Investigations on Coleoptera Communities in different habitats. II. The Carabid fauna from 'Les Hautes Fagnes' (Mont Rigi, Belgium).

by Konjev DESENDER.

Summary

A survey on the carabid fauna of three different habitats from 'Les Hautes Fagnes' has been made by means of pitfall trapping between 20 April 1977 and 27 April 1978.
The study was performed in the surroundings of the 'Station Scientifique des Hautes Fagnes du Mont Rigi' (Belgium).

Each habitat is characterised by a number of species but the *Picea* stand and the replanted site after clearcutting show a higher level of similarity as compared to the bog site.
The phenology of the most abundant species is given, together with data on wing polymorphism in all species. The results are further discussed in connection with faunistic interest and propositions for management are given.

Introduction

In the scope of an arachnological and entomological study of the surroundings of the Scientific Station (University of Liège) situated in The National Nature Reserve 'Les Hautes Fagnes' (Mont Rigi, Belgium), three different sites were sampled by means of pitfall trapping (cf. BAERT & KEKENBOSCH, 1982).
In an earlier paper we already reported on *Trechus rivularis* n. sp. Belg. (Coleoptera, Carabidae), a relict species which had been found during this study (DESENDER, 1983).

Sampling sites

The Scientific Station is situated on the 'plateau des Hautes Fagnes' at an altitude of 670 m. The sampling sites have been described in detail by BAERT & KEKENBOSCH (1982).
Only a short description is presented here :
- *Station MR 1* : replanted site (7 years old stand of *Sorbus aucuparia* and *Fagus sylvatica*) after clearing from the original *Picea abies* stand, with some naturally established bush species ; arboreal cover : 40%, mean height : 2-5 m ; herb layer with a great variety of species (as compared to the *Picea abies* stand) and a cover of 95%, maximal height : 80 cm.
- *Station MR 2* : *Picea abies* stand (80 years old) : 70% cover, height : 30 m ; bush layer : 15% cover, height : 5 m ; well developed herb and moss layer.
- *Station MR 3* : Bog ('Fagne de la Poleur') : distinct herb layer (cover 100%) ; moss layer with different *Sphagnum* species.

Methods

On each site five pitfall traps were installed (ca. 1,5 m apart). Each trap was partially filled with saturated aqous picric acid solution as a fixing agent.
The traps were emptied at fortnightly intervals except during winter months.
Trapping was performed from 20 April 1977 till 27 April 1978.

All adult carabid beetles were identified (nomenclature according to LINDROTH, 1974), and the sex and the development of hind wings were also determined.
The interpretation of pitfall yields was based upon the theoretical investigations of this method by MAELFAIT & BAERT (1975).

In order to compare the taxocoenosis according to the species composition and the abundance of the species present, the following similarity indices were calculated :
(1) qualitative index of Sørensen (SØRENSEN, 1948) :

$C_s = \frac{2j}{a+b}$, where j is the number of species common to the two samples and a and b are respectively the total number of species in each sample ;

(2) Mean fractional similarity per shared species :

$$j_{m.\,fract.} = \frac{j.\,fract.}{j} \text{ , with } j.\,fract. = \sum_{i=1}^{i=j} \frac{V1}{V2} \quad (V1<V2)$$

with *V1/V2* the ratio of species numbers in both sampling units (HUBLE & MAELFAIT, 1982).

This index assesses the sampling units similarity according to the abundances of the shared species ;
(3) Quantitative similarity index of Renkonen (RENKONEN, 1938) which is obtained by summation of the minimal percentage occurrence values for all species common to both samples ;
(4) Quantitative similarity index of Pianka (PIANKA, 1974) :

$$P_{jk} = \frac{\sum_{i=1}^{n} P_{ij}P_{ik}}{\sqrt{\sum_{i=1}^{n} P_{ij}^2 \sum_{i=1}^{n} P_{ik}^2}}$$

