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The status of biodiversity in Flanders 10 years after Rio

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Abstract

It is estimated that about 40,000 to 50,000 species occur in Belgium, of which 80% can be found in Flanders. 75% belong to invertebrates, 24% are plants. Birds, mammals, reptiles and amphibians constitute the remaining 1%. Red Lists were produced for a number of species groups (all vertebrates and vascular plants, some invertebrates). These lists show that about one-third of the species are vulnerable or extinct. Trends analyses over the last ten years for birds, amphibians and butterflies illustrate that several species still got extinct and/or declined, even the common species. Several new invasive aliens were recorded. In general, many rare species are severely threatened, while only a small number of local common species and imported aliens spread further, contributing to the biotic homogenisation and impoverishment of our biodiversity.

Keywords: biodiversity, Flanders, red lists, amphibians, butterflies, birds, aliens, biotic homogenisation

Samenvatting

Het aantal soorten dat in België leeft wordt geschat op 40.000 à 50.000. 80% van deze soorten wordt in Vlaanderen aangetroffen. 75% behoort tot de ongewervelden, 24% zijn planten, terwijl vogels, zoogdieren, amfibieën en reptielen samen slechts 1% vertegenwoordigen. Er werden voor een aantal groepen reeds Rode Lijsten opgesteld (alle gewervelden en vasculaire planten, sommige ongewervelden). Deze tonen aan dat ongeveer één derde van de Vlaamse fauna en flora bedreigd of verdwenen is. Trendanalyses over de laatste tien jaar voor vogels, amfibieën en vlinders tonen aan dat verscheidene soorten nog steeds achteruitgaan (zelfs de algemene soorten) of verdwenen zijn. Daarnaast werden ook een aantal nieuwe invasieve exoten opgetekend. Algemeen genomen blijken een groot aantal zeldzame soorten sterk bedreigd te zijn terwijl slechts een klein aantal lokaal algemene soorten en ingevoerde exoten zich verder verspreiden, wat tot een algemene biotische homogenisatie en verarming van de biodiversiteit leidt.

Trefwoorden: biodiversiteit, Vlaanderen, Rode Lijsten, amfibieën, vlinders, vogels, exoten, biotische homogenisatie

1. Introduction

At present roughly 1.75 million species have been described worldwide (HAWKSWORTH & KALIN-ARROYO, 1995), but this is only a fraction of the total biodiversity on Earth. New species are discovered every day. Even for well-known groups such as larger mammals, new species are described roughly every three years (PINE, 1994). Because the majority of living organisms are much smaller and lead a hidden life, many more remain to be discovered. It is estimated that on average 300 new species, across all life forms, are being described every day. Even in Flanders species new to science are described at regular intervals (e.g. SCHEIRS, 1996). Extrapolation of existing evidence estimates that the 1.75 million described species only constitute roughly 10% of the total biodiversity (HAWKSWORTH & KALIN-ARROYO, 1995).

Species come and go. The basis of organic evolution is underpinned by the appearance of some species and the disappearance of others; extinction is therefore a natural process. This is illustrated by the vast amount of fossils. At present, over 300,000 fossil records are known (ORIANS, 1997). However, the rapid loss of species that we are witnessing today is estimated to be 100 to 10,000 times greater than the background or expected natural extinction rate of pre-human time (PIMM *et al.*, 1995; LAWTON & MAY, 1995; PURVIS *et al.*, 2000). Currently, several millions of populations and 3,000 to 30,000 species go extinct annually, or up to one species every 20 minutes (WILSON, 1992; PIMM *et al.*, 1995; LAWTON & MAY, 1995; HUGHES *et al.*, 1997). Probably at least 250,000 species went extinct in the last century, and 10 to 20 times that many are expected to disappear this century (WOODRUFF, 2001). If current area-species curve-based projections are correct, we could lose up to 50% of the planet's species in the next 1,000 years (WOODRUFF, 2001). In response to the on-going rapid decline of biomes and the homogenisation of biota, models and theories predict changes in species geographic ranges, genetic risks of extinction, genetic assimilation, natural selection, mutation rates, shortening of food chains, increase in nutrient-enriched niches permitting the ascendancy of microbes, and differential survival of ecological generalists. But, although we can identify the most threatened biomes and species in some groups, we cannot make acceptably rigorous predictions about the consequences of these extinctions for the future evolution of life or for the integrity of the biosphere's environmental services that we still take for granted (PIMM *et al.*, 1995; HUGHES *et al.*, 1997; PURVES *et al.*, 2000).

2. Biodiversity in Flanders

What about Flanders? It is estimated that about 40,000 to 50,000 species occur in Belgium (viruses, bacteria, Protista, 'algae' not included) (2.8% of the world's biodiversity), of which 80% can be found in Flanders (VAN GOETHEM, 1998; GYSELS, 1999). Of these, 75% are invertebrates (insects, spiders, etc.), 24% are 'plants' (vascular plants, mosses, lichens and fungi), whereas vertebrates (birds, mammals, reptiles, amphibians and fishes) constitute the remaining 1%. Most likely, the reported figures are substantial underestimations, especially for invertebrates. As an example, we can cite the insect order Diptera (flies, mosquitoes, midges). At present, some 4,500 species are reported for the Belgian fauna (GROOTAERT *et al.*, 1991). Based on the checklists of the surrounding countries, it is estimated that the total species richness should amount to over 6,000 species. This implies that for about 1,500 to 2,000 species, it is even uncertain whether or not they occur in Flanders. If we extrapolate this to the other insect orders and invertebrate groups, this may imply that thousands of organisms still remain to be discovered.

3. Red Lists

The IUCN categories of threatened species are widely recognised, especially through their use in Red Data Books and Red Lists (IUCN Species Survival Commission, 1994; GÄRDENFORS *et al.*, 2001). They provide an easily understood method for highlighting species at risk of extinction, and they help to focus attention on conservation measures to protect them.

