Bull. Soc. neuchâtel. Sci. nat., tome 116 - 1 (p. 125 a 131) / C.R. XIIIe Coll. europ. Arachnol., Neuchâtel 2-6 sept. 1991

Long-term changes in spider communities of drained fens

par
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1. INTRODUCTION

The paper characterizes changes in spider communities in the peatland of Biebrza valley (22°30'–23°60') after 25 years. The study was carried out in 1955 in wet, extensively utilized natural grasslands and in managed drained parts of fen. The investigations were repeated in 1979–1980. Over the 25 years, the drained area has largely been extended. Large parts of wasteland and woods have disappeared. The valley has been covered with vast managed grassland. All managed grasslands (old and actual) have been drained in a similar way by ditches of the same depth, soil surface has been levelled by ploughing and rolling, and all of them were sawn with a mixture of grasses with addition of clover. Although the grasslands were situated on soils developed from two types of peats, alderswamp peat or tall sedge peat, natural grasslands were much more differentiated, than managed ones (table I). Therefore, the material from managed grasslands is most suitable for comparisons.

Table 1. Characteristics of studied grassland sites

	Graslands									
	Natural				Managed					
	old		actual		old		actual			
Sites	1	2	3	4	5	6	7	8	9	10
Peat origin	ud	A	TS	TS	A	A	TS	TS	TS	A
Patch ≤2 ha	+					+	+	+		
Size <20 ha					+				+	+
>20 ha		+	+	+						
Environmental stress: water level	sw	sw	fl	fl	-	-	-	-	-	-
Number of mowings	1	1	1	0-1	2	2	2	3	3	3
Number of plant species	ud	25	12	24	ud	10	29	30	43	ud

ud - undetermined, A - alder fen peat, TS - tall sedge, sw - standing water above ground level, fl - flooded

2. METHODS

The comparison of spider species composition was based on materials collected using a quadrat method. This technique was improved with time. The sample size was reduced from 0.25 m^2 to 0.065 m^2. In 1955 spiders were collected by hand, whereas in the recent study, samples of the turf were cut out, and the spiders were shaken out of them onto a plastic sheet. In addition, all vegetation was carefully searched for spiders. This procedure increased the accuracy of density estimates, but the frequency of sampling was reduced, as well as the size of the sampled area.

Sampling was performed from May to November, every week in 1955 and once a month in later investigations. In 1979 and 1980 pitfall trapping was done 2–3 days every month. 10 pitfalls were placed in each site.

Because of differences in the sampling technique, it is difficult to estimate changes in the density of spiders, and it is also difficult to analyse detail changes in the composition of uncommon species. Thus, the comparison is limited to the composition of families and to the species abundance, at least at one site. The Shannon index of species diversity (H') was analysed in comparisons also.

3. RESULTS

Significant differences occurred between natural and managed sites of former grasslands with respect to the proportion of particular families (table II). The most abundant families in natural grasslands were Lycosidae (about 30% of individuals caught),

Araneidae, Thomisidae, and Linyphiidae. The most abundant families in the managed grasslands were Tetragnathidae (about 30% of the spiders). The proportion of Linyphiidae was higher and Lycosidae markedly lower than in natural sites, whereas the proportion of Araneidae had not changed.

Table 2. Family composition in natural (N) and managed (M) grasslands (per cent)

	N Old		M Old		M Actual			
Sites	1	2	5	6	7	8	9	10
Linyphiidae	11.6	13.0	18.2	24.5	50.4	56.5	73.0	66.3
Tetragnathidae	4.4	2.1	39.8	32.2	20.7	21.7	18.1	23.0
Lycosidae	29.2	37.0	6.6	9.2	25.2	19.1	6.9	7.3
Total: Li+Te+Ly	45.2	52.1	64.6	65.9	96.3	97.3	98.0	96.6
Thomisidae	14.8	11.7	5.0	8.9	2.5	0.9	1.8	1.9
Araneidae	22.0	11.5	24.1	14.9	-	-	-	-
Salticidae	3.8	4.1	0.4	0.4	-	0.9	-	-
Others	14.2	20.6	5.9	9.9	1.2	0.9	0.2	0.5

Formerly grasslands, both natural and managed, supported a high proportion of species permanently associated with the field layer. This was the case of the species either constructing webs in the field layer, laying egg sacs, or building shelters in this layer. Now the field layer is searched by epigean species only. The species characteristic of the field layer, exclusively associated with it, totally disappeared. The most important change is the complete lack of the family Araneidae. Not even single individuals were recorded in any of the grasslands, including both natural and managed. Earlier two species of this family, *Araneus quadratus* and *Singa pygmaea*, predominated on both the managed, mown grasslands and the natural ones. Another abundant species that totally disappeared is *Tibellus maritimus*.

