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Effects of groundwater catchment and grassland management on the spider fauna of the dune nature reserve 'De Westhoek' (Belgium)

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ABSTRACT

An evaluation of groundwater level fluctuations and nature conservation management on the spider fauna of wet grasslands in the dune nature reserve 'De Westhoek' (Belgium) is made. Changes in spider fauna are demonstrated.

INTRODUCTION

The Belgian coast is a narrow strip of lime rich sand, one to two kilometres wide, some 60 km long, and extends between the North Sea and the Polder Region.

After World War II mass tourism led to the transformation of the beach front to an almost continuous wall of concrete and apartment buildings. The landward side of the dunes was turned into camping and caravanning sites. Only a fraction of our dune areas survived. The more important dune relicts are situated near the French and Dutch borders. During recent years, intensive but not sufficient, efforts have been made to preserve the remaining dune areas. Active management, including, for instance, prevention of sea buckthorn from invading open short vegetation and decreasing intensity of groundwater extraction will be needed. The effects of these nature conservation management efforts should not be monitored by vegetation studies alone. As it has been known for a long time that invertebrate communities respond in quite a different way to management practices than vegetation does (e.g. Morris 1971; Duffey *et al.* 1974). As it was done for other habitats (Desender *et al.* 1991 1992, 1992; Maelfait 1993; Maelfait & Baert 1988; Maelfait & Desender 1990a, b; Maelfait *et al.* 1989, 1990a, b, 1992a, b, 1994, 1995), studies on invertebrates should be incorporated to get a more complete picture. Our results from dune ecosystems demonstrate that invertebrates, especially spiders, can be used.

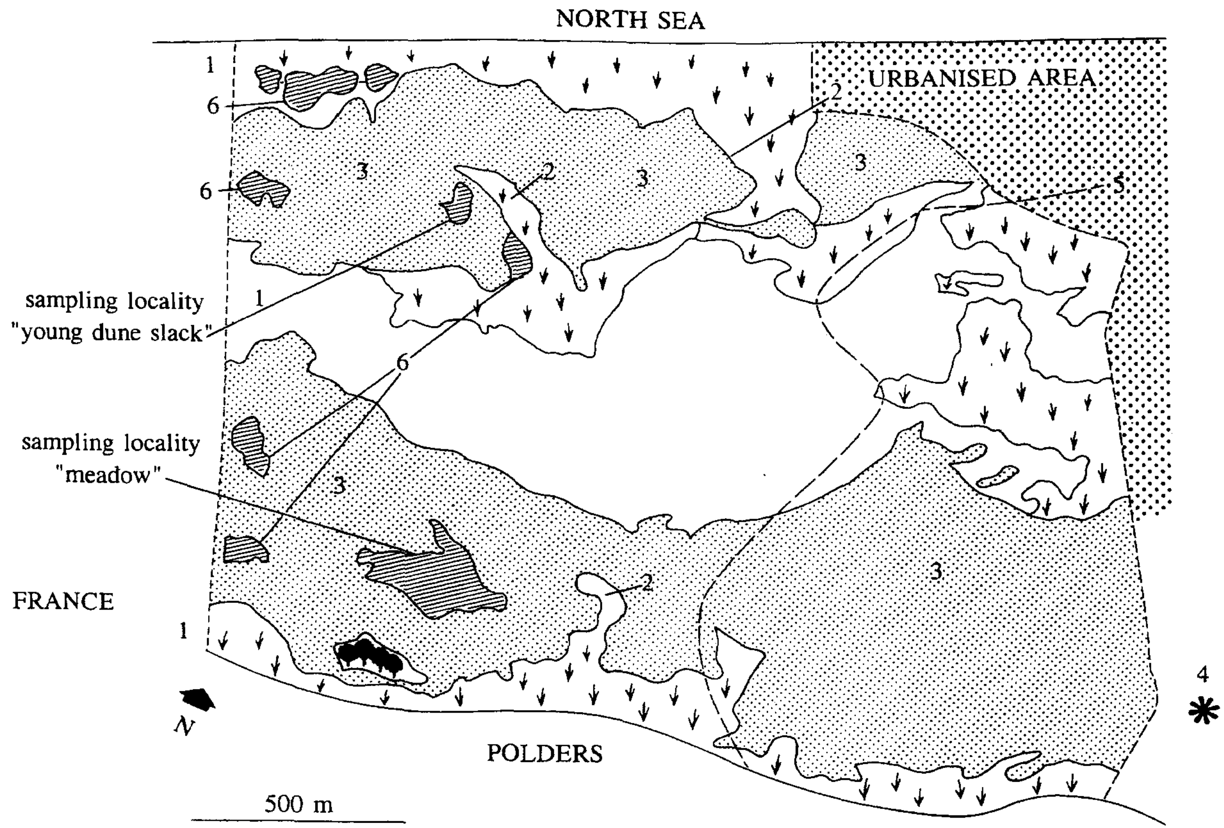

Fig. 1. Sampling localities in the dune nature reserve 'De Westhoek'. 1: northern, central and southern dune ridge, 2: parabolic dunes, 3: dune slacks with sea buckthorn scrub, 4: groundwater pumping station, 5: lowering of the groundwater table by the end of the 70s, 6: areas in which sea buckthorn invasion is prevented through a yearly cutting.

