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Influence of environmental factors on the community structure of spiders in a humidity gradient of extensively managed, moist pastures

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ABSTRACT

Spiders were studied in extensively managed, moist pastures west of the Dümmer (lake in NW-Germany) from April to September 1994. The investigation area is characterised by a soil humidity gradient and a mosaic of different plant communities. In addition to the recording of spiders along this gradient (in pitfall traps and by square sampling) the environmental factors (soil humidity, ground water level, vegetation height, and cattle density) were measured frequently.

The aims of the investigation were to find the main factors determining the distribution of spider species in the habitat and to distinguish ecological groups of species indicating special habitat conditions.

On the basis of the achieved results it is possible to distinguish several spider coenoses within the spider community. A species group typically found in the *Molinio-Arrhenatheretea* plant communities is composed of species which are able to cope with a quite wide ecological amplitude concerning the environmental factors. The abundance of these species is primarily negatively correlated with the humidity factors and secondary positively with cattle density. Another species group is highly restricted to the reeds (*Caricetum gracilis*). The abundance of these species is positively correlated with the humidity factors and vegetation height and negatively with cattle density. Soil humidity as well as vegetation structure and management are mainly responsible for the distribution of spider species in moist pastures.

INTRODUCTION

The presence or absence of species (even specialised or endangered) does not, in itself, indicate the ecological value of an area. Because animals are (in contrast to plants) able to move, it may be possible to find single specimens also in habitats which are not typical for them.

The evaluation of a site is more reliable if the species composition of the whole community is taken into account. Ideally, it is possible to distinguish several groups within the community, which are composed of species with comparable demands as to their habitat. These species, which make up a coenosis, indicate the environmental conditions of a site quite clearly by similar distribution patterns. A coenosis is a group of species which are often found together. Typically, a number of coenoses contribute to each community.

Usually such a species group is composed of different kinds of species: Some species are found very frequently together in the special type of habitat studied, but it is also possible to find them in other habitat types, where they are integrated in a different coenosis. This depends on their ecological amplitudes and on their strength of competition. Other species are found quite rarely, but exclusively in this particular habitat type and nowhere else.

Constant presence and exclusivity are two criteria to assign a species to a particular coenosis. The species which are found in the group with high constancy (and sometimes with more or less high abundance) are very typical of the coenosis, but they are not seldom widespread and common. Species exclusively found in one particular coenosis are suitable for distinguishing it from other coenoses (Martin 1988).

Spiders are well known for indicating environmental conditions quite reliably. Many spider species are very sensitive to changes in their habitats. In this investigation the spider community is studied in extensively managed, moist pastures. The investigation area is characterised by a soil humidity gradient and a mosaic of different plant communities. The meaning of the environmental factors for the distribution of spider species or species groups is of special interest. In this context the following questions are of significance: What are the main factors determining the distribution of spider species in the habitat? Which demands or limitations do species that share a habitat have in common? To what extent is it possible to distinguish species groups within the community consisting of species which show comparable demands as to their habitat and similar distribution patterns on the site? To what extent is it possible to use such species groups as indicators of site quality?

MATERIAL AND METHODS

The investigation area

The spiders were studied in extensively managed pastures west of the Dümmer (a lake in Lower Saxony, NW-Germany) from April to September 1994. The investigation area is situated right behind the dike which surrounds the lake. Near the dike the site is characterised by extended areas of reeds (*Caricetum gracilis*) (Fig.1). Here the ground water stays on a high level all year long. The vegetation (dense stocks of *Carex gracilis*) grows up to 80-100 cm in early summer. In greater distances from the lake the reeds are followed by different *Molinio-Arrhenatheretea* plant communities in the drier part of the region (*Ranunculo repentis-Alopecuretum geniculati*, *Lolio-Cynosuretum*, *Bromo-Senecionetum aquatici*). Here the ground water level sinks down to 60-70 cm in summer, and the grass reaches heights of 20-30 cm only. The whole site is extensively grazed by cattle, the drier parts are used more intensively.