For Flanders, Red Lists have been compiled for mammals (CRIEL, 1994), carabids and cicindelids (DESENDER *et al.*, 1995), amphibians and reptiles (BAUWENS & CLAUS, 1996), dragonflies (DE KNIJF & ANSELIN, 1996), spiders (MAELFAIT *et al.*, 1998), freshwater fish (VANDELANNOOTE *et al.*, 1998), breeding birds (DEVOS & ANSELIN, 1999), butterflies (MAES & VAN DYCK, 1999), mosses (HOFFMANN, 1999a), lichens (HOFFMANN, 1999b), mushrooms (WALLEYN & VERBEKE, 2000), grasshoppers and crickets (DECLEER *et al.*, 2000), long-legged flies (POLLET, 2000) and vascular plants (BIESBROEK *et al.*, 2001). The Red List categories are those proposed by the IUCN Species Survival Commission (IUCN Species Survival Commission, 1994), adapted to Flanders (MAES & VAN SWAAY, 1997). The knowledge on the status of Flemish biodiversity is strongly biased towards vertebrates and vascular plants, of which the status of respectively 100% and 58-70% of the species has been established. On the other hand, the status of fungi and invertebrates is only known for respectively 10% and 5-6% (tab. 1).

	Estimated number of species	% of total	Red List status known	
Belgium	40,000-50,000[1]			
Flanders	32,000-40,000	80%		
Fungi	5,000-6,000	16%	552	10%
Flora[2]	2,680-3,600	8%	2,089	58-78%
Invertebrates	24,000-30,000	75%	1,365	5-6%
Vertebrates	295 (± 500[3])	1%	295	(100%)

[1] Not included: Viruses, Bacteria, Protista, 'Algae'
[2] Flora here includes vascular plants, mosses, lichens
[3] ± 500 species includes non-breeding, migratory birds

Tab. 1. Estimated number of species and number of species with known Red List status for the major taxa of Flemish flora and fauna.

Overall, a little more than one-third (4,264 species) of all taxa can be considered as extinct or threatened, encompassing the Red List categories 'critically endangered', 'endangered' and 'vulnerable' (DE BRUYN, 2001) (fig. 1). About 7.5% (319 species) are extinct, i.e. species for which there have been no records since 1980. About 30% (1,279 species) are threatened in one way or another. This rises to 47% (2,004 species) when susceptible species are included. When we extrapolate these relative figures to the estimated numbers of organisms that should occur in Flanders, taking into account the proportion of 'Belgian' species living in Flanders and the number of 'undiscovered' invertebrates, it is possible to obtain a rough estimate on the status of biodiversity in Flanders. Of the 42,000 species occurring on the Flemish territory, about 14,000 should occur on the Red Lists, and 5,000 species thereof could be considered as extinct. This implies that many species went extinct before they were discovered in Flanders. These figures are most likely an underestimation of the real situation because groups such as algae, unicellular organisms (± 5,000 in the Netherlands) or Bacteria (> 1,000 in the Netherlands) were not taken into account.

4. Rio de Janeiro: ten years later

At the 1992 'Earth Summit' in Rio de Janeiro, world leaders agreed on a comprehensive strategy for 'sustainable development'. One of the key agreements adopted was the Convention on Biological Diversity. The Convention has three main goals: the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising from the use of genetic resources. Belgium signed the Convention on 5 June 1992, during the Rio Conference. The Convention only came into force in Belgium on 20 February 1997.

The previous paragraphs consider the state of nature based on long-term data collected during the last century. In the following paragraphs, we try to evaluate the status and trends of

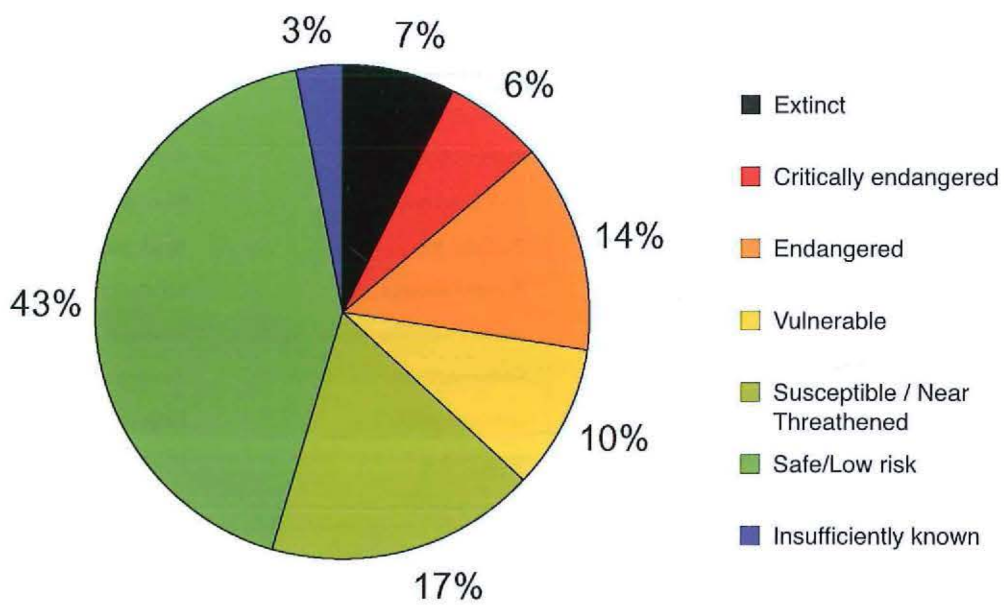

Fig. 1. Relative distribution over Red List categories of the screened Flemish biota. Data are based on the Red Lists of mammals, breeding birds, amphibians, reptiles, fish, dolichopodids, butterflies, carabids, dragonflies, spiders, grasshoppers, vascular plants, mosses, lichens and a number of mushroom groups.

biodiversity for the Flemish territory over the last ten years. In order to be able to assess trends on such a short timescale, detailed data are needed. We use distribution and abundance data compiled for three groups: the rare, colonial and alien breeding birds (DEVOS & ANSELIN, 1996), a selected set of amphibians (COLAZZO *et al.*, 2001) and butterflies (MAES & VAN DYCK, 1999).

