreasing order of richness, the Lorraine, Middle Belgium, the Hautes Fagnes and Lower Belgium (incl. the Kempen). A tight ecological network together with underground cavities and accessible man-made structures are of essential importance for the Chiroptera. The wild cat (*Felis silvestris*), the common dormouse (*Muscardinus avellanarius*) and some other mammalian species are highly dependent on leafy and more or less undisturbed forests.

Since 1900, the following species have been introduced in Belgium: the mouflon (*Ovis aries*), raccoon dog (*Nyctereutes procyonoides*), raccoon (*Procyon lotor*), American mink (*Mustela vison*), Siberian chipmunk (*Tamias sibiricus*), muskrat (*Ondatra zibethicus*) and coypu (*Myocastor* *coypus*). The castor (*Castor fiber*) has been reintroduced illegally. See PEETERS & VAN GOETHEM (2002) for communications on the Siberian chipmunk, muskrat, coypu, badger (*Meles meles*), beech marten (*Martes foina*), European otter (*Lutra lutra*) and on Chiroptera.

Eighteen cetacean and five pinniped species have been observed at least once in Belgian waters, and a few more could be expected as vagrants. Only five marine mammals can be considered as indigenous in the Belgian part of the North Sea. Of these, the bottlenose dolphin (*Tursiops truncatus*) was regularly seen until the mid-twentieth century, but is now almost extinct in the North Sea. On the contrary, groups of white-beaked dolphins (*Lagenorhynchus albirostris*) have been observed regularly since 1960. The harbour porpoise (*Phocoena phocoena*) is the only relatively common cetacean in the shallow coastal waters of the southern North Sea. It is regularly observed in Belgian waters, especially in late winter and spring. Individuals of the harbour seal (*Phoca vitulina*) are continuously present and even winter in Belgian waters. Young animals are observed each year, mainly in the summer period. These probably originate from colonies in France (Somme Estuary), the United Kingdom (Wash Estuary) and the Netherlands (Zeeland, Wadden Sea). Young grey seals (*Halichoerus grypus*) are observed each year during the winter period. Adult are less common than harbour seals. In June 2003, a female of the harp seal (*Phoca groenlandica*) stranded on the beach of Middelkerke, being the first Belgian record of this species which normally occurs at the edge of the Arctic pack-ice. A database on strandings and sightings is kept by the Marine Ecosystem Management Department of the Royal Belgian Institute of Natural Sciences. The main mammal collections, including marine species, are housed in the Royal Belgian Institute of Natural Sciences and the Zoological Museum of the University of Liège.

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Table 4. Overview of the Metazoa in Belgium and the world. For Belgium, recorded and expected species (= recorded + additional expected species) are given. The last column indicates the world-wide number of described species per taxon. When available and higher than the described number world-wide, a guesstimate of the real total species number is added in italic.

Taxon	Recorded	Expected	Described	*Expected*
Porifera	32	32	> 7,000	(*10,000*)
Myxozoa	10	100-120	1,400	(*3,000-5,000*)
Cnidaria	33	⩾ 100	9,000	
Ctenophora	2	4	100	
Turbellaria	± 400	> 450	8,000	(*15,000-20,000*)
Trematoda	103	325	15,000-18,000	
Monogenea	21	300-500	7,000-8,000	(> *20,000*)
Cestoda	144	> 250	5,000	
Gnathostomulida	0	9-22	80	(*250*)
Dicyemida	0	3-15	200	
Orthonectida	0	⩾ 6	22	
Nemertea	10	20-30	1,200	
Nematoda	545	2,500	25,000	(*100,000-1,000,000*)
Nematomorpha	12	> 17	324	(*400*)
Acanthocephala	3	12-25	1,150	
Rotifera	300	1,000	1,800	(> *10,000*)
Cycliophora	0	1-2	3	
Kinorhyncha	2-4	17-24	150	
Priapula	0	1-3	17	
Gastrotricha	37	> 50	450	
Loricifera	0	6	25 (125)	(*500*)
Entoprocta	10	20	150	(*300*)
Araneae	679	> 679	40,000	
Pseudoscorpiones	24	29	3,000	
Opiliones	26	30	2,400	(*3,500-5,000*)
Acari	970	1,220	30,000	(*500,000*)
Pycnogonida	14	14	1,000	
Protura	5	40-50	660	(*6,600*)
Diplura	2-3	7-10	800	
Collembola	130	250	6,000	(*50,000*)
Thysanura	5	6-7	250	
Ephemeroptera	65	± 65	2,100	
Odonata	69	70	5,300	(*10,000*)
Plecoptera	48	58	2,000	
Blattodea	8	8	3,500	

Taxon	Recorded	Expected	Described	Expected
Mantodea	1	1	2,000	
Orthoptera	51	56	20,000	
Dermaptera	4	5	1,900	
Psocoptera	73	82	3,000-4,000	
Anoplura	15	28	400	
'Mallophaga'	124	⩽ 873	4,300	
Heteroptera	620	650	62,000	
Auchenorrhyncha	393-408	430-460	35,000	(*100,000-1,000,000*)
Psylloidea	64	79	2,000	
Aleyrodidea	7	13	1,200	
'Adelgoidea'	4	22	150	
Aphidoidea	371	500	4,700	
Coccoidea	19	100-125	7,600	
Thysanoptera	< 20	⩾ 110	5,000	
Neuroptera	37	42	5,000	
Megaloptera	2	2	300	
Raphidioptera	4	4	150	
Mecoptera	7-8	7-8	550	
Siphonaptera	43	51	2,400	
Coleoptera	± 4,500	4,600-5,000	370,000	(⩾ *2,000,000*)
Strepsiptera	5	10	560	
Diptera	4,474	± 6,670	120,000-150,000	(⩾ *2,000,000*)
Trichoptera	202	220-225	7,000	
Lepidoptera	2,423	2,500	165,000	(⩾ *1,000,000*)
Hymenoptera	± 3,500	7,200	198,000	(⩾ *2,000,000*)
Chilopoda	31	41-51	3,000	
Symphyla	5	25	200-500	
Diplopoda	50	< 60	10,000	(*80,000*)
Pauropoda	11	22-36	700	
Cladocera	80	85	500-600	
'Phyllopoda'	7	9	410	
Ostracoda	105	165	9,000	
Copepoda	279	± 500	13,000	(*130,000*)
Branchiura	1	3	130	
Tantulocarida	0	1-3	25	
Cirripedia	13	16-17	800	
Nebaliacea	1	1	20	
Bathynellacea	1	2-3	160 (incl. Anaspidacea)	

Taxon	Recorded	Expected	Described	Expected
Stomatopoda	0	1-3	400	
Mysidacea	19	25	1,022	
Cumacea	12	15-27	1,200	
Tanaidacea	3	12	850	
Isopoda	66	82-87	10,000	
Amphipoda	126	246	7,500	
Euphausiacea	1	1	90	
Decapoda	60	72	10,000	
Pentastomida	0	3	110	
Polychaeta (incl. 'Archiannelida')	200-250 (+ 5 A.)	± 450 (+ 25 A.)	9,000 (+ 50 A.)	*(19,000)*
Hirudinea	20	> 20	500	*(1,200)*
Oligochaeta	86	> 112	6,000	
Sipuncula	3	12	300	
Echiura	1	4	140	
Caudofoveata	0	1	120	
Solenogastres	0	5	230	
Polyplacophora	1	2	890	
Gastropoda	220	250	80,000-90,000	*(160,000-180,000)*
Bivalvia	80	90-100	12,000-15,000	*(25,000-30,000)*
Scaphopoda	2	2	± 600	
Cephalopoda	8	13-17	± 900	
Tardigrada	45	145	800	
Ectoprocta	50	90-100	5,700	
Brachiopoda	0	2-5	350	
Phoronida	1	4	14	
Chaetognatha	2	2	110	
Hemichordata	0	2-7	96	
Echinodermata	15	20-22	8,000	*(15,000)*
Tunicata	18	24	1,250-2,000	*(3,000)*
Cephalochordata	1	1	20-30	
Hyperoartia and Hyperotreti (Agnatha)	3	3	84	
Chondrichthyes	22	22	846	
Teleostomi (Osteichthyes)	149	⩾ 150	27,000	*(50,000)*
Amphibia	16	> 21	4,800	*(5,800)*
Reptilia	7	7	8,000	*(9,000-9,500)*
Aves	179	± 179	9,800	*(± 10,000)*
Mammalia	73	75	4,629	*(± 5,000)*

5. Conclusions

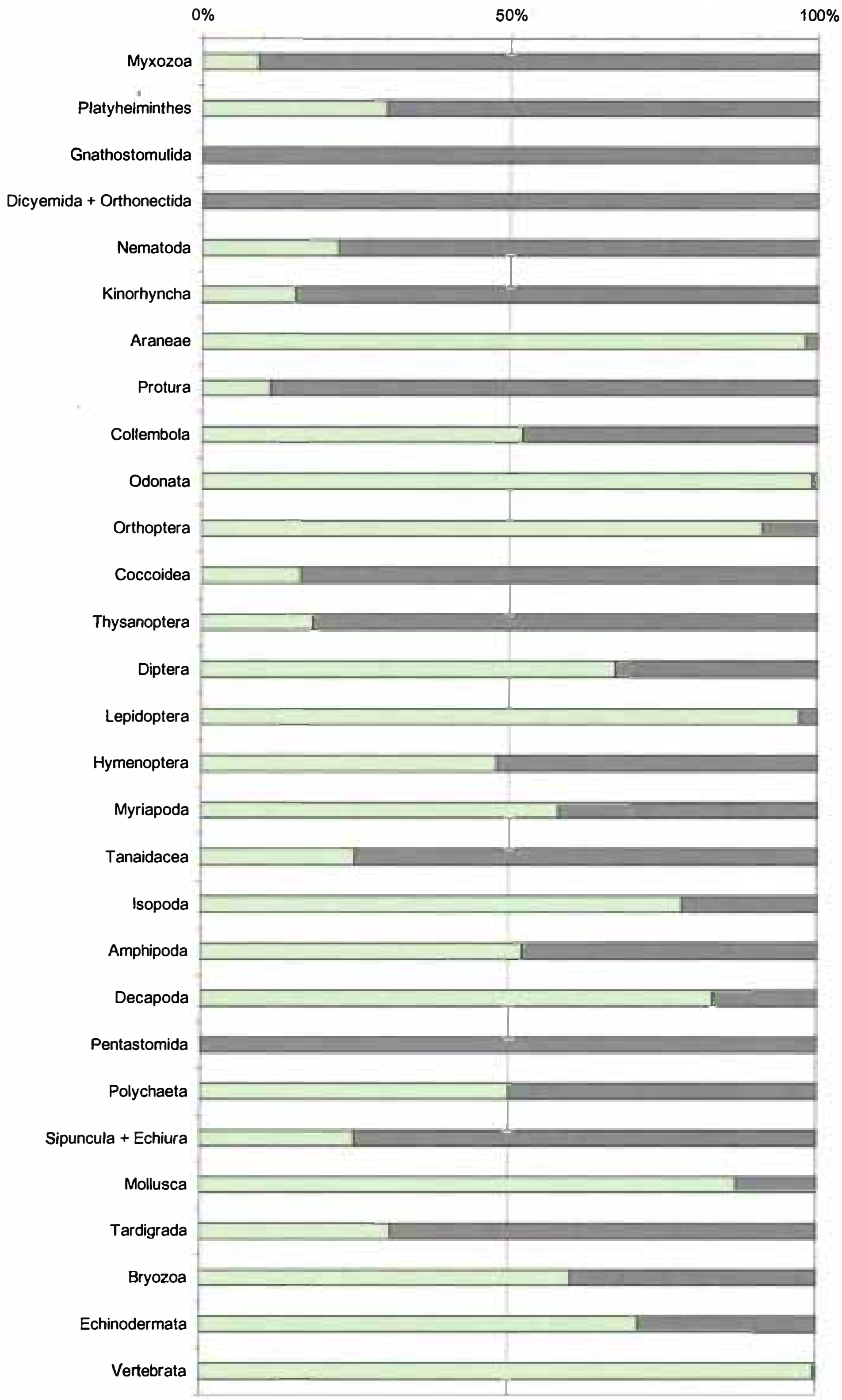
Approximately 22,500 animal species have been recorded so far in Belgium. The number of expected species ranges from 34,000 to 35,000 (table 4). As a consequence, roughly one-third of the animal species living in Belgium are still waiting to be discovered.

Knowledge of the Belgian fauna is unevenly balanced. Taxonomic groups of which individuals are easily observable, 'charismatic', economically significant or practical indicators for nature conservation are subject to sustained scientific attention. For these groups, e.g. vertebrates, ground beetles, butterflies, dragon- and damselflies, the number of recorded species probably reflects quite accurately the real number of existing species. In essence, this number is only influenced by the arrival of alien species, or by the disappearance of species, e.g. because of human activities.

In contrast, when species are small or obscure, difficult to study or regarded as of no direct human interest, e.g. protozoans and many groups of invertebrates, recorded totals are likely to reflect only a part of the real number of existing species, with a few exceptions such as sponges, sea spiders, some insect taxa, etc. (table 4). New collection methods and increased sampling efforts yielded significant numbers of new taxa for the Belgian fauna, even up to the class level (!), e.g. sampling of subterranean habitats by remote sucking, surveying ship wrecks in the Belgian marine waters by SCUBA diving.

Figure 38 summarises current knowledge for a variety of faunal groups. Vertebrates, from lampreys to mammals, not unexpectedly form the best-known major taxonomic group in Belgium, with a total of 449 recorded species and possibly another 10-15 expected. Besides vertebrates, other well-known groups are the Porifera (sponges), Araneae (spiders), Pycnogonida (sea spiders), and a number of insect orders such as the Ephemeroptera (mayflies), Odonata (dragon- and damselflies), Coleoptera (beetles) and Lepidoptera (butterflies and moths). For some other groups, our knowledge can be considered as good to quite good, e.g. Orthoptera (grasshoppers, locusts and crickets), Mollusca (molluscs), Decapoda (shrimps, lobsters, crabs, etc.) and Isopoda (isopods). Totals of well-known high-level invertebrate taxa are as follows: insects, more than 17,000 recorded species, about 8,000 additional species expected; arachnids, such as spiders, mites, etc., some 1,700 species recorded, possibly 300 more to be found; crustaceans, almost 800 species recorded, another 300 expected; molluscs, ca. 320 species recorded, some 50 more may be expected.

In addition to the popularity criteria mentioned above, the reasons for this unevenly balanced knowledge vary. In some cases, continuous research on selected groups was carried out during long periods at universities and scientific institutes. Some taxa can even be linked to a scientist who devoted his/her life to the study of that particular group. For popular groups, numerous accomplished naturalists, often actively organised in associations, contributed significantly to the inventory, distribution and phenology of the Belgian fauna. Synergies between these naturalists and professional researchers should be encouraged and further developed, as their endless field observations and collecting efforts provide invaluable material for the monitoring of biological diversity.



38

Some faunal groups in Belgium. Percentage of recorded (green) versus additionally expected (grey) numbers.

For quite a number of taxa, only about half of the species living in Belgium are known, e.g. Collembola (springtails), Hymenoptera (bees, ants, wasps and sawflies are well known, but not the parasitic wasps), Myriapoda (centipedes and millipedes are well known, but not the symphylans and pauropodans), Amphipoda (water flies), Polychaeta (bristle worms), Cestoda (tapeworms) and Ectoprocta (moss animals). The majority of the taxonomic groups dealt with in this chapter have to be regarded as poorly known, if the percentage of recorded versus expected species is considered. Only 10 to 30% of the species estimated to be present in Belgium are known for a.o. Protozoa (protozoans), Myxozoa (myxozoans), Turbellaria (free-living flatworms), Trematoda (flukes), Nematoda (roundworms), Rotifera (rotifers), Kinorhyncha (muddragons), Protura (proturans), Mallophaga (chewing or biting lice), Coccoidea (scale insects and mealy bugs), Thysanoptera (thrips), Symphyla (symphylans), Tanaidacea (tanaids), Sipuncula (peanut worms), Echiura (spoon worms), and Tardigrada (water bears). Nevertheless, these groups have an ecologic, ecosystemic and/ or socio-economic value as well.

The situation is even worse for groups such as Monogenea or monogenetic flukes (only about 5% of the expected species recorded) and for a number of marine groups, totally unknown, which are expected to occur in Belgium, such as: Gnathostomulida (jaw worms), Cycliophora (cycliophorans), Priapula (priapulans), Loricifera (loriciferans), Tantulocarida (tantulocarids), Stomatopoda (mantis shrimps), Pentastomida (tongue worms), Aplacophora (aplacophorans), Brachiopoda (lamp shells) and Hemichordata (hemichordates), as well as for the internal parasite taxa Dicyemida and Orthonectida (formerly classified in the Mesozoa). Finally, some taxa currently ranked at phylum level have not yet been complemented since the publication of their first species lists for Belgium, e.g. Nemertea or ribbon worms (1861, 1883), Nematomorpha (1943) and Kinorhyncha (1869), resulting in completely obsolete data. The same is true for a number of lower taxonomic groups such as the Dermaptera or earwigs (1888).

Terrestrial habitats have probably been the best sampled and inventoried, together with marine benthic and pelagic communities, and intertidal zones. However, about two-thirds of the roughly 12,000 animal species, not yet discovered but supposed to occur in Belgium, live in terrestrial habitats, e.g. Hymenoptera (especially the parasitic wasps or ichneumons), Diptera (true flies, mosquitoes, gnats) and other insect orders, Acari (mites), Nematoda (roundworms), etc. Possibly more than 2,000 species can still be expected from marine habitats, particularly crustaceans, rotiferans, bristle worms, roundworms, free-living flatworms, etc. This leads to the conclusion that existing collections may not be adequately studied, and/or that many of these habitats need new, innovative and repeated sampling.

Marine species living on hard substrates in subtidal waters are hardly known. Many new species can be expected within the Hydrozoa (hydroids and hydromedusae), Amphipoda (water fleas), Polychaeta (bristle worms), Gastropoda (snails and slugs), Ectoprocta (moss animals), etc. The marine interstitial habitats also are poorly known and many species belonging to the microbenthos can be expected, e.g. Protozoa (protozoans), Rotifera (rotiferans), Gnathostomulida (jaw worms). In brackish and freshwater habitats, particularly interstitial ones, and in subterranean environments, many new species for the Belgian fauna (even new species to science) can be expected within the Protozoa (protozoans), Rotifera (rotiferans), microscopic crustaceans and insect families such as the dipteran

Chironomidae (non-biting midges), Ceratopogonidae (biting midges), etc. Finally, also parasitic groups are generally poorly known, or not studied at all, e.g. Myxozoa (myxozoans), Trematoda and Monogenea (flukes), Cestoda (tapeworms), Acanthocephala (thorny-headed worms), etc.

For many zoological groups, the existence and location of major reference collections is indicated throughout the chapter. Natural history collections are most certainly indispensable for modern biological research, of which they are an integrated part. These collections will become even more important in assessing global change, loss of biodiversity and nature conservancy. Hence, more than ever before, natural history collections have a major role to play in science and society.

Acknowledgements

The authors wish to acknowledge most sincerely all the experts who provided information via the questionnaire, personal communications and other means, as well as all peer-reviewers who contributed to scientific accuracy. Harry VAN PAESSCHEN and Marylise LECLERCQ provided invaluable artistic help with the numerous line drawings. Claudine CLAES and Yves BARETTE were helpful with the processing of illustrations. The first author expresses sincere thanks to his wife, daughters, parents and brother for their indulgence and encouragements.

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Major faunal series in adjacent countries

(The main Belgian series on fauna, together with the main Belgian series on flora and nature in general, are enumerated in annex 1)

Archives de l'Institut Grand-Ducal de Luxembourg, Section des sciences naturelles, physique et mathématique, 1906-ongoing. Centre Universitaire de Luxembourg.

Bulletin de la Société Zoologique de France, 1876-ongoing. Société Zoologique de France, Paris.

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Marc PEETERS
Jackie VAN GOETHEM
Department of Invertebrates
Royal Belgian Institute of Natural Sciences
Vautierstraat 29
1000 Brussels

CHAPTER 5

BELGIAN ECOSYSTEMS LISTED IN THE HABITATS DIRECTIVE

Eckhart KUIJKEN, Marc DUFRÊNE & Jurgen TACK

1. THE HABITATS DIRECTIVE

This chapter gives an overview of the Belgian ecosystems listed in the EU 'Habitats Directive'. The Habitats Directive[1] is a legislative instrument in the field of nature conservation that was adopted by the European Community in 1992. It establishes a common framework for the conservation of wild animal and plant species and natural habitats of Community importance.

The Habitats Directive provides for the creation of a coherent ecological network of Special Areas of Conservation, called Natura 2000, to "maintain and restore, at favourable conservation status, natural habitats and species of wild fauna and flora of Community interest". In order to make this huge task manageable, it focuses on rare and threatened habitats and species, which are listed as annexes within the Directive. Annex I contains 198 habitats (originally 164) and Annex II lists 200 animal and 435 plant species for which Special Areas of Conservation are to be designated. In addition, a series of Annex I habitats and Annex II species are afforded priority status as these are judged to be in particular danger of disappearance.

Unlike other pieces of legislation that protect wildlife, the Habitats Directive has two special features: it covers both terrestrial and marine habitats and it takes into account economic, cultural, social and recreational needs of local communities.

The Natura 2000 network also includes the Special Protection Areas designated under the 'Birds Directive'. This directive[2], adopted by the European Community in 1979, is concerned with the conservation of all species of naturally occurring birds in the wild within the territory of member states.

2. CORINE BIOTOPE CLASSIFICATION

Annex I is based on the hierarchical classification of European habitats developed by the CORINE Biotopes project (1985-1990) since it was the only existing classification of habitats at European level. In December 1991, while the Directive was being adopted, a thorough revision of the CORINE classification was published (DEVILLERS *et al.* 1991). This revision introduced numerous changes within codes and habitat types, in particular involving the division into subtypes. Consequently, Annex I codes no longer correspond

[1] Council Directive 92/43 EEC
[2] Council Directive 79/409 EEC

fully to the codes and descriptive content of the various categories of CORINE, resulting in considerable ambiguities in the interpretation of Annex I on the basis of the CORINE classification. In this chapter, the current CORINE classification is given for each of the habitats.

3. Palaearctic classification

With time, the CORINE biotope classification has been expanded at pan-European level under the Council of Europe, in order to cover Central European, Eastern European and Baltic countries. The new classification is called the Palaearctic habitat classification (Devillers & Devillers-Terschuren 1993). It has been used in the framework of the Emerald programme, which aim is to develop a network of areas of special conservation interest at pan-European level. For EU member states, Emerald network sites are those of the Natura 2000 network. The implementation phase of the Emerald network started in 1999 for non-EU states.

4. EUNIS classification

The EUNIS habitat classification has been developed by the European Environment Agency to facilitate harmonised description and collection of data across Europe through the use of criteria for habitat identification.

It is a comprehensive pan-European system, covering all habitats from natural to artificial, from terrestrial to freshwater and marine types (Moss & Davies 2002). It is built to link to and correspond with other major habitat systems in Europe:

- it cross-references to all EU Habitats Directive habitat types used for EU Member States and can be used as a basis for EU Habitats Directive extension for Accession Countries;
- it builds on the CORINE and Palaearctic habitat classifications. It will continue to include the Palaearctic habitat classification's most detailed units as they are further developed over Europe for the Emerald network (Resolution no. 4);
- it contains and will continue to include relevant marine habitat types as they are developed in collaboration with the OSPARCOM marine work;
- it cross-references to the CORINE Land Cover classification, to some regional and national classifications, and to other systems such as the European Vegetation Survey.

The EUNIS web application (http://mrw.wallonie.be/dgrne/sibw/EUNIS/home.html) gives access to the whole pan-European EUNIS habitat classification and all information about the hierarchy and definition of classes (with diagrams), text and code keys to be used for identifying specific classes.

5. Biological Evaluation Map of Belgium

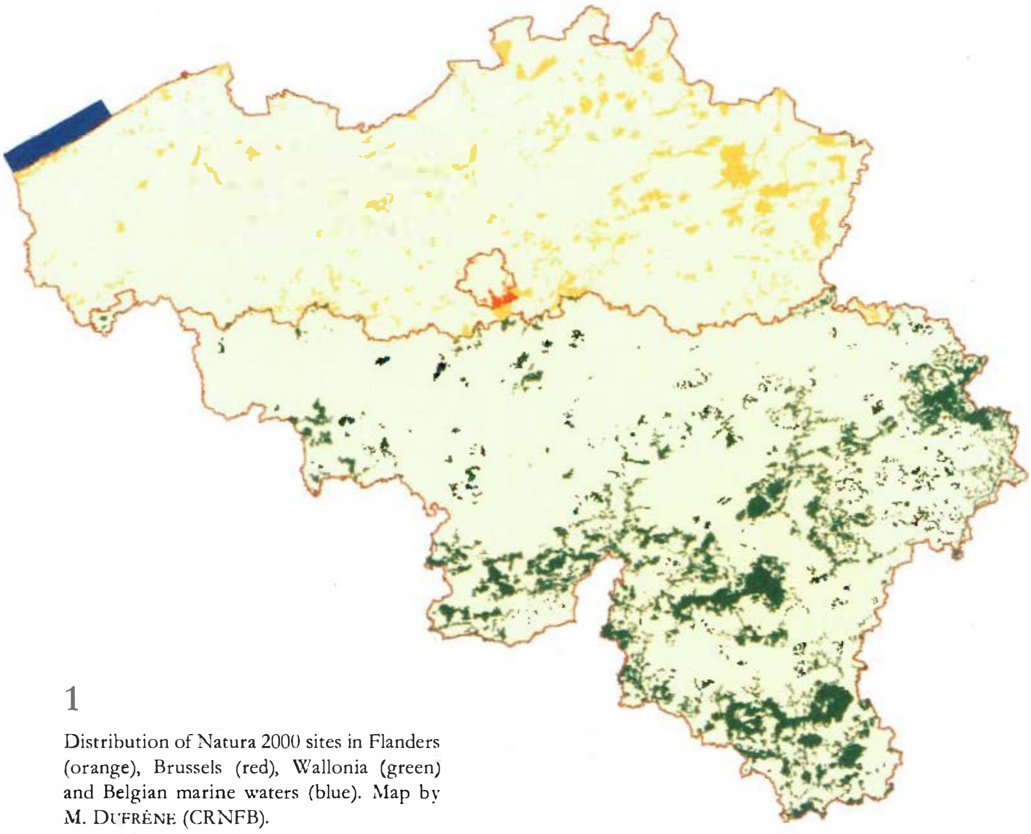
The Biological Evaluation Map (BWK) is based on a standardised, uniform survey and evaluation of the biotic environment of Belgium (De Blust *et al.* 1985a, b; Kuijken & Heirman 1984). The mapping scale is 1:25,000. The maps are published in sets of eight, covering 640 km^2. A monograph is published with each set of maps, in which the biotic, abiotic and cultural-historical landscape characteristics of the region are described.

In 1978, the Minister of Public Health asked scientific institutes and universities to set up a national mapping project for the biotic environment. Within a year the project started. However, in 1986 the project ended as a national one. Since then, the regions have been supposed to finish the remaining fieldwork and update and publish the remaining maps. In the Walloon Region, there has been no continuation until now. In the Flemish Region, the Institute of Nature Conservation carried on with the mapping project. DE BLUST *et al.* (1994) give a full description of the Biological Evaluation Map, while the biannual report on the status of nature in Flanders presents an assessment of the area of all (semi-)natural habitats occurring in Flanders (KUIJKEN 1999). The Brussels Capital Region also finalised the project. It achieved this with the help of the Flemish Region, as its territory is embedded within Flemish territory (map IGN31). The map and monograph for Brussels were published in 2000 (BRICHAU *et al.* 2000).

An English translation of all units of the Biological Evaluation Map of Belgium is given in annex 2.

6. THE NATURA 2000 NETWORK IN BELGIUM

The Natura 2000 network (figure 1) includes Special Protection Areas (SPAs) under the Birds Directive and Special Conservation Areas (SACs) under the Habitats Directive. Table 1 details the state of advancement of designations for Belgium (December 2002). Designations have been made by the three regions and at the federal level, for a marine site within the Belgian territorial waters of the North Sea.



1

Distribution of Natura 2000 sites in Flanders (orange), Brussels (red), Wallonia (green) and Belgian marine waters (blue). Map by M. DUFRÊNE (CRNFB).

Sites in the Brussels Capital Region and in Belgian territorial waters have been designated only under the Habitats Directive (table 1). Due to their importance for biodiversity, some sites in the other two regions have been designated under both Habitats and Birds Directives. For these regions, the Natura 2000 network currently totals (including sites with overlapping status):

- 97,745 ha for SPAs and 101,891 ha for SACs in Flanders, and
- 82,483 ha for SPAs and 196,617 ha for SACs in Wallonia.

Table 1. The Natura 2000 network per Region, as of December 2002. Special Protection Areas are designated under the Birds Directive and Special Areas of Conservation under the Habitats Directive. Areas with both status correspond to sites designated under both Directives.

	Special Protection Areas only (ha)	Special Areas of Conservation only (ha)	Areas with both status (ha)	Total area (ha)	% of the territory
Brussels Capital Region		2,321		2,321	14% [1]
Flemish Region	61,149	65,295	36,596	163,040	12% [1]
Walloon Region	20,923	135,057	61,560	217,540	13% [1]
Belgian territorial waters		18,120		18,120	5% [2]
Total	82,072	220,793	98,156	401,021	12% [3]

(1) Percentage of the area of the Region
(2) Percentage of the area of the Belgian marine waters
(3) Percentage of the total area of Belgium (including marine waters)

7. Belgian ecosystems listed in the Habitats Directive

Fifty-eight Annex I habitats are legally protected under regional laws in Belgium, including twelve priority types. A full description of all habitats listed in the Habitats Directive is given in the 'Interpretation Manual of European Union Habitats' (European Commission 1999).

The **descriptions** of the Belgian habitats in this chapter are adapted from this manual. They refer specifically to the Belgian situation and not to the characterisation of the habitats in the European context. For each habitat, cross-references are made to the different habitat classifications in use in Europe. Habitats are listed following the codes given by the EU interpretation manual (European Commission 1999). An asterisk between brackets (*) indicates a priority habitat.

An overview is also given of designated **sites** in the different regions of Belgium. These sites have been selected following a procedure that differed from one region to another. The main objective of this chapter is to bring all existing information together. The area given is the estimated total cover of the habitat in a given site; it has been approximated to the nearest tenth of hectare. This rough estimation may change when detailed assessments of the Natura 2000 sites will have been carried out. The number of sites containing the habitat is given between brackets.

Names of sites in Belgium enumerated as examples for a given habitat have been selected using a quantitative criterion: only the 10 sites with the largest area for the habitat are cited when there are more than 10 sites containing the habitat in a given region. This does not mean that these sites are qualitatively the most important for the habitat. Sites are listed in decreasing order of size.

Maps are also provided for each habitat. They illustrate the locations of all Natura 2000 sites hosting the habitat. An idea of the relative cover of the habitats in the sites is given through the size of the dots. Five sizes of dots correspond to an increasing cover of the habitat: 0-5%, 5-10%, 11-25%, 26-50% and 51-100% of the site, respectively.

It should be clear that most sites contain more than one habitat. If the text mentions that a specific habitat is found at a certain site, this site will certainly contain other habitats. These latter habitats can be part of the list given in this chapter, but they can also correspond to other (less or not threatened) habitats not included here. For example, habitat 2310: 'dry sand heaths with *Calluna* and *Genista*' can be found at the following sites:

- Flemish Region: De Maten, Vallei- en brongebied van de Zwarte Beek, Bolisserbeek en Dommel met heide en vengebieden, Demervallei, Bovenloop van de Grote Nete met Zammelsbroek, Langdonken en Goor, Bossen en heiden van zandig Vlaanderen: oostelijk deel, Valleien van de Winge en de Motte met valleihellingen, Schelde- en Durme-estuarium van de Nederlandse grens tot Gent, Heesbossen en vallei van Marke en Merkske en Ringven met valleigronden langs de Heerlese Loop, Bossen van de Vlaamse Ardennen en andere Zuidvlaamse bossen, Bossen van het zuidoosten van de Zandleemstreek, Vennen, heiden en moerassen rond Turnhout, Kalmthoutse Heide, Klein en Groot Schietveld, Valleien van de Laambeek, Zonderikbeek, Slangebeek en Roosterbeek met vijvergebieden en heiden, Hageven met Dommelvallei, Beverbeekse heide, Warmbeek en Wateringen, Mangelbeek en heide- en vengebieden tussen Houthalen en Gruitrode
- Walloon Region: Affluents brabançons de la Senne (Braine-l'Alleud, Braine-le-Château, Ittre, Tubize), Vallée de l'Escaut en aval de Tournai (Celles, Estaimpuis, Pecq), Bois de La Houssière (Braine-le-Comte, Ittre), Bord nord du bassin de la Haine (Beloeil, Bernissart, Saint-Ghislain), Vallée de la Trouille (Estinnes, Frameries, Mons, Quévy), Vallée de l'Ourthe entre Hamoir et Comblain-au-Pont (Anthisnes, Comblain-au-Pont, Ferrières, Hamoir, Ouffet), Camp militaire de Lagland (Arlon, Etalle, Saint Léger)

This does not mean that only dry sand heaths with *Calluna* and *Genista* are found on the sites. The first site mentioned in the list for the Flemish Region is 'De Maten'. Other Annex I habitats are also found there: habitat 2330 'inland dunes with open *Corynephorus* and *Agrostis* grasslands' and habitat 3110 'oligotrophic waters containing very few minerals of sandy plains (*Littorelletalia uniflorae*)'. Furthermore, 'De Maten' also houses a multitude of other habitats not listed in Annex I of the Habitats Directive.

Annex I habitats may sometimes only occupy a very small proportion of the area of the designated site. This is the case for both terrestrial and marine habitats. In particular, the marine sites listed are much larger than the actual distribution of Annex I habitat(s).

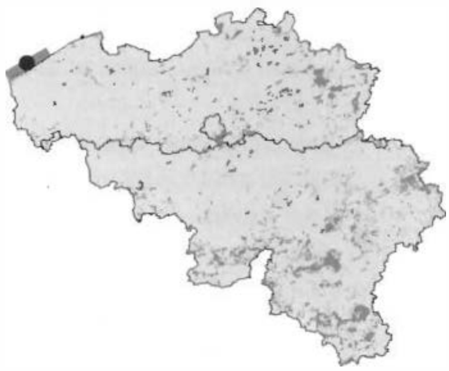
If, for a given habitat, no site is mentioned for one of the regions, this does not necessarily mean that the habitat does not occur in that part of the country. It rather indicates that there is no site in the region where this habitat is legally protected.

1110 - Sandbanks which are slightly covered by sea water all the time

Sublittoral non-vegetated sandbanks, permanently submerged. Water depth is seldom more than 20 m below Chart Datum. Sandbanks with vegetation belonging to the *Zosteretum marinae* and *Cymodoceion nodosae* as described by the EU Interpretation Manual of European Union Habitats do not occur anymore near the Belgian coast.

Habitat codes:

- Palaearctic Classification: 11.125, 11.22, 11.31
- EUNIS: A4, A2.7/B-LMS.Zos
- CORINE: 11.25
- BWK: no code



Distribution and estimated area:

- Belgian territorial waters: 5100 ha (1 site)

Site:

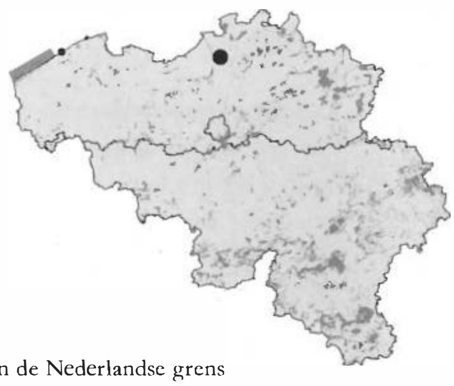
- Belgian territorial waters: Trapegeer-Stroombank

1130 - Estuaries

Downstream part of a river valley, subject to the tide and extending from the limit of brackish waters. River estuaries are coastal inlets where, unlike 'large shallow inlets and bays', there is generally a substantial freshwater influence. The mixing of fresh water and sea water and the reduced current flows in the shelter of the estuary lead to deposition of fine sediments, often forming extensive intertidal sand and mud flats. Where the tidal currents are faster than flood tides, most sediments deposit to form a delta at the mouth of the estuary.

Habitat codes:

- Palaearctic Classification: 13.2, 11.2
- EUNIS: X01
- CORINE: 13.2
- BWK: brackish part of Scheldt and IJzer estuaries



Distribution and estimated area:

- Flemish Region: 637.9 ha (2 sites)

Sites:

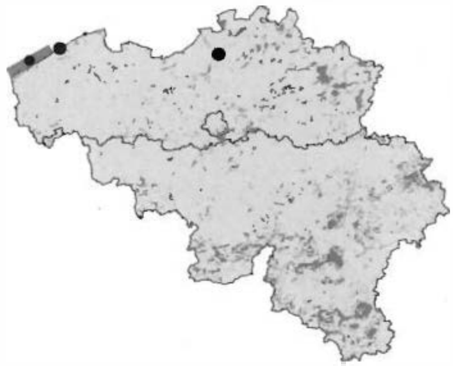
- Flemish Region: Schelde- en Durme-estuarium van de Nederlandse grens tot Gent, Duingebieden inclusief IJzermonding en Zwin

1140 - Mudflats and sandflats not covered by sea water at low tide

Sands and muds of the coasts of the oceans, their connected seas and associated lagoons, not covered by sea water at low tide, devoid of vascular plants, usually coated by blue algae and diatoms. They are of particular importance as feeding grounds for water birds and waders.

The diverse intertidal communities of invertebrates and algae that occupy them can be used to define subdivisions.

Habitat codes:
- Palaearctic Classification: 14
- EUNIS: A2.2, A2.3
- CORINE: 14
- BWK: dz and ds between patches of da and ds in salt or brackish water part of Scheldt and IJzer estuaries



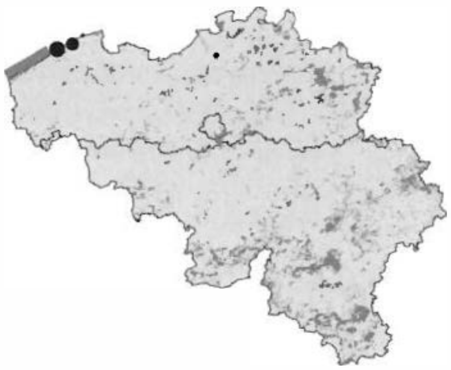
Distribution and estimated area:
- Flemish Region: 808.7 ha (2 sites)
- Belgian territorial waters: 170.0 ha (1 site)

Sites:
- Flemish Region: Duingebieden inclusief IJzermonding en Zwin, Schelde- en Durme-estuarium van de Nederlandse grens tot Gent
- Belgian territorial waters: Trapegeer-Stroombank

1310 - *Salicornia* and other annuals colonising mud and sand

Formations composed mostly or predominantly of annuals, in particular of the *Salicornia 'europaea'* group and/or *Suaeda maritima*, colonising periodically inundated muds and sands of marine or interior salt marshes. Other specific species are *Spergularia marina*, *S. maritima* and *Glaux maritima*.

Habitat codes:
- Palaearctic Classification: 15.1
- EUNIS: A2.65
- CORINE: 15.1
- BWK: parts of ds in marine intertidal areas and parts of da



Distribution and estimated area:
- Flemish Region: 62.0 ha (3 sites)

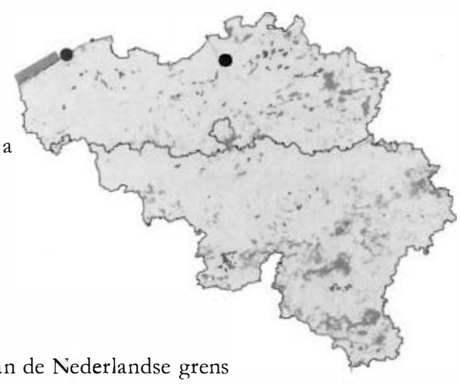
Sites:
- Flemish Region: Duingebieden inclusief IJzermonding en Zwin, Polders, Schelde- en Durme-estuarium van de Nederlandse grens tot Gent

1320 - *Spartina* swards (*Spartinion maritimae*)

Perennial pioneer grasslands of coastal salt muds, formed by *Spartina* or similar grasses. *Spartina maritima* does not exist anymore in Belgium. The species is pushed aside by *Spartina townsendii*.

Habitat codes:

- Palaearctic Classification: 15.2
- EUNIS: A2.65
- CORINE: 15.2
- BWK: parts of ds in brackish areas and parts of da



Distribution and estimated area:

- Flemish Region: 9.7 ha (2 sites)

Sites:

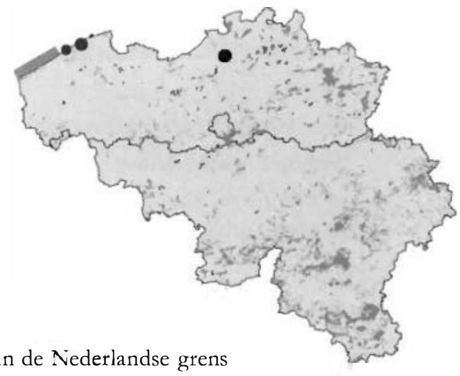
- Flemish Region: Schelde- en Durme-estuarium van de Nederlandse grens tot Gent, Duingebieden inclusief IJzermonding en Zwin

1330 - Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)

Salt meadows only inundated at spring tide. *Puccinellia maritima* is a typical species on low, muddy meadows while *Halimione portulacoides* is typical on places with fast silting.

Habitat codes:

- Palaearctic Classification: 15.3
- EUNIS: A2.6/P-15.3
- CORINE: 15.3
- BWK: da, da in hpr or hpr*



Distribution and estimated area:

- Flemish Region: 478.8 ha (3 sites)

Sites:

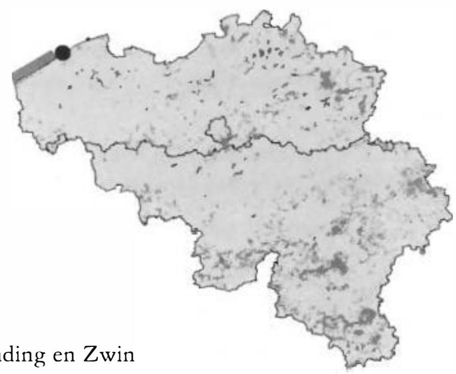
- Flemish Region: Schelde- en Durme-estuarium van de Nederlandse grens tot Gent, Duingebieden inclusief IJzermonding en Zwin, Polders

2110 - Embryonic shifting dunes

Formations of the coast representing the first stages of dune construction, constituted by ripples or raised sand surfaces of the upper beach or by a seaward fringe at the foot of the tall dunes.

Habitat codes:

- Palaearctic Classification: 16.211
- EUNIS: B1.3/P-16.211
- CORINE: 16.211
- BWK: specific beaches and part of dd or dm



Distribution and estimated area:

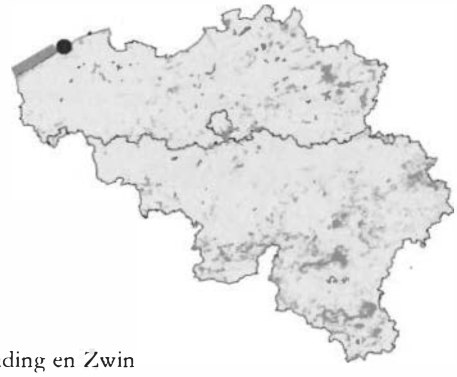
- Flemish Region: 3.7 ha (1 site)

Site:

- Flemish Region: Duingebieden inclusief IJzermonding en Zwin

2120 - Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes)

Mobile dunes forming the seaward cordon or cordons of dune systems of the coast.



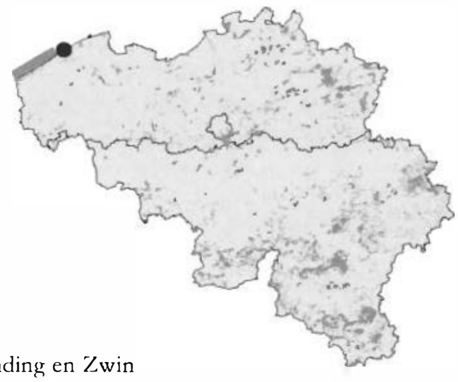
Habitat codes:
- Palaearctic Classification: 16.212
- EUNIS: B1.3/P-16.212
- CORINE: 16.212
- BWK: dd

Distribution and estimated area:
- Flemish Region: 485.8 ha (1 site)

Site:
- Flemish Region: Duingebieden inclusief IJzermonding en Zwin

2130 - (*) Fixed coastal dunes with herbaceous vegetation (grey dunes)

Fixed dunes, stabilised and colonised by more or less closed perennial grasslands and abundant carpets of lichens and mosses.



Habitat codes:
- Palaearctic Classification: 16.221
- EUNIS: B1.4/P-16.221
- CORINE: 16.221-16-227
- BWK: hd, parts of had

Distribution and estimated area:
- Flemish Region: 784.8 ha (1 site)

Site:
- Flemish Region: Duingebieden inclusief IJzermonding en Zwin

2150 - (*) Atlantic decalcified fixed dunes (*Calluno-Ulicetea*)

Decalcified dunes colonised by heaths of the alliances *Calluno-Genistion* or *Ulicion minoris*. These alliances are almost not found in Belgium.

Habitat codes:
- Palaearctic Classification: 16.24
- EUNIS: B1.5
- CORINE: 16.24
- BWK: parts of had

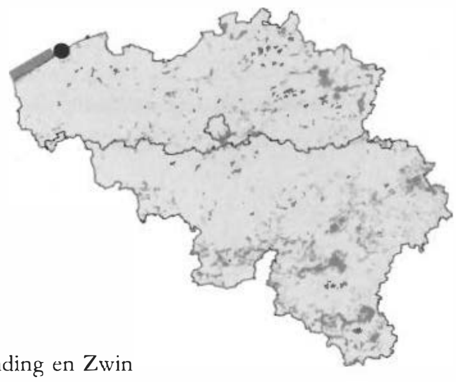
Distribution and estimated area:
- Flemish Region: 37.4 ha (1 site)

Site:
- Flemish Region: Duingebieden inclusief IJzermonding en Zwin

2160 - Dunes with *Hippophae rhamnoides*

Sea-buckthorn formations of forest colonisation in both dry and humid dune depressions.

Habitat codes:
- Palaearctic Classification: 16.251
- EUNIS: B1.6/P-16.251
- CORINE: 16.251
- BWK: sd



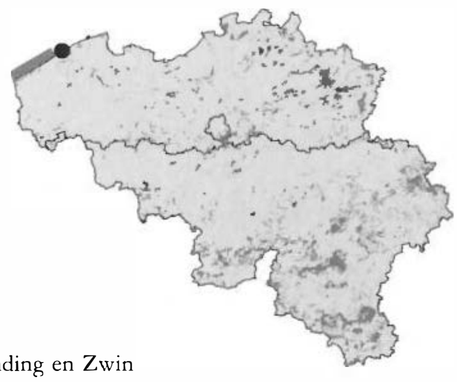
Distribution and estimated area:
- Flemish Region: 635.3 ha (1 site)

Site:
- Flemish Region: Duingebieden inclusief IJzermonding en Zwin

2170 - Dunes with *Salix repens* ssp. *argentea* (*Salicion arenariae*)

Salix repens communities colonising wet dune slacks. Following the lowering of the groundwater table or accumulation of drift sand, these communities may develop into mesophilous communities as the *Pyrolo-Salicetum* (with *Pyrola rotundifolia* and *Viola canina*) or into xerophilous *Salix* communities (with *Carlina vulgaris* and *Thalictrum flavum*) or into *Salix repens* communities with *Mesobromion* elements.

Habitat codes:
- Palaearctic Classification: 16.26
- EUNIS: B1.6
- CORINE: 16.26
- BWK: parts of mp, dd and hd



Distribution and estimated area:
- Flemish Region: 3.7 ha (1 site)

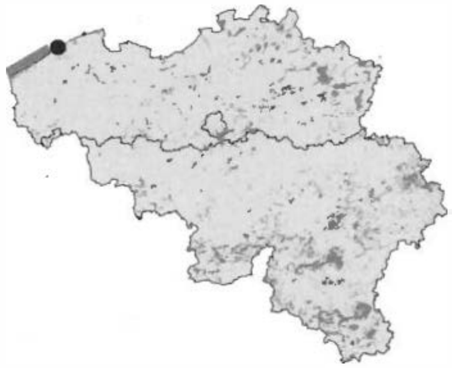
Site:
- Flemish Region: Duingebieden inclusief IJzermonding en Zwin

2180 - Wooded dunes of the Atlantic, Continental and Boreal region

Natural or semi-natural forests (long established) of coastal dunes with a well-developed woodland structure and an assemblage of characteristic woodland species. Wooded dunes do not have a natural distribution in Belgium.

Habitat codes:

- Palaearctic Classification: 16.29
- EUNIS: B1.7
- CORINE: 16.29
- BWK: qd, rud, ru in coastal dunes (also other q- and f-forests or sf in the dunes)



Distribution and estimated area:

- Flemish Region: 635.3 ha (1 site)

Site:

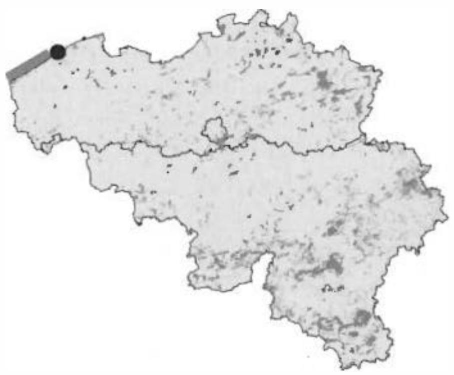
- Flemish Region: Duingebieden inclusief IJzermonding en Zwin

2190 - Humid dune slacks

Humid depressions of dunal systems. Humid dune slacks are extremely rich and specialised habitats, very threatened by the lowering of water tables.

Habitat codes:

- Palaearctic Classification: 16.3
- EUNIS: B1.8
- CORINE: 16.31-16.35
- BWK: mp and ae, ao, mr, mc, mm, hc, hj in the dunes



Distribution and estimated area:

- Flemish Region: 37.4 ha (1 site)

Site:

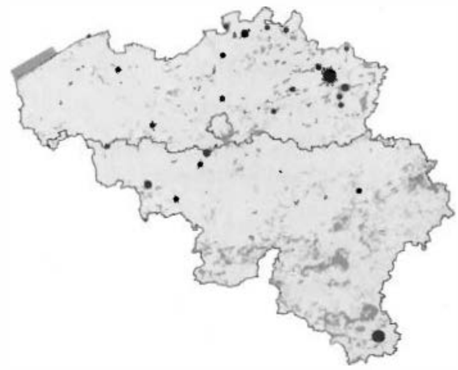
- Flemish Region: Duingebieden inclusief IJzermonding en Zwin

2310 - Dry sand heaths with *Calluna* and *Genista*

Dunes formed of quartzic sands originating in redeposited and reworked glacial drift and outwash. They are highly siliceous in the Netherlands, northern Belgium and northwestern Germany, progressively slightly less oligotrophic and with a more continental species assemblage in northeastern Germany, Poland and the eastern Baltic plain. The dune systems, particularly the large ones, harbour a unique ensemble of interacting communities and harbour many specialised and localised organisms. They have considerably regressed and the remaining examples are fragile and often threatened. Vegetation is dominated by heaths with *Calluna* and *Genista*.

Habitat codes:

- Palaearctic Classification: 64.1 x 31.223
- EUNIS: (E1.9/P-64.11, E1.9/P-64.12, E1.9/P-64.13) x F4.2/P-31.23
- CORINE: 64.1 x 31.223
- BWK: parts of cg and cgb



Distribution and estimated area:

- Flemish Region: 667.2 ha (16 sites)
- Walloon Region: 542.9 ha (7 sites)

Major sites:

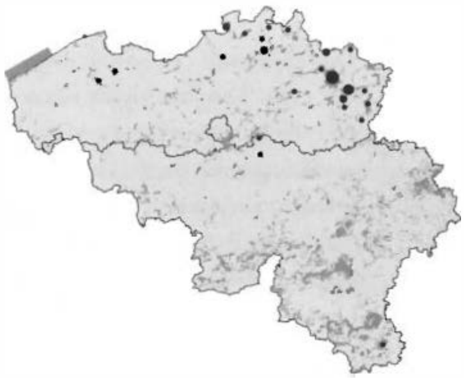
- Flemish Region: Vallei- en brongebied van de Zwarte Beek, Bolisserbeek en Dommel met heide en vengebieden, Mangelbeek en heide- en vengebieden tussen Houthalen en Gruitrode, Klein en Groot Schietveld, Vennen, heiden en moerassen rond Turnhout, Valleien van de Laambeek, Zonderikbeek, Slangebeek en Roosterbeek met vijvergebieden, Kalmthoutse Heide, Hageven met Dommelvallei, Beverbeekse Heide, Warmbeek en Wateringen, Heesbossen en vallei van Marke en Merkske en Ringven met valleigronden langs de Heerlese Loop, Schelde- en Durme-estuarium van de Nederlandse grens tot Gent, Bossen van de Vlaamse Ardennen en andere Zuidvlaamse bossen
- Walloon Region: Camp militaire de Lagland (Arlon, Etalle, Saint Léger), Bord nord du bassin de la Haine (Beloeil, Bernissart, Saint-Ghislain), Affluents brabançons de la Senne (Braine-l'Alleud, Braine-le-Château, Ittre, Tubize), Bois de La Houssière (Braine-le-Comte, Ittre), Vallée de la Trouille (Estinnes, Frameries, Mons, Quévy), Vallée de l'Escaut en aval de Tournai (Celles, Estaimpuis, Pecq), Vallée de l'Ourthe entre Hamoir et Comblain-au-Pont (Anthisnes, Comblain-au-Pont, Ferrières, Hamoir, Ouffet)

2330 - Inland dunes with open *Corynephorus* and *Agrostis* grasslands

Open formations found on inland dunes with dry siliceous soils, often species-poor and with a strong representation of annuals. It includes formations of unstable Germano-Baltic fluvio-glacial inland sands with *Corynephorus canescens*, *Carex arenaria*, *Spergula morisonii*, *Teesdalia nudicaulis* and carpets of fruticose lichens (*Cladonia*).

Habitat codes:

- Palaearctic Classification: (64.11 or 64.12) x 35.2
- EUNIS: (E1.9/P-64.11, E1.9/P-64.12) x E1.9
- CORINE: 64.1 x 35.2
- BWK: ha, hab



Distribution and estimated area:

- Flemish Region: 1719.9 ha (20 sites)
- Walloon Region: 37.5 ha (3 sites)

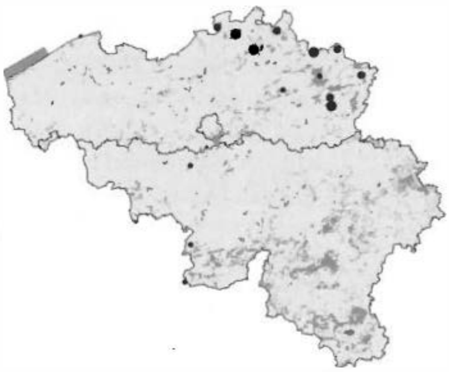
Major sites:

- Flemish Region: Vallei- en brongebied van de Zwarte Beek, Bolisserbeek en Dommel met heide en vengebieden, Mangelbeek en heide- en vengebieden tussen Houthalen en Gruitrode, Kalmthoutse Heide, Valleien van de Laambeek, Zonderikbeek, Slangebeek en Roosterbeek met vijvergebieden, Bos- en heidegebieden ten oosten van Antwerpen, Valleigebied van de Kleine Nete met brongebieden, moerassen en heiden, Vennen, heiden en moerassen rond Turnhout, Klein en Groot Schietveld, Hageven met Dommelvallei, Beverbeekse Heide, Warmbeek en Wateringen, De Maten

- Walloon Region: Camp militaire de Lagland (Arlon, Etalle, Saint Léger), Vallée de la Nethen (Beauvechain, Grez-Doiceau), Vallée du Train (Chaumont-Gistoux, Grez-Doiceau)

3110 - Oligotrophic waters containing very few minerals of sandy plains (*Littorelletalia uniflorae*)

Shallow oligotrophic waters with few minerals and base-poor, with an aquatic to amphibious low perennial vegetation belonging to the *Littorelletalia uniflorae* order, on oligotrophic soils of lake and pond banks (sometimes on peaty soils). This vegetation consists of one or more zones, dominated by *Littorella*, *Lobelia dortmana* or *Isoetes* although all zones may not be found at a given site.



Habitat codes:

- Palaearctic Classification: 22.11 x 22.31
- EUNIS: C1.1 x C3.4/P-2231
- CORINE: 22.11 x 22.31
- BWK: parts of ao (BWK version 1); parts of aom (BWK version 2)

Distribution and estimated area:

- Flemish Region: 476.3 ha (11 sites)
- Walloon Region: 2.5 ha (3 sites)

Major sites:

- Flemish Region: Valleigebied van de Kleine Nete met brongebieden, moerassen en heiden, Klein en Groot Schietveld, De Maten, Bos- en heidegebieden ten oosten van Antwerpen, Kalmthoutse Heide, Hageven met Dommelvallei, Beverbeekse Heide, Warmbeek en Wateringen, Itterbeek met Brand, Jagersborg en Schootsheide en Bergerven, Valleien van de Laambeek, Zonderikbeek, Slangebeek en Roosterbeek met vijvergebieden, Vennen, heiden en moerassen rond Turnhout, Vallei- en brongebied van de Zwarte Beek, Bolisserbeek en Dommel met heide en vengebieden
- Walloon Region: Haute vallée de la Thure (Beaumont, Sivry-Rance), Vallée de l'Oise et de la Wartoise (Chimay, Momignies), Bois de La Houssière (Braine-le-Comte, Ittre)

3130 - Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or *Isoeto-Nanojuncetea*

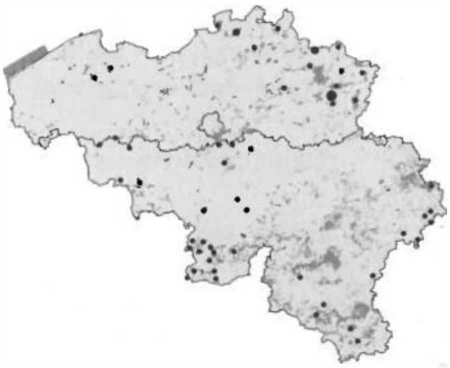
22.12 x 22.31 - aquatic to amphibious short perennial vegetation, oligotrophic to mesotrophic, of lake, pond and pool banks and water-land interfaces belonging to the *Littorelletea uniflorae* order.

22.12 x 22.32 - amphibious short annual vegetation, pioneer of land interface zones of lakes, pools and ponds with nutrient-poor soils, or which grows during periodic drying of these standing waters: *Isoeto-Nanojuncetea* class.

These two units can grow together in close association or separately. Characteristic plant species are generally small ephemerophytes.

Habitat codes:

- Palaearctic Classification: 22.12 x (22.31 and 22.32)
- EUNIS: C1.2 x (C3.4/P-22.31 and C3.4/P-22.32)
- CORINE: 22.12 x (22.31 and 22.32)
- BWK: parts of ao (BWK version 1); parts of aom (BWK version 2)



Distribution and estimated area:

- Flemish Region: 782.4 ha (16 sites)
- Walloon Region: 358.9 ha (36 sites)

Major sites:

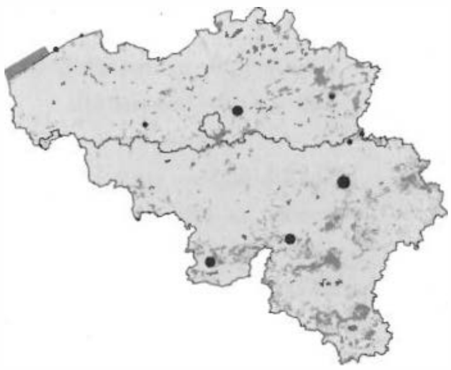
- Flemish Region: Valleien van de Laambeek, Zonderikbeek, Slangebeek en Roosterbeek met vijvergebieden, Valleigebied van de Kleine Nete met brongebieden, moerassen en heiden, Klein en Groot Schietveld, De Maten, Bovenloop van de Grote Nete met Zammelsbroek, Langdonken en Goor, Kalmthoutse Heide, Hageven met Dommelvallei, Beverbeekse Heide, Warmbeek en Wateringen, Mangelbeek en heide- en vengebieden tussen Houthalen en Gruitrode, Mechelse Heide en vallei van de Ziepbeek, Itterbeek met Brand, Jagersborg en Schootsheide en Bergerven
- Walloon Region: Vallée de l'Argentine (La Hulpe, Lasne, Rixensart, Waterloo), Vallée de l'Escaut en aval de Tournai (Celles, Estaimpuis, Pecq), Haute-Vierre (Bertrix, Herbeumont, Libramont, Chevigny, Neufchâteau), Vallée de l'Oise et de la Wartoise (Chimay, Momignies), Bois de Bourlers et de Baileux (Chimay, Couvin), Vallée de l'Eau Blanche à Virelles (Chimay, Couvin, Froidchapelle), Bord nord du bassin de la Haine (Beloeil, Bernissart, Saint-Ghislain), Vallée de la Lasne (Rixensart, Wavre), Vallée de la Hante (Beaumont, Froidchapelle, Sivry-Rance), Bassin de la Semois d'Etalle à Tintigny (Etalle, Habay, Tintigny)

3140 - Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.