MATERIAL AND METHODS

The material was gathered in the State Nature Reserve 'De Westhoek' (Fig. 1), an important dune reserve of some 340 hectares situated at the French border of the Belgian coast. It consists of northern and southern dune ridge, dominated by *Ammophila arenaria*, a broad central ridge of almost bare sand (number 1 in Fig. 1) and of parabolic dunes (number 2 in Fig. 1) with associated depressions or dune slacks (number 3 in Fig. 1). In the northern part of the central ridge new dune slack formation is still going on. The two sampling localities ('young dune slack' and 'meadow') are indicated in Fig. 1. An important threat to the nature of the reserve are the activities of a nearby groundwater catchment to the south-east of the reserve (number 4 in Fig. 1), especially during the summer, the tourist season, resulting in a pronounced decrease of water table (Fig. 1).

A second threat to the reserve is that the major part of the slacks is being overgrown by dune shrubs. A general aim of the management there is to clear parts of that scrubs by means of cutting and also to protect the remaining open areas against the invasion of sea buckthorn, *Hippophaea rhamnoides* (number 6 in Fig. 1).

The arthropod fauna active on the soil surface was sampled by pitfall traps - glass jars 9.5 cm in diameter and about 10 cm deep. The traps were emptied at fortnightly intervals between mid-March 1987 and the end of January 1988. From January, both dune slacks were completely flooded for about six months. Our first sampling station was a small (about 0.3 hectare) open area in the northern part of the reserve, completely surrounded by 40 year old sea buckthorn scrub ('young dune slack', Fig. 1). Some ten years ago the site was even smaller due to partial invasion of sea buckthorn from the surrounding scrub which resulted in floristic diversity decrease. Therefore, in the early 80s it was decided to eliminate the invading buckthorn and to remove the raw organic matter accumulated underneath. Since then the whole area has been mown at the end of each summer and the dried biomass has been removed. This sampling station can be characterized as a moist dune slack with a lime rich mineral soil. The dominant plant species are: *Salix repens*, *Epipactis palustris*, *Agrostis stolonifera*, *Galium uliginosum* and *Lythrum salicaria*. Because one of the dominant plant species is *Parnassia palustris*, we refer to it as to 'Parnassia Slack (PS)'. It was sampled by six pitfall traps in 87-88.

The second sampling station was situated in the adjacent sea buckthorn scrub, dominated by *Hippophae rhamnoides*. We will refer to it as 'Buckthorn Scrub (BS)'. There, three pitfall traps were operating during 87-88.

Three sampling stations were situated in the large open area (3.5 hectares) in the south of the reserve (indicated as 'meadow' in Fig. 1). It is a much older dune slack than the one we sampled in the north of the reserve. During the 19th century it was partly used as arable land and was irregularly fertilised. Between the First and Second Wars it was grazed by cattle. The area is therefore called the 'Meadow'. After the Second War it was no longer used by man. This led to the development of a rough vegetation of tall herbs, sedges and grasses with a thick litter layer (dominant plant species: *Carex riparia*, *Iris pseudacorus* and *Lysimachia vulgaris*). The site was sampled with six pitfall traps in 1973-74. The results of that sampling were only available as the total number caught per six traps (not per individual trap) during the same months of sampling as in 87-88. We will refer to it as '73 Meadow (73M)'. From the early 80s the managing authorities started a yearly mowing of that area with the removal of the cut biomass. Thus a large patch of rough vegetation (12 by 70 meters) was eliminated. Three pitfall traps were installed there ('Rough Meadow', RM) during 87-88. Besides that large patch, some ten small islands (1-2 m in diameter) of vegetation were left uncut and developed a rough vegetation with a well developed litter layer. Three of them were sampled in 87-88 by one pitfall trap each (sampling station 'Islands Meadow', IM). Six traps were distributed over the mown part of the meadow ('Mown Meadow', MM) sampling station.

RESULTS AND DISCUSSION

The number of individuals caught per three pitfall traps for the six sampling stations are given in Tab. 1. They belong to 141 species and represent 17 families.