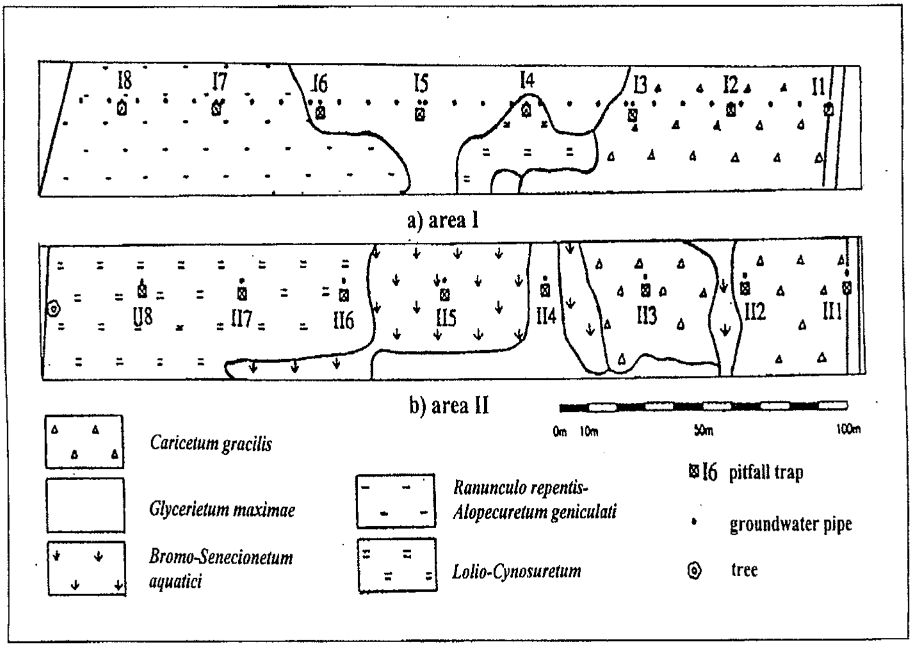

Fig. 1. The investigation area: phytosociological characterization and location of the pitfall traps.

Collecting

The spiders were caught in pitfall traps and by square sampling. Two rows of eight pitfall traps each filled with a solution of ethanol, water, glycerine, acetic acid, and detergent were installed along the humidity gradient in different plant communities (Fig. 1). Further spiders were sampled in small defined areas with a standard size of 0.25 m^2 (square sampling). By means of a metal frame every 40 samples were taken in the *Caricetum gracilis* and in the *Ranunculo-Alopecuretum* in June 1994 with a standard sampling time of one hour. Spiders within the frame were picked off with an exhaustor and a pair of tweezers.