In the actual managed grasslands, a further increase in the importance of Linyphiidae is observed. This family accounts for 50–73% of the spiders recorded from each site. The dominant species in all habitats are *Erigone atra* (17–26%) and *Dicymbium nigrum* (5–20%). In some sites, *Oedothorax fuscus*, *Oe. retusus* and *Centromerita bicolor* predominate as well. In former grasslands the most abundant species in that family were. *Meioneta rurestris*, *Linyphia pusilla* and *Dicymbium nigrum* (table III). Changes in the family Lycosidae are reflected in the dominant position of *Pardosa palustris*. Earlier on managed meadows this species was outnumbered by *Pardosa pullata* and *Trochosa spinipalpis*. In sum, the bulk of the spiders occurring in the grasslands is now represented by three families: Linyphiidae, Lycosidae, and Tetragnathidae. Earlier they accounted for not much more than 60% of the total number of spiders (table II).

The disappearing species have not been replaced by other species. This is indicated by a significant reduction of the indices of species diversity in the actual managed grasslands as compared with former ones (table IV).

Table 3. Composition of abundant species in per cent

Managed grasslands						
	Old		Actual			
Sites	5	6	7	8	9	10
Araneus quadratus	20.5	9.80	-	-	-	-
Singa pygmaea	2.8	3.0	-	-	-	-
Meionetha rurestris	3.9	5.8	-	-	1.4	3.8
Linyphia pusilla	5.3	3.4	-	-	-	-
Centromerita biocolor	1.9	1.3	7.9	2.6	2.5	2.9
Dicymbium nigrum	0.9	2.3	10.4	5.2	20.0	9.6
Erigone atra	0.2	-	16.8	26.0	19.2	26.0
Pardosa palustris	0.7	-	21.3	15.6	5.1	3.8
Pachygnatha degeeri	31.9	20.75	10.0	14.8	14.9	17.3
P. degeeri + E. atra + D. nigrum + P. palustris	33.7	23.05	58.5	61.6	59.2	62.2

Plate 4. Diversity indices (H') and number of species (S) in managed grasslands

	Old		Actual			
	5	6	7	8	9	10
H'	5.06	4.13	3.66	3.46	3.60	3.50
Var H'	0.014	0.015	0.011	0.033	0.009	0.018
S	36	26	26	22	27	18
Number of ind. examined	208	202	202	115	275	104

All differences between old and actual grasslands significant (t - test 2.48-3.57, $p<0.02$-$p<0.001$)

4. DISCUSSION

What factors determine the diversity of spider communities? Is it possible to identify factors responsible for reduction of species diversity? We have analysed the effect of three factors that seem to be important: (1) the intensity of stress affecting spider communities, (2) the size of grasslands managed in the same way, and (3) the diversity of the herb layer as measured by the number of plant species.

Stress is defined here as a set of factors that can eliminate some species. Floods accounting for a large amplitude of water level on grasslands were considered as the heaviest stress. A weaker stress resulted from a high, but showing little seasonal variation, ground water level. Also haymaking was a source of stress changing environmental conditions, and limiting living space for spiders. It was assumed that the rate of species elimination was proportional to the frequency of mowing.

It can also be assumed that the size of the grassland is important as it can determine the possibility of immigration or emigration when the conditions deteriorate. It can thus determine the possibility of survival in a given area despite occasional unfavourable periods.

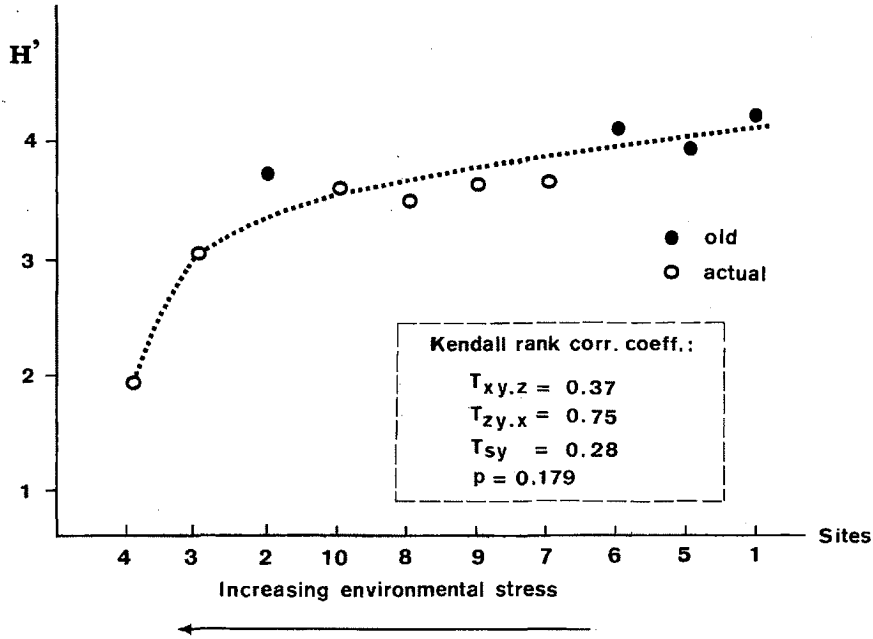

Fig. 1. Correlation between environmental stress (x), patch size (z), number of plant species in sward (s) and spider species diversity (y)