4.1. BREEDING BIRDS

Historical data collection on Flemish birds was fragmentary before 1994 (for references see DEVOS & ANSELIN, 1996). The only distribution atlas that covered all species and the complete Flemish territory was compiled during the 1970s (DEVILLERS *et al.*, 1988). In 1994, a project started to census rare (45 species), colonial (15 species) and (invasive) alien (7 species) breeding birds in Flanders (tab. 2) (DEVOS & ANSELIN, 1996). Since then, the target birds have been monitored annually using the standardised and detailed territory mapping method described in HUSTINGS *et al.* (1985) and VAN DIJK (1993). The research areas are visited several times during the breeding season (March-July). All territories are mapped and the breeding pairs and/or nests are counted. The results are reported at regular intervals (DEVOS & ANSELIN, 1996; ANSELIN *et al.*, 1998) (tab. 2).

An analysis of the old observation data revealed that during the first part of the 20th century, 163 bird species were known as regular breeders (DEVOS & ANSELIN, 1999). At the start of the 1990s, four species turned out to be extinct: the ruff, *Philomachus pugnax* (1977), black tern, *Chlidonias niger* (1984), hoopoe, *Upupa epops* (end of the 1980s), and tawny pipit, *Anthus campestris* (end of the 1980s). The detailed monitoring further revealed that another three species became extinct after 1990: the black grouse, *Tetrao tetrix* (still present, but no breeding records for the past five years), great reed warbler, *Acrocephalus arundinaceus* (no breeding records already for several years), and ortolan bunting, *Emberiza hortulana* (territorial males reported, but no breeding records since 1994). For the red backed shrike, *Lanius collurio*, there have been no breeding records for two or three years, but the species reappeared in 2001 with one breeding pair and five breeding pairs were counted in 2002.

The remaining rare and colony breeders are also under severe threat (fig. 2): 31 of the 62 species are only represented by fewer than ten breeding pairs. Between 1994 and 1996, the number of breeding pairs decreased for 12 species, increased for 22 species, while it was stable or fluctuating for 28 species. Most species that were represented with only few breeding pairs in 1994 showed a decreasing trend (e.g. great grey shrike, *Lanius excubitor*, and penduline tit, *Remiz pendulinus*) or showed no clear trend (fig. 3). However, many of the latter are already so rare (e.g. wryneck, *Jynx torquilla*, corncrake, *Crex crex*, melodious warbler, *Hippolais polyglotta*) that the slightest decrease would wipe them out. The situation seems to improve for only a few species such as the bittern, *Botaurus stellaris*, common gull, *Larus canus*, and little bittern, *Ixobrychus minutus*. All birds with over 100 breeding pairs are stable or show an increase:

Scientific name	English name
Rare species (N=45)	
Accipiter gentilis	Goshawk
Acrocephalus arundinaceus	Great reed warbler
Actitis hypoleucos	Common sandpiper
Alcedo atthis	Kingfisher
Anas acuta	Northern pintail
Anas querquedula	Garganey
Anser anser	Greylag goose
Asio flammeus	Short eared owl
Botauris stellaris	Bittern
Carduelis flammea cabaret	Lesser redpoll
Carduelis spinus	Siskin
Carpodacus erythrinus	Common rosefinch
Cettia cetti	Cetti's warbler
Charadrius alexandrinus	Kentish plover
Charadrius hiaticula	Ringed plover
Cinclus cinclus	Dipper
Circus aeruginosus	Marsh harrier
Circus cyaneus	Hen harrier
Circus pygargus	Montagu's harrier
Crex crex	Corn crake
Cygnus olor	Mute swan
Egretta garzetta	Little egret
Emberiza hortulana	Ortolan bunting
Falco peregrinus	Peregrine falcon
Galerida cristata	Crested lark
Ixobrychus minutus	Little bittern
Jynx torquilla	Wryneck
Lanius collurio	Red backed shrike
Lanius excubitor	Great grey shrike
Locustella luscinioides	Savi's warbler
Loxia curvirostra	Crossbill
Merops apiaster	European bee-eater
Milvus migrans	Black kite
Milvus milvus	Red kite
Motacilla cinerea	Grey wagtail
Oenanthe oenanthe	Wheatear
Panurus biarmicus	Bearded tit
Pernis apivorus	Honey buzzard
Podiceps nigricollis	Black necked grebe
Porzana porzana	Spotted crake
Remiz pendulinus	Penduline tit
Serinus serinus	European serin
Sterna albifrons	Little ringed plover
Tetrao tetrix	Black grouse
Tringa totanus	Common redshank
Colonial species (N=15)	
Ardea cinerea	Blue heron
Corvus frugilegus	Rook
Larus argentatus	Herring gull
Larus canus	Common gull
Larus fuscus	Lesser black backed gull
Larus melanocephalus	Mediterranean gull
Larus ridibundus	Black headed gull
Nycticorax nycticorax	Night heron
Phalacrocorax carbo	Cormorant
Recurvirostra avosetta	Avocet
Riparia riparia	Sand martin
Sterna albifrons	Little tern
Sterna hirundo	Common tern
Sterna paradisaea	Arctic tern
Sterna sandvicensis	Sadwich tern
Alien species (N=7)	
Aix galericulata	Mandarin duck
Alopochen aegyptiacus	Nile goose
Anser albifrons	White fronted goose
Branta canadensis	Canada goose
Branta leucopsis	Barnacle goose
Myiopsitta monachus	Monk parakeet
Psittacula krameri	Ring-necked parakeet

Tab. 2. Breeding bird species currently monitored in Flanders.

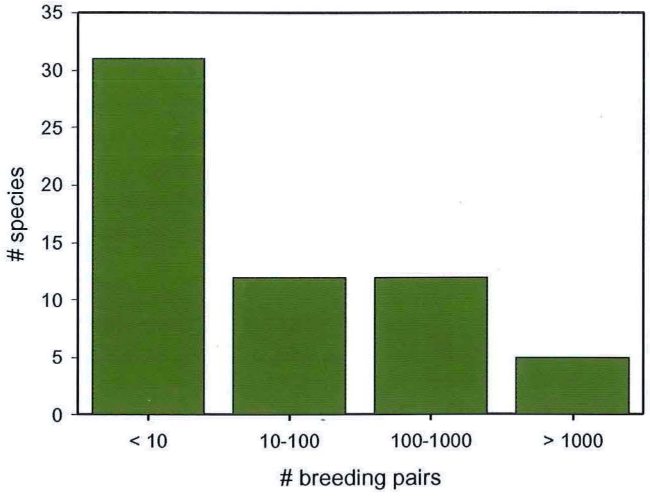

Fig. 2. Breeding density frequency distribution for 62 monitored rare and colony breeding birds (average number of breeding pairs in Flanders for the period 1994-1996).

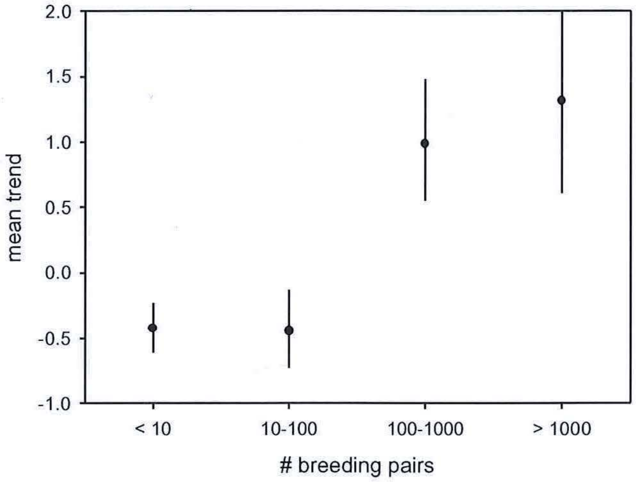

Fig. 3. Mean trend for the period 1994-1996 in the number of breeding pairs for 62 rare and colony breeding birds (data are mean ± SE).

examples include the blue heron, *Ardea cinerea*, rook, *Corvus frugilegus*, cormorant, *Phalacrocorax carbo*, and herring gull, *Larus argentatus*. It is important to remark that for some of the more common colony breeders such as the little tern (*Sterna albifrons*) and the sandwich tern (*Sterna sandvicensis*), all breeding pairs are confined to a single colony, which makes them also vulnerable. For example, the sandwich tern decreased from over 1,500 breeding pairs in 2001 to about 40 in 2002!

Although many birds are under threat, other species have recently started to breed, or have returned as breeders, in Flanders since 1990. These are the little egret, *Egretta garzetta* (1995), Eurasian spoonbill, *Platalea leucorodia* (1999), middle spotted woodpecker, *Dendrocopos medius* (probably halfway the 1990s, some records from 2000), common sandpiper, *Actitis hypoleucos* (1996), and peregrine falcon, *Falco peregrinus* (1995).

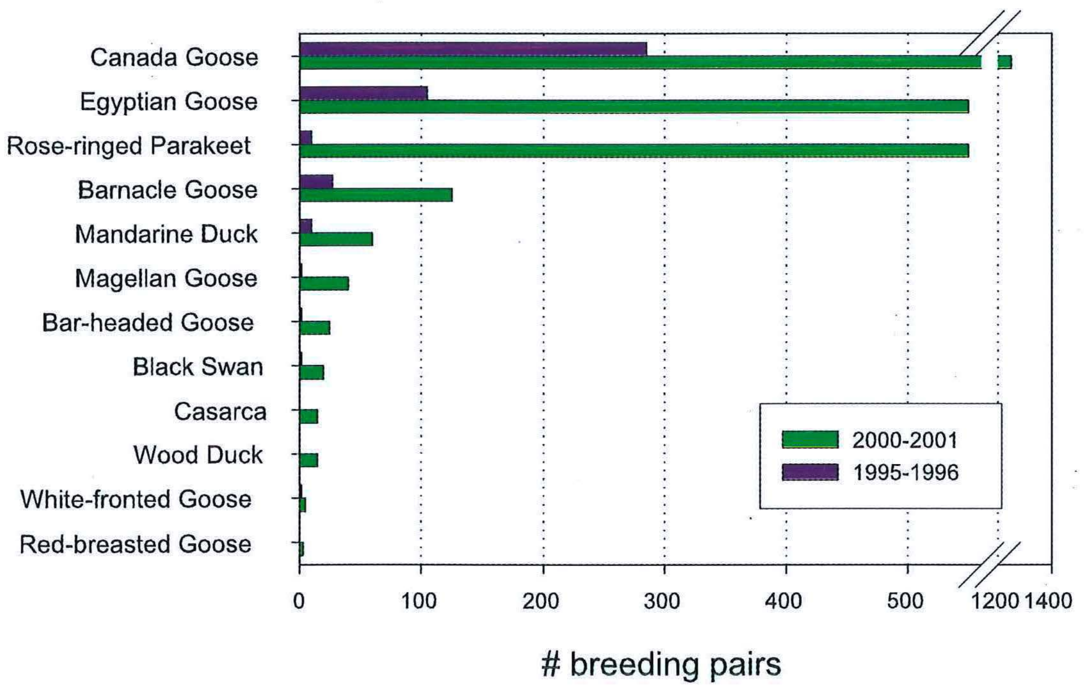

Fig. 4. Comparison of the number of breeding pairs for 12 alien bird species in Flanders during two census periods.

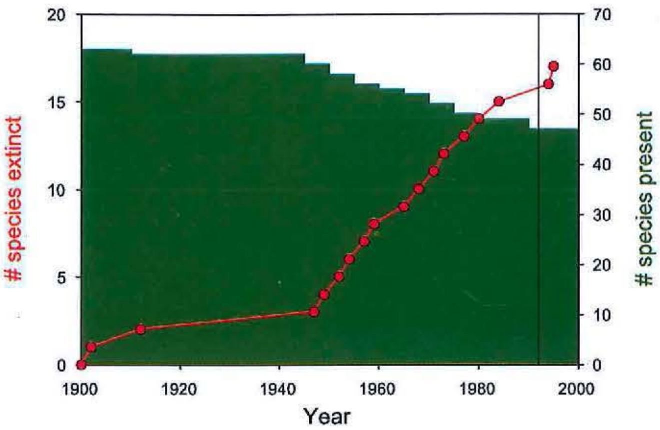

Fig. 5. The evolution of butterfly species richness in Flanders for the previous century. Bars: number of species present; line: cumulative number of extinct species.

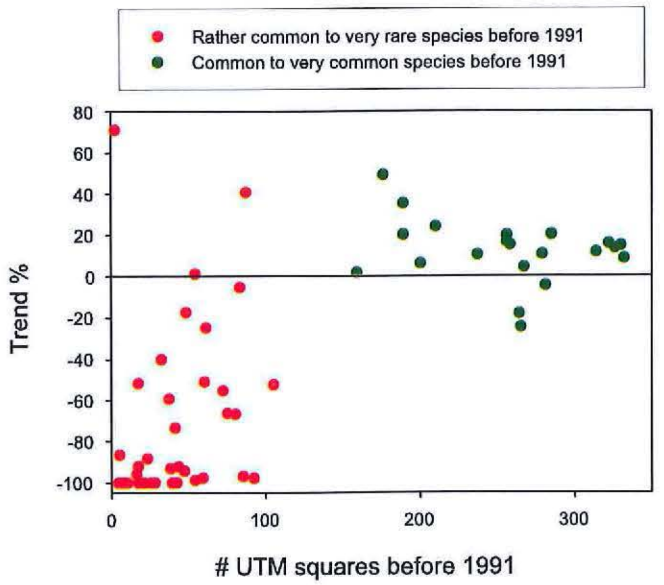

Fig. 6. Relationship between abundance and trend for Flemish butterflies.

Among the breeding birds, another 12 species recently invaded Flanders. Unlike the previous group however, they did not reach the Flemish territory on their own, but their presence is the result of intentional or unintentional human introductions. For most species, only few breeding records were known in 1996 (fig. 4). In 2000-2001, some of the species had already spread over the larger part of Flanders, e.g. the Canada goose (*Branta canadensis*), Egyptian goose (*Alopochen aegyptiacus*) and ring-necked parakeet (*Psittacula krameri*). The Canada goose has already reached between 900 and 1,200 breeding pairs.

4.2. BUTTERFLIES

The Flemish butterfly atlas contains about 190,000 records that have been collected since 1830 (MAES & VAN DYCK, 1999; MAES & VAN DYCK, 2001). Butterfly presence is recorded in 5 x 5 km Universal Transverse Mercator (UTM) squares. Distribution and trend analyses were performed using the year 1991 as a pivotal date. To estimate extinction rates, the number of species was counted per five-year period in the 20th century.

During the last century, butterfly diversity continuously decreased (fig. 5), first slowly, but later more dramatically (eight fold!) during the second part of the 20th century (MAES & VAN DYCK, 2001). The first species to disappear were the tree grayling, *Hipparchia statilinus* (1902), and scarce heath, *Coenonympha hero* (1912). From the end of the 1940s onwards, species disappeared one after the other. Successively these were the high brown fritillary, *Fabriciana adippe* (1947), pearl-bordered fritillary, *Clossiana euphrosyne* (1949), Oberthür's grizzled skipper, *Pyrgus armoricanus* (1952), false heath fritillary, *Melitaea diamina* (1954), poplar admiral, *Limenitis populi* (1957), marsh fritillary, *Eurodryas aurinia* (1959), black-veined white, *Aporia crataegi* (1965), heath fritillary, *Mellicta athalia* (1968), dark green fritillary, *Mesoacidalia aglaja* (1971), dingy skipper, *Erynnis tages* (1973), niobe fritillary, *Fabriciana niobe* (1977), scarce large blue, *Maculinea teleius* (1980), and idas blue, *Lycaeides idas* (1984). Since 1992, the year of the Rio Convention, two other species have become extinct on the Flemish territory: the small pearl-bordered fritillary, *Clossiana selene* (1994), and the large heath, *Coenonympha tullia* (1995). As a result, butterfly species richness declined by 30%, from 62 species in 1900 to 47 species at present. Another 50% of the species are threatened (MAES & VAN DYCK, 2001).

The number of diversity hotspots (5 x 5 km squares with 26 species or more) decreased from 57 before 1991 to 22 after 1991. 51 hotspots were lost while 16 were gained. The Red List species hotspots (5 x 5 km squares with 5 Red List species or more) dropped from 107 to 25 (96 lost, 14 gained) (MAES & VAN DYCK, 2001). Whereas the loss of hotspots is a result of local species extinction, the authors attribute the gain of new hotspots to a higher recording intensity during the second period.

The Red List of butterflies shows that over 50% of the species are threatened. Compared to the period before 1991, the distribution range of 17 species has shrunk (decline of at least one rarity category), 20 species are more or less stable (no category change) and 11 have extended their range (MAES & VAN DYCK, 1999). These changes are not equal for different Red List categories (fig. 6). In general, species that were common to very common in the past (e.g. meadow brown, *Maniola jurtina*, holly blue, *Celastrina argiolus*, map, *Araschnia levana*) are stable or have even increased their distribution range, except for the small copper, *Lycaena phlaeas*, wall brown, *Lasiommata megera*, and small heath, *Coenonympha pamphilus*. On the other hand, rare species such as the Queen of Spain fritillary, *Issoria lathonia*, purple

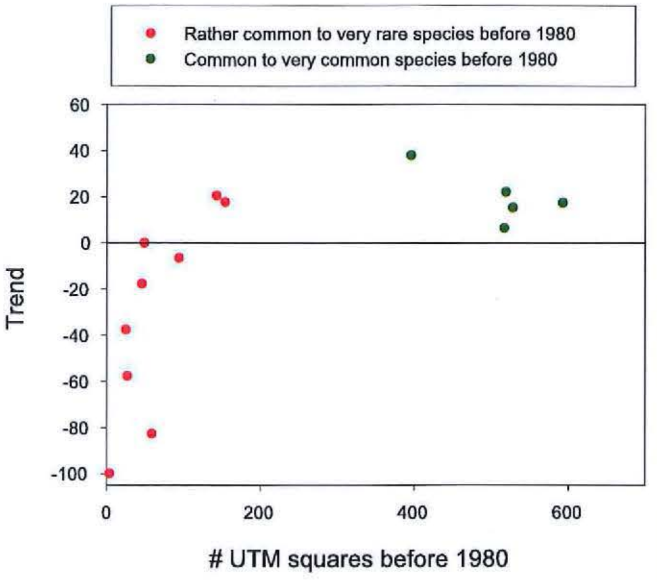

Fig. 7. Relationship between abundance and trend for Flemish amphibians.

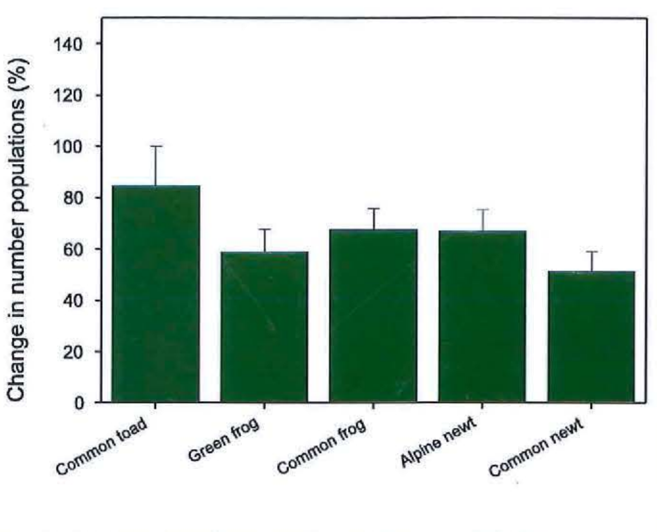

Fig. 8. Relative abundance (pools inhabited in 1999-2001 compared to 1975-1989) combined over the 9 regions (data are mean ± SE).

emperor, *Apatura iris*, or white admiral, *Ladoga camilla*, experience further decline. This is not the case, however, for the small skipper, *Thymelicus sylvestris*, brown argus, *Aricia agestis*, and marbled white, *Melanargia galathea*.

4.3. AMPHIBIA

Recent reports show a worldwide decline of amphibians (WAKE, 1991; ALFORD & RICHARDS, 1999). Research in Flanders, based on presence/absence data in 4 x 4 km grid squares of species distribution maps, also shows that several species declined significantly or even became extinct during the last century (BAUWENS & CLAUS, 1996). The yellow-bellied toad (*Bombina variegata*) has been extinct since 1984, while only a few populations -mostly with less than 10 calling males!- of the tree frog (*Hyla arborea*) are left at present. The same overall pattern is observed as in butterflies (fig. 7). Here too, the rare species such as the midwife toad, *Alytes obstetricans*, or the common spadefoot, *Pelobates fuscus*, are the first ones to show a decline (except for the palmate newt, *Triturus helveticus*, and great crested newt, *Triturus cristatus*, that show a modest upward trend). On the other hand, populations of species with relatively wide distributions (e.g. Alpine newt, *Triturus alpestris*, and common newt, *Triturus vulgaris*) appear to show stable or even increasing numbers of occupied grid cells.

However, it has been shown that trend estimation based on relatively large grid cells (e.g. 4 x 4 km or larger) tends to underestimate population losses, especially for species of intermediate rarity or common species (THOMAS & ABERY, 1995). When grid squares contain several populations of a given species, its disappearance will not become apparent till all of the populations in the cell have perished. Therefore, it is desirable to monitor species distributions and abundances at a finer scale.

Pools and small ponds constitute an important breeding habitat for amphibians in Flanders (BAUWENS & CLAUS, 1996). In the past, these landscape elements served primarily as cattle ponds. Nowadays, however, this function has been lost. Traditional practices such as periodical deepening have ceased and many pools have become silted up or have been filled in. Fortunately, recent management agreements and subsidy arrangements between local governments and farmers promote the restoration and/or (re)construction of pools and ponds within the scope of specific 'pond-projects' or municipal nature development plans.

In 1999-2001, a detailed inventory campaign was carried out in Flanders (COLAZZO *et al.*, 2001). The research focused on areas for which detailed inventories from the near past were available (period 1975-1989: DE FONSECA, 1980; SANDERS, 1987). This made it possible to obtain well-documented abundance and distribution trends over the last decade for a number of species (COLAZZO *et al.*, 2002). Overall, about 1,600 ponds scattered over 9 regions were examined, 750 of which were visited during both periods. Analyses of distribution changes were carried out only for common amphibian species, since these species were the most likely not to have shown significant changes as a result of the grid counting method. The study focused on the common toad (*Bufo bufo*), the green frog (*Rana esculenta* synklepton), the common frog (*Rana temporaria*), the Alpine newt and the common newt.

The combined data for all species and regions showed that the actual number of local populations was only 64% of the formerly recorded number, which implies a reduction of about one-third over the past 15-25 years. All species studied show a decreasing trend (fig. 8). This trend was strongest for the green frog (-41%) and the common newt (-48%). The reduction for the common toad is only moderate (-15%) and does not indicate a significant reduction in the number of local populations.

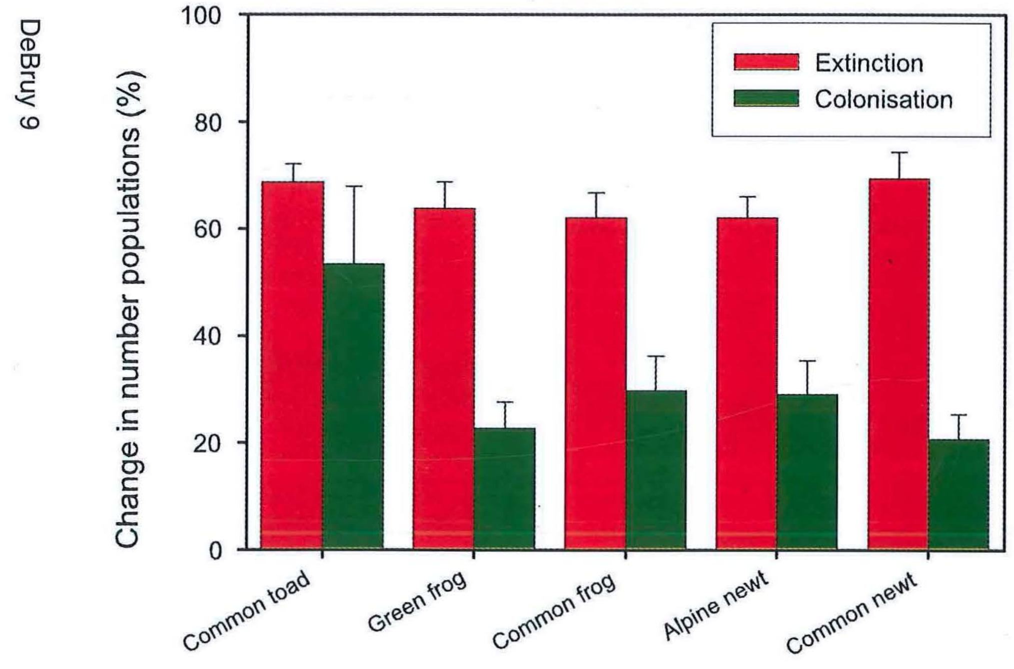

Fig. 9. Mean species specific turnover combined over the 9 regions (extinctions and colonisations in 1999-2001 compared to 1975-1989) for 5 common amphibian species in Flanders (data are mean ± SE).

Many amphibian populations have distributions and spatial structure characteristics of metapopulations (MANN *et al.*, 1991). They breed in discrete patches and use the surrounding habitat for hibernation and foraging. Local demographic events and dispersal among sites can result in high species turnover in the ponds (HECNAR & M'CLOSKEY, 1996). The observed occupancy rate of a species is a combination of local extinctions and new colonisations. The present study revealed a high species turnover in the investigated ponds (fig. 9). The extinction rate was highly similar for the five species studied, and ranged between 62% and 70%. However, the number of newly discovered populations was considerably higher for the common toad (53%) than for the other species (20-30%). The seemingly stable situation for the common toad is not a result of local population persistence. The high rate of local population extinction is compensated by the (re)colonisation of ponds, where the other species fail to do so. This observation is in agreement with previous results. It was already shown that the common toad is a long-distance disperser with broad habitat requirements. The other species have more restricted dispersal abilities and usually exhibit more specific habitat requirements, which hamper their colonisation abilities (MANN *et al.*, 1991; BAKER & HALLIDAY, 1999).

The results also differ among regions in Flanders (COLAZZO *et al.*, 2002). Except for the Voeren Region, there is a gradient from east to west (fig. 10). Averaged over species, the decrease was strongest in West-Flanders, where the occupancy rate was reduced to 40-50%! This is mainly a result of a very high extinction rate (up to 80%) and a low (re)colonisation (about 20%). In the eastern part of Flanders, the 'Hoge Kempen', virtually no change in the occupation rate was observed. Here, the extinction rate of nearly 50% is compensated by an equal (re)colonisation rate.

5. Discussion

The results of the present study reveal four major points:

- 37 to 54% of the Flemish biodiversity is threatened to some extent;
- species continue to become extinct, even after the signature of the Biodiversity Convention (but note that for Belgium, the Convention only entered into force in 1997...);
- in general, rare species are more threatened than common species;
- more and more (invasive) alien species settle and spread over the territory.

The causes of the biodiversity crisis are well known and include human impacts on habitats (habitat destruction, degradation, fragmentation, and restructuring) and on organisms (overexploitation, introduction of exotic competitors, predators and parasites, and creating new pests) (WILSON, 1991; PIMM *et al.*, 1995; VITOUSEK *et al.*, 1996; MOONEY & CLELAND, 2001). For Flanders, the same disturbance factors have been cited (e.g. BAUWENS & CLAUS, 1996; KUIJKEN *et al.*, 2001; MAES & VAN DYCK, 2001). Environmental pressure on nature in Flanders is strong because of the high population densities, leaving only about 11% of the territory for nature (DE BRUYN *et al.*, 2002). The remaining surface suffers strongly from various environmental stresses (VAN STEERTEGEM, 2001), of which one of the main agents is agri-

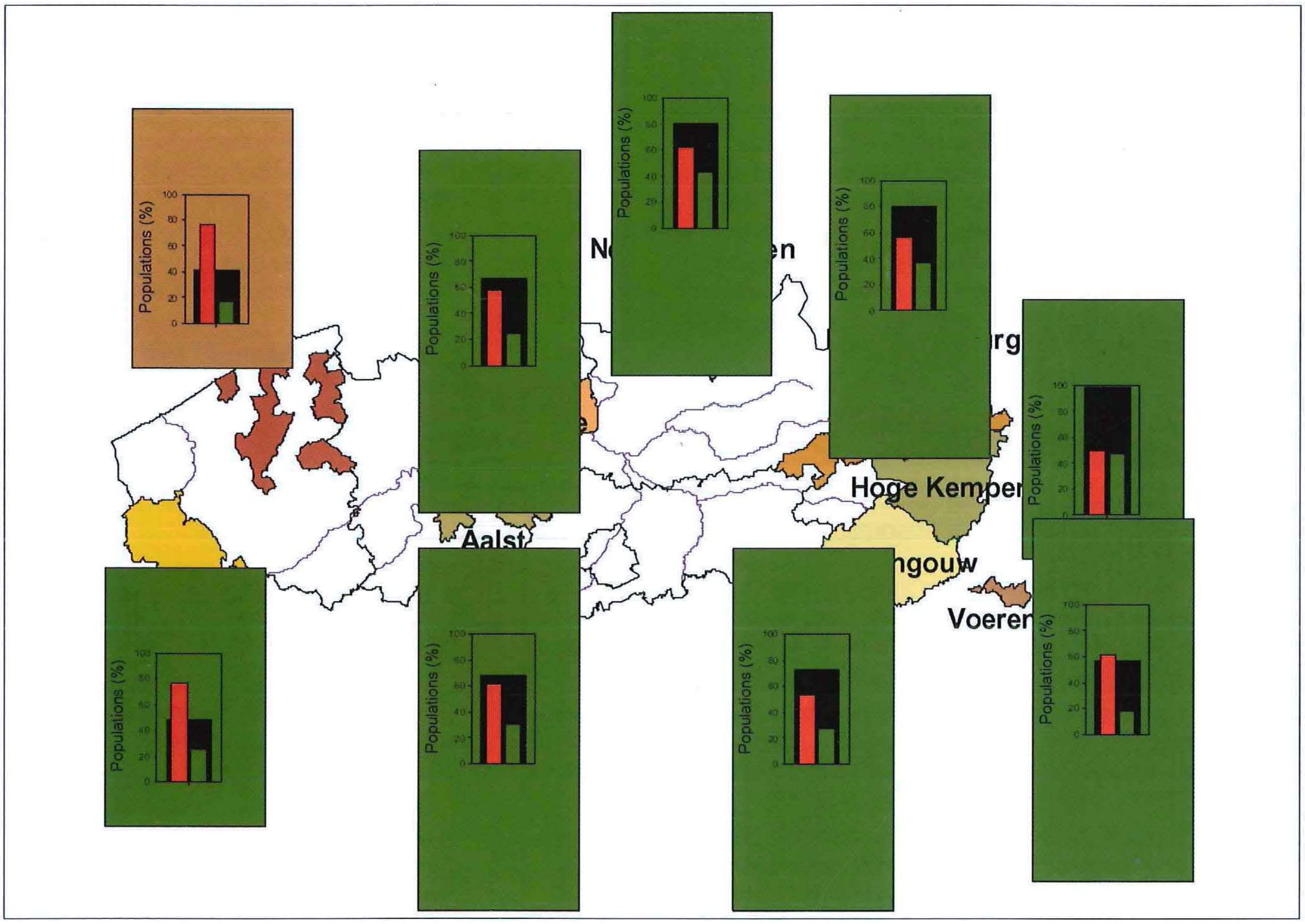

Fig. 10. Mean amphibian species specific turnover between 1999-2001 and 1975-1989 for the 9 investigated Flemish regions. Black: relative abundance (pools inhabited in 1999-2001 compared to 1975-1989), red: extinction rate, green: colonisation rate.

cultural practice. Agriculture is extremely intensive in Flanders, emitting Europe's highest levels of nutrients into the environment (OECD database for 2001 at www.oecd.org). This over-fertilisation is causing species extinctions. For example, it is one of the main reasons why nearly a third of the region's butterfly species have been wiped out during the past century (MAES & VAN DYCK, 2001). The farming system also influences the distribution and abundance of farmland birds (ALFORD & RICHARDS, 1999; CHAMBERLAIN & FULLER, 2001; DONALD *et al.*, 2001). For instance, agricultural intensification has been blamed for the plummeting populations of the house sparrow, *Passer domesticus*, in Western Europe in recent decades (HOLE *et al.*, 2002).

Human activities are not random in their negative and positive impact on biota. Widespread environmental change reduces the geographic range of many local, endemic species that cannot tolerate human activities, but also promotes the geographic expansion of others. Previous mass extinctions often produced low-diversity biota, dominated by a few widespread, broadly adapted species (ERWIN, 2002). The same process now recurs on a global scale as a result of two influences: environmental modification and transportation of exotic species (MCKINNEY & LOCKWOOD, 1999). Species susceptible to human impact are in general characterised by specific habitat requirements and low dispersal abilities. In a review covering many types of human activities, at many spatial scales, MCKINNEY & LOCKWOOD (1999) show that many species, usually 50%, are adversely affected. This figure is much higher than the number actually entered in the list of threatened species (www.redlist.org). One possible explanation is that species may be in decline, but their abundances may not be low enough to arouse an alarm as illustrated in our amphibian data.

Species invasions have been elevated to unprecedented rates accompanying the increased globalisation of the world (LODGE, 1993). About 2% of birds (LOCKWOOD, 1999) and 1% of mammals (LEVER, 1987) are reported as successfully introduced into new environments, while about 2% of plants are considered successful invasive weeds (DAEHLER, 1998). Invasive species are, in general, habitat generalists with high dispersal ability. As they invade, they can alter the evolutionary pathways of native species by competitive exclusion, niche displacement, hybridisation, introgression, predation, and ultimately extinction (MOONEY & CLELAND, 2001).

MCKINNEY & LOCKWOOD (1999) report that the number of 'winners' is much smaller than the number of 'losers'. It is estimated that 1-2% of the Earth's biota were imported successful invaders, while 5-29% expand their range locally. As a result, a few winners replace many losers, a process also called biotic homogenisation (e.g. HARRISON, 1993). Our study shows that these general global trends are also observed at the local, Flemish scale. Many rare species are severely threatened, while only a small number of local common species and imported aliens further spread, contributing to the biotic homogenisation and impoverishment of our biodiversity.

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