Lakes and pools with waters fairly rich in dissolved bases (pH often 6-7) (21.12) or with mostly blue to greenish, very clear, waters poor (to moderate) in nutrients, base-rich (pH often > 7.5) (21.15). The bottom of these unpolluted water bodies are covered with charophyte, *Chara* and *Nitella*, algal carpets.

Habitat codes:

- Palaearctic Classification: (22.12 or 22.15) x 22.44
- EUNIS: (C1.2 or C1.1) x (C1.1/P-22.44, C1.2/P-22.44, C1.4/P-22.44)
- CORINE: 22.12 x 22.44
- BWK: parts of ae



Distribution and estimated area:

- Flemish Region: 27.4 ha (4 sites)
- Walloon Region: 60.7 ha (5 sites)

Sites:

- Flemish Region: Valleigebied tussen Melsbroek, Kampenhout, Kortenberg en Veltem, Bossen van de Vlaamse Ardennen en andere Zuidvlaamse bossen, Duingebieden inclusief IJzermonding en Zwin, Valleien van de Laambeek, Zonderikbeek, Slangebeek en Roosterbeek met vijvergebieden

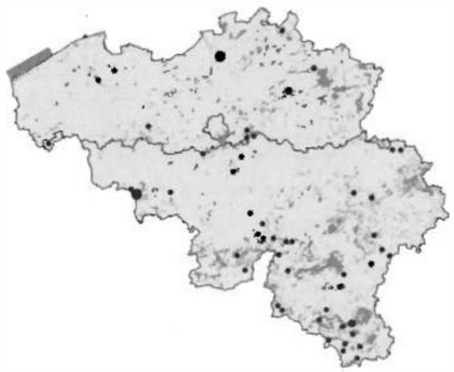
- Walloon Region: Bois d'Anthisnes et d'Esneux (Anthisnes, Comblain-au-Pont, Esneux, Nandrin, Neupré, Ouffet, Tinlot), Vallée de l'Eau Blanche à Virelles (Chimay, Couvin, Froidchapelle), Bassin de l'Iwène (Ciney, Houyet, Rochefort), Basse vallée du Geer (Bassenge, Juprelle, Oupeye, Visé), Montagne Saint-Pierre (Bassenge, Oupeye, Visé)

3150 - Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation

Lakes and ponds with mostly dirty grey to blue-green, more or less turbid, waters, particularly rich in dissolved bases (pH usually > 7), with free-floating surface communities of *Lemna* spp., *Spirodela polyrhiza*, *Wolffia arhiza*, *Azolla filiculoides*, *Ricciocarpus natans* and *Riccia fluitans*, or in deep, open waters, with associations of large pondweeds (*Hydrocharis morsus-ranae*).

Habitat codes:

- Palaearctic Classification: 22.13 x (22.41 or 22.421)
- EUNIS: C1.3 x (C1.3/P-22.41(p) or C1.2/P-22.412)
- CORINE: 22.13 x (22.41 or 22.421)
- BWK: ae*, aer*, aev, aev*, parts of ae



Distribution and estimated area:

- Flemish Region: 402 ha (8 sites)
- Walloon Region: 680.1 ha (42 sites)

Major sites:

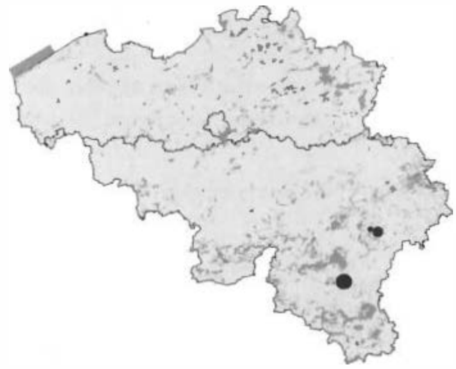
- Flemish Region: Schelde- en Durme-estuarium van de Nederlandse grens tot Gent, Demervallei, Valleien van de Dijle, Laan en IJse met aangrenzende bos- en moerasgebieden, Vennen, heiden en moerassen rond Turnhout, Bossen en heiden van zandig Vlaanderen: oostelijk deel, Bossen van de Vlaamse Ardennen en andere Zuidvlaamse bossen, Bovenloop van de Grote Nete met Zammelsbroek, Langdonken en Goor, Bossen, heiden en valleigebieden van zandig Vlaanderen: westelijk deel
- Walloon Region: Vallée de la Haine en aval de Mons (Bernissart, Boussu, Hensies, Jurbise, Mons, Quaregnon, Saint-Ghislain), Vallées du Ruisseau de Mellier et de Mandebras (Habay, Léglise, Neufchâteau), Vallée de la Thyle (Court-Saint-Etienne, Genappe, Les Bons Villers, Villers-la-Ville), Haute-Vierre (Bertrix, Herbeumont, Libramont, Chevigny, Neufchâteau), Bassin fagnard de l'Eau Blanche en aval de Mariembourg (Couvin, Doische, Philippeville), Vallée de la Lys (Comines-Warneton), Haute-Wimbe (Beauraing, Daverdisse, Gedinne, Wellin), Vallée de la Semois en aval d'Alle (Bièvre, Vresse-sur-Semois), Bassin de la Marche (Chiny, Florenville, Meix-devant-Virton), Etangs de Longchamps et de Noville (Bastogne, Bertogne)

3160 - Natural dystrophic lakes and ponds

Natural lakes and ponds with brown tinted water due to peat and humic acids, generally on peaty soils in bogs or in heaths with natural evolution toward bogs. pH is often low, 3 to 6.

Habitat codes:

- Palaearctic Classification: 22.14
- EUNIS: C1.4
- CORINE: 22.14
- BWK: parts of ao (under investigation)



Distribution and estimated area:

- Walloon Region: 16.4 ha (3 sites)

Sites:

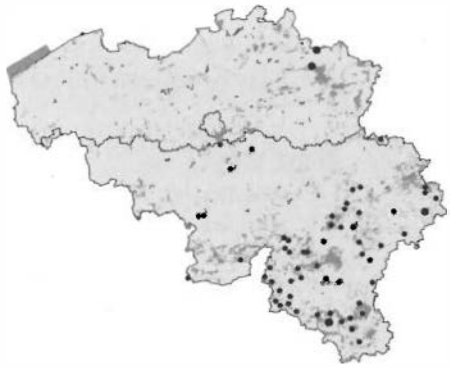
- Walloon Region: Bassin supérieur de l'Ourthe occidentale (Libramont, Chevigny), Fagnes de Samrée et de Tailles (Houffalize, La Roche-en-Ardenne, Manhay, Vielsalm), Fanges des sources de l'Aisne (La Roche-en-Ardenne, Manhay, Vielsalm)

3260 - Water courses of plain to montane levels with *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation

Water courses of plain to montane levels, with submerged or floating vegetation of the *Ranunculion fluitantis* and *Callitricho-Batrachion* (low water level during summer) or aquatic mosses.

Habitat codes:

- Palaearctic Classification: 24.4
- EUNIS: C2.1/P-24.4
- CORINE: 24.4
- BWK: code under investigation



Distribution and estimated area:

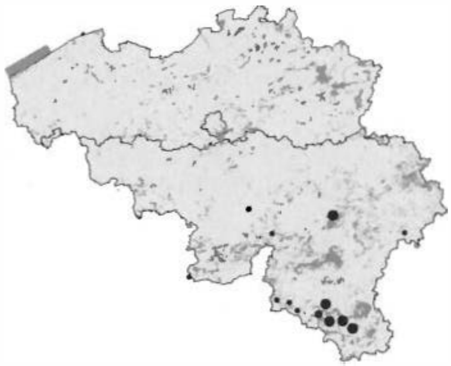
- Flemish Region: 107.8 ha (3 sites)
- Walloon Region: 664.4 ha (60 sites)

Major sites:

- Flemish Region: Valleigebied van de Kleine Nete met brongebieden, moerassen en heiden, Bovenloop van de Grote Nete met Zammelsbroek, Langdonken en Goor, Voerstreek
- Walloon Region: Bassin de la Semois de Jamoigne à Chiny (Chiny, Florenville, Herbeumont), Haute vallée de l'Amblève entre Heppenbach et Montenau (Amel), Bassin de la Lomme de Poix-Saint-Hubert à Grupont (Libin, Saint-Hubert, Tellin), Vallée de l'Ourthe entre Hotton et Barvaux-sur-Ourthe (Durbuy, Hotton, Somme-Leuze), Basse vallée de l'Aisne (Durbuy, Erezée, Ferrières, Manhay), Bassin de la Semois du Maka à Bouillon (Bouillon), Bassin de la Semois entre Tintigny et Jamoigne (Chiny, Habay, Léglise, Tintigny), Massif forestier de Daverdisse (Daverdisse, Libin, Tellin, Wellin), Basse-Vierre (Chiny, Herbeumont, Léglise, Neufchâteau, Tintigny), Haute-Sambre en amont de Thuin (Lobbes, Merbes-le-Château, Thuin)

3270 - Rivers with muddy banks with *Chenopodion rubri* p.p. and *Bidention* p.p. vegetation

Muddy river banks of plain to submontane levels, with annual pioneer nitrophilous vegetation of the *Chenopodion* spp., *Rorippa* spp., *Polygonum* spp., *Xanthium* spp. and the *Bidens* spp. alliances. During the spring and at the beginning of the summer, sites look like muddy banks without any vegetation (later development in the year). If the conditions are not favourable, this vegetation has a weak development or could be completely absent.



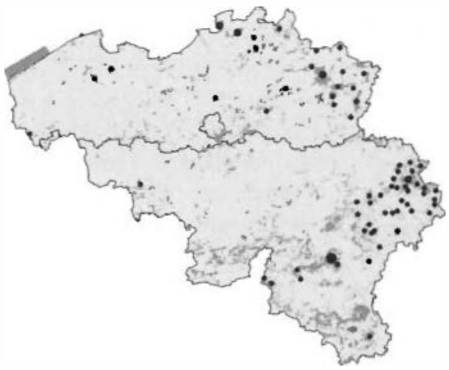
Habitat codes:
- Palaearctic Classification: 24.52
- EUNIS: C3.5/P.24.52
- CORINE: 24.52
- BWK: for muddy banks, parts of ds and/or ku (under investigation)

Distribution and estimated area:
- Walloon Region: 148.7 ha (13 sites)

Major sites:
- Walloon Region: Bassin de la Semois de Jamoigne à Chiny (Chiny, Florenville, Herbeumont), Bassin de la Semois d'Etalle à Tintigny (Etalle, Habay, Tintigny), Bassin de la Semois entre Tintigny et Jamoigne (Chiny, Habay, Léglise, Tintigny), Haute-Vierre (Bertrix, Herbeumont, Libramont, Chevigny, Neufchâteau), Vallée de l'Ourthe entre Hotton et Barvaux-sur-Ourthe (Durbuy, Hotton, Somme-Leuze), Bassin de la Semois de Florenville à Auby (Bertrix, Florenville, Herbeumont), Vallée de la Semois en aval d'Alle (Bièvre, Vresse-sur-Semois), Bassin de la Semois du Maka à Bouillon (Bouillon), Bassin de la Semois de Bouillon à Alle (Bièvre, Bouillon, Paliseul, Vresse-sur-Semois), Vallée de l'Ulf (Burg-Reuland, Gouvy)

4010 - Northern Atlantic wet heaths with *Erica tetralix*

Humid, peaty or semi-peaty heaths, other than blanket bogs, of the Atlantic and sub-Atlantic domains.



Habitat codes:
- Palaearctic Classification: 31.11
- EUNIS: F4.1/P-31.11
- CORINE: 31.11
- BWK: ce, ceb (excluding ces)

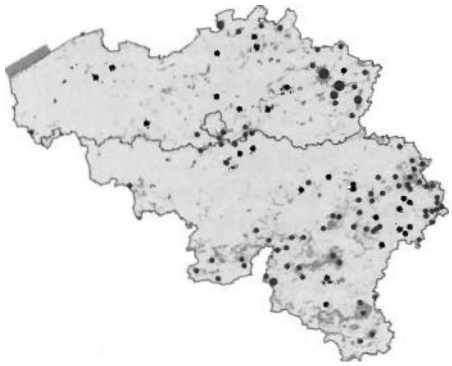
Distribution and estimated area:
- Flemish Region: 1499.6 ha (23 sites)
- Walloon Region: 2132.1 ha (47 sites)

Major sites:
- Flemish Region: Klein en Groot Schietveld, Vallei- en brongebied van de Zwarte Beek, Bolisserbeek en Dommel met heide en vengebieden, Kalmthoutse Heide, Mangelbeek en heide- en vengebieden tussen Houthalen en Gruitrode, Vennen, heiden en moerassen rond Turnhout, Valleigebied van de Kleine Nete met brongebieden, moerassen en heiden, Mechelse Heide en vallei van de Ziepbeek, Valleien van de Laambeek, Zonderikbeek, Slangebeek en Roosterbeek met vijvergebieden, Bos- en heidegebieden ten oosten van Antwerpen, Bovenloop van de Grote Nete met Zammelsbroek, Langdonken en Goor
- Walloon Region: Haute-Wamme et Masblette (La Roche-en-Famenne, Marche-en-Famenne, Nassogne, Saint-Hubert, Tellin, Tenneville), Plateàu des Hautes-Fagnes (Baelen, Bütgenbach, Jalhay, Malmedy, Waimes), Forêt de Freyr (Libramont, Chevigny, Saint-Hubert, Saint-Ode, Tenneville),

Fagnes de Malchamps et de Stoumont (Aywaille, Spa, Stavelot, Stoumont, Theux), Vallée de la Helle (Baelen, Eupen, Waimes), Bord nord du bassin de la Haine (Beloeil, Bernissart, Saint-Ghislain), Fagnes de la Polleur et de Malmedy (Malmedy, Waimes), Bassin supérieur de la Salm (Gouvy, Vielsalm), Fagnes du Nord-Est (Eupen, Raeren, Waimes), Vallée de la Hulle (Gedinne)

4030 - European dry heaths

Mesophile or xerophile heaths on siliceous, podsolic soils in moist Atlantic and sub-Atlantic climates of plains and low mountains.



Habitat codes:

- Palaearctic Classification: 31.2
- EUNIS: F4.2
- CORINE: 31.2
- BWK: cg, cgb, cv, sgu

Distribution and estimated area:

- Brussels Capital Region: 20.6 ha (1 site)
- Flemish Region: 7799.8 ha (30 sites)
- Walloon Region: 2851.3 ha (88 sites)

Major sites:

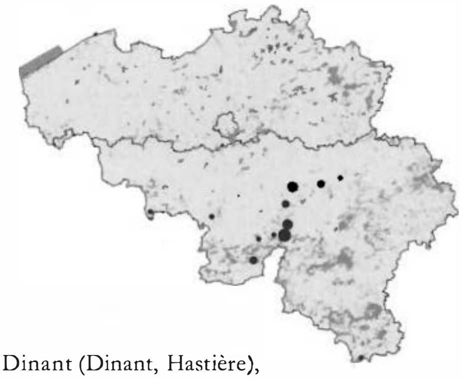
- Brussels Capital Region: Forêt de Soignes avec lisières et domaines boisés avoisinants et la Vallée de la Woluwe / Zoniënwoud met aangrenzende bosgebieden en Woluwevallei (Zoniënwoud / Forêt de Soignes)
- Flemish Region: Vallei- en brongebied van de Zwarte Beek, Bolisserbeek en Dommel met heide en vengebieden, Mangelbeek en heide- en vengebieden tussen Houthalen en Gruitrode, Mechelse Heide en vallei van de Ziepbeek, Valleien van de Laambeek, Zonderikbeek, Slangebeek en Roosterbeek met vijvergebieden, Kalmthoutse Heide, Klein en Groot Schietveld, Bos- en heidegebieden ten oosten van Antwerpen, Hageven met Dommelvallei, Beverbeekse Heide, Warmbeek en Wateringen, Valleigebied van de Kleine Nete met brongebieden, moerassen en heiden, Bosbeekvallei en aangrenzende bos- en heidegebieden te As-Opglabbeek-Maaseik
- Walloon Region: Vallée de la Houille en amont de Gedinne (Bièvre, Gedinne), Camp militaire d'Elsenborn (Büllingen, Bütgenbach), Haute-Wamme et Masblette (La Roche-en-Famenne, Marche-en-Famenne, Nassogne, Saint-Hubert, Tellin, Tenneville), Basse vallée de l'Aisne (Durbuy, Erezée, Ferrières, Manhay), Fagnes du Nord-Est (Eupen, Raeren, Waimes), Plateau des Hautes-Fagnes (Baelen, Bütgenbach, Jalhay, Malmedy, Waimes), Bassin supérieur de la Salm (Gouvy, Vielsalm), Vallée de la Hulle (Gedinne), Massif forestier de Daverdisse (Daverdisse, Libin, Tellin, Wellin), Vallée de l'Ourthe entre Comblain-au-Pont et Angleur (Chaudfontaine, Comblain-au-Pont, Esneux, Liège, Neupré, Sprimont)

5110 - Stable xerothermophilous formations with *Buxus sempervirens* on rock slopes (*Berberidion* p.p.)

Stable xerothermophilous and calcicolous scrubs dominated by *Buxus sempervirens*, of hill and montane levels. These formations correspond to xerothermophilous *Buxus* thickets with their fringe associations of the *Geranion sanguinei* alliance on calcareous or siliceous substratum. They also constitute the natural woodland edge of calcareous dry forests rich with *Buxus*.

Habitat codes:

- Palaearctic Classification: 31.82
- EUNIS: F3.1/P.31.82
- CORINE: 31.82
- BWK: sx



Distribution and estimated area:

- Walloon Region: 452.5 ha (12 sites)

Major sites:

- Walloon Region: Vallée de la Meuse d'Hastière à Dinant (Dinant, Hastière), Vallée de la Meuse de Dinant à Yvoir (Anhée, Dinant, Onhaye, Yvoir), Vallée de la Meuse de Dave à Marche-les-Dames (Namur), La Calestienne entre Frasnes et Doische (Couvin, Doische, Philippeville, Viroinval), Vallée de la Meuse à Huy et vallon de la Solières (Amay, Huy, Wanze), Vallée de la Meuse d'Yvoir à Dave (Anhée, Assesse, Namur, Profondeville, Yvoir), Haute-Sambre en amont de Thuin (Lobbes, Merbes-le-Château, Thuin), Vallée du Ruisseau de Féron (Doische, Florennes, Hastière, Onhaye), Vallée de la Chinelle (Florennes, Philippeville), Affluents de la Meuse entre Huy et Flémalle (Amay, Engis, Flémalle, Modave, Nandrin, Neupré)

5130 - *Juniperus communis* formations on heaths or calcareous grasslands

Formations with *Juniperus communis* of plain to montane levels.

Habitat codes:

- Palaearctic Classification: 31.88
- EUNIS: F3.1/P-31.88
- CORINE: 31.88
- BWK: part of cg

Distribution and estimated area:

- Flemish Region: 1.3 ha (2 sites)
- Walloon Region: 29.7 ha (11 sites)

Major sites:

- Flemish Region: Overgang Kempen-Haspengouw, Bosbeekvallei en aangrenzende bos- en heidegebieden te As-Opglabbeek-Maaseik
- Walloon Region: La Calestienne entre Frasnes et Doische (Couvin, Doische, Philippeville, Viroinval), Basse vallée de la Lienne (Lierneux, Stoumont), Fagnes de Malchamps et de Stoumont (Aywaille, Spa, Stavelot, Stoumont, Theux), Forêt de Freyr (Libramont, Chevigny, Saint-Hubert, Saint-Ode, Tenneville), Fagnes de la Crépale et prairies de Malempré (Lierneux, Manhay), Fagnes de Stavelot et vallée de l'Eau Rouge (Jalhay, Malmedy, Stavelot), Bassin de la Lesse entre Villers-sur-Lesse et Chanly (Nassogne, Rochefort, Tellin, Wellin), Vallées de Laclaireau et du Rabais (Etalle, Saint-Léger, Virton), Vallée de la Wimbe (Beauraing, Rochefort, Wellin), Fagnes de Samrée et de Tailles (Houffalize, La Roche-en-Ardenne, Manhay, Vielsalm)

6110 - (*) Rupicolous calcareous or basophilic grasslands of the *Alysso-Sedion albi*

Open xerothermophile pioneer communities on superficial calcareous or base-rich soils (basic volcanic substrates), dominated by annuals and succulents of the *Alysso alyssoidis-*

Sedion albi. Similar communities may develop on artificial substrates. These should not be taken into account.

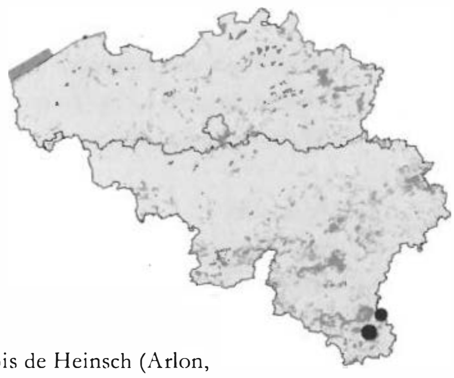
Habitat codes:
- Palaearctic Classification: 34.11
- EUNIS: E1.1/P-34.11
- CORINE: 34.11
- BWK: parts of hk (under investigation)

Distribution and estimated area:
- Walloon Region: 178.9 ha (30 sites)

Major sites:
- Walloon Region: Vallée de la Meuse de Dinant à Yvoir (Anhée, Dinant, Onhaye, Yvoir), Vallée de la Molignée (Anhée, Florennes, Mettet, Onhaye), Vallée de la Chinelle (Florennes, Philippeville), Vallée de l'Eau Blanche entre Aublain et Mariembourg (Chimay, Couvin), Bassin fagnard de l'Eau Blanche en aval de Mariembourg (Couvin, Doische, Philippeville), Vallée de l'Ourthe entre Bomal et Hamoir (Durbuy, Ferrieres, Hamoir, Ouffet), Vallée de l'Ourthe entre Hotton et Barvaux-sur-Ourthe (Durbuy, Hotton, Somme-Leuze), Vallée de la Meuse de Dave à Marche-les-Dames (Namur), Bois calcaires de Nettinne (Somme-Leuze), La Calestienne entre Frasnes et Doische (Couvin, Doische, Philippeville, Viroinval)

6120 - (*) Xeric sand calcareous grasslands

Dry, frequently open grasslands on more or less calciferous sand with a subcontinental centre of distribution (*Koelerion glaucae*, *Sileno conicae-Cerastion semidecandri*, *Sedo-Cerastion* p.).



Habitat codes:
- Palaearctic Classification: 34.12
- EUNIS: E1.12/P-34.12
- CORINE: 3.2.1.
- BWK: hd

Distribution and estimated area:
- Walloon Region: 5.1 ha (2 sites)

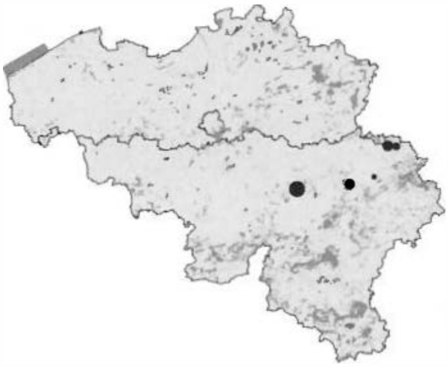
Sites:
- Walloon Region: Marais de la Haute Semois et Bois de Heinsch (Arlon, Attert, Etalle, Habay), Bassin de l'Attert (Arlon, Attert, Martelange)

6130 - Calaminarian grasslands of the *Violetalia calaminariae*

Generally open natural or semi-natural grasslands 1) on natural rock outcrops, rich in heavy metals (e.g. zinc, lead); 2) on river gravels and shingles; 3) on old terrils or spoil heaps around mines. These open grasslands are characterised by a highly specialised flora, with subspecies and ecotypes adapted to heavy metals. The threatened endemic taxa are generally absent from the pioneer vegetation of younger terrils. This pioneer vegetation is not considered to be a priority.

Habitat codes:

- Palaearctic Classification: 34.2, 36.44
- EUNIS: E1.B
- CORINE: 34.2
- BWK: hv



Distribution and estimated area:

- Walloon Region: 55.0 ha (5 sites)

Sites:

- Walloon Region: Vallée de la Meuse de Marche-les-Dames à Andenne (Andenne, Ohey), Vallée de la Gueule en aval de Kelmis (Plombières, Welkenraedt), Vallée de l'Ourthe entre Comblain-au-Pont et Angleur (Chaudfontaine, Comblain-au-Pont, Esneux, Liège, Neupré, Sprimont), Vallée de la Gueule en amont de Kelmis (Kelmis, Lontzen, Raeren, Welkenraedt), Coteaux calcaires de Theux et Le Rocheux (Theux)

6210 - Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*) (* important orchid sites)

Dry to semi-dry calcareous grasslands. Important orchid sites should be interpreted as sites that are important on the basis of one or more of the following three criteria:

(a) the site hosts a rich suite of orchid species;
(b) the site hosts an important population of at least one orchid species considered not very common on the national territory;
(c) the site hosts one or several orchid species considered to be rare, very rare or exceptional on the national territory.

Habitat codes:

- Palaearctic Classification: 34.31 to 34.34
- EUNIS: E1.2/P.34.311, E1.22, E1.23, E1.24, E1.2/P.34.317, E1.2/P.34.32, E1.2/P.34.33, E1.2/P.34.34
- CORINE: 34.31-34
- BWK: hk, sk

Distribution and estimated area:

- Flemish Region: 96.2 ha (6 sites)
- Walloon Region: 1167.7 ha (71 sites)

Major sites:

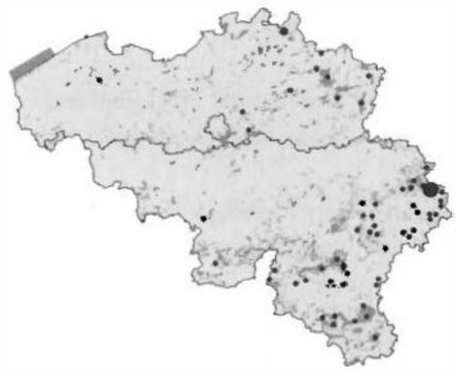
- Flemish Region: Voerstreek, Bossen en kalkgraslanden van Haspengouw, Plateau van Caestert met hellingbossen en mergelgrotten, Jekervallei en bovenloop van de Demervallei, Overgang Kempen-Haspengouw, Bossen van de Vlaamse Ardennen en andere Zuidvlaamse bossen
- Walloon Region: La Calestienne entre Frasnes et Doische (Couvin, Doische, Philippeville, Viroinval), Vallée de la Meuse de Dinant à Yvoir (Anhée, Dinant, Onhaye, Yvoir), Vallée de l'Eau Blanche à Virelles (Chimay, Couvin, Froidchapelle), La Calestienne entre Oppagne et Barvaux (Durbuy, Erezée), Vallée de l'Eau Blanche entre Aublain et Mariembourg (Chimay, Couvin), Vallées des Ruisseaux de Rempeine et de la Scheloupe (Beauraing), Vallée de l'Ourthe entre Bomal et Hamoir (Durbuy, Ferrières, Hamoir, Ouffet), Vallée de la Chinelle (Florennes, Philippeville),

Bassin de la Lesse entre Villers-sur-Lesse et Chanly (Nassogne, Rochefort, Tellin, Wellin), La Famenne entre Eprave et Havrenne (Rochefort)

6230 - (*) Species-rich *Nardus* grasslands, on siliceous substrates in mountain areas (and sub-mountain areas, in Continental Europe)

Closed, dry or mesophile, perennial *Nardus* grasslands occupying siliceous soils in Atlantic or sub-Atlantic or Boreal lowland, hill and montane regions. Vegetation highly varied, but the variation is characterised by continuity. *Nardetalia*: 35.1-*Violo-Nardion* (*Nardio-Galion saxatilis*, *Violon caninae*); 36.31-*Nardion*. Species-rich sites should be interpreted as sites which are remarkable for a high number of species. In general, the habitats which have become irreversibly degraded through overgrazing should be excluded.

Habitat codes:
- Palaearctic Classification: 35.1, 36.31
- EUNIS: E1.7, E4.3/P-36.31
- CORINE: 35.1, 36.31
- BWK: hn and parts of hmo, ce, ha



Distribution and estimated area:
- Flemish Region: 112.8 ha (11 sites)
- Walloon Region: 1045.9 ha (51 sites)

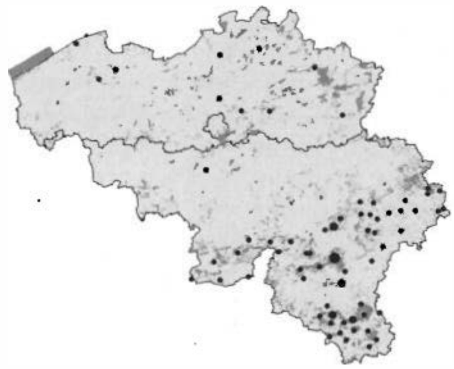
Major sites:
- Flemish Region: Vennen, heiden en moerassen rond Turnhout, Vallei- en brongebied van de Zwarte Beek, Bolisserbeek en Dommel met heide en vengebieden, Demervallei, Valleigebied van de Kleine Nete met brongebieden, moerassen en heiden, Bovenloop van de Grote Nete met Zammelsbroek, Langdonken en Goor, Valleien van de Dijle, Laan en IJse met aangrenzende bos- en moerasgebieden, Mechelse Heide en vallei van de Ziepbeek, Valleien van de Laambeek, Zonderikbeek, Slangebeek en Roosterbeek met vijvergebieden, Bossen, heiden en valleigebieden van zandig Vlaanderen: westelijk deel, Itterbeek met Brand, Jagersborg en Schootsheide en Bergerven
- Walloon Region: Camp militaire d'Elsenborn (Büllingen, Bütgenbach), Vallée de la Houille en aval de Gedinne (Beauraing, Gedinne), Haute vallée de l'Amblève entre Heppenbach et Montenau (Amel), Fagnes de Stavelot et vallée de l'Eau Rouge (Jalhay, Malmedy, Stavelot), Vallée de la Warche en amont de Bütgenbach (Büllingen, Bütgenbach), Vallée de l'Emmels (Amel), Basse-Vierre (Chiny, Herbeumont, Léglise, Neufchâteau, Tintigny), Fagnes du Nord-Est (Eupen, Raeren, Waimes), Fagnes de la Roer (Bütgenbach, Waimes), Bassin supérieur de l'Ourthe occidentale (Libramont, Chevigny)

6410 - *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*)

Molinia meadows of plain to montane levels, on more or less wet nutrient-poor soils (nitrogen, phosphorus). They stem from extensive management, sometimes with a mowing late in the year, or they correspond to a deteriorated stage of draining peat bogs. Two subtypes can be distinguished:
- on neutro-alkaline to calcareous soils with a fluctuating water table, relatively rich in species. The soil is sometimes peaty and becomes dry in summer;
- on more acid soils of the *Junco-Molinion* except species-poor meadows, or on degraded peaty soils.

Habitat codes:

- Palaearctic Classification: 37.31
- EUNIS: E3.5/P-37.31
- CORINE: 37.31
- BWK: hm, parts of hc in sandy regions



Distribution and estimated area:

- Flemish Region: 134.6 ha (10 sites)
- Walloon Region: 2549.1 ha (60 sites)

Major sites:

- Flemish Region: Bos- en heidegebieden ten oosten van Antwerpen, Bovenloop van de Grote Nete met Zammelsbroek, Langdonken en Goor, Valleigebied tussen Melsbroek, Kampenhout, Kortenberg en Veltem, Jekervallei en bovenloop van de Demervallei, Schelde- en Durme-estuarium van de Nederlandse grens tot Gent, Bossen en heiden van zandig Vlaanderen: oostelijk deel, Bossen, heiden en valleigebieden van zandig Vlaanderen: westelijk deel, Valleien van de Winge en de Motte met valleihellingen, Polders, Bossen van het zuidoosten van de Zandleemstreek
- Walloon Region: Haute-Wamme et Masblette (La Roche-en-Famenne, Marche-en-Famenne, Nassogne, Saint-Hubert, Tellin, Tenneville), Basse-Vierre (Chiny, Herbeumont, Léglise, Neufchâteau, Tintigny), Bassin supérieur de l'Ourthe occidentale (Libramont, Chevigny), Camp militaire de Marche-en-Famenne (Hotton, Marche-en-Famenne, Somme-Leuze), Vallées du Ruisseau de Mellier et de Mandebras (Habay, Léglise, Neufchâteau), Bassin de la Semois de Jamoigne à Chiny (Chiny, Florenville, Herbeumont), Bassin de la Semois entre Tintigny et Jamoigne (Chiny, Habay, Léglise, Tintigny), Haute-Sûre (Fauvillers, Léglise, Libramont, Chevigny, Martelange, Neufchâteau, Vaux-sur-Sûre), Camp militaire d'Elsenborn (Büllingen, Bütgenbach), Bassin de la Semois d'Etalle à Tintigny (Etalle, Habay, Tintigny)

6430 - Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels

37.7 - Wet and nitrophilous tall herb edge communities, along water courses and woodland borders belonging to the *Glechometalia hederaceae* and the *Convolvuletalia sepium* orders (*Senecion fluviatilis*, *Aegopodion podagrariae*, *Convolvulion sepium*, *Filipendulion*).
37.8 - Hygrophilous perennial tall herb communities of montane to alpine levels of the *Betulo-Adenostyletea* class. Belgium does not have well-developed examples of this subtype.

Habitat codes:

- Palaearctic Classification: 37.7 and 37.8
- EUNIS: E5.4, E5.5
- CORINE: 37.7 - 37.8
- BWK: hf, hfb, hfc, hft, parts of hr and ku

Distribution and estimated area:

- Brussels Capital Region: 27.9 ha (3 sites)
- Flemish Region: 2268.2 ha (21 sites)
- Walloon Region: 5552.6 ha (168 sites)

Major sites:

- Brussels Capital Region: Forêt de Soignes avec lisières et domaines boisés avoisinants et la Vallée de la Woluwe / Zoniënwoud met aangrenzende bosgebieden en Woluwevallei (Zoniënwoud / Forêt de

Soignes, Tournay-Solvaypark / Parc Tournay-Solvay, Etang de Boitsfort / Vijver van Bosvoorde, Etang des Silex / Silexvijver, Plateau de la Foresterie / Plateau van de Vorsterie, Bergoje, Parc de Woluwe / Woluwepark, Parc Malou / Maloupark, Hof-ter-Musschen), Zones boisées et ouvertes au sud de la Région bruxelloise / Bosgebieden en open gebieden in het zuiden van het Brussels Gewest (Kinsendaal / Kinsendael, Kriekenput, Herdies, Buysdellevallei / Vallée du Buysdelle, Moensberg, Kauwberg), Les zones boisées et les zones humides de la Vallée du Molenbeek au nord-ouest de la Région bruxelloise / De bosgebieden en vochtige zones van de vallei van de Molenbeek in het noordwesten van het Brussels Gewest (Marais de Jette-Ganshoren / Moeras van Jette-Ganshoren)

- Flemish Region: Bovenloop van de Grote Nete met Zammelsbroek, Langdonken en Goor, Bossen en heiden van zandig Vlaanderen: oostelijk deel, Valleigebied van de Kleine Nete met brongebieden, moerassen en heiden, Bossen van de Vlaamse Ardennen en andere Zuidvlaamse bossen, Schelde- en Durme-estuarium van de Nederlandse grens tot Gent, Jekervallei en bovenloop van de Demervallei, Vallei- en brongebied van de Zwarte Beek, Bolisserbeek en Dommel met heide en vengebieden, Mangelbeek en heide- en vengebieden tussen Houthalen en Gruitrode, Bosbeekvallei en aangrenzende bos- en heidegebieden te As-Opglabbeek-Maaseik, Bossen en kalkgraslanden van Haspengouw
- Walloon Region: Vallée de la Haine en aval de Mons (Bernissart, Boussu, Hensies, Jurbise, Mons, Quaregnon, Saint-Ghislain), Forêt d'Anlier (Attert, Habay, Léglise, Martelange), Haute-Sûre (Fauvillers, Léglise, Libramont, Chevigny, Martelange, Neufchâteau, Vaux-sur-Sûre), Marais de la Haute Semois et Bois de Heinsch (Arlon, Attert, Etalle, Habay), Haute-Wamme et Masblette (La Roche-en-Famenne, Marche-en-Famenne, Nassogne, Saint-Hubert, Tellin, Tenneville), Bassin de la Semois d'Etalle à Tintigny (Etalle, Habay, Tintigny), Affluents de l'Our entre Setz et Schoenberg (Amel, Saint-Vith), Bassin inférieur de l'Ourthe orientale (Gouvy, Houffalize, La Roche-en-Ardenne), Bassin supérieur de la Vire et du Ton (Aubange, Messancy, Musson, Saint-Léger, Virton), Haute vallée de l'Aisne (Erezée, La Roche-en-Ardenne, Manhay, Rendeux)

6510 - Lowland hay meadows (*Alopecurus pratensis*, *Sanguisorba officinalis*)

Species-rich hay meadows on lightly to moderately fertilised soils of the plain to submontane levels, belonging to the *Arrhenatherion* and the *Brachypodio-Centaureion nemoralis* alliances. The last alliance is probably not relevant for Belgium. These extensive grasslands are rich in flowers and are cut once or twice a year after grasses flower.

Habitat codes:

- Palaearctic Classification: 38.2
- EUNIS: E2.2
- CORINE: 38.2
- BWK: hu and parts of hp* and hpr*

Distribution and estimated area:

- Brussels Capital Region: 1.4 ha (1 site)
- Flemish Region: 1076.1 ha (17 sites)
- Walloon Region: 7063.2 ha (109 sites)

Major sites:

- Brussels Capital Region: Zones boisées et ouvertes au sud de la Région bruxelloise / Bosgebieden en open gebieden in het zuiden van het Brussels Gewest (Kauwberg, Engeland)
- Flemish Region: Bovenloop van de Grote Nete met Zammelsbroek, Langdonken en Goor, Hageven met Dommelvallei, Beverbeekse Heide, Warmbeek en Wateringen, Demervallei, Heesbossen en vallei van Marke en Merkske en Ringven met valleigronden langs de Heerlese Loop, Uiterwaarden langs de Limburgse Maas met Vijverbroek, Schelde- en Durme-estuarium van de

Nederlandse grens tot Gent, Itterbeek met Brand, Jagersborg en Schootsheide en Bergerven, Voerstreek, Bossen en kalkgraslanden van Haspengouw, Valleien van de Winge en de Motte met valleihellingen

- Walloon Region: Bassin de la Semois entre Tintigny et Jamoigne (Chiny, Habay, Léglise, Tintigny), Vallée de la Meuse à Huy et vallon de la Solières (Amay, Huy, Wanze), Bassin de la Semois de Jamoigne à Chiny (Chiny, Florenville, Herbeumont), Basse-Vierre (Chiny, Herbeumont, Léglise, Neufchâteau, Tintigny), Camp militaire de Marche-en-Famenne (Hotton, Marche-en-Famenne, Somme-Leuze), Bassin de la Semois d'Etalle à Tintigny (Etalle, Habay, Tintigny), Vallée de l'Eau Blanche entre Aublain et Mariembourg (Chimay, Couvin), Bassin supérieur de la Chevratte (Meix-devant-Virton, Tintigny, Virton), Vallée de la Semois en aval d'Alle (Bièvre, Vresse-sur-Semois), Vallée de l'Oise et de la Wartoise (Chimay, Momignies)

6520 - Mountain hay meadows

Species-rich mesophile hay meadows of the montane and subalpine levels.

Habitat codes:

- Palaearctic Classification: 38.31
- EUNIS: E2.3 P-38.31
- CORINE: 38.231
- BWK: parts of hu (under investigation)

Distribution and estimated area:

- Walloon Region: 1408.5 ha (54 sites)

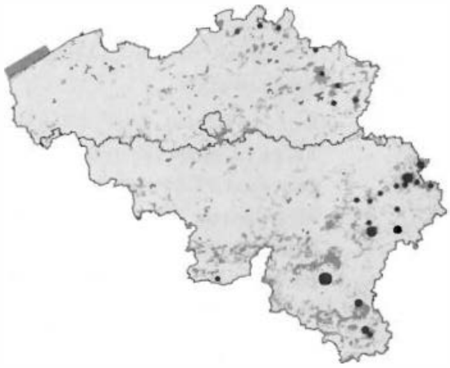
Major sites:

- Walloon Region: Bassin supérieur de l'Ourthe occidentale (Libramont, Chevigny), Camp militaire d'Elsenborn (Büllingen, Bütgenbach), Massif forestier de Daverdisse (Daverdisse, Libin, Tellin, Wellin), Sources de l'Our et de l'Ensebach (Büllingen), Haute-Wamme et Masblette (La Roche-en-Famenne, Marche-en-Famenne, Nassogne, Saint-Hubert, Tellin, Tenneville), Haute vallée de l'Amblève entre Heppenbach et Montenau (Amel), Fagnes de la Crépale et prairies de Malempré (Lierneux, Manhay), Fagnes de Samrée et de Tailles (Houffalize, La Roche-en-Ardenne, Manhay, Vielsalm), Affluents de l'Our entre Setz et Schoenberg (Amel, Saint-Vith), Fagnes de la Roer (Bütgenbach, Waimes)

7110 - (*) Active raised bogs

Acid bogs, ombrotrophic, poor in mineral nutrients, sustained mainly by rain water, with a water level generally higher than the surrounding water table, with perennial vegetation dominated by *Sphagnum* spp. allowing for the growth of the bog (*Erico-Sphagnetalia magellanici*). The term 'active' must be taken to mean still supporting a significant area of vegetation that is normally peat forming, but bogs where active peat formation is temporarily at a standstill, such as after a fire or during a natural climatic cycle (e.g. a period of drought), are also included.

Habitat codes:



- Palaearctic Classification: 51.1
- EUNIS: D1.1/P-51.1
- CORINE: 51.1
- BWK: t, ces, ct

Distribution and estimated area:

- Flemish Region: 27.8 ha (8 sites)
- Walloon Region: 380.6 ha (21 sites)

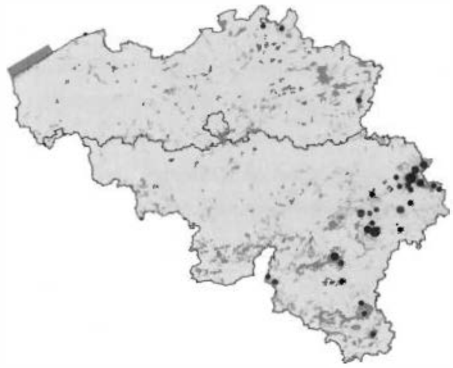
Major sites:

- Flemish Region: Vallei- en brongebied van de Zwarte Beek, Bolisserbeek en Dommel met heide en vengebieden, Valleigebied van de Kleine Nete met brongebieden, moerassen en heiden, Mangelbeek en heide- en vengebieden tussen Houthalen en Gruitrode, Mechelse Heide en vallei van de Ziepbeek, Vennen, heiden en moerassen rond Turnhout, Klein en Groot Schietveld, Heesbossen en vallei van Marke en Merkske en Ringven met valleigronden langs de Heerlese Loop, De Maten
- Walloon Region: Haute-Lomme (Libin, Libramont, Chevigny, Saint-Hubert), Plateau des Hautes-Fagnes (Baelen, Bütgenbach, Jalhay, Malmedy, Waimes), Fagnes de Samrée et de Tailles (Houffalize, La Roche-en-Ardenne, Manhay, Vielsalm), Marais de la Haute Semois et Bois de Heinsch (Arlon, Attert, Etalle, Habay), Haute-Sûre (Fauvillers, Léglise, Libramont, Chevigny, Martelange, Neufchâteau, Vaux-sur-Sûre), Fagnes du Nord-Est (Eupen, Raeren, Waimes), Bassin supérieur de la Salm (Gouvy, Vielsalm), Noir Ru et vallée du Rechterbach (Malmedy, Saint-Vith, Stavelot, Trois-Ponts), Camp militaire de Lagland (Arlon, Etalle, Saint Léger), Fagnes de Malchamps et de Stoumont (Aywaille, Spa, Stavelot, Stoumont, Theux)

7120 - Degraded raised bogs still capable of natural regeneration

These are raised bogs where there has been disruption (usually anthropogenic) to the natural hydrology of the peat body, leading to surface desiccation and/or species change or loss. Vegetation on these sites usually contains species typical of active raised bogs as the main component, but the relative abundance of individual species is different. Sites judged to be still capable of natural regeneration will include those areas where the hydrology can be repaired and where, with appropriate rehabilitation management, there is a reasonable expectation of re-establishing vegetation with peat-forming capability within 30 years. Sites unlikely to qualify as SACs are those that consist largely of bare peat dominated by agricultural grasses or other crops, or where components of bog vegetation have been eradicated by closed canopy woodlands.

Habitat codes:



- Palaearctic Classification: 51.2
- EUNIS: D1.1/P-51.2
- CORINE: 51.2
- BWK: tm, ctm

Distribution and estimated area:

- Flemish Region: 8.[redacted] ha (3 sites)
- Walloon Region: 1687.9 ha (32 sites)

Major sites:

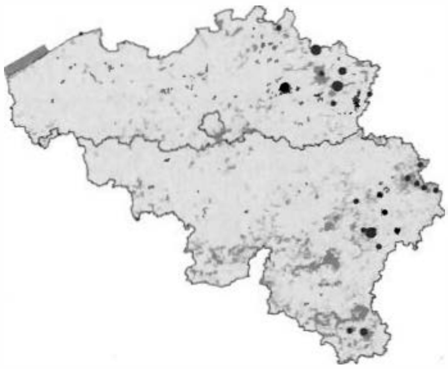
- Flemish Region: Mechelse Heide en vallei van de Ziepbeek, Vennen, heiden en moerassen rond Turnhout, Heesbossen en vallei van Marke en Merkske en Ringven met valleigronden langs de Heerlese Loop
- Walloon Region: Plateau des Hautes-Fagnes (Baelen, Bütgenbach, Jalhay, Malmedy, Waimes), Fagnes de Samrée et de Tailles (Houffalize, La Roche-en-Ardenne, Manhay, Vielsalm), Fagnes du Nord-Est (Eupen, Raeren, Waimes), Haute-Wamme et Masblette (La Roche-en-Famenne, Marche-en-Famenne, Nassogne, Saint-Hubert, Tellin, Tenneville), Fanges des sources de l'Aisne (La Roche-en-Ardenne, Manhay, Vielsalm), Fagnes de la Roer (Bütgenbach, Waimes), Vallée de la Helle (Baelen, Eupen, Waimes), Noir Ru et vallée du Rechterbach (Malmedy, Saint-Vith, Stavelot, Trois-Ponts), Basse vallée de l'Aisne (Durbuy, Erezée, Ferrières, Manhay), Fagnes de Stavelot et vallée de l'Eau Rouge (Jalhay, Malmedy, Stavelot)

7140 - Transition mires and quaking bogs

Peat-forming communities at the surface of oligotrophic to mesotrophic waters, with characteristics intermediate between soligenous and ombrogenous types. They present a large and diverse range of plant communities. In large peaty systems, the most prominent communities are swaying swards, floating carpets or quaking mires formed by medium-sized or small sedges, associated with *Sphagnum* or brown mosses. They are generally accompanied by aquatic and amphibious communities.

Habitat codes:

- Palaearctic Classification: 54.5
- EUNIS: D2.3
- CORINE: 54.5
- BWK: md, ms and parts of ce and ao



Distribution and estimated area:

- Flemish Region: 188.3 ha (9 sites)
- Walloon Region: 146.1 ha (16 sites)

Major sites:

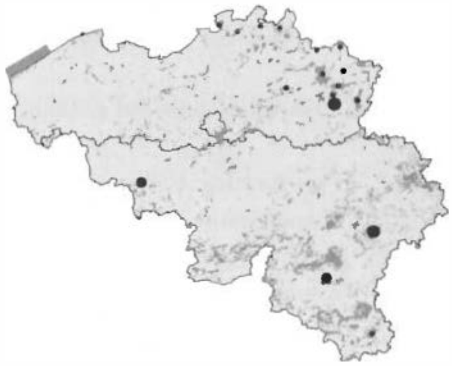
- Flemish Region: Demervallei, Valleigebied van de Kleine Nete met brongebieden, moerassen en heiden, Mangelbeek en heide- en vengebieden tussen Houthalen en Gruitrode, Abeek met aangrenzende moerasgebieden, Vallei- en brongebied van de Zwarte Beek, Bolisserbeek en Dommel met heide en vengebieden, Uiterwaarden langs de Limburgse Maas met Vijverbroek, De Maten, Mechelse Heide en vallei van de Ziepbeek, Vennen, heiden en moerassen rond Turnhout
- Walloon Region: Fagnes de Samrée et de Tailles (Houffalize, La Roche-en-Ardenne, Manhay, Vielsalm), Marais de la Haute Semois et Bois de Heinsch (Arlon, Attert, Etalle, Habay), Fagnes du Nord-Est (Eupen, Raeren, Waimes), Bassin inférieur de l'Ourthe orientale (Gouvy, Houffalize, La Roche-en-Ardenne), Vallée de l'Olefbach (Büllingen), Bassin supérieur de la Salm (Gouvy, Vielsalm), Bassin de la Semois d'Etalle à Tintigny (Etalle, Habay, Tintigny), Plateau des Hautes-Fagnes (Baelen, Bütgenbach, Jalhay, Malmedy, Waimes), Mardelles d'Arbrefontaine et vallons fangeux de Fosse (Lierneux, Trois-Ponts, Vielsalm), Camp militaire d'Elsenborn (Büllingen, Bütgenbach)

7150 - Depressions on peat substrates of the *Rhynchosporion*

Highly constant pioneer communities of humid exposed peat, or sometimes sand, with *Rhynchospora alba*, *R. fusca*, *Drosera intermedia*, *D. rotundifolia*, *Lycopodiella inundata*, forming on stripped areas of blanket bogs or raised bogs, but also on naturally seep- or frost-eroded areas of wet heaths and bogs, in flushes and in the fluctuation zone of oligotrophic pools with sandy, slightly peaty substratum. These communities are similar and closely related to those of shallow bog hollows and of transition mires.

Habitat codes:

- Palaearctic Classification: 54.6
- EUNIS: D2.3/P-54.6
- CORINE: 54.6
- BWK: ce



Distribution and estimated area:

- Flemish Region: 47.8 ha (13 sites)
- Walloon Region: 10.9 ha (4 sites)

Major sites:

- Flemish Region: Vallei- en brongebied van de Zwarte Beek, Bolisserbeek en Dommel met heide en vengebieden, De Maten, Demervallei, Valleigebied van de Kleine Nete met brongebieden, moerassen en heiden, Mangelbeek en heide- en vengebieden tussen Houthalen en Gruitrode, Mechelse Heide en vallei van de Ziepbeek, Valleien van de Laambeek, Zonderikbeek, Slangebeek en Roosterbeek met vijvergebieden, Vennen, heiden en moerassen rond Turnhout, Abeek met aangrenzende moerasgebieden, Klein en Groot Schietveld
- Walloon Region: Fagnes de Samrée et de Tailles (Houffalize, La Roche-en-Ardenne, Manhay, Vielsalm), Camp militaire de Lagland (Arlon, Etalle, Saint Léger), Bord nord du bassin de la Haine (Beloeil, Bernissart, Saint-Ghislain), Haute-Lomme (Libin, Libramont, Chevigny, Saint-Hubert)

7210 - (*) Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*

Cladium mariscus beds of the emergent-plant zones of lakes, fallow lands or succession stage of extensively farmed wet meadows in contact with the vegetation of the *Caricion davallianae* or other *Phragmition* species (*Cladietum marisci*). This habitat type is only found in Flanders. However, based on the 'Florabank', the typical species for this habitat, *Carex davalliana*, is not observed in Flanders.

Habitat codes:

- Palaearctic Classification: 53.3
- EUNIS: D5.2
- CORINE: 53.3
- BWK: mm

Distribution and estimated area:

- Flemish Region: 51.4 ha (4 sites)

Sites:

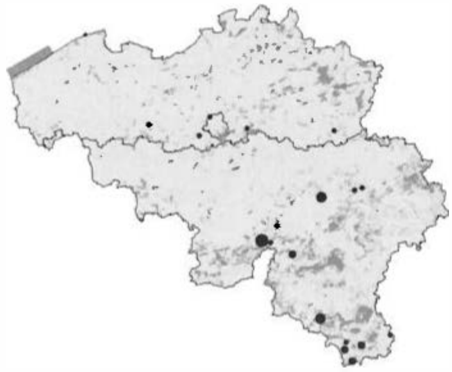
- Flemish Region: Bovenloop van de Grote Nete met Zammelsbroek, Langdonken en Goor, Valleigebied van de Kleine Nete met brongebieden, moerassen en heiden, Hageven met Dommelvallei, Beverbeekse Heide, Warmbeek en Wateringen, Valleigebied tussen Melsbroek, Kampenhout, Kortenberg en Veltem

7220 - (*) Petrifying springs with tufa formation (*Cratoneurion*)

Hard water springs with active formation of travertine or tufa. These formations are found in such diverse environments as forests or open countryside. They are generally small (point or linear formations) and dominated by bryophytes (*Cratoneurion commutati*).

Habitat codes:

- Palaearctic Classification: 54.12
- EUNIS: D4.1/P-54.12
- CORINE: 54.12
- BWK: situated in 91E0, vc



Distribution and estimated area:

- Brussels Capital Region: 1.2 ha (1 site)
- Flemish Region: 14.1 ha (4 sites)
- Walloon Region: 32.6 ha (13 sites)

Major sites:

- Brussels Capital Region: Zones boisées et zones humides de la Vallée du Molenbeek dans le nord-ouest de la Région bruxelloise / Bosgebieden en vochtige zones van de vallei van de Molenbeek in het noordwesten van het Brussels Gewest (Bois du Poelbos / Poelbos, Bois du Laerbeek / Laarbeekbos, Bois de Dieleghem / Dielegembos)
- Flemish Region: Bossen van de Vlaamse Ardennen en andere Zuidvlaamse bossen, Valleien van de Dijle, Laan en IJse met aangrenzende bos- en moerasgebieden, Bossen en kalkgraslanden van Haspengouw, Hallerbos en nabije boscomplexen met brongebieden en heiden
- Walloon Region: Bassin de l'Hermeton en aval de Vodelée (Doische, Florennes, Hastière, Philippeville), Vallées du Hoyoux et du Triffoy (Clavier, Huy, Marchin, Modave, Ohey), Bassin de la Semois de Florenville à Auby (Bertrix, Florenville, Herbeumont), Vallées de Laclaireau et du Rabais (Etalle, Saint-Léger, Virton), Vallée du Biran (Beauraing, Houyet, Rochefort), Vallée du Ton et Côte bajocienne de Montquinquin à Ruette (Rouvroy, Virton), Vallées de la Chevratte (Meix-devant-Virton, Rouvroy), Vallée de la Meuse en amont d'Hastière (Beauraing, Doische, Hastière, Houyet), Bassin supérieur de la Chevratte (Meix-devant-Virton, Tintigny, Virton), Vallée de l'Eisch et de Clairefontaine (Arlon)

7230 - Alkaline fens

Wetlands mostly or largely occupied by peat- or tufa-producing small sedge and brown moss communities on permanently waterlogged soils, with a soligenous or topogenous base-rich, often calcareous water supply, and with the water table at, or slightly above or below, the substratum. Peat formation, when it occurs, is infra-aquatic. Calciphile small sedges and other Cyperaceae usually dominate the mire communities, which belong to the *Caricion davallianae*, characterised by a usually prominent 'brown moss' carpet formed by *Campylium stellatum*, *Drepanocladus revolvens*, *Fissidens adianthoides*, *Bryum pseudotriquetrum* and others, a grasslike growth of *Schoenus nigricans*, *Eriophorum latifolium*, *Carex lepidocarpa*, *C. hostiana*, *Juncus subnodulosus*, *Eleocharis quinqueflora*, and a very rich herbaceous flora including *Dactylorhiza incarnata*, *Herminium monorchis*, *Utricularia intermedia*, *Parnassia palustris* and *Schoenus nigricans*.

Habitat codes:
- Palaearctic Classification: 54.2
- EUNIS: D4.1
- CORINE: 54.2
- BWK: mk and parts of mp

Distribution and estimated area:
- Flemish Region: 99.1 ha (2 sites)
- Walloon Region: 120.4 ha (5 sites)

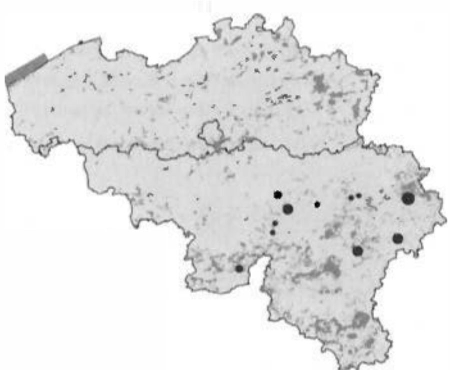
Sites:
- Flemish Region: Valleigebied van de Kleine Nete met brongebieden, moerassen en heiden, Valleigebied tussen Melsbroek, Kampenhout, Kortenberg en Veltem
- Walloon Region: Bassin de la Semois d'Etalle à Tintigny (Etalle, Habay, Tintigny), Vallée du Ruisseau de Breuvanne (Chiny, Florenville, Tintigny), Marais de la Haute Semois et Bois de Heinsch (Arlon, Attert, Etalle, Habay), Bassin de la Semois entre Tintigny et Jamoigne (Chiny, Habay, Léglise, Tintigny), Bassin de la Marche (Chiny, Florenville, Meix-devant-Virton)

8110 - Siliceous scree of the montane to snow levels (*Androsacetalia alpinae* and *Galeopsetalia ladani*)

This habitat consists of:

a) communities of siliceous scree of the upper montane level to the permanent snow level, growing on more or less moving 'cryoclastic systems' with variable granulometry and belonging to the order *Androsacetalia alpinae*;

b) vegetation of the montane level of the west and centre of Europe growing on screes sometimes of artificial origin (extraction of materials). It consists of alpine communities often rich in bryophytes, lichens and sometimes ferns.



Habitat codes:
- Palaearctic Classification: 61.1
- EUNIS: H2.3
- CORINE: 61.1
- BWK: parts of kr (under investigation)

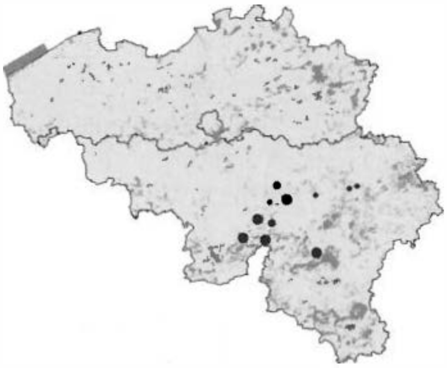
Distribution and estimated area:
- Walloon Region: 79.1 ha (12 sites)

Major sites:
- Walloon Region: Vallée de la Warche et du Bayehon en aval du barrage de Robertville (Malmedy, Waimes), Vallée de l'Ourthe entre Nisramont et La Roche (Houffalize, La Roche-en-Ardenne, Rendeux), Bassin du Samson (Andenne, Assesse, Gesves, Namur, Ohey), Bassin supérieur de la Salm (Gouvy, Vielsalm), La Calestienne entre Frasnes et Doische (Couvin, Doische, Philippeville, Viroinval), Vallée de la Meuse de Dave à Marche-les-Dames (Namur), Vallée du Bocq (Assesse, Yvoir), Vallée de l'Ourthe entre Hamoir et Comblain-au-Pont (Anthisnes,

Comblain-au-Pont, Ferrières, Hamoir, Ouffet), Bassin supérieur de la Salm (Gouvy, Vielsalm), Basse vallée de l'Amblève (Aywaille, Comblain-au-Pont, Sprimont)

8160 - (*) Medio-European calcareous scree of hill and montane levels

Calcareous or marly screes of the hill and montane levels extending into mountainous regions (subalpine and alpine), often in dry, warm stations in associations with *Stipetalia calamagrostis*.



