

EKOLOGIA POLSKA (Ekol. pol.)	39	4	517—543	1991
---	-----------	----------	----------------	-------------

Jadwiga ŁUCZAK

Department of Ecological Bioindication, Institute of Ecology, Polish Academy of Sciences,
Dziekanów Leśny (near Warsaw), 05—092 Łomianki, Poland

THE ROLE OF FOREST ISLANDS IN DISTRIBUTION AND DYNAMICS OF THE ARANEAE COMMUNITIES

ABSTRACT: This paper gives data on the abundance of spiders, the species richness and ecological groups, the common, exclusive and dominant species occurring on eight forest islands of the agricultural landscape in the Masurian Lakeland District, near lake Jorzec, close to Mikołajki, in northern Poland. The influence of the forest islands origin, size, location in space, and the presence of water, on the abundance and biomass of spiders which inhabit vegetation, is discussed. Four forest islands are remnants of the Pino-Quercetum forest; four are birch-aspen woodlots of a young successive stage growing naturally on farm wastelands. The sizes of islands range between 0.125 ha and 35 ha; one is surrounded by cultivated fields and located far from other woodland areas, two forest islands contain water reservoirs.

KEY WORDS: Araneae, landscape ecology, forest islands.

1. INTRODUCTION

Forest islands occurring in agricultural areas are common elements of the landscape. They result from deforestation of large forest areas which are changed into cultivated fields. This leads to the formation of different sizes woodlots, the remnants of previously existing forests. Forest islands are also formed naturally, on left over farm wastelands, e.g. in the vicinity of standing water reservoirs, or on low hills with a difficult access for farm works. They are of different sizes and origin depending on the type of the cleared forest, and the possibility of growth and development of different species of trees.

There is a growing interest in the world about forest islands remote from large forest areas, and about their role in the landscape; their maintenance of ecological equilibrium in the landscape, and thus about their ecological and biological

properties which disturb or strengthen the landscape stability; and also about their importance for the plants and animals which inhabit them. Burgess and Sharpe (1981) important book includes the problems of forest islands in the USA. Their results pertain mainly to plants, and to mammals and birds. Two volumes published by Dąbrowska-Prot (1984, 1987) contain some works of Polish authors on the subject of communities occurring in different environments of the industrial landscape in Poland.

Studies of the fragments of landscape in Silesia having such basic elements as woodlots neighbouring forest ecosystems, meadows and fields, have shown that most spiders occur in forests and woodlots, and thus live in conditions more protected from industrial dust. In less polluted areas of the industrial landscape, open ecosystems have more spiders than in heavily contaminated regions (Łuczak 1984). Other studies on forest and woodlot biocoenosis in an industrial landscape showed, that spider communities of woodlots (including forest islands) do not contain fewer species than forests, however, the abundance of spiders is generally higher in forests. Seasonal dynamics of numbers is similar in forests and woodlots, and seasonal maxima occur at the same time. On the other hand, the biomass of spiders in woodlots is often greater than in forests, particularly those in strongly contaminated areas (Łuczak 1986, 1987).

The numbers of the major spider families, such as Araneidae (including Metidae), Tetragnathidae, Theridiidae, and Linyphiidae, making up 84–97% of the spider community in an industrial landscape, contribute a smaller percent (with difference about 2–18%) to the woodlot community than to forests. This suggests a greater family diversity of woodlots. It is corroborated by a smaller than in forests, contribution of dominant species to the woodlot community. The family Linyphiidae, which prefers forests, is the most numerous, while the family Theridiidae which prefers woodlots is much less numerous (Łuczak 1987). Finally it has been ascertained, that in an agricultural landscape, woodlots are for spiders substitutes of forests, and are reservoirs of forest spiders of the surrounding areas. Spiders in woodlots, make an additional, in relation to predators of the open space, agglomeration of predators hunting for insects which fly through the woodlot. Thus they may contribute to the reduction of insect populations in an agricultural landscape, and probably also to the maintenance of its biocoenotic equilibrium (Łuczak 1987). Present investigations of woodlots, called forest islands, and their ecotones, in a post-glacial lake landscape in Mazury, northeastern Poland, are conducted in an agricultural environment of this region, characterized by the presence of many lakes and forests. Forest islands in the area of lake Jorzec are surrounded by cultivated fields (Fig. 1).