with n = the number of species, p_{ij} and p_{ik} the proportion of species i in sample j and k.
All similarity values were converted to percentages. The sampling sites were classified into a dendrogram (average linkage, SOUTHWOOD, 1978).
The most numerous species were also clustered according to their occurence in the different samples (Pianka-index) in order to distinguish different possible species associations.
Finally, the phenology data from those species, represented by at least 60 individuals, were extrapolated into values for each month and presented in histogram.
To compare the results from the three different sampling sites species-individuals relatonships (collector-curves) were calculated based on the results from the different pitfall traps.
For each combination of traps into groups of 1, 2, ... 5 traps the number of species and individuals was calculated and regression analysis performed upon the mean values for each group and for the different stations.
After calculation of different curve types ($y = A.X$, $Y = A + B.X$, $Y = A.e^{B.X}$, $Y = 1/(A + B.X)$, $Y = A + B/X$, $Y = A + B.\text{Log}(X)$, $Y = A.X^B$, $Y = X/(A + B.X)$), in each case best fit was obtained for a power curve $Y = A.X^B$.

RESULTS

1. Species inventory and diversity.

Table I summarizes the results from the three sites at Mont Rigi.
On the whole 1573 individuals, belonging to 35 carabid species, were caught.
On Fig. 1. the species-abundance curves are plotted for these different sites.
Apparently MR 2, the *Picea* stand, shows the lowest species diversity, the replanted site the highest and the bog site intermediate diversity.
On the other hand it is obvious from these curves that a plateau is far from reached, indicating that a higher sampling effort would reveal more species.

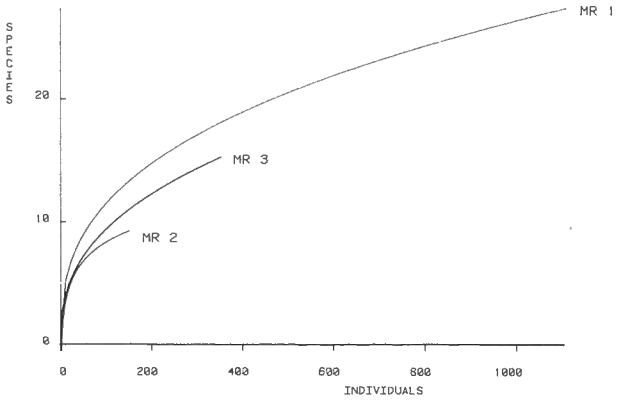
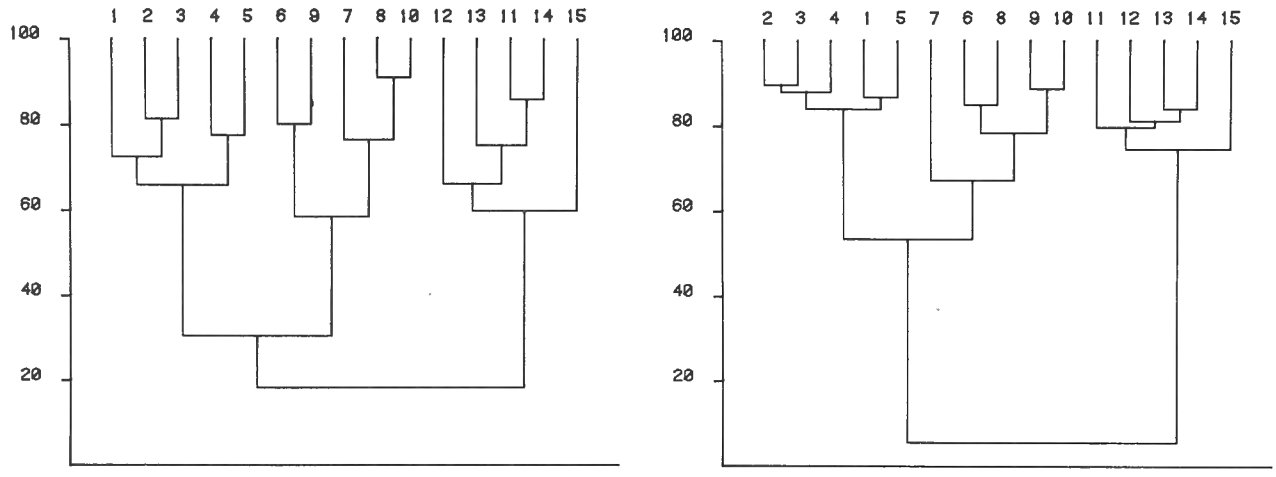


Fig. 1. Number of species versus number of individuals, plotted for each station : MR 1 $Y = 2{,}214.\ X^{0.359}$, $r^2 = 0.998$; MR 2 $Y = 1{,}603.\ X^{0.383}$, $r^2 = 0.994$; MR 3 : $Y = 1{,}949.\ X^{0.314}$, $r^2 = 0.997$; see text for further explanation.

2. Similarities between the catching units and species associations.

Figs. 2, 3, 4 and 5 present the dendrograms from the different sampling units, based on respectively Sørensen, Renkonen, Pianka and Mean Fractional similarity index.
In each case almost all individual pitfalls group at a high level within one station, whereas at a lower level station MR 1 and MR 2 are grouped, compared to MR 3 (bog). On Fig. 6. the dendrogram based on Pianka similarity between the most numerous species is presented.
Two different groups are found : species 1 to 5 are associated at a high level and are all typical fenland species : *Trechus rivularis* only occurs in bogs and has a subarctic distribution, the remaining species are also found in fens (*Pterostichus diligens*, *Agonum fuliginosum* and *Pterostichus nigrita*) whereas finally *Dyschirius globosus*, a species especially abundant in different fenland-types, also regularly occurs in different kinds of other habitats with a high relative humidity. The other species group (6-18) is composed of many species, some species only being grouped at a higher similarity level : in this group species 6-8 are typical woodland species (*Agonum assimile*, *Carabus problematicus* and *Pterostichus oblongopunctatus*), whereas the remaining species were mainly found in the replanted site.
Species especially abundant on this site are : *Trechus secalis*, *Bradycellus harpalinus*, *Trechus obtusus*, *Pterostichus madidus* and *Pterostichus strenuus*.
This last group is partly composed of some ubiquistic species occurring in woodland as well as other habitat types (e.g. grasslands : *Pterostichus strenuus*, *Trechus obtusus*).



*Figs. 2, 3, 4 and 5. Dendrograms based on similarities between the different sampling units respectively by means of S*θrensen (2), Renkonen (3), Pianka (4) and Mean fractional (5) similarity index.

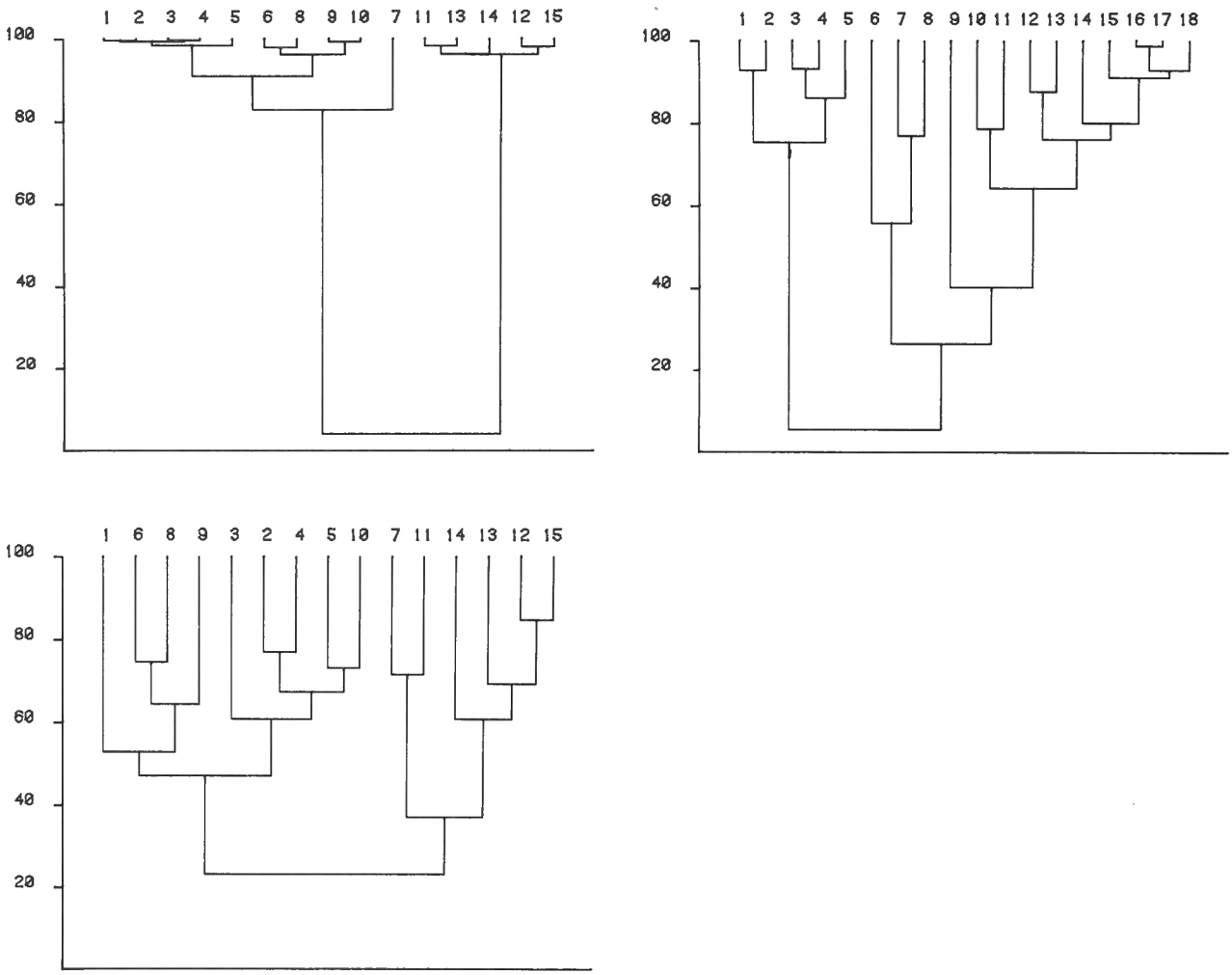


Fig. 6. Dendrogram between the most abundant species according to their occurrence in the sampling units (Pianka-index; 1 = Agonum fuliginosum, 2 = Pterostichus nigrita, 3 = Dyschirius globosus, 4 = Pterostichus diligens, 5 = Trechus rivularis, 6 = Agonum assimile, 7 = Carabus problematicus, 8 = Pterostichus oblongopunctatus, 9 = Notiophilus palustris, 10 = Bembidion lampros, 11 = Notiophilus biguttatus, 12 = Amara communis, 14 = Pterostichus strenuus, 15 = Carabus violaceus, 16 = Bradycellus harpalinus, 17 = Trechus obtusus, 18 = Trechus secalis).

3. Phenology of the most abundant species.

Phenology histograms were plotted for the most abundant species after monthly extrapolation of the data (Fig. 7 : A, B, C, D, E, F, G, H).
Different types of phenology patterns were found : *Pterostichus strenuus*, *P. diligens*, *P. oblongopunctatus* and *P. madidus* are mainly active during Spring ('Spring Breeders') with a secondary activity peak during Autumn caused by hatched adults from the new generation. *Trechus obtusus*, *T. secalis* and *T. rivularis* show their main activity period during July, August and September. These species reproduce during Summer/Autumn with sometimes additional reproduction the next early Spring (DESENDER et al., 1980).
Finally *Bradycellus harpalinus* shows an alternative phenology pattern : the activity is spread over the entire year with peaks during Autumn/Winter and during Spring.
This species most probably reproduces mainly during winter (cf. DEN BOER et al, 1980).

4. Wing development.

Table II summarizes the results on wing development for the different sites.
A high percentage of brachypterous or dimorphic and polymorphic species were found in each station, but on the whole macropterous species are most numerous.
When taking the individuals into account it is obvious that a very high percentage of brachypterous beetles is found (65-95% from the total catch in each station).

DISCUSSION

Comparision of the species list with DERENNE (1957) reveals some species with special faunistic interest :
- *Trechus rivularis* n. sp. Belg. (cf. DESENDER, 1983)
- *Trichocellus placidus* : was only known from Beverloo and Lichtaart ; we have recently discovered this species on different other sites in Belgium (unpublished data) ; the very much related species *(Trichocellus coagntus* was already reported from Baraque-Michel but we have not yet been able to confirm this identification ;
- *Trichotichnus nitens* : rare woodland species, known from three other sites in Belgium (La Roche, Lacuisine and Rulles) ;
- *Trechus rubens* : rare species, mostly found in bog sites, already reported from Stockem, Samrée, Houffalize, Sart, Jalhay and Baraque-Michel) ;
- *Dromius fenestratus* : rare, known from four sites only (La Roche, Beausaint, Liège and Strée) ;
- *Notiophilus quadripunctatus* : rare ;
- *Pristonychus terricola* : rare, especially on obscure sites.

No doubt, the presence of relict species as *Trechus rivularis* (other insect species with subarctic or boreo-alpine distribution have been reported from 'Les Hautes Fagnes' by other authors) gives this sites special faunistic interest.

Cluster analysis of our data reveals that each trap is grouped within the station, when taking only the presence or absence of species as well as when taking the number of individuals into account.
The *Picea* stand and the replanted site group at a higher level compared to the bog site.
This means that, as far as carabids are concerned, a number of woodland species are present in the cleared and replanted site. This is indeed expected because this site is a strip within a *Picea* stand, which made originaly part of it.
However it is obvious that on the cleared site much higher abundances are obtained and that other species are added as compared to the *Picea* stand.
This corresponds with the results summarized by THIELE (1977) indicating that woodlands are inhabited by fewer carabid species and that lower abundance levels are reached as compared to different grassland types.
On the basis of spider data, BAERT & KEKENBOSCH (1982) did find more similarity between the cleared site and the bog site, probably due to the open character of both habitat types.
One feature which is much interesting in our case is the higher diversity reached in cleared and replanted woodland as compared to the *Picea* stand.
On the whole, the most interesting habitat type however is the bog site, due to the presence of the relict species *Trechus rivularis*.
BAERT & KEKENBOSCH (1982) did find most spider species, some of which with a northern distribution, on this site as compared to the other sampled stations. (cf. relict species of spider : *Maro lehtineni* (BAERT & KEKENBOSCH, 1979). We therefore think it is necessary to prevent further forestation on these sites.
Due to the relatively small surfaces of much of these bog sites in 'Les Hautes Fagnes' today, the species inhabiting them might be more vulnerable to extinction than would be the case in larger areas.
We think it could be worthwile to clearcut previously planted bog sites as a first step in a management leading to the original situation.

The results on phenology and reproduction type are in agreement with literature data (as far as existing, cf. THIELE (1977)).
However, when comparing the phenology for *Trechus obtusus* with data from coastal dunes (De Panne, Western Flanders ; DESENDER et al., 1980) it is

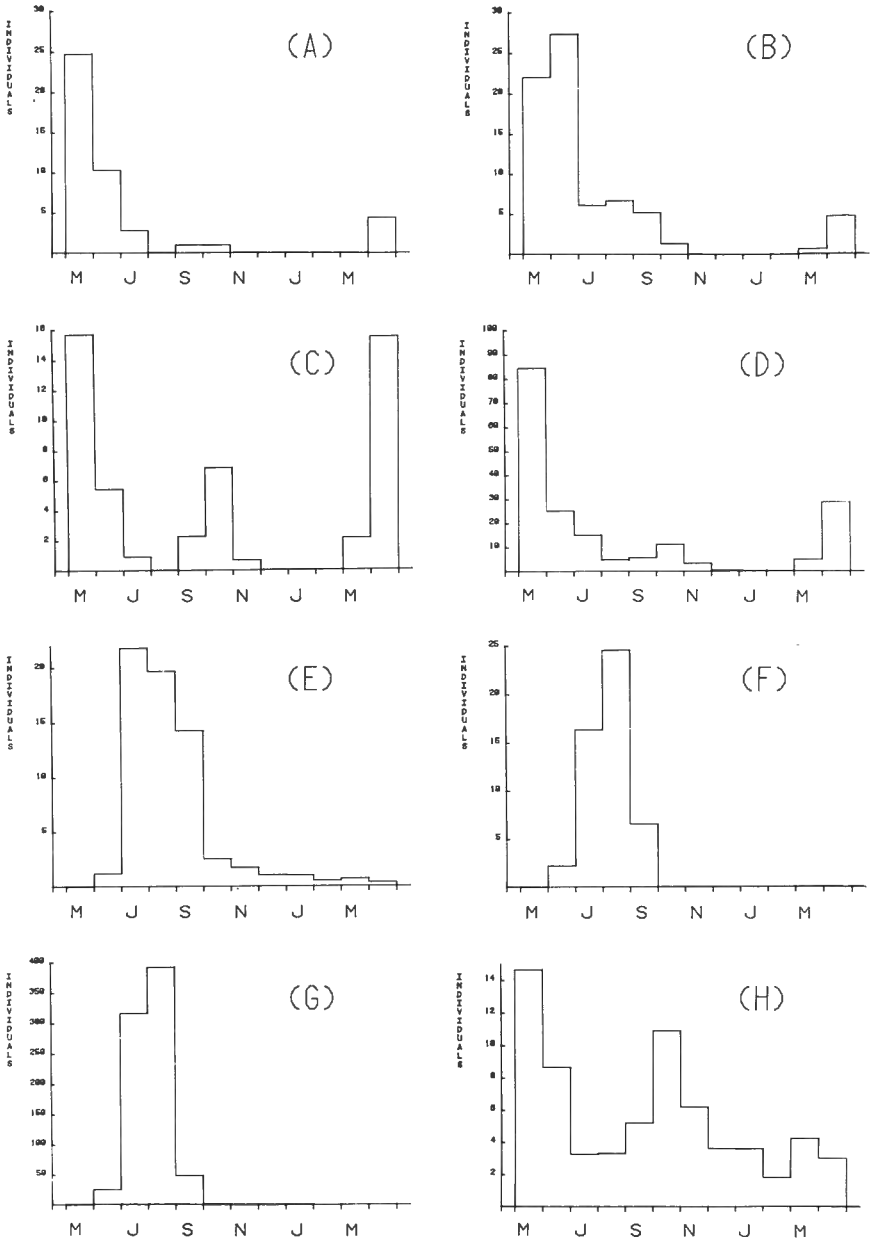


Fig. 7. Phenology of the most abundant species (monthly extrapolated) (A = Pterostichus oblongopunctatus, B = P. madidus, C = P. strenuus, D = P. diligens, E = Trechus obtusus, F = T. rivularis, G = T. secalis, H = Bradycellus harpalinus).

obvious that the phenology peak is about six weeks earlier in 'Les Hautes Fagnes'. This shift is probably linked to more severe conditions in 'Les Hautes Fagnes' from September onwards.
As a result reporductive activity has to take place earlier to complete the year cycle from this species, which reproduces during Autumn resulting in hibernating larvae.

The results on wing polymorphism show a remarkable number of brachypterous individuals and species.
This means that many species were found with a low dispersal capacity and, in concordance with the results from DEN BOER et al. (1980), this shows on the one hand the marked ecological maturity of thsi region, on the other hand it stresses the vulnerability of the carabid fauna present in this isolated relict area.

Acknowledgements

We are indebted to Dr. L. Baert and Mr. J. Kekenbosch for giving us the opportunity to study the beetles collected at Mont Rigi.
Many thanks are also due to Prof. Dr. J. Hublé for critical reading of the manuscript.

Table I.
Carabidae (Coleoptera) (number of ♀♀/number of ♂♂) from three sites at Mont Rigi ('les Hautes Fagnes', Belgium); five pitfall traps on each site from April 1977 - April 1978 ; nomenclature according to LINDROTH (1974).

SITE / SPECIES	MR 1	MR 2	MR 3	TOTAL
Agonum assimile (PAYKULL)	1/	3/1	-	4/1
fuliginosum (PANZER)	-	-	6/10	6/10
Amara communis (PANZER)	9/10	-	4/1	13/11
lunicollis SCHIØDTE	1/2	-	1/	2/2
Bembidion lampros (HERBST)	9/10	/1	1/1	10/12
unicolor CHAUDOIR	-	-	3/	3/
Bradycellus harpalinus (SERVILLE)	26/45	-	1/	27/45
ruficollis STEPHENS	2/	-	-	2/
Carabus monilis FABRICIUS	/1	-	-	/1
problematicus HERBST	1/	3/6	-	4/6
violaceus LINNAEUS	10/8	-	-	10/8
Cychrus caraboides (LINNAEUS)	/3	-	/1	/4
Clivina fossor (LINNAEUS)	1/1	-	-	1/1
Dyschirius globosus (HERBST)	-	-	25/20	25/20
Dromius fenestratus FABRICIUS	-	/1	-	/1
Notiophilus biguttatus (FABRICIUS)	7/7	5/3	-	12/10
palustris (DUFTSCHMID)	1/2	-	1/1	2/3
quadripunctatus DEJEAN	/1	-	-	/1
Harpalus rubripes (DUFTSCHMID)	-	-	/1	/1
Leistus rufescens (FABRICIUS)	1/	2/	-	3/
Pristonychus terricola (HERBST)	/1	-	-	/1
Pterostichus diligens STURM	/1	-	89/106	89/107
nigrita PAYKULL	-	-	4/3	4/3
niger (SCHALLER)	/1	-	-	/1
madidus (FABRICIUS)	33/44	-	-	33/44
melanarius ILLIGER	1/3	-	-	1/3
oblongopunctatus (FABRICIUS)	10/12	15/15	-	25/27
strenuus (PANZER)	23/27	-	-	23/27
Trechus obtusus ERICHSON	34/32	-	-	34/32
rivularis GYLLENHAL	-	-	33/18	33/18
rubens (FABRICIUS)	-	-	1/	1/
secalis (PAYKULL)	375/337	46/30	4/7	425/374
Trichocellus placidus (GYLLENHAL)	/2	-	-	/2
Trichocellus laevicollis DUFTSCHMID	1/	-	-	1/
nitens HEER	2/1	/1	-	2/2
NUMBER OF INDIVIDUALS	548/551	74/58	173/169	795/778
NUMBER OF SPECIES	27	9	15	35

Table II.
Hind wing development of carabid beetles at three sites at Mont Rigi: 1) at the species level: A = species known as constantly brachypterous, B = species known as dimorphic or polymorphic, C = species known as macropterous; 2) at individual level: E = brachypterous individuals from brachypterous species, F = brachypterous individuals from dimorphic or polymorphic species. G = macropterous individuals from dimorphic or polymorphic species and H = macropterous individuals from macropterous species.

	MR 1	%	MR 2	%	MR 3	%	TOTAL	%
SPECIES								
A	7	26.0	2	22.2	4	26.7	9	25.7
B	10	37.0	2	22.2	6	40.0	12	34.3
C	10	37.0	5	55.6	5	33.3	14	40.0
INDIVIDUALS								
E	813	74.0	85	64.4	66	19.2	964	61.3
F	132	12.0	2	1.5	256	74.9	390	24.7
G	99	9.0	7	5.3	5	1.5	111	7.1
H	55	5.0	38	28.8	15	4.4	108	6.9

References

BAERT, L. and KEKENBOSCH, J. 1979. Le genre *Maro* O.P. Cambridge 1906 (*Araneae : Linyphiinae*) en Belgique. - *Bull. Ann. Soc. r. belge Ent.*, vol. 115, pp. 117-120.
1982. Araignées des Hautes Fagnes II. Ecologie (Ecology of Belgian Spiders III). - *Bull. Inst. r. Sci. nat. Belg.*, vol. 54, pp. 1-21.

DEN BOER, P.J., VAN HUIZEN, T.H.P., DEN BOER-DAANJE, W., AUKEMA, B. and DEN BIEMAN, C.F.M. 1980. Wing Polymorphism and Dimorphism in Ground Beetles as Stages in an Evolutionary Process (*Coleoptera : Carabidae*). -*Entom. Gen.*, vol. 6, pp. 107-134.

DERENNE, E. 1957. Catalogue des Coléoptères de Belgique. I. *Caraboidea Carabidae*. - *Soc. Roy. d'Entom. Belg.*, 116 p.

DESENDER, K. *Trechus rivularis* Belg. n. sp. (*Coleoptera, Carabidae*) une espèce subarctique des Hautes Fagnes (Mont Rigi, Belgique). -*Bull. Ann. Soc. r. Ent. belge*, vol. 119, pp. 177-183.

DESENDER, K., MAELFAIT, J.-P. and DEURINCK, R. 1980. Ecological data on *Trechus obtusus* De Geer (*Coleoptera, Carabidae*) collected by pitfall trapping in coastal dunes (Belgium). - *Biol. Jb. Dodonaea,* vol. 48, pp. 90-101.

HUBLE, J. and MAELFAIT, J.-P. 1982. Analysis of the Spider Fauna from a North and a South Facing Slope of a Coastal Dune (Belgium). - *Faun. -ökol. Mitt.* vol. 5, pp. 175-189.

LINDROTH, C.H. 1974. Handbooks for the Identification of British Insects. Vol. IV. Part 2. Coleoptera, Carabidae - *Roy. Ent. Soc. London*, 148 p.

MAELFAIT, J.-P. and BAERT, L. 1975. Contribution to the knowledge of the arachno- and entomofauna of different woodhabitats. I. Sampled habitats, theoretical study of the pitfall method, survey of the captured taxa. - *Biol. Jb. Dodonaea*, vol. 43, pp. 179-196.

RENKONEN, O. 1938. Statistisch-Okologische Untersuchungen über die terrestrische Käferwelt der finnischen Bruchmoore. *Ann. Zool. Soc. Zool. Bot. Fenn.*, vol. 6, pp. 1-226.

SØRENSEN, T. 1948. A method of establishing groups of equal amplitude in plant sociology based en similarity of species content and its application to analyses of the vegetation on Danish commons. *Biol. Skr.*, vol. 5, pp. 1-34.

SOUTHWOOD, T.R.E. 1978. Ecological Methods with particular reference to the study of Insect Populations (2nd ed.) - *Chapmann and Hall, London*, 524 p.

PIANKA, E.R. 1974. Niche overlap and diffuse competition. - *Proc. Nat. Acad. Sci. USA*, vol. 71, pp. 2141-2145.

THIELE, H.U. 1977. Carabid beetles in their environments. - *Springer Verlag, Heidelberg, New York*, 369 p.

Konjev DESENDER
Laboratorium voor Oecologie der Dieren,
Zoögeografie en Natuurbehoud
K.L. Ledeganckstraat 35)
B-9000 Gent, BELGIUM.