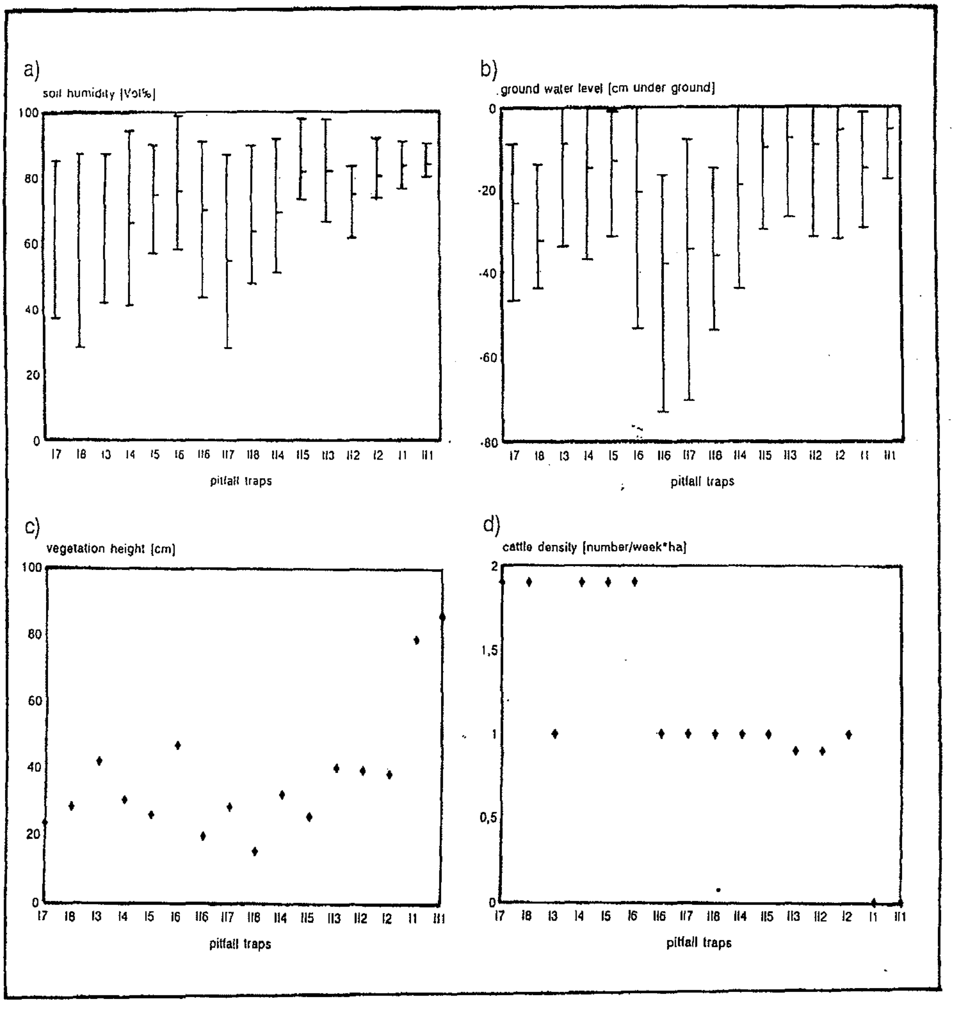

Fig. 2. Soil humidity (a), ground water level (b), average vegetation height (c) and cattle density (d) near every pitfall trap. The order of the pitfall traps corresponds to the ecological gradient of species communities determined by the canonical correspondence analysis (cf Tab. 1). a, b: averages as well as minimally and maximally measured levels are indicated.

Measuring of environmental factors

Parallel to the recording of the spiders the environmental factors were documented by phytosociological relevés, regular measurements of ground water level, soil humidity, and vegetation height, and by assessments of the influence of grazing near every pitfall trap.

The relevés of vegetation were taken according to the method of Braun-Blanquet (1964). The water table was measured weekly in thin pipes of synthetic material which were drilled through in regular distances and sunk into the earth. The soil humidity was determined every two weeks by weighing samples of soil, drying them and weighing them again. The difference in weight corresponds to the evaporated volume of water. The vegetation height was weekly measured with a ruler.

Locations of pitfall traps

While the pitfall traps I1, I2, and II1-II5 were installed at places with a constantly high water table and soil humidity level as well as a complex vegetation structure, the remaining pitfall traps were influenced by rather big ranges of ground water and soil humidity, and by a quite sparse vegetation structure. The spiders in area I had to cope with twice the number of cattle than those in area II (Fig. 2).

Statistical methods

The gained faunistic data were subjected to a canonical correspondence analysis. By means of this procedure the spider community is analysed with regard to distribution patterns which species in the area have in common. Locations with similar colonisation and species with similar distribution patterns move up closer in the table where the data are summarised and can be identified easily as groups. Finally the locations of pitfall traps are arranged in an order which represents the most effective ecological gradient of species communities (Fründ 1995).

The regression analysis is an obvious method for investigating the correlation between the distribution patterns of species and the quality of environmental factors. The correlation coefficient determines the degree of correlation between the abundance of species and the average measured soil humidity, ground water level, vegetation height and number of cattle.

RESULTS

13,385 mature spiders from 64 species and 8 families were caught altogether by pitfall traps and square sampling. The Linyphiidae (39 species, 9,297 individuals) and Lycosidae (14 species, 3,580 individuals) are the dominant families in the investigated area.

The results of the correspondence analysis are shown in Tab. 1. On the basis of the achieved results it is possible to distinguish three species groups. The first group is found above all in the *Molinio-Arrhenatheretea* plant communities. Some species belonging to this group are widespread in the whole investigation area and are represented by high numbers of individuals.