I. Variation in carabid and spider communities of the stations sampled in 87-88

We first analyzed the influence of the management, age and history of the dunes slack on the composition of the arthropod communities (spiders and beetles) sampled in 87-88. For each species the total number of individuals caught between the beginning of the sampling until the flooding was used. Each species was treated equally by standardising the captures per species. In order to avoid the large random variation caused by small numbers, only the species caught in a number equal or larger than the total number of sampling units, considered in a particular analysis, were used. The analysis technique that was used is Detrended Correspondence Analysis (DCA) by Hill (1979). For both taxonomic groups an ordination was made of: (1) the sampling units of the first sampling locality ('young dune slack'): 9 traps, (2) the sampling units of the second ('meadow'): 12 traps and (3) of the 21 pitfall traps of both sampling localities. For both groups the sampling units are analyzed together according to sampling station (Fig. 2). This means that the species composition and the abundance of the species vary according to the differences in habitat. Thus both groups are good indicators to evaluate the effects of the differences in management between the sampling stations. For the spiders it is once more confirmed that vegetation structure plays a very important role in occurrence. For instance, there is very clear separation between the spider sampling units of the meadow (middle right in comparison with middle left of Fig. 2). The importance of vegetation structure in determining spider community composition can also be seen in the ordination of the 21 sampling units. In contrast to the result obtained for the carabids, we see that the most important axis of variation is related to vegetation structure: from yearly mown sites through scrub and tall, rough vegetation, resulting in occurrence and abundance (probably also soil wetness: see below) (Fig. 2 bottom, left).

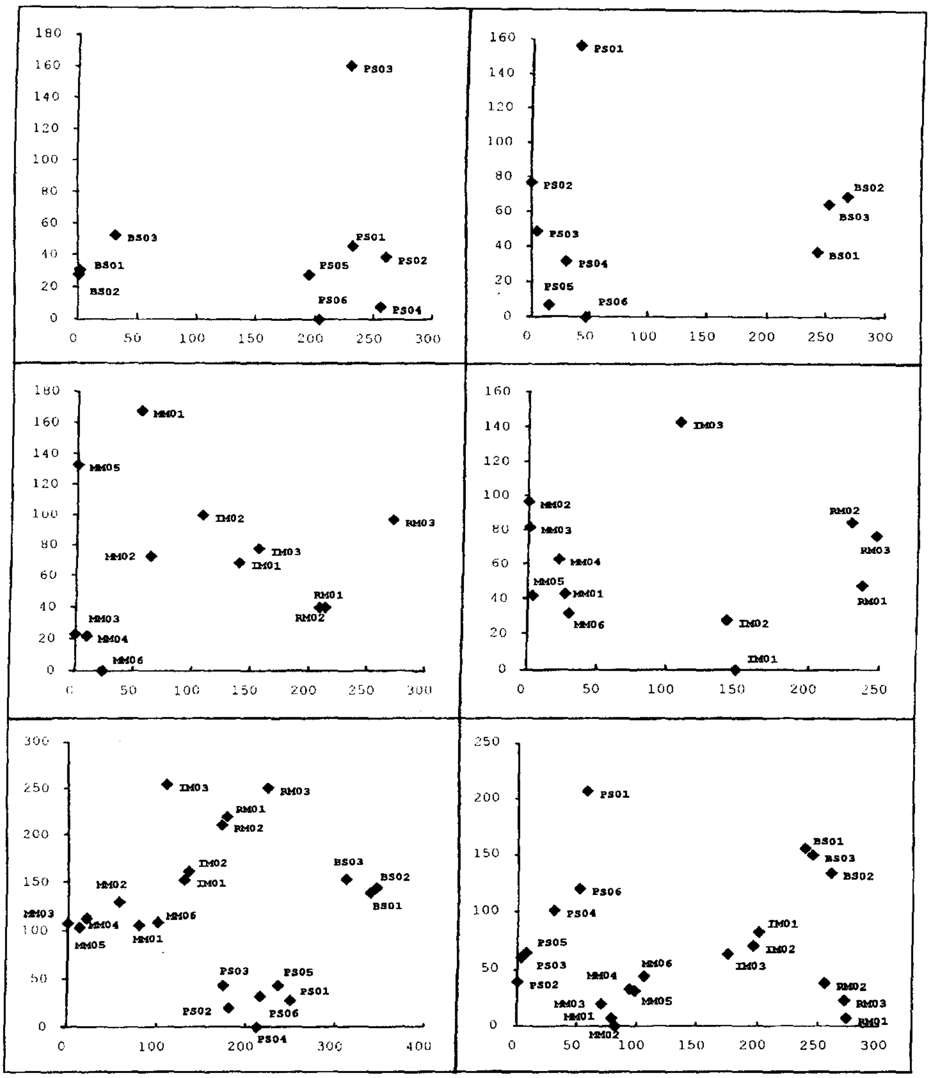

Fig. 2. DCA-ordination of the sampling units of 87-88 on the basis of the most abundantly caught carabid species (left) and spider species (right) of the young dune slack (top), the meadow (middle) and of both sampling localties (bottom).

II. Comparison between the spider faunas of the yearly mown young dune slack and the yearly mown part of the meadow

The gathered material gives us the opportunity to compare two sites with the same management (yearly cutting) and therefore not so different in vegetation structure: sampling station PS and MM.

Altogether, 82 species were caught in MM and 101 in PS. To understand that difference, we listed (Tab. 2) the species where at most one single individual was caught in one of the two habitats, whereas a considerable number were caught in the other.