Habitat codes:

- Palaearctic Classification: 61.313
- EUNIS: H2.6/P-61.313
- CORINE: 61.312
- BWK: parts of kr (under investigation)

Distribution and estimated area:

- Walloon Region: 77.3 ha (12 sites)

Major sites:

- Walloon Region: Vallée de la Lomme de Grupont à Rochefort (Rochefort, Marche-en-Famenne, Nassogne), Vallée de la Molignée (Anhée, Florennes, Mettet, Onhaye), Bassin du Samson (Andenne, Assesse, Gesves, Namur, Ohey), Vallée de la Meuse en amont d'Hastière (Beauraing, Doische, Hastière, Houyet), Vallée de la Chinelle (Florennes, Philippeville), Vallée de la Meuse de Dinant à Yvoir (Anhée, Dinant, Onhaye, Yvoir), Vallée de la Meuse de Dave à Marche-les-Dames (Namur), Vallées du Hoyoux et du Triffoy (Clavier, Huy, Marchin, Modave, Ohey), Vallée de la Meuse d'Yvoir à Dave (Anhée, Assesse, Namur, Profondeville, Yvoir), Vallée de l'Ourthe entre Hamoir et Comblain-au-Pont (Anthisnes, Comblain-au-Pont, Ferrières, Hamoir, Ouffet)

8210 - Calcareous rocky slopes with chasmophytic vegetation

Vegetation of fissures of limestone cliffs belonging essentially to the *Potentilletalia caulescentis* and *Asplenietalia glandulosi* orders.

Habitat codes:

- Palaearctic Classification: 62.1
- EUNIS: H3.2
- CORINE: 62.1
- BWK: parts of kr and km, eventually also of hk and kk (under investigation)

Distribution and estimated area:

- Walloon Region: 452.6 ha (41 sites)

Major sites:

- Walloon Region: Vallée de la Meuse de Dave à Marche-les-Dames (Namur), Vallée de la Meuse d'Hastière à Dinant (Dinant, Hastière), Vallée de la Molignée (Anhée, Florennes, Mettet, Onhaye), Vallées des ruisseaux de Fenffe et du Vachau (Ciney, Houyet, Rochefort), Vallée de la Semois en aval d'Alle (Bièvre, Vresse-sur-Semois), Vallée de la Meuse de Marche-les-Dames à Andenne

(Andenne, Ohey), Vallée de la Meuse d'Yvoir à Dave (Anhée, Assesse, Namur, Profondeville, Yvoir), Bassin de la Semois de Bouillon à Alle (Bièvre, Bouillon, Paliseul, Vresse-sur-Semois), Vallées de la Chevratte (Meix-devant-Virton, Rouvroy), Vallée de l'Ourthe entre Hotton et Barvaux-sur-Ourthe (Durbuy, Hotton, Somme-Leuze)

8220 - Siliceous rocky slopes with chasmophytic vegetation

Vegetation of fissures of siliceous inland cliffs, which presents many regional subtypes. Typical vegetation in Belgium includes *Androsacetalia vandellii*, *Asplenietalia lanceolata-obovati*, *Asplenietalia billotii*.

Habitat codes:

- Palaearctic Classification: 62.2
- EUNIS: H3.1
- CORINE: 62.2
- BWK: parts of kr and km (under investigation)

Distribution and estimated area:

- Walloon Region: 247.8 ha (31 sites)

Major sites:

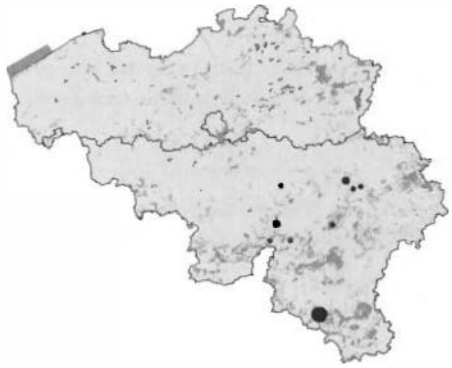
- Walloon Region: Massif forestier de Daverdisse (Daverdisse, Libin, Tellin, Wellin), Vallée de la Semois en aval d'Alle (Bièvre, Vresse-sur-Semois), Bassin du Ruisseau du Ru au Moulin (Bièvre, Gedinne, Vresse-sur-Semois), Vallée du Bocq (Assesse, Yvoir), Vallées du Hoyoux et du Triffoy (Clavier, Huy, Marchin, Modave, Ohey), Vallée du Ruisseau des Aleines (Bertrix, Bouillon, Paliseul), Bassin de la Semois de Bouillon à Alle (Bièvre, Bouillon, Paliseul, Vresse-sur-Semois), Bassin inférieur de l'Ourthe orientale (Gouvy, Houffalize, La Roche-en-Ardenne), Bassin de l'Hermeton en aval de Vodelée (Doische, Florennes, Hastière, Philippeville), Bassin de l'Iwène (Ciney, Houyet, Rochefort)

8230 - Siliceous rock with pioneer vegetation of the *Sedo-Scleranthion* or of the *Sedo albi-Veronicion dillenii*

Pioneer communities colonising superficial soils of siliceous rock surfaces. As a consequence of drought, this open vegetation is characterised by mosses and lichens (*Rhizocarpon*, *Umbilicaria*, *Ramalina*, *Cornicularia*, *Rhizoplaca*).

Habitat codes:

- Palaearctic Classification: 62.42
- EUNIS: H3.1/P-62.42
- CORINE: 62.42
- BWK: parts of kr and km (under investigation)



Distribution and estimated area:

- Walloon Region: 99.1 ha (9 sites)

Sites:

- Walloon Region: Bassin de la Semois de Florenville à Auby (Bertrix, Florenville, Herbeumont), Bois d'Anthisnes et d'Esneux (Anthisnes, Comblain-au-Pont, Esneux, Nandrin, Neupré, Ouffet, Tinlot), Vallée de la Meuse de Dinant à Yvoir (Anhée, Dinant, Onhaye, Yvoir), Vallée de la Meuse de Dave à Marche-les-Dames (Namur), Camp militaire de Marche-en-Famenne (Hotton, Marche-en-Famenne, Somme-Leuze), Vallée de la Lesse entre Villers-sur-Lesse et Houyet (Houyet, Rochefort), Vallée de la Meuse en amont d'Hastière (Beauraing, Doische, Hastière, Houyet), Vallée de l'Ourthe entre Hamoir et Comblain-au-Pont (Anthisnes, Comblain-au-Pont, Ferrières, Hamoir, Ouffet), Basse vallée de l'Amblève (Aywaille, Comblain-au-Pont, Sprimont)

8310 - Caves not open to the public

Caves not open to the public, including their water bodies and streams, hosting specialised or endemic species, or that are of paramount importance for the conservation of Annex II species (e.g. bats, amphibians).

Habitat codes:

- Palaearctic Classification: 65
- EUNIS: H1
- CORINE: 65
- BWK: code under investigation

Distribution and estimated area:

- Flemish Region: 66.0 ha (1 site)
- Walloon Region: 34.1 ha (32 sites)

Major sites:

- Flemish Region: Plateau van Caestert met hellingbossen en mergelgrotten
- Walloon Region: Vallée de la Meuse de Dinant à Yvoir (Anhée, Dinant, Onhaye, Yvoir), La Calestienne entre Frasnes et Doische (Couvin, Doische, Philippeville, Viroinval), Bassin de la Lesse entre Villers-sur-Lesse et Chanly (Nassogne, Rochefort, Tellin, Wellin), Basse vallée de l'Aisne (Durbuy, Erezée, Ferrières, Manhay), Vallée du Ton et Côte bajocienne de Montquinquin à Ruette (Rouvroy, Virton), Vallée de la Hante (Beaumont, Froidchapelle, Sivry-Rance), Vallée de la Lesse en aval de Houyet (Dinant, Houyet), Vallée de l'Ourthe entre Hotton et Barvaux-sur-Ourthe (Durbuy, Hotton, Somme-Leuze), Vallées du Hoyoux et du Triffoy (Clavier, Huy, Marchin, Modave, Ohey), Sources de la Hante (Cerfontaine, Froidchapelle)

9110 - *Luzulo-Fagetum* beech forests

Fagus sylvatica and, in higher mountains, *Fagus sylvatica-Abies alba* or *Fagus sylvatica-Abies alba-Picea abies* forests on acid soils.

Habitat codes:

- Palaearctic Classification: 41.11
- EUNIS: G1.6/P-41.11
- CORINE: 41.11
- BWK: fl

Distribution and estimated area:

- Flemish Region: 167.5 ha (3 sites)
- Walloon Region: 40234.7 ha (129 sites)

Major sites:

- Flemish Region: Voerstreek, Bossen van de Vlaamse Ardennen en andere Zuidvlaamse bossen, Zoniënwoud
- Walloon Region: Forêt d'Anlier (Attert, Habay, Léglise, Martelange), Haute-Wamme et Masblette (La Roche-en-Famenne, Marche-en-Famenne, Nassogne, Saint-Hubert, Tellin, Tenneville), Bassin de la Lomme de Poix-Saint-Hubert à Grupont (Libin, Saint-Hubert, Tellin), Bassin de la Semois de Florenville à Auby (Bertrix, Florenville, Herbeumont), Massif forestier de Daverdisse (Daverdisse, Libin, Tellin, Wellin), Forêt de Freyr (Libramont, Chevigny, Saint-Hubert, Saint-Ode, Tenneville), Massifs forestiers entre Momignies et Chimay (Chimay, Momignies), Bassin de la Semois entre Tintigny et Jamoigne (Chiny, Habay, Léglise, Tintigny), Vallée de l'Amblève du Pont de Targnon à Remouchamps (Aywaille, Stoumont, Theux), Bois de Bourlers et de Baileux (Chimay, Couvin)

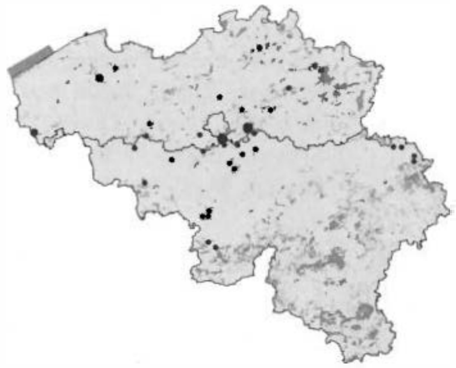
9120 - Atlantic acidophilous beech forests with *Ilex* and sometimes also *Taxus* in the shrublayer (*Quercinion robori-petraeae* or *Ilici-Fagenion*)

Beech forests with *Ilex*, growing on acid soils, of the plain to montane levels under humid Atlantic climate. The acid substrate corresponds to alterations of acid rocks or to silt with flints more or less degraded or to old alluvial deposits. The soils are of acid brown type, leaching or with an evolution towards podsol type. The humus is of moder to dysmoder type. These beech forests present different varieties:

(a) sub-Atlantic beech-oak forests of the plains and hill levels with *Ilex aquifolium*;
(b) hyper-Atlantic beech-oak forests of the plains and hill levels with *Ilex* and *Taxus* rich in epiphytes;
(c) pure beech forests or acidophilous beech-fir forests of the montane level, with *Ilex aquifolium* in the field layer.

Habitat codes:

- Palaearctic Classification: 41.12
- EUNIS: G1.6/P-41.12
- CORINE: 41.12
- BWK: large parts of qs and fs, qb on nutrient-rich bottoms, fl outside the 'Voeren' region



Distribution and estimated area:

- Flemish Region: 6929.2 ha (13 sites)
- Walloon Region: 2705.1 ha (21 sites)

Major sites:

- Flemish Region: Zoniënwoud, Valleien van de Dijle, Laan en IJse met aangrenzende bos- en moerasgebieden, Bossen, heiden en valleigebieden van zandig Vlaanderen: westelijk deel, West-vlaams Heuvelland, Bossen en heiden van zandig Vlaanderen: oostelijk deel, Bos- en heidegebieden ten oosten van Antwerpen, Bossen van het zuidoosten van de Zandleemstreek, Bossen van de Vlaamse Ardennen en andere Zuidvlaamse bossen, Valleien van de Winge en de Motte met valleihellingen, Valleigebied tussen Melsbroek, Kampenhout, Kortenberg en Veltem
- Walloon Region: Bord nord du bassin de la Haine (Beloeil, Bernissart, Saint-Ghislain), Vallée de l'Argentine (La Hulpe, Lasne, Rixensart, Waterloo), Vallées de la Dendre et de la Marcq (Ellezelles, Flobecq, Frasnes-lez-Anvaing, Lessines), Haute-Sambre en aval de Thuin (Charleroi, Courcelles, Fontaine-l'Evêque, Lobbes, Thuin), Sources de la Dyle (Court-Saint-Etienne, Genappe, Ottignies, Louvain-la-Neuve), Vallée de la Thyle (Court-Saint-Etienne, Genappe, Les Bons Villers, Villers-la-

Ville), Vallée de la Lasne (Rixensart, Wavre), Vallée de la Dyle à Ottignies (Ottignies, Louvain-la-Neuve, Wavre), Bois d'Enghien et de Silly (Enghien, Silly), Vallée de la Rhosnes (Flobecq)

9130 - *Asperulo-Fagetum* beech forests

Fagus sylvatica and, in higher mountains, *Fagus sylvatica-Abies alba* or *Fagus sylvatica-Abies alba-Picea abies* forests on neutral or near-neutral soils, with mild humus (mull), characterised by a strong representation of species belonging to the ecological groups of *Anemone nemorosa*, of *Lamiastrum (Lamium) galeobdolon*, of *Galium odoratum* and *Melica uniflora* and, in mountains, various *Dentaria* spp., forming a richer and more abundant herb layer than in the forests of 9110 and 9120.

Habitat codes:

- Palaearctic Classification: 41.13
- EUNIS: G1.6/P-41.13
- CORINE: 41.13
- BWK: fm, qe, fe

Distribution and estimated area:

- Brussels Capital Region: 204.0 ha (2 sites)
- Flemish Region: 1914.7 ha (8 sites)
- Walloon Region: 11564.9 ha (80 sites)

Major sites:

- Brussels Capital Region: Forêt de Soignes avec lisières et domaines boisés avoisinants et la Vallée de la Woluwe / Zoniënwoud met aangrenzende bosgebieden en Woluwevallei (Zoniënwoud / Forêt de Soignes, Ter Kamerenbos / Bois de la Cambre, Tournay-Solvaypark / Parc Tournay-Solvay, Vijver van Bosvoorde / Etang de Boitsfort, Bergoje, Hertoginnedal / Val Duchesse, Woluwepark / Parc de Woluwe, Maloupark / Parc Malou), Zones boisées et ouvertes au sud de la Région bruxelloise / Bosgebieden en open gebieden in het zuiden van het Brussels Gewest (Verrewinkel, Buysdellebos / Bois du Buysdelle)
- Flemish Region: Bossen van de Vlaamse Ardennen en andere Zuidvlaamse bossen, Hallerbos en nabije boscomplexen met brongebieden en heiden, Westvlaams Heuvelland, Zoniënwoud, Bossen en kalkgraslanden van Haspengouw, Valleien van de Dijle, Laan en IJse met aangrenzende bos- en moerasgebieden, Bossen van het zuidoosten van de Zandleemstreek, Voerstreek
- Walloon Region: Massif forestier de Cerfontaine (Cerfontaine, Chimay, Couvin, Froidchapelle, Philippeville), Bassin supérieur de la Vire et du Ton (Aubange, Messancy, Musson, Saint-Léger, Virton), Vallée de la Lesse en aval de Houyet (Dinant, Houyet), Bassin de l'Attert (Arlon, Attert, Martelange), Bassin de l'Iwène (Ciney, Houyet, Rochefort), Affluents brabançons de la Senne (Braine-l'Alleud, Braine-le-Château, Ittre, Tubize), Massifs forestiers entre Momignies et Chimay (Chimay, Momignies), Vallée du Ton et Côte bajocienne de Montquinquin à Ruette (Rouvroy, Virton), Bassin de la Marche (Chiny, Florenville, Meix-devant-Virton), Bois Massart et Forêt de Sivry-Rance (Chimay, Froidchapelle, Sivry-Rance)

9150 - Medio-European limestone beech forests of the *Cephalanthero-Fagion*

Xerothermophile *Fagus sylvatica* forests on calcareous, often superficial, soils, usually of steep slopes, with a generally abundant herb and shrub undergrowth, characterised by sedges (*Carex digitata*, *C. flacca*, *C. montana*, *C. alba*), grasses (*Sesleria albicans*, *Brachypodium* *pinnatum*), orchids (*Cephalanthera* spp., *Neottia nidus-avis*, *Epipactis leptochila*, *E. microphylla*) and thermophile species, transgressive of the *Quercetalia pubescenti-petraeae*. The bush layer includes several calcicolous species (*Ligustrum vulgare*, *Berberis vulgaris*) and *Buxus sempervirens* can dominate.

Habitat codes:

- Palaearctic Classification: 41.16
- EUNIS: G1.6/P-41.16
- CORINE: 41.16
- BWK: fk

Distribution and estimated area:

- Brussels Capital Region: 20.6 ha (1 site)
- Flemish Region: 21.4 ha (2 sites)
- Walloon Region: 2780.1 ha (36 sites)

Major sites:

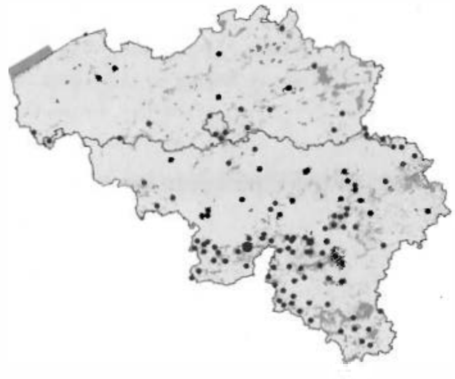
- Brussels Capital Region: Forêt de Soignes avec lisières et domaines boisés avoisinants et la Vallée de la Woluwe / Zoniënwoud met aangrenzende bosgebieden en Woluwevallei (Zoniënwoud / Forêt de Soignes)
- Flemish Region: Plateau van Caestert met hellingbossen en mergelgrotten, Voerstreek
- Walloon Region: Bassin de la Lesse entre Villers-sur-Lesse et Chanly (Nassogne, Rochefort, Tellin, Wellin), Vallée de la Meuse d'Hastière à Dinant (Dinant, Hastière), La Calestienne entre Marenne et Hotton (Hotton), Bois calcaires de Nettinne (Somme-Leuze), Vallée de la Lesse en aval de Houyet (Dinant, Houyet), Vallée de l'Ourthe entre Hotton et Barvaux-sur-Ourthe (Durbuy, Hotton, Somme-Leuze), Vallée de la Wimbe (Beauraing, Rochefort, Wellin), Vallée de la Meuse de Dinant à Yvoir (Anhée, Dinant, Onhaye, Yvoir), Bassin de la Lesse entre Villers-sur-Lesse et Chanly (Nassogne, Rochefort, Tellin, Wellin), Vallée de l'Ourthe entre La Roche et Hotton (Erezée, Hotton, La Roche-en-Ardenne, Rendeux)

9160 - Sub-Atlantic and medio-European oak or oak-hornbeam forests of the *Carpinion betuli*

Forests of *Quercus robur* (or *Quercus robur* and *Quercus petraea*) on hydromorphic soils or soils with high water table (bottoms of valleys, depressions or in the vicinity of riparian forests). The substrate corresponds to silts, clayey and silt-laden colluvions, as well as to silt-laden alterations or to siliceous rocks with a high degree of saturation. Forests of *Quercus robur* or natural mixed forests composed of *Quercus robur*, *Quercus petraea* and *Carpinus betulus*.

Habitat codes:

- Palaearctic Classification: 41.24
- EUNIS: G1.A/P-41.24
- CORINE: 41.24
- BWK: qa, fa



Distribution and estimated area:

- Brussels Capital Region: 297.3 ha (3 sites)
- Flemish Region: 1970.3 ha (17 sites)
- Walloon Region: 21986.0 ha (108 sites)

Major sites:

- Brussels Capital Region: Forêt de Soignes avec lisières et domaines boisés avoisinants et la Vallée de la Woluwe / Zoniënwoud met aangrenzende bosgebieden en Woluwevallei (Zoniënwoud / Forêt de Soignes, Ter Kamerenbos / Bois de la Cambre, Drie Linden Taluds / Talus des trois Tilleuls, Domeinen St. Anna en Hertoginnedal / Domaines Ste Anne et Val Duchesse, Parmentierpark / Parc Parmentier, Ter Bronnenpark / Parc des Sources, Maloupark / Parc Malou), Zones boisées et ouvertes au sud de la Région bruxelloise / Bosgebieden en open gebieden in het zuiden van het Brussels Gewest (Kriekenput, Buysdellevallei / Vallée du Buysdelle, Fond' Roy), Zones boisées et zones humides de la Vallée du Molenbeek dans le nord-ouest de la Région bruxelloise / Bosgebieden en vochtige zones van de vallei van de Molenbeek in het noordwesten van het Brussels Gewest (Poelbos / Bois du Poelbos, Laarbeekbos / Bois de Laerbeek, Dielegembos / Bois de Dieleghem)
- Flemish Region: Bossen en kalkgraslanden van Haspengouw, Valleien van de Dijle, Laan en IJse met aangrenzende bos- en moerasgebieden, Valleigebied tussen Melsbroek, Kampenhout, Kortenberg en Veltem, Bossen van de Vlaamse Ardennen en andere Zuidvlaamse bossen, Valleien van de Winge en de Motte met valleihellingen, Bovenloop van de Grote Nete met Zammelsbroek, Langdonken en Goor, Zoniënwoud, Bossen van het zuidoosten van de Zandleemstreek, Schelde- en Durme-estuarium van de Nederlandse grens tot Gent, Demervallei
- Walloon Region: Bassin fagnard de l'Eau Noire (Doische, Hastière, Philippeville), La Famenne entre Eprave et Havrenne (Rochefort), Bois de Grandhan, de Petit Han, de Famenne et de Biron (Durbuy, Erezée, Hotton), Vallée de la Meuse en amont d'Hastière (Beauraing, Doische, Hastière, Houyet), Bassin fagnard de l'Eau Blanche en aval de Mariembourg (Couvin, Doische, Philippeville), Massif forestier de Cerfontaine (Cerfontaine, Chimay, Couvin, Froidchapelle, Philippeville), Camp militaire de Marche-en-Famenne (Hotton, Marche-en-Famenne, Somme-Leuze), Vallée de la Houille en aval de Gedinne (Beauraing, Gedinne), Vallées des ruisseaux de Fenffe et du Vachau (Ciney, Houyet, Rochefort), Bassin de l'Hermeton en aval de Vodelée (Doische, Florennes, Hastière, Philippeville)

9180 - (*) *Tilio-Acerion* forests of slopes, screes and ravines

Mixed forests of secondary species (*Acer pseudoplatanus*, *Fraxinus excelsior*, *Ulmus glabra*, *Tilia cordata*) of coarse scree, abrupt rocky slopes or coarse colluvions of slopes, particularly on calcareous, but also on siliceous, substrates.

Habitat codes:

- Palaearctic Classification: 41.4
- EUNIS: G1.A/P-41.4
- CORINE: 41.4
- BWK: ek, es

Distribution and estimated area:

- Walloon Region: 2991.3 ha (89 sites)

Major sites:

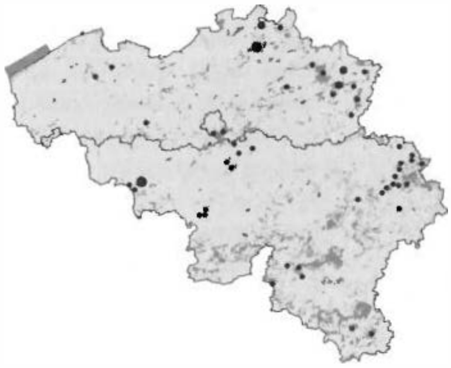
- Walloon Region: Bassin inférieur de l'Ourthe orientale (Gouvy, Houffalize, La Roche-en-Ardenne), Vallée de la Molignée (Anhée, Florennes, Mettet, Onhaye), Vallée de l'Ourthe entre Bomal et Hamoir (Durbuy, Ferrières, Hamoir, Ouffet), Haute-Wamme et Masblette (La Roche-en-Famenne, Marche-en-Famenne, Nassogne, Saint-Hubert, Tellin, Tenneville), Vallée de la Houille en aval de Gedinne (Beauraing, Gedinne), Vallée de la Lesse en aval de Houyet (Dinant, Houyet), Vallée de l'Ourthe entre Comblain-au-Pont et Angleur (Chaudfontaine, Comblain-au-Pont, Esneux, Liège, Neupré, Sprimont), Basse-Vierre (Chiny, Herbeumont, Léglise, Neufchâteau, Tintigny), Vallée de la Warche et du Bayehon en aval du barrage de Robertville (Malmedy, Waimes), Massif forestier de Daverdisse (Daverdisse, Libin, Tellin, Wellin)

9190 - Old acidophilous oak woods with *Quercus robur* on sandy plains

Acidophilous forests of the Baltic-North Sea plain, composed of *Quercus robur*, *Betula pendula* and *Betula pubescens*, often mixed with *Sorbus aucuparia* and *Populus tremula*, on very oligotrophic, often sandy (or moraine) and podsolised or hydromorphic soils; the bush layer, poorly developed, includes *Frangula alnus*; the herb layer is formed by *Deschampsia flexuosa* and other grasses and herbs of acid soils (sometimes includes *Molinia caerulea*), and is often invaded by bracken. Forests of this type often prevail in the northern European plain (e.g. Flanders) and occupy more limited edaphic enclaves elsewhere (e.g. Ardenne).

Habitat codes:

- Palaearctic Classification: 41.51 and 41.54
- EUNIS: G1.8/P-41.51, G1.8/P-41.54
- CORINE: 41.51 and 41.54
- BWK: qb within the borders of old forest



Distribution and estimated area:

- Brussels Capital Region: 36.0 ha (2 sites)
- Flemish Region: 1767.5 ha (16 sites)
- Walloon Region: 1273.8 ha (31 sites)

Major sites:

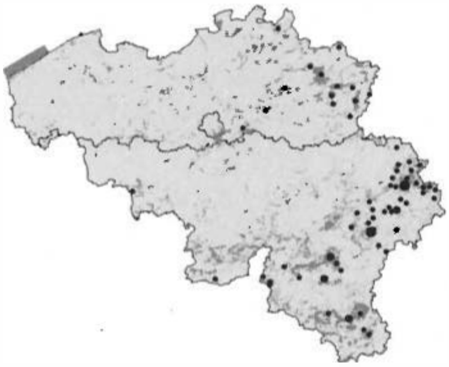
- Brussels Capital Region: Forêt de Soignes avec lisières et domaines boisés avoisinants et la Vallée de la Woluwe / Zoniënwoud met aangrenzende bosgebieden en Woluwevallei (Forêt de Soignes / Zoniënwoud), Zones boisées et ouvertes au sud de la Région bruxelloise / Bosgebieden en open gebieden in het zuiden van het Brussels Gewest (Kauwberg, Engeland)
- Flemish Region: Bos- en heidegebieden ten oosten van Antwerpen, Heesbossen en vallei van Marke en Merkske en Ringven met valleigronden langs de Heerlese Loop, Abeek met aangrenzende moerasgebieden, Mangelbeek en heide- en vengebieden tussen Houthalen en Gruitrode, Bossen, heiden en valleigebieden van zandig Vlaanderen: westelijk deel, Mechelse Heide en vallei van de Ziepbeek, Bovenloop van de Grote Nete met Zammelsbroek, Langdonken en Goor, Valleien van de Laambeek, Zonderikbeek, Slangebeek en Roosterbeek met vijvergebieden, Itterbeek met Brand, Jagersborg en Schootsheide en Bergerven, Demervallei
- Walloon Region: Bord nord du bassin de la Haine (Beloeil, Bernissart, Saint-Ghislain), Bois de Bon-Secours (Bernissart, Péruwelz), Vallée de la Thyle (Court-Saint-Etienne, Genappe, Les Bons Villers, Villers-la-Ville), Sources de la Dyle (Court-Saint-Etienne, Genappe, Ottignies, Louvain-la-Neuve), Vallée de la Lembrée et affluents (Aywaille, Durbuy, Ferrières, Stoumont), Vallée de la Lasne (Rixensart, Wavre), Massif forestier de Daverdisse (Daverdisse, Libin, Tellin, Wellin), Fagnes de Stavelot et vallée de l'Eau Rouge (Jalhay, Malmedy, Stavelot), Bois de la Géronstère (Jalhay, Spa), Vallée de la Dyle à Ottignies (Ottignies, Louvain-la-Neuve, Wavre)

91D0 - (*) Bog woodland

Coniferous and broad-leaved forests on a humid to wet peaty substrate, with the water level permanently high and even higher than the surrounding water table. The water is always very poor in nutrients (raised bogs and acid fens). These communities are generally dominated by *Betula pubescens*, *Frangula alnus*, *Pinus sylvestris*, *Pinus rotundata* and *Picea abies*, with species specific to bogland or, more generally, to oligotrophic environments, such as *Vaccinium* spp., *Sphagnum* spp., *Carex* spp.

Habitat codes:

- Palaearctic Classification: 44.A1 to 44.A4
- EUNIS: G1.5/P-44.1, G3.E/P-44.4
- CORINE: 44.A1 and 44.A4
- BWK: vt



Distribution and estimated area:

- Flemish Region: 43.0 ha (14 sites)
- Walloon Region: 3108.2 ha (54 sites)

Major sites:

- Flemish Region: Vallei- en brongebied van de Zwarte Beek, Bolisserbeek en Dommel met heide en vengebieden, Demervallei, Bovenloop van de Grote Nete met Zammelsbroek, Langdonken en Goor, Valleien van de Dijle, Laan en IJse met aangrenzende bos- en moerasgebieden, Mangelbeek en heide- en vengebieden tussen Houthalen en Gruitrode, Mechelse Heide en vallei van de Ziepbeek, Vennen, heiden en moerassen rond Turnhout, Valleien van de Laambeek, Zonderikbeek, Slangebeek en Roosterbeek met vijvergebieden, Valleien van de Winge en de Motte met valleihellingen, Hageven met Dommelvallei, Beverbeekse Heide, Warmbeek en Wateringen
- Walloon Region: Fagnes de la Polleur et de Malmedy (Malmedy, Waimes), Fagnes de Samrée et de Tailles (Houffalize, La Roche-en-Ardenne, Manhay, Vielsalm), Noir Ru et vallée du Rechterbach (Malmedy, Saint-Vith, Stavelot, Trois-Ponts), Haute-Lomme (Libin, Libramont, Chevigny, Saint-Hubert), Haute-Wamme et Masblette (La Roche-en-Famenne, Marche-en-Famenne, Nassogne, Saint-Hubert, Tellin, Tenneville), Vallées du Ruisseau de Mellier et de Mandebras (Habay, Léglise, Neufchâteau), Vallée de la Hulle (Gedinne), Vallée de l'Amblève entre Montenau et Baugné (Amel, Malmedy, Waimes), Fagnes du Nord-Est (Eupen, Raeren, Waimes), Bassin supérieur de la Salm (Gouvy, Vielsalm)

91E0 - (*) Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Pandion*, *Alnion incanae*, *Salicion albae*)

Riparian forests of *Fraxinus excelsior* and *Alnus glutinosa*, of temperate and Boreal Europe lowland and hill watercourses (44.3: *Alno-Padion*); riparian woods of *Alnus incanae* of montane and submontane rivers of the Alps and the northern Apennines (44.2: *Alnion incanae*); arborescent galleries of tall *Salix alba*, *S. fragilis* and *Populus nigra*, along medio-European lowland, hill or submontane rivers (44.13: *Salicion albae*). All types occur on heavy soils (generally rich in alluvial deposits) periodically inundated by the annual rise of the river (or brook) level, but otherwise well drained and aerated during low water. The herbaceous layer invariably includes many large species (*Filipendula ulmaria*, *Angelica sylvestris*, *Cardamine* spp., *Rumex sanguineus*, *Carex* spp., *Cirsium oleraceum*) and various vernal geophytes can occur, such as *Ranunculus ficaria*, *Anemone nemorosa*, *A. ranunculoides*, *Corydalis solida*.

Habitat codes:

- Palaearctic Classification: 44.3, 44.2 and 44.13
- EUNIS: G1.2/P-44.3, G1.1/P-44.2, G1.1/P-44.13
- CORINE: 44.3, 44.2 and 44.13
- BWK: va, vo, vm, vc, vf, vn

Distribution and estimated area:

- Brussels Capital Region: 46.3 ha (3 sites)
- Flemish Region: 4632.5 ha (32 sites)
- Walloon Region: 7199.5 ha (200 sites)

Major sites:

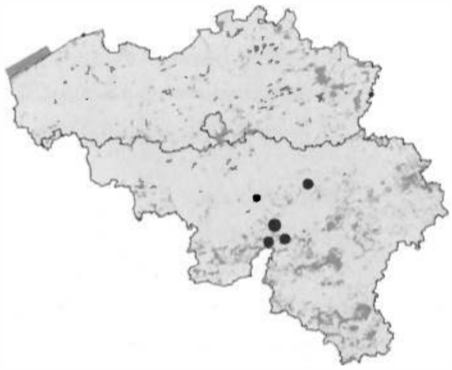
- Brussels Capital Region: Forêt de Soignes avec lisières et domaines boisés avoisinants et la Vallée de la Woluwe / Zoniënwoud met aangrenzende bosgebieden en Woluwevallei (Zoniënwoud / Forêt de Soignes, Bergoje, Hertoginnedal / Val Duchesse, Ter Bronnenpark / Parc des Sources, Maloupark / Parc Malou), Zones boisées et ouvertes au sud de la Région bruxelloise / Bosgebieden en open gebieden in het zuiden van het Brussels Gewest (Kinsendaal / Kinsendael, Kriekenput, Herdies, Buysdellebos en -vallei / Vallée et bois du Buysdelle, Fond' Roy), Zones boisées et zones humides de la Vallée du Molenbeek dans le nord-ouest de la Région bruxelloise / Bosgebieden en vochtige zones van de vallei van de Molenbeek in het noordwesten van het Brussels Gewest (Poelbos / Bois du Poelbos, Laarbeekbos / Bois de Laerbeek, Dielegembos / Bois de Dieleghem)
- Flemish Region: Bovenloop van de Grote Nete met Zammelsbroek, Langdonken en Goor, Bossen en heiden van zandig Vlaanderen: oostelijk deel, Valleien van de Winge en de Motte met valleihellingen, Bossen van de Vlaamse Ardennen en andere Zuidvlaamse bossen, Schelde- en Durme-estuarium van de Nederlandse grens tot Gent, Valleigebied tussen Melsbroek, Kampenhout, Kortenberg en Veltem, Valleigebied van de Kleine Nete met brongebieden, moerassen en heiden, Bos- en heidegebieden ten oosten van Antwerpen, Vennen, heiden en moerassen rond Turnhout, Vallei- en brongebied van de Zwarte Beek, Bolisserbeek en Dommel met heide en vengebieden
- Walloon Region: Vallées du Ruisseau de Mellier et de Mandebras (Habay, Léglise, Neufchâteau), Bassin de la Semois d'Etalle à Tintigny (Etalle, Habay, Tintigny), Basse-Vierre (Chiny, Herbeumont, Léglise, Neufchâteau, Tintigny), Marais de la Haute Semois et Bois de Heinsch (Arlon, Attert, Etalle, Habay), Haute vallée de l'Aisne (Erezée, La Roche-en-Ardenne, Manhay, Rendeux), Bassin inférieur de l'Ourthe orientale (Gouvy, Houffalize, La Roche-en-Ardenne), Massif forestier de Daverdisse (Daverdisse, Libin, Tellin, Wellin), Haute-Wamme et Masblette (La Roche-en-Famenne, Marche-en-Famenne, Nassogne, Saint-Hubert, Tellin, Tenneville), Bassin de la Lomme de Poix-Saint-Hubert à Grupont (Libin, Saint-Hubert, Tellin), Vallée de la Hulle (Gedinne)

91F0 - Riparian mixed forests of *Quercus robur*, *Ulmus laevis* and *Ulmus minor*, *Fraxinus excelsior* or *Fraxinus angustifolia*, along the great rivers (*Ulmenion minoris*)

Forests of hardwood trees of the major part of the river bed, liable to flooding during regular rising of water level or of low areas liable to flooding following the raising of the water table. These forests develop on recent alluvial deposits. The soil may be well drained between inundations or remain wet. Following the hydric regime, the dominating woody species belong to *Fraxinus*, *Ulmus* or *Quercus* genus. The undergrowth is well developed.

Habitat codes:

- Palaearctic Classification: 44.4
- EUNIS: G1.2/P-44.4
- CORINE: 44.4
- BWK: ru Maas / Meuse valley



Distribution and estimated area:

- Flemish Region: 0.6 ha (1 site)
- Walloon Region: 22.6 ha (5 sites)

Sites:

- Flemish Region: Uiterwaarden langs de Limburgse Maas met Vijverbroek
- Walloon Region: Vallée de la Meuse de Dinant à Yvoir (Anhée, Dinant, Onhaye, Yvoir), Vallée de la Meuse en amont d'Hastière (Beauraing, Doische, Hastière, Houyet), Vallée de la Lesse en aval de Houyet (Dinant, Houyet), Vallée de la Meuse à Huy et vallon de la Solières (Amay, Huy, Wanze), Vallée de la Sambre en aval de la confluence avec l'Orneau (Floreffe, Namur)

Acknowledgements

The authors would like to thank Jean-Louis GATHOYE, Thierry KERVYN (both RCNFW), Christine KEULEN (ULg, now at RCNFW), Desiré PAELINCKX and Geert STERCKX (both Institute of Nature Conservation) for their contribution.

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Eckhart KUIJKEN
Jurgen TACK
Institute of Nature Conservation
Kliniekstraat 25
1070 Brussels

Marc DUFRÊNE
Research Centre on Nature, Forests and Wood
Ministry of the Walloon Region
Avenue Maréchal Juin 23
5030 Gembloux

CHAPTER 6

BIODIVERSITY OF THE REGIONS AND NORTH SEA

Biodiversity in the Brussels Capital Region

Machteld GRYSEELS

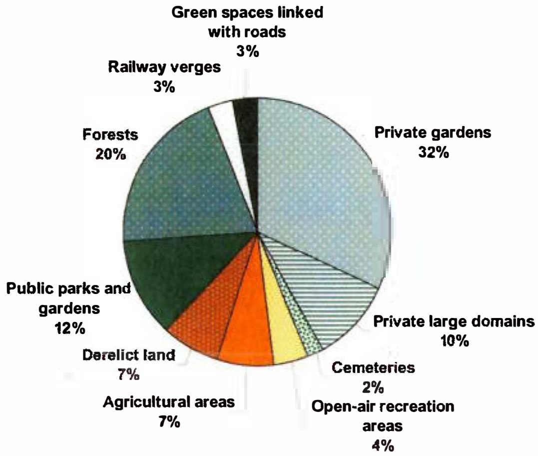
1. INTRODUCTION: THE PARTICULAR STATUS OF THE REGION

The Brussels Capital Region holds a distinctive position due to its limited area (± 160 km^2) and its very high urbanisation level, high population density (almost 1 million inhabitants), tight infrastructure network and intense economic activity. It appears as a small, highly urbanised island embedded in the Flemish Region.

Available historical information on biological diversity within the Brussels Capital Region shows that it is among the richest areas in plant and animal species in northwestern Europe. This can be explained partly by a more important biological prospecting effort in urban areas in former times: many naturalists used to carry out their activities close to home, when transport was more difficult than nowadays. Nature is often better known in urban areas than anywhere else! It does not explain everything however. Cities did not develop at random locations but were generally situated near rivers (for water and transport), forests and rocky outcrops (for fuel and construction), arable land (for food production), etc. In this perspective, the case of Brussels is striking. The urban settlement started to take shape around 1,000 A.D. in an area with extremely varied physico-geographical characteristics: a high geomorphological diversity (asymmetric large plain valley with marshes, slopes and higher areas) and high geological diversity (clays, sands, calcareous sandstone, loamy deposits) combined with the presence of forests and arable land of good quality. Moreover, Brussels is situated in a biogeographical zone where Atlantic and medio-European biological elements meet (LEBRUN 1998). Thanks to this particular context, the flora and fauna developed a very high biological diversity, which, from the medieval period till the 20th century, was positively influenced by human activities.

During the 20th century, the rich biological heritage developed during centuries did not escape the general loss of biodiversity observed all over western Europe. Yet, contrary to popular belief, the present flora and fauna in the urban environment is anything but poor or trivial. The great variety of biotopes, both relict and newly developed (even typically urban ones), and the good contact and exchange possibilities have led to a typical urban biodiversity with its own ecosystems and its own species diversity.

An accurate perception of present biodiversity in an urban area requires a good understanding of the specific interrelation between the urban web and the remaining green open spaces. Although 1,000 years of civilisation and urbanisation have led to major changes, the region still offers a mosaic of urban landscapes. Four major zones can be identified. They are determined by the presence of water (web subregion), the city and its infrastructure (densely urbanised subregion), forests (forest subregion) and rural relics of the periphery (rural subregion) (GRYSEELS 1998a, BRICHAU *et al.* 2000). Despite its high urbanisation degree, the Brussels Capital Region is still very green: green open areas (non built-up areas) cover 8,563 ha and account for 53% of the region's surface area. These green areas comprise the 'green spaces' and 'blue spaces', as detailed in figure 1 and below (GRYSEELS 1998a).



1

Types of green spaces in % of total open and green surface area (8,563 ha) of the Brussels Capital Region (IBGE-BIM)

1.1. Green spaces

1.1.1. Private green spaces

Private greenery occupies a high proportion (42%) of the green open areas. It consists mostly of gardens and large domains not accessible to the public, and amounts to about 22% of the region's total surface area.

1.1.2. Public green spaces

Public green spaces include parks, forests and nature reserves. Public parks cover 1,044 ha and consist of classic urban parks, contemporary parks, scenic ('English landscape') parks and ecologically managed parks. Public forests amount to 1,735 ha. The main contributor is the section of the Sonian Forest located on Brussels' territory (1,642 ha) [1].

1.1.3. Green spaces linked to the railway infrastructure

These green spaces, generally inaccessible to the public, cover a surface area of 222 ha. They constitute ecological corridors as well as refuges for wild flora and fauna.

1.1.4. Derelict land

The presence of a significant amount of unmanaged land is typical of the urban environment of Brussels. Derelict areas correspond to spaces abandoned during or after industrial and urban activities, as well as relic and/or marginal farming land spontaneously colonised by vegetation. They are refuges for both relic and typically urban flora and fauna, with a mix of indigenous and exotic species. Derelict lands amount to about 613 ha and are subject to a very high urbanisation pressure.

[1] The entire Sonian Forest covers more than 4,000 ha distributed over the three Belgian regions (Brussels, Flanders and Wallonia). It is however almost completely embedded in the southern part of Brussels' agglomeration.

1.1.5. Agricultural areas

Agricultural areas under economic activity (agriculture, horticulture, poplar cultivation) cover 606 ha and are mostly situated on the periphery of the region, where they mark the region border. They often exist in combination with derelict land and are also subject to great urbanisation pressure.

1.1.6. Other green spaces

Other urban green spaces comprise graveyards, roadsides and open-air recreation areas. These typical urban areas often accommodate a surprising diversity (e.g. old graveyards).

1.2. Blue spaces

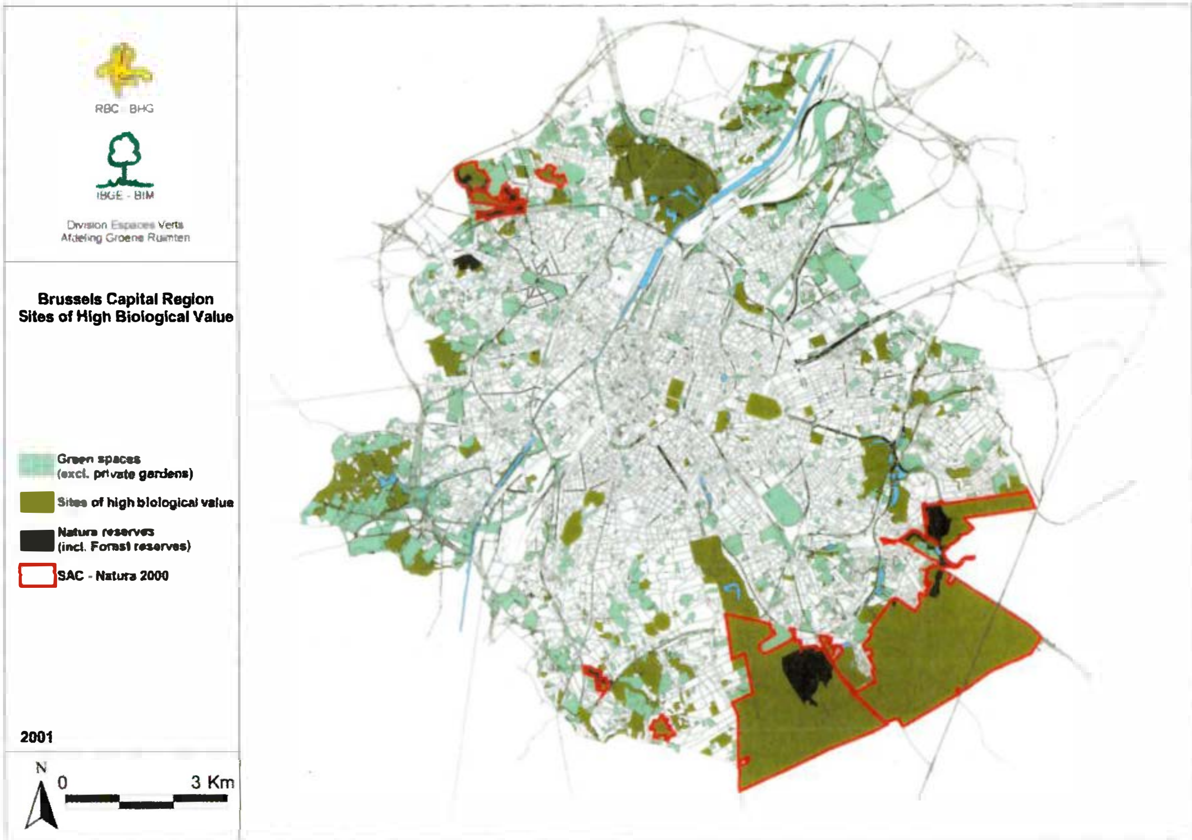
The presence of water is essential to preserve diversity. The only major open navigable waterway is the canal linking Brussels (Willebroek) to Charleroi. The most important natural waterway is the Senne, but the river and many of its tributaries have been vaulted over a large part of their course. Brussels also hosts a number of rivers, brook systems and ponds, which are often found in parks or forested areas. Ponds make up some 113 ha, and the total surface of open water reaches 172 ha.

2. Ecosystems and areas of high biological value

The majority of Brussels' green spaces with presumed biological importance have been studied to ascertain their biological value. The evaluation was carried out within the framework of an assessment at regional and national level. The biological value of an area was attributed on the basis of the diversity in vegetation structure, vegetation maturity, rarity of communities, fauna, (semi-)natural character, and to a lesser extent the importance for indigenous wild fauna (Gryseels 1998a). The study revealed that not only relics of semi-natural landscapes and nature areas (marshland, forests, meadows, etc.) but also artificially created urban open spaces (derelict land) with spontaneous nature development have a 'high biological value'. Typical urban green spaces (parks and squares) are also important. Although their ecological value has been recognised for a long time, their function for nature conservation and biodiversity is still too often considered of marginal importance.

Areas with a high to very high biological value cover about 2,540 ha (figure 2). They represent about 44% of the surface area of green spaces excluding private gardens or 15% of the region's total area. This estimation includes all forested areas (1,735 ha), considered to be very valuable from a biological viewpoint. When forests are excluded from the estimation, the proportion of areas with high biological value (805 ha) represents 19% of the total surface of green spaces.

Green spaces with a high biological value are essential for the conservation and development of biodiversity in the urban environment. They are often situated at the periphery of the region (figure 2): the Sonian Forest, the Woluwe river valley with its semi-natural parks, forest relics, agricultural derelict land and wetland areas in the south-west, forest and



2

Map of the Sites of High Biological Value

marshes in the north-west and the large, inaccessible Royal Domain. These areas with high biological value concern the following ecosystems:

- broad-leaved forests with typical spring flora;
- forests on limestone;
- alluvial alder and ash forests;
- semi-natural grassland;
- dry grassland on acid (heathland relic) and limy soil;
- marsh vegetation (sedge and reed vegetation);
- eutrophic ponds with marsh vegetation;
- brushwood in various colonisation stages and various environments (industrial, urban, railways or agricultural environments).

A detailed description of the ecosystems can be found in the text accompanying the Biological Evaluation Map of the Brussels Capital Region (BRICHAU *et al*. 2000).

A large share of the natural green areas is made up of woodlands. The southeast of the region is particularly rich in forested areas but sizeable woodlands can also be found in the northwest. Two types of forests, with different origins, can be differentiated. In the southeast, a large area is occupied by the Sonian Forest and its remnants (e.g. the Verrewinkel). Before the Sonian Forest was given permanent protection in 1842, these remnant areas were part of private estates and often incorporated into wealthy neighbourhoods of villas, or into large wooded parks. They comprise mainly acidophilic beech or oak

3

The Laarbeekbos / Bois du Laerbeek is situated in the northwestern part of Brussels and characterised among others by wild garlic carpets in springtime (photograph by M. GRYSEELS, BIM-IBGE).

forest, in addition to oak-hornbeam stands, with spring flora. The second type of forest corresponds to the wooded areas of the northwest -Laarbeekbos / Bois du Laerbeek, Poelbos / Bois du Poelbos and Dielegembos / Bois de Dieleghem- that developed during the afforestation of former calcareous sandstone quarries. They consist of beech and oak on calcareous soil, with abundant growth of wild garlic (*Allium ursinum*) in springtime. Ash-alder woods are also frequent and are generally found in large forested areas, such as the Sonian Forest and the Kinsendael. They correspond to alluvial ash forests with springtime flora, nitrophilous alder and typical vegetation of springs.

The numerous parks (public and private) are a unique characteristic of Brussels' urban area. Many have a great ecological value. Wooded parks and estates still containing original 'ancient woodland vegetation' with spring flora are very typical. This is also the case of large landscape parks featuring ponds, old high forests, grasslands and a varied contour in a 'natural' English landscape style. These parks are ideally suited for an ecologically-oriented site management, which is nowadays being applied expressly in some of them. For example, actions are taken to stimulate the development of natural and potential features in the Woluwe river valley, in particular in flower-rich humid meadows (e.g. Woluwe Park).

Many ponds are found in parks and estates. Although they are nearly all fitted out with artificial and/or reinforced banks and may be influenced by plantations, they occasionally feature natural aquatic plants and/or riparian vegetation. Most of the ponds serve as suitable habitat for fauna, among others birds and bats. This is particularly the case of some of the large ponds in the Woluwe river valley. In addition to open water spaces in parks, there are also remnants of natural marshy zones along the numerous small rivers and brooks. These remnants correspond mainly to reed marshes and consist of often ruderalised, small-surface sedge and tall herb vegetation.

Acidophilic vegetation of dry meadows and heathland used to be widespread on the Brusselian sands. It has now become very rare following its conversion into built-up areas. A few remnants are found mainly in Uccle, on dry meadows and on roadsides. Heather (*Calluna vulgaris*) can be encountered occasionally on these roadsides and in the Sonian Forest. Mesophilic 'flower-rich' meadows on sandy calcareous subsoil appear locally alongside railway embankments and highways.

A few farming zones with fields on loamy soil and meadows remain in Brussels, usually on valley fringes. They are often in the hands of declining farm holdings. One of the consequences is that they are generally managed rather extensively and are frequently rich in species. Embankments, hedges and trees form still part of the landscape.

The most typical urban vegetation type in Brussels is no doubt found on derelict lands. These derelict lands may be abandoned farmlands or vegetable gardens, wasteland or former landfills in abandoned quarries (often filled in with household and other waste and covered with a thin layer of soil) where vegetation develops spontaneously. Well-known examples include the sites of the Plateau van de Vorsterie / Plateau de la Foresterie, Gulledelle, Scheutbos, Josaphat and Tour & Taxis. These intrinsically 'common' waste-lands are rapidly gaining added value, as they are the only lands where nature can develop spontaneously in the urban environment. All stages of vegetation development are represented, from herbaceous to scrub species. The larger wastelands often host a variety of habitats. This is due to the fact that they have been neglected in different periods in time and their topography has been altered by the addition of various types of soil material as well as soil shifting. This ecological multiplicity, with accompanying side effects and structural complexity, is the main reason why these sites are so rich, both in local and exotic flora and

4

An important biotope of the Kinsendael is the alluvial ash-alder forest, which has been designated as a priority habitat under the Habitats Directive (photograph by M. GRYSEELS, BIM-IBGE).

fauna. The vegetation of open wastelands usually benefits from sunny conditions that lead to the production of an abundance of flowers, in particular along railway lines. This environment proves to be an invaluable refuge for insects and other invertebrates.

Apart from these semi-natural ecosystems under varying levels of human influence, several typical urban man-made habitats are also suitable for biodiversity. For example old buildings, walls or roofs serve as habitat substitutes for some species: they replace holes in rocks for swifts (*Apus apus*) or stony habitats for succulent plant species (*Sedum* sp.), they serve as shelter for house-dwelling species like bats or simply become suitable habitats for plant species with great adaptation power such as *Buddleia davidii*.

3. Activities and threats to biodiversity

The urban nature of the Brussels Capital Region and its social-economic context create severe threats for biodiversity. High population levels and urbanisation result in a concentration of threatening activities and a high recreation pressure. Cities are also important immigration areas for alien plants and animals introduced either with or without the help of man. This results in a high pressure from invasive alien species on the native fauna and flora.

Activities and threats listed below have been compiled using the following references: IBGE-BIM (1997), Gryseels & Onclincx (1994), Gryseels (1998b), Onclincx *et al.* (1998, 2000).

3.1. High population density

The Brussels Capital Region has currently about 950,000 inhabitants and an average regional population density of 59.2 inhabitants/ha (by comparison, the density for Belgium is 3.1 inhabitants/ha). This high population density is unevenly distributed and varies from 19 (Watermaal-Bosvoorde / Watermael-Boitsfort) to 180 inhabitants/ha (Sint-Joost / Saint-Josse). The majority of inhabitants -about 75% of the households- have no, or only very small, gardens. They have to resort to parks and semi-natural areas (especially forests) for their recreational activities. The main consequence is a very high recreation pressure on the green open spaces. In addition, there is also real pressure from the commuters, whose number is estimated at least at 300,000 a day.

3.2. Occupation of space

About half (47%) of the region's total surface area is built up. Traffic infrastructure occupies 2,485 ha (15% of the total area) of this urbanised area. This represents 2,000 km of canal, roads and railways. Car parks and infrastructure for public transport increase this proportion to 21%. Residential, industrial, commercial or public buildings take up the remainder (26%).

Open spaces are still being converted into built-up areas, however at a slower rate than in the 1980s. Data for 1990-95 indicate an increase of 2.7% for built-up land and 1.2% for the traffic infrastructure, as compared to a rise of 9% and 11.6% respectively in the 1980s.

Nevertheless, vast open spaces are still converted into offices, dense housing areas and commercial estates. Land reserve areas (land without a defined planning destination), which often contain vast semi-natural areas of high biological value, are especially at stake.

The ecological consequences of this high level of urban development are the following:
- there is a continued decrease in semi-natural areas with spontaneous flora and fauna (particularly of derelict land). According to the current Regional Plan of Soil Affectation, few 'open' spaces with undetermined destination are left available;
- the relentless split-up of existing green spaces leads to a reduction of green areas, parcelling, habitat fragmentation and the destruction of linear connecting elements;
- soil is increasingly impenetrable to rainfall, with local drought or local flooding as a consequence;
- a general drying up is caused by groundwater pumping for soil stability (underground buildings and spaces, underground traffic infrastructure, etc.) and the drainage of wetlands for construction purposes.

3.3. Pollution

3.3.1. Atmospheric pollution

In all major agglomerations, traffic and domestic heating have replaced industry as the main source of atmospheric pollution. The Brussels Capital Region is no exception to this phenomenon. Even if the situation is not as dramatic as in other European metropolises, some trends remain alarming. Air pollution is intrinsically linked to energy consumption. Air pollutants concern in particular SO_2, NO_x, ozone, CO, heavy metals such as lead, volatile organic substances, dust, black smoke as a result of diesel use, etc. The most worrisome of these are ozone, nitrogen oxides and volatile compounds. Domestic heating is responsible for more than 70% of CO_2 and SO_x emissions and 45% of N_2O. Transport accounts for about 80% of CO, NH_3 and polycyclic aromatic hydrocarbons (PAH) emissions, 58% of NO_x and 69% of lead. Industrial processes are the main contributors to CH_4, dioxin, cadmium and mercury emissions.

Atmospheric pollution contributes to two major environmental problems, acidification and eutrophication. Acidifying emissions disrupt air, surface water and soil composition and can contribute to forest decline, even though their direct effects are difficult to apprehend. Eutrophication is caused by an excessive supply of nitrogen compounds. Its direct effect on biodiversity is noticed by a degradation of vegetation through the decline of vulnerable species and the dominance of competitive species, mostly tall herbs. Indirect effects are very complex and difficult to measure. There are indications that air pollution causes changes in insect composition, which could be responsible for the decline in forest bird diversity (see subchapter 4).

3.3.2. Water pollution

Water pollution constitutes a huge problem in Brussels. There is only one water treatment installation currently active in the region. Situated in the south of Brussels, it treats only part of the household water and industrial waste water of the region, reaching only 360,000 inhabitants-equivalents. However, a new and large water treatment installation is under construction in the north of the agglomeration. It should be able to treat 1,100,000 inhabitants-equivalents and would cover the northern and Woluwe hydrographic basins.

Most of the waterways are still used for the discharge of waste water and are therefore of very poor water quality. The Senne receives all rain water and all waste water. Consequences are: low concentrations in dissolved oxygen (less than 1 mg/l during a 1998 survey, indicating heavy pollution), high amounts of total nitrogen concentration and sludge pollution with heavy metals. The Belgian Biotic Index, used to characterise the biological quality of water, is also very low. Usually, it does not exceed two in a scale from zero (very low quality) to ten (very good quality). The Brussels-Charleroi canal theoretically does not receive any waste water, except in case of thunderstorms. Still, its water quality is rather poor. The 1998 survey has shown that water quality decreases between its regional entrance and exit points, with a change from six to five in the Belgian Biotic Index. Important deterioration in the water quality may also occur during accidental pollutant flows as well as during droughts, when water quality decreases through eutrophication, mineralisation and decomposition of accumulated sludge.

Luckily, the picture is not completely dark. A number of surface waters still show excellent water quality, as for example in the Woluwe river basin. The 1998 study indicated that nitrogen and phosphorus concentrations were low all year round and heavy metals were absent.

The region is currently developing a more ecological approach to water management and is setting up a project for integrated water management: the 'blue network'. This programme is designed to improve the region's water basins through the improvement of water quality and the re-establishment of the continuity of the water network. Diverting clean water from waste water collectors should re-establish river flows, feed the ponds and wetland areas and reduce the quantity of water to be processed in the treatment stations, as well as limit flooding problems. An improvement in the quality of surface waters and the restoration of river banks, ponds and wetlands should make it possible to improve the ecological, landscape and recreational values of the sites.

3.3.3. Soil pollution

Soil pollution has mainly an historic origin. It is found on old industrial sites and old waste dumps. Problems are mostly linked to soil and surface water. Its effects on biodiversity have not been investigated yet.

3.3.4. Noise pollution

Noise is the greatest environmental nuisance in Brussels, with transport (road, railway and air) considered as the main source of acoustic discomfort. It is followed by noise generated by industrial activities, construction sites, neighbourhood (e.g. schools) and public transport (e.g. tramways). Noise nuisance, especially from aircrafts, is often resulting in unacceptable noise levels for the population but negative effects on the fauna have also been noted (see subchapter 4).