Using Kendall partial rank correlation, a negative relationship was found between the intensity of environmental stress, patch size and spider diversity (=–0.37). It was shown, that patch size is an important factor influencing species diversity. When the effect of stress has been partialled out, the correlation between the size of the area and spider diversity is –0.75 (figure 1). The number of plant species in the sward is of smaller importance. The correlation between the plant diversity and spider diversity for all the sites combined is 0.28, p=0.179. A higher correlation has been found for the group of natural grasslands (=0.67, p=0.167).

What is the living strategy of the species that survived and predominate on the actual, managed grasslands?

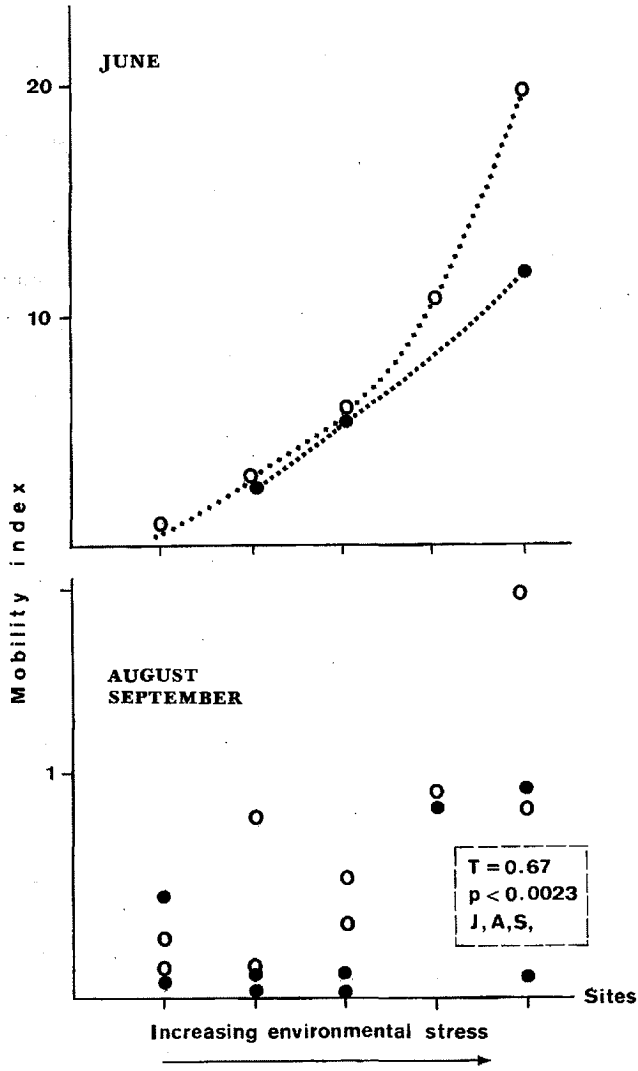

Fig. 2. Correlation between environmental stress and mobility index of spiders.

In all sites the community is predominated by 4 species: *Pardosa palustris*, *Erigone atra*, *Dicymbium nigrum* and *Pachygnatha degeeri*. They account for more than 55% of the total number of individuals caught by quadrat method. All of them are eurytopic species (RUZICKA 1987), common in crop fields, and characterized by well developed tendency to migrations. It has been found that *P. palustris* is characterized by the highest aerial dispersal rate within the genus *Pardosa* (RICHTER 1970).

Moreover, individuals of this species migrate from grasslands to crop fields on the ground surface (CIESIELSKA et al. in press). It is also that Linyphiidae are strongly aeronautic (GLÜCK et al. 1990, SUNDERLAND et al. 1986, THORNHILL 1983). The mobility index (the ratio of mean number of individuals per one pitfall trap to the density) was compared in all actual, managed grasslands.

It was found, that the mobility increases with the increase of environmental stress, so with the deterioration of living conditions for spiders (figure 2).

It seems, therefore, that the ability to migrate by air or on the ground surface is the important factor determining the possibility of survival and dominance of spider species at the present intensity of grassland management.

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