The large abundance of *Ceratinella brevipes* and *Tiso vagans* in the Mown Meadow and of *Pirata hygrophilus*, *Antistea elegans* and *Gnathonarium dentatum* in the Parnassia Slack indicates that the latter site is wetter than the first. Indeed, from the habitat characteristic (e.g. Hänggi *et al.* 1995; Heimer & Nentwig, 1991; Locket & Millidge 1951, 1953; Roberts 1985, 1987), it can be deduced that the last three species are much more hygrophilous than the other two. Another hygrophilous species which is represented in the Parnassia Slack but not in the Meadow is *Trochosa ruricola* (Tab. 1). It seems that the young dune slack in 87-88 was not yet influenced by the activities of the groundwater pumping station.

A bit surprising at first sight is that *Cheiracanthium virescens* was caught in that Parnassia Slack but not in the Meadow (Tab. 2). The same applies to other species caught in lower numbers like *Argenna subnigra*, *Drassodes cupreus*, *Zelotes electus* and *Oxyptila sanctuaria* (Tab. 1). These species are all known as being xerophilous (same literature sources as above). This observation can be understood by the small size of the Parnassia Slack and the very close presence of dry habitats. It is especially in these dry dune habitats that the most rare dune spiders are found, like the ones mentioned. They often have more southern distribution.

III. Changes in the spider fauna of the 'Meadow' between 73-74 and 87-88

To evaluate the changes of the spider community of the meadow before and after the mowing management we first ordinated (DCA: Hill 1979a) and classified (TWINSPAN: Hill 1979b) the samples made in the six kinds of habitats (Fig. 3). For each of the abundant species we used the total numbers caught in three pitfall traps of these sampling stations. There is thus a clear separation along the first axis of the DCA and in the dendrogram summarising the TWINSPAN between habitats with high and litter rich vegetation and more open sampling stations. This again illustrates the important role of vegetation and litter layer structure in spider communities composition. The second axis of the DCA seems to be related to soil wetness with PS being the most wet, MM the least wet and 73M having an intermediate wetness.

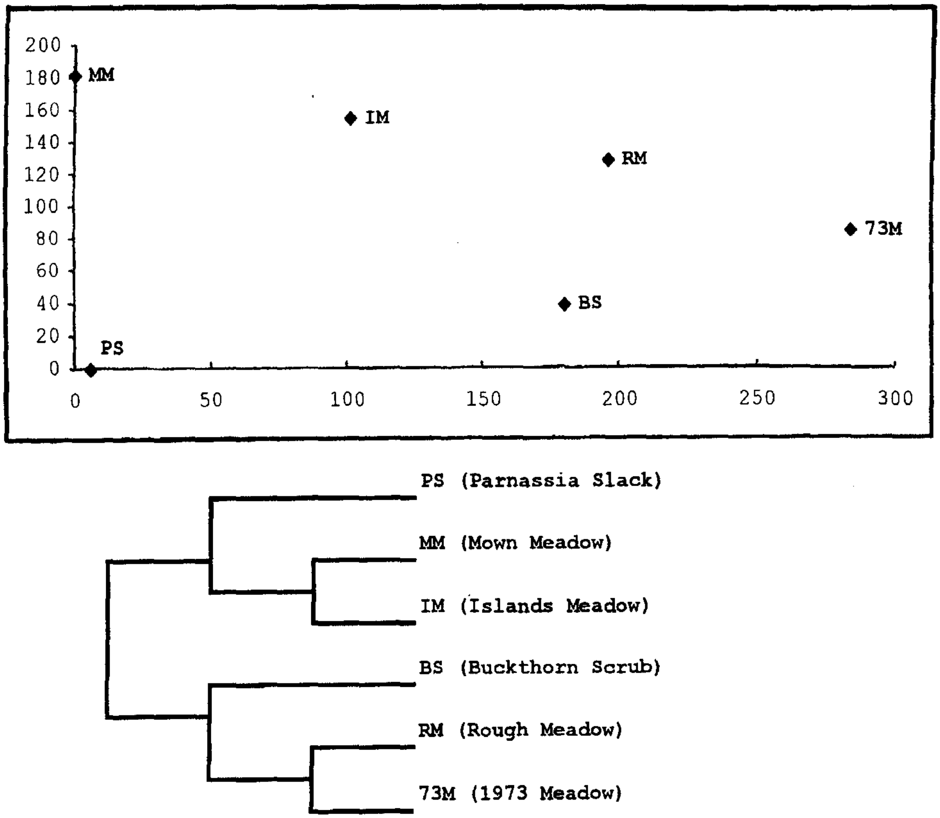

Fig. 3. DCA-ordination (top) and TWINSPAN-classification (bottom) for the spiders of the six sampling stations on the basis of the most abundantly caught spider species.