The purpose of this investigation on spiders has been the estimate of various parameters of the spider community inhabiting the herb layer of forest islands, in an agricultural landscape of the Masurian Lake District. These parameters have been estimated depending on the size, origin, location, and ecological conditions of the forest islands studied. Another problem has been the investigation of differences between spider communities in the interior of forest islands and in their ecotones. The purpose was to estimate the possible exchange of spiders between these zones, and between a forest island and the open space. The latter problem will be discussed in a separate paper.

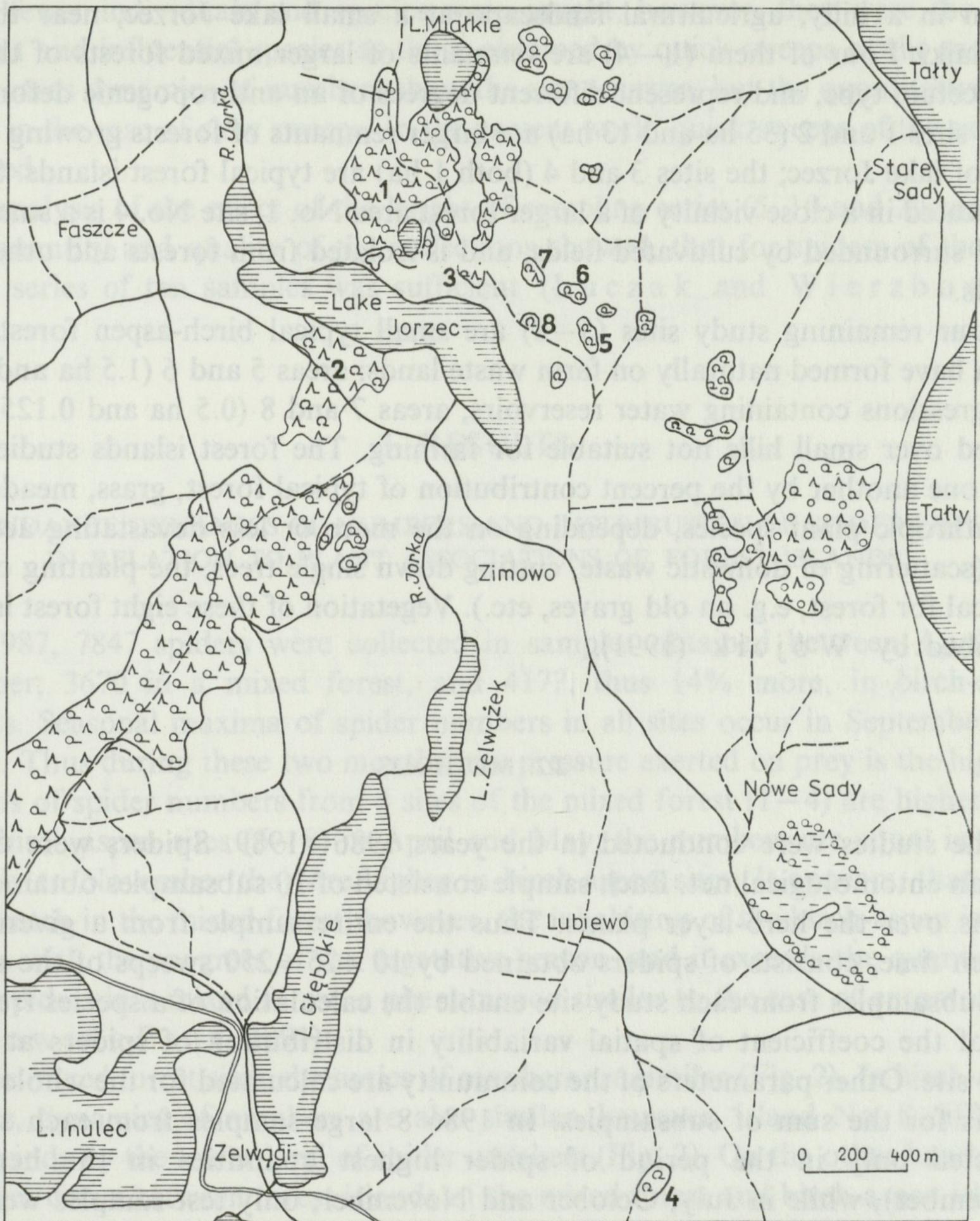


Fig. 1. Distribution of the forest islands under study in the agricultural forest landscape (after Dąbrowska-Prot 1991)