3.4. *Exploitation of natural resources*

Historically, sand and sandy limestone used to be extracted within the territory of the region. Nowadays, the exploitation of natural resources is limited to the extraction of ground water (4% of needs) in Ter Kamerenbos / Bois de la Cambre and the nearby portion of the Sonian Forest. The effect of water catchment on the forest ecosystem is not apparent, but it has never really been examined.

3.5. *High recreation pressure*

Growing and changing recreation needs are typical urban threats to biodiversity. The population pressure on the remaining open spaces is high. Even though Brussels is considered a 'green city', nearly one million inhabitants basically rely on 8,500 ha of green spaces, of which half is public but not always within reach: only 2,860 ha are accessible to the inhabitants as public parks and forests. On average, an inhabitant in Brussels has access to about 30^2 m of public greenery. If the Sonian Forest is not taken into account this decreases to about 9 m^2. Moreover, this figure depends on the area of the city, as access to greenery ranges from less than 1 m^2 in the town centre to more than 20 m^2 per inhabitant in the peripheral neighbourhoods.

There is a big difference between urban parks and larger semi-natural areas. Degradation of neighbourhood greenery or public parks in densely urbanised areas has to be placed in a social context -the small offer of green spaces- and can only be solved from that perspective. The degradation of larger green areas in the periphery of the region (especially of forests) constitutes however a real threat to biodiversity. It has reached alarming levels. The following observations can be made:

- visitor pressure is too high, especially during week-ends (exact figures are not available). Related problems are traffic congestion and increased areas used as parking spaces;
- too many visitors do not respect elementary rules of conduct and have no respect for the green spaces. This is translated by walking outside paths and treading on vegetation, excessive picking of mushrooms and flowers, high noise levels (radios, shouting, etc.) with as a consequence the destruction of flora and the disturbance of fauna;
- a number of new recreation forms such as mountain biking cause important damage to the soil and vegetation;
- the increasing number of dogs is an ever growing problem. They disturb the fauna when allowed to run loose.

These problems lead to habitat fragmentation (creation of new paths), soil degradation (trampling, compaction), destruction of flora and fauna, etc. It is difficult to find solutions: stronger regulations and a more repressive attitude from authorities are difficult to conciliate with the social role of the green areas. More importance should therefore be given to education and public awareness.

3.6. *Human impacts on semi-natural areas*

The urban context can also induce unexpected threats to semi-natural areas. For example, the 'park transformation' of semi-natural areas -or the landscape design of wild areas in order to meet recreation needs- can yield mixed results. Positive examples include the creation of footpaths to protect vulnerable zones. Negative impacts often result from the ordering and/or embellishment of nature, e.g. through so-called ecological plantations, the removal of 'potentially dangerous' dead trees or the creation of access to previously inaccessible areas. Another threat to spontaneous vegetation is the transformation of natural areas into vegetable and allotment gardens. This is certainly a commendable initiative from a social perspective, but, because of a lack of space, it often adversely affects relic semi-natural areas.

3.7. Alien and invasive species

The urban environment is a privileged immigration place for species: the concentration of transport facilities, the human influence, the presence of substitute biotopes, the contact and exchange possibilities all give rise to a typical urban biodiversity. However, in recent years, it has appeared that a number of these phenomena have had negative consequences. Many exotic species find optimum conditions in the disturbed, contact-rich urban environment, and seem to become, by their explosive development, a specific threat to indigenous species diversity. More insight into this matter will be given in the following subchapter.

4. Species diversity in relation to urban threats and alien species

Reliable and recent overview data about species in the Brussels Capital Region are available for the following groups: mammals, birds, amphibians, reptiles, higher plants, mosses, macrofungi and lichens. Since 1992, data collection has been co-ordinated within the framework of the establishment of a bio-indicator information network (IBGE-BIM 1998). Only fragmentary recent information is available for invertebrate species.

As the Brussels Capital Region is embedded within the Flemish Region, data interpretation for Brussels may not be useful from a purely scientific perspective. The major green spaces run across region borders (e.g. Sonian Forest), while a number of taxonomic groups are dependent on ecosystems present in surrounding regions (e.g. birds). The interpretation of criteria such as rarity, vulnerability and threatened status is therefore a complex matter and must be adapted to the specific context of the urban environment (Gryseels 1998c). Current distribution data must also be evaluated in combination with threats and impacts generated by alien species.

Recent data are summarised in table 1 below. Red lists of threatened species and species of special European importance have not officially been designated yet. Research, data validation and discussions are currently being carried out for a number of taxonomic groups. It should be noted, as presented in table 1, that all vertebrate species except fish are legally protected in Brussels.

Table 1. Estimation of species numbers for major groups in the Brussels Capital Region. [(1) The 'Regional Law pertaining to wild fauna and hunting' (29 August 1991) protects all vertebrates (except fish), and bans all hunting; (2) Wild flora is only protected by the federal law 'Pertaining to measures aimed at protecting certain plant species growing in the wild' (16 February 1976), which is not adapted to the rare urban flora and its threats.]

Groups	Total	Indigenous	Exotic	Endangered	Vulnerable	Declining	Extinct (since ± 1950)	Legally protected	Remarks
Mammals (DEVILLERS *et al.* 2000)	42 (+ 6?)	39 (+ 6?)	3	7	11		2	All (1)	Status of at least 10 spp. unknown; at least 6 others are rare
Birds (WEISERBS & JACOB 2001)	99	90	9	8 + 6	18	12	± 15-20	All (1)	
Amphibians (WEISERBS & JACOB 2001)	7 (8?)	6 (7?)	1	1 (1)	5		3 (4?)	All (1)	
Reptiles (WEISERBS & JACOB 2001)	3 (1?)	3 (4?)	1	1 (1?)	1	2		All (1)	
Fish	No detailed data available								
Invertebrates	No detailed data available								
Higher plants (GRYSEELS 1998c)	± 730	± 580	± 150	± 65	± 62	?	187	14 (2)	Rare + vulnerable + endangered spp. = ± 231
Mosses (VANDERPOORTEN 1996)	223	223		49	67	?	40	1 (2)	
Macrofungi (VANHOLEN *et al.* 2000, 2001)	± 913		1						Total recorded spp. (20th century) = ± 1,334
Lichens (VANHOLEN *et al.* 2000, 2001)	36								Total recorded spp. (20th century) = ± 120

4.1. Mammals

Most of this subchapter has been compiled using the following information: DEVILLERS & DEVILLERS-TERSCHUREN (1997, 1998a, 1998b, 1999, 2000). Other sources are indicated in the text.

The mammalian fauna of Brussels includes at least 42 existing species and 9 extinct or probably extinct species. The beaver (*Castor fiber*), wolf (*Canis lupus*), brown bear (*Ursus arctos*) and dormouse (*Muscardinus avellanarius*), disappeared before the 20th century. Other extinctions occurred only recently: the otter (*Lutra lutra*) disappeared in 1990 and the badger (*Meles meles*) in 1993.

The presence of a further 6 species is probable or possible. These numbers reflect a rather high species richness for the small surface concerned (160 km^2). It is close to, or slightly above, the richness expected on the basis of the continental species-area curve. The important forest cover in the region is no doubt one of the main reasons for this richness, combined with the total protection of mammals since 1991.

Bats represent a particularly significant part of the mammalian fauna, with 14 species known to occur and a further 3 whose presence is probable (out of a total of 19 species recorded in Belgium). The soprano pipistrelle (*Pipistrellus pygmaeus*) was discovered as recently as 2002. This chiropterological richness can be explained by the very high biological value of the Sonian Forest, coupled to favourable feeding grounds in its periphery, in particular above and around the ponds of the Woluwe river hydrographic network. The presence of many old trees with cavities, both in the Sonian Forest and in the nearby parks, is essential as most of the sensible species are tree- or forest-dwelling species (e.g. *Nyctalus noctula, Myotis daubentonii*). Nevertheless, city buildings also offer opportunities for house-dwelling species (e.g. *Pipistrellus pipistrellus, Eptesicus serotinus*). The common pipistrelle (*P. pipistrellus*) is certainly the most frequent species in the city.

The richness in bat species has justified the designation of Natura 2000 areas in the Brussels Capital Region (figure 2) (GRYSEELS 1996). The Sonian Forest hosts three species of Annex II of the Habitats Directive: the greater mouse-eared bat (*Myotis myotis*), notch-eared bat (*Myotis emarginatus*) and barbastelle bat (*Barbastella barbastellus*). Other populations of international importance found in Brussels include Natterer's bat (*Myotis nattereri*), Daubenton's bat (*Myotis daubentonii*) and the pond bat (*Myotis dasycneme*).

Although bats have few natural enemies, they are extremely vulnerable. Pesticides, noxious wood treatment products (e.g. in attics) and the disappearance of suitable habitats (e.g. removal of old, hollow dead trees) are the main causes of their vulnerability. An indirect threat for bat populations is the decrease in insect diversity and abundance due to habitat loss and pesticide use. House-dwelling species also suffer from the closure of openings in church and house roofs, carried out to prevent pigeon damage. Measures taken for the protection of bats in Brussels include total legal protection, better-adapted forest management, the installation of nest boxes, etc. Further action could include adaptation of historic ice houses to host bat populations, as it is already carried out in other regions of Belgium (IBGE-BIM 2001, 2002).

Urban populations of fox (*Vulpes vulpes*), hedgehog (*Erinaceus europaeus*), red squirrel (*Sciurus vulgaris*) and roe deer (*Capreolus capreolus*) are also very interesting when replaced in the European urban context. Foxes have been observed in the Sonian Forest for more than forty years. Since the protection of the species, foxes have been moving closer into the city, using railroad embankments and wooded parks as dwelling spaces and stepping-stones in their progression. It is a typical example of a species that has adapted well to the urban environment and which represents an improvement in urban biodiversity. The fox is present in forested areas in high densities, but is also spreading towards more urban as well as more rural areas. Population dynamics are currently investigated in order to better assess its presence (cohabitation with man) and possible epidemiological risks (KERVYN *et al.* 2001, DE BLANDER *et al.* 2002).

Hedgehogs are linked to the presence of scenic parks and the important surface of private gardens. Red squirrels are increasingly spreading into dense urban areas from their important source population in the Sonian Forest. This progression is carried out via wooded scenic landscape parks, private estates and private gardens (VERBEYLEN *et al.* 2001). Like for hedgehogs, their recent positive development is linked to their total legal protection since 1991, coupled with a better ecological understanding by green spaces managers and a greater public awareness concerning those 'nice animals'. The suburban population of roe deer is limited to the Sonian Forest, where it is under severe pressure. Population estimations suggest a presence of less than 100 individuals. Stress is linked to the disturbance caused by dogs and visitors, as well as to forest fragmentation due to road and railway infrastructures.

Several species have become very rare and are threatened. This includes most mammals linked to forest environments. Mustelids are a noteworthy example. Stoats (*Mustela erminea*) are nearly exclusively limited to the Sonian Forest, while weasels (*Mustela nivalis*) seem to be somewhat more frequent both in the Sonian forest and in other forested areas of the region. The western polecat (*Mustela putorius*), beech marten (*Martes foina*) and pine marten (*Martes martes*) are rather uncommon and difficult to observe.

Three exotic mammals are found in Brussels: the brown rat (*Rattus norvegicus*) (although generally not considered any more as an exotic species), muskrat (*Ondatra zibethicus*) and Siberian chipmunk (*Tamias sibiricus* = *Eutamias sibiricus*). The first two species have important effects on public health and riverbank stability, but they do not seem to cause any direct problems for indigenous species. The case of *T. sibiricus* is interesting (RIEGEL *et al.* 2001). The species established a stable population from the release of captive-bred animals in the 1970s. Until now, its presence has been recorded only in the Sonian Forest, where it has constituted substantial populations reaching up to 2,000 individuals. Its prevalence has been suggested as a possible cause for the severe regression of bird populations, particularly of insectivore passerines. However, until now, studies on this topic have not been able to detect a significant impact on bird populations. Within current knowledge, the presence of the Siberian chipmunk therefore does not appear to represent a serious management concern.

High pressure factors on the Brussels mammal fauna, such as the disappearance, fragmentation and degradation of habitats, have been more or less stabilised for wetlands and wooded habitats thanks to site protection and ecologically-oriented site management. For open habitats however, shrinking areas and fragmentation remain important stress factors. Disturbance by dogs is also a highly significant threat.

4.2. *Birds*

Major references used in the following subchapter are IBGE-BIM (1992-1997), WEISERBS & JACOB (1996, 1998, 1999a, 2000, 2001a, 2001b), WEISERBS *et al.* (1997), DE SCHUTTER *et al.* (1998), VANGELUWE & ROGGEMAN (2000).

The avian fauna of the Brussels Capital Region comprises about 100 breeding species, which is quite typical for an urban area of this size. It is estimated that, in a medium-term perspective, the number of indigenous bird species will probably slowly decrease while the number of exotic species will increase. This phenomenon has been observed in several other countries, and is more marked in heavily urbanised regions (10% of Brussels bird species are exotic). Since 1961 (table 2), 14 indigenous species disappeared as breeding bird, although isolated cases of reproduction are still possible. During the same period, 8 new indigenous species have appeared, often as the result of an increase in their population levels and distribution area elsewhere in Belgium. In the waterfowl category, population levels of the most demanding species remain very low. Habitat changes have favoured more adaptable species such as Corvidae and Columbidae. Formerly persecuted species such as the grey heron (*Ardea cinerea*) have recovered thanks to protection measures. Birds of prey also beneficiate from such protection and have progressed significantly both in terms of species and abundance.

Table 2. Evolution of the avifauna composition since 1960 (after WEISERBS & JACOB 2001b).

	1961-1968	1973-1977	1989-1991	1997-2001
Source	LIPPENS & WILLE 1972	DEVILLERS *et al.* 1988	RABOSÉE *et al.* 1995	WEISERBS & JACOB, in prep.
Indigenous breeding species	97	95	93	90
Exotic breeding species	3	5	7	9
Total	100	100	100	99

Diversified habitats in cities produce heterogeneous communities. This is reflected both in terms of the number and the distribution of species. For the period 1989-1991, an average of 36 species per km^2 was observed, with a range of 12 to 71 species per km^2. Omnipresent species are heavily represented and are favoured by the fact that they are well tolerated and that all indigenous bird species are protected. Consequently, opportunistic Columbidae and passerines are widespread and abundant and can be observed at close range (e.g. *Columba palumbus, Turdus merula, Pica pica*). Two anthropophilous species linked to the urban environment, the black redstart (*Phoenicurus ochruros*) and black swift (*Apus apus*), are abundant. Their evolution is now under study, as modern building methods do not seem to be beneficial to these two species.

Amongst those species that adapt to city life, the peregrine falcon (*Falco peregrinus*) reappeared recently after it stopped breeding in the city nearly 70 years ago. Observations of this general predator become more and more frequent and it is assumed that there has been one breeding couple in Brussels in 2001. This pattern is similar to those observed for other diurnal birds of prey (*Falco tinnunculus* and *Accipiter nisus*). It can be attributed to the falcon's ability to adapt, in particular regarding nesting sites and the predation of a small number of abundant species (feral pigeons!). The presence since 1966 of a colony of grey herons (*Ardea cinerea*) in the Royal Domain should also be noted (141 nests were recorded in 2001).

Several species in regression in Belgium have been declining more rapidly in Brussels than in the neighbouring regions. The numbers of house martins (*Delichon urbica*) have decreased dramatically. This could be due to problems linked to wintering, such as migration hazards in their route towards Africa or expanding desert areas in the Sahel. But other hypotheses, directly related to the urban environment, have also been put forward: the lack of mud -a necessary material for nest-building- in urban areas, the deliberate destruction of nests by uninformed people or changes in availability of flying insects. The disappearance of the barn swallow (*Hirundo rustica*) is undoubtedly related to agriculture intensification and, in the Brussels region, to the gradual disappearance of farms and agricultural areas. The dramatic decline of the house sparrow (*Passer domesticus*), formerly one of the most common birds in Brussels and the symbol of anthropophilous species, has been observed for several years. A number of causes have been put forward to account for the observed changes, but no convincing explanation has been found until now. Several factors may act in combination: changes in nest sites availability (less adapted houses and roofs), changes in food supply (disappearance of arable fields and wastelands as main food source, reduction in insect populations) or predation (e.g. by the numerous domestic cats!).

Spectacular decline or disappearance have also been observed for several species that were widespread in wooded areas in the past. The cuckoo (*Cuculus canorus*) and golden oriole (*Oriolus oriolus*) have disappeared. The tree pipit (*Anthus trivialis*), redstart (*Phoenicurus phoenicurus*) and wood warbler (*Phylloscopus sibilatrix*) are scarcely found. This is partly due to the high recreation pressure on suburban forest areas, but it cannot explain everything. There are serious indications that the decline in forest bird diversity is linked to changes in insect composition, the main food source for the birds. These changes may be due to increased air pollution from roads or motorways crossing the Sonian Forest. However, the constant noise from road and air traffic seems to be the main cause of the catastrophic decline: a linear negative relationship between forest breeding birds and traffic noise from motorways has been observed (WEISERBS & JACOB 1996).

Outside the nesting season, the arrival of migratory and wintering birds in forested areas is sometimes spectacular. This depends among others on the extent of beechnut production in the Sonian Forest. Elsewhere, migratory and wintering birds are less numerous or are difficult to observe.

For the past 30 years, there has been a major increase in the exotic bird fauna in Brussels, both in terms of numbers and species. Part of the exotic 'population' is made up of solitary birds and/or species not habituated to our climate and whose presence is anecdotal. The occurrence of these birds is sometimes due to caretakers of public parks, as for example the peacock (*Pavo cristatus*) or the black swan (*Cygnus atratus*) that are the subject of attempts of reproduction in semi-captivity. In addition, birds escape from captivity or are sometimes released intentionally. They contribute to the variety of avian fauna, such as parrots (Psittacidae family) and waterfowl (e.g. the wood duck, *Aix sponsa*).

In general, isolated individuals are considered to have little or no impact on the indigenous fauna. However, some species may acclimatise and start reproducing. The resulting habitat colonisation may lead to growing competition between exotic and indigenous species. Only breeding species that are a potential threat for native birds are described below. It should be noted that exotic passerines have not acclimatised, as opposed to what has been observed in southern Europe.

Three species of parrots are breeding in Brussels, two of them having done so for over 20 years. The ring-necked parakeet (*Psittacula krameri*) can be declared as the symbol of exotic species present in the Brussels Capital Region. The origin of the Brussels population is related to the release in 1974 of some forty birds following the closure of a wildlife park. The first nesting observations were made the same year. Since then, the rate of expansion of this parakeet has been particularly high. Population counts at the only roost in Evere show an exponential population increase resulting in a total of nearly 4,500 birds in 2001 and 5,300 in 2002! This population increase has been accompanied by an expansion of the breeding area in the city.

The parakeet can now also be found outside the region. Bird monitoring activities in Brussels so far have not indicated any direct negative impact of this species on indigenous breeding birds. The availability of nesting cavities and food sources are possible points of contention. It has often been suggested that indigenous tree- or cavity-dwelling species would be naturally susceptible to this type of competition. However recent studies have not shown any signs of regression in their populations yet, even in areas where the parakeet is very abundant. As far as food is concerned, feeding by citizens does make a sizeable contribution to the parakeet's diet.

The monk parakeet (*Myiopsitta monachus*) is the second parakeet present in Brussels since the end of the seventies. Current populations amount to 50-60 individuals. This species most interestingly is the only parakeet to build big collective nests made of branches and twigs. Monk parakeet colonies are located in heavily urbanised areas. Their impact on the local fauna is low as there is only a small number of species with which they co-exist. In addition, it is likely that artificial feeding is a determining factor for the survival of the species.

The Alexandrine parakeet (*Psittacula eupatria*) first appeared in the region in 1998, as the result of individual birds that escaped from captivity. The current population is estimated at 20-30 birds. As soon as it appeared in Brussels, the Alexandrine parakeet associated with *P. krameri* in terms of nesting, feeding and gathering at the dormitory. The exponential development of *P. krameri* has raised concern about the potential increase in this new species. In 1999, as the numbers of *P. eupatria* were still relatively low, a capture campaign was planned by the Brussels Institute for Management of the Environment (BIME) in order to prevent its implantation. This delicate action was finally not carried out. Like for

P. krameri, the issue of the impact of *P. eupatria* on the indigenous fauna has been raised. It essentially concerns the competition with indigenous cave-dwelling species. *P. eupatria* being more robust, the interaction with indigenous species could be different from *P. krameri*. However, the actual population is currently too small to have any considerable impact.

Alien waterfowl species are the other major category of exotic bird species found in Brussels. The mute swan (*Cygnus olor*) has been domesticated and commonly found as early as the 19th century. The urban population is stable. Interaction with indigenous birds (e.g. *Podiceps cristatus, Fulica atra*) and the destruction of nests have been reported but the small population has very little impact on the indigenous fauna. The Egyptian goose (*Alopochen aegyptiacus*) is breeding since 1984. Twenty-seven nesting couples were recorded in 1990-1991, whereas 234 individual birds were counted in 1999. During the moulting season, population concentrations are observed in some parks. The impact of the species on indigenous populations was studied between 1992 and 2000. The Egyptian goose is a rather aggressive animal and its influence on the breeding success of indigenous waterfowl seems probable. However, WEISERBS & JACOB (2001) could not so far detect any direct negative impact. There seems to be no signs of indigenous waterfowl population reductions at regional level. This provisional conclusion could be explained by the fact that densities of *A. aegyptiacus* per site remain small and that resources are sufficient to avoid or to contain competition. However, discussions between scientists and managers goes on (see e.g. VANGELUWE & ROGGEMAN 2000) and the study continues.

The mandarin duck (*Aix galericulata*), introduced for ornamental purposes, has been reproducing freely in Brussels since 1989. It most often stays in damp forested areas but can also be found in city parks. It is a discreet cave-dwelling species and is not a potential threat to indigenous birds. The wood duck, *Aix sponsa*, has been observed regularly in the past several years but no attempts to nest were reported in Brussels.

The Magellan goose (*Chloephaga picta*) comes from the Royal Domain and has formed a small urban population of less than 5 nesting couples. Its threat potential will depend on its reproduction rate in future years. Initial observations indicate that it is currently not very aggressive and not very prolific. A likely important breeding species is the Canadian goose, *Branta canadensis*, as it has been increasing significantly in other regions of the country. Several hundred individuals have been recorded in Wallonia and up to several thousands in Flanders. The large increase of observations for the Brussels region suggests that it might soon start reproducing. It is most likely that this will cause interaction problems with indigenous species. Another probable breeding species is the barnacle goose (*Branta leucopsis*), with several individuals observed breeding in a park close to the Brussels region. Other man-attributed species are mingling with the Brussels bird fauna, such as hybrids between wild and domesticated ducks or various forms of domesticated geese and ducks. Their presence in high numbers points to the extremely artificial nature of some ponds and could give problems on these sites.

Two other exotic species breeding in Brussels are worth mentioning. The pheasant (*Phasianus colchicus*) is still found in small numbers in the countryside in the periphery of the city. Until the 1960s, this species was very common due to artificial releases for hunting purposes. The ban on hunting in the Brussels region has led to a halt in the replenishing and artificial feeding of the species. As a result, its numbers gradually fell. The other species, *Columba livia* (rock dove or feral pigeon), settled in the first half of the 20th century. It is now one of the most common species in heavily urbanised areas. However, its ecological niche is very different from that of other urban birds and no negative influence has been observed. However, their droppings are a scourge for buildings.

4.3. Amphibians and reptiles

General information can be found in PERCSY (1998) and WEISERBS & JACOB (2001).

The herpetofauna of Brussels is currently composed of 10 indigenous species: three reptiles and seven amphibians. The natural occurrence of some of these species can be debated, particularly of the grass snake (*Natrix natrix*) and the common midwife toad (*Alytes obstetricans*). The grass snake reproduces in the marshy areas of Jette-Ganshoren, whereas two populations of unknown origin of *A. obstetricans* are maintained on private and isolated sites. The last known natural populations of the toad have been extinct since the 1980s.

5

The marshy area of Jette-Ganshoren is one of the most important of the region (photograph by M. GRYSEELS, BIM-IBGE).

Amphibians and reptiles constitute a very vulnerable species group in urban areas. Not only do they depend on various ecological conditions (water and land), but they are also very sensitive to fragmentation (roads as barriers for migration) and to the degradation of their habitats (water pollution, drainage or drying up of ponds). The distribution of indigenous species at the periphery of the region relies therefore on the occurrence of wetlands of sufficient quality, which are essentially protected areas. Species diversity has been reduced both by direct and indirect human action. The indigenous herpetofauna suffers from the release of animals sold on the pet market, such as turtles and snakes, as well as from the introduction of exotic or other species in private artificial ponds and wetlands.

Two exotic species are present in natural areas in Brussels. The first one is the red-eared terrapin -also called the 'Florida turtle' (*Trachemys scripta elegans*)- which is present in many ponds in parks and in the Sonian Forest. The presence of this species is the result of releases by individuals: when turtles are too big to be kept in aquaria, they are dumped in neighbouring ponds. The species has not acclimatised, and no reproduction has been observed yet. However, it seems to be insensible to hard winters and grows very large and old. The red-eared terrapin is a threat to invertebrates, which are eaten by the young turtles (i.e. individuals less than five years old). Vegetation is a major source of food for adults. In the Brussels region, threats from this species are not too severe as most of the occupied sites are heavily urbanised. However, the species has also appeared in the richest semi-natural sites, such as in the Sonian Forest, where its presence seems to become a nuisance. Public infatuation for these reptiles is not fading and it is unlikely that releases will decrease in the short term. Although importation of this species is now banned, importation of similar species is still allowed. In the medium-term, a fall in releases of Florida turtles will probably be counterbalanced by the appearance of new species, in particular those of the genus *Chrysemys*, whose feeding habits are similar to *T. scripta elegans*.

The second exotic 'species' actually corresponds to a group of closely related green frog species: the exotic green frogs *Rana ridibunda* and *R. perezi* have been observed in and around a dozen sites. Populations are often small and their connection is uncertain. These frogs are a threat to the indigenous green frogs (i.e. the pool frog, *R. lessonae*), with which they produce hybrids (*Rana esculenta* synklepton). However, as the latter has probably disappeared from the Brussels region, these exotic green frogs are no longer considered a serious threat in the urban region of Brussels. *Rana catesbeiana* however, already present in the other regions, could constitute a future problem.

4.4. *Invertebrates*

Synoptic data on invertebrates are not yet available. Several studies have been carried out, providing information on a few taxonomic groups. Some of the available information is presented below.

Studies on insect and spider populations in the Sonian Forest have indicated the faunistic importance of this 'ancient' forest. As far as insects are concerned, the only systematic study has been carried out for carabid beetles and identified 38 different species (Desender *et al.* 1987). The presence of the endemic coloured form of the beetle *Carabus auronitens* var. *putzeysi* is well documented. Another interesting characteristic concerns the presence of viable populations of the stag beetle (*Lucanus cervus*), not only in the Sonian Forest but also in adjacent forest parks and forest relics with old oaks. *L. cervus* is a species of European importance, listed in Annex II of the EU Habitats Directive.

As for spiders, a total of 137 species have been recorded, including a species unique in Belgium (*Philodromus praedatus*) and several rare species (e.g. *Achaearanea simulans* and *Walckenaeria corniculans*). A population of about 100 individuals of the rare spider *Atypus affinus* was recently discovered. It should be noted that this spider is the only mygalomorph species present in Belgium. Causes of vulnerability are on the one hand the disappearance and degradation of its preferred habitats (heathlands and sandy open spaces), and on the other hand the compaction and erosion of soils following timber skidding and public recreation.

Although no general investigations have been carried out in wastelands, on the vegetation of open sunny derelict lands, those sites appear to be indispensable and valuable refuges for insects and other invertebrates. For example, the blue-winged grasshopper (*Oedipoda caerulescens*) has been discovered in derelict railway areas (Josaphat, Tour & Taxis).

As far as Hymenoptera are concerned, preliminary sampling of the ant fauna carried out in 2000-2001 in city parks resulted in the observation of 16 species. *Myrmeca rubra* and *Lasius niger* were the most abundant species. The exotic ant *Hypoponera punctatissima* has been recorded in one site, suggesting that this species might be able to adapt to local climatic conditions (DELTENRE & DE BISEAU 2002).

Currently, a research project investigates the effect of the ecological management of grasslands in urban parks in relation to bat diversity. It addresses, among others, foraging opportunities (i.e. insects) for bats species.

The Brussels Capital Region is also concerned with potential threats from invasive alien insect species. A few examples are detailed hereafter.

For the past two years, urban trees have suffered from defoliation by an exotic moth, the horse chestnut leafminer (*Cameraria ohridella*). This moth species has been spreading throughout central, southern and western Europe over the last 15 years, causing severe damage to *Aesculus* species and in particular to the horse chestnut, *Aesculus hippocastanum*. The horse chestnut is one of Brussels most common and typical trees along streets and is frequent in urban parks. A small research project is currently going on to develop an optimal control strategy for *C. ohridella*.

Special attention has also been given to the arrival and behaviour of beech bark beetles (Coleoptera, Scolytidae) in the Sonian Forest, following the severe economic damage they caused to the Wallonian beech forests during the past few years. Three of these beech bark beetles (*Trypodendron domesticum*, *T. signatum* and *Anisandrus dispar*) are indigenous to the Belgian fauna and cannot be considered as exotic invasive species, but a fourth species, *Xylosandrus germanus*, is an alien introduced from East Asia (Japan, China). Interestingly, this species is more specifically found in the Sonian Forest and not in Wallonia. The moment of its arrival is unknown, but is probably relatively recent. Investigation cam-

6

The multicoloured Asian ladybird *Harmonia axyridis* (Coleoptera, Coccinellidae) is sold by private companies as biological control agent of aphid populations. Reproductive populations have now been found in the wild at several Belgian locations (photo by S. BAUER, courtesy of ARS, USDA).

paigns in 2001 and 2002 seem to indicate that the beech bark beetles do not cause major threats to the Sonian Forest. Research is continued on a small scale (GRÉGOIRE 2002).

An emerging problem concerns the arrival of the multicoloured Asian ladybird, *Harmonia axyridis* (Coleoptera, Coccinellidae) in urban parks in Brussels (figure 6). Because of its facility to be mass-produced, this Asian species has been used for some years as a biological control agent to reduce aphid densities in greenhouses. Until recently, no wild observations of *H. axyridis* were reported in Belgium. However, data collected in Flanders and in Brussels during the summer of 2002 showed that the ladybird was able to reproduce in the wild. The extension of *H. axyridis* is followed with great attention, as it has shown competitive abilities towards native species during its introduction in North America.

4.5. Higher plants

This subchapter has been compiled using IBGE-BIM (1999), GRYSEELS (1998c), SAINTENOY-SIMON (1995, 1996, 1998, 2001) and GODEFROID (1996a, 1996b, 2001).

An exhaustive inventory of higher plants was carried out in 1991-94. The total number of spontaneously present plants was found to be about 730 species, which represents half of the Belgian flora. This high species number can largely be explained by the landscape diversity of the Brussels Capital Region and human activities such as agriculture, as well as by the fact that cities are important immigration areas for alien plants introduced either with or without the help of man.

Atlantic and sub-Atlantic influences on the vegetation are very pronounced. Species encountered include the bluebell (*Hyacinthoides non-scripta*) and narcissus (*Narcissus pseudonarcissus*), as well as species like *Gagea spathacea*, *Carex strigosa* and *Tamus communis*. The medio-European and sub-medio-European elements are represented by species such as *Oreopteris limbosperma* and *Phyteuma spicatum*. Even the sub-Mediterranean element is present, with species like *Ceterach officinalis* and *Ophrys apifera*.

Out of the 730 species, at least 231 indigenous species are considered to be rare, vulnerable and even threatened. Interesting and very rare species include *Aristolochia clematitis, Lycopodium clavatum* and *Neottia nidus-avis*.

The flora of Brussels is made up of the following eco-sociological groups:
- pioneer species of artificial habitats in anthropised and perturbed biotopes such as wastelands, roads and railway embankments, arable lands: 25% of the urban flora (e.g. *Berteroa incana, Bromus tectorum*);

- species of forests and woodlands: 20% of the urban flora. This can be explained by the importance of the Sonian Forest in Brussels territory (e.g. *Hyacinthoides non-scripta, Anemone nemorosa*);
- species of wood fringes: 14% of the urban flora (e.g. *Aegopodium podagraria, Silene dioica*);
- species of dry grasslands: 10%. This group includes species of typical dry urban habitats like rocks and walls. They are rare due to the restoration of ancient buildings (e.g. *Asplenium ruta-muraria, Cymbalaria muralis*);
- species of humid grasslands: 10% (e.g. *Carex disticha, Lychnis flos-cuculi*);
- species of water and wetlands: 10% (e.g. *Caltha palustris, Phragmites australis*);
- pioneer species of semi-natural habitats: 8% (e.g. *Centaurium pulchellum, Scirpus setaceus*);
- heath species of dry and poor soils: 3%. They are found as relics in the Sonian Forest and surroundings (e.g. *Calluna vulgaris, Molinia caerulea*).

The specific floristic richness varies greatly and depends on the localisation in the region. The densely urbanisedurbanised centre hosts only about 50 species per km^2. Species richness at the periphery can reach 200-250 species per km^2 in forested areas (e.g. Sonian Forest) to 300 species per km^2 in semi-natural relic areas (e.g. wetlands and marshes)

7

The Kauwberg is one of the rare semi-natural sites embedded in the urban matrix (photograph by M. GRYSEELS, BIM-IBGE).

adjacent to derelict land in direct contact to railway areas. The species richness in derelict lands bordering transport infrastructure illustrates the importance of human influence in species composition. Transportation is responsible for the movement of seeds over long distances and thus for the dispersal of local species or the arrival of new, exotic species. It shows that the railway network can act as 'green corridors' and support significant areas of biodiversity importance.

Vegetation composition in Brussels is characterised by the presence of many exotic species, as approximately 20% of the 730 species are considered non-indigenous. The largest part of these exotic species (about 60%) results from voluntary introductions for ornamental purposes in gardens and parks or for cultivation, followed by the escape and naturalisation of the species. The remaining 40% is the result of accidental introductions, mostly by road, railway or boat transport.

GODEFROID (1996a) and SAINTENOY-SIMON (2001) provide an interesting survey of the origin of the naturalised plants: 16% have an American origin, with about 30 naturalised species; 16% African, with only one naturalised species; 34% Asian, with 12 naturalised species and 34% European, with about 10 naturalised species. The presence of introduced (and naturalised) exotic species in the urban area is mostly interpreted as 'being part of urban biodiversity' and as one of the reasons for the relatively high biodiversity of urban areas. Alien species tend to occur preferentially in well-lit, dry, nitrogen rich, alkaline and warm places: common habitats in urban areas, often resulting from human impacts through eutrophication, drainage, deforestation, soil enrichment with construction rubble and climate warming.

It is generally accepted that the flora of Brussels has become impoverished due to urbanisation impacts such as the loss and fragmentation of habitats as well as intensive recreation pressure. From 1943 to 1990, at least 187 species have disappeared, of which 140 indigenous ones. At the same time, the total number of plant species has remained more or less stable for the past fifty years, ranging from 789 to 730 species. There may therefore not be a significant quantitative reduction in species, but the qualitative impoverishment is obvious: native species of semi-natural areas (especially humid and forest ecosystems) and agricultural areas are regressing. Their regression is compensated by the arrival of non-indigenous species.

The introduction of alien species on derelict lands and in relics of natural ecosystems is worrying. Due to their invasive character, some naturalised species have become a serious threat to indigenous vegetation: once installed, their explosive development (often due to rhizomatic extension) mostly leads to monospecific patches and to the replacement of the native flora.

In this regard, threats from some Asian species are well known. *Impatiens parviflora* is spreading in the herbaceous layer of forested areas. Dense and monospecific populations of *Fallopia japonica* and *F. sachalinensis* dominate in many railway verges, derelict lands, woodlands and forest fringes and suppress every other species. The giant hogweed (*Heracleum mantegazzianum*), a dangerous plant whose phototoxic substances can cause injuries to the human skin, has been locally present for more than 50 years. During the past 15 years, it has been showing rapid progression along roadsides and railways and now forms tall monospecific vegetation patches. American species seem to be less invasive, except for the Canada and late goldenrods (*Solidago canadensis, S. gigantea*). Their appearance is followed quickly by a spectacular extension of the population leading to large monospecific stands. More recently, Brussels has experienced the remarkable extension of *Senecio inaequidens,* a plant native to South Africa that is invading and quickly dominating dry open, and often derelict, lands.

Many exotic species, sometimes even locally invasive, are not always considered a direct threat but are also seen as an enrichment of the urban flora if they do not seem to be in competition with indigenous species. A well-known example is the butterfly bush (or summer lilac), *Buddleia davidii*. This exotic shrub of Chinese origin now feels quite at home in Europe, where it was introduced as an ornamental during the 19th century. It rapidly escaped from its cultivated state, colonising typical man-made stony habitats like walls, old houses or derelict buildings. It is well appreciated because of his attractiveness for butterflies. However, the question whether such exotic species really lead to the enrichment of the urban flora remains a point of discussion.

4.6. Mosses

An inventory between 1993 and 1996 recorded 223 species, of which 49 are threatened and 67 vulnerable. The number of deteriorating species is not known. At least 40 species have disappeared since 1980 (VANDERPOORTEN 1997).

The richest area in mosses of the Brussels region is the Sonian Forest, where for example *Sphagnum flexuosum* and a few very rare species such as *Ephemerum stellatum* are found. Recent research by SOTIAUX *et al.* (1999) points out that the number of bryophytes has not decreased from previous inventories. However, although some forest species of great phytogeographic interest were newly found, moss diversity is now largely due to the spread of non-forest species from their natural habitats into ruderal and man-made habitats. Genuine and rare forest species have disappeared, or are becoming increasingly rare: currently, about 30% of the species occur in only one or a few localities.

4.7. Macrofungi

The information below was compiled using the following sources: DE KESEL (1996, 1998a, 1998b), SCHREURS (1996), VANHOLEN & DE KESEL (1999, 2000), VANHOLEN *et al.* (2001).

Macrofungi are excellent bio-indicators as well as good biodiversity indicators: they are vitally significant in forests, breaking down dead organic material, acting as mycorrhizae or forming an important part of the diet of many animals. In this context, an inventory was carried out in 1996-2000 in the most important green spaces for macrofungi, the Sonian Forest and the adjacent Ter Kamerenbos / Bois de la Cambre. Due to the presence of very old historical forests dominated by beech and oak on loamy (locally calcareous) soils, macrofungi biodiversity is very high in the Brussels region. This is especially due to the exceptional species richness of the Sonian forest for macrofungi. About 1,334 species have been recorded when using information from historical data and literature sources. Mycologists estimate that the total number of macrofungi in the Brussels Capital Region could reach 3,000 species. Indeed, due to the intermittent presence of mushrooms, long investigation periods are needed to obtain an approximate number. About 913 species are currently present, of which some 748 species are rather rare to very rare. Nearly half (394) of the species have to be considered as very rare.

Air pollution -in particular nitrogen fallout- is a general threat. However, its direct effects on macrofungi are rarely evocated. Intensive forest management practices and exploitation often lead to severe consequences with an alarming effect on mycorrhizae fungi, important for tree health. Until now, the attention given to fungal diversity in forest management has been rather low. Results of the inventory have however influenced forest managers to adapt their management practices to take biodiversity into account.

Major threats arise from the social function of the forest. For the past few years, there has been a significant increase in mushroom picking, both for commercial purposes as well as for family use. Mushroom picking has become a very popular and fashionable occupation. On the one hand, this may be regarded as a rather positive fact as it shows that there is a growing number of city inhabitants interested in nature. On the other hand, the over-exploitation of wild mushrooms is becoming a real concern. It is worth mentioning that formerly common species of high culinary importance, like *Boletus edulis*, are becoming increasingly rare just because of this reason. In order to be able to allow future sustainable mushroom picking, regulations are urgently needed today. Whether mushroom picking could be tolerated in a controlled way or whether it should be forbidden to preserve biodiversity in our overstressed urban forests is still much debated. However, as control measures seem very difficult to establish and implement, total prohibition of picking may be the only effective manner to preserve fungal biodiversity.

Until now, only one alien macrofungus has been recorded in the Sonian Forest. *Anthurus archeri* was first discovered in the seventies, and was probably introduced with tropical hardwood. So far, the species is only very locally present and does not seem to pose any threat to indigenous species.

4.8. Lichens

Research on the presence of epiphytic macrolichens in Brussels combining herbarium material, historical and literature sources and field inventories (1998-2000) produced a list of about 120 different species. Only 36 species have actually been found between 1998 and 2000. Many lichen species must therefore be considered as having been extinct for a more or less long period of time. As lichens are excellent indicators for good air quality, this large number of extinct species is not surprising for an area that underwent major urbanisation changes since 1850. However, more frequent observations of lichens on trees are made nowadays and the recent rediscovery of *Usnea* cf. *U. subfloridana*, last observed in 1916, may be indicating an increase in lichen diversity following the improvement of air quality (mainly due to the reduction in sulphur emissions). So far, no exotic lichens have been recorded (Vanholen & De Kesel 2000, Vanholen *et al.* 2001).

4.9. Conclusions

Contrary to popular belief, the recent data and studies *in-situ* presented above seem to indicate that alien species may not -so far!- always pose alarming direct threats to the indigenous fauna of the Brussels Capital Region. However, the competition between exotic and indigenous waterfowl species remains a serious point of discussion. There are certainly nuisances linked to the presence of invasive species, such as noise caused by the concentration of parakeets in big roosts. The high number of exotic geese in urban parks causes management problems for the grasslands, due to excessive amounts of droppings, trampling effects and excessive grazing.

The situation is quite different for plants. Some exotic species may have a true negative influence on the indigenous vegetation composition. In Brussels' urban area however, this often concerns typically man-made habitats or perturbed sites (like derelict areas) and it cannot be concluded that rare indigenous species or biotopes are threatened by the arrival of alien species. In order to avoid the arrival and/or explosive development of those species in areas with rare and vulnerable species (where threats to indigenous diversity are real), careful monitoring must be carried out constantly.

Scientists, environmental managers and the general public may one day have to accept the presence of alien species as part of the very diversified urban habitat. The main decline in biodiversity has occurred in the last decades, through the loss and fragmentation of habitats and through widespread pollution. Although the situation has improved nowadays thanks to a better ecological consciousness, it is still continuing in a less conspicuous way and on a

8

The Woluwe Park, one of Brussels' public parks beneficiating from ecologically-oriented site management, forms an essential link in the green and blue network (photograph by M. Gryseels, BIM-IBGE).

smaller scale. This subtle degradation should really be the first cause of worry. But at the same time, continued attention should be paid to the presence and threats of alien species. As eradication seems illusory in most cases, preventive measures and control are necessary.

In the Brussels Capital Region, the discussion on the development of action plans towards the control or eradication of alien species has been going on for some time. Experimental action plans and information campaigns regarding parrots (Psittacidae) and plants such as *Fallopia* sp. (e.g. Japanese knotweed) were not very successful as they arrived well after the explosive development of these exotic populations.

Recent investigations have shown that the success of exotic bird species is linked among others to bird feeding by the population. Information campaigns to limit or prohibit this activity are very difficult and not very successful, due to the high social impact of this popular, enjoyable and inexpensive hobby in the urban environment (parks), especially among children and lonely elderly people.

As far as exotic waterfowl is concerned, local control measures are now experimented in order to prevent nuisances caused by high densities of already present exotic goose species (e.g. *Alopochen aegyptiacus*), while precaution measures are prepared in order to tackle species that have just arrived (e.g. *Branta canadensis*). Are preventive action plans realistic? It is indeed difficult to predict the arrival or the behaviour of new species. For example, the weed *Senecio inaequidens* has been present in Brussels since 1981, but has only shown explosive development recently. The direct negative impact of the Egyptian goose (*A. aegyptiacus*) may not be entirely clear for the moment, but what will happen if the species continues its extension? What if the only roost of *Psittacula krameri* splits up? What if the 'Florida turtle' *Trachemys scripta elegans* starts reproducing? It seems impossible to predict whether or when an alien species will become invasive, and how dangerous it can become for the local flora and fauna. Management on local scale is not very effective. The presence of exotic species therefore needs constant monitoring and information networks and action plans with other regions (and similar urban areas) should be developed.

5. Some remarks on the strategies and actions to develop biodiversity

From what has been presented above, it is clear that the Brussels Capital Region hosts a wide diversity of ecosystems and an often unexpectedly rich flora and fauna. It also demonstrates that the urban environment is compatible with wildlife. It therefore makes sense to take biodiversity into consideration when developing plans and strategies for the general management of the urban environment.

Any discussion concerning nature conservation in an urban environment, particularly at the small scale of the Brussels Capital Region, could seem trivial. It is clear that few animal or plant species depend on the preservation of their urban populations for their survival. On the other hand, at times where almost half of the world's population lives in urban areas, a debate on nature conservation in urban areas -however complicated- has become inevitable. The aim goes far beyond the preservation of species or the protection of nature relics by tight regulations. More than elsewhere, policy requires a sustainable dimension. The main issue is not nature in itself, but rather the development of a pleasant living environment, of which biodiversity is a fundamental part. The social dimension of nature conservation in cities should not be underestimated. Little or no contacts with nature are known to lead to the increased occurrence of stress, depression and violence.

In this regard, it is essential to make city inhabitants aware of the wealth of biodiversity that surrounds them. While forming the majority of the population, they often have the least access to biodiversity or nature. Moreover, cities are major development poles where strategic decisions are made. If nature and biodiversity cannot be endorsed and developed in cities, it is unlikely that they will be taken into consideration as an essential part of development by the population and decision-makers. Biodiversity must thus be rendered accessible to a maximum of citizens, of course in a sustainable manner (DE SCHUTTER *et al.* 2000).

In this context, the Brussels Institute for Management of the Environment has laid down its major orientation lines for the development of the biological heritage in the Brussels Capital Region. The various plans are part of a strategy that takes into account the specific problems and characteristics of the city, including its complicated social aspects (DE SCHUTTER *et al.* 1999, GRYSEELS 2000, KEMPENEERS 2001).

The concept of the green and the blue network is presented below as an example (IBGE-BIM 2000). The green network emphasizes the cohesion and continuity of green spaces and semi-natural areas in the urban environment. The intention is to integrate the scenic, esthetical, social, recreational and ecological functions of the green spaces and to develop their inter-connectivity by greenways and new green areas. Simultaneously, work is being done to implement the blue network. Its purpose is to have an integrated, durable and ecologically-justified management of the open waterways in the region. This requires active co-operation between the various sectors, in particular between the green spaces managers and the infrastructure department. Much attention is devoted to the increase of natural values and biodiversity in such a way that the public still has access to the areas concerned. In this context, a project oriented towards the enhancement of bat populations is currently under way. (IBGE-BIM 1998b, 1999, 2001, 2002, VAN DER WIJDEN *et al.* 2001).

Acknowledgements

Special thanks are due to Anne WEISERBS and Jean-Paul JACOB, for their notes on bird biodiversity, to Jacqueline SAINTENOY-SIMON, for her notes on exotic plant species, and to Serge KEMPENEERS and his team of the Division Green Spaces of the Brussels Institute for Management of the Environment, for their consciousness and willingness to integrate biodiversity into the general management of the regional green spaces of Brussels.

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Machteld GRYSEELS
Division Green Spaces - Direction Nature & Forests
Brussels Institute for Management of the Environment
Gulledelle 100
1200 Brussels

State of Nature in Flanders

Eckhart KUIJKEN, Jurgen TACK & Luc DE BRUYN

1. INTRODUCTION

The information in this subchapter is based on the Nature Reports of 1999 (KUIJKEN 1999) and 2001 (KUIJKEN *et al.* 2001). These two documents have been compiled by the Institute of Nature Conservation, following its legal obligation to report every two years on the state of nature in Flanders. Information on the main biotopes in Flanders and the status of major taxonomic groups is presented, as well as an overview of the most important threats to biodiversity in Flanders. An outline of actions taken and of strategies under development to protect biodiversity in Flanders is given to conclude this subchapter.

2. SPECIES DIVERSITY

Recent information estimates the total number of species in Belgium between 40,000 and 50,000. Approximately 80% of the species are found in Flanders. Most of them -about 75%- are invertebrates (insects, spiders, etc.). The 'flora' (higher plants and fungi) and vertebrate animals respectively represent 24% and 1% of the species. The numbers are probably underestimated, especially for invertebrates. For example, 4,500 Diptera species (flies, mosquitoes, etc.) are recorded in Belgium (GROOTAERT *et al.* 1991). In neighbouring countries, the total number of Diptera is estimated to be more than 6,000. This indicates that it is not known whether or not an extra 1,500 to 2,000 species are present in Belgium. If those figures are extrapolated to other orders of insects and groups of invertebrates, it can be assumed that several thousands of species still have to be discovered.

Knowledge on the distribution and densities of most species is still very limited. Information is usually available on traditional groups like vertebrate animals, higher plants and the larger, colourful groups of invertebrates. For most of those groups, Flanders has compiled Red Lists of threatened species. Table 1 gives an overview of the status of the major groups of organisms in Flanders and figure 1 summarises the proportion of species for each Red List category.

About one-third of the investigated species living in Flanders are extinct or threatened to disappear (Red List categories extinct, critically endangered, endangered and vulnerable). Approximately 7.5% of the species have not been found since 1980 and are considered as extinct (319 species). If those figures are used to estimate the species numbers of the different groups -taking into account the share of the Flemish fauna in the Belgian fauna and the number of invertebrates not yet discovered- it can be estimated that out of a total of 42,000 species in Flanders, about 14,000 can be considered as Red List species. Of those Red List species 5,000 are already extinct (several species in Flanders certainly became extinct before being discovered). Those figures are probably underestimations since algae and other unicellular organisms (approximately 5,000 existing species in the Netherlands), and bacteria (> 1,000 existing species in the Netherlands) were not taken into account.

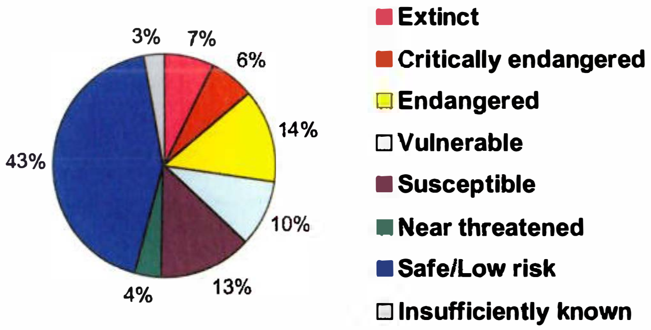
Table 1. Number of Red List species in different taxa in Flanders (adapted from MAES & VAN DYCK 2001). Total numbers refer to native species.

Taxonomic group	Total species number	Extinct species	Red List species	% E + RL
Mammals (CRIEL 1994)	60	11 (18%)	13 (22%)	40%
Breedings birds (DEVOS & ANSELIN, in prep.)	159	4 (3%)	44 (28%)	31%
Amphibians & reptiles (BAUWENS & CLAUS 1996)	19	2 (11%)	6 (32%)	43%
Fish (VANDELANNOOTE & COECK 1998)	55	11 (20%)	2 (4%)	24%
Butterflies (MAES & VAN DYCK 1996)	64	19 (30%)	22 (34%)	64%
Carabid beetles (DESENDER *et al.* 1995)	352	32 (9%)	66 (19%)	28%
Grasshoppers (DECLEER *et al.* 2000)	39	5 (13%)	13 (33%)	46%
Dragonflies (DE KNIJF & ANSELIN 1996)	61	9 (16%)	20 (34%)	50%
Dolichopodid flies (POLLET 2000)	260	22 (8%)	39 (15%)	23%
Spiders (MAELFAIT *et al.* 1998)	604	9 (1%)	144 (24%)	25%
Higher plants (BIESBROUCK *et al.* 2001)	1416	81 (6%)	325 (23%)	29%
Mosses (HOFFMANN 1999)	502	33 (7%)	126 (25%)	32%
Lichens (HOFFMANN 1999)	338	50 (15%)	170 (50%)	65%
Macrofungi (WALLEYN & VERBEKEN 1999)	552	43 (8%)	230 (42%)	50%

For some groups, the speed of decline is decreasing. Bats, the most threatened group of vertebrates, underwent a strong decline after World War II but numbers have stabilised in recent years. However, the number of bats is so low that their populations are still very vulnerable. Their recent stabilisation can probably be explained by the use of less toxic pesticides (e.g. ban on DDT) as well as the protection and management of their winter residence (VERKEM & VERHAGEN 2000). This example shows that correct measures can make a difference. A major problem is the time lapse between measures taken and subsequent visual improvements of biotopes or species.

2.1. *Mammals*

In Flanders, 69 species of mammals have been recorded. Sixty are considered as native (18 species of bats, 39 species of land mammals and three species of marine mammals), seven species are considered as exotic and two as gone wild (CRIEL *et al.* 1994). Strictly, only one marine mammal, the common seal (*Phoca vitulina*), is found in Flanders. The other two are found in the North Sea, which is federal territory.



1

Proportion of species in Flanders in each of the Red List categories.

Eight species of insectivores (Insectivora) can be found in Flanders. They belong to three families: hedgehogs (Erinaceidae), moles (Talpidae) and shrews (Soricidae). The mole (*Talpa europaea*) is common and is able to maintain its populations in Flanders. The hedgehog (*Erinaceus europaeus*) is also a common species. It can be found principally in areas where forests are bordering grasslands. However, there is a clear lack of information on population densities and their evolution. Road traffic is probably the most important threat to the species (populations can be decimated locally), with mowing being another source of danger. Systematic information on traffic and mowing victims is currently still lacking. Of all insectivores present in Flanders, shrews are the most affected by population decline.

Bats are found mainly in the double belt of fortresses around Antwerp, in the marl pits of southern Limburg and in ice cellars spread across the region. Of the 18 species present in Flanders, 14 are on the Red List. Bats are especially active in the evening and at night and this explains the limited ecological research carried out on those species. Because bats do not make nests, they depend on natural and/or artificial cavities. Bats can be classified in two groups: tree- and cave-dwelling bats. As Flanders only has a limited amount of natural caves, cave-dwelling bats must make use of artificial constructions reproducing natural conditions. This has serious consequences towards nature management for the different bat species.

Lagomorphs (Lagomorpha) are represented in Flanders by two species: the rabbit (*Oryctolagus cuniculus*) and the hare (*Lepus europaeus*). The rabbit is one of the most widespread mammals living in Flanders. The hare is also ubiquitous, however in much smaller numbers. The history of the rabbit is rather special: the species was present in Flanders before the last glaciations, and then disappeared before being reintroduced from the Mediterranean by the Romans.

Fourteen species of rodents (Rodentia) can be found in Flanders. Another three species have been introduced: the Siberian chipmunk (*Tamias sibiricus*), coypu (*Myocastor coypus*) and muskrat (*Ondatra zibethicus*). Only the muskrat is well adapted and widespread. The other two species survive in small local populations. The hamster (*Cricetus cricetus*) is probably the most threatened rodent. It is the only land mammal in the Red List category 'critically endangered'.

Siberian chipmunks were first imported in the 1960s for the pet trade. Now, there are a small number of distinct wild populations in Flanders. Populations in the Sonian Forest increased from about 150 individuals in 1981 to several thousand individuals in 1998 (Van den Broecke 2002). Coypu were imported from South America for their fur at the beginning of the 20th century. In Flanders, they have now established wild populations in the Province of Limburg. With only a few hundred individuals in Belgium, numbers are still relatively low compared to other European countries. However, due to the absence of cold winters in the past few years, coypu numbers have been increasing, raising concern about their potential negative impacts on local ecosystems (VERBEYLEN & STUYCK 2002). The muskrat was also introduced for the fur trade in the early 20^{th} century and originates from North America. It has an extremely high reproductive capacity and provokes serious harm to waterways. Active and intensive eradication campaigns are carried out to limit its damage (STUYCK 2002).

The order Carnivora is represented in Flanders by 11 species. Eight of them are native: the weasel (*Mustela nivalis*), ermine (*Mustela erminea*), polecat (*Mustela putorius*), stone marten (*Martes foina*), pine marten (*Martes martes*), badger (*Meles meles*), otter (*Lutra lutra*) and fox (*Vulpes vulpes*). Three exotic species or subspecies are found in addition to the native ones: the American mink (*Mustela vison*), ferret (*Mustela putorius furo*) and cat (*Felis catus*). The two last species are wild pets. The raccoon (*Procyon lotor*) and raccoon dog (*Nyctereutes procyonoides*) are only sporadic but are considered as escaped animals (e.g. from animal parks). Badgers and foxes are currently expanding their range. The last remaining localities where the badger can be found are situated in the most southeastern part of Flanders. After a long lasting decline, the populations have increased slightly since the nineties. During the same period, Flanders has also experienced a remarkable increase in density and area expansion of the stone marten, which can be replaced in the context of the general increase in populations in Europe from the 1960s onwards.

The order Artiodactyla is represented in Flanders by the wild boar (*Sus scrofa*) and roe deer (*Capreolus capreolus*). The commercial raising of fallow deer (*Dama dama*) for human consumption could lead to an introduction of this non-native species. The red deer (*Cervus elaphus*) disappeared in Flanders at the end of the 18^{th} century as a consequence of massive poaching.

Several species of whales have been encountered in Belgian marine waters or washed ashore along Flemish beeches. However, only the porpoise (*Phocoena phocoena*) and bottlenose dolphin (*Tursiops truncates*) are considered to belong to the native fauna of Belgium. Both species are recorded on the Red List. The short and narrow coastal strip of Flanders does not offer much adequate space for seals. The only seal species that can be considered as native in Flanders is the common seal.

Legal protection and international importance

In Flanders, 34 land and three marine mammals are legally protected (DE PUE *et al.* 1998) by the Royal Decree on Nature Conservation in Flanders (1980) and its amendments. All insectivores, except the mole, are protected by the aforesaid law. Twenty-three terrestrial and two marine mammals are listed in Annex II of the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention, 1979). One species is listed in Annex II, 11 terrestrial and two marine mammals are listed in Annex II and IV and 15 terrestrial mammals are listed in Annex IV of the EU Habitats Directive. All bats and marine mammals are listed in Annex II of the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention, 1979).

It should be noted that the legal protection of mammal species cannot be effective if no action is undertaken against the destruction of, and the damage to, their natural habitats.

2.2. Birds

2.2.1. Summer visitors

Since the beginning of the twentieth century, 159 bird species have bred in Flanders during at least ten years. Non-native species are not taken into account in this number. During the twentieth century, four native breeding bird species became extinct, a little more than a quarter are threatened, 10% are rare and a little more than half of the species are not threatened. Four species do not breed any more on a yearly basis.

For a large number of breeding bird species, there are not enough quantitative data to show trends. However, sufficient information is available to give a general overview of trends during the last decades for a number of species. Comparison of the number of present-day populations with estimations and/or extrapolations of numbers of breeding birds in Flanders in the past shows a negative trend for most of the species. One of the most obvious conclusions is the dramatic decline of reed and marsh birds such as the black tern (*Chlidonias niger*), great bittern (*Botaurus stellaris*), little bittern (*Ixobrychus minutus*), Savi's warbler (*Locustella luscinioides*) and great reed warbler (*Acrocephalus arundinaceus*). The sedge warbler (*Acrocephalus schoenobaenus*) and reed bunting (*Emberiza schoeniclus*) also show a decline but no detailed figures are available. The decline for those species is partly caused by the disappearance of their habitat (marsh) and by the worsening situation in their hibernation sites. For species inhabiting dryer biotopes, like the northern wheatear (*Oenanthe oenanthe*), black grouse (*Tetrao tetrix*), common skylark (*Alauda arvensis*), woodlark (*Lullula arborea*), European nightjar (*Caprimulgus europaeus*), tree pipit (*Anthus trivialis*) and common stonechat (*Saxicola torquata*), the situation is not much better. The tawny pipit (*Anthus campestris*) even completely disappeared as breeding bird in Flanders since 1987. The populations of the northern wheatear, woodlark and crested lark (*Galerida cristata*) show a strong decline that can be related to the decreasing surface of hatching sites. Those species suffer from growing tourism pressure as well, especially along the coast.