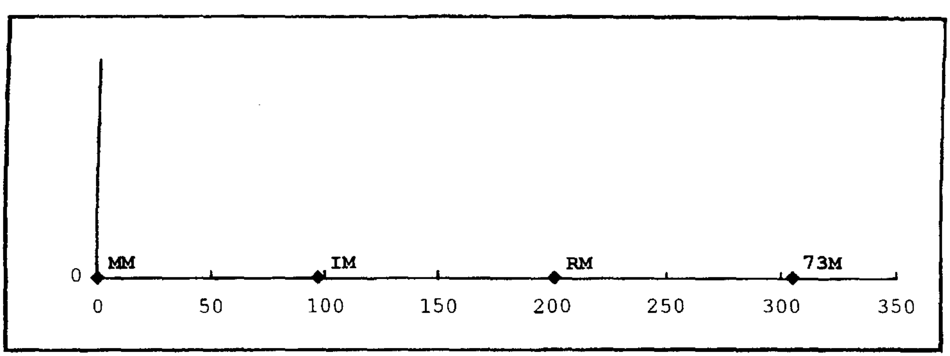

Fig. 4.-DCA-ordination for the spiders of the four situations sampled in the Meadow.

In Fig. 4 the different sampling stations of the Meadow are ordinated according to a DCA based on the numbers of the most abundantly caught species (numbers caught in three pitfalls per station). This ordination confirms the change between the situation sampled in 73-74 and the situations sampled in 87-88. To find the environmental factors responsible for that, we compared the faunal composition of 73M with the rough vegetation habitats sampled in 87-88 (IM + RM). In both situations 84 species were caught. As can be seen from Tab. 1 a number of new species arrived and an equal number disappeared. To reveal the nature of that species turnover in Tab. 4 we listed those species not caught or represented by only 1 individual in one site and by more than a very few individuals in the other site. The presence or the higher abundance of *Pardosa palustris*, *Ceratinella brevipes*, *Erigone atra* and *Tiso vagans* are easy to understand as the species are related to short vegetation types occurring in quite large numbers in the mown part of the meadow. Other new colonisers or species which could enlarge their population size due to the mowing of the major part of the meadow are (Tab. 1): *Arctosa leopardus*, *Erigone atra*, *Erigone dentipalpis*, *Erigone promiscua*, *Agyneta decora*, *Centromerita bicolor* and *Centromerita concinna*. *Erigone promiscua* is very rare in Belgium; the spiders occurring in the mown part of the meadow and in the Parnassia slack are the only two populations known to occur in our country (Baert 1996). During 1995-96 intensive sampling in both localities, the species was only found back in the Parnassia slack (Bonte 1996). Why four other species appeared or increased in population size in the rough parts is not clear. For *Floronia bucculenta* and *Saaristoa abnormis* this may be related to the presence of transition zones between higher and lower vegetation. The species mentioned before are much less hygrophilous than the species which disappeared or diminished clearly in numbers. Of these last *Pardosa amentata*, *Antistea elegans*, *Baryphyma pratense*, *Gnathonarium dentatum* and *Tallusia experta* are known to be found in very wet and litter rich localities. *Baryphyma pratense* is a very rare species in our country occurring only in the west (Baert 1996); it has also been recorded from litter rich localities along streams.

It can be said that mowing resulted in higher spider community richness. This is due to the appearance of species bound to wet, short vegetation. This positive development is however counteracted by the loss or the decrease of species bound to very wet conditions, especially *Baryphyma pratense*. This last effect was also observed for the carabid beetles (Desender *et al.* 1991, 1992). It is most probably caused by the lowering of the water table caused by nearby catchment.

Tab. 1. Number of individuals caught per three pitfall traps from half March to the end of January (87-88, 73-74) in the six sampling stations of 'De Westhoek'

Family/Species	PS	BS	MM	IM	RM	73M
Dictynidae						
Argenna subnigra	9	0	1	2	0	0
Dictyna viridissima	0	0	1	0	0	0
Gnaphosidae						
Drassodes cupreus	7	0	0	0	0	5
Haplodrassus signifer	1	0	1	0	0	0
Micaria pulicaria	2	0	0	0	0	0
Zelotes electus	6	0	1	0	0	1
Zelotes longipes	0	0	0	0	0	4
Clubionidae						
Cheiracanthium virescens	12	1	0	0	0	0
Clubiona compta	1	0	0	0	0	1
Clubiona diversa	3	0	1	0	0	0
Clubiona lutescens	0	4	0	2	3	12
Clubiona neglecta	2	0	0	0	0	0
Clubiona phragmitis	0	0	0	3	1	2
Clubiona reclusa	1	0	1	2	2	10
Clubiona similis	1	0	0	0	0	0
Clubiona subtilis	1	0	1	0	2	9
Phrurolithus festivus	2	2	0	0	0	0
Liocranidae						
Agroeca cuprea	0	0	0	0	0	1
Agroeca lusatica	0	0	0	0	0	1
Agroeca proxima	36	37	13	8	13	35
Zoridae						
Zora spinimana	2	1	0	1	5	73
Thomisidae						
Oxyptila atomaria	3	0	0	0	0	0
Oxyptila praticola	2	2	0	1	0	2
Oxyptila sanctuaria	6	0	0	0	0	0
Oxyptila simplex	54	6	22	18	13	28
Xysticus cristatus	133	1	57	14	0	10
Xysticus erraticus	0	0	3	2	0	2
Xysticus kochi	32	0	51	7	1	1
Xysticus ulmi	0	0	1	1	10	17
Philodromidae						
Philodromus cespitum	3	0	0	0	0	0
Thanatus striatus	1	0	1	0	0	5
Tibellus maritimus	2	0	0	0	0	2
Salticidae						