1–4 — Pino-Quercetum forest islands, 5–8 — birch-aspen forest islands

2. AREA AND METHODS

2.1. STUDY AREA

The study area is located in north-eastern Poland. It is a lake land originated during the last glaciation; it belongs to the meso-region of the Masurian Great Lakes (Kondracki 1978). Eight forest islands of different size and origin, were

chosen in a hilly, agricultural landscape at a small lake Jorzec, near the town Mikołajki. Four of them (1–4) are remnants of larger mixed forests of the Pino-Quercetum type, and represent different degrees of an anthropogenic deformation. Study sites 1 and 2 (35 ha and 13 ha) are larger remnants of forests growing on both sides of lake Jorzec; the sites 3 and 4 (both 1 ha) are typical forest islands. Site No. 3 is located in a close vicinity of a larger forest area No. 1; site No. 4 is a small forest island surrounded by cultivated fields, and is isolated from forests and other forest islands.

Four remaining study sites (5–8) are small typical birch-aspen forest islands which have formed naturally on farm waste lands; areas 5 and 6 (1.5 ha and 0.5 ha) in depressions containing water reservoirs; areas 7 and 8 (0.5 ha and 0.125 ha) are located over small hills not suitable for farming. The forest islands studied differ from one another by the percent contribution of typical forest, grass, meadow, and synanthropic plant species, depending on the more or less devastating activity of man (scattering of domestic waste, cutting down single trees, the planting of plants atypical for forest, e.g. on old graves, etc.). Vegetation of these eight forest islands is described by Wójcik (1991).

2.2. METHODS

The studies were conducted in the years 1986–1989. Spiders were collected with an entomological net. Each sample consisted of 10 subsamples obtained by 25 sweeps over the herb-layer plants. Thus the entire sample from a given site, in a given time, consists of spiders obtained by $10 \times 25 = 250$ sweeps of the sampler. Ten subsamples from each study site enable the calculation of a species frequency, and of the coefficient of spatial variability in distribution of spiders at a given study site. Other parameters of the community are calculated for the whole sample, that is for the sum of subsamples. In 1986 8 large samples from each site were collected only in the period of spider highest quantities in the herb layer (September), while in July, October and November, only test samples were taken at each site. Altogether 2918 spiders were collected. In 1987 in the vegetative season between April and November one sample was obtained at each site once a month, which gave altogether 64 large samples from 8 sampling sites containing 7847 spiders.

In 1988 samples were only taken from forest islands No. 4, 6 and 7, including the interior of the woodlots, forest ecotone, and the neighbouring field. Altogether 9 sampling sites were considered. In each of these environments, eight samples were taken in the season yielding 8054 spiders. During three years of studies, 18 819 spiders were collected and identified.

For the species of the Araneae group living in the herb layer, this method has proved as representative for the spider communities inhabiting this environment. This has been ascertained by the effect of the varying sweeps of the net (quick and slow) on the dynamics of spider numbers (Łuczak 1958). In the case of slow

sweeps, fewer individuals and species were caught, however, they were the same dominant and influential species as those obtained by quick sweeps of the sampler. In both cases dynamics of numbers show the same curves, but the quantitative level is lower in the case of slow sweeps. In the present work, quick sweeps of the sampler were used.

An analysis of the effect of the length of sampling series (5, 10 and 20 samples) on the quantity and quality of the collections showed, that for spiders of the herb layer, a series of ten samples was sufficient (Łuczak and Wierzbowska 1959).

3. RESULTS

3.1. ABUNDANCE DYNAMICS OF NUMBERS AND DISTRIBUTION OF SPIDERS IN SPACE IN RELATION TO PLANT ASSOCIATIONS OF FOREST ISLANDS

In 1987, 7847 spiders were collected in samples obtained between April and November; 3670 in a mixed forest, and 4177, thus 14% more, in birch-aspen woodlots. Seasonal maxima of spider numbers in all sites occur in September and October. Thus during these two months, the pressure exerted on prey is the highest. The sums of spider numbers from 4 sites of the mixed forest (1–4) are higher than from 4 birch-aspen sites (5–8) in April and May; the numbers are equal in June; from July to November they are higher in birch-aspen sites. It appears, that more spiders hatch in the mixed forest, however, the inhabiting of the birch-aspen islands increases with the progress of the vegetative season, and it exceeds the quantitative level of spiders in a mixed forest, a phenomenon similar to the case of entomofauna (Dąbrowska-Prot 1991).