Bird species inhabiting agricultural landscapes also have problems to maintain their populations. Species of wet, extensively used agricultural land show a strong decrease in numbers, e.g. corn crake (*Crex crex*), common snipe (*Gallinago gallinago*), whinchat (*Saxicola rubetra*) and garganey (*Anas querquedula*). Species from small-scaled agricultural areas with linear landscape elements and traditional cultivation techniques are seriously threatened, e.g. red-backed shrike (*Lanius collurio*), northern shrike (*Lanius excubitor*) and ortolan bunting (*Emberiza hortulana*). Various data also show a dramatic decline in numbers for the grey partridge (*Perdix perdix*), tree sparrow (*Passer montanus*), corn bunting (*Miliaria calandra*) and yellowhammer (*Emberiza citrinella*) in Flanders during the past twenty years.

The programme 'Bijzondere Broedvogels Vlaanderen' monitors rare, colonial and introduced breeding bird species in Flanders. Alien bird species already breeding are the lesser white-fronted goose (*Anser erythropus*), Canadian goose (*Branta canadensis*), barnacle goose

(*Branta leucopsis*), Egyptian goose (*Alopochen aegyptiacus*), mandarin duck (*Aix galericulata*), ring-necked parakeet (*Psittacula krameri*) and monk parakeet (*Myiopsitta monachus*).

Legal protection and international importance

All native birds living in the wild are protected in Flanders. It is prohibited to catch, kill, eradicate, transport, import and export them, at all times. The protection not only concerns the birds themselves but also their eggs, nests and feathers. Annex I of the EU Birds Directive lists 25 species of birds found in Flanders. The European conservation status of 15 species is considered as vulnerable, 40 species as stable, 18 species as declining and one species is considered as localised.

2.2.2. Migratory birds and winter visitors

For many bird species, Flanders is an important hibernation area. Flanders is also an important staging area for migratory birds. The presence of protected areas with suitable resting and feeding grounds is an essential factor. Different monitoring projects register numbers and area distribution of winter visitors and migrant birds. However, available data differ from species to species. The data gathered for specific species groups (e.g. water birds, raptors, seabirds, passerines) are strongly influenced by numbers, biotope choice and the difficulty of observation.

The following paragraphs illustrate the importance of Flanders as a hibernation and stopping place for migratory water birds. Even though Flanders lacks major wetlands, it is an important to very important area for certain species of water birds. This can be explained by the geographical location of Flanders in the European lowland plain, its mild winter climate and its rigidly enforced hunting regulations. Water birds belong to the following families: divers (Gaviidae), grebes (Podicipidae), cormorants (Phalacrocoracidae), herons and egrets (Ardeidae), storks (Ciconiidae), ibises and spoon bills (Threskiornithidae), swans, geese and ducks (Anatidae) and rails (Rallidae). Waders (Charadrii), gulls and terns (Laridae) also fit into this group but are not discussed because of the lack of standardised counting data in Flanders. Traditional midwinter counts of 'wildfowl' started in 1967.

In Flanders, 67 species of water birds can be considered as yearly winter visitors and/or migratory birds (exotic species excluded). For 47 of those species, Flanders is of minor importance, mostly because the species reach the outer limit of their distribution range in Flanders or because suitable habitats are lacking. Species for which minimum 1% of the total northwestern European population stays regularly in Flanders are the little grebe (*Tachybaptus ruficollis*), great crested grebe (*Podiceps cristatus*), great cormorant (*Phalacrocorax carbo*), tundra swan (*Cygnus columbianus*), pink-footed goose (*Anser brachyrhynchus*), greater white-fronted goose (*Anser albifrons*), greylag goose (*Anser anser*), common shelduck (*Tadorna tadorna*), gadwall (*Anas strepera*), common teal (*Anas crecca*), mallard (*Anas platyrhynchos*), northern pintail (*Anas acuta*), northern shoveler (*Anas clypeata*), common pochard (*Aythya ferina*), tufted duck (*Aythya fuligula*) and common coot (*Fulica atra*). Three other species reach this 1% criterion occasionally, mostly during harsh winters: bean goose (*Anser fabalis*), barnacle goose (*Branta leucopsis*) and smew (*Mergus albellus*).

The number of wintering water birds in Flanders has shown a strong increase during the last decades. Until the early nineties, no clear trend emerged and large differences between winters could be explained by weather conditions. The average number of water birds was approximately 113,500 during mild winters and increased to 172,500 in severe winters. In 1986, numbers peaked following the large influx of geese from the north during a severe cold spell. Since the nineties, there has been a continuous increase in the numbers of water birds: from 140,000 in 1992 to more than 300,000 in 1997. Again, weather conditions played an important role. The winters of 1993-94 and 1994-95 were very wet in Flanders. Floods in the valleys attracted large populations of water birds. The following two winters were very cold, so larger numbers of water birds flew in from the north. A remarkable fact is that the recent numbers of water birds during cold winters are much larger than during the cold winters of the eighties.

The recent increase in numbers of water birds is not caused by just a few species. From the 17 most important species of water birds, 14 show a significant increase between 1979 and 1997. Only the little grebe, mallard and northern shoveler show a status quo or a fluctuating trend. There is no negative trend for any of the species, except for the common pochard in the second part of the eighties.

Population growth is not always caused by the same factor. Most of the time, a combination of different factors is observed. For some species, increasing numbers in Flanders just follow the increasing numbers of the whole northwest-European population (e.g. pink-footed goose and gadwall). Fluctuating weather conditions are often responsible for short-term fluctuations. Hard frost can drive birds from more northern areas to migrate to Flanders, as for the common pochard and Eurasian wigeon (*Anas penelope*). The improvement in water quality during the past 10 years may also have contributed to the population growth. Fish-eaters like the great crested grebe and great cormorant probably took advantage of the increasing fish stock. The improved quality of the lower part of the river Scheldt -with increasing numbers of invertebrates as a food source- is probably responsible for the growing numbers of water birds in this part of Flanders.

Legal protection and international importance

All free-living birds of the European Union are legally protected in Flanders. It not only concerns breeding birds, as seen in the previous paragraph, but migratory birds, wintering birds and vagrants as well.

Exceptions are made to this strict legislation for some species: harmful birds, cage birds and game birds. As foreseen in the hunting decree of July 1991, a large number of birds are added to the category of game birds. Listed game birds include species mentioned earlier such as the mallard, gadwall, northern shoveler, tufted duck, common pochard, northern pintail, common teal, garganey, Eurasian wigeon, greylag goose, bean goose, greater white-fronted goose, pink-footed goose, Canada goose, common coot and common snipe. Other species include the greater scaup (*Aythya marila*), common moorhen (*Gallinula chloropus*), jack snipe (*Lymnocryptes minimus*), northern lapwing (*Vanellus vanellus*) and golden plover (*Pluvialis apricaria*). Hunting seasons are determined for each species individually, with a revision every five years by the Flemish Government. For example, between 1 July 1998 and 30 June 2003, hunting is only allowed and regulated for the Canadian goose, mallard, Eurasian wigeon and common coot. It is specified where, when and how each of those species can be hunted. The other game birds cannot be hunted during that period. In some EU Birds Directive areas and in Ramsar areas, specific hunting restrictions apply.

Some conventions and European directives protect bird species at the international level. The Bern Convention offers stringent protection within Europe to bird species listed in its Annex II. In Flanders, the Royal Decree of 1981 protects all Annex II species. A special agreement under the Bonn Convention also provides special protection to a number of migratory species (Agreement on the Conservation of African-Eurasian Migratory Waterbirds, 1996).

2.3. Amphibians and reptiles

Flanders hosts 14 indigenous species of amphibians and five species of reptiles. The green frog synklepton of three closely related species is counted as one species. One species of each group became extinct in the second part of the twentieth century. The yellow-bellied toad (*Bombina variegata*) has been absent in Flanders since 1984, whereas no natural populations of the grass snake (*Natrix natrix*) have been found between 1975 and 1994. There is currently one re-introduced population of the grass snake.

Six other species (four amphibians and two reptiles) show a clear decrease in their distribution range and are now part of the Red List: the common midwife toad (*Alytes obstetricans*), common spadefoot (*Pelobates fuscus*), common tree frog (*Hyla arborea*), fire salamander (*Salamandra salamandra*), adder (*Vipera berus*) and smooth snake (*Coronella austriaca*). Four amphibian and two reptile species, fairly common or rare, are listed as susceptible: the natterjack (*Bufo calamita*), moor frog (*Rana arvalis*), northern crested newt (*Triturus cristatus*), palmate newt (*T. helveticus*), slow worm (*Anguis fragilis*) and viviparous lizard (*Lacerta vivipara*). Only five species, all amphibians, are not threatened for the moment: the Alpine newt (*T. alpestris*), common newt (*T. vulgaris*), common toad (*Bufo bufo*), common frog (*Rana temporaria*) and edible frog (*Rana esculenta* synklepton).

The distribution range of amphibians and reptiles is decreasing for most of the native species (BAUWENS & CLAUS 1996). The decline is caused by a series of factors that vary as a function of the location and the species, the most important ones being the loss of natural biotopes, habitat fragmentation, acidification, eutrophication and desiccation.

Most amphibians and reptiles are very sensitive to habitat loss. Amphibian survival is directly linked to the presence of suitable 'wet' and 'dry' biotopes, with a good linkage between both. Native snakes divide their activities between summer and winter habitats. When one of these disappears, or when the migration between the two becomes impossible, the population will react negatively. It can lead to the extinction of the population if no suitable alternatives can be found in the immediate neighbourhood.

The disappearance of linear landscape elements and the creation of migration barriers (roads, cultivated land, etc.) lead to the fragmentation of habitats. This can result in smaller populations, which face risks of extinction even if the habitats are appropriate.

The acidification of surface waters has a negative effect on the reproductive success of most species of amphibians. When the degree of acidity drops below a threshold value, different for each species, normal egg development is hindered. This problem is very acute for species living in relatively acid waters, like *Triturus helveticus*, *Bufo calamita* and *Rana arvalis*.

Eutrophication of surface waters leads to algal blooms. The consequent shortage of oxygen in the water can result in an increased mortality of amphibian eggs and larvae. Eutrophication also influences the terrestrial habitats of amphibians and reptiles. The loss of nutrient-poor habitats is only one example.

The lowering of the water table level, following the pumping of groundwater for drinking water and industrial purposes, results in dry reproduction pools early in the reproductive season. Massive mortality of larvae has been observed as a logic consequence.

Species diversity for amphibians and reptiles is highest in the eastern part of Flanders. Other species-rich areas are the valley of the upper Scheldt, the forest complexes of the Brabant hills (Hallerbos, Meerdaalwoud, Rodebos), the valley of the Demer and the area of Voeren.

Introductions of non-native amphibian and reptile species as pets or for ornamental purposes in garden ponds are very common in Belgium. In Flanders, the marsh frog (*Rana ridibunda*) and American bullfrog (*R. catesbeiana*) have already built reproductive populations in the river valleys of the Scheldt, Dijle and Grote Nete. The marsh frog lives in strong ecological competition with the indigenous edible frog and also threatens the populations of native species at the genetic level. The influence of the bullfrog on European green frogs remains speculative and needs to be further investigated. The North American red-eared terrapin (*Trachemys scripta elegans*) is probably the most commonly kept exotic turtle. Feral populations are now found in numerous ponds, rivers and canals throughout the region as the result of the dumping or escaping of pet turtles (JOORIS 2002). Largest concentrations are found in the neighbourhood of large cities and tourist regions (coastal area).

Legal protection and international importance

The Royal Decree on Nature Conservation in Flanders (1980) strictly protects all native amphibians and reptiles. The only exceptions are the edible frog and the common frog. They can be caught and killed in private rearing ponds if the owner has a special license.

The Bern Convention legally protects indigenous species. The following species listed in its Annex II are found in Belgium: the yellow-bellied toad, common midwife toad, spadefoot and natterjack as well as the common tree frog, moor frog, northern crested newt and smooth snake. Specific laws have to guarantee the protection of Annex II species and of their environment. Annex III lists all other native species, for which special protection measures need to be taken. These protection measures are included in the Flemish Decree on Nature Conservation of 1997. Two species found in Belgium are listed in Annex II of the EU Habitats Directive: the northern crested newt and yellow-bellied toad. For amphibians and reptiles, Annex IV of the Habitats Directive is identical to Annex II of the Bern Convention.

The legal protection of amphibians and reptiles is well regulated in Flanders but this is not enough to prevent the extinction of some species. Additional measurements and management of the species are necessary.

2.4. *Fresh and brackish water fish*

Seventy-nine species of fish can be found in Flanders: 40 species are defined as freshwater fish while the other 39 species are considered as brackish water fish or marine fish temporarily migrating to brackish or fresh water. A species is called a freshwater species when it remains for the largest part of its life cycle in fresh water. In addition to those 79 fish species, two freshwater species recently became extinct while five other species are caught only occasionally and do not reproduce anymore in Flanders. Another six species have not been seen for more than 20 years. The highest diversity in species is found in the eastern part of Flanders (Kempen), with local hotspots in other areas (e.g. polders region).

While all brackish and seawater fish are native, this is only the case for 26 out of 45 species of freshwater fish. The other 19 species have their original distribution range in Eastern Europe or were accidentally introduced from North America and Asia. VANDELANNOOTE & COECK (1998) compared the fish fauna in 457 sections (100 m long) of brooks and rivers in Flanders during 1983-87 and 1994-97. All parts of the watercourses were sampled. During both periods, an average of 2.9 fish species was found in each section. When both inventories were compared, the number of species stayed constant in 154 sections, decreased in 179 sections and increased in 124 sections. The average decrease (2.3 species) was smaller than the average increase (3.2 species). Water treatment can lead to a spectacular increase of the fish stock, especially when water treatment is carried out in a basin with a reasonable fish stock and without migration obstructions. However, positive results in some areas are obscured by the loss of fish life in other areas. The number of brooks with no fish life increased significantly. Pollution is the source of the problem most of the time, but the decreased input of water due to land consolidation is a major cause especially in the upper part of the watercourses.

A thorough literature study recorded the introduction of 35 fish species belonging to nine families in Flanders since 1800. Recent introduction of fish species has been characterised by two peaks: first, at the end of the 19th century for sport and ornamental purposes and later on around the 1960s for aquaculture and angling. About 13 non-indigenous species are currently encountered in Flemish surface waters, of which seven have become established (ANSEEUW *et al.* 2002). Established American exotic species, like the eastern mudminnow (*Umbra pygmaea*), pumpkinseed (*Lepomis gibbosus*) and brown bullhead (*Ameiurus nebulosus*) do not spread spectacularly anymore. Since the 1990s, a new Asian species, the stone moroko (*Pseudorasbora parva*), has established reproductive populations and spread very quickly over the whole Flemish territory.

Monitoring of the fish fauna in the Scheldt estuary since 1991 has led to the observation of eight introduced fish species. All marine species recorded in the estuary arrived from North America while all freshwater species arrived from Eastern Europe and Asia. The presence of marine species is probably due to transport via ballast water of ships docking at the port of Antwerp. Freshwater species almost invariably occur following deliberate introductions (STEVENS *et al.* 2002).

The opening of the Main-Danube canal in 1992, linking the Danube to the Main and indirectly to the Rhine, might lead to the arrival of new eastern European species in Belgium, as it has been observed already in the Netherlands (ANSEEUW *et al.* 2002).

Legal protection and international importance

In Flanders, 12 fish species enjoy total protection through the freshwater fisheries legislation (1992). Other species receive a more limited protection through minimal catch size (15 species), discontinued fishing periods and a ban on specific fishing gear.

Six species still present in Flanders are listed in Annex II of the EU Habitats Directive: the brook lamprey (*Lampetra planeri*), river lamprey (*L. fluviatilis*), bitterling (*Rhodeus sericeus*), spined loach (*Cobitis taenia taenia*), weatherfish (*Misgurnus fossilis*) and bullhead (*Cottus gobio*). Annex II of the Habitats Directive lists six species extinct in Flanders: sea lamprey (*Petromyzon marinus*), salmon (*Salmo salar*), allis shad (*Alosa alosa*), twaite shad (*Alosa fallax*), houting (*Coregonus oxyrinchus*) and Atlantic sturgeon (*Acipenser sturio*). Annex V of the Habitats Directive lists species still present in Flanders such as the river lamprey and barbel (*Barbus barbus*) and extinct species like the salmon, allis shad, twaite shad, houting, Atlantic sturgeon and grayling (*Thymallus thymallus*).

The Red List of worldwide threatened species (IUCN 1996) lists five species present in Flanders: river lamprey, brook lamprey, weatherfish, crucian carp (*Carassius carassius*) and smelt (*Osmerus eperlanus*). It also lists four species presently extinct: Atlantic sturgeon, allis shad, twaite shad and houting.

2.5. Invertebrates

2.5.1. Butterflies

In Flanders, 89 species of butterflies (Lepidoptera, Rhopalocera) have been observed since the middle of the 19th century. Sixty-four species are considered as resident butterflies, four species are regular migrating butterflies and 21 species are considered as erratic and/or introduced. A Red List of butterflies in Flanders was established in 1996 (MAES & VAN DYCK 1996). Thirty-seven species have been included in the list: 19 of those are regarded as extinct (MAES & VAN DYCK 2001) and one-third are more or less threatened (eight critically endangered, six endangered and seven vulnerable species). Of the remaining species, 5% are rare and 35% are not threatened. There is not enough information available for the classification of one species. Currently, the areas richest in butterflies are found on the sandy soils in northeastern Flanders (Kempen), where heathlands, nutrient-poor grasslands and forested areas still co-occur.

Butterfly diversity in Flanders declined strongly during the 20th century, with 44 species showing a negative trend and only 13 a positive one. The proportion of extinct species is amongst the highest in Europe. MAES & VAN DYCK (2001) calculated that the average extinction rate was 0.95 species per five-year period during the 20th century but with very high differences between 1901-1950 (0.20 species per five-year period) and 1951-2000 (1.70 species per five-year period), indicating that the extinction rate increased more than eight fold during the second half of the 20th century.

Furthermore, about 90% of the former hot spots (both diversity and Red List species hot spots) have been lost despite the strong increase in recording intensity. Causes vary from one area to another. Butterfly species typical of open woodlands, grasslands and heathlands in forest clearings have disappeared from forested areas around Brussels following economic exploitation of the woodlands or the lack of appropriate conservation management. In the coastal dune areas, increased urbanisation for tourism led to the disappearance of semi-natural grasslands and to the cessation of grazing in several of the remaining plots, reducing the availability of early successional habitats favourable to many species. In northeastern Flanders, nutrient-poor grasslands and heathlands were transformed into arable lands, conifer plantations or other land uses (MAES & VAN DYCK 2001).

Species restricted to oligotrophic habitats particularly suffer from population decline, compared to mobile species and species from eutrophic habitats. The limited dispersal rate makes it very difficult for sedentary species to find suitable new habitat patches once their original habitat has been destroyed. Species of oligotrophic habitats were found chiefly in traditionally managed agricultural landscapes. The intensification of agriculture during the second part of the twentieth century has led to massive emissions of nitrogen and phosphorus: 201,451 tons of nitrogen and 22,649 tons of phosphorus have been cited for 2001 (VAN STEERTEGEM 2002). This eutrophication of oligotrophic grasslands has had for consequence the disappearance of the natural habitats of several species of butterflies and, of course, of the species themselves.

Policy-makers are well aware of the existing problems. The development of the Flemish Ecological Network aims to create an ecological network of large nature units (total area: 125,000 ha), large nature development units (total area: 150,000 ha) and ecological corridors. However, populations of some Red List species (*Thecla betulae*, *Satyrium w-album*, *Cupido minimus*, *Aricia agestis*, *Polyommatus semiargus* and *Melitaea cinxia*) are mainly situated outside the preliminary defined networks and need additional protection measures (MAES & VAN DYCK 2001).

Legal protection and international importance

In Flanders, 13 species of butterflies are legally protected. Three legal instruments play an important role in the protection of butterflies: the Royal Decree on Nature Conservation (1980) and two international instruments, the Bonn and Bern Conventions. A few butterflies are also listed in the EU Habitats Directive.

The Alcon blue (*Maculinea alcon*) is the only species with legal protection status under Flemish law still present in Flanders. Three other protected species are now considered as extinct: the false ringlet (*Coenonympha oedippus*) since 1912, the marsh fritillary (*Euphydryas aurinia*) since 1959 and the scarce large blue (*Maculinea teleius*) since 1980. Some of the protected species have never been resident butterflies in Flanders: the Arran brown (*Erebia ligea*), large copper (*Lycaena dispar*), dusky large blue (*Maculinea nausithous*), scarce swallowtail (*Iphiclides podalirius*), large blue (*Maculinea arion*), woodland brown (*Lopinga achine*) and scarce fritillary (*Euphydryas maturna*). The monarch (*Danaus plexippus*) is occasionally observed as vagrant.

Five butterflies (once) present in Flanders are mentioned in the proposed European Red List of Butterflies (VAN SWAAY *et al.* 1997) in the category 'vulnerable': the scarce large blue, Alcon blue, marsh fritillary, large heath (*Coenonympha tullia*) and scarce heath (*C. hero*). Three of those species became extinct many years ago. Only the large heath, with probably only one population present or recently extinct, and the Alcon blue are still found in Flanders. The World Red List of threatened species (IUCN 1996) lists two species in the category 'low risk/near threatened' with a dispersal in Flanders: the Alcon blue and scarce large blue. Species threatened at the international level are only found in the northeastern part of Flanders.

2.5.2. Carabid beetles

Since the middle of the 19th century, 368 species of carabid beetles (ground and tiger beetles) have been observed in Flanders. Of these, 352 are indigenous while 16 are considered as vagrants. Carabid beetles occupy all types of terrestrial habitats, whether natural, semi-natural or heavily influenced by man (e.g. fields, pastures or urban areas). These characteristics, together with a high degree of habitat preference, make them excellent indicators of habitat quality. About 28% of the native species are listed on the Red List of threatened species for Flanders: 32 extinct, 20 critically endangered, 21 endangered and 25 vulnerable species. Another 91 species are rare, seven are data deficient and 144 are not threatened.

Table 2. Percentage of threatened species of carabid beetles (Extinct, Critically endangered, Endangered, Vulnerable, Rare and Indeterminate) per habitat in Flanders (after DESENDER *et al.* 1995).

Habitat	% threatened
Chalk grasslands, stony slopes and other xerothermic habitats	96,43
Dunes and beaches	95,45
Salt marshes	88,00
River and rivulet banks	84,62
Heathland and bogs	80,00
Woodland (stenotopic species)	74,29
Dry grasslands and other habitats on dry sandy soil (stenotopic species)	62,32
Oligotrophic standing water	55,56
Moist grasslands	43,75
Woodland (eurytopic species)	43,48
Ruderal sites and arable land	40,91
Marshes and eutrophic standing water	40,48
Dry habitats (eurytopic species)	5,41
Moist habitats (eurytopic species)	3,45

As mentioned earlier, the protection of species is extremely difficult without the protection of their natural habitats. Table 2 shows clearly that chalk grasslands and stony slopes, dunes and beaches, salt marshes, river and rivulet banks, heathland and bogs, woodland, dry grasslands and other habitats on dry sandy soils are the most threatened habitats for carabid beetles. Those habitats need to be protected and managed properly in order to protect their typical fauna and flora.

Legal protection and international importance

In Flanders, all species of the family Cicindelidae (tiger beetles, four species) and of the genera *Carabus* (15 species) and *Calosoma* (four species) are legally protected by the Royal Decree on Nature Conservation. Maelfait *et al.* (1992) showed that the Flemish legislation is outdated and that the protected groups are not representative of currently strongly endangered carabid beetles in Flanders. A re-evaluation of the list would be desirable. Protection should target species rather than whole genera, in which some species do not require any protected status.

No ground beetles present in Flanders are mentioned in the annexes of the Bern Convention or in the EU Habitats Directive. The International Red List of threatened species (IUCN 1996) lists one species (*Carabus intricatus*) probably extinct in Flanders.

2.5.3. Grasshoppers and crickets (Orthoptera)

A provisional Red List for Flanders is based on the temporary atlas of the Belgian grasshoppers and crickets (Decleer *et al.* 2000). So far, 39 species of grasshoppers and crickets have been found in Flanders. Five (13%) of them are extinct, whereas 13 species can be considered as minimally vulnerable, eight species as rare and 12 species as not threatened. Not enough information is available to place one species in a specific category.

The highest number of species is found in the eastern part of the region (Kempen), where also the majority of Red List species are located (40% of the occurring species). Despite its severe deterioration, the coastal dune landscape also accommodates important metapopulations of several species, with a total diversity of about 20 species (Decleer & Devriese 1992).

Most of the Red List species are typical of rather dry biotopes, such as unfertilised dry grasslands and heathlands, where four out of five extinct grasshopper species used to be found (*Decticus verrucivorus*, *Gampsocleis glabra*, *Tetrix bipunctata* and *Psophus stridulus*) and where it is still possible to come across two species threatened with extinction (*Stenobothrus lineatus* and *Gomphocerripus rufus*) and one vulnerable species (*Chorthippus mollis*). Six Red List species of grasshoppers are typical for humid grasslands and heath: one extinct species (*Locusta migratoria*), one threatened with extinction (*Tetrix tenuicornis*), and four vulnerable species (*Tetrix ceperoi*, *Stethophyma grossum*, *Omocestus viridulus* and *Chorthippus montanus*).

Legal protection and international importance

The Royal Decree on Nature Conservation lists only two Orthoptera: *Locusta viridissima* and *Oedipoda caerulescens*. None of the grasshoppers and crickets found in Flanders are listed in the annexes of the Bern Convention or the EU Habitats Directive.

2.5.4. Dragonflies

In Flanders, 65 species of dragonflies have been observed out of a total of 69 species recorded in Belgium. Only 52 species were observed during the period 1990-95. Of the 65 species mentioned above, four species are only known as vagrant. Three of these species, with several populations in Flanders, originate from the Mediterranean region.

Of the original dragonfly species of Flanders, 16% are extinct, 34% are more or less threatened, 10% are rare, 4% are not well known and 36% can be considered as not threatened (DE KNIJF & ANSELIN 1996). The occurrence of Red List species shows that the most diverse dragonfly fauna is located in the central and eastern part of Flanders (province Antwerp and Limburg). Nevertheless, they occur over the whole Flemish territory. Species threatened with extinction require high quality habitats and their distribution is almost limited to the provinces Antwerp and Limburg, where relatively large and undisturbed nature entities including brook valleys and several oligotrophic pools can still be found. The Red List species labelled as threatened are found in the same area. Species found outside those provinces all correspond to *Coenagrion pulchellum*, *Cordulegaster boltonii* and *Sympecma fusca*. The species belonging to the Red List category vulnerable are more widespread compared with the former two Red List categories. The distribution of the species belonging to the Red List category rare is historically limited to the provinces Antwerp and Limburg, exception made for *Calopteryx splendens*.

During the past 15 years, eight species of dragonflies with a 'normal' distribution in the south of Belgium were observed more frequently: *Lestes barbarus*, *Coenagrion scitulum*, *Aeshna affinis*, *Anax parthenope*, *Orthetrum brunneum*, *Crocothemis erythraea*, *Sympetrum meridionale* and *Sympetrum fonscolombii*. Up to the beginning of the 1990s, those species were observed occasionally, but they are now present every year in Flanders, including several observations of reproduction.

Legal protection and international importance

The Royal Decree on Nature Conservation protects all dragonfly species. Three species extinct in Flanders are listed on the Red List of species threatened at the global level (IUCN 1996). The species mentioned in the annexes of the Bern Convention and of the EU Habitats Directive are no longer present in Flanders.

2.5.5. Dolichopodid flies

In contrast to well-known and frequently collected invertebrate groups such as butterflies, dragonflies, ground beetles and spiders, most dipteran families including long-legged or dolichopodid flies are quite obscure, even to most entomologists. Nevertheless, dolichopodid flies show all the features that make this family especially suitable for bio-indicatory purposes (high species richness, distinct habitat affinity, high sensitivity to environmental alterations). POLLET (2000) states that a total of 295 species has been established in Belgium with certainty, 260 of which occur in Flanders. A complete species list is given by the author. Of these species, 22 are extinct in Flanders, 10 critically endangered, 14 endangered, 16 vulnerable, 86 susceptible or rare, 39 insufficiently known and 73 are considered safe/at low risk.

The dolichopodid fauna of salt marshes is by far the most threatened in Flanders with 68% of threatened and/or rare species. In reed marshes and other marshlands, moderately to very humid woodlands, coastal dunes and humid heathlands, threatened and rare species constitute one-third or more of the entire dolichopodid fauna, which makes these habitats among the most valuable in Flanders. Nearly all threatened and rare salt marsh species are typical for this habitat, whereas characteristic heathland and coastal dune species make up about half of the threatened and/or rare species in these habitats.

Legal protection and international importance

Neither the European, Belgian nor Flemish legislation foresee the protection of dolichopodid flies.

2.5.6. Spiders

The Red List of spiders in Flanders (MAELFAIT *et al.*, in preparation) mentions 604 species out of about 700 species for Belgium. About half of the 592 species are not threatened, 9% are threatened with extinction, 14% are threatened and 10% are vulnerable. Another 10% of the species are rare, whereas 1% is extinct. A Red List for the family Lycosidae was prepared by ALDERWEIRELDT & MAELFAIT (1992).

Because of their numerousness and their occurrence in all biotopes, spiders are excellent organisms to measure the quality of the environment (MAELFAIT & BAERT 1997). With the exception of the water spider (*Argyroneta aquatica*), all spiders are terrestrial and occupy a vast range of biotopes. The species most at risk are found in the sandy habitats of eastern Flanders (Kempen) and in the coastal dune areas.

The wasp spider (*Argiope bruennichi*) appeared in Belgium for the first time around 1870. The spider's distribution has slowly extended northwards and, since the 1980s, has reached its most northern distribution in Flanders. Its expansion occurs through the valleys of the main waterways and their tributaries, as is typical of southern species progressing northwards. Although its opportunistic behaviour of colonising man-made habitats has enabled its progression, the species remains vulnerable due to the unstable characteristics of its habitats (PUTS 1989).

Legal protection and international importance

The Royal Decree on Nature Conservation protects four species of spiders in Flanders: the wasp spider (*Argiope bruennichi*), purse-web spider (*Atypus affinis*), raft spider (*Dolomedes fimbriatus*) and water spider (*A. aquatica*). The latter three species belong respectively to the Red List categories vulnerable, critically endangered and vulnerable. There are currently no native spiders listed in the annexes of the Bern Convention and EU Habitats Directive.

2.6. *Higher plants*

Historically, 1,416 species of higher plants belonging to the wild flora have been observed in Flanders (BIESBROUCK *et al.* 2001). Of these, 1,039 species belong to the original native flora, while 358 were introduced by man and became naturalised (VERLOOVE 2002). Nineteen species have an uncertain status. Of the exotic species, 115 were introduced after the major voyages of discovery. Almost 6% of the higher plants are extinct in Flanders, a quarter are more or less threatened, 15% are rare and a little more than half of the species are momentarily not threatened.

Hot spots of Red List higher plant species can be divided into 5 eco-regions: coastal dunes, polders, sandy region, loamy region and Kempen. Major hot spots in the coastal dunes area can be found in the western part of this region, such as in the Westhoek (De Panne) nature reserve and the Ter Yde-Groenendijk (Oostduinkerke) dune complex. Important biotopes for higher plants are humid dune valleys, unfertilised dry grasslands of decalcified dunes and scrubs on calcareous soils. In the polders, important hot spots can be found in unfertilised wet (salty) grasslands (e.g. Lissewegen), coves (e.g. Assenede, Sint-Laureins) and salt marshes along the lower part of the river Scheldt. In the sandy region, a number of sites contain many Red List species: Vloetemveld en Gulkse putten (Wingene) and the valleys of the Moervaart and Dam. Important flora elements are found in unfertilised wet pioneer vegetations. In the loamy region, hot spots are found especially in thickets and forests (e.g. Sonian Forest, Vlaamse Ardennen, Hallerbos, etc.). Large numbers of Red List species are also found in species-rich permanent pastures (e.g. Voeren). In the Kempen, the most important hot spots can be found in wet heaths, raised bogs, degraded heaths and some grasslands.

Higher plants are often introduced from other regions in the world. Some of the exotic species become problematic because of their fast spread. Examples of invasive higher plant species are the black cherry (*Prunus serotina*), water pennywort (*Hydrocotyle ranunculoides*), Japanese knotweed (*Polygonum cuspidatum*), common waterweed (*Elodea canadensis*), and common cordgrass (*Spartina angelica*).

Legal protection and international importance

Legal protection exists for 79 species of the Flemish native higher plants (DE PUE *et al.* 1997). The legislation concerning protected plants dates back to 1976 (Royal Decree on the protection of wild plant species, based on the Law on Nature Conservation of 1973). The figures given below only concern native species. However, a number of legally protected Belgian species were never found in the wild in Flanders. The legislation uses three categories:

- category A contains 38 species. Those species enjoy total protection except in gardens and parks. Picking, transplanting, damaging, trading or transporting are forbidden (also in dried condition);
- category B contains 36 species. Those species enjoy protection for subterranean parts. Digging out, transplanting, damaging, trading or transporting of those parts are forbidden (also in dried condition);
- category C contains 5 species. The complete species is protected against harvesting, transporting or exporting for commercial purposes (also in dried condition).

At the European level, species of Annex I of the Bern Convention are protected by the same measures as the species that enjoy complete protection in Flanders (category A). It concerns three species for Flanders: the creeping marshwort (*Apium repens*), fen orchid (*Liparis loeselii*), and floating water-plantain (*Luronium natans*). As far as species of Annex II of the

EU Habitats Directive are concerned, Flanders has to designate and protect areas in such a way that the existing populations of those species can survive. For Flanders, they are the same species as those listed in Annex I of the Bern Convention.

2.7. *Mosses*

Around 500 species of mosses are found in Flanders. Because of the lack of a reference situation, it is extremely difficult to place existing species into Red List categories. Based on best professional judgement, HOFFMANN (1999) states that a quarter of moss species in Flanders are more or less threatened, a quarter are declining and half are not threatened.

Important areas for the biodiversity of mosses are the lake areas in the central part of the Province of Limburg, specifically 'De Maten' and 'Het Wik' in Genk, 'Het Groot Schietveld' in Brasschaat, the freshwater part of the intertidal area of the river Scheldt and the Flemish coastal dunes. Forested areas in the centre of Flanders (Meerdaalwoud, Zoniënwoud, Walenbos, etc.) are also noteworthy moss habitats, as well as the fens and marshes in the eastern part of the region (Kempen).

Legal protection and international importance

All *Sphagnum* species are protected under Annex C of the 1976 Royal Decree on the protection of wild plant species.

2.8. *Lichens*

The description of the situation of lichens is currently under preparation. Based on observations in the field, herbarium material and literature sources, the maximum number of observed lichens in Flanders is estimated at 338 species. Fifty of these species can now be considered as extinct. The major part of the extinct species has not been seen since the beginning of the twentieth century. If the species found in Brabant are taken off this estimation (it is not sure that the species are found in the Flemish part of the district), the total number of species found in Flanders decreases to 308. Of those species, 35 are extinct. This brings the present number of lichen species in Flanders to 273.

A Red List for the lichens of Flanders does not exist at present. Broad repartition into rarity categories indicate that about half of the lichen flora is threatened to some extent (from very rare to extremely rare), about 60 species are rare and the rest is common to very common. This latter category only represents 11% of the Flemish lichens.

A general requirement for lichens is the absence of nutrients. In comparison with mosses and higher plants, lichens are very weak competitors and therefore mainly occur in locations where mosses and higher plants have great difficulties to establish stable populations. This explains why they prefer dry heaths, dry calcareous grasslands, unfertilised dry grasslands of decalcified dunes and bare forests.

As epiphytic lichens prefer areas with a low degree of air pollution, hot spots for those species are found in the coastal dune areas, polders and large forests of the loamy region.

Hot spots for stone-growing lichens mainly correspond to old artificial stone substrates such as found in old churches and graveyards. Because of the buffering effect of the substratum, these species suffer less from the acidic effect of air pollution.

Legal protection and international importance

Only the species of the subgenus *Cladina* (reindeer moss) are protected against harvesting, transporting and exporting for commercial purposes under the Flemish law (Annex C of the 1976 Royal Decree on the protection of wild plant species). The EU Habitats Directive protects none of the lichens present in Flanders.

2.9. *Macrofungi*

In 1999, WALLEYN & VERBEKEN produced a documented Red List of macrofungi in Flanders. Due to the very large number of species and because sufficient information is not available for a number of groups, the authors only used groups for which they had relevant information to carry out quantitative judgements. These groups consist of 552 native species observed in Flanders. It is estimated that they correspond to about 20% of the total species of macrofungi. In the groups studied, 8% of the species are currently extinct (43 species) and 47% of the species still present are on the Red List (46 threatened with extinction, 66 threatened, 118 vulnerable, 35 rare and 32 in decline and probably threatened because they are found in rare to very rare biotopes). This means that only one-third of the macrofungi species can be considered as not threatened.

WALLEYN & VERBEKEN (1999) also describe trends and threats in relation to macrofungi: the decline seems to be higher within ectomycorrhizal species (only 32% of species are considered as safe) than within saprophytic species (40% are safe). The decline of the mycoflora is a widespread phenomenon, with eutrophication probably being the main underlying cause. Species of poor grasslands, marshes, peat bogs, wet heathlands, coastal dunes and most of the forest types are particularly threatened. Numerous ectomycorrhizal fungi appear to be banished from forest areas to poor grassy roadsides or parks. The adequate management of these mycorrhizal refuges is necessary for the conservation of threatened species. Conservation actions include: the increase in the volume of dead wood, the protection and appropriate management of sites with a high number of Red List species, a more frequent burning of logging waste *in-situ*, the plantation of indigenous tree species rather than exotic ones, and the conservation and/or development of endangered habitats. A significant reduction of soil eutrophication is of paramount importance.

Legal protection and international importance

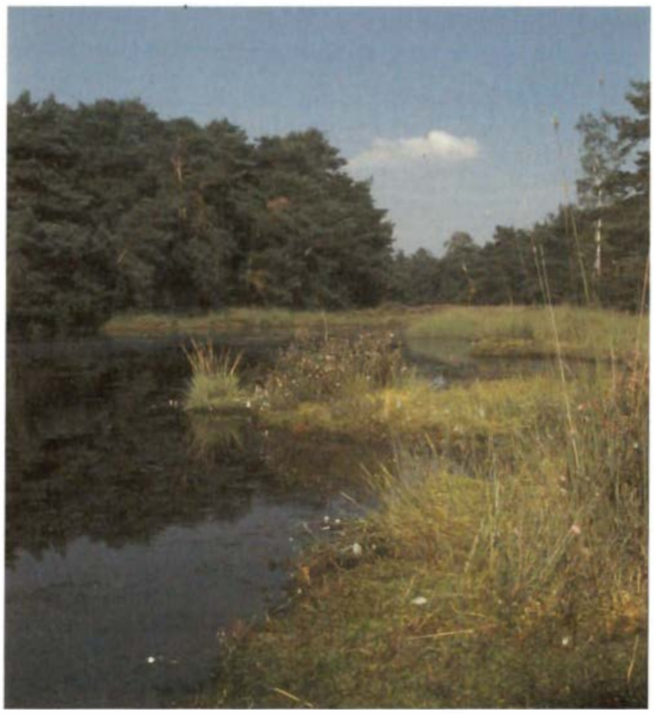
None of the Red List macrofungus species in Flanders are protected. The only protection macrofungi enjoy in Flanders is the ban to harvest them in most nature reserves and areas listed in the Flemish Forest Decree. At the European level, there exists a European list that is not connected to any legislative instrument.

3. Ecosystems and areas of high biological value

The description of the Flemish biotopes is based on the Biological Evaluation Map for Flanders and on derived land use maps. Table 3 summarises available information for the main biotopes found in Flanders. As a region is often described as a complex of mapping units, it is difficult to give a precise estimation of the surface area of a biotope and data are presented as 'minimal area' and 'maximal area'.

Table 3. Surface area of the main (semi-)natural biotopes in Flanders (after Van Landuyt *et al.* 1999).

Biotope	Minimal area (ha)	Maximal area (ha)
Heathlands and fens	9,800	18,400
Marshes	5,800	15,400
Wetlands	8,925	11,985
Dunes	1,440	2,940
Semi-natural grasslands	4,640	8,870
Species-rich grasslands	9,270	11,450
Grasslands with disseminated biological value	29,050	42,630
Pioneer vegetation	3,750	6,610
Scrubs	585	985
Mesophilic forests	22,550	56,410



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Forest fen with *Sphagnum* and purple moor-grass, *Molinia caerulea*. Koersel, Province of Limburg (photograph by J. Packet, Institute of Nature Conservation).

3.1. *Heathlands and fens*

Heathlands are ecosystems developing on poor, usually acid, sandy or gravely soils in lowlands while fens are ecosystems developing on alkaline, neutral or slightly acid wet peat. In Flanders, biotopes belonging to these groups include oligotrophic to mesotrophic waters, dry heath, Atlantic wet heath (*Ericetum tetralicis*), sometimes with species of raised bogs, dry heath with *Vaccinium* (*Calluno-Vaccinietum*), heath of raised bogs (*Vaccinio-Ericetum*), sometimes with dominance of *Molinia caerulea*, several types of degraded heath, inland drift sands, active raised bogs, degraded raised bogs, species-rich *Nardus* grasslands (*Violion caninae*) and unfertilised dry grasslands (*Thero-Airion*).

Heathlands and fens together cover 0.7 to 1.4% (9,800-18,400 ha) of the total surface of Flanders. They are mostly found in the northeastern part of the region (Kempen). Heathlands in East and West Flanders are particular, as they form an intermediate variant of the North Atlantic heath (from Kempen to North Germany) and the Atlantic heath (England-Brittany). Nowadays, the area of this heathland is very reduced and only small remnants still exist. More than half of the surface area of heathlands and fens disappeared during the past decades, following the lack of management (i.e. spontaneous forest development) or deforestation. Fens also suffered heavily from atmospheric pollution and eutrophication.

Although heathlands host a relatively low number of plant and vertebrate species, they are of crucial importance for invertebrates. They also accommodate the greatest number of Red List species, in particular for plants and invertebrates. For example, 11 species of butterflies are found in Flemish heathlands, three of these are extinct while the other eight are threatened.

Legal protection and international importance

Heathlands and fens are now better protected, thanks to their status as Special Areas of Conservation under the EU Habitats Directive and their inclusion in the Flemish Ecological Network. Appropriate management practices start to improve the state of flora and fauna in the large heathlands. Management of small heathlands and fens remains inadequate, especially when these are surrounded by agricultural land. Small areas should be better isolated from the influences of intensive agriculture, especially regarding drainage and fertilisation. Special interventions in the water systems are required and buffer zones with less intensive agricultural activities should be established around the heathlands.

3.2. *Marshes and wetlands*

Marshes are typical plant communities developing on wet but not peaty soil. They include herbaceous vegetations as well as marsh forests and form a rather heterogeneous group of biotopes, of which the main ones are reedlands (*Phragmition*), vegetations of *Scirpus maritimus*, vegetations of *Cladium mariscus*, tall sedge vegetations (*Magnocaricion*), quaking fens, acid fens (*Caricion curto-nigrae*), alkaline fens (*Caricion davallianae*), dune slack calcareous fens and moist tall herbaceous vegetation with *Filipendula ulmaria*.

Marshes cover only 0.5 to 1.1% of the total surface of Flanders. They consist mostly of reedland, moist tall herbaceous vegetation with *Filipendula ulmaria* and mesotrophic ash-alder wood. Other biotopes occupy very limited surfaces (max. 300-600 ha). Marshes are distributed all over the Flemish territory, mostly in brook and river valleys. Alkaline fens are only found in the Kempen region.

Recent trends in the distribution of marshes and wetlands are not available, but the comparison between historical maps and the current situation shows that they have strongly regressed. Their surface area is now highly fragmented. The main regression causes include drainage and changing land uses (including reforestation, deforestation and transformation into grasslands). Most types of marshes disappeared almost completely. Tall herbaceous vegetations with *Filipendula ulmaria* are rare to extremely rare in Flanders while reedland is rare to very rare.

Their fauna and flora are very rich and specific. Many threatened plant species are found in tall sedge vegetation, quaking fens, acid and alkaline fens. About half of Flemish Red List dragonflies (14 species), five of which are already extinct, are characteristic of marshes and wetlands. For butterflies, the situation is not better. Out of a total of eight species found in marshy areas, six are currently extinct in Flanders and two are threatened.

The conservation of marshes and wetlands is only possible through the strict protection of a number of rare habitat types. Marshes play a crucial role for water purification and storage as well as nature conservation. This is particularly the case in buffer zones and verges of waterways or in flood plains. Thus, the amelioration of water quality, in particular the reduction of pesticides and nutrients, is a primary condition for the conservation of biodiversity in those areas.

Other wetlands occupy only 0.4 to 0.6% (5,260-7,970 ha) of the Flemish territory. Eutrophic waters occupy the largest surface (3,240-5,130 ha) and are concentrated in the valleys of the rivers Scheldt, Demer, Dijle, Senne, Nete and in the 'Vijvergebied Midden-Limburg'.

Biotopes typical for salt and brackish water are only found along the coast, the upper part of the river Scheldt, in the creek area of the Province of East Flanders and in the polders. All biotopes typical for salt and brackish water are extremely rare and are recognised of international importance.

Legal protection and international importance

Many marsh and wetland areas are now protected under the EU Birds and Habitats Directives or under international conventions. The Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention, 1971) has put forward a number of criteria in order to determine whether a wetland area is of international importance to water birds. Two of the most important criteria are based on bird numbers. The first criterion requires the regular presence of at least 1% of all individuals of a population or subpopulation. The second criterion requires the regular presence of at least 20,000 water birds.

The first designation of Belgian Ramsar sites in 1984 was based upon KUIJKEN (1972). Following information from the Flemish Institute of Nature Conservation, SCOTT & ROSE

(1996) gave an overview of all areas in Flanders where the 1% criterion is reached from 1991/92 to 1995/96.

Four sites in Flanders are currently protected under the Ramsar Convention: 'Het Zwin' and its surroundings (530 ha), 'De Blankaart en de IJzerbroeken' (2,460 ha), 'De Schorren van de Beneden-Zeeschelde' (398 ha), and 'Kalmthoutse Heide' (2,183 ha). The coastal shallows 'Vlaamse Banken' in the North Sea (1,700 ha) belong to the federal competence. Three more sites have been proposed but have not officially been designated yet.

Flanders accommodates more than 5% of the total population of seven species, which makes it an area of international importance for those species: the pink-footed goose, greater white-fronted goose, Eurasian wigeon, gadwall, common teal, northern shoveler and common pochard. The Flemish coastal polders accommodate among others more than 90% of the total Spitsbergen population of pink-footed goose each winter.

3.3. Grasslands

The group of biotopes referred to as 'historically permanent grasslands' include semi-natural grasslands, species-rich grasslands (including relics of semi-natural grasslands) and grasslands with disseminated biological value.

Semi-natural grasslands include dry calcareous grasslands (*Brometalia erecti*), grasslands on decalcified dunes, moderately fertilised wet meadows (*Calthion*), unfertilised wet meadows (*Molinion caeruleae*), mesophilic hay meadows (*Arrhenatherion elatioris*) and the moderately fertilised wet meadows dominated by *Juncus*. Species-rich grasslands include species-rich permanent pastures (sometimes in transition to wet meadows) and salt marshes with permanent pastures containing ditches or micro-relief. Grasslands with disseminated biological value include species-rich permanent pastures with ditches or micro-relief sometimes including elements of reedlands or *Calthion* grasslands.

Semi-natural grasslands occupy only 0.3 to 0.6% of the Flemish territory (4,640 to 8,870 ha). The total surface of species-rich grasslands is not exactly known for Flanders. Grasslands with disseminated biological value are considered rare, covering 0.9 to 1.3% of the Flemish territory. These grasslands have been mown and/or grazed for many years, leading to a high biological diversity. When ploughed and re-sown, much of this diversity is lost. Eutrophication, overgrazing and desiccation through the lowering of the water table also threaten biodiversity. Random samples taken in the Flemish polders indicate that 50% of the total surface of historically permanent grasslands was lost between 1980 and 2000.

Little quantitative data are available for species in grasslands. Most of the existing data refers to semi-natural grasslands. For example, more than one-third of Red List species of spiders and one-third of Red List species of butterflies are found on unfertilised dry grasslands. This large number indicates the importance of those grasslands for biodiversity in Flanders. It should be noted that one-third of the species originally occupying semi-natural grasslands have already become extinct.

Legal protection and international importance

Adequate rules are urgently needed to stop this negative trend, as historically permanent grasslands are unique and very important among others for migrating birds. The Nature Decree of 1997 forbids the change of historically permanent grasslands into specific categories of land use destinations. Fertilisation limitations and management agreements can also bring improvements. However, due to the fragmented and *ad hoc* application, effectiveness is very low. Moreover, the multi-functional use of the historically permanent grasslands causes much tension and challenge. At the European level, the EU Habitats Directive protects most types of historically permanent grasslands found in Flanders, while the EU Birds Directive protects a number of grassland bird species.

3

Meadow with soft rush, *Juncus effusus*, and cuckoo flower, *Cardamine pratensis* (photograph by Y. Adams, Institute of Nature Conservation).

3.4. Forests

The forest cover is relatively low in Flanders (less than 10% of the territory). It differs considerably from one area to another, the major wooded areas being located in the Kempen.

Much of the forest biodiversity has been lost over centuries due to massive deforestation and very intensive forest use. Present Flemish forests often consist of relatively young, even-aged stands with little structural variation. Old trees, bright clearings and dead wood are rather scarce. Remaining forested areas are very fragmented -less than 10% cover more than 400 ha- and often incomplete from a biological point of view. Forest also suffers from environmental impacts such as acidification. As a consequence, many forest species are threatened or extinct. This is the case of mushrooms (macrofungi), for which many forest species are currently threatened: many mycorrhizae and saprophyte species of nitrogen-poor forests suffer from eutrophication, whereas other species are sensitive to acidification. This latter factor particularly affects conifer forests, where 18% of typical mushroom species are currently extinct and another 29% are critically endangered. As far as the fauna is concerned, studies carried out in 56 wooded areas identified 932 species from 43 taxa, of which at least 12% stand on the Red List. Occurrence varies greatly from one group to another and it is difficult to extract general distribution patterns.

Legal protection and international importance

Fortunately, forest management practices changed during the last decade. The Flemish Forest Decree (1990) lays the basis for the new forest policy, in which the protection of the remaining 'old-growth' or semi-natural forests is a key element for the conservation of biodiversity. The transformation into a more diverse structure and composition, the use of local tree and bush species, the aging of trees, the preservation of dead wood and the creation of bright clearings are strongly encouraged.

Data on the results of this change in management strategy are not available yet. Of course, changes in forest maturity cannot be carried out on a short-term basis. Although there is already more dead wood in our forests, it is still limited. The trend for a number of forest species improves, especially for birds. The latter is mainly attributed to the aging of trees. Many threatened plants and invertebrates react much more slowly to habitat improvements. Some factors are also far more difficult to recover. One of these is acidification of forest soils, which still continues. This is particularly threatening for forests of moderately acidic soils such as the valuable 'old-growth' forest complexes in the central part of Flanders. Soil acidification is also one of the major causes of increasing tree mortality. This cannot be solved by improved forest and nature policy alone. A fine tuned general environmental policy will be needed.

Eight forested habitats listed under the EU Habitats Directive are found in Flanders, including two priority types (bog woodlands and relict alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior*).

3.5. Running and stagnant water

Waterways (rivers, streams, canals and polder ditches) and their valleys are important linear elements of the landscape. They do not necessarily accommodate typical flora and fauna, but form very important migration routes for many species. Waterways can be divided into four major types: streams (11,923 km or 74%), rivers (501 km, 3%), tidal rivers (224 km, 1%) and man-made waterways (3,564 km, 22%). The amount of standing waters is also quite extensive, with some 5,700 lakes and ponds inventoried in Flanders (7,500 ha). The percentage of waterways and ponds with good water quality in combination with valuable structural characteristics is extremely low.

During the nineties, the extension of water purification plants resulted in reduced water pollution. A number of invertebrate and fish species reappeared in the region. The Belgian Biotic Index (based on the inventory of invertebrates) shows that water quality of most brooks improved during the last decade. The highest improvement was recorded for the most polluted waters. The number of sample points with very high water quality increased too, but is still restricted to only 7% of the locations. The fish index indicates a critical to poor quality: only 10 of the 965 locations sampled showed an index of high natural quality, the basins of the Meuse (8 locations) and Nete (2 locations) being the most valuable. Spring brooklets and the larger lowland brooks are amongst the most valuable brooks. However, even in the most precious brooks, invertebrate populations vary strongly from year to year, which indicates instability. Only some of the smaller spring brooklets and lowland brooks that flow through pristine river valleys attain a continuously high water quality.

Too often, severe environmental pressures affect very valuable watercourses. Although direct dumping of waste materials clearly decreases, diffuse pollution continues to grow. In watercourses with naturally very low phosphate concentrations, a small increase is measured which is due to a gradual influx. Even these limited changes are responsible for changes in the aquatic communities. In addition, historical pollution such as the accumulation of heavy metals causes more and more problems. Intensive land use in river valleys results in reduced water quality and simplification of structural characteristics of the courses. Naturally meandering rivers and brooks are only found in marshes, forests or historically permanent grasslands. In agricultural land, these watercourses are usually straightened, while riverbanks are usually reinforced in urban areas. At numerous locations, dams, culverts or waterfalls block the network of watercourses. Migration of many species, especially fish, is seriously hampered or even impossible, which results in isolated and fragmented populations.

Flemish standing waters are strongly polluted. Most water bodies suffer from a vast nutrient influx. Fens in the Kempen and the Flemish sandy region are usually acidified. Only in a very limited number of relict areas, water quality of standing waters is still satisfactory. Some smaller and younger brook systems and deeper excavations are of better quality. To restore the pure quality of standing waters, a general improvement of the environmental quality (atmospheric depositions, ground and surface waters) is needed. The management practice applied in many standing waters is far from nature friendly. Progress is urgently needed.

4

The 'Goorvijver' in Retie (Province of Antwerp) originated as a consequence of sand extraction and is now part of a designated Habitats Directive site. On the foreground, in the water: bulrush (*Typha latifolia*) and common reed (*Phragmites australis*). On the background: grey willow (*Salix cinerea*), silver birch (*Betula pendula*) and Scots pine (*Pinus sylvestris*) (photograph by J. PACKET, Institute of Nature Conservation).

Legal protection and international importance

The new water policy regulation is steered by the European directive for establishing a framework for community action in the field of water policy (the EU Water Framework Directive, adopted in 2000). The aim is a better integration of water use and water management. To achieve the quality ambitions in the field, a better integration of the 'renewed' environmental and country planning is necessary. Together with transport and agriculture policy, these policy fields have to generate more space for water and nature. The development of area-specific standards, better tuned to the specific needs of the water-courses, is necessary.

The main objective of the EU Water Framework Directive is to reach a good ecological quality in all surface waters. A good ecological quality is described as a situation showing at the maximum a slight disturbance compared to an undisturbed situation. In addition to a global quality improvement, the Directive asks specific attention for the quality of estuarine and coastal waters. Towards 2004, the EU Member States are bound to prepare a list with protected areas under the Water Directive. The specific objectives for each of those protected areas should be completed by 2015.

3.6. *Coastal dunes*

Coastal dunes include different biotopes such as embryonic shifting dunes, shifting dunes along the shoreline with *Ammophila arenaria* (white dunes), fixed coastal dunes with herbaceous vegetation (grey dunes), Atlantic decalcified fixed dunes (*Calluno-Ulicetea*), dunes with *Hippophae rhamnoides*, dunes with *Salix repens* ssp. *argentea* (*Salicion arenariea*), wooded dunes and humid dune slacks.

Dunes can be found all along the Flemish coastline. However, they are very fragmented as more than 50% of the original dune area has already disappeared. The high pressure on dune ecosystems arises mainly from tourism, including the expansion of tourist accommodation, but also from agriculture, industry and desiccation. Desiccation is caused by the pumping of groundwater, the drainage of polders and a diminished rainwater infiltration due to urbanisation. It is a very important pressure for nature conservation in the dunes.

The coast and coastal dunes are very rich in species. For instance, 862 species of higher plants (67% of the Flemish total) are found in an area of 7,500 ha (0.55% of the Flemish region). Depending on the taxonomic group, 5 to 10% of the species distributed along the coast can be considered as specific to the dune biotopes. The management of the coastal dunes is still dominated by their protective role against the sea. In the future, an adequate management of the coastal dunes has to give more importance to the natural values of these habitats.

Legal protection and international importance

In the seventies, the zoning plans for the Flemish coastal areas protected approximately 3,100 ha of coastal dunes under the status of nature reserves. During the following years, a large part of this area was lost to ever-increasing urbanisation pressures. The Dune Decree of 14 July 1993 now distinguishes two categories of protected areas: areas where limited agricultural activity is allowed and protected areas where building activities are absolutely forbidden, except for nature development and coastal protection.

Coastal dunes are also included in the list of habitats protected under the EU Habitats Directive. Two priority habitats are found in Flanders: fixed coastal dunes with herbaceous vegetation ('grey dunes') and decalcified fixed dunes with *Empetrum nigrum*.

3.7. *Urban areas*

Nature in urbanised areas corresponds to green areas within the surrounding grey urban environment, pockets where one feels good and wild flora and fauna can establish spontaneously. In general, the Flemish urban environment harbours less species than the surrounding natural areas. Many species are very common species, usually adapted to cultivated conditions, or imported (invasive) species. The natural state can be improved by planting native species, or by allowing spontaneous (re)colonisation.

4. Environmental disturbances

Changes in environmental quality due to eutrophication, acidification, desiccation, pollution and/or habitat fragmentation impose heavy pressure on fauna and flora. These major problems in Flanders are detailed below. Other human influences on nature include the over-exploitation of natural resources (hunting, fishing, harvesting) and the trade in exotic species (agriculture, forestry, gardening, pet trade, aquaria, etc.).

4.1. *Eutrophication*

Nature is flooded by an excessive nutrient influx from the air, surface waters, ground water and too often through direct over-fertilisation. These nutrients are assimilated by the vegetation or animals, fixed to the soil, or are transported downstream by means of ground and surface waters to river valleys, estuaries, and finally to the sea. The nutrient level in Flemish watercourses is amongst the highest in Europe. Nitrogen concentrations in Flemish watercourses are decreasing but remain high, with more than 40% of the sample points above the 50 mg/l level (VAN STEERTEGEM 2002). Because the nutrient input exceeds the nutrient output in most systems, nutrients accumulate practically everywhere. In every ecosystem, the nutrient excess disturbs the ecological balance. In most cases, biodiversity drops. During last century, vegetations of nutrient-rich environments gradually replaced the vegetations of nutrient-poor environments all over Flanders.

Over-fertilisation also induces the regression of many species groups such as invertebrates or fungi. The present policy that aims to tackle the problems at the source should limit nutrient emissions. However, the atmospheric nitrogen depositions barely decreased. Nitrogen emissions are still far above the medium-length objectives set out by the 1991 EU Nitrates Directive for maximum admissible concentrations (VAN STEERTEGEM 2002). Nutrients continue to accumulate in nature, constituting a disturbance factor that will last for a long time in the future. Nutrient load can be reduced locally by reducing the input or by exporting nutrients through hay or sod removal. The knowledge on nutrient flows through the landscape and the consequences for nature is still very fragmentary. There is an urgent need for monitoring, norms based on natural limitations and modelling of nutrient flows with particular attention for the most vulnerable ecosystems.

4.2. *Acidification*

Natural acidification is accelerated by atmospheric depositions, and sometimes by changes in hydrology and vegetation. An important side effect of acidification is the release of toxic aluminium. During the last 50 years, soils of many Flemish forests have become more acidic. Biodiversity in these forests, especially for naturally moderately acidic forests, is threatened. In particular, the state of the old broad-leaved forests of the loamy region and of mesotrophic waters is critical. Thanks to the reduced emission of sulphur dioxide, acid depositions have decreased from more than 17,000 million acid equivalents in 1990 to less than 11,000 million acid equivalents in 2001 (VAN STEERTEGEM 2002). However, these depositions are still too high for nature. In order to reach policy goals (national emission maxima) more effective actions are needed. The area-specific policy in relation to acidification has to pay particular attention to ecosystems of moderately acidic environments. More applied research is necessary to formulate recovery actions for degraded forest soils, while data collection should be organised to follow up the state of sensitive ecosystems.