Tab. 1 cont.

Family/Species	PS	BS	MM	IM	RM	73M
Euophrys frontalis	1	0	0	0	0	1
Heliophanus flavipes	1	0	0	0	0	0
Lycosidae						
Alopecosa barbipes	0	0	1	0	0	0
Alopecosa cuneata	1	0	0	0	0	0
Alopecosa fabrilis	0	0	1	0	0	0
Alopecosa pulverulenta	162	14	68	86	32	4
Arctosa leopardus	423	3	32	1	0	1
Pardosa amentata	1	0	0	0	1	12
Pardosa monticola	2	0	1	0	0	0
Pardosa nigriceps	12	6	4	34	42	161
Pardosa palustris	2	0	158	26	1	0
Pardosa pullata	565	41	201	148	82	18
Pirata hygrophilus	23	79	1	1	29	5
Pirata latitans	503	84	353	72	71	89
Pirata piraticus	19	2	4	1	1	13
Trochosa ruricola	5	0	0	0	0	0
Trochosa terricola	6	10	38	50	89	20
Xerolycosa miniata	5	0	2	0	0	0
Pisauridae						
Pisaura mirabilis	1	0	1	6	4	0
Agelenidae						
Tegenaria agrestis	1	0	0	0	0	0
Hahniidae						
Antistea elegans	248	169	1	1	0	124
Hahnia pusilla	1	0	0	0	0	0
Theridiidae						
Enoplognatha ovata	0	1	0	0	1	0
Enoplognatha thoracica	0	0	6	4	0	0
Episinus angulatus	2	1	0	0	0	0
Ero cambridgei	1	1	0	0	3	5
Ero furcata	0	4	1	0	13	19
Ero tuberculata	0	0	0	0	1	0
Euryopis flavomaculata	6	0	3	0	0	1
Robertus lividus	8	28	9	34	44	42
Tetragnathidae						
Pachygnatha clercki	52	11	72	40	32	66
Pachygnatha degeeri	311	2	581	81	6	4
Metidae						
Metellina mengei	0	2	0	0	1	0
Metellina merianae	1	0	0	0	0	0
Metellina segmentata	0	0	0	0	2	0

Tab. 1 cont.

Family/Species	PS	BS	MM	IM	RM	73M
Araneidae						
Araneus diadematus	0	0	0	0	1	0
Erigoninae						
Baryphyma pratense	0	0	0	0	0	29
Ceratinella brevipes	0	1	80	61	48	1
Ceratinella brevis	0	0	0	0	2	13
Ceratinella scabrosa	1	0	9	2	4	0
Dicymbium nigrum	7	5	180	113	35	7
Diplocephalus permixtus	36	8	2	0	0	1
Dismodicus bifrons	3	9	1	2	2	1
Erigone atra	63	1	229	36	4	1
Erigone dentipalpis	27	0	30	3	0	0
Erigone promiscua	57	0	21	0	0	0
Erigone vagans	1	0	0	0	0	0
Gnathonarium dentatum	12	0	0	0	1	116
Gonatium rubens	5	33	1	1	58	16
Gongylidiellum vivum	124	79	84	39	41	41
Gongylidium rufipes	1	4	1	0	0	0
Hypomma bituberculatum	0	0	0	0	0	5
Lophomma punctatum	0	0	0	0	0	4
Maso gallicus	1	4	1	5	0	0
Maso sundevalli	9	22	0	6	7	81
Metopobactrus prominulus	1	0	0	0	0	0
Micrargus herbigradus	6	12	3	18	12	0
Micrargus subaequalis	0	0	1	1	0	0
Monocephalus fuscipes	1	1	1	0	4	0
Oedothorax apicatus	0	0	1	0	0	1
Oedothorax fuscus	274	0	340	9	4	0
Oedothorax gibbosus	0	0	0	0	0	2
Oedothorax retusus	347	3	333	49	2	1
Pelecopsis parallela	0	0	1	0	0	0
Pelecopsis radicicola	0	0	1	0	0	0
Pocadicnemis juncea	20	8	2	11	52	287
Tapinocyba insecta	0	0	0	0	1	0
Tapinocyba praecox	18	6	13	7	49	10
Thyreostenius parasiticus	0	0	1	0	0	0
Tiso vagans	1	1	44	29	3	1
Troxochrus scabriculus	2	0	11	11	0	2
Typhochrestus digitatus	1	0	0	0	0	0
Walckenaeria acuminata	3	19	3	0	29	67
Walckenaeria antica	39	1	2	1	0	2
Walckenaeria atrotibialis	4	5	9	21	29	4

Tab. 1 cont.