The second group of species is also found in the drier parts of the area but with a clear preference to area II. The high share of Lycosidae which are discussed to be especially sensitive to intensification of management (Ingrisch *et al.* 1989) in this group is conspicuous. It seems to be obvious that the representatives of this spider family avoid the disturbing effects by cattle which are greater in area I.

Tab. 1. Results of pitfall traps. Common main emphasis of activity is indicated by framing.

species	pitfall traps															
	I7	I8	I3	I4	I5	I6	II6	II7	II8	II4	II5	II3	II2	I2	I1	III1	sum
Erigone atra	294	350	143	153	123	203	110	183	244	83	97	217	106	94	68	73	2,541
Oedothorax fuscus	421	411	200	323	286	285	317	314	394	155	230	174	150	73	18	7	3,758
Oedothorax retusus	106	110	39	52	63	118	49	62	101	37	9	30	33	16	9	4	838
Erigone dentipalpis	33	60	10	17	15	7	6	5	41	1	6	11	4	.	.	2	218
Erigone longipalpis	15	38	2	1	4	4	.	.	3	.	.	.	.	.	.	.	67
Oedothorax apicatus	13	13	1	2	11	2	1	1	2	1	.	.	.	.	.	.	47
Pardosa agrestis	4	5	2	1	1	.	5	1	11	1	.	.	2	.	.	1	34
Leptorhoptrum robustum	4	3	1	3	.	2	2	.	5	1	.	.	1	.	.	2	24
Pachygnatha degeeri	6	8	1	2	3	3	1	3	5	1	1	1	1	.	.	.	36
Pardosa amentata	69	121	71	105	67	61	184	132	170	155	65	45	92	46	28	13	1,424
Alopecosa pulverulenta	.	.	.	.	.	.	12	4	2	10	.	.	1	.	.	.	29
Pardosa prativaga	2	.	4	3	7	3	19	21	12	63	29	15	18	1	5	3	205
Pardosa palustris	1	1	.	.	.	1	28	8	19	1	1	.	.	.	.	.	60
Pardosa pullata	.	.	.	.	.	.	11	3	1	4	.	.	.	1	1	.	21
Arctosa leopardus	.	.	3	.	7	1	1	1	1	1	.	1	1	.	.	.	17
Dicymbium nigrum	.	.	.	.	.	.	2	1	2	3	1	.	.	1	.	.	10
Alopecosa cuneata	.	.	.	.	.	.	1	3	1	1	.	.	.	.	.	.	6
Agyneta decora	.	.	.	.	.	.	1	5	1	.	.	1	.	.	.	.	8
Gongylidiellum vivum	.	.	.	1	.	2	2	2	.	3	.	.	1	.	.	1	12
Pirata piraticus	41	23	98	57	40	90	86	105	50	168	169	193	204	131	109	138	1,702
Gnathonarium dentatum	1	1	2	1	.	1	1	.	.	5	7	9	1	9	8	2	48
Bathyphantes approximatus	.	1	1	2	.	.	3	4	.	9	7	5	3	10	10	13	68
Allomengea vidua	.	1	.	.	.	.	1	.	.	5	1	4	4	1	20	16	53
Lophomma punctatum	1	.	.	2	.	1	.	.	1	1	5	3	2	4	1	11	32
Oedothorax gibbosus	.	.	1	.	.	.	2	.	.	3	.	16	11	14	6	28	81
Silometopus elegans	.	.	.	.	.	.	.	.	.	.	.	5	5	1	1	1	13
Antistea elegans	.	.	.	.	.	.	.	1	.	1	.	4	1	2	4	8	21
Savignia frontata	3	1	3	1	2	3	3	7	1	.	.	10	4	3	5	21	67

Tab. 1 continued

species	pitfall traps																
	I7	I8	I3	I4	I5	I6	II6	II7	II8	II4	II5	II3	II2	I2	I1	II1	sum
Pirata hygrophilus	.	2	.	1	3	1	.	1	.	.	.	.	2	2	23	14	49
Pirata piscatorius	.	.	.	.	.	.	.	.	.	1	.	1	.	.	3	1	6
Bathyphantes gracilis	53	43	26	30	14	39	4	45	20	37	22	37	30	35	49	32	516
Pachygnatha clercki	8	13	39	34	22	32	18	10	6	33	26	40	45	27	21	9	383
Tallusia experta	.	.	7	1	.	1	3	.	.	4	5	3	8	1	.	1	34
Clubiona stagnatilis	.	.	2	1	.	.	1	.	.	1	2	5	2	.	.	.	14
Ceratinella brevipes	.	.	.	.	.	1	.	.	2	1	1	.	.	2	1	.	8
Lepthyphantes tenuis	.	.	.	.	.	.	2	1	.	2	1	.	.	.	2	.	8
Centromerita bicolor	1	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	3
Walckenaeria vigilax	.	.	.	1	.	.	.	.	.	.	1	.	1	.	.	.	3
Porrhomma pygmaeum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	3
Araeoncus humilis	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	.	2
Clubiona reclusa	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1	2
Baryphyma pratense	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1	.	2
Pirata tenuitarsis	.	.	.	.	.	.	.	.	1	.	.	1	.	.	.	.	2
Diplocephalus permixtus	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	2
Meioneta rurestris	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Pardosa paludicola	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Robertus lividus	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Trochosa ruricola	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Robertus arundineti	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Pelecopsis parallela	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1
Diplostyla concolor	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
Drepanotylus uncatus	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1
Zelotes clivicola	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
Larinioides cornutus	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1
Micrargus herbigradus	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1
Taranucnus setosus	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1
Tiso vagans	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1

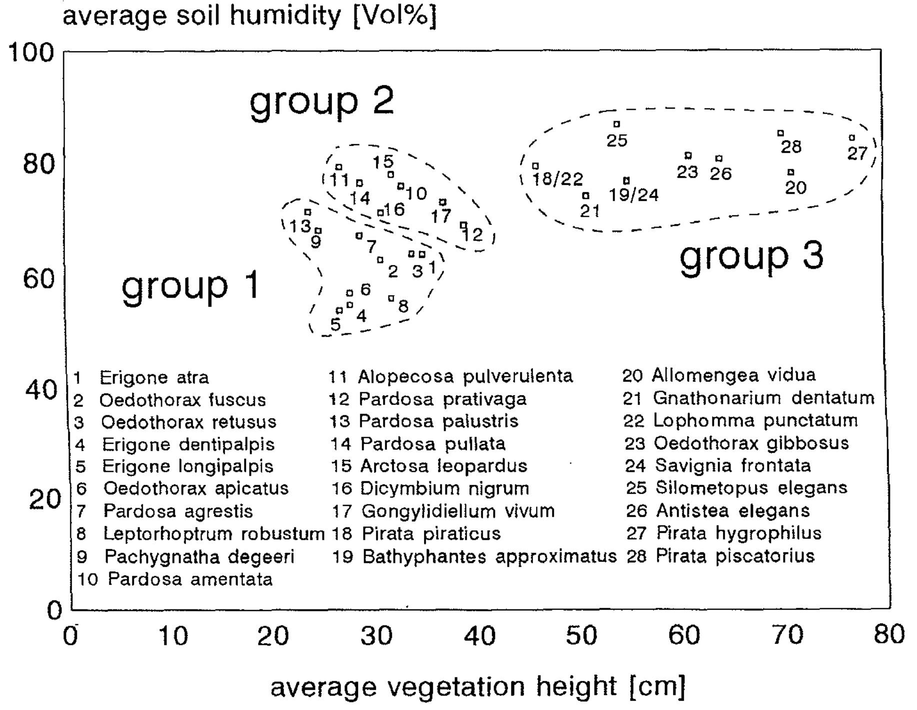

Fig. 3: Species-specific means concerning soil humidity and vegetation height (calculated on the basis of the results of trapping and the simultaneously measured environmental factors).

The species of the third group are more or less restricted to the very wet parts of the area with complex vegetation structures, especially to the *Caricetum gracilis*.

The calculated correlation coefficients between the abundance of species and several environmental factors are shown in Tab. 2. Soil humidity and vegetation structure are the main factors determining the distribution of spider species in moist pastures. Most of the species preferring the *Molinio-Arrhenatheretea* plant communities show a significant negative correlation with the factors of humidity, but some of them are positively correlated with the cattle density. Unlike this the species restricted to the reeds are positively correlated with soil humidity and vegetation height and negatively with the cattle density. Especially the distribution patterns of *Bathyphantes approximatus*, *Allomengea vidua*, *Oedothorax gibbosus* and *Antistea elegans* are first and foremost influenced by vegetation structure and intensity of grazing, but also considerably by soil humidity. *Pirata hygrophilus*, *Pirata piscatorius*, and *Savignia frontata* seem to be influenced only by the parameters of structure and use. They are highly dependent on a complex vegetation structure and undisturbed places.

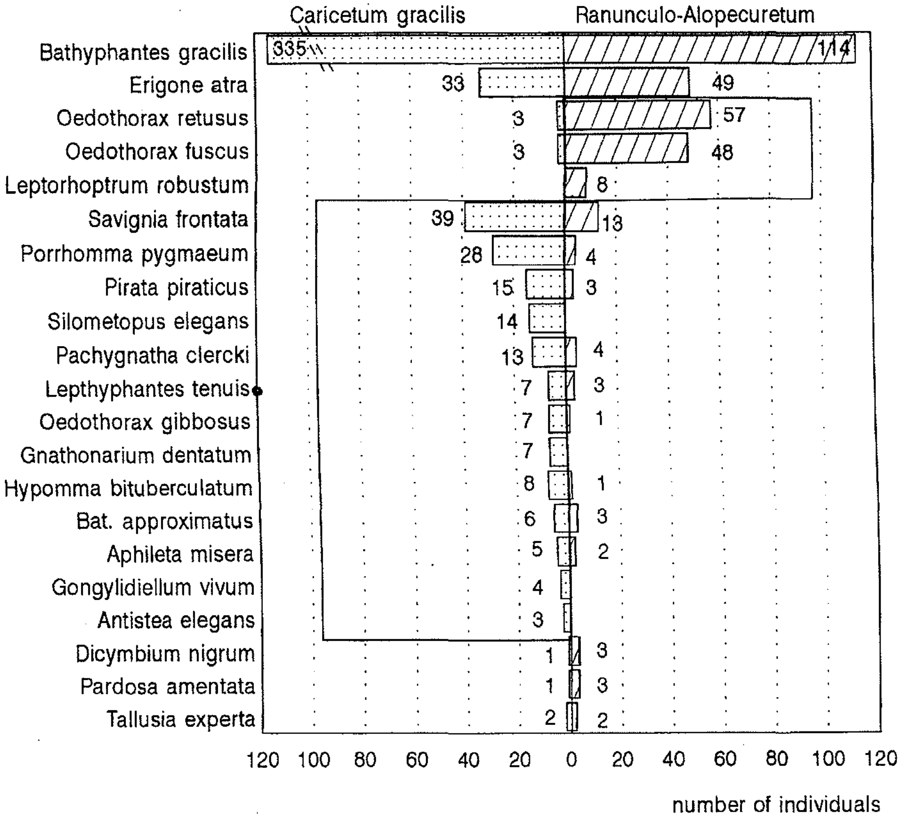

Fig. 4. Number of individuals in the samples of square sampling taken in the *Caricetum gracilis* and in the *Ranunculo-Alopecuretum*. Only species with at least three individuals are taken into account.

The species-specific means concerning soil humidity and vegetation height (calculated on the basis of the results of trapping and the simultaneously measured environmental factors; Merkens 1995) are shown in Fig. 3. As has been expected, the spider species with similar distribution patterns in the area prefer similar environmental conditions. On the basis of the achieved results it is possible to divide species very clearly into three groups having the same composition as the groups in Tab. 1.

The results of square sampling are shown in Fig. 4. In contrast to the pitfall traps this method records the real existing density of individuals, not only their moving activity. The density both of individuals and of species is much higher in the *Caricetum gracilis* than in the investigated *Ranunculo-Alopecuretum*. Especially in the reeds there were caught several species by square sampling in high numbers which are not or rarely represented in the pitfall traps. Based on the results *Porrhomma pygmaeum*, *Hypomma* *bituberculatum*, and *Aphileta misera* have to be added to the coenosis of species typical of the reeds.

Tab. 2. Significant correlations between abundance of individuals of several species and environmental factors. Limits of significance: α = 0.05: 0,497 (*); α = 0,01: 0,623 (**); α = 0,001: 0,742 (***). Significant correlation coefficients are indicated. ř = average

species	soil humidity (ř)	ground water level (ř)	number of cattle/week and ha	vegetation height (ř)
Erigone atra	-0,743***	-0,522*	+0,611*	.
Oedothorax fuscus	-0,839***	-0,772**	+0,782***	-0,802***
Oedothorax retusus	-0,763***	-0,659**	+0,747***	-0,506*
Erigone dentipalpis	-0,787***	-0,519*	+0,534*	.
Erigone longipalpis	-0,676**	.	+0,509*	.
Oedothorax apicatus	-0,665**	.	+0,685**	.
Pardosa agrestis	-0,641**	-0,686**	.	.
Leptorhoptrum robustum	-0,705**	-0,520*	.	.
Pachygnatha degeeri	-0,836***	-0,626**	+0,669**	-0,508*
Pardosa amentata	-0,630**	-0,799***	.	-0,706**
Alopecosa pulverulenta	.	-0,518*	.	.
Pardosa palustris	.	-0,742**	.	.
Pardosa pullata	.	-0,553*	.	.
Alopecosa cuneata	.	-0,630**	.	.
Agyneta decora	.	-0,500*	.	.
Pirata piraticus	+0,677**	+0,558*	-0,580*	.
Gnathonarium dentatum	+0,634**	+0,542*	.	.
Bathyphantes approximatus	+0,677**	.	-0,777***	+0,662**
Allomengea vidua	+0,554*	.	-0,781***	+0,884***
Lophomma punctatum	.	+0,562*	-0,514*	+0,581*
Oedothorax gibbosus	+0,617*	+0,578*	-0,639**	+0,684**
Antistea elegans	+0,630**	.	-0,746***	+0,841***
Savignia frontata	.	.	-0,583*	+0,710**
Pirata hygrophilus	.	.	-0,647**	+0,850***
Pirata piscatorius	.	.	-0,663**	+0,720**
Pachygnatha clercki	.	+0,589*	.	.

DISCUSSION

The spider community in the investigated moist pastures consists of various species coenoses which characterise the different plant communities in the area. The coenosis typically found in the *Molinio-Arrhenatheretea* plant communities in the drier parts of the region is composed of species which are widespread and common. Typically, these species are able to cope with a quite wide ecological amplitude concerning the environmental factors. By efficient spreading strategies (ballooning) and by producing many descendants, they are well adapted to unforeseen disturbances. Some of the species (e.g. *Oedothorax apicatus*) are typically found in agricultural habitats.

In contrast to this the spider coenosis frequently found in the *Caricetum gracilis* is mainly composed of species with high demands on stable environmental conditions. Most of these species are extremely limited to a complex vegetation structure as well as a constantly high soil humidity and react very sensitively to disturbances.

While some species of the coenosis of *Molinio-Arrhenatheretea* are also represented in the *Caricetum gracilis* (but with clearly smaller individual numbers) the species of the latter coenosis are more or less restricted to the reeds. This species group is very appropriate for indicating the ecological quality of a site. In its typical composition, this coenosis is found only in habitats which offer the described stable conditions. In this context it is very important to look at the composition of the whole spider community. Single specimens of the coenosis are also found in the drier parts of the area, but never in this typical species composition.

The value of such a species group, indicating the extent of disturbance or maturity in open moist habitats, for the interests of nature conservation is obvious. Especially mature moist habitats with a stabilised, highly adapted community are nowadays part of the very endangered habitat types.

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