4.3. *Desiccation*

Flemish legislation and policy plans increasingly recognise the problem of desiccation. However, progress in the field is slow. The implementation of the European Water Framework Directive should speed up actions. The total amount of water resources is crucial in policy actions against desiccation. Based on the specificity of each type of environment, the sectors involved in water extraction should evaluate the amount of the different types of water sources that can be used for different activities. The number of water extraction points (among others for agricultural use) is still rising, and, coupled to additional illegal extractions, leads to an ever-increasing desiccation problem. Keeping ground water for high quality usage (e.g. drinking water) and using alternative sources (e.g. rain) where possible should improve the state of nature. Actions to reduce desiccation go hand in hand with actions to reduce flooding. These are area-specific initiatives where knowledge of the water system on the one hand, and of water extraction and drainage on the other, is crucial. Objective methods to assess desiccation effects and long-term monitoring of (ground) water levels are necessary as a base to formulate policy measures. The realisation is of primary importance.

There is a strong interaction between desiccation, acidification and eutrophication. A disturbed water balance influences soil properties. Maintaining acid rain in the upper layer or decreasing seepage can cause acidification of the soil. The lowering of the groundwater table leads to an increased mineralisation of organic matter and can lead to an increased eutrophication.

4.4. Pollution

Heavy metals constitute an important problem in several Flemish localities. Measurements in plants, woodlice, spiders, fish and tits (*Parus* spp.) indicate that heavy metals accumulate in the food chain. The distribution patterns coincide with historical contamination sources. For a number of contaminants, the latter is regionally determined. As an example, important cadmium and zinc concentrations are found in contaminated soils in the Kempen area for both woodlice and fish. There are only limited data available on the possible effects for these organisms. Some point studies indicate deleterious effects in various organism groups from different trophic levels in the food chain. These are growth limitations in plants, genetic adaptations in spiders, a reduced condition in gudgeon (*Gobio gobio*) and reproductive problems in tits. In order to assess the effects of pollution such as heavy metals on ecosystems, it will be necessary to select appropriate indicator species and to develop a continuous monitoring system. At the moment, much attention is paid to the reduction of emissions to prevent further pollution. However, parallel to this, additional attention is needed to study existing historical contamination and contaminant flows through the system. These are not only responsible for the present effects on ecosystems, but will be of continuous importance because of lag effects. In some situations, such as heavy metal contamination of ground and surface waters, important effects have not appeared yet!

4.5. Habitat fragmentation

Fragmentation can be defined as the loss of structures and order. Habitats become smaller and more isolated. The connectivity between habitats is also reduced due to intensified land use (such as urbanisation) and the associated increase in disturbances, such as pollution and noise. The number and size of barriers increase, and, as a consequence, small isolated populations become vulnerable to extinction.

The knowledge on the impact of habitat fragmentation on nature is itself very fragmental. The problem of fragmentation is recognised in present policy and is incorporated in several policy plans and notes. The realisation of these plans is a priority aim for the next years. A small number of 'defragmentation' (or connectivity restoration) actions are prepared, but due to elaborate administrative procedures, the realisation in the field is largely delayed. The realisation of these 'defragmentation' actions is not sufficient. It is necessary to assess the effective use by the target species, and to monitor the impact on their populations.

Many freshwater fish populations decrease because their migration routes are blocked by weirs, water mills and dams. The impulse to migrate disappears because the water speed decreases above a weir. The Benelux Decree concerning Fish Migration postulates that by 2010 fish migration should be possible, for all fish species in all watercourses of the Benelux. To comply with this, a priority map was constructed. Based on the standstill principle (nature should not decline any further), it was chosen to start with the most valuable watercourses. The migration bottlenecks of this priority map can be consulted at http://vismigratie.instnat.be (in Dutch).

Habitat fragmentation is caused especially by an increased use of the open space: the surfaces occupied for residential building (+25%), industry (+29%) and trade (+19%) all increased during the last decade. On the other hand, the use of open space for agriculture decreased with 5% (Van Steertegem 2002).

For many animals, road infrastructure is an important barrier. The impact of increased traffic, as seen in Flanders, needs to be carefully interpreted. Increasing traffic seems to have only a limited effect on major roads as these roads are always a barrier, even with low traffic intensity. On smaller roads however, traffic intensity is a much more important factor.

5. Actions to develop and sustain biodiversity

5.1. *Towards more space for nature*

The Birds Directive (1979) and the Habitats Directive (1992) are European directives for respectively the protection of birds, and the conservation of natural habitats and wild fauna and flora. Special Protection Areas under the Birds Directive have been designated in 1988. Special Areas of Conservation under the Habitats Directive have been identified and, after approval by the Flemish government, proposed to the European Commission for their incorporation in the list of 'Sites of Community Importance' that will constitute the European ecological network (Natura 2000). The European Commission announced in September 2000 that they would take Belgium to the European Court of Justice because the translation of the Habitats Directive into national legislation was not sufficient. The Flemish government decided to accelerate this translation and, in 2001, 42,000 ha were added to the list of proposed sites (while 10,000 ha were dropped due to refinements). At the moment, about 102,000 ha have been designated. Like practically all European members, Flanders experiences some problems with the protection of its designated areas: in 2001, 11 cases on specific violations of the Birds and Habitats Directives were on trial in Flanders. A better structured organisation to handle these cases and transparent procedures to follow up violations are needed. An important issue is the need for the rapid realisation of agreed compensation measures when designated areas are affected for "compulsory reasons of general and critical public interest".

The Special Protection Areas and the proposed Sites of Community Interest will be included in the 'Flemish Ecological Network' (VEN), or in nature zones with mixed function. The VEN is a coherent and ecologically functional cluster of natural areas wherein management practices are oriented towards the conservation and development of high-standard nature. Nature conservation precedes other activities. The Flemish government endeavours to designate 125,000 ha.

The VEN is supported by an 'Integral Interweaving and Supportive Network' (IVON) that is composed of so-called interweaving areas (150,000 ha) and of interconnecting areas between the natural areas of VEN and IVON. Although the aim of management is to preserve high-standard nature, other human activities such as agriculture, forestry, military activities or the extraction of drinking water are allowed in IVON. The connective areas are also important to allow the migration of plants and animals between populations and natural areas. The Flemish government plans to designate 150,000 ha as nature zones with mixed function.

At the moment, the preparation of the designation process has started. It is a complicated process that requires frequent tuning with other policy fields and local authorities. Agricultural structure, regional planning, regulation of environmental quality, integral water management and the like are all involved. During the process, much attention is devoted to an easy communication and early policy agreements. This procedure should result in an improvement of the integrated management at the official level. It is recommended that voluntary organisations that are directly involved (forest, agricultural and nature organisations) can play a formal role. In this way, they are also more closely involved in the subsequent distribution of information and the enforcement of the plans. Based on the present state of the designation procedure, it is doubtful whether it will be realised towards 2003. More people are needed, both in the administration and the scientific staff.

Regional planning forms an important base to create the necessary space for nature and, as a consequence, the designation of VEN and IVON. The administration of regional planning is responsible for the enforcement of the Decree on Regional Planning (1997) and the Spatial Structure Plan for Flanders (1997). Due to the extensiveness of the assignments, priorities need to be formulated. At the moment, the implementation plans barely take nature into account. The total area of natural areas and nature reserves listed in the country planning schemes has increased by 6,411 ha during the period 1994-2001. In order to achieve the goal of an extra 38,000 ha of green areas towards 2007, as fixed in the Spatial Structure Plan for Flanders, an accelerated implementation is needed. The major obstacles that remain concern the old, not yet expired land parcelling and the illegal weekend cottages in green areas. Good complementarity is needed between the three decision-making levels (regions, provinces and local authorities), in order to attain a coherent system of protection. It is therefore important to keep the provinces and local authorities formally informed on the progress made in the designation of the regional VEN and IVON. The provinces can actively contribute through the associated Provincial Spatial Structure Plans. For the time being, it is necessary that both the Provincial and the Municipal Spatial Structure Plans state that they will give priority to VEN and IVON over their own plans, when more information becomes available.

5.2. *Higher quality for nature*

Nature and forest reserves fulfil an important role in the realisation of high quality nature. Early 2001, Flanders comprised 743 nature and forest reserves with a total surface of 19,700 ha for nature reserves and 1,600 ha for forest reserves (these include both officially recognised reserves and reserves that applied for ratification). It is clear that the total surface of nature reserves increases, but it is insufficient to reach the goal of 50,000 ha by 2007. Many reserves are located on rented land and their status is insecure in the long run, even though financial support by the Flemish government has increased. Moreover, the nature reserves are not evenly distributed over the different ecoregions. There are relatively more nature reserves in the sandy regions in the eastern part of Flanders. Because forests are under-represented in Flanders, the Flemish government aims to extend the total surface with 10,000 ha towards 2007. However, the present progress is too slow to realise this goal.

Early 2001, 268 nature and forest reserves (11,243 ha) were officially recognised in Flanders by the government. This status can only be granted to natural areas belonging to associations or the government. The recognition of a reserve entails a contract with specified results, which must be achieved, and allows subsidies for management, monitoring and public access. Management practices should conserve or develop predefined specific nature target types. In this regard, a first manual for monitoring focal species and groundwater levels in recognised reserves has been compiled, while a second one is in preparation (monitoring of management). A monitoring programme for forest reserves was started in 2000. There are no monitoring requirements for the other types of reserves.

Specific 'nature development projects' are usually designed for large interconnected areas for which 90% of the surface area is situated within the Flemish Ecological Network or in green, park, buffer or forest areas of the country-planning scheme. Nature development projects comprise a set of measures and activities focussed on the optimal organisation of space for conservation, restoration or development of nature. In January 2001, 13 nature development projects were finished on paper (total surface of 4,190 ha). End 2002, the implementation of one project was finalised. Several others are in progress for the moment.

Area-specific concepts are developed for large areas with a high amount of interconnected nature. Four of those are presented here.

During the last century, the coast has been transformed into an urban network, where the only currently remaining natural functions are filled in by the few residual dune areas. Within the natural areas, nature management and development have allowed some progress, but outside these areas (e.g. inner dunes), nature development is much more laborious.

The project 'Living Border-Maas' uses an innovative and transboundary approach (Flanders-the Netherlands) to nature development, gravel extraction, river management and flood protection. This project should create a large continuous natural area and should improve the status of a number of species such as the corn crake (*Crex crex*), night heron (*Nycticorax nycticorax*), kingfisher (*Alcedo atthis*), barbel (*Barbus barbus*) and greater yellow rattle (*Rhinanthus alectorolophus*). The implementation of the project, however, is very laborious because of obscure objectives and ineffective co-operation and communication among the different policy levels involved.

The Scheldt estuary is a tidal system with a gradient from fresh to salt water, and contains numerous natural areas of international importance (Ramsar, Birds Directive, Habitats Directive). Fish biodiversity increased thanks to improved water quality. Several areas with a nature designation are situated along the banks of the Sea-Scheldt. In the river forelands, this is less the case, but a positive shift from a sectoral to an integral approach in the planning of management is noticeable. The realisation in the field, however, is very laborious.

Integrated water management aims at a better integration of the different functions of river valleys. At the moment, two instruments are operational: 1) the ecosystem visions, usually for un-navigable watercourses, and 2) the ecological area visions for navigable watercourses. Possibilities for nature development are formulated, taking into account the strict basic conditions in the valley. A number of ecosystem visions are finalised on paper (Demer, Zwarte beek, Yser and Durme), but there is no realisation in the field, except for the Dijle valley where some first initiatives have been taken.

5.3. *Nature everywhere*

Agriculture, as the most important manager of open spaces, shoulders a large part of the responsibility for the state of nature. Rural development schemes under the European Common Agricultural Policy offer farmers the possibility to endorse nature management agreements. In this way, they commit themselves to enforce the so-called 'agri-environmental measures' on their land. These include for example the postponing of mowing dates, the development of grasslands of high biological value and the preservation and creation of hedgerows or ponds. The system has just started but there is no monitoring program to follow up the effects. Due to the standstill principle (no decline of nature) and the 'obligation to be careful' (possible damage to nature has to be prevented, restricted or recovered), the attention for nature grows in rural renovation and land re-parcelling schemes. Since 2000, ecological requirements are integrated in the land re-parcelling process and the resulting effects are monitored.

The 'Environmental licence' postulates that an official permission is required for certain activities such as filling ponds or ploughing historically permanent grasslands. However, this obligation is not applicable to all areas, leading to a lack of legal protection in some particular situations. For example, historically permanent grasslands in agricultural areas of high landscape value are not protected and can still be transformed into agricultural fields. Private owners need to apply for a licence to the local authorities (municipalities), while governmental services must apply to the provinces. The 'Nature administration' provides advice. The number of applications has increased gradually over time. During 1999-2000, about 75% of the 3,000 applications concerned the felling of trees and hedgerows. Many fail to apply for authorisation for activities such as ploughing up historically permanent grasslands. For practically all permissions, special stipulations are imposed, such as re-plantation. Only a small number of applications are rejected. Often, there is no legal action when regulation is violated. Under other circumstances (e.g. felling of trees), the regulations are not very relevant for nature conservation. To make regulations more effective and give more time to the priority aims of nature policy, one can search for alternative instruments. One of these priorities is to increase the awareness of the community and public authorities on the nature development permits.

There are few data available on the integration of nature motives in other systems of permits (town planning, environment, etc.). Legislation there is merely symbolic and too vague for concrete application. More precise knowledge is needed on how to better integrate nature conservation objectives in granting permissions. The compilation of directives and the propagation of knowledge concerning nature-friendly actions could (hopefully) motivate local administrators.

The application of compensations for habitat loss needs a reference context, in order to provide guidance to the administrations that give advice on, or issue permits. In order to be able to follow up on the countervailing measures, it is necessary to make an inventory of the measures that have been agreed upon and carried into effect. It is the only way to check if the standstill principle has been respected.

Recent regulations on town planning and land parcelling show an increased interest in nature. The term 'spatially vulnerable areas' was introduced in certain implementation regulations on regional planning. The future VEN, as it will be designated, is taken into consideration. According to the new regulations, the administration should give advice on the new applications for land parcelling or town planning, for all sites which are in the framework of spatially vulnerable areas, such as green areas, parks, forests or agricultural land with ecological importance. The administrations involved, however, are insufficiently trained in the application of the regulations on changes in vegetations and small landscape elements.

5.4. Man and nature

Proper nature policy needs broad public support. The concept 'public support' is rather new in the Flemish nature and environmental policy. It means that the public does not only accept policy measures, but also that the public is actively committed to the conservation of nature. Public support not only concerns the general public, but also civil servants and politicians. Research on this topic in Flanders has mainly focused on the general public. It has shown that 94.5% of the Flemish population regards nature as important. For more precise questions, social factors such as area of residence, social class (education, profession, income) and age become determining for the answers. The amount of public support is not static. It can be increased by social (education, communication), legal (legislation, rules and regulations) and economic (taxes and grants) instruments. The Nature Report 2001 stresses the importance of a good communication to create a solid public support for nature.

Ecological insight, appreciation of nature and nature-friendly behaviour can be stimulated by education. Education is a term with many angles of incidence. In our fast evolving society, it is no longer restricted to children and schools. Teaching about nature is done by public bodies and volunteer associations in different manners at different levels in society. Many volunteers are involved in nature and environmental education. The primary and secondary education have taken their own responsibility by formulating minimum requirements on what pupils need to know. Higher education also takes initiatives. The most important bottleneck is the division of labour and complementarity. Target groups with high impact on nature get too little attention. They need a specialised education.

5.5. *More data for nature reporting*

A solid, well co-ordinated monitoring system is needed to compile a biannual report on the state of nature. Far more species need to be monitored. Networks for environmental monitoring need area-specific refinements. A (better) formulation of nature target types should allow the comparison of results recorded by the monitoring system with predefined objectives. A systematic monitoring of policy (both for measures taken, as well as for the results for nature) is needed. Finally, public support and education for nature can only be evaluated based on relevant indicators. Monitoring has to be tuned to specific needs of the system (species, habitats, measures, etc.) but needs integration where possible.

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Eckhart KUIJKEN
Jurgen TACK
Luc DE BRUYN
Institute of Nature Conservation
Kliniekstraat 27
1070 Brussels

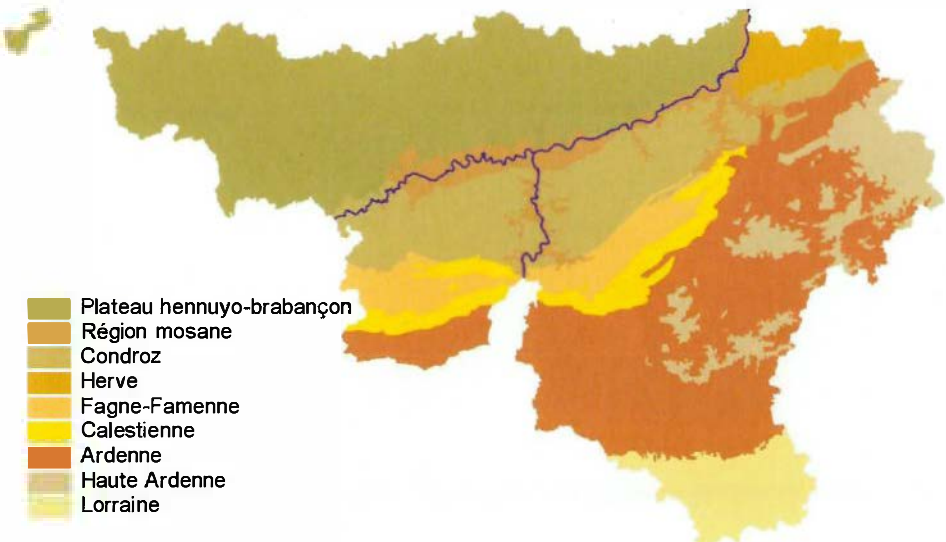
Biodiversity in Wallonia

Etienne BRANQUART, Catherine DEBRUYNE, Louis-Marie DELESCAILLE & Philippe GOFFART

1. General overview

Wallonia occupies a privileged position in Europe. It is not only located at the crossroads of the Atlantic and Continental regions, but also exposed locally to Boreal and sub-Mediterranean influences. This specific location and the existence of a marked topographical, climatic and geological gradient are at the origin of a great diversity of habitats and species over a very small territory (16,844 km^2). The diversity of abiotic conditions, together with the variety of past and present land use practices, make up the driving forces explaining current biodiversity.

Nine biogeographical regions can be defined in Wallonia on the basis of landscape, climatic and soil conditions (see figure 1 and table 1). Each of them is characterised by specific land use practices and habitats. The 'hennuyo-brabançon' plateau corresponds to the area situated north of the Sambre and Meuse valleys. As its soil is made of a deep loamy and fertile layer, it is intensively used for agriculture and very few forests and extensive areas remain on this plateau. The southern part of the region is much more diversified and made of eight biogeographical areas. The soils are often shallow and contain different kinds of sedimentary rocks according to the region (e.g. limestone, sandstone and shale). The forest cover is still important as these areas are not suitable for intensive land use.



1
The main biogeographical regions in Wallonia (based on data from the Research Centre for Nature, Forests and Wood).

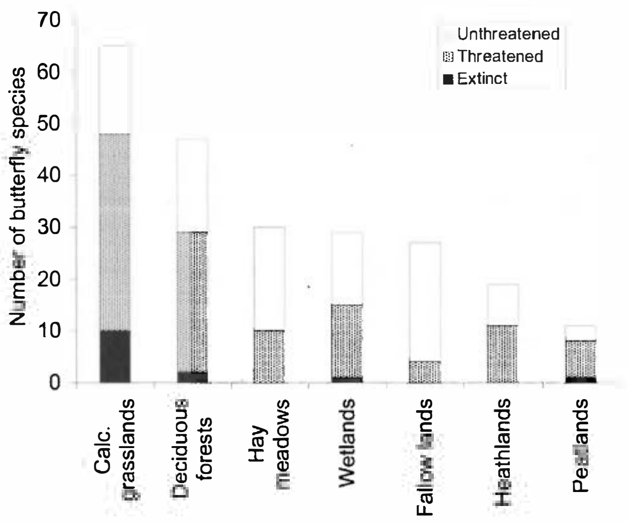
Table 1. Presentation of the main natural regions in Wallonia.

Natural region	Bedrock	Land use	Typical forest type	Peculiarities
Plateau hennuyo-brabançon	loam and sand	intensive crops	*Fago-Quercetum*	–
Région mosane	limestone, schist, sandstone and gravel	forests and meadows	–	cliffs, calcareous grasslands and slope forests (*Acerion*)
Condroz	sandstone and limestone	crops, meadows and forests	*Primulo-Carpinetum*	parklands and overmature trees, hay meadows, calacareous grasslands
Pays de Herve	chalk, limestone, schist	meadows and crops	–	orchards, hedgerows
Fagne-Famenne	schist (and limestone)	forest and meadows	*Stellario-Carpinetum*	hay meadows, heathlands
Calestienne	limestone	crops, meadows and forests	*Carici-Fagetum*	calcareous grasslands, slope forests
Ardenne	schist and sandstone	forests and meadows	*Luzulo-Fagetum*	wet grasslands and heathlands, slope forests
Haute-Ardenne	schist and shale	forests and meadows	*Vaccinio-Betuletum*	peat-lands, heathlands, wet grasslands and hay meadows
Lorraine	sand, sandstone and limestone	crops, meadows and forests	*Melico-Fagetum*	hay meadows, heathlands, peatlands, hedgerows, calcareous grasslands

2. Historical evolution of the landscapes in Wallonia

Before the rise of human populations in Western Europe, natural landscapes were dominated by oak and beech forest ecosystems where a very rich biodiversity was to be found. Because of the development of agriculture and the exploitation of woody resources, such forests were progressively transformed, cleared and fragmented. As a result, pristine and natural forests are currently reduced to very small areas in Europe. As the naturalness of forest ecosystems decreased, some woodland inhabitants disappeared from our country. Auroch (*Bos taurus*), European bison (*Bison bonasus*), brown bear (*Ursus arctos*), capercaillie (*Tetra urogallus*), elk (*Cervus elaphus*) and lynx (*Lynx lynx*) are famous examples of animals that lived previously in our forest ecosystems. Numerous small-sized species of plants and insects linked to old-growth forests and damp microclimate underwent the same fate, for instance those species depending on overmature trees and large amounts of dead wood.

Though they had a negative impact on true woodland species, ancient silvo-pastoral practices also created interesting habitats for wildlife. Traditional management such as coppicing, pollarding, slash and burn practices, sod cutting, grazing, mowing, reed cutting, etc. favoured landscape openness and the formation of specific habitats such as extensive grasslands, heaths, peatlands, reed beds, hay meadows, hedgerows, orchards, coppice and pasture woodlands. Such habitats have been widely represented all over Wallonia during previous centuries, especially on stony and wet soils of the Fagne-Famenne, Calestienne, Ardenne and Lorraine regions. They sheltered very diversified plant and animal communities that formed a substantial part of the Walloon biodiversity. Hence, one-third of the Belgian flora is closely linked to heaths, dry grasslands and hay meadows (STIEPERAERE & FRANSEN 1982). Numerous threatened butterfly species are also found in the same types of habitats (figure 2). As they have favoured habitat diversification and species richness at the landscape level, traditional practices are part of our bio-cultural heritage and deserve to be carried on in the framework of a strategy for nature conservation.



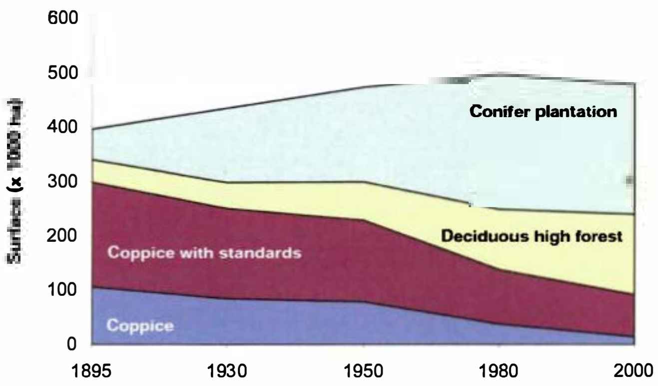
2
Habitat and status of butterflies in Wallonia (based on GOFFART & DE BAST 2000).

Traditional villages usually included small farms with enclosed gardens and orchards surrounded by arable fields fertilised with manure produced by cattle and horse. These animals used to graze in coppice woodlands or forests. In many areas, herbs and grasses were cut after coppicing and the upper part of the litter was stripped and burned when dried out. The coppiced area was used for cereal production during 1 or 2 years. Thereafter, broom (*Cytisus scoparius*) sown or developing from the soil seed bank, was used as fodder for sheep or as litter. Wet meadows, situated along streams and rivers, mires, wet heaths and fens were mown for winter fodder or litter. Animals usually grazed under the lead of herdsmen or shepherds and were taken back to the village every evening for milking and, especially, manure harvesting (DELESCAILLE 2002).

Crowded flocks of sheep and goat exerted a major grazing pressure on wooded landscapes and transformed them in open habitats such as heaths and moors on acidic soils and calcareous grasslands on limestone. In 1850, the number of sheep exceeded 150,000 in the Ardenne, with pastoral landscapes covering about 130,000 ha (NOIRFALISE 1989).

The surface of extensive landscapes has begun to decrease in Belgium since the 1847 law on commons improvement in a context of timber shortage and increasing international trading of food and wool. Since then, extensive grazing has progressively been abandoned and cattle and horses have been driven away from woodlands. Heathlands, peatlands and calcareous grasslands were considered as 'unproductive' areas and were afforested with pines and Norway spruce or transformed into permanent pastures and cereal fields. At the end of World War II, land reclamation speeded up with the use of new agricultural techniques and tools such as chemical fertilisers, ensilage and imported protein food for livestock (LAMBERT *et al.* 2000, DELESCAILLE 2002).

As a result, more than 90% of the landscapes produced by traditional management practices have been lost during the last century. At the same time, the total forest area increased by 20% while woodland structure and composition changed significantly. Coppice surfaces



3
Evolution of the forest stand structure in Wallonia during the 20th century (based on GÉRARD & LAURENT 1995 and LECOMTE *et al.* 2003).

were progressively abandoned and transformed into conifer plantations for timber production (figure 3) (GÉRARD & LAURENT 1995).

These trends can be illustrated by two studies on landscape evolution: the Tailles Plateau in the Ardenne and the Viroin Valley in the Calestienne. On the Tailles Plateau, peat- and heathlands occupied more than 50% of the total area around 1770. Two centuries later, most have been improved or reclaimed for permanent pastures or spruce plantations whereas relict peat- and heathland cover today less than 1% of the same area. The cover of broad-leaved forest also decreased considerably following the transformation of old coppice into conifer plantations (table 2) (DUMONT 1975).

Table 2. Evolution of landscape units in Ardenne (Tailles plateau) between 1770 and 1970. The trend refers to a surface ratio onto the 1770 situation (after DUMONT 1975).

	1770		1970		Trend
	Area (ha)	% of tot. area	Area (ha)	% of tot. area	
Broad-leaved forests	14,500	25%	6,500	11%	55%
Coniferous plantations	0	0%	25,100	43%	+ + +
Heaths and moors	28,600	49%	100	0.2%	99%
Bogs	950	2%	500	1%	47%
Peat-lands and wet grasslands	5,400	9%	100	0.2%	98%
Urban and intensive agricultural areas	8,550	15%	25,900	45%	+ 203%

The evolution of the limestone landscape displays similar trends. Calcareous grasslands that were largely distributed on stony soils of Devonian and Carboniferous limestone (Viroin, Meuse, Lesse and Ourthe valleys) vanished from most areas because of scrub colonisation or pine plantation; 92% of the calcareous grasslands of the Viroin valley have disappeared since 1770 (table 3). Current grassland relicts are strongly isolated and impoverished (LEDUC 2002).

In summary, the evolution of land use practices in Wallonia have led to the progressive closure of the landscape, the increase in standing wood resources and the intensification of remaining agricultural areas.

Table 3. Evolution of the surface (ha) of landscape units in the Viroin valley (Calestienne) between 1770 and 2002. The trend refers to a surface ratio in comparison with the 1770 situation (after LEDUC 2002).

	1770	1870	1964	2002	Trend
Forests	288	712	750	1,607	+ 458%
Fallows and calcareous grasslands	611	477	716	51	– 92%
Crops	2,205	1,885	855	766	– 65%
Intensive grasslands	389	357	1,072	951	+ 144%
Urban areas	55	82	127	155	+ 182%

3. Biodiversity and current status of some habitats in Wallonia

3.1. *Semi-natural open habitats*

Semi-natural open habitats are characterised by specific and diversified plant communities that often produce mass flowering. They provide interesting resources exploited by plenty of specialised anthophilous and phytophagous insects. Heathlands as well as dry and humid grasslands are key habitats for numerous insects species (e.g. Orthoptera, Hemiptera, Lepidoptera and Hymenoptera). They are also often visited by specific and threatened reptiles and birds. For instance, the remaining population of black grouse (*Tetrao tetrix*) is strictly dependent on large areas of heathlands while whinchats (*Saxicola rubetra*) and corn crakes (*Crex crex*) are mostly found in hay meadows. Two lizard species (*Podarcis muralis* and *Lacerta agilis*) and the smooth snake (*Coronella austriaca*) are typically found in dry grasslands and heathland ecosystems.

Some open habitats have developed under drastic azonal climatic conditions. Bogs of the Hautes-Fagnes Plateau are under the influence of Boreal and mountain climates characterised by cold winters and large amounts of precipitations. Nordic vegetation and fauna are found in these bogs such as, for instance, several species of Boreal dragonflies: the northern damselfly *Coenagrion hastulatum*, subarctic darner *Aeshna subarctica*, northern emerald *Somatochlora arctica* and nordic marsh dragonfly *Leucorrhinia rubicunda*. On the other hand, sub-Mediterranean species (e.g. grasshoppers and cicadas) typically live in dry grasslands found on south-facing rocky slopes of the Calestienne, Fagne-Famenne and Lorraine.

As described previously, most of the open areas resulting from traditional management drastically decreased during the 19^{th} and 20^{th} centuries. Relicts are still present and are sometimes included into protected areas. Nowadays, calcareous grasslands are mostly represented in the Calestienne and Condroz, hay meadows in Fagne-Famenne and Lorraine, and humid meadows, heathlands and peatlands in Ardenne.

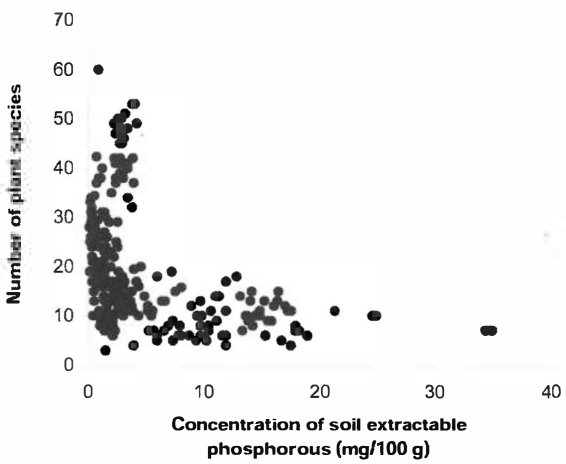
Detailed data about the exact area of such habitats are very difficult to obtain as no systematic habitat survey has been performed so far in Wallonia. Crude estimations of areas included into the Natura 2000 network give however a first idea about the current extent of open semi-natural habitats, providing that the global quality of the site is good (A in table 4). Based on these values, one may estimate that more than 2,000 ha of heaths, 1,300 ha of various types of dry grasslands, 1,200 ha of tall-herb humid meadows, 1,000 ha of hay meadows and 200 ha of bogs are still present in Wallonia. These values need to be confirmed after a detailed mapping of each of the Natura 2000 sites (currently in progress).

Table 4. Main open habitat types included into the Natura 2000 network in Wallonia and the global biological quality and estimated area for each of them. Priority habitat types are marked with (*) (based on data from the Research Centre for Nature, Forests and Wood).

Code	Habitat types	Global quality		Total area
		A	B + C	
	Inland dunes			
2310	Dry sand heaths with *Calluna* and *Genista*	60%	40%	530 ha
2330	Inland dunes with open *Corynephorus* and *Agrostis* grasslands	95%	5%	40 ha
	Temperate heath and scrub			
4010	Northern Atlantic wet heaths with *Erica tetralix*	40%	60%	2,090 ha
4030	European dry heaths	45%	55%	1,980 ha
	Sub-mediterranean and temperate scrub			
5110	Stable xerothermophilous formations with *Buxus sempervirens* on rock slopes	70%	30%	400 ha
5130	*Juniperus communis* formations on heaths or calcareous grasslands	55%	45%	30 ha
	Natural grasslands			
6110 (*)	Rupicolous calcareous or basophilic grasslands of the *Alysso-Sedion albi*	60%	40%	170 ha
6130	Calaminarian grasslands of the *Violetalia calaminariae*	20%	80%	50 ha
	Semi-natural dry grasslands			
6210 (*)	Semi-natural dry grasslands and scrubland facies on calcareous substrates	35%	65%	1,060 ha
6230 (*)	Species-rich *Nardus* grasslands, on siliceous substrates in submountain areas	80%	20%	990 ha
	Semi-natural tall-herb humid grasslands			
6410	*Molinia* meadows on calcareous, peaty or clayey- silt- laden soils	30%	70%	2,300 ha
6430	Hydrophilous tall herb fringe communities	10%	90%	5,390 ha
	Mesophile grasslands			
6510	Lowland hay meadows (*Alopecurus pratensis, Sanguisorba officinalis*)	10%	90%	6,680 ha
6520	Mountain hay meadows	30%	70%	1,360 ha
	Sphagnum acid bogs			
7110 (*)	Active raised bogs	55%	45%	240 ha
7120	Degraded raised bogs still capable of natural regeneration	40%	60%	1,600 ha
7140	Transition mires and quaking bogs	50%	50%	110 ha
	Calcareous fens			
7230	Alkaline fens	20%	80%	120 ha

A large number of sites have a lower global quality (categories B and C), reflecting either their small surface or their low phytocoenotic integrity (alteration of plant communities); they should deserve to be restored as soon as possible through adequate management and conservation practices. Bad site qualities can be explained through the following threats: eutrophication and water pollution (habitat codes as referred to in table 4: 6410, 6430, 6510, 6520), fertilisation, early mowing and intensive grazing (6230, 6410, 6430, 6510, 6520), acid rain (6210), drainage (6410, 6430, 7110, 7120, 7140), conifer plantations (most habitat types), natural colonisation by trees and scrub (most habitat types), invasion by alien species (6410, 6430).

Richness decrease of plant communities in old permanent grasslands of Western Europe is illustrative of the impact of the intensification of agricultural practices on biodiversity. Grasslands that formerly sheltered as much as 120 plant species are today strongly impoverished due to early mowing and NPK fertilisation. Phosphorous is particularly detrimental to biodiversity as a high concentration of this element in the soil reduces plant species richness to less than 20 species (figure 4). Restoration of the typical diversified vegetation of such grasslands is a very long and exacting process as phosphorous forms stable and persistent stocks in the soil and is weakly exported in forages (JANSSENS *et al.* 1998).



4
Impact of the concentration of soil extractable phosphorus on plant species richness in old permanent grasslands from Western Europe (based on JANSSENS *et al.* 1998).

In a nutshell, it can be said that semi-natural open habitats are threatened by air and water pollution, land reclamation practices and the cessation of traditional management. Often, restoration based on traditional practices will deserve to be adapted to the conservation of rare and sensitive species. Mowing, for example, has to be delayed or applied each year only to a part of the site (rotational management) to allow specific invertebrate species to survive (DELESCAILLE *et al.* 1990, GOFFART *et al.* 2001).

3.2. Forest ecosystems

Forest areas cover about 475,000 ha, i.e. one third of the Walloon territory. Half of the forest cover is made of semi-natural deciduous woodlands. The other part includes plantations of exotic species, mainly conifer trees (LECOMTE *et al.* 2003). Thanks to the high geomorphological diversity of the territory, a wide range of different forest types is found (NOIRFALISE 1984), including three priority forest types and seven other forest types of the Habitats Directive (table 5).

The quality of forest biodiversity in Wallonia is hereafter evaluated in three successive steps: (1) the biological value or biodiversity potential in each forest type, (2) the conservation value, i.e. forest landscapes as key habitats for red list species and (3) the natural value or naturalness, i.e. the relative proximity of forests to the structure of pristine ecosystems and their natural dynamics.

(a)

(b)

(c)

(d)

(e)

(f)

Plate 1

(a) Old-growth beech forest of the Brandehaag (Hertogenwald). Overmature tree and dead wood are two key components for forest biodiversity. Both are unfortunately poorly represented in Walloon woodlands (photograph by F. Hidvegi).

(b) As a major cause of the reduction of forest areas, grazing had a major impact on landscape structure up to World War II. It created valuable habitats for biodiversity such as heathlands and extensive grasslands. Grazing management is still used today to restore such habitats for conservation purposes (see pictures c and d) (photograph by J.-L. Gathoye).

(c) Because of the decline of sheep breeding and large-scale reforestation, heathland surfaces decreased drastically during the two last centuries. Remnants are currently represented into military areas and in small forest gaps (photograph by J.-L. Gathoye).

(d) Calcareous grasslands are also the legacy of past traditional grazing practices. They form one of the most species-rich terrestrial ecosystems in Western Europe and are included into the priority habitats of the EU Habitats Directive (photograph by J.-L. Gathoye).

(e) Bog ecosystems are mainly represented in Haute-Ardenne and host specific Boreal and Alpine species assemblages (photograph by Ph. Goffart).

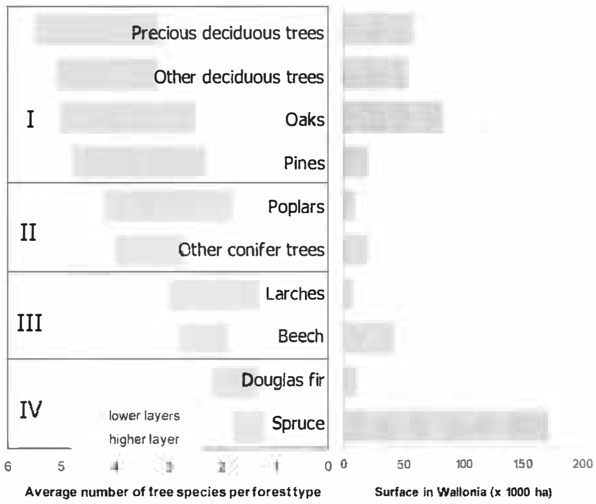
(f) Freshwater biodiversity hotspots are mainly located in the Ardenne, especially in areas with a high forest cover and low human population density (e.g. Lesse, Ourthe and Semois basins). These hotspots host rare flagship species such as the pearl mussel (*Margaritifera margaritifera*) and otter (*Lutra lutra*) (photograph by J.-L. Gathoye).

Table 5. Forest types included into the Natura 2000 network in Wallonia and estimated area for each of them. Priority habitat types are marked with (*) (based on data from the Research Centre for Nature, Forests and Wood).

Code	Forest type	Estimated area (ha)
	Beech forests	
9110	*Luzulo-Fagetum* beech forests	39,910
9120	Atlantic acidophilous beech forests	2,710
9130	*Asperulo-Fagetum* beech forests	11,660
9150	Medio-European limestone beech forests	2,860
	Oak forests	
9160	Oak and oak-hornbeam forests	22,390
9190	Old acidophilous oak woods on sandy plains	1,240
	Other forest types	
9180 (*)	Forests of slopes, screes and ravines	2,890
91D0 (*)	Bog woodland	1,970
91E0 (*)	Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior*	6,700
91F0	Riparian mixed forests	20

3.2.1. Biological value

Stand types recognised across the Permanent Survey of Woody Resources (LECOMTE & LAURENT 1999) are characterised by contrasting tree species richness. Stands dominated by heliophilous tree species as oak, ash, birch or pine are much more diversified than those made of shade-tolerant trees (figure 5). Data presented elsewhere (BRANQUART *et al.* 2003) confirm that the former tree species have a larger potential for associated taxa (phytophagous, saproxylic, saprophagous and epiphytic organisms) and have therefore a higher biological value. It should be noted that regardless of tree species, the biodiversity potential of trees is highly dependent on their age. Stand types characterised by a high biological value and potential for biodiversity cover about 45% of the Walloon forest.



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Forest stands in Wallonia. Average tree species richness (left) and relative amount of the different stand types (right). Stand types were gathered into 4 groups according to tree species richness in the lower and higher vegetation layers. Precious deciduous trees refer to stand types dominated by *Acer*, *Fraxinus*, *Prunus* and *Ulmus* or by a mixture of oak and beech trees (based on the Permanent Survey of Woody Resources and LECOMTE *et al.* 2003).

3.2.2. Conservation value

As detailed in table 6, forest ecosystems provide a habitat for numerous plant and animal species. Considering all groups together, about half of these species are rare or threatened. Current pressures on these organisms are (1) plantation of exotic trees, (2) closure of the forest canopy (steep wood margins, increase of shade-tolerant trees, coppice cessation, scarcity of extensive openings) and (3) rarity of overmature trees and dead wood. Saproxylic organisms are probably the most threatened species, as indicated by the high proportion of endangered species among lichens, hover flies and cavity-nesting bats and birds.

Some examples of recent population increase can however be found among emblematic bird species, as it is the case for the black stork (*Ciconia nigra*), middle-spotted woodpecker (*Dendrocopos medius*) and black woodpecker (*Dryocopus martius*). These species take advantage of the current ageing of high deciduous forests. Unfortunately, the regeneration shortage of broad-leaved trees (LEMAIRE 2001) and the recent decrease in rotation time in most forest types challenge the long term survival of such populations.

Table 6. Richness of forest flora and fauna in Wallonia and proportion of rare and threatened species [after DIEDERICH & SÉRUSIAUX 2000 (1), BRANQUART *et al.* 2003 (2), Anonyme 2003 (3) and SPEIGHT *et al.* 2000 (4)].

Taxonomic group	Number of forest species	Proportion of rare or threatened species	Ref.
Epiphytic lichens	354	73%	1
Indigenous trees	64	27%	2
Ground beetles (Carabidae)	47	23%	3
Butterflies (Rhopalocera)	48	67%	3
Saproxylic hoverflies (Syrphidae)	52	83%	4
Other hoverflies (Syrphidae)	105	50%	4
Birds	77	31%	3
Mammals	42	45%	3

3.2.3. Natural value

Because of the intensive human activity in woodlands since the Neolithic, the naturalness of the Walloon forest is quite low. Overmature trees are very scarce and the mean volume of dead wood (snags and logs) is only about 6.6 m^3/ha (LECOMTE & LAURENT 1999), as compared to volumes over 100 m^3/ha in natural forest ecosystems (VALLAURI *et al.* 2002).

A recent study based on ancient forest plants showed that plots corresponding to original forest conditions and forest continuity (HERMY *et al.* 1999) are mainly located in lower valleys of the Meuse tributaries: Hermeton, Lesse, Ourthe, Semois, Warche, etc. They are typically found on uneven sampling plots (steep slopes) with diverse and fertile soil conditions and high deciduous cover (BRANQUART *et al.* 2003). Some of them should deserve to be designated as strict forest reserves in order to restore natural processes and old growth conditions.

As a conclusion, it can be said that Walloon forests present a very high potential for biodiversity, which is however threatened by modern forest management practices. This potential could be enhanced in the future providing that conservation management practices (e.g. close-to-nature forestry, opening of forest canopy, green tree retention, restoration of degraded habitats) be adopted in woodland ecosystems, together with the creation of a representative network of strict forest reserves.

3.3. Running waters

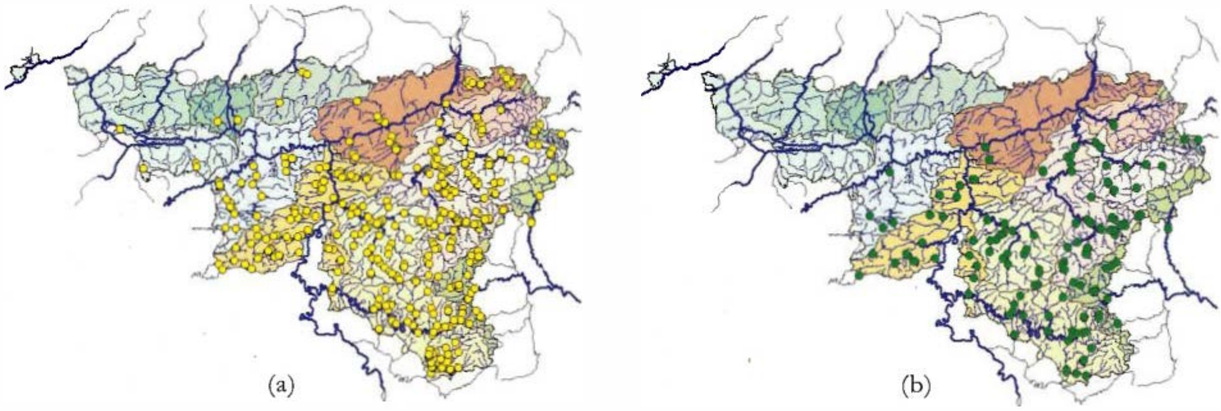
The water quality of waterways and surface waters in Wallonia is controlled by means of several biological, physico-chemical and bacteriological monitoring networks (DE PAUW *et al.* 2001). One of these monitoring programmes uses the biotic index method, which is based on the sampling of benthic macro-invertebrate communities (worms, molluscs, insect larvae, etc.). The biotic index allows the characterisation of both the quality and biodiversity of waterways (IBGN, Norme AFNOR NF T 90-350). The programme has been running since 1997 and concerns 200 waterways in Wallonia that are systematically assessed through 400 collecting sites sampled in a three-yearly cycle.

In addition to the diversity of river substrates, benthic communities are extremely useful to appraise water quality. A non-polluted river exhibits a high faunal diversity and is characterised by invertebrate taxa that are very sensitive to organic pollution and very demanding in oxygen, such as larvae of stoneflies (Plecoptera), caddisflies (Trichoptera) and mayflies (Ephemeroptera). In the presence of pollution, these taxa disappear and biological diversity decreases significantly. Results from the monitoring programme indicate that most of the waterways situated north of the Sambre-Meuse axis present very impoverished invertebrate complexes (biotic index inferior to 8/20). This situation arises from the contamination of surface waters by domestic, agricultural and industrial effluents. On the opposite, running waters in southern Wallonia are usually much less polluted and host more diverse benthic invertebrate communities (biotic index higher than 12/20). They beneficiate from the important forest cover and from a lower urbanisation.

Results obtained from other inventories of pollution-sensitive taxa confirm these tendencies. In this regard, the bullhead (*Cottus gobio*) and brook lamprey (*Lampetra planeri*) are confined to rivers characterised by a high biotic index and a low pollution load (figure 6). This is also the case for the white-throated dipper (*Cinclus cinclus*), otter (*Lutra lutra*) and pearl mussel (*Margaritifera margaritifera*). Unfortunately, populations of the last species do not reproduce any more in Wallonia probably as a consequence of excessive water turbidity and bad river bed conditions (LAUDELOUT & LIBOIS 2003).

The establishment of monitoring networks for aquatic biodiversity (benthic macro-invertebrates, fish, bryophytes, etc.) is too recent to deduce conclusions relating to its long-term evolution. The fragmentary information that can be gathered seems to show some improvement in the aquatic biodiversity of the Meuse and Sambre rivers, and can be linked to a reduction in industrial pollution in these waterways. This pollution decrease is counterbalanced by an increase in domestic effluents, which are responsible for the eutrophication of smaller-sized watercourses such as the Ourthe or the Lesse (PHILIPPART 2000). Moreover, information gathered on dragonflies in Wallonia by GOFFART (2000) shows that species with larvae living in fast running water (e.g. *Oxygastra curtisii, Onychogomphus forcipatus* and *Gomphus vulgatissimus*) are proportionally more threatened than other dragonfly species. They particularly suffer from the deterioration of riverbanks and eutrophication. Riverbank alteration or reclamation has also deleterious effects on the populations of the kingfisher (*Alcedo athis*) and sand martin (*Riparia riparia*) that declined drastically in recent years (LAUDELOUT & LIBOIS 2003).

The Walloon hydrographic network thus presents rather contrasted situations. Streams with good physico-chemical water quality and well-structured riverbanks can nonetheless be found (e.g. Lesse, Ourthe, Rulles, Semois, Sûre et Viroin). They still host very diversified aquatic communities and critically endangered species with specific ecological requirements. They form true 'biodiversity hotspots' that must be protected at all costs.



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Distribution map of post-1980 observation of (a) the bullhead (*Cottus gobio*) and (b) the river lamprey (*Lampetra planeri*) in Wallonia (based on data from the Research Centre for Nature, Forest and Wood).

4. SPECIES SURVEYS

4.1. *Monitoring programmes*

Species monitoring programmes in Wallonia focus on seven indicator taxa, i.e. orchids (up to 2001), dragonflies, butterflies, amphibians, reptiles, birds and bats. These taxa are monitored on a periodic basis in order to detect regressions and expansions within distribution areas. Data are recorded by specialised working groups made of volunteers (naturalists, foresters, etc.) and validated by scientists working in universities or within the Research Centre for Nature, Forests and Wood (under the DGRNE), hereafter referred to as RCNFW. Generally, data are recorded on a presence/absence basis in specific sites and refer to 5 km x 5 km UTM plots. They are gathered in a central biological database managed by the RCNFW. From this database, synthesis information is regularly produced as distribution maps, red data lists, ecological preferences and identification of major threats. This information is available through the following website: http://mrw.wallonie.be/dgrne/sibw and will be used in the future to develop species action plans for priority taxa.

These data are complemented by short-term and specific surveys on other taxonomic groups such as flora, grasshoppers, ladybird and carabid beetles, fishes, etc. Biological information is also gathered through other programmes like the survey on biological quality of running waters (see 3.3.), the Permanent Survey of Woody Resources and the Survey of Key Sites for Biodiversity Conservation (SGIB).

More recently, specific monitoring programmes were launched by the RCNFW in close collaboration with universities and research consultancies to follow up population trends of species listed in the Habitats Directive (see annex 3).

4.2. Trends and red data lists

Red data lists have been produced for the different indicator taxa monitored through the regular survey programme. Partial information is also available for other groups such as vascular plants (SAINTENOY-SIMON, in prep.), grasshoppers (DECLEER *et al.* 2002) or ladybird beetles (BAUGNÉE & BRANQUART 2000). The pivotal years used for the analysis of population trends are 1950 and 1990. The former is a turning point corresponding to the intensification of farming and forestry systems as well as to urban development and the expansion of transport infrastructure (see subchapter 2).

Results gathered through the monitoring programmes show that the Walloon flora and fauna undergo a drastic decline in a large number of species, together with the geographic expansion of a very limited number of common and widespread taxa. The table below gives a general overview of the number of species found in Wallonia and is divided into five IUCN categories: extinct, endangered, vulnerable, non-threatened and introduced. According to the taxonomic group, between 40 to 83% of the species display a clear population decrease (mean: 57%). The most threatened taxa are orchids, butterflies, reptiles, amphibians, breeding birds and bats. A more detailed analysis of trends for each biogeographical region shows that the 'brabanço-hennuyer' plateau and the Meuse region are the areas with the most frequent cases of population decreases. Declining species display specific life-history traits. They are often found in a narrow habitat range, for instance semi-natural open habitats (e.g. dry grasslands, heathlands, peatlands) and forest habitats. They are also specialist feeders and poor dispersers, highly susceptible to habitat quality and fragmentation (HALLET 1993).

These data do not give information about how population densities evolve within individual sampling plots (5 km x 5 km UTM plots) and shade population trends of widespread species. The quantitative survey of common bird species performed recently by Aves (VANSTEENWEGEN & JACOB, in press) shows that many species previously considered as unthreatened (no contraction of distribution area) are actually subjected to a marked population decrease. It is the case of several common species living in man-made and agricultural habitats such as the house martin (*Delichon urbica*), meadow pipit (*Anthus trivialis*), skylark (*Alauda arvensis*), tree sparrow (*Passer montanus*) and some bunting species (*Emberiza* spp. & *Miliaria calandra*). So far, the causal factor of their regression remains unclear.

Table 7. Species status for the different taxonomic groups surveyed in Wallonia [after BOURNÉRIAS 1998 (1), Anonyme 2003 (2) and GOFFART & DE BAST 2000 (3)].

Taxonomic group	Total number of species	Number of extinct species	Number of endangered species	Number of vulnerable species	Number of introduced species	Proportion of extinct or threatened species	Ref.
Orchids	52	7	19	17	0	83%	1
Dragonflies	66	4	10	17	0	47%	2
Butterflies	114	16	25	39	0	70%	3
Amphibians	17	3	2	4	2	53%	2
Reptiles	9	1	1	3	1	56%	2
Breeding birds	170	9	26	40	7	48%	2
Mammals	69	2	8	18	10	40%	2

Species that extend their geographic range are usually synanthropic and plastic species able to take advantage of human activity. The fox (*Vulpes vulpes*) and black-headed gull (*Larus ridibundus*) are typical examples of this situation. Surprisingly, other expanding species are found among charismatic birds that were previously subjected to population decline. Predatory birds as the great crested grebe (*Podiceps cristatus*), cormorant (*Phalacrocorax carbo*), grey heron (*Ardea cinerea*), black stork (*Ciconia nigra*), sparrowhawk (*Accipiter nisus*), peregrine (*Falco peregrinus*) and eagle owl (*Bubo bubo*) are typical examples of such species with recovering populations. They undoubtedly take advantage of hunting regulation, fish density increase and abandonment of pesticides with a high bio-accumulation potential that were widely used during the sixties and the seventies.

The number of introduced species able to become invasive is rather limited within the investigated taxa. Few species however begin to become abundant and potentially harmful to the environment and indigenous species. Because they already have caused damage abroad, the following species deserve to be carefully monitored and controlled when appropriate: the North American bullfrog (*Rana catesbeiana*), lake frog (*Rana ridibunda*), red-eared terrapin (*Trachemys scripta elegans*), Egyptian goose (*Alopochen aegyptiacus*), Canada goose (*Branta canadensis*), ring-necked parakeet (*Psittacula krameri*), American mink (*Mustela vison*) and muskrat (*Ondatra zibethicus*).

4.3. *Major threats*

Results presented above show that the future of many species is strongly jeopardised. Some of them have already disappeared from the Walloon territory and many others are on the verge of extinction. Species erosion is the result of three major threats described hereafter (HALLET 1993).

4.3.1. Habitat loss, degradation and fragmentation

The first cause of biodiversity loss in Wallonia is undoubtedly habitat loss, degradation and fragmentation. It is the direct consequence of the high human pressure on the environment: intensification of land use practices, expansion of urban, infrastructure and industrial areas, etc. All the habitat types are currently affected by this process. Most of extensive open habitats have been transformed and reclaimed while remaining ones urgently need to be managed in an appropriate way to limit invasion by scrubs and trees. The intensive use of pesticides and fertilisers, as well as the rarity of hedgerows and refuge areas, is a direct threat to agricultural biodiversity (see 3.1.). Forestry practices underwent major changes during the last century. Many forest species declined as a consequence of both the closure of the forest cover and the scarcity of old-growth forest areas. In woodlands, heliophilous species urgently need to be favoured and regenerated through active management. On the other hand, clumped ageing plots and strict forest reserves have to be created to conserve species linked to veteran trees and high dead wood volumes. Draining, filling, straightening and cleaning-out of waterways are standard practices unfavourable to freshwater and wetland biodiversity. Finally, the increasing pressure of recreation and leisure activities on the natural environment is a direct threat for the remaining natural areas, including waterways, cliffs and underground cavities.

4.3.2. Chemical pollution and global change

Pollution and climate change consist in a second threat to biodiversity that affects various habitats and needs to be added to their physical alteration. Air pollution has direct consequences on forest decline and on the balance of soil nutriments in grassland and meadow ecosystems. For instance, atmospheric nitrogenous supply changes the composition of the flora, favours nitrophilous species and decreases plant diversity. It is also well known that the impact of eutrophication and water pollution on freshwater and wetland biodiversity is very harmful.

On the other hand, climate change is expected to alter the distribution and abundance of organisms throughout the world and to disrupt life-cycle movements and the functioning of communities (ROOT *et al.* 2003). Some cases of climate-induced populations extinctions have been already recorded especially within habitat specialists. Such changes in distribution range are mostly induced by climate warming and increasing stochasticity in meteorological events (WARREN *et al.* 2001, MC LAUGHLIN *et al.* 2002). Recent arrivals of southern species have been recently recorded in Wallonia within several taxa like plants, bees, dragonflies and birds. Though these new species participate to enhance global biodiversity in Wallonia, an extinction of Boreal species found in raised bogs and an alteration of these ecosystems is to be feared in the Ardenne (GOFFART & DE SCHAETZEN 2001).

4.3.3. Invasion by alien species

The problem of the invasion of natural ecosystems by alien species is rather recent, although some species already invaded freshwater ecosystems a long time ago. Up to now, consequences on biodiversity are still limited but this situation may evolve in the following years. New invasive alien species appear each year and the phenomenon deserves to be carefully monitored. Potential damage caused by these species are habitat degradation, transmission of parasites or diseases, species introgression and elimination of native species through competition and predation interactions.

In addition to the species quoted in the subchapter 4.2., the following detrimental invasive species have to be carefully monitored and controlled through adequate measures. They are found among vascular plants (*Elodea* spp., *Fallopia japonica, Impatiens* spp., *Solidago* spp., *Senecio inaequidens*), molluscs (*Dreissena polymorpha*), crustaceans (*Dikerogammarus villosus*, exotic crayfishes) and ladybirds (*Harmonia axyridis*). It has to be noted that these species are especially encountered within aquatic habitats as well as disturbed terrestrial habitats (alluvial sites, fallow lands, road embankments, etc.).

5. Conservation management, a challenging future

The presented data show that Wallonia has a very nice potential for biodiversity thanks to its diverse biogeographical influences and its former traditional management practices. Even though they are threatened by various pressures, interesting plant and animal communities are still present on its territory and include numerous species and habitats from the EU Birds and Habitats Directives.

Strategies, action plans and concrete measures need to be developed in a near future to protect this precious bio-cultural heritage and to mitigate biodiversity loss. Existing and planned actions focussing on biodiversity conservation are shortly described hereafter.

5.1. Existing biodiversity actions and policies

5.1.1. Network of nature and forest reserves

In Wallonia, state and private nature reserves cover about 6,540 and 1,410 ha respectively (data: Nature & Forest Administration). Most of these correspond to semi-natural open habitats and are subjected to clearing, mowing and grazing management. Some 550 ha are also protected through the status of 'forest reserve'. They are designed to protect specific vegetation types but are still subjected to conventional logging. Strict forest reserves do not exist as such. The mean size of nature and forest reserves is quite low (about 60 ha), with the exception of the Hautes-Fagnes nature reserve that forms a complex of heathland and bog landscapes of 4,500 ha. Currently, 41 wetlands and 57 caves of special biological and scientific interests are also officially recognised in Wallonia and gain from specific conservation measures as detailed in their designation act.

5.1.2. Restoration projects

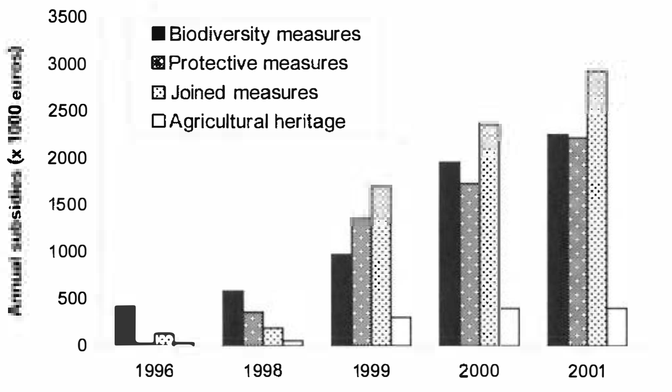
Large-scale restoration projects are currently undertaken by non-governmental organisations (RNOB, Ardenne & Gaume) and the Nature & Forest Administration to restore semi-natural open habitats through EC funding mechanisms (LIFE nature and INTERREG programmes, see table 8). Money is mainly used for land purchase, restoration management and scientific monitoring. Such areas frequently need to be cleared from scrubs and trees before starting standard mowing or grazing management in collaboration with farmers.

Table 8. Examples of restoration projects undertaken in Wallonia thanks to EC funding. Estimated surfaces concerned by the projects: (1) restoration, grazing/mowing management; (2) land purchase and (3) global perimeter of target habitats (total area of nature reserves or of Natura 2000 sites).