Family/Species	PS	BS	MM	IM	RM	73M
Walckenaeria cucullata	1	0	1	1	0	1
Walckenaeria nudipalpis	1	25	2	2	12	4
Walckenaeria unicornis	4	15	2	3	13	69
Linyphiinae						
Agyneta conigera	3	4	2	13	6	97
Agyneta decora	3	0	23	4	1	0
Agyneta ramosa	2	0	0	0	0	0
Agyneta subtilis	5	22	0	0	0	0
Allomengea vidua	0	0	0	0	0	2
Bathyphantes approximatus	0	0	0	0	0	2
Bathyphantes gracilis	68	109	159	195	75	55
Bathyphantes parvulus	4	37	26	123	95	349
Bolyphantes alticeps	1	0	0	0	0	0
Centromerita bicolor	5	0	30	6	2	0
Centromerita concinna	71	0	22	8	1	1
Centromerus prudens	1	5	3	1	3	2
Centromerus sylvaticus	16	135	36	118	300	159
Diplostyla concolor	0	0	1	0	0	0
Floronia bucculenta	1	11	0	7	15	0
Kaestneria pullata	0	2	1	3	14	19
Lepthyphantes ericaeus	3	39	4	30	59	25
Lepthyphantes pallidus	5	18	21	41	49	11
Lepthyphantes tenuis	34	12	86	66	18	17
Lepthyphantes zimmermanni	1	4	0	2	0	1
Neriene clathrata	0	3	0	5	13	18
Linyphia triangularis	3	3	0	7	2	0
Meioneta rurestris	2	0	1	0	0	0
Meioneta saxatilis	0	0	6	17	4	1
Microneta viaria	0	0	0	0	0	5
Porrhomma oblitum	0	0	0	0	0	2
Porrhomma pygmaeum	0	0	0	0	0	1
Saaristoa abnormis	1	3	3	3	29	0
Stemonyphantes lineatus	15	0	0	1	1	2
Tallusia experta	0	0	0	0	0	14
Tapinopa longidens	0	0	0	1	9	4

Tab. 2. Number of individuals caught per three pitfall traps in the Parnassia Slack (PS) and the Mown Meadow (MM).

	PS	MM
Ceratinella brevipes	0	80
Tiso vagans	1	44
Cheiracanthium virescens	12	0
Pirata hygrophilus	23	1
Antistea elegans	248	1
Gnathonaruim dentatum	12	0

Tab. 3. Number of individuals caught (per three pitfall traps) in the 1973 Meadow (73M) and the rough patches of the meadow in 87-88 (RM+IM).

	73M	RM+IM
Pardosa palustris	0	14
Ceratinella brevipes	1	55
Erigone atra	1	20
Micrargus herbigradus	0	15
Tiso vagans	1	16
Floronia bucculenta	0	11
Meioneta saxatilis	1	11
Saaristoa abnormis	0	16
Pardosa amentata	12	1
Antistea elegans	124	1
Baryphyma pratense	29	0
Ceratinella brevis	13	1
Gnathonarium dentatum	116	1
Tallusia experta	14	0

CONCLUSIONS

The spiders are quite sensitive to different environmental factors and are good indicators for evaluating the effects of particular management practices on dune ecosystems. It will be very important to include them in monitoring studies of nature management projects.

For the localities studied the conclusions are:

- To prevent further degradation of the arthropod fauna of the southern part of the reserve the high pumping activity during summer should be stopped.
- The management of the 'meadow' (yearly cutting of the major part of it combined with patches of rough vegetation) resulted in a richer spider fauna in comparison with the unmanaged situation of the 70s.

- In the future, in order to obtain the same result, a more natural kind of management should be tried, resulting in the same combination of vegetation structures. This could be a low density grazing management.

REFERENCES

Baert L. 1996. Catalogus van de Belgische spinnen. XIV. Linyphiidae (Erigoninae). Studiedocumenten K.B.I.N., **82**: 1-179.

Desender K., Alderweireldt M. & Maelfait J.-P. 1992. Dry heathland vegetation structure and carabid beetles. Proc. 4th Europ. Congr. Ent./XIII. Int. Symp. Entomofaun. Mitteleuropas, Gödöllö, 1991, pp. 149-152.

Bonte D. 1996. Onderzoek naar vespreidings-, activiteits- en groeipatronen van spinnen (Araneae) in de beheerde percelen van het staatsnatuurreservaat 'De Westhoek'. Unpublished dissertation, University Ghent, Belgium.