In the mixed forest sites, dynamics of numbers are similar (Fig. 2). In birch-aspen woodlots, dynamics of numbers are also similar, however, island No. 8 differs in some periods by the lower level of spider numbers (Fig. 2). On the other hand, high differences occur between forest islands of the mixed forest and birch-aspen islands. There is a much greater similarity of spider numbers in Pino-Quercetum than in birch-aspen islands; in the latter case each island has its own individual level of numbers. In addition, in mixed forest islands, following the period of equalized quantitative levels of spiders from spring till August, there is a high peak of numbers in September. In birch-aspen islands the numbers increase gradually during the vegetative season (Fig. 2).

3.2. SPIDER BIOMASS, DYNAMICS OF BIOMASS AND ITS DISTRIBUTION IN SPACE IN RELATION TO PLANT ASSOCIATIONS OF FOREST ISLANDS

In 1987 samples obtained between April and November contained 48 138 mg of wet spider weight; 20 238 mg from Pino-Quercetum sites, and 27 900 mg (38% more)

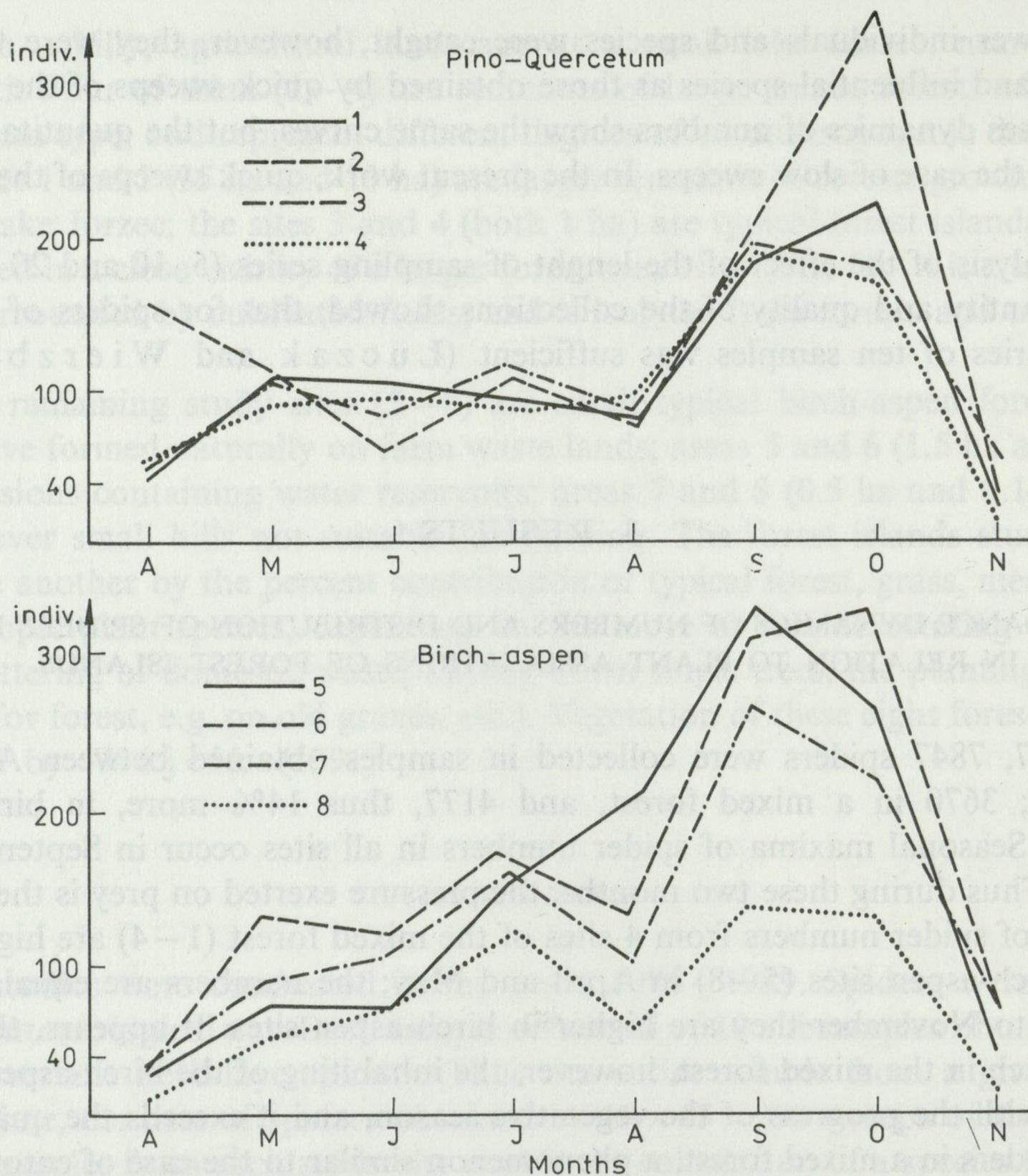


Fig. 2. Abundance dynamics of spiders in mixed-forest (Pino-Quercetum) islands in 1987: woodlots 1–4 and in birch-aspen islands: woodlots 5–8

from birch-aspen sites. This difference in biomass level, in favour of birch-aspen islands, is much greater than that in numbers.

Seasonal maxima of spider biomass, and thus periods of their highest pressure on insects, occur in September (Fig. 3). This is related to the appearance during this month of large, adult individuals of the dominant species *Meta segmentata* and *Linyphia triangularis*. The highest biomass of spiders occurs in birch-aspen woodlots 5, 6 and 7 in September, and on islands 5 and 6 also in October (Fig. 3). The total biomasses of spiders from four sites are higher in Pino-Quercetum islands only in April; beginning with May they are always higher, sometimes considerably, in birch-aspen sites (Fig. 3). For example, in September they are 45%, and in October 65% higher. The studies of Dąbrowska-Prot (1991) have also shown the much more extensive inhabiting by entomofauna of the birch-aspen woodlots, than mixed forests.

Seasonal dynamics of spider biomass and its levels are very similar in all four sampling sites of the mixed forest. In birch-aspen islands, biomass dynamics are also similar, however, the smallest island No. 8 differs from the others, by the generally

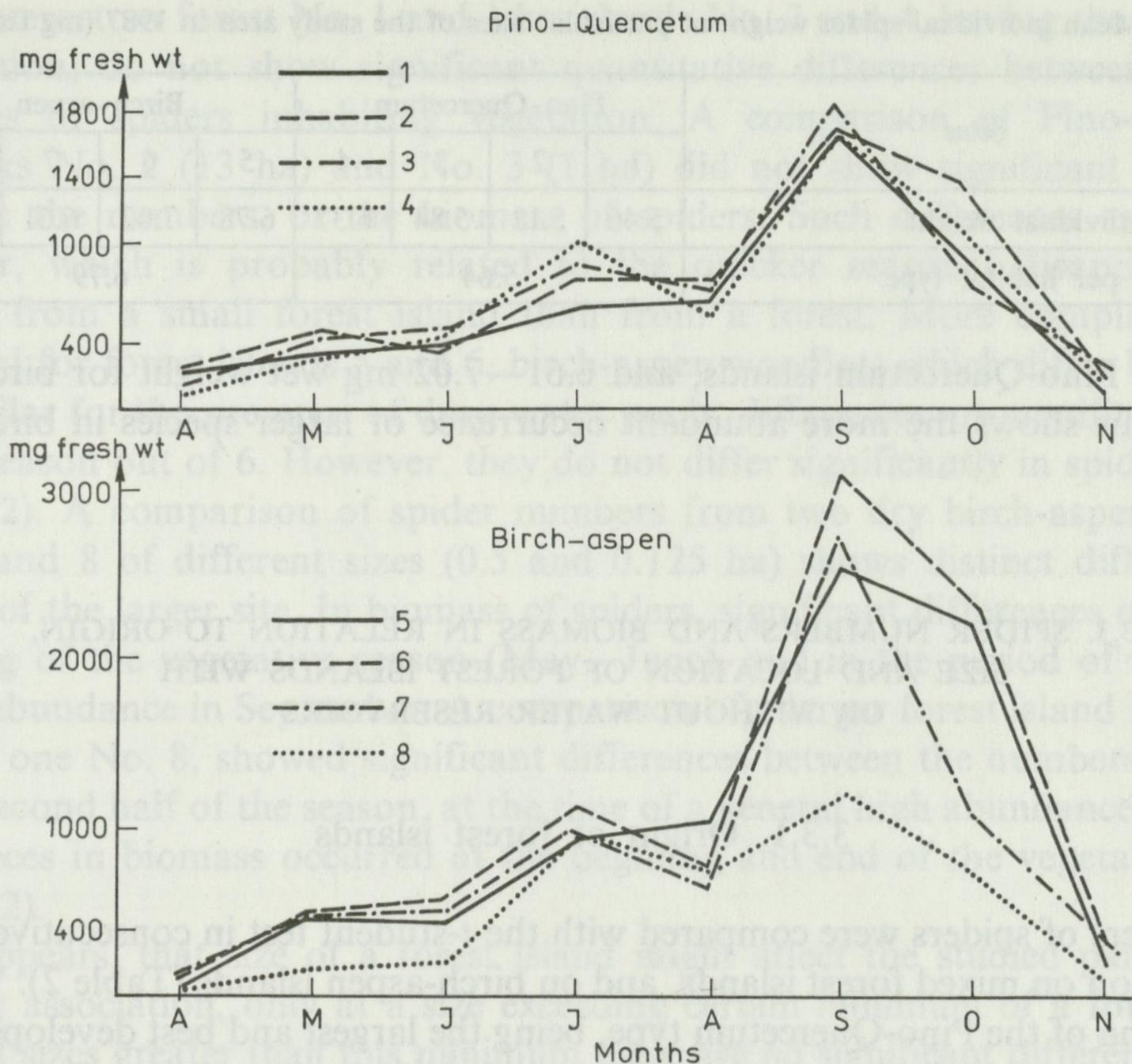


Fig. 3. Spider biomass dynamics in 1987
Explanations as in Figure 2

lower biomass level. Similarly to the dynamics of numbers, in the case of biomass, greater individual differences are shown in birch-aspen sites (Fig. 3). This is in contrast to the entomofauna results shown by Dąbrowska-Prot (1991). A high peak of spider biomass occurs there in September, while quantities of spiders increase gradually. This may be the effect of the differences of vegetation in both types of the forest islands studied (Wójcik 1991).

Studies on the vegetation show (Wójcik 1991) that there is a greater similarity between plants of individual woodlots of the Pino-Quercetum type, than between the vegetation of birch-aspen forest islands. Thus, there are 41–46 plant species forming the mixed forest associations; only island 4, having many synanthropes has 50 species. In birch-aspen woodlots, the numbers of species differ more and range between 31 and 53. The contribution of the forest species to the vegetation of Pino-Quercetum association, is also higher and more uniform, than in the birch-aspen associations.

Differences in spider biomass may also be related to the mean body weight of spiders. This coefficient pertains to the body size of spiders, and in a very general way defines the mean size of species (including all development stages) from the total of species and individuals having different body sizes. Mean weight of a statistical spider is higher in birch-aspen sites (Table 1). Even the ranges of mean body weights on islands of each vegetative formation are different, and they are: 5.11–6.37 mg wet

Table 1. Mean individual spider weight at particular sites of the study area in 1987 (mg fresh wt)

Sites	Pino-Quercetum				Birch-aspen			
	1	2	3	4	5	6	7	8
Mean individual weight	5.46	5.11	5.84	6.37	6.78	7.02	6.61	6.63
Average per habitat type	5.64				6.79			

weight for Pino-Quercetum islands, and 6.61 – 7.02 mg wet weight for birch-aspen islands. This shows the more abundant occurrence of larger species in birch-aspen woodlots.

3.3. SPIDER NUMBERS AND BIOMASS IN RELATION TO ORIGIN, SIZE AND LOCATION OF FOREST ISLANDS WITH OR WITHOUT WATER RESERVOIRS

3.3.1. Origin of forest islands

Numbers of spiders were compared with the *t*-student test in consecutive periods of the season on mixed forest islands, and on birch-aspen islands (Table 2). Woodlot No. 1. 35 ha of the Pino-Quercetum type, being the largest and best developed forest environment, was considered as the basis for the comparison. Generally, no differences were found between the numbers of spiders in forest No. 1 and other Pino-Quercetum islands. However, significant differences occurred between forest No. 1 and birch-aspen woodlots; in No. 5 during the entire season except October; in No. 6 excluding spring; in sites 7 and 8 significant differences occurred only in some periods of the season (Table 2). A comparison of spider numbers from island 5 and other birch-aspen forest islands revealed less similarity, than between spider numbers from the Pino-Quercetum islands. Islands No. 7 and 8 differ from each other significantly, islands 5 and 8 differ at the end of the season, while islands 5 and 6 at the beginning of the season (Table 2).

In spite of the different sizes of sampling sites, no significant differences were found between spider biomass of three Pino-Quercetum woodlots, and that in forest No. 1. However, a comparison of forest No. 1 with birch-aspen woodlots, showed (except for island No. 7) much more significant differences in biomass of spiders (Table 2.). Different origin of forest islands, which are characterized by varying plant associations, is important for the shaping of quantitative relations in communities of spiders.

3.3.2. Size of forest islands

Data on numbers and biomass of spiders from forest islands given earlier, show that the size of an island does not affect these parameters (Table 2). The 35 ha

Pino-Quercetum forest No. 1 and 1 ha islands No. 3 and 4, having the same plant association, do not show significant quantitative differences between the communities of spiders inhabiting vegetation. A comparison of Pino-Quercetum woodlots No. 2 (13 ha) and No. 3 (1 ha) did not show significant differences between the numbers, or the biomass of spiders. Such differences are found in October, which is probably related to the quicker seasonal disappearance of spiders from a small forest island than from a forest. More complex result is obtained for forest islands 5 and 6, birch-aspen woodlots which differ by size, but are similar for the presence of deep water pools; differences are significant 3 times in the season out of 6. However, they do not differ significantly in spider biomass (Table 2). A comparison of spider numbers from two dry birch-aspen woodlots No. 7 and 8 of different sizes (0.5 and 0.125 ha) shows distinct differences, in favour of the larger site. In biomass of spiders, significant differences occur at the beginning of the vegetative season (May–June), and in the period of the highest spider abundance in September. A comparison of a larger forest island No. 5, with a small one No. 8, showed significant differences between the numbers of spiders in the second half of the season, at the time of a general high abundance of spiders; differences in biomass occurred at the beginning and end of the vegetative season (Table 2).

It appears, that size of a forest island might affect the studied parameters of a spider association, only at a size exceeding certain minimum of a forest surface area. At sizes greater than this minimum there are no significant differences for the numbers and biomass of spiders. However, one case is not enough to formulate a rule, the more so, that no corresponding example has been found for the Pino-Quercetum islands.

3.3.3. Location of forest islands

The numbers and biomass of spiders on two Pino-Quercetum islands (3 and 4) were compared. The islands are of the same size (1 ha); one (No. 3) is located close to a large forest complex No. 1; the second (No. 4) is surrounded by cultivated fields, and is situated far from forests. No significant differences were found, neither in the numbers, or the biomass of spiders of these islands (Table 2). As in the case of the influence of the size of an island, this result should be verified.

3.3.4. Presence of water pools in forest islands

Two birch-aspen woodlots were compared (No. 6 and 7), of the same size and location, but differing in the presence of water. Spider numbers and biomass did not show significant differences, except at the beginning (May) and end (October) of the vegetative season (Table 2).

Table 2. Comparison of numbers and biomass of the Columns 1–7 — comparison of all forest islands with the Pino-Quercetum forest (35 ha); 8 — birch-aspen islands of different size, one with water pool and other dry; 11 — comparison of a sizeable birch-aspen islands, dry but differing in size; 13 — comparison of birch-aspen islands of even size but fields, the other located in a

Site pairs compared		1	2	3	4	5	6	7
		1–2	1–3	1–4	1–5	1–6	1–7	1–8
Num- bers	May	NS	NS	NS	S(0.05)	NS	NS	S(0.001)
	June	S(0.05)	NS	NS	S(0.05)	NS	NS	S(0.05)
	July	NS	NS	NS	S(0.002)	S(0.001)	S(0.001)	NS
	Aug.	NS	NS	NS	S(0.001)	S(0.05)	NS	NS
	Sept.	NS	NS	NS	S(0.001)	S(0.01)	S(0.02)	NS
	Oct.	S(0.02)	NS	NS	NS	S(0.05)	NS	S(0.05)
Biomass	May	NS	NS	NS	NS	S(0.05)	NS	S(0.05)
	June	NS	NS	NS	NS	NS	NS	S(0.05)
	July	S(0.05)	S(0.05)	NS	S(0.02)	S(0.001)	S(0.05)	S(0.05)
	Aug.	NS	NS	NS	S(0.05)	NS	NS	NS
	Sept.	NS	