	Surface (1)	Surface (2)	Surface (3)	Location	Priority habitat and/or species
Hay meadows					
LIFE94 NAT/B/001516 LIFE97 NAT/B/004796	120 ha 150 ha	130 ha 150 ha	10,000 ha 7,200 ha	Fagne-Famenne Fagne-Famenne	humid and hay meadows (corn crake)
Wetlands					
LIFE99 NAT/B/006285	250 ha	40 ha	600 ha	Semois valley	humid grasslands, marshes and fens
LIFE00 NAT/B/007148	70 ha	60 ha	900 ha	Haine valley	reed beds
LIFE02 NAT/B/008590	unknown	100 ha	2,000 ha	Rulles, Sûre & Our	running waters & wetlands (pearl mussel)
LIFE03 NAT/B/	300 ha	80 ha	10,000 ha	Saint-Hubert	peat-lands
INTERREG EMR.INT2.96.09.3.024	220 ha	-	-	Hertogenwald	humid grasslands and hay meadows
Calcareous habitats					
LIFE00 NAT/B/007168	70 ha	40 ha	500 ha	Lesse & Lomme	dry grasslands, scrubs and woodlands
LIFE02 NAT/B/008593	180 ha	80 ha	2,100 ha	Upper Meuse	dry grasslands, scrubs and woodlands

5.1.3. Agri-environmental schemes

Annual subsidies for agri-environmental practices have steadily been increasing since 1996 and reached about 8 million EURO in 2001 (figure 7). The total amount of money for biodiversity measures (e.g. delayed mowing, orchards, hedgerows and ponds conservation) has been multiplied by 5 from 1996 to 2001. The relative amount of money for these schemes however declined from 70% to 30% of the total budget during the same period, in favour of soil protection and joined measures. Studies performed in other countries already suggest that agri-environmental schemes are not always very cost-efficient from a biodiversity point of view (see e.g. KLEIJN *et al.* 2001). In Wallonia, in absence of a thorough biodiversity monitoring programme and a careful scientific evaluation of these management schemes, it is actually difficult to know if we really succeed in yielding biodiversity benefits for the money spent.



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Evolution of the total amount of annual agri-environmental subsidies in Wallonia. Global budget is broken down into four categories according to final purposes: biodiversity, soil protection, combination of previous purposes and preservation of agricultural heritage and old varieties (based on WALOT 2002).

5.1.4. Others

Other initiatives contribute to conservation actions in the field. Council plans for nature development and river basin agreements intend to involve rural actors into a participative process designed to enhance or restore biodiversity at a local scale and to enhance public awareness about nature conservation issues. Delayed mowing of road embankments, fitting out of roofs and church tower for bat and owl populations, installation of nesting boxes for raptors and owls, conservation of old fruit tree varieties, hedgerow restoration are other examples of nature-oriented actions subsidised by the Ministry of the Walloon Region (DGRNE).

5.2. Next biodiversity strategies and action plans

5.2.1. Natura 2000 network

The major future challenging issue in the field of nature conservation in Wallonia will be to adequately design management plans for the 217,500 ha of the Natura 2000 network. It includes the definition of clear management goals and prescriptions for the different sites and species. Moreover, restoration actions will have to be developed for huge surfaces in order to improve the global quality of degraded sites. It will enhance the actions started towards LIFE nature and INTERREG projects for the restoration of semi-natural open habitats. Natura 2000 will also be an excellent opportunity to take care about biodiversity conservation issues in woodland ecosystems, that have often been neglected by conservationists up to now.

5.2.2. Nature action plan

The nature action plan aims at developing a long-term strategy for nature conservation in Wallonia. It will integrate biodiversity related issues through existing initiatives and sectoral policies and identify urgent tools to be developed in the future, using the ecological network as a core concept. Priorities for nature conservation will be identified for several habitat types (forest, wetlands, agriculture, urban areas, etc.) and species action plans will be prepared. This plan is currently in preparation.

5.2.3. Forest biodiversity guidelines and strategy

Forest biodiversity guidelines are currently prepared through a participative process between scientists, policy makers and field practitioners under the initiative of the Nature & Forest Administration and the Belgian Forum on Forest Biodiversity. These guidelines aim at developing an ecological network in forest areas and at defining benchmarks for forest management in the different zones of the network.

Acknowledgements

The authors would like to thank Thierry DEMOL, Marc DUFRÊNE, Fabrice ETIENNE, Violaine FICHEFET, Philippe FRANKARD, Jean-Louis GATHOYE, Pierre GÉRARD, Jean-François GODEAU, Marie-Céline GODIN, Joëlle HUYSECOM, Jean-Paul JACOB, Alain LANGER, Arnaud LAUDELOUT, Hughes LECOMTE, Roland LIBOIS, Grégory MOTTE, Alain PEETERS, Jean-Claude PHILIPPART, Jacqueline SAINTENOY-SIMON, Herman STIEPERAERE, Jean-Pierre VANDEN BOSSCHE, Alexandre VANDENDORPEL, Thierri WALOT and Catherine WARNAFFE who kindly provided useful information for this review chapter.

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Etienne BRANQUART
Louis-Marie DELESCAILLE, Philippe GOFFART
Research Centre for Nature, Forests and Wood
Avenue Maréchal Juin 23
5030 Gembloux

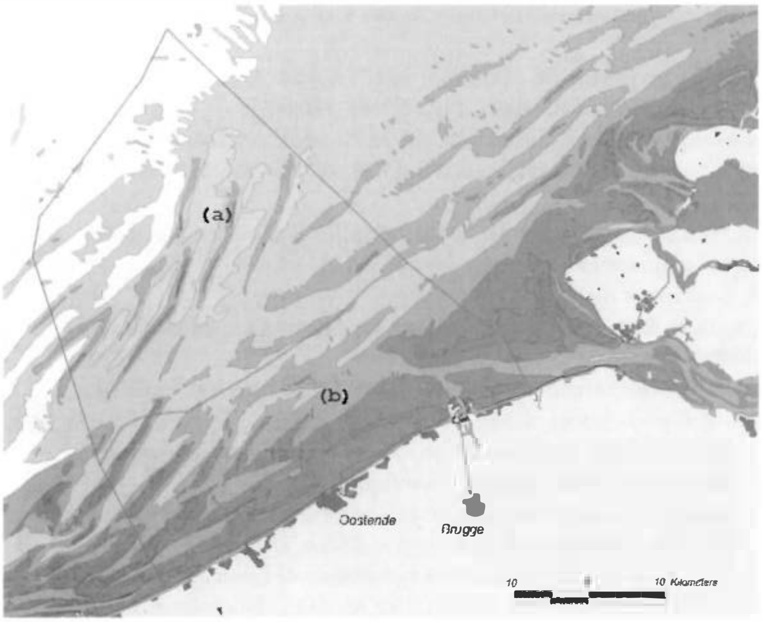
Catherine DEBRUYNE
Nature & Forest Administration
DGRNE
Ministry of the Walloon Region
Avenue Prince de Liège 15
5100 Namur

Biodiversity of the Belgian marine areas

Francis KERCKHOF & Jean-Sébastien HOUZIAUX

1. Introduction

The marine areas under Belgian federal jurisdiction (further referred to as 'Belgian marine areas') are situated in the southernmost part of the North Sea, which is a shallow, semi-enclosed shelf sea that constitutes a 'Large Marine Ecosystem' of the north-eastern Atlantic Ocean. The Belgian marine areas (figure 1) can be subdivided into the territorial sea (12 nautical miles) and the Exclusive Economic Zone (EEZ). They total an area of nearly 3,500 km^2 (MAES *et al.* 2000), which is about 0.5% of the North Sea surface. The maximum seaward breadth of the area under Belgium's jurisdiction amounts to some 87 km. Its average depth is about 20 m, the maximum depth being 45 m. The Belgian coastline is very short, only 65.5 km. The boundaries of the Belgian EEZ coincide with the Belgian Continental Shelf (BCS), the latter term being frequently misunderstood when used to designate the whole Belgian maritime zone, i.e. BCS + territorial sea. The intertidal areas do not fall under federal jurisdiction, but, as they form an integral part of the marine environment, they are taken into account in this text.



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The Belgian marine areas encompass the Exclusive Economic Zone (EEZ, a) and the Belgian territorial waters (b). The boundaries, and thus also the surface, of EEZ and Belgian Continental Shelf (BCS) are identical (adapted from MAES *et al.* 2000, courtesy of the Belgian Federal Science Policy Office).

Belgium's marine areas are characterised by several geomorphological, chemical and physical gradients, determining the ecology of a region that has been affected by human activities throughout history.

The Belgian marine waters are influenced by water masses of different origins. There is an influx of Atlantic water through the English Channel. This 'Channel water' is clear, has a high salinity and a relatively low nutrient content. In the coastal region, there is an input of fresh water through discharges from the rivers IJzer and Scheldt, and from canals. This 'continental coastal water' is characterised by a lower salinity, a high nutrient content and a high turbidity. Both water types remain separated. The strong semi-diurnal tidal currents and the alongshore residual current, flowing towards the north-east, tend to keep the nearshore waters well mixed. The water masses thus display a gradient from well-mixed coastal waters towards more oceanic transparent and less productive offshore waters. The coastal waters are very productive.

A typical feature consists in the existence of a turbidity maximum and high mud contents in the surficial sediments in front of the coast, mainly between Ostend and Zeebrugge. Muddy environments occur in some places and their distribution, driven by local hydrodynamics, is influenced by human intervention at sea such as the construction of the outer wall of Zeebrugge harbour or the navigation channels (FETTWEIS & VAN DEN EYNDE 2003). However, holocene peat and mud layers are also present (BAETEMAN 1999). In the past, the occurrence of this high turbidity zone was ascribed to a closed hydrodynamic system (gyre) in front of the coast with resuspension of local fine sediments (e.g. NIHOUL 1975, GULLENTOPS *et al.* 1976). However, FETTWEIS & VAN DEN EYNDE (2003) could not observe this feature in their sediment transport model. They consider that the local enrichment in Suspended Particular Matter (SPM) is due to a 'congestion' of the general NE-directed transport in front of the Belgian coast, most of the SPM probably originating from the Dover strait.

The Belgian marine waters are important feeding and nursery areas for higher trophic levels such as fish and birds. Especially the well-studied western area of the Belgian coast, with its very shallow subtidal sandbanks, has an important ecological value owing to the occurrence of diverse and abundant benthic communities, which are a food source for many wintering birds.

2. MARINE HABITATS

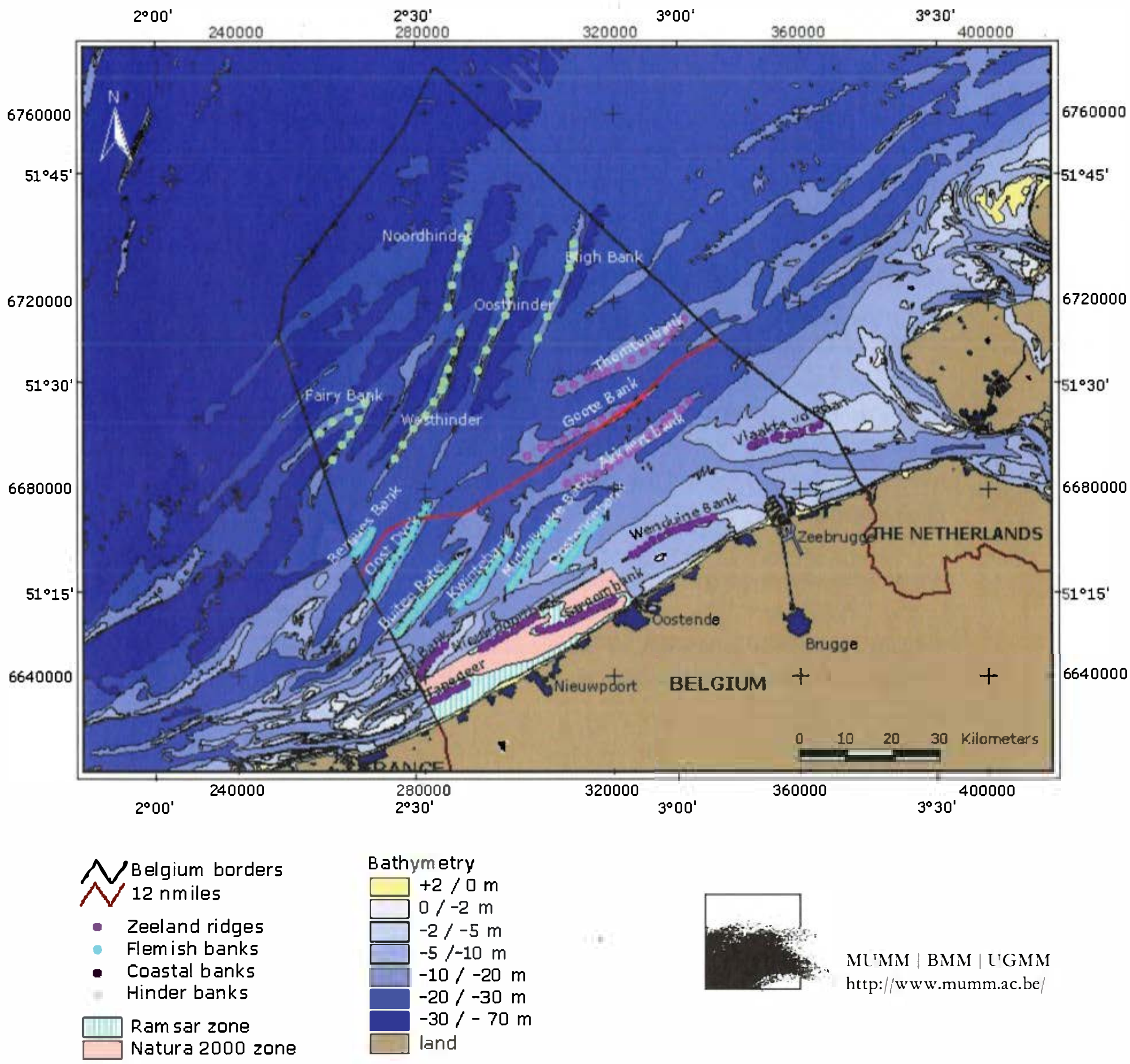
The main natural habitats of the Belgian coast include dunes, sandy beaches and subtidal sandbank systems. The subtidal marine areas and the beaches consist predominantly of deposits of soft sediments, mainly fine to medium sands. Mud fields occur on some places. Natural hard substrata are scarce and poorly documented.

2.1. Soft sediments

The subtidal sandbanks are characteristic for Belgian waters. They form a unique and very dynamic system of elongated megaridges and gullies, subject to relatively strong tidal currents, sometimes surpassing 1.5 m/s.

Four sandbank systems can be distinguished (CATTRIJSSE & VINCX 2001) (figure 2). The 'Kustbanken' (Coastal Banks) are located in the nearshore area. They consist of sandbanks virtually parallel to the coast. They can be subdivided in an eastern and a western group. The tops of a few banks, such as the Broersbank, part of the western group, are uncovered at the lowest spring tides. Further offshore, two more sandbank systems can be recognised: the 'Vlaamse Banken' (Flemish Banks) in the west and the 'Zeelandbanken' (Zeeland Ridges) in the northeast. Finally the 'Hinderbanken' (Hinder Banks) are located further offshore, in the northern part of the Belgian Continental Shelf.

The largest part of the intertidal area consists of sandy beaches (plate 1, b). All beaches have a semi-diurnal macrotidal regime with a spring tidal range of 4.5 to 5 m and a neap tidal



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Bathymetry and sandbanks of the Belgian marine waters (map by S. JANS and L. VIGIN, MUMM / RBINS).

range of 3.7 to 3.9 m (DEGRAER *et al*. 2003). Most beaches are of the ultra-dissipative type, although beaches of the low tide bar/rip type also occur (DEGRAER loc. cit.). They consist mainly of fine sandy sediments. However, for the past decades, repeated beach nourishment for coastal defence works have taken place using coarser sands. This may have resulted in a coarsening of the sands on almost all Belgian beaches.

At some locations along the Belgian coast, small areas with intertidal mudflats, salt marshes and estuaries can still be found. They can be regarded as part of the ecological continuum formerly existing between the land and the sea. These are relics from historical times, when the Belgian coast used to be part of a large 'wadden' area extending from northern France to Denmark and consisting of a remarkable system of tidal mud flats, sand flats, sea gullies and salt marshes, bordered by a series of dune barrier islands. These features can still be found for example in the northern part of the Netherlands (the Wadden Sea).

In the coastal area between Ostend and the Dutch border, zones with more or less unconsolidated mud occur. These unstable habitats, somewhat on the edge between hard and soft substrata, are yet poorly studied.

2.2. *Hard substrata*

Natural hard substrata consist of peat banks (plate 1, d) and solid Tertiary clay banks as well as zones with gravel, pebbles and boulders. All other hard substrata along the Belgian coast are artificial. These include groynes, breakwaters, dikes, harbour walls and jetties, and wrecks (plate 1, a, e & f). They form a habitat for a community typical for rocky shores, with a high species diversity and biomass.

On some beaches (e.g. in Raversijde) it was possible, until recently, to find outcropping peat and clay banks (JOCQUÉ & VAN DAMME 1971). Because of the construction of a lot of groynes for coastal defence and beach nourishment, they have now disappeared under the sand. Such outcropping littoral clay banks were also documented by GILSON (1914), for instance on the beach of Zeebrugge. However, peat and clay banks are still observed offshore. The peat banks are relics of the former 'wadden' area mentioned above.

The existence of zones with pebbles and boulders is poorly documented. They were already mentioned by former authors such as VAN BENEDEN (1883), who describes "boulder fields off Oostende" with a high species richness, and GILSON (1900), who mentioned the occurrence of gravel in the area of the Westhinder Bank. More recently, GULLENTOPS *et al.* (1976), MAERTENS (1989) and DELEU (2002) confirmed the existence of such regions with pebbles and boulders. So far, studies on the fauna of these areas have never been performed in the Belgian waters. A typical and rich epibenthic community has been described in similar habitats in the French part of the North Sea (e.g. PRYGIEL *et al.* 1988, DAVOULT *et al.* 1988), suggesting that a similar fauna could be found in Belgian marine waters. However, the original status of these poorly documented deposits has possibly changed during the last century due to fishery, responsible for the removal and displacement of boulders by fishing gear.

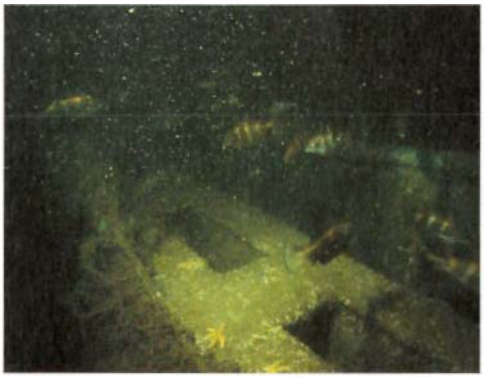
Until the beginning of the 1900s, native oyster beds (*Ostrea edulis*) occurred off the Belgian coast (LANSZWEERT 1868, VAN BENEDEN 1883). Oysters are known to form reef-like structures with rich epifauna. Like almost everywhere else along the coasts of north-western Europe, they have now disappeared, most likely as a result of fishery activities. Another important reef-forming species is the sand mason (*Lanice conchilega*), a tube-building polychaete worm. The sand mason is considered to play an important role in sediment transport by consolidating sand bottoms. The tubes also increase the structural complexity of the bottom, allowing the occurrence of a relatively high species diversity (plate 1, c).

(a)

(b)

(c)

(d)



(e)

(f)

Plate 1

(a) Pier and groyne marking the entrance to the harbour of Nieuwpoort (photograph by M. DECLEER). (b) Example of an ultra-dissipative sandy beach (Zeebrugge) (photograph by M. DECLEER). (c) Patch of tubes of the sand mason, *Lanice conchilega*, in the intertidal zone. Details of the end of the tubes are shown (photograph by M. DECLEER). (d) Holocene peat and clay banks on the beach of Middelkerke (around 1980) with marks of medieval peat cutting/exploitation (photograph by E. COOLS). (e) Pout (= bib, *Trichopterus luscus*) swimming above the Birkenfels wreck (photograph by A. NORRO, MUMM / RBINS). The Birkenfels sunk in 1966 and is already covered with a rich fauna (f): among others the common starfish (*Asterias rubens*, bottom left corner), dahlia anemone (*Urticina felina*, picture centre), common brittle-star (*Ophiothrix fragilis*, orange arms just under picture centre), orange-striped anemone (*Diadumene cincta*, orange-red tentacle ring, bottom right corner), and smaller species of the classes Hydrozoa (probably genus *Tubularia*, top left) and Anthozoa (bottom right) (photograph by A. NORRO, MUMM / RBINS). Some 203 ship wrecks occur on the Belgian seabed, illustrating the importance of these artificial hard substrata for biodiversity.

3. Overview of the Belgian marine biodiversity

Belgium holds a long tradition in marine sciences, in particular biology. The scientific interest for marine life started around the 1850s with pioneers such as F. Lanszweert, P. J. and E. Van Beneden, etc. However, it is only around 1900 that ecological and oceanographic considerations motivated marine biological research, with the work of G. Gilson, sampling not only biota from all compartments of the ecosystem, but also sediments and water (see Gilson 1900). This resulted in a large collection of marine samples not fully exploited yet (van Loen *et al.* 2002). In the following decades, several taxonomists worked on the collections of the aforementioned pioneers, but apart from some fishery and a few planktonic studies, actual contributions to the ecology of the area were virtually absent. It is only in the 1970s that the Belgian authorities developed an integrated marine science project, the first nationally co-ordinated 'Sea programme'. Since then, several research and monitoring projects have been conducted, strongly improving our knowledge of the region's ecology. An exhaustive overview of the Belgian marine biodiversity has however never been performed.

Many marine biota have been studied in Belgian marine areas, the best-studied components being plankton, nekton and, particularly since the mid-1990s, subtidal infauna. Recently, within the framework of the Belgian Federal Science Policy Office programme 'Sustainable management of the North Sea', research in the Belgian marine waters has received a new impulse that will lead to more holistic knowledge of the marine ecosystem. Besides the ongoing studies, less well-known areas, habitats and components are now being addressed. Since many of these studies are in progress, it was not possible to take them fully into account in the following tentative overview. Detailed taxonomic overviews of the flora and fauna recorded so far in the Belgian marine areas are provided in chapters 3 (flora) and 4 (fauna).

3.1. Plankton

Planktonic species are generally defined as organisms living in the water column and depending on marine currents for their horizontal movements. Categories of planktonic organisms are discriminated by size (femto-, pico-, nano-, micro-, meso-, macro- and megaplankton) and by the character of organisms (bacterioplankton, phytoplankton and zooplankton). Phytoplankton ensures the primary production in the water column. Its development is mainly controlled by light penetration, water turbulence, nutrient concentrations and grazing by zooplankton. Zooplankton feeds on phytoplankton and on protistan zooplankton, transferring carbon to higher trophic levels. It can be divided in two main categories: the holoplanktonic species, which spend their whole life in the plankton, and the meroplankton, which consists of larvae of other ecosystem compartments (benthos and nekton). Both bacterioplankton (decomposition) and zooplankton (excretion) ensure the regeneration of nutrients in the water column. Planktonic species of the North Sea are part of the North Atlantic fauna. An overview of plankton ecology in the North Sea is given by Johns & Reid (2001).

The distribution of planktonic species in Belgian marine waters is mainly driven by water masses. In both phyto- and zooplankton, gradients are observed in species composition from coastal waters to offshore Channel waters. The bacterioplankton is still poorly documented and is not considered in this overview.

3.1.1. Phytoplankton

MEUNIER (1913, 1915) performed a first taxonomic characterisation of the phytoplankton of the southern North Sea, largely based on the samples collected by G. GILSON. VAN MEEL (1975, 1976) summarised the phytoplankton spectrum of the years 1951-1953 in the area of the Hinder Banks as largely dominated by diatoms, in particular Bacillariophyceae (average of 80.6% of the total species number) and Dinophyceae (average of 18.2%). The genus *Bidulphia* and *Chaetoceros* are quoted to account for 12 and 25.3% of the Bacillariophyceae biomass respectively. VAN MEEL further mentions the dominance of neritic species in early spring and the dominance of oceanic species during summer in the same area. In winter, the waters are poor in phytoplanktonic species. Two main blooms of diatom species are observed, in early spring and late summer, and are more pronounced in coastal waters. In summer, the densities tend to be lower near the coast and to increase offshore. POLK (1977) gives similar conclusions for the early 1970s. A very detailed analysis of plankton communities formerly occurring in the southern North Sea, including the successions of species in algal blooms, can also be found in LOUIS *et al.* (1974) and LOUIS & SMEETS (1981). M'HARZI *et al.* (1998) observed in winter a predominance of Chrysophyta and Euglenophyta in the area of the western coastal banks, the latter being replaced by Chlorophyta on the more offshore Westhinder bank. They identified 123 phytoplankton taxa.

Since a few decades, a major change has been observed in the composition and biomass of phytoplankton of the southern North Sea. Indeed, a general increase in phytoplanktonic biomass as well as in algal blooms frequency is noted (CADÉE 1986). Extended blooms of the colonial flagellate *Phaeocystis globosa* happen every year, producing large foam (mucilage) accumulations on the beaches. Apparently, such blooms are a natural phenomenon in the North Sea, but they have become more important during the last decades owing to the anthropogenic increase in nutrient inputs (eutrophication process or, more accurately, 'dystrophication'). In spring, a first bloom of diatoms is observed, immediately followed by an extensive bloom of *P. globosa,* which can represent up to 90% of the cell numbers (LANCELOT & MATHOT 1987).

3.1.2. Zooplankton

The highest concentrations of zooplankton are observed about 20 kilometres offshore. The diversity of zooplankton is clearly related to the origin of water masses. Further offshore, in Atlantic waters, the density of phytoplankton is low, whereas the diversity of zooplankton is very high. This zooplankton consists of copepods (Copepoda), larvaceans (Appendicularia) and arrow worms (Chaetognatha). In nearshore waters, the plankton communities are characterised by higher biomass and lower species diversity. Numerically, copepod crustaceans constitute 90% of the overall zooplankton in winter (M'HARZI *et al.* 1998), mainly represented by *Temora longicornis*, *Pseudocalanus elongatus* and *Centropages hamatus*. *Acartia clausi*, *Paracalanus parvus* and *Calanus helgolandicus* are found in smaller abundances. M'HARZI *et al.* (1998) observed differences in copepod species abundances between the Westhinder and the more coastal banks, probably indicating a transition from coastal, mixed waters to

Channel waters. Off the Belgian coast and part of the southern Dutch coast, three communities were recognised, each with a specific distribution related to the (hypothetical) gyre off the Belgian eastern coast and controlled by the run-off water of the Scheldt (HECQ & GOFFART 1996). These communities consist of herbivores such as *Temora longicornis* and *Oikopleura dioica*, found in the neighbourhood of the phytoplankton concentrations. A community of carnivorous species, amongst which *Sagitta setosa* is the commonest together with two cladoceran species (*Evadne nordmanii* and *Podon leuckarti*) occurs more northerly. A community of omnivores, predominantly consisting of *Acartia clausi*, *Euterpina acutifrons* and *Noctiluca miliaris*, can be found in between, off the Scheldt estuary.

3.2. Benthos

The benthos consists of organisms and communities found on, in or near the seabed. These include animals (zoobenthos) and plants (phytobenthos), living on the substrate (epibenthos) or in the bottom (endobenthos), as well as organisms living in the water layer close to the seabed (hyperbenthos). The benthos may be further subdivided on the basis of size into three categories. Large benthic animals caught by grabs or dredges and retained on a 1 mm sieve are collectively referred to as macrobenthos. The meiobenthos includes organisms that pass through a 1 mm sieve, but are retained by a 38 μm sieve. The microbenthos consists of organisms that pass through a 38 μm sieve.

The sampling devices used in benthic fauna assessments play a major role in the definition of invertebrate communities. For instance, most 'macrobenthos' investigations are performed with grabs, which allow quantitative sampling of large infaunal species but are not suitable for the more patchy epifauna. Consequently, most described 'macrobenthic communities' are in fact mainly constituted of infauna. On the other hand, beam trawls and dredges, commonly used to collect larger epibenthic species, are unable to collect the infauna quantitatively. Finally, only special devices such as the 'hyperbenthic sledge' are able to accurately collect animals living near the bottom. These technical limitations have led to the subdivision of the benthic communities in three main compartments, namely 'macrobenthos', 'epibenthos' and 'hyperbenthos', chiefly for practical reasons. The definition of invertebrate communities is thus strongly instrument-dependent and the decision to consider certain species for community analysis is not always obvious. This problem is currently being overcome with recent developments in high resolution acoustic technologies (such as side-scan sonar) and digital imagery, which allow accurate mapping of the seafloor. For instance, BROWN *et al.* (2001) strongly recommend the combined use of grab, beam trawl, acoustic instruments and video recording to accurately map and characterise heterogenous gravelly areas and their benthic communities. Such techniques are also being implemented for the monitoring of important habitats in Belgian waters (see DEGRAER *et al.* 2002).

In an extensive literature review, CATTRIJSSE & VINCX (2001) summarised research on benthos performed by Belgian scientists between 1970 and 1998. In the earlier days, most of the benthic studies concerned the subtidal area focusing on infauna (macro- and meiobenthos) of soft substrata. In general, research efforts in the territorial waters and the Flemish Banks were higher than in other regions. Indeed, most of the monitoring studies were related to activities such as sand and gravel extraction and the dumping of industrial waste occurring in these areas. Owing to their ecological importance, the western Belgian coastal banks were well studied too. The intertidal and subtidal hard substrata received little attention and data concerning the epifauna are scarce. The Belgian sandy beaches have only recently been subjected to a systematic investigation (DEGRAER 1999, DEGRAER *et al.* 2003).

The structural biodiversity of the Belgian marine benthos is well documented for soft bottom meiobenthos (mainly nematodes and harpacticoid copepods) and macrobenthos (mainly polychaetes, bivalves and crustaceans). These stationary communities, easily collected with standard procedures, are directly affected by changes in the environmental conditions such as pollution or climate. Subsequently, they can be considered as bio-indicators of the local environmental quality (DEGRAER *et al.* 2002) and are the target of important research efforts.

3.2.1. General patterns

In their review, CATTRIJSSE & VINCX (2001) were able to identify some general patterns in average species richness and densities, at least for meiobenthos, macrobenthos and hyperbenthos. A positive east-west gradient of species richness occurs in inshore waters. The lower species richness of the eastern areas is possibly related to a lower diversity of habitats (or seascapes), to a higher content of fine particles in both the water column and the sediments and to the freshwater input as well as pollution from the Scheldt. Former authors described a second gradient, perpendicular to the coastline, with larger species diversity in offshore areas. Although not in contradiction with these views, more recent data tend to indicate a more complicated situation. Some environmental parameters such as habitat diversity might indeed be more decisive to explain differences in species diversity than the parameter 'distance from the shore'. On the other hand, it is established that densities are in general highest in the more productive inshore waters.

The review of CATTRIJSSE & VINCX (2001) also highlights large disparities in sampling efforts. For instance, the macrobenthos is better documented in the western coastal banks than in other regions. They also underlined that observations from the 1970s and the 1990s were performed via different procedures. This leads to discrepancies in data analysis and, subsequently, hampers attempts to quantify the long-term evolution, which is an important tool in human impact assessment.

Despite recent intensive research efforts in this field, the benthic biodiversity of the Belgian marine areas is thus still far from being understood. Some of the gaps that became apparent are now addressed in specific research projects. Moreover, certain specific habitats such as the strandlines, the fauna of floating algae and the hyperbenthos of the surfzone are now also being investigated.

3.2.2. Soft sediment benthos

3.2.2.1. Microbenthos

The microbenthos (benthic bacteria, unicellular algae and protozoa) of the Belgian marine areas is poorly studied. Hence, almost no data on the species composition and on the spatial and temporal dynamics of this compartment are available. This is mainly due to the fact that these organisms are difficult to sample. However, microphytobenthos, such as diatoms, is a primary source of nutrition for larger grazers in shallow waters and, suspended by wave action, is probably an important food source for filter-feeding bivalves.

3.2.2.2. Epibenthos

The larger epibenthos, which includes mobile epifauna such as decapods, certain fish and echinoderms, has been monitored since the 1970s. Most data have been collected on commercial species in the framework of fishery investigations and much information remains unavailable. The sessile components of the epibenthic fauna, in particular certain erect colonial organisms such as conspicuous hydroids (e.g. *Sertularia cupressina*, *Hydrallmania falcata*) and bryozoans (e.g. *Flustra foliacea*, *Alcyonidium* spp.) and even sponges (e.g. *Haliclona oculata*) are underrepresented in the samples, and most data are unavailable. Occasionally, the standard macrobenthic samplers catch epibenthic species, but these gear are inappropriate for the sampling of this category of benthic organisms.

3.2.2.3. Hyperbenthos

The hyperbenthos consists mainly of small crustaceans such as mysids, amphipods or cumaceans (permanent or holohyperbenthos), as well as larvae of epibenthic invertebrates and fish (merohyperbenthos). From the beginning of the 1990s, hyperbenthos has received more attention. DEWICKE *et al.* (2003) were able to identify six biotic communities and the earlier views of inshore-offshore and east-west gradients of species diversity were more or less confirmed. High densities of hyperbenthos have been observed in the whole coastal zone, while the highest diversities are found in the open sea, especially in the region of the Flemish Banks. Larvae of decapods and fish dominate in the coastal zone and the latter region. The holohyperbenthos is dominated by mysids (*Schistomysis kervillei, Schistomysis spiritus, Gastrosaccus spinifer* and *Mesopodopsis slabberi)* and is most abundant in the coastal zone. Off the eastern coast, mysids show a remarkable seasonal migration pattern between coastal and more offshore regions. As mysids play an important role in marine food webs, this is a possible illustration of the energy fluxes between the coastal waters and the open sea, which gives way to functional considerations on benthic biodiversity.

3.2.2.4. Macrobenthos

GOVAERE *et al.* (1980) made a first attempt towards a classification of the benthic infaunal communities in the southern bight of the North Sea. They discerned three zones (coastal area, transitional area and open sea) which host specific benthic communities. The macrobenthic biodiversity was found to increase offshore, which confirms the views of pioneers such as GILSON (1900), who considered the area of the Hinder Banks to host the highest numbers of benthic species (VAN LOEN *et al.* 2002).

However, in a recent analysis of data obtained between 1994 and 2000, covering also the macrobenthos of the beaches, VAN HOEY *et al.* (subm.) adjust this coastal-offshore gradient. They suggest a more complex situation, evidenced in areas where a more diversified seabed morphology is found, such as in the western coastal banks. The important habitat parameters of the subtidal communities are currently considered to be depth as well as sediment median grain size and mud content (DEGRAER *et al.* 2002).

Using statistical clustering methods, VAN HOEY *et al.* (subm.) identified four major soft-bottom communities, one intertidal and three subtidal, defined as follows.

- The ***Abra alba-Mysella bidentata* community** occurs in fine sandy sediments with a relatively high mud content. The three dominant taxa are polychaetes, crustaceans and bivalves. It is a very rich community with a high species diversity and density, characterised by the occurrence of the bivalves *Spisula subtruncata*, *Abra alba* and *Mysella bidentata*, the polychaetes *Sthenelais boa* and the reef building sand mason *Lanice conchilega* (plate 1, c), and the crustacean *Pariambus typicus*. This community is dominant in the western coastal zone, especially in the gullies between the coastal and Flemish Banks.

- The ***Nephtys cirrosa* community** occurs in well-sorted, medium sandy sediments with low mud contents. This is a less diverse community with low densities. It is characterised by polychaetes and low densities of bivalves that in some cases are even lacking. The burrowing sea urchin *Echinocardium cordatum* is a typical member of this community. The community is typical for sandbanks further offshore.

- The ***Ophelia limacina-Glycera lapidum* community** occurs in sediment characterised by medium to coarse sand, with an important fraction of shell fragments. This community is found predominantly on the tops of sandbanks. It consists mainly of interstitial polychaetes and is further characterised by a low species diversity and density.

- The ***Eurydice pulchra-Scolelepis squamata* community** is exclusively found high in the intertidal zone of sandy beaches. It is characterised by a low diversity and high densities of the crustaceans *Eurydice pulchra* and *Bathyporeia* sp., and the polychaete *Scolelepis squamata*.

These macrobenthic communities are not isolated from each other and several transitional species associations were found.

3.2.2.5. Meiobenthos

CATTRIJSSE & VINCX (2001) provide a good overview of meiobenthic research performed so far. They conclude that areas with different meiobenthic species richness and community composition can be identified in the Belgian marine waters. Recent research by VANAVERBEKE *et al.* (2000) suggests that sandbanks can be regarded as geographically isolated 'islands'. Indeed, they identified four distinct communities characterised by specific free-living nematode faunas and controlled by sedimentological differences within the studied sandbanks (Flemish, Hinder and Zeeland bank systems).

3.2.3. Hard substrate benthos

Hard substrata, although generally known to host a more diverse flora and fauna than soft substrata, have been poorly studied. Only the intertidal hard substrata were adequately investigated [e.g. DARO 1969, 1970, VAN DER BEN *et al.* 1977 (all three papers on artificial substrata) and JOCQUÉ & VAN DAMME 1971 (peat and clay banks), while DE VOS studied the algae of the (jetty) mole of Zeebrugge e.g. DE VOS (1979)].

3.2.3.1. Artificial hard substrata

The intertidal artificial substrata such as groynes, dykes and other coastal defence works (plate 1, a) are the only places where large benthic brown (Phaeophyta), red (Rhodophyta) and green (Chlorophyta) macroalgae can be found. They harbour a community typical for a moderately exposed rocky coast, characterised by barnacles (*Semibalanus balanoides, Balanus crenatus, Elminius modestus*), dense mussel clusters (*Mytilus edulis*) and occasionally fucoid algae. Many other invertebrates are living in the mussel clusters. The community can be regarded as an impoverished version of the rocky shore communities existing along the coasts of the English Channel (e.g. the French 'Boulonnais' coast). For instance, large brown algae such as *Laminaria* sp. or *Himanthalia elongata*, as well as a zone dominated by red macroalgae, commonly found in the English Channel, do not occur along the Belgian coast. More comprehensive studies are currently ongoing on the flora and fauna of the artificial intertidal hard substrata (ENGLEDOW *et al.* 2001, VOLCKAERT *et al.* 2003).

The subtidal fauna of ship wrecks (plate 1, e & f), never studied before, is under investigation since 2001. SCUBA-diving techniques are used to perform an inventory of the fauna associated to these artificial substrata, generally considered as 'oases' of marine life. These studies have already revealed many species new to the Belgian marine fauna (MASSIN *et al.* 2002).

Finally, the many buoys, used to demarcate shipping routes and subtidal obstacles, form another particular artificial habitat. They are distributed all over the Belgian waters but are more frequent in the vicinity of harbours. Their number is increasing. Recent investigation of the fouling community living on the buoys revealed the presence of several species new to the Belgian fauna and even to the North Sea (KERCKHOF & CATTRIJSSE 2001; KERCKHOF, in prep.). Although these floating objects form a specific habitat, the community living on them has clear affinities with the fouling community on other (mainly man-made) hard substrata such as wrecks and intertidal constructions.

3.2.3.2. Natural hard substrata

DEGRAER (1999) identified a macrobenthic community in outcropping Tertiary clay layers nearby Oostende, which he defined as the *Barnea candida* community. This community is typical for bottoms of firm clay and peat. It has a low species diversity, characterised by boring bivalves such as *Petricola pholadiformis* and *Barnea candida*. This community also occurred formerly in intertidal localities, for example at Raversijde, between Oostende and Middelkerke (JOCQUÉ & VAN DAMME 1971), or along the eastern coast (see GILSON 1914) (plate 1, d). The *Barnea candida* community is considered to be rare. However, it might be more common than believed, especially off the eastern coast (in particular off Zeebrugge) where there are indications of its presence (pers. obs. F. KERCKHOF). The sampling gear commonly used in macrobenthic research do not allow an adequate sampling of this particular community.

An additional macrobenthic community, the 'pebble community with epifauna', might also be present off the Belgian coast, although it was not mentioned at all during the last three decades. Indeed, a "boulder field" hosting a very high epibenthic species diversity (including several sessile erect species and *Ostrea edulis*) is mentioned to occur "off Oostende" by VAN BENEDEN (1883). French researchers, using a 'Raillier du Baty' dredge instead of a Van Veen grab, discerned and described this particular community along the French coasts of the southern North Sea (PRYGIEL *et al.* 1988, DAVOULT *et al.* 1988). The species composition of this community differs drastically from the surrounding sandy sediment communities and shows affinities with the macrofauna of rocky substrata and with the epifauna of ship wrecks. It is a very rich community, with a high diversity of sessile species such as sponges (Porifera), cnidarians (Cnidaria), bryozoans (Bryozoa), and a diversified mobile epifauna of decapods (Decapoda) and echinoderms (Echinodermata). This community certainly occurs in Belgian waters too, as indicated by occasional observations for instance in the region of the Hinder Banks (MAERTENS 1989; GILSON, unpublished data) and off Zeebrugge (pers. obs. F. KERCKHOF).

We can conclude that although the Belgian marine subtidal areas are dominated by fine to medium sand bottoms and, in some coastal areas, by mud fields, it also hosts naturally hard substrata species associations, largely undersampled and poorly known. These probably contribute to a large extent to the overall species richness of the 'natural' Belgian marine fauna, what calls for further research on this topic.

3.3. Nekton

The nekton represents all animals able to move horizontally in the water column independently from currents. These represent the higher trophic levels of the marine food webs and consists of molluscs (cephalopods), fish, turtles, mammals and even some birds (penguins). Apart from some cephalopod molluscs (e.g. *Loligo*, *Sepia* or *Octopus*), the nekton of the Belgian area is largely dominated by fish. The marine mammals will be presented in a separate section.

The fish fauna can be divided in two groups: pelagic species, living in the water column, and demersal fish, living near the seabed. As Belgian marine waters form only a small part of the North Sea, and because of the high mobility of fish, their fauna has to be considered on a larger scale. DAAN *et al.* (1990) recorded 224 species for the North Sea. However, a high proportion of the total fish biomass consists of a limited number of species, most of which are commercially exploited. In chapter 4, some earlier studies on the Belgian marine fish fauna are listed.

The fish fauna of the North Sea is well studied, mainly by fishery research institutes. DAAN *et al.* (1990) identified three fish communities. In the south-eastern community -relevant to Belgian waters- the dab (*Limanda limanda*), whiting (*Merlangius merlangus*), grey gurnard (*Chelidonichthys gurnardus*) and plaice (*Pleuronectes platessa*) are considered to be the most important species.

Other important demersal species are cod (*Gadus morhua*), sole (*Solea solea*), flounder (*Platychthys flesus*) and brill and turbot (*Scophthalmus* spp.). Belgian coastal waters are important spawning grounds and nursery areas for the sole. They also form a nursery area for other commercially important fish species, such as plaice and cod.

In Belgian waters, lacking rocky shores or bottoms, some fish species are almost exclusively found in the vicinity of wrecks. These fish, such as the ling (*Molva molva*), conger eel (*Conger conger*) and tompot blenny (*Parablennius gattorugine*), are considered to be rare. Given the large number of wrecks off the Belgian coast, it is possible that some of them are not as rare as thought. Some species, such as the common goby (*Pomatoschistus microps*) and black goby (*Gobius niger*), are uncommon at sea, but may be locally common in and near ports. Other species, such as the shanny (*Lipophrys pholis*) and butterfish (*Pholis gunnellus*), may occur rather frequently on breakwaters and harbour walls.

It is clear that most elasmobranchs (skates, rays and sharks), which are long living, slowly reproducing predators formerly common in our waters, have severely declined. These fish are generally not targeted by fisheries but are collected as by-catch. WALKER (1998) has evidenced major changes in the population dynamics of North Sea rays. Increased fish mortality is considered to be the cause of observed shifts in species composition, leading to an expansion of species with the lowest age and size at sexual maturity (e.g. starry ray, *Amblyraja radiata*) and severe declines in more sensitive species such as the thornback ray (*Raja clavata*). The common skate (*Dipturus batis*), the largest species of the area, is considered as extirpated from the North Sea since the 1950s (NILSEN *et al.* 2002). For shark species, data are scarce since most fishery statistics do not identify the catch at the species level. But the landings of several species that used to be common in the area have dramatically decreased in the southern North Sea, as is observed elsewhere (HEESSEN 2003).

Most commercial species are far less abundant in the North Sea than they used to be. This is the case for the herring (*Clupea harengus*), mackerel (*Scomber scombrus*), cod (*Gadus morhua*) and plaice (*Pleuronectes platessa*). Herring used to be a very important resource for Belgian fishermen (POLL 1947). The main reason for the decline is overfishing. Although there is no evidence of a major change in species composition in the North Sea over the last century, there is more convincing evidence of changes in size composition. The increasing exploitation of the North Sea fish stocks resulted in a shift towards smaller-sized fish. Overfishing, together with river construction works, habitat destruction and pollution, also led to severe decline or disappearance of all diadromic fish, including the salmon (*Salmo salar*), sturgeon (*Acipenser sturio*), smelt (*Osmerus eperlanus*) and allis shad (*Alosa alosa*).

3.4. Marine Birds

High numbers of sea birds occur in the southern North Sea owing to food availability (e.g. fish and benthic invertebrates). In a study by BirdLife International, the whole region from the north of France up to the Dutch Wadden Sea, including half of the Belgian waters, has been designated as an Important Bird Area (SKOV *et al.* 1995). The importance of the Belgian marine waters as a wintering area became evident once more after the oil spill of the TRICOLOR in winter 2003, when thousands of oiled birds, mainly auks (*Alca torda*) and guillemots (*Uria aalge*), stranded on the Belgian beaches. The Belgian waters, in particular the coastal sandbanks of the western coast, are important for the common scoter (*Melanitta nigra*).

The Channel area, including the Belgian marine waters, is a very important corridor for many migratory species. During the 20th century, the abundance of most species of sea birds have increased in the North Sea, predominantly due to the availability of discards from fishing activities (MC GLADE 2002).

Sea birds are one of the most conspicuous faunal groups and can traditionally boast of a great deal of interest. Because they occupy high trophic levels, sea birds can be used as indicators of changes in the marine environment. Especially after World War II, increasing interest for activities such as sea watching and beached bird surveys arose among various individuals and groups. The results were -if at all- published in a scattered way. In 1992, a sea bird monitoring programme was set up at the Flemish Institute of Nature Conservation, aimed to fill the lack of information on the distribution of sea birds in the Belgian marine waters. This has resulted in various publications (e.g. OFFRINGA *et al*. 1996, SEYS *et al*. 1999, etc.) which emphasised the importance of the Belgian marine waters for birds. At present, the knowledge of the species and numbers occurring seasonally in these waters is good.

In a recent study, SEYS (2001) gives a comprehensive overview of the Belgian marine and coastal birds. During the period 1992-1998, 124 bird species were encountered at sea. Of these, 23 true marine species occur in relatively high densities within the Belgian marine areas. Six out of these 23 were retained as 'focal species', i.e. species that require increased attention due to both insufficient conservation efforts at the international level and a remarkable high abundance in Belgian areas. They include species that attain 1% of the flyway population and are listed in international conventions such as the EU Birds Directive or the Bern and Bonn Conventions. These species are the little gull (*Larus minutus*), red-throated diver (*Gavia stellata*), common scoter (*Melanitta nigra*), Sandwich tern (*Sterna sandvicensis*), common tern (*Sterna hirundo*) and little tern (*Sterna albifrons*). Five species, the great crested grebe (*Podiceps cristatus*), great skua (*Stercocarius skua*), lesser black-backed gull (*Larus fuscus*), herring gull (*Larus argentatus*) and great black-backed gull (*Larus marinus*) were classified as 'locally important species'. These are species that surpass the 1% criterion but are not included in the highest priority lists of the international conventions.

The harbour of Zeebrugge must be mentioned as a particularly important area for terns. Indeed, three species, the Sandwich tern, common tern and little tern, have established breeding colonies there. Apparently, they found in these vast areas new nesting opportunities after their natural nest sites on beaches and in dunes became gradually unavailable as a consequence of, among others, evolving mass tourism (SEYS 2001). Moreover, the importance of the outer harbour of Zeebrugge is also illustrated by the occurrence of a huge breeding colony of the lesser black-backed gull.

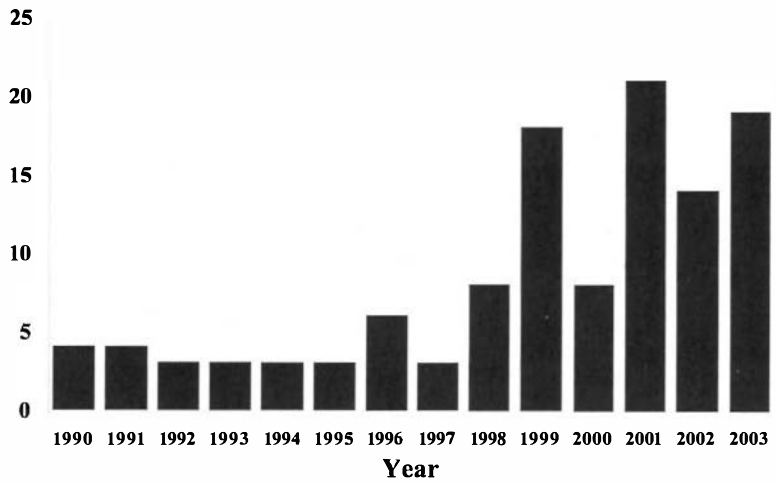
During the study cited above, marked differences in counting efforts were reported between regions and seasons. Most data were collected during winter and autumn, and there were important data gaps for areas further offshore. Attempts are going on to fill these gaps gradually.

3.5. Marine mammals

Marine mammals, as birds, are important top predators controlling the marine food chain with widely distributed populations that can only be protected within international agreements. In Belgium, a large number of historical data on cetacean strandings have been collected by the Royal Belgian Institute for Natural Sciences (RBINS) and published by De Smet (1974, 1981). From these publications, it is obvious that strandings of small, inconspicuous but perhaps common cetaceans were usually not documented, whereas the stranding of larger toothed whales or baleen whales, most of which do normally not occur in the southern North Sea, received a more widespread media and public attention. Stranding records have been systematically gathered from the late 1970s by Van Gompel (1991, 1996), while the RBINS has coordinated technical interventions and collected specimens.

In 1992, an intervention network was established with the aim of meeting specific obligations of the Belgian government in the framework of the North Sea Conferences and ASCOBANS (Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas, Bonn, 1997). This interdisciplinary network is responsible for the scientific investigations on both marine mammals and sea birds washed ashore or by-caught in Belgium.

Only five species of marine mammals can be considered indigenous in the Belgian part of the southern North Sea: the harbour porpoise (*Phocoena phocoena*), white-beaked dolphin (*Lagenorhynchus albirostris*), bottlenose dolphin (*Tursiops truncatus*), harbour seal (*Phoca vitulina*) and grey seal (*Halichoerus grypus*). Other species are regarded as irregular visitors or stragglers.



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Number of harbour porpoises, *Phocoena phocoena*, washed ashore per year in Belgium from 1990 to June 2003.

The bottlenose dolphin is nowadays only rarely encountered off the Belgian coast as well as in the whole southern North Sea, leading to the conclusion that the species can be considered as 'extinct' there. Groups of white-beaked dolphins are regularly observed, predominantly offshore. The harbour porpoise became rare during the second part of the 20th century, but the number of observations (inshore and offshore) as well as the number of strandings has been rising again since 1995 (figure 3).

During the early 20th century, harbour seals were commonly encountered on beaches. Since then, the species virtually disappeared from Belgian waters. Nowadays, adults are occasionally observed at sea and in harbours, and each year, in summer, five to twenty pups, originating from colonies present in France, the United Kingdom or the Netherlands, wash up on the shores in Belgium. Adult grey seals are less common in Belgium than harbour seals, although a small number of grey seal pups wash ashore each year in winter.

In the years 1988-1989, an estimated 72% of the North Sea population of harbour seal was affected by a morbilivirus, the 'Phocine Distemper Virus' (PDV), leading to mass stranding events (see JAUNIAUX & COIGNOUL 2001). In 1998, and even more remarkably in 2002, a new morbilivirus infection led again to a dramatic increase in the numbers of stranded common seals. The causes for such epidemiological disasters are still unknown. So far, there is no evidence that the body burden of micropollutants, known to weaken the resistance of the populations to such infections, is involved. Similarly, fishing practices, by affecting the number of individuals in the population, may be involved but their role as facilitator can hardly be evidenced.

4. Main threats to the Belgian marine biodiversity

Marine biodiversity worldwide is threatened in many ways. During the past 50 years, the composition and organisation of the ocean's biota and of their habitats underwent dramatic changes owing to increased human activities at sea and significant climate change. This is especially the case in coastal zones and shelf seas where the direct and indirect disturbances, resulting in a general deterioration of the environment quality, are concentrated (GRAY 1997). These areas are highly productive as compared with the open sea. Losses of species and habitats in coastal areas have therefore a high impact on the marine biodiversity as a whole.

The coasts of the shallow southern North Sea, surrounded by densely populated developed countries, are a good example of such a very productive but intensively exploited coastal zone. This region produces several consumption goods and plays an important role in the socio-economics of its surrounding countries, in particular Belgium.

The Belgian marine areas have been intensely used for several purposes since long. As a consequence, no region of the Belgian marine waters can actually be considered as pristine. Furthermore, local impacts on marine biodiversity are superimposed on larger-scale impacts and natural variability, making it difficult to identify cause-consequence relationships. Observed changes cannot be attributed to one single cause and should be regarded as the result of a cascade of adverse effects.

4.1. Human activities at sea and their impacts

The main activities occurring in the Belgian marine area and their main effects can be summarised as follows (see also MAES *et al.* 2000).

4.1.1. Fisheries

Fishing has been an important activity along the Belgian coast for centuries (figure 4). But since the beginning of the 20^{th} century, a sharp increase of its impact on all levels of marine life has resulted from several technological innovations. The main fishing method currently


4

On the left, a decked 'cutter', typical for Belgian offshore fishing around 1900, landing its fish. Note the large beam trawl equipped with a wooden beam (archives of G. GILSON, RBINS). On the right a modern powerful fishing vessel operating two beam trawls in parallel (photograph by the Aerial Surveillance Unit of the MUMM / RBINS).

used in Belgian waters is beam trawling, targeting demersal fish and brown shrimp (*Crangon crangon*). The trawling intensity is very high, especially inshore. Apart from the general, well-known environmental problems generated by fisheries such as overexploitation of target species, threats to sensitive by-catch species, or increase in populations of resistant, short-living and opportunistic species, the beam trawl specifically has strong adverse effects on the sea bottom (LINDEBOOM & DE GROOT 1998, LAVALEYE *et al.* 2000). Beam trawl tracks can be observed on sandy bottoms several days after fishing. It is therefore also considered as a very important threat to sensitive benthic habitats and biological associations, especially those related to reef or bank-forming species ('structuring' species). In coastal areas, JACKSON *et al.* (2001) showed that ecological extinction caused by overfishing always precedes all other pervasive disturbances. They stated that overfishing was the initial factor in the deterioration of coastal ecosystems worldwide. Thus, adverse effects due to other causes such as pollution, degradation of water quality or (anthropogenic) climate changes are favoured, if not amplified, in overfished areas.

4.1.2. Chronic pollution

The sea is the ultimate recipient of pollutants from activities carried out by man. They reach the sea from land-based activities (80%) through river runoff (mainly the Scheldt in Belgium), atmospheric deposition, direct discharges and maritime traffic (oil spills and operational ship-borne pollution). Several organic and inorganic micropollutants are produced intentionally or as by-product and accumulate in living organisms (bioaccumulation) and food chains (biomagnification). When high tissue concentrations are reached, several adverse effects occur (reproduction impairment, endocrine disorders, genetic mutations, increased sensitivity to natural diseases, etc.). They lead to a general weakening of populations of sensitive species, in particular the highest trophic levels (larger fish, birds, mammals) making them more vulnerable to other human pressures but also to natural events such as diseases or unusual climatic conditions. However, their effects may vary considerably from one species to another and are generally difficult to identify because of the interaction of several other factors affecting biodiversity.

4.1.3. Eutrophication

An increased load of land-based nutrients (N, Si, P), originating from transboundary sources (SW Atlantic, Rhine) and, to a lesser extent, from local riverine inputs (in Belgium, Scheldt and IJzer), is responsible for strong eutrophication problems in coastal areas of the southern North Sea. Since the 1970s, increasing algal biomasses have been reported to result from the increased nutrient content of the coastal waters. Furthermore, anthropogenic nutrient sources lead to changes in the nutrient balance (in particular N/P ratio) in the water column and, consequently, in the species successions normally occurring during blooms. Blooms of phytoplankton species harmful to marine animals and humans (such as *Gyrodynium*, *Dinophysis* or *Alexandrium*) have caused much concern. Since the 1970s, an increase in the bloom frequency of the colonial flagellate *Phaeocystis globosa* also seems to occur. This species is not grazed by the zooplankton. The large quantity of ungrazed algae, resulting from the larger biomasses and higher bloom frequency, increase the quantity of organic material decomposed in the water column or on the bottom. This leads to severe oxygen depletion in some areas of the North Sea (such as the German bight) responsible for mass mortalities in invertebrate and fish species. Several studies reported also an increase in biomass of benthic organisms especially in coastal waters although these effects have not been reported for the Dutch coastal waters (LAVALEYE *et al.* 2000).

4.1.4. Sand and aggregate extraction

Besides fisheries, the only other natural resources exploited in Belgian marine waters are minerals. Although several areas were designated for sand extraction, most of the sand has been extracted from the Kwinte Bank. Considerable amounts of sand and gravel are landed each year and used for building and beach nourishment. This activity locally affects the benthic communities. Generally, organisms living in the highly dynamic environment of sandbanks are able to withstand high level of environmental disturbance by waves and currents. However, the sand and gravel extraction activities form an additional stress factor. Currently, the demand for aggregate extraction is increasing.

4.1.5. Dredging and dredge spoil dumping

The eastern Belgian coast is subject to extensive maintenance dredging operations to remove large sediment accumulations occurring in ports and navigation channels. The large quantities of dredged material resulting from these activities are dumped back in the sea in specifically designated areas. This practice locally increases the mud content of the surface sediment, which directly affects the local benthic communities. On a larger scale, dredging and dumping increase the turbidity in the water column and allow the resuspension of contaminants such as trace metals initially trapped in the sediment, making them available to the trophic chains.

4.1.6. Alien species introductions

Introduction of non-indigenous species (plate 2) takes place in different ways. The southern North Sea is one of the most frequented maritime routes in the world, and Belgium hosts two major ports: Zeebrugge and Antwerp. This leads to the import of several non-indigenous species by ships in ballast waters or as fouling. Leisure navigation and marinas also contribute to this phenomenon. Another source of introductions is the mariculture, since undesirable non-indigenous species are also imported together with the target species. Climate change may also lead to the extension of the geographic distribution of species not found in the area before. Most alien species cannot find an appropriate ecological niche to survive. However, a few species that are able to settle down can colonise the area and enter into competition with local species.

4.1.7. Coastal defence, harbour works and coastal constructions

Man-made constructions have a strong impact on the coastal hydrodynamics and sediment balance. They have negative consequences in subtidal and intertidal habitats, but also on land (dunes). Furthermore, they represent artificial habitats allowing many non-indigenous species to settle down. As a result of continuous and ongoing beach nourishment on nearly all the Belgian beaches, the natural sediments have been replaced by coarser sand, more appropriate for coastal defence. The effects on the beach fauna are unknown since the study of the Belgian beach fauna started only after the sand suppletions. On the other hand, those artificial substrata are colonised by typical flora and fauna. In harbours, harsh conditions prevail and favour the development of resistant, often non-indigenous species.

4.1.8. Recreation

The Belgian coast is also an important recreative area in summer. Activities take place at sea, on beaches and in dune areas. High disturbance levels are known to have negative impacts on the local populations of marine mammals. A very large portion of the Belgian coast is covered with constructions developed to the detriment of dunes and other important natural features, fragmenting coastal habitats and affecting the land-sea sediment balance. The extreme population increase in summer also affects the microbiological quality of the coastal waters. A particular problem is the ecological impact of mechanical beach cleaning, which is carried out by many local authorities to keep popular beaches clean. The frequent removal of natural strandline detritus, even in winter, and the disturbance of the sand by raking has led to the almost complete disappearance of the specific flora and invertebrate fauna of the strandline. This practice also prevents the natural formation of embryonic dunes.

4.1.9. Storage of WWI chemical weapons

About 100 to 500 tons of toxic material is estimated to be present in the 'Paardenmarkt', a shallow area situated east of Zeebrugge where 35,000 tons dumped German ammunition dating from World War I lay since 1919. An important layer (2-4 m) of anoxic sediment has covered the weapons following natural sand transport and preserves them from corrosion by sea water. Two types of chemical weapons constitute the main environmental threat: the 'mustard gas' (Yperite), a blistering agent, and the vomiting agents 'Clark I' and 'Clark II'. Although responsible for severe acute intoxication, it is unlikely that the mustard gas could cause important environmental damage. On the contrary, the hydrolysis of 'Clark' reagents will lead to the release of organic and inorganic arsenic, a severe poison threatening marine wildlife (FRANCKEN & RUDDICK 2003). Fishing activities and ship species mentioned above, four species are only known as vagrant. Three of these species, with several populations in Flanders, originate from the Mediterranean region.

Of the original dragonfly species of Flanders, 16% are extinct, 34% are more or less threatened, 10% are rare, 4% are not well known and 36% can be considered as not threatened (DE KNIJF & ANSELIN 1996). The occurrence of Red List species shows that the most diverse dragonfly fauna is located in the central and eastern part of Flanders (province Antwerp and Limburg). Nevertheless, they occur over the whole Flemish territory. Species threatened with extinction require high quality habitats and their distribution is almost limited to the provinces Antwerp and Limburg, where relatively large and undisturbed nature entities including brook valleys and several oligotrophic pools can still be found. The Red List species labelled as threatened are found in the same area. Species found outside those provinces all correspond to *Coenagrion pulchellum*, *Cordulegaster boltonii* and *Sympecma fusca*. The species belonging to the Red List category vulnerable are more widespread compared with the former two Red List categories. The distribution of the species belonging to the Red List category rare is historically limited to the provinces Antwerp and Limburg, exception made for *Calopteryx splendens*.

During the past 15 years, eight species of dragonflies with a 'normal' distribution in the south of Belgium were observed more frequently: *Lestes barbarus*, *Coenagrion scitulum*, *Aeshna affinis*, *Anax parthenope*, *Orthetrum brunneum*, *Crocothemis erythraea*, *Sympetrum meridionale* and *Sympetrum fonscolombii*. Up to the beginning of the 1990s, those species were observed occasionally, but they are now present every year in Flanders, including several observations of reproduction.

Legal protection and international importance

The Royal Decree on Nature Conservation protects all dragonfly species. Three species extinct in Flanders are listed on the Red List of species threatened at the global level (IUCN 1996). The species mentioned in the annexes of the Bern Convention and of the EU Habitats Directive are no longer present in Flanders.

2.5.5. Dolichopodid flies

In contrast to well-known and frequently collected invertebrate groups such as butterflies, dragonflies, ground beetles and spiders, most dipteran families including long-legged or dolichopodid flies are quite obscure, even to most entomologists. Nevertheless, dolichopodid flies show all the features that make this family especially suitable for bio-indicatory purposes (high species richness, distinct habitat affinity, high sensitivity to environmental alterations). POLLET (2000) states that a total of 295 species has been established in Belgium with certainty, 260 of which occur in Flanders. A complete species list is given by the author. Of these species, 22 are extinct in Flanders, 10 critically endangered, 14 endangered, 16 vulnerable, 86 susceptible or rare, 39 insufficiently known and 73 are considered safe/at low risk.

The dolichopodid fauna of salt marshes is by far the most threatened in Flanders with 68% of threatened and/or rare species. In reed marshes and other marshlands, moderately to very humid woodlands, coastal dunes and humid heathlands, threatened and rare species constitute one-third or more of the entire dolichopodid fauna, which makes these habitats among the most valuable in Flanders. Nearly all threatened and rare salt marsh species are typical for this habitat, whereas characteristic heathland and coastal dune species make up about half of the threatened and/or rare species in these habitats.

Legal protection and international importance

Neither the European, Belgian nor Flemish legislation foresee the protection of dolichopodid flies.

2.5.6. Spiders

The Red List of spiders in Flanders (MAELFAIT *et al.*, in preparation) mentions 604 species out of about 700 species for Belgium. About half of the 592 species are not threatened, 9% are threatened with extinction, 14% are threatened and 10% are vulnerable. Another 10% of the species are rare, whereas 1% is extinct. A Red List for the family Lycosidae was prepared by ALDERWEIRELDT & MAELFAIT (1992).

Because of their numerousness and their occurrence in all biotopes, spiders are excellent organisms to measure the quality of the environment (MAELFAIT & BAERT 1997). With the exception of the water spider (*Argyroneta aquatica*), all spiders are terrestrial and occupy a vast range of biotopes. The species most at risk are found in the sandy habitats of eastern Flanders (Kempen) and in the coastal dune areas.

The wasp spider (*Argiope bruennichi*) appeared in Belgium for the first time around 1870. The spider's distribution has slowly extended northwards and, since the 1980s, has reached its most northern distribution in Flanders. Its expansion occurs through the valleys of the main waterways and their tributaries, as is typical of southern species progressing northwards. Although its opportunistic behaviour of colonising man-made habitats has enabled its progression, the species remains vulnerable due to the unstable characteristics of its habitats (PUTS 1989).

Legal protection and international importance

The Royal Decree on Nature Conservation protects four species of spiders in Flanders: the wasp spider (*Argiope bruennichi*), purse-web spider (*Atypus affinis*), raft spider (*Dolomedes fimbriatus*) and water spider (*A. aquatica*). The latter three species belong respectively to the Red List categories vulnerable, critically endangered and vulnerable. There are currently no native spiders listed in the annexes of the Bern Convention and EU Habitats Directive.

2.6. *Higher plants*

Historically, 1,416 species of higher plants belonging to the wild flora have been observed in Flanders (BIESBROUCK *et al.* 2001). Of these, 1,039 species belong to the original native flora, while 358 were introduced by man and became naturalised (VERLOOVE 2002). Nineteen species have an uncertain status. Of the exotic species, 115 were introduced after

On the other hand, some scavengers and predators have increased. This is the case for some crustaceans, such as the hermit crab *Eupagurus bernhardus*, and gastropods, such as the netted dog whelk (*Nassarius reticulatus*), as well as the common starfish (*Asterias rubens*). During the past decades, another hermit crab, *Diogenes pugilator*, became extremely common. This species has taken advantage of the warming up and has spread more to the north. It uses empty shells of small gastropods for protection, in most cases the shells of *Nassarius*. To what extent the appearance of *Nassarius* might have benefited the occurrence and spreading of *Diogenes pugilator* by providing shelter remains an intriguing question.

4.2.2. Eutrophication

The most striking effects of eutrophication in our waters are the phytoplankton blooms in spring and, to a lesser extent, also in autumn, in particular the yearly occurrence of *Phaeocystis globosa* (see section 4.1.3.). TUNGARAZA *et al.* (2003) conclude that the succession of the diatoms and *Phaeocystis* blooms in the southern bight of the North Sea is controlled by the concentrations of silica and ammonium in the water. The silica concentration is the limiting factor for the diatoms, which use it for the constitution of their exoskeleton, while the level of ammonium controls the prevalence of diatoms or *Phaeocystis* for nitrogen uptake. It seems that *Phaeocystis* blooms, to a large extent not grazed by the local zooplankton species (GASPARINI *et al.* 2000), have become more important during the last decades, although evidences of earlier explosive blooms in the North Sea exist (VAN MEEL 1975, CADÉE & HEGEMAN 2002).

An example of a species of a higher trophic level thriving in eutrophic habitats is the clam *Corbula gibba*, which is currently spreading worldwide, mainly in eutrophic harbour environments. Although indigenous to Europe, it has been recently introduced in several harbours and estuarine environments of the southern North Sea (Zeebrugge, Dunkerque and the Scheldt estuary) (KERCKHOF 1998).

4.2.3. Hazardous substances

Biodiversity effects induced by organic and inorganic pollutants have not been reported as such from the Belgian marine areas. Indeed, the typical effects of contaminant families vary greatly from species to species and synergistic or antagonist effects may occur between different compounds. The real dose-effect relationship is therefore often very difficult to establish. Environmental risk assessment largely relies on the definition of 'acceptable' levels of the various compounds based on their toxicological effect in laboratory experiments. Due to their high trophic position, marine mammals and birds tend to accumulate high quantities of pollutants and are therefore subject to several ecotoxicological investigations and monitoring procedures. Lower trophic levels such as invertebrates or fish are mainly monitored within the framework of seafood safety programmes.

One of the most striking examples of the potential effect of high body burdens of pollutants is the case of the antifouling agent tributyltin (TBT), an additive in ship paints. TBT is responsible for the appearance of a phenomenon known as 'imposex', being for example the development of male sexual organs in females in some invertebrate species, and leading to dramatic changes in their sex ratios and a subsequent population decline (OSPAR Commission 2000). The most obvious consequence of the occurrence of this antifouling agent in sea water was the complete eradication of the dog whelk (*Nucella lapillus*) in Belgian waters. This mollusc was once a common predator on the groynes along the Belgian coast but disappeared during the first half of the 1980s (KERCKHOF 1988). There are no signs of recovery yet. So far, the consequences of the loss of this important predator have not been studied. But many other species, invertebrates as well as vertebrates, show effects of TBT and the decline of some of them, e.g. the whelk (*Buccinum undatum*), could at least partly be attributed to the use of this antifouling agent. At present, TBT is still being used as ship paints additive, but should soon be banned within agreements at the level of the International Maritime Organisation (IMO) (NILSEN *et al.* 2002).

Well-studied substances like trace metals and organic micropollutants, such as polychlorinated biphenyls (PCBs) or poly-aromatic hydrocarbons (PAHs), have been listed in international agreements as priority substances, the emissions of which must be lowered. For these and other more recently recognised substances (for instance dioxin-like compounds), measures have resulted in a general decrease in the emissions (NILSEN *et al.* 2002) as well as in the levels measured in marine fauna (e.g. VINCKE *et al.* 1999, GUNS *et al.* 1999, ROOSE *et al.* 1998). However, other substances for which long-term effects on living organisms are poorly documented, such as volatile organic compounds (ROOSE & BRINKMAN 2000), endocrine disruptors or brominated flame retardants (NILSEN *et al.* 2002), still threaten marine life.

The monitoring of such 'cocktails' of anthropogenic contaminants in the marine environment and food chains calls for a battery of expensive laboratory analyses, although their overall effects are largely unknown. Therefore, cost-effective analysis techniques aimed at measuring the biological effects of contaminants rather than the levels of individual compounds are increasingly popular and currently attract a great deal of innovative analytic research in Belgium and elsewhere.

4.2.4. Sand and gravel extraction

The effects of sand extraction on the benthic fauna, especially on the Flemish banks, and more specifically the Kwinte Bank, have been investigated in some studies. The continuous extraction activities since 1977 on the Kwinte Bank (BAETEMAN 1982) have resulted in a clear depression in the centre of the bank and also in a coarsening of the grain size (BONNE 2003). This author was able to demonstrate a clear impact of sand and gravel extraction on the meiofauna. By comparing data on the species composition of benthic harpacticoid copepods on the Kwinte Bank sampled between 1978 and 1997, BONNE found drastic changes both in sediment characteristics and in the associated copepod communities. In the centre of the sandbank, the copepod diversity decreased and a shift was recorded from a species-rich northern community to a less diverse southern community with more interstitial species instead of epi- and endobenthic species, obviously related to the changes in sediment characteristics. On the other hand, the author could not demonstrate changes in the community structure of the macrobenthic fauna of the Kwinte Bank. This was due to differences in sampling methods between the different sampling campaigns and because they were not designed for long-term investigation of the macrobenthic fauna.

Hot spots for stone-growing lichens mainly correspond to old artificial stone substrates such as found in old churches and graveyards. Because of the buffering effect of the substratum, these species suffer less from the acidic effect of air pollution.

Legal protection and international importance

Only the species of the subgenus *Cladina* (reindeer moss) are protected against harvesting, transporting and exporting for commercial purposes under the Flemish law (Annex C of the 1976 Royal Decree on the protection of wild plant species). The EU Habitats Directive protects none of the lichens present in Flanders.

2.9. *Macrofungi*

In 1999, Walleyn & Verbeken produced a documented Red List of macrofungi in Flanders. Due to the very large number of species and because sufficient information is not available for a number of groups, the authors only used groups for which they had relevant information to carry out quantitative judgements. These groups consist of 552 native species observed in Flanders. It is estimated that they correspond to about 20% of the total species of macrofungi. In the groups studied, 8% of the species are currently extinct (43 species) and 47% of the species still present are on the Red List (46 threatened with extinction, 66 threatened, 118 vulnerable, 35 rare and 32 in decline and probably threatened because they are found in rare to very rare biotopes). This means that only one-third of the macrofungi species can be considered as not threatened.

Walleyn & Verbeken (1999) also describe trends and threats in relation to macrofungi: the decline seems to be higher within ectomycorrhizal species (only 32% of species are considered as safe) than within saprophytic species (40% are safe). The decline of the mycoflora is a widespread phenomenon, with eutrophication probably being the main underlying cause. Species of poor grasslands, marshes, peat bogs, wet heathlands, coastal dunes and most of the forest types are particularly threatened. Numerous ectomycorrhizal fungi appear to be banished from forest areas to poor grassy roadsides or parks. The adequate management of these mycorrhizal refuges is necessary for the conservation of threatened species. Conservation actions include: the increase in the volume of dead wood, the protection and appropriate management of sites with a high number of Red List species, a more frequent burning of logging waste *in-situ*, the plantation of indigenous tree species rather than exotic ones, and the conservation and/or development of endangered habitats. A significant reduction of soil eutrophication is of paramount importance.

Legal protection and international importance

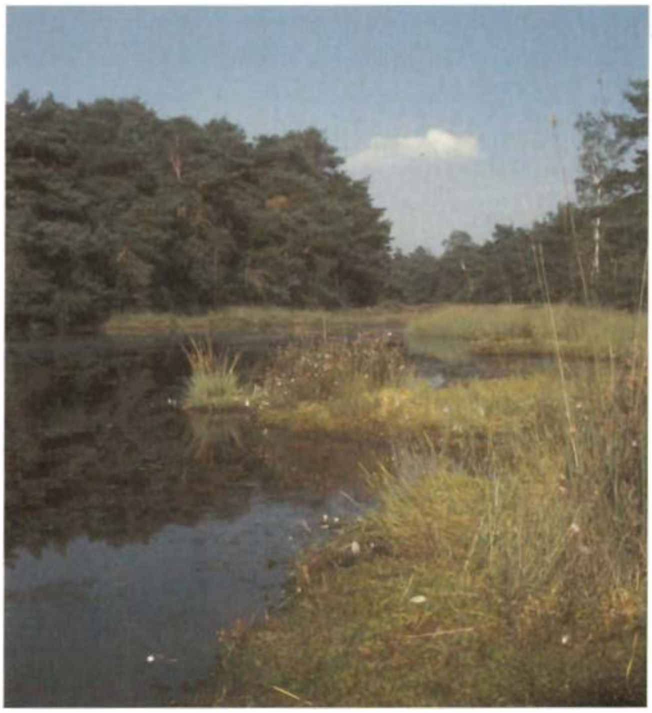
None of the Red List macrofungus species in Flanders are protected. The only protection macrofungi enjoy in Flanders is the ban to harvest them in most nature reserves and areas listed in the Flemish Forest Decree. At the European level, there exists a European list that is not connected to any legislative instrument.

3. Ecosystems and areas of high biological value

The description of the Flemish biotopes is based on the Biological Evaluation Map for Flanders and on derived land use maps. Table 3 summarises available information for the main biotopes found in Flanders. As a region is often described as a complex of mapping units, it is difficult to give a precise estimation of the surface area of a biotope and data are presented as 'minimal area' and 'maximal area'.

Table 3. Surface area of the main (semi-)natural biotopes in Flanders (after Van Landuyt *et al.* 1999).

Biotope	Minimal area (ha)	Maximal area (ha)
Heathlands and fens	9,800	18,400
Marshes	5,800	15,400
Wetlands	8,925	11,985
Dunes	1,440	2,940
Semi-natural grasslands	4,640	8,870
Species-rich grasslands	9,270	11,450
Grasslands with disseminated biological value	29,050	42,630
Pioneer vegetation	3,750	6,610
Scrubs	585	985
Mesophilic forests	22,550	56,410



2

Forest fen with *Sphagnum* and purple moor-grass, *Molinia caerulea*. Koersel, Province of Limburg (photograph by J. Packet, Institute of Nature Conservation).

appearance of this species in the *Abra alba* community are not well understood nor even studied, but its appearance certainly has consequences on the abundance of other invertebrates. Indeed, bivalves like *Cerastoderma* spp., *Tellina* spp. or *Mactra* spp., all species that used to be common, have now apparently declined, although the relationship with the explosive expansion of *E. directus* has not been evidenced so far. Therefore, long-term monitoring of some habitats as well as the development of more accurate sampling strategies is needed.

During the last decades, the intertidal hard substrata of the Belgian waters also underwent important changes. Two of the most commonly observed organisms on artificial substrata, the New Zealand barnacle, *Elminius modestus*, and the pacific oyster, *Crassostrea gigas*, are in fact alien species (plate 2, b & c). The introduction of *E. modestus* in European waters took place during World War II. It is now the most common barnacle on artificial substrata along the Belgian coast. But even more striking is the recent explosive population increase of the pacific oyster, *C. gigas*. This species, although already introduced earlier in the 1970s for mariculture purposes, established stable wild populations in the early 1990s, obviously favoured by an increase in temperature. Now, pacific oysters can be found in huge numbers on groynes, all the offshore buoys and in harbour environments, where they often form reefs. The population increase of this newcomer causes concern since it could result in the substitution of the original mussel community by a pacific oyster community, which would have dramatic effects on the local fauna. On the other hand, pacific oyster reefs may by no means be regarded as an alternative for the reefs of the indigenous flat oyster, *Ostrea edulis*, which disappeared from the area. *Crassostrea gigas* is indeed mainly an intertidal species, while *Ostrea edulis* used to live offshore in a very specific subtidal habitat.

Another striking example is the recent increase in numbers of the slipper limpet, *Crepidula fornicata* (plate 2, d). This species has been introduced into Europe from North America at the end of the 19th century. In Belgian waters, it was already present in 1911 (POLK 1962). The slipper limpet is now extremely common, not only on hard substrata, but also on offshore soft sediments where it lives attached to substrata such as empty shells and behaves as a filter feeding bivalve. In the latter habitat, it recently underwent an explosive expansion, a feature also noted along other western European coasts (e.g. France). It is thought that bottom trawling practices favour the development of this species (HAMON 1996).

Harbours, with their many man-made constructions and harsh conditions, constitute a special environment characterised by a low species richness and by the dominance of species well adapted to environmental stress. In such conditions, several opportunistic alien species can thrive. This is also the case in Belgian harbours where alien species dominate the species associations. During preliminary studies, about 30 alien species were identified. But more specific research of the fauna and flora of the Belgian ports would certainly reveal the presence of many more non-indigenous species.

Even tourist activities play a major role in species introductions. Indeed, some large marinas exist along the Belgian coast and increasing yachting and sailing activities certainly favour the spreading and (secondary) introduction of fouling alien species. Recent examples are the barnacle *Balanus amphitrite* (KERCKHOF 1996) and the Indo-Pacific macro-alga *Undaria pinnatifida* (DUMOULIN & DE BLAUWE 1999).

Surprisingly, there are no known cases of species disappearing in the North Sea as a result of exotic species introductions, as is the case in freshwater environments and estuaries. Even the American piddock *Petricola pholadiformis*, which was introduced a long time ago and lives in the same environment as the native piddock *Barnea candida* (namely peat and clay banks), was not able to outcompete the latter, although it was frequently argued that this would happen. Another example can be found within the barnacle fauna. From the five common species found nowadays, three are non-indigenous. The newcomers have restricted the occurrence of the indigenous species but none of the native species have disappeared (Kerckhof 2002). However, the newcomers tend to reduce the populations of local species, which might then be more sensitive to other environmental stresses.

It may be argued that the introduced species increase biodiversity e.g. in the harbour environments. But the newcomers are usually fast-growing species that are able to withstand disturbance and pollution. The above-cited species *Crassostrea gigas, Ensis directus, Crepidula fornicata, Elminius modestus* and *Balanus amphitrite* are all examples of such opportunist species. They feel very much at home in environments created or heavily influenced by man, such as harbours and coastal areas. Such disturbed areas are highly suitable for relatively undemanding immigrants, affecting the distribution of indigenous species or, in the worst case, even displacing them. Consequently, there is a worldwide risk that marine flora and fauna will become similar and the regional differences blurred. So, even if introduced species may result in greater diversity locally, on a worldwide scale they may lead to the impoverishment of biodiversity.

5. Tools for marine biodiversity preservation: MMM-law and Marine Protected Areas

An important indirect threat to biodiversity is the weakness of legal systems and institutions. Contrary to nature conservation on land, the conservation of the marine environment and the marine life, e.g. the establishment of Marine Protected Areas (MPAs), started much later and was, until recently, difficult to implement. However, Belgium recently took several important initiatives to improve nature conservation at sea.

MPAs are an important tool for the conservation and restoration of ecological values that are needed to stop the loss of biodiversity and, where possible, to restore its natural values. To achieve these objectives, a whole battery of legal instruments, operating on a local or global scale, have been established.

A first impulse in the creation of marine protected areas was the Ramsar Convention (Iran, 1972 ratified by Belgium in 1975). Under this convention, the shallow coastal sandbanks in the western part of the Belgian coast, from the low water mark up to three nautical miles offshore, are protected as 'Wetland of International Importance for Bird Species' (figure 2). The area has an international importance for wintering sea birds, especially for the common scoter (*Melanitta nigra*).

At European level, two directives play a key role. The Birds Directive provides for the designation of Special Protection Areas (SPAs). Under the Habitats Directive, member states have to designate Special Areas of Conservation (SACs). Both SPA and SAC aim at the conservation of biodiversity by the protection and/or restoration of certain vulnerable

(1996) gave an overview of all areas in Flanders where the 1% criterion is reached from 1991/92 to 1995/96.

Four sites in Flanders are currently protected under the Ramsar Convention: 'Het Zwin' and its surroundings (530 ha), 'De Blankaart en de IJzerbroeken' (2,460 ha), 'De Schorren van de Beneden-Zeeschelde' (398 ha), and 'Kalmthoutse Heide' (2,183 ha). The coastal shallows 'Vlaamse Banken' in the North Sea (1,700 ha) belong to the federal competence. Three more sites have been proposed but have not officially been designated yet.

Flanders accommodates more than 5% of the total population of seven species, which makes it an area of international importance for those species: the pink-footed goose, greater white-fronted goose, Eurasian wigeon, gadwall, common teal, northern shoveler and common pochard. The Flemish coastal polders accommodate among others more than 90% of the total Spitsbergen population of pink-footed goose each winter.

3.3. Grasslands

The group of biotopes referred to as 'historically permanent grasslands' include semi-natural grasslands, species-rich grasslands (including relics of semi-natural grasslands) and grasslands with disseminated biological value.

Semi-natural grasslands include dry calcareous grasslands (*Brometalia erecti*), grasslands on decalcified dunes, moderately fertilised wet meadows (*Calthion*), unfertilised wet meadows (*Molinion caeruleae*), mesophilic hay meadows (*Arrhenatherion elatioris*) and the moderately fertilised wet meadows dominated by *Juncus*. Species-rich grasslands include species-rich permanent pastures (sometimes in transition to wet meadows) and salt marshes with permanent pastures containing ditches or micro-relief. Grasslands with disseminated biological value include species-rich permanent pastures with ditches or micro-relief sometimes including elements of reedlands or *Calthion* grasslands.

Semi-natural grasslands occupy only 0.3 to 0.6% of the Flemish territory (4,640 to 8,870 ha). The total surface of species-rich grasslands is not exactly known for Flanders. Grasslands with disseminated biological value are considered rare, covering 0.9 to 1.3% of the Flemish territory. These grasslands have been mown and/or grazed for many years, leading to a high biological diversity. When ploughed and re-sown, much of this diversity is lost. Eutrophication, overgrazing and desiccation through the lowering of the water table also threaten biodiversity. Random samples taken in the Flemish polders indicate that 50% of the total surface of historically permanent grasslands was lost between 1980 and 2000.

Little quantitative data are available for species in grasslands. Most of the existing data refers to semi-natural grasslands. For example, more than one-third of Red List species of spiders and one-third of Red List species of butterflies are found on unfertilised dry grasslands. This large number indicates the importance of those grasslands for biodiversity in Flanders. It should be noted that one-third of the species originally occupying semi-natural grasslands have already become extinct.

Legal protection and international importance

Adequate rules are urgently needed to stop this negative trend, as historically permanent grasslands are unique and very important among others for migrating birds. The Nature Decree of 1997 forbids the change of historically permanent grasslands into specific categories of land use destinations. Fertilisation limitations and management agreements can also bring improvements. However, due to the fragmented and *ad hoc* application, effectiveness is very low. Moreover, the multi-functional use of the historically permanent grasslands causes much tension and challenge. At the European level, the EU Habitats Directive protects most types of historically permanent grasslands found in Flanders, while the EU Birds Directive protects a number of grassland bird species.

3

Meadow with soft rush, *Juncus effusus*, and cuckoo flower, *Cardamine pratensis* (photograph by Y. Adams, Institute of Nature Conservation).

Gaps in knowledge represent an indirect but real threat to marine biodiversity. Indeed, biodiversity preservation (and restoration) through jurisdictional constraints completely relies on our actual knowledge of structure and functioning processes. Consequently, the management actions undertaken in order to protect the environment may lead to ineffective measures if they are based on inadequate information. A striking example of this is the worldwide decline of several shark and ray species, due to overfishing and a lack of fundamental life history data for the identification of appropriate management measures. On the other hand, insufficient knowledge is generally used to argue that the environmental impact of human activities is minimal. This has recently been acknowledged and corrected in environmental regulations that were based on an abusive interpretation of the 'principle of precaution'.

The definition of a 'sustainable biodiversity level' in Belgian marine areas requires a revisitation of older research, the gathering of data on poorly understood compartments and an increase in sampling effort in poorly documented areas. This has recently been undertaken and will certainly provide key information for the future management of the area. As has been emphasised many times, there is also a need for long-term, standardised monitoring activities in order to enable one to detect changes over a long period. So far, such studies have remained scarce because they are thought to be expensive, and hence are not a priority to policy and decision-makers. But how is it possible to discern between natural and anthropogenic causes of changes, in the absence of long-term data? The concept of 'sustainable development' defined within the Convention on Biological Diversity however acknowledges the need for an integration of environmental concern within socio-economic policies. This principle is now fully integrated in national marine research programmes. Research on marine 'ecosystem functioning', and in particular on the role played by biodiversity, as well as the implementation of an 'ecosystem approach' in marine environmental management are increasing worldwide and will probably allow to fill important gaps in our knowledge.

However, it is feared that one 'species' necessary to undertake such integrated research might become extinct soon, i.e. the marine taxonomist. Indeed, just as it is the case for taxonomists in general, its population is growing so old that questions arise as to how future generations will benefit from their expertise and knowledge in biodiversity assessments...

Acknowledgements

The authors wish to warmly thank the following persons for providing information, support and/or peer-review: D. CASEAU, C. CLAES, M.H. DARO, F. FRANCKEN, S. DEGRAER, B. GODDEERIS, S. JANS, Th. JACQUES, J. HAELTERS, Cl. MASSIN, A. NORRO, G. VAN HOEY, H. VAN LOEN, L. VIGIN, as well as the editors of the book for their patience.

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The 'Goorvijver' in Retie (Province of Antwerp) originated as a consequence of sand extraction and is now part of a designated Habitats Directive site. On the foreground, in the water: bulrush (*Typha latifolia*) and common reed (*Phragmites australis*). On the background: grey willow (*Salix cinerea*), silver birch (*Betula pendula*) and Scots pine (*Pinus sylvestris*) (photograph by J. PACKET, Institute of Nature Conservation).

Legal protection and international importance

The new water policy regulation is steered by the European directive for establishing a framework for community action in the field of water policy (the EU Water Framework Directive, adopted in 2000). The aim is a better integration of water use and water management. To achieve the quality ambitions in the field, a better integration of the 'renewed' environmental and country planning is necessary. Together with transport and agriculture policy, these policy fields have to generate more space for water and nature. The development of area-specific standards, better tuned to the specific needs of the watercourses, is necessary.

The main objective of the EU Water Framework Directive is to reach a good ecological quality in all surface waters. A good ecological quality is described as a situation showing at the maximum a slight disturbance compared to an undisturbed situation. In addition to a global quality improvement, the Directive asks specific attention for the quality of estuarine and coastal waters. Towards 2004, the EU Member States are bound to prepare a list with protected areas under the Water Directive. The specific objectives for each of those protected areas should be completed by 2015.

3.6. *Coastal dunes*

Coastal dunes include different biotopes such as embryonic shifting dunes, shifting dunes along the shoreline with *Ammophila arenaria* (white dunes), fixed coastal dunes with herbaceous vegetation (grey dunes), Atlantic decalcified fixed dunes (*Calluno-Ulicetea*), dunes with *Hippophae rhamnoides*, dunes with *Salix repens* ssp. *argentea* (*Salicion arenariea*), wooded dunes and humid dune slacks.

Dunes can be found all along the Flemish coastline. However, they are very fragmented as more than 50% of the original dune area has already disappeared. The high pressure on dune ecosystems arises mainly from tourism, including the expansion of tourist accommodation, but also from agriculture, industry and desiccation. Desiccation is caused by the pumping of groundwater, the drainage of polders and a diminished rainwater infiltration due to urbanisation. It is a very important pressure for nature conservation in the dunes.

The coast and coastal dunes are very rich in species. For instance, 862 species of higher plants (67% of the Flemish total) are found in an area of 7,500 ha (0.55% of the Flemish region). Depending on the taxonomic group, 5 to 10% of the species distributed along the coast can be considered as specific to the dune biotopes. The management of the coastal dunes is still dominated by their protective role against the sea. In the future, an adequate management of the coastal dunes has to give more importance to the natural values of these habitats.

Legal protection and international importance

In the seventies, the zoning plans for the Flemish coastal areas protected approximately 3,100 ha of coastal dunes under the status of nature reserves. During the following years, a large part of this area was lost to ever-increasing urbanisation pressures. The Dune Decree of 14 July 1993 now distinguishes two categories of protected areas: areas where limited agricultural activity is allowed and protected areas where building activities are absolutely forbidden, except for nature development and coastal protection.

Coastal dunes are also included in the list of habitats protected under the EU Habitats Directive. Two priority habitats are found in Flanders: fixed coastal dunes with herbaceous vegetation ('grey dunes') and decalcified fixed dunes with *Empetrum nigrum*.

3.7. *Urban areas*

Nature in urbanised areas corresponds to green areas within the surrounding grey urban environment, pockets where one feels good and wild flora and fauna can establish spontaneously. In general, the Flemish urban environment harbours less species than the surrounding natural areas. Many species are very common species, usually adapted to cultivated conditions, or imported (invasive) species. The natural state can be improved by planting native species, or by allowing spontaneous (re)colonisation.

4. Environmental disturbances

Changes in environmental quality due to eutrophication, acidification, desiccation, pollution and/or habitat fragmentation impose heavy pressure on fauna and flora. These major problems in Flanders are detailed below. Other human influences on nature include the over-exploitation of natural resources (hunting, fishing, harvesting) and the trade in exotic species (agriculture, forestry, gardening, pet trade, aquaria, etc.).

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Francis KERCKHOF
Marine Ecosystem Management
Royal Belgian Institute of Natural Sciences
2de en 23ste Linieregimentsplein
8400 Ostend

Jean-Sébastien HOUZIAUX
Department of Invertebrates
Royal Belgian Institute of Natural Sciences
Rue Vautier 29
1000 Brussels

General conclusions

This country study is the first comprehensive overview of the biological diversity in Belgium. It is based on original data provided by a wide range of experts. Attention is focused on the species level of biodiversity and we have provided information on major aquatic and terrestrial habitat types. Biodiversity at the genetic level, and agricultural or horticultural biodiversity are not dealt with, as we feel that these subjects deserve separate accounts.

The geographical and geological characteristics of Belgium, together with long-standing human impact in land use, resulted in an amazing diversity of habitats for such a small territory, many of which are of European importance. No less than 58 of them are listed in the EU Habitats Directive, which includes 198 entries. When granted protection status, they form the backbone of the Natura 2000 network, which also comprises the Special Protection Areas designated under the EU Birds Directive. At the end of December 2002, this network already totalised 401,021 ha, representing 12-14% of the regions' territories and 5% of the Belgian marine areas. It is a major step towards an ecosystem approach for biodiversity conservation, i.e. the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. The Biological Evaluation Map of Belgium, a project set up nationally in 1978 and transferred to the regions in 1986, offers a valuable tool for enhancing the network. It is based on a standardised, uniform survey and assessment of our country's biotic environment.

The Belgian diversity of life forms comprises around 36,300 recorded species of micro-organisms, plants, fungi and animals. However, expert extrapolations suggest that the actual number should range between 52,000 and 55,000 species. Bacteria and blue-green algae are not included in these numbers. Roughly 6,000 species of bacteria are known worldwide, but this is supposed to be only a fraction of the real number. As many bacteria species are cosmopolitan, we assume that at least a few thousand of them occur in Belgium. In addition, some 300 species of blue-green algae have been found in Belgium, and many more are expected to be discovered. Hence, the total number of species living in Belgium probably amounts to over 55,000 species. This figure exceeds all previous estimates. It indicates that at present less than two-thirds of the species living in our country have been recorded.

Our knowledge of the taxa is unbalanced. The best known are the vascular plants (flowering plants, conifers, ferns, horsetails, quillworts and clubmosses), vertebrates (lampreys, fish, amphibians, reptiles, birds and mammals), carabids (ground beetles), butterflies, and dragon- and damselflies. They are often used to underpin and justify conservation measures and many species are well-known bio-indicators. Yet they represent less than 4% of the species living in Belgium. Obviously, expanding our knowledge of the remaining 96% of organisms is urgently required if we are to improve, refine and optimise Belgian conservation policies and actions.

Detailed monitoring and thorough comparisons of old collection and observation data with more recent ones show that many species in Belgium are in decline or even have disappeared. In Flanders, at least 7% of formerly recorded species are extinct, 20% are endangered and 27% are vulnerable to near threatened; only 43% are considered safe or at low risk. A similar situation exists in Wallonia, as, depending on the taxonomic group, between 40 and 83% of the species show an obvious population decline, with an average of 57%. In the Brussels Capital Region, 187 higher plant species (out of the ca. 580 indigenous ones recorded before 1950), some 15 to 20 bird species (out of 90) and half of the six or seven amphibian species have disappeared. Today, dozens of plant and animal species in Belgium are only known from fewer than five populations and are therefore in critical danger. Many hundreds, probably thousands of species are at risk. The loss of local populations implies a loss of genetic diversity, which in turn may result in a loss of resilience to environmental change, i.e. the ability to resist to, or recover from, natural and human-induced pressures. Hence, urgent conservation measures are needed to protect vulnerable and endangered species and populations against extirpation. Threatened species should benefit from adequate long-term policy, and the restoration of degraded habitats should favour the re-establishment of species that had disappeared from our country. To this end, a National Biodiversity Strategy would be a most helpful tool to support the integration and the fine-tuning of regional action plans. Unfortunately, such a strategy is still lacking although it is an obligation under the Convention on Biological Diversity.

Proximate causes of biodiversity loss are mostly man-induced. Land conversion -whether for urban and industrial expansion, agriculture, infrastructure or tourism- is undoubtedly the main cause in our country. It results in the loss, degradation or fragmentation of habitats, and currently affects all habitat types. In Flanders, changes in environmental quality due to eutrophication also impose a heavy pressure on the fauna and flora. This problem is probably less acute in Wallonia, but pollution (including eutrophication) is nevertheless considered as the second threat to biodiversity in the region. The urban nature of the Brussels Capital Region leads to specific problems, such as a very high recreation pressure on green areas. Cities are also important introduction points for alien plants and animals. Marine biodiversity is particularly threatened in our coastal zone and shelf sea, where direct and indirect disturbances are concentrated. Threats include the overexploitation of marine resources, adverse effects of fishing methods on the sea bottom, the introduction of alien species, and land-based and marine pollution such as eutrophication and the spilling of hazardous substances.

Invasive alien species are currently a major focus of international conservation concern. It is generally admitted to be the second cause of biodiversity loss worldwide, after the degradation and fragmentation of habitats. In Belgium, there appears to be a growing attention to this issue, especially given the rapid expansion of introduced plants, fish, frogs, turtles, geese, and of invertebrates such as insects, crayfish, mussels, land slugs, etc. Specific information on this issue is provided throughout the present work. Several alarming conclusions emerge with regard to the highly predatory nature of some exotic species, and the colonising and competitive potential of others. Hence, the monitoring of aliens is imperative in order to cope adequately with them. Moreover, the general public should be duly informed of potential risks resulting from exotic species released in the wild, and raising awareness should be common policy.

Taxonomy and systematics provide the basic framework for the whole field of biology. Together with ecology they are the most fundamental disciplines for biodiversity studies. As very basic data are still lacking for the vast majority of taxa in Belgium, systematic and ecological research should be stimulated and should receive much more support. This would allow, among others, intensified and innovative sampling and the compilation of revisions, checklists and identification keys. Especially the latter are poorly targeted in Belgium.

Biological diversity has many dimensions, the importance of which is still not adequately addressed. In view of the many gaps identified in this synopsis, it is imperative to complete the inventory of Belgium's biodiversity and to improve the understanding of the role of biodiversity in ecosystem functioning. Bridging the gaps between existing knowledge and information needs for enhanced conservation policies can only be undertaken by close co-operation between all biodiversity partners in Belgium. One of *our* main objectives is to produce additions and regular updates of the present information, and to ensure that it reaches the widest possible readership, as biological diversity concerns us all.

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Eliomys, 1976-ongoing. Zoogdierenwerkgroep van de Jeugdbond voor Natuurstudie en Milieubescherming, Gent (mainly mammalogy).

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Liparis, 1995-ongoing. Studiegroep Europese en Mediterrane Orchideeën (SEMO) Vlaanderen, Antwerpen (European and Mediterranean Orchids).

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Natura Mosana, 1948-ongoing. Société des Naturalistes Namur-Luxembourg, Namur.

Natuur.focus, 2002-ongoing. Natuurpunt, Mechelen.

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Streepzaad, 1995-ongoing. FLO.WER vzw, Meise (floristics in Flanders).

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Annex 2. Legend units of the Biological Evaluation Map of Belgium (after DE BLUST *et al.* 1994)

(* = legend unit characterised by a list of species)

a. Stagnant waters

ah	brackish waters*
ae	eutrophic waters (*Nympheion*)*
aer	newly created (mineral soil)
aev	well established (mud)
am	mesotrophic waters without permanent vegetation
ao	oligotrophic waters (e.g. *Littorellion*)*
ap	deep or very deep waters (sand pits, Y)
apo	with gentle slopes
app	with steep slopes
ad	sedimentation basin
ab	barrage lake

m. Marshes

mr	reedland (*Phragmition*)*
mz	vegetation of *Scirpus maritimus**
mm	vegetation of *Cladium mariscus**
mc	tall sedge vegetations (*Magnocaricion*)*
md	quaking fen
ms	acid fens (*Caricion curto-nigrae*)*
mk	alkaline fens (*Caricion davallianae*)*
mp	dune slack calcareous fens

h. Grasslands

1. semi-natural humid grassland
(variants: Yb with shruhs and trees)

hc	moist moderately fertilised meadow (*Calthion*)*
hj	moist moderately fertilised meadow, dominated by *Juncus**
hf	moist tall herbaceous vegetation wih *Filipendula ulmaria**
hfc	presence of *Cirsium oleraceum*
hft	presence of *Thalictrum flavum*
hm	unfertilised wet meadow (*Molinion caerulea*)
hmo	oligotrophic subtype*
hmm	mesotrophic subtype*
hme	eutrophic subtype*

2. dry grassland
(variants: Yb with shrubs and trees)

ha	unfertilised dry grassland (*Thero-Airion*)*
had	of decalcified dunes
hn	species rich *Nardus* grassland (*Violion caninae*)*
hk	dry calcareous grasland (*Brometalia erecti*)*
hd	xeric grassland on calcareous sand (*Galio-Koelerion*)*
hv	calaminarion grassland (*Violion calaminariae*)*
hz	grassland on polluted soils

3. mesophilic agricultural grassland

hu	mesophilic hay meadows (*Arrhenatherion elatioris*)*
hp	species rich permanent pasture (e.g. *Cynosurion*)*
hp*	transition to wet meadow
hpr	permanent pasture with ditches or microrelief
hx	species poor pasture
hr	abandoned pasture and meadow

c. Heaths
(variants: Yb with shrubs and trees)

cg	dry heath (*Calluno-Genistetum*)*
ce	Atlantic wet heath (*Ericetum tetralicis*)*
ces	with species of raised bogs*
cm	degraded heath, dominance of *Molinia caerulea*
cd	degraded heath, dominance of *Deschampsia flexuosa*
cp	degraded heath, dominance of *Pteridium aquilinum*
cv	dry heath with *Vaccinium* (*Calluno-Vaccinietum*)*
ct	heath of raised bogs (*Vaccinio-Ericetum*)*
ctm	with dominance of *Molinia caerulea*

t. Raised bogs

t	active raised bog (*Sphagnion atlanticum*)
tm	degraded raised bog, dominance of *Molinia caerulea*

d. Dunes, muds and salt marshes

dz	sand bank
dl	beach
ds	mudflat
da	salt marsh*
dd	coastal dunes with *Ammophila* (white dunes)
dm	inland drift sands

s. Scrubs

1. scrubs on dry soils

sg	broom scrub (*Sarothamnion*)
sgu	with *Ulex europaeus*
sp	thorn thicket (*Rubion subatlanticum*)*
sk	scrub on calcareous soils (*Berberidion*)*
sx	stable *Buxus* scrubs (*Berberidion*)
se	scrubs of clearings (Epilobietalia)*
sd	dune scrubs (*Hippophaetum*)*
sz	scrubs on abandoned land

2. scrubs on wet soils

sm	scrubs with *Myrica gale* (*Myricetum gale*)*
so	willow scrub on acid soils, bogs (*Saliceto-Franguletum*)*
sf	willow scrub on mesotrophic to eutrophic soils (*Salicetum triandrae-viminalis*)*

f. and q. Mesophilic forests

1. forests on acid soils

qb	acidophilous oak wood (*Querco-Betuletum*)*
fb	acidophilous beech wood (*Querco-Betuletum*)
qs	mesotrophic acidophilous oak wood (*Fago-Quercetum*)*
fs	mesotrophic acidophilous beech wood (*Fago-Quercetum*)*
ql	oak wood with *Luzula luzuloides* (*Luzulo-Quercetum*)*
fl	beech wood with *Luzula luzuloides* (*Luzulo-Quercetum*)*
ff	beech wood with *Festuca altissima**
qd	wood of coastal dunes
qx	xerophilic oak wood on slate*

2. forests on neutral soils

qa	oak-hornbeam wood (*Stellario-Carpinetum*)*
fa	beech wood with *Anemone* (*Milio-Fagetum*)*
qe	oak-hornbeam wood with *Endymion* (*Endymio-Carpinetum*)*
fe	beech wood with *Endymion* (*Endymio-Fagetum*)*
fm	beech wood with *Melica* (*Melico-Fagetum*)*

3. forests on calcareous soils

qk	calcareous oak-hornbeam wood (*Ligustro-Carpinetum*)*
fk	calcareous beech wood (*Cephalanthero-Fagetum*)*

e. Escarpment forests

ek	escarpment wood on calcareous soil (*Tilio-Aceretum*)*
es	escarpment wood on acid soil (*Ulmo-Aceretum*)*

v. Woodland of alluvial soils, fens and bogs

1. woods on alluvial soils (Alno-Padion)

va	alluvial ash elm wood (*Ulmo-Fraxinetum*)*
vf	alder-oak wood
vb	mesotrophic ash-alder wood of fast-flowing rivers (*Stellario-Alnetum*)*
vn	tall herb alder wood (*Macrophorbio-Alnetum*)*
vc	alder-ash wood of sprongs and spring rivulets (*Carici-Fraxinetum* and *Cardamini-Alnetum*)*

2. bog woodland

vm	mesotrophic alder wood with sedges (*Carici elongatae-Alnetum*)*
vo	oligotrophic alder wood with *Sphagnum* (*Sphagno-Alnetum*)*
vt	birch bog woodland (*Vaccinio-Betuletum pubescentis*)*

r. Ruderal forests

ru	elm wood (*Violo odoratae-Ulmetum*)*

p, l, n. Plantations

pp	plantations of *Pinus*
ppi	young plantation
ppa	dense plantation, without undergrowth
ppm	older plantaton with undergrowth
ppmh	with grasses
ppms	with dwarfshrubs
ppmb	with shrubs and small trees
p	other conifer plantation (except *Pinus*)
pi	young plantation
pa	dense plantation, without undergrowth
pm	older plantation with undergrowth
pmh	with grasses
pms	with dwarfshrubs
pmb	with shrubs and small trees
l	poplar plantations
lh	poplar plantation on wet soil
lhi	with grasses or tall herbs
lhb	with shrubs and small trees
ls	poplar plantation on dry soils
lsh	with grasses and herbs
lsi	with tall herbs
lsb	with shrubs or small trees
n	other plantations of broad-leaved trees

b. Arable land

bs	arable land on sand
bl	arable land on loam
bu	arable land on clay
bg	arable land on stony loam
bk	arable land on calcareous stony loam
bc	arable land on chalk

k. Individual elements

kn	watering-place
kb	row of trees
kh	hedge
khw	wooded bank
ks	abandoned railway or important railway verge
kw	sunken road
km	old wall or ruines with important vegetation
kt	talus
kd	dike
kr	cliff

kra	acid
krc	calcareous
kv	pingo
kk	karst
ka	duck decoy
ku	undefined pioneer vegetation
ku*	on calcareous raised grounds
kc	quarry
ko	dumping ground
kg	rubble heap
kf	abandoned fort
ki	airfield
kj	tall trees orchard
kl	low trees orchard
kp	park and/or graveyard
kpk	castle park
kpa	arboretum
kq	nursery or greenhouse
kz	raised ground or industrial ground

u. Urban areas

ud	densely built up areas
ua	residential areas with gardens
un	residential areas in 'green environment'
ur	buildings in agricultural area
ui	industrial plants
uv	recreation site
uc	camping site

Annex 3. List of species of Birds Directive (79/409/EEC) and Habitats Directive (92/43/EEC) present in Wallonia

Plants

1381	*Dicranum viride*	
1393	*Drepanocladus vernicosus*	
1421	*Trichomanes speciosum*	Trichomanès radicant
1831	*Luronium natans*	Flûteau nageant
1882	*Bromus grossus*	Brome épais
1903	*Liparis loeselii*	Liparis de Loesel

Molluscs

1029	*Margaritifera margaritifera*	Moule perlière
1032	*Unio crassus*	Mulette épaisse
1014	*Vertigo angustior*	
1016	*Vertigo moulinsiana*	

Insects

1083	*Lucanus cervus*	Lucane cerf-volant
1074	*Eriogaster catax*	Laineuse du prunellier
1065	*Euphydryas aurinia*	Damier de la succise
1060	*Lycaena dispar*	Cuivré des marais
1044	*Coenagrion mercuriale*	Agrion de Mercure
1041	*Oxygastra curtisii*	Cordulie à corps fin

Fishes

1099	*Lampetra fluviatilis*	Lamproie fluviatile
1096	*Lampetra planeri*	Petite lamproie
1106	*Salmo salar*	Saumon atlantique
1134	*Rhodeus sericeus amarus*	Bouvière
1149	*Cobitis taenia*	Loche de rivière
1145	*Misgurnus fossilis*	Loche d'étang
1163	*Cottus gobio*	Chabot

Amphibians

1166	*Triturus cristatus*	Triton crêté

Birds (list of breeding species)

A 008*	*Podiceps nigricollis*	Grèbe à cou noir	
A 021	*Botaurus stellaris*	Grand butor	RR
A 022	*Ixobrychus minutus*	Blongios nain	RR
A 023	*Nycticorax nycticorax*	Bihoreau gris	RR
A 030	*Ciconia nigra*	Cigogne noire	
A 031	*Ciconia ciconia*	Cigogne blanche	RR
A 048*	*Tadorna tadorna*	Tadorne de Belon	
A 051*	*Anas strepera*	Canard chipeau	
A 052*	*Anas crecca*	Sarcelle d'hiver	RR
A 055*	*Anas querquedula*	Sarcelle d'été	RR
A 056*	*Anas clypeata*	Canard souchet	
A 059*	*Aythya ferina*	Fuligule milouin	
A 072	*Pernis apivorus*	Bondrée apivore	
A 073	*Milvus migrans*	Milan noir	
A 074	*Milvus milvus*	Milan royal	
A 081	*Circus aeruginosus*	Busard des roseaux	RR
A 082	*Circus cyaneus*	Busard Saint-Martin	RR
A 084	*Circus pygargus*	Busard cendré	RR
A 099*	*Falco subbuteo*	Faucon hobereau	
A 103	*Falco peregrinus*	Faucon pèlerin	RR
A 104	*Bonasa bonasia*	Gelinotte des bois	
A 118*	*Rallus aquaticus*	Râle d'eau	
A 119	*Porzana porzana*	Marouette ponctuée	RR
A 122	*Crex crex*	Râle des genêts	RR

A 131	*Himantopus himantopus*	Echasse blanche	RR
A 132	*Recurvirostra avosetta*	Avocette élégante	RR
A 136*	*Charadrius dubius*	Petit gravelot	
A 140	*Pluvialis apricaria*	Pluvier doré	RR
A 153*	*Gallinago gallinago*	Bécassine des marais	RR
A 182*	*Larus canus*	Goéland cendré	
A 215	*Bubo bubo*	Grand-duc d'Europe	
A 222	*Asio flammeus*	Hibou des marais	RR
A 223	*Aegolius funereus*	Chouette de Tengmalm	
A 224	*Caprimulgus europaeus*	Engoulevent d'Europe	
A 229	*Alcedo atthis*	Martin pêcheur d'Europe	
233*	*Jynx torquilla*	Torcol fourmilier	RR
A 234	*Picus canus*	Pic cendré	
A 236	*Dryocopus martius*	Pic noir	
A 238	*Dendrocopos medius*	Pic mar	
A 246	*Lullula arborea*	Alouette lulu	
A 249*	*Riparia riparia*	Hirondelle de rivage	
A 272	*Luscinia svecica*	Gorgebleue à miroir	
A 275*	*Saxicola rubetra*	Traquet tarier	
A 276*	*Saxicola torquata*	Traquet pâtre	
A 277*	*Oenanthe oenanthe*	Traquet motteux	RR
A 282*	*Turdus torquatus*	Merle à plastron	
A 292*	*Locustella luscinioides*	Locustelle luscinioïde	RR
A 295*	*Acrocephalus schoenobaenus*	Phragmite des joncs	RR
A 298*	*Acrocephalus arundinaceus*	Rousserolle turdoïde	RR
A 322*	*Ficedula hypoleuca*	Gobemouche noir	
A 338	*Lanius collurio*	Pie-grièche écorcheur	
A 340*	*Lanius excubitor*	Pie-grièche grise	
A 341*	*Lanius senator*	Pie-grièche à tête rousse	RR
A 409	*Tetrao tetrix*	Tétras lyre	RR

Birds (list of overwintering and/or migratory species)

A 001	*Gavia stellata*	Plongeon catmarin	RR
A 002	*Gavia arctica*	Plongeon arctique	RR
A 026	*Egretta garzetta*	Aigrette garzette	RR
A 027	*Egretta alba*	Grande aigrette	RR
A 029	*Ardea purpurea*	Héron pourpré	RR
A 034	*Platalea leucorodia*	Spatule blanche	RR
A 037	*Cygnus bewickii*	Cygne de Bewick	RR
A 038	*Cygnus cygnus*	Cygne sauvage	
A 068	*Mergus albellus*	Harle piette	
A 094	*Pandion haliaetus*	Balbuzard pêcheur	RR
A 098	*Falco columbarius*	Faucon émerillon	
A 127	*Grus grus*	Grue cendrée	
A 139	*Charadrius morinellus*	Pluvier guignard	RR
A 151	*Philomachus pugnax*	Combattant varié	
A 152*	*Lymnocryptes minimus*	Bécassine sourde	
A 166	*Tringa glareola*	Chevalier sylvain	
A 176	*Larus melanocephalus*	Mouette mélanocéphale	RR
A 193	*Sterna hirundo*	Sterne pierre-garin	
A 195	*Sterna albifrons*	Sterne naine	RR
A 196	*Chlidonias hybridus*	Guifette moustac	RR
A 197	*Chlidonias niger*	Guifette noire	
A 255	*Anthus campestris*	Pipit rousseline	
A 379	*Emberiza hortulana*	Bruant ortolan	RR

(* Migratory species from the article 4.2 of the 79/409/EEC Directive; RR = very rare in Wallonia)

Mammals

1304	*Rhinolophus ferrumequinum*	Grand rhinolophe
1303	*Rhinolophus hipposideros*	Petit rhinolophe
1308	*Barbastella barbastellus*	Barbastelle commune
1323	*Myotis bechsteini*	Vespertilion de Bechstein
1318	*Myotis dasycneme*	Vespertilion des marais
1321	*Myotis emarginatus*	Vespertilion à oreilles échancrées
1324	*Myotis myotis*	Grand murin
1337	*Castor fiber*	Castor d'Eurasie
1355	*Lutra lutra*	Loutre d'Europe

Abbreviations and acronyms

AERW Arrêté de l'Exécutif régional wallon (Walloon Regional Executive Order)
AFNOR Association française de Normalisation (French Association for Normalisation)
AM Arbuscular mycorrhiza(e)
AMINAL Administratie Milieu-, Natuur-, Land- en Waterbeheer van het Vlaams Gewest (Environment, Nature, Land and Water Management Administration of Flanders)
ARS Agricultural Research Service
ASCOBANS Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas
ATCC American Tissue Culture Collection

BAHC Belgian Avifaunal Homologation Committee
BCCM Belgian Co-ordinated Collections of Micro-organisms
BCS Belgian Continental Shelf
BHG Brussels Hoofdstedelijk Gewest (Brussels Capital Region)
BIM Brussels Instituut voor Milieubeheer (Brussels Institute for Management of the Environment)
BIME Brussels Institute for Management of the Environment
BOJ Belgian Official Journal
BWK Biologische Waarderingskaart (Biological Evaluation Map)

CBD Convention on Biological Diversity
CCAP Culture Collection of Algae and Protozoa
CCIEP Co-ordinating Committee for International Environmental Policy
CEH Centre for Ecology and Hydrology
CH Commission d'Homologation (Homologation Commission)
CNB Cercles des Naturalistes de Belgique (Naturalists Cercles of Belgium)
CONSSO Committee of North Sea Senior Officials
COP Conference of the Parties
CORINE Coordination de la Recherche de l'Information en Environnement (Coordination of Information on the Environment)
CRNFB Centre de Recherche de la Nature, des Forêts et du Bois (Research Centre for Nature, Forests and Wood)

DDT Dichlorodiphenyltrichloroethane
DGRNE Direction générale des Ressources naturelles et de l'Environnement (Directorate General for Natural Resources and Environment)
DML Dunstaffnage Marine Laboratory
DMS Dimethyl sulfide
DNA Deoxyribonucleic acid

EEC European Economic Union
EEZ Exclusive Economic Zone
ERMS European Register of Marine Species
EU European Union
EUNIS European Nature Information System

FES Flemish Entomological Society
FUSAG Faculté Universitaire des Sciences Agronomiques de Gembloux (Gembloux Agricultural University)

GDP Gross Domestic Product

IBD Indice Biologique Diatomées (Diatom Biological Index)
IBGE Institut Bruxellois pour la Gestion de l'Environnement (Brussels Institute for Management of the Environment)
IBGN Indice Biologique Global Normalisé (Global Standardised Biological Index)
IBW Instituut voor Bosbouw en Wildbeheer (Institute for Forestry and Game Management)
ICE Inter-ministerial Conference for the Environment
IGN Institut géographique national (National Geographic Institute)
IHEM Institute for Hygiene and Epidemiology, Mycology collection (now: Scientific Institute of Public Health - Louis Pasteur)
IMO International Maritime Organisation
IN Instituut voor Natuurbehoud (Institute of Nature Conservation)
INTERREG Inter-regional Co-operation (European Community initiative)
IPCC Intergovernmental Panel on Climatic Change
IRM Institut Royal Météorologique (Royal Meteorological Institute)
ISN Institut national de Statistique (National Institute of Statistics)
ITIS Integrated Taxonomic Information System
IUCN International Union for the Conservation of Nature and Natural Resources - The World Conservation Union
IVON Integraal Verwevings- en Ondersteunend Netwerk (Integral Interweaving and Supportive Network)

KMI	Koninklijk Meteorologisch Instituut (Royal Meteorological Institute)
KNNV	Koninklijke Nederlandse Natuurhistorische Vereniging (Royal Dutch Society for Study of Wildlife)
KUL	Katholieke Universiteit Leuven (Catholic University of Leuven)
LIFE	L'Instrument Financier pour l'Environnement (Financial Instrument for the Environment)
LMG	Laboratory for Microbiology Ghent
Ma	Million years ago
MARBENA	MARine Biodiversity research in the European economic area and the Newly Associated states
MIRA	Milieu- en natuurrapport Vlaanderen (Environmental and nature report Flanders)
MMM	Marien Milieu Marin (Marine environment)
MNHN	Muséum National d'Histoire Naturelle
MPA	Marine Protected Area
MUCL	Mycothèque de l'Université catholique de Louvain (Mycological Collection of the Catholic University of Louvain)
MUMM	Management Unit of the North Sea Mathematical Models
NATO	North Atlantic Treaty Organisation
NBGB	National Botanic Garden of Belgium
NEAT	North East Atlantic Taxa
NFP	National Focal Point
NGI	Nationaal Geografisch Instituut (National Geographic Institute)
NHM	The Natural History Museum
NIS	Nationaal Instituut voor de Statistiek (National Institute of Statistics)
NPK	Nitrogen, phosphorous and potassium
OFFH	Observatoire de la Faune, de la Flore et des Habitats (Observatory of the Fauna, the Flora and Habitats)
OSPARCOM	Oslo and Paris Commissions (OSPAR Convention = Convention for the Protection of the Marine Environment of the North-East Atlantic)
PAH	Poly-aromatic hydrocarbons
PCB	Poly-chlorinated biphenyls
PDV	Phocine Distemper Virus
PIH	Provinciaal Instituut voor Hygiëne (Provincial Institute for Hygiene)
RBC	Région de Bruxelles-Capitale (Brussels Capital Region)
RBINS	Royal Belgian Institute of Natural Sciences
RCNFW	Research Centre for Nature, Forests and Wood
RMCA	Royal Museum for Central Africa
RMI	Royal Meteorological Institute
RNA	Ribonucleic acid
RNOB	Réserves Naturelles et Ornithologiques de Belgique (Belgian Nature and Ornithological Reserves)
RUCA	Rijksuniversitair Centrum Antwerpen (University of Antwerp, partim)
SAC	Special Area of Conservation
SGIB	Sites de Grand Intérêt Biologique (Sites of Great Biological Interest)
SIBW	Système d'Information sur la Biodiversité en Wallonie (Information System on Biodiversity in Wallonia)
SPA	Special Protection Area
SPM	Suspended Particulate Matter
TBT	Tributyltin
UA	Universiteit Antwerpen (University of Antwerp)
UCL	Université catholique de Louvain (Catholic University of Louvain)
UGENT	Universiteit Gent (Ghent University)
UIA	Universitaire Instelling Antwerpen (University of Antwerp, partim)
ULB	Université Libre de Bruxelles (Free University of Brussels)
ULg	Université de Liège (University of Liège)
UMH	Université de Mons-Hainaut (University of Mons-Hainaut)
UN	United Nations
USDA	United States Department of Agriculture
UTM	Universal Transverse Mercator (Grid)
VEN	Vlaams Ecologisch Netwerk (Flemish Ecological Network)
VLM	Vlaamse Landmaatschappij (Flemish Land Agency)
WCMC	World Conservation Monitoring Centre
WEHAB	Water and sanitation, Energy, Health, Agriculture, Biodiversity

Index of scientific and english terms

Contact Information

Belgian National Focal Point to the Convention on Biological Diversity
Royal Belgian Institute of Natural Sciences

Vautierstraat 29 rue Vautier • B-1000 Brussels • Belgium
T + 32 2 627 45 45 • F + 32 2 627 41 41 • E cbd-nfp@naturalsciences.be

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