Desender K., Maelfait J.-P. & Baert L. 1991. Carabid beetles as ecological indicators in dune management (Coleoptera: Carabidae). Elytron, **5**: 239-247.

Desender K., Maelfait J.-P. & Baert L. 1992. Monitoring carabid beetles in Belgian coastal dunes. Proc. 4th Europ. Congr. Ent. /XIII. Int. Symp. Entomofaun. Mitteleuropas, Gödöllö, 1991, pp. 153-158.

Duffey E., Morris M. G., Sheail J., Ward L. K., Wells D. A. & Wells T. C. E. 1974. Grassland Ecology and Wildlife Management. Chapmann and Hall, London.

Hänggi A., Stöckli E. & Nentwig W. 1995. Lebensräume mitteleuropäischer Spinnen. Misc. Faun. Helv., **4**: 1-460.

Heimer S. & Nentwig W. 1991. Spinnen mitteleuropas: ein Bestimmungsbuch. Paul Parey, Berlin.

Hill M. O. 1979a. DECORANA: a FORTRAN program for detrended correspondence analysis and reciprocal averaging. Section of Ecology and Systematics, Cornell University.

Hill M. O. 1979b. TWINSPAN: a FORTRAN program for averaging multivariate data in an ordered two-way table by clasification of the individuals and the attributes. Section of Ecology and Systematics, Cornell University.

Locket G. H. & Millidge A. F. 1951. British spiders. Volume 1. Ray Society, London.

Locket G. H. & Millidge A. F. 1953. British spiders. Volume 2. Ray Society, London.

Maelfait J.-P. 1993. Hydrology, vegetation structure and spider fauna of the Buitengoor, a small wet heathland area in the northern part of Belgium. Boll. Acad. Gioenia Sci. nat., **26** (345): 237-244.

Maelfait J.-P. & Baert L. 1988. Les araignées sont-elles de bons indicateurs écologiques? Comptes rendus Xčme Coll. europ. Arachnol., Bull. Soc. sci. Bret., 59 h.s. **1**: 155-160.

Maelfait J.-P., De Knijf G., De Becker P. & Huybrechts W. 1995. Analysis of the spider fauna of the riverine forest nature reserve 'Walenbos' (Flanders, Belgium) in relation to hydrology and vegetation. In: Růžička V. (ed.), Proc. 15th Europ. Coll. Arachnol., Institute of Entomology, České Budějovice, pp. 125-135.

Maelfait J.-P. & Desender K. 1990. Possibilities of short- term Carabid sampling for site assessment studies. In: Stork N. E. (ed.), The role of Ground Beetles in Ecological and Environmental Studies, Intercept, Andover, pp. 217-225.

Maelfait J.-P. & Desender K. 1990. Carabids as ecological indicators for dune management evaluation. In: Stork N. E.. (ed.), The role of Ground Beetles in Ecological and Environmental Studies, Intercept, Andover, pp. 331-333.

Maelfait J.-P., Desender K. & Baert L. 1989. Examples of the practical use of carabid beetles and spiders as ecological indicators. Proc. Symp. Inv. Belg., pp. 437-442.

Maelfait J.-P., Desender K. & Dufrene M. 1994. Carabid beetles and nature conservation resaerch in Belgium: a review. In: Desender K., Dufrene M., Loreau M., Luff M. & Maelfait J.-P. (eds.), Carabid beetles: ecology and evolution, Kluwer Academic Press, Dordrecht, pp. 319-324.

Maelfait J.-P., Desender K., Pollet M., Segers H. & Baert L. 1992. Carabid beetle and spider communities of Belgian forest stands. Proc. 4th Europ. Congr. Ent./XIII. Int. Symp. Entomofaun. Mitteleuropas, Gödöllö, 1991, pp: 187-194.

Maelfait J.-P., Pollet M. & Janssen M. 1992. Spiders of marshland habitats in the north of East Flanders (Belgium). Proc. 4th Europ. Congr. Ent./XIII. Int. Symp. Entomofaun. Mitteleuropas, Gödöllö, 1991, pp: 195-200.

Maelfait J.-P., Jocqué R., Baert L. & Desender K. 1990. Heathland management and spiders. Acta Zool. Fenn., **190**: 261- 266.

Maelfait J.-P., Segers H., Baert L. 1990. A preliminary analysis of the forest floor spiders of Flanders (Belgium). Bull. Soc. europ. Arachnol., hors série, **1**: 242-248.

Morris M. G. 1971. The management of grassland for the conservation of invertebrate animals. In: Duffey E. & Watt A. S. (eds.), The Scientific Management of Animal and Plant Commmunities for Conservation, Blackwell, Oxford, pp: 527-552.

Roberts M. J. 1985. The spiders of Great Britain and Ireland. Volume 1. Atypidae to Theridiosomatidae. Harley Books, Colchester.

Roberts M. J. 1987. The spiders of Great Britain and Ireland. Volume 2. Linyphiidae and check list. Harley Books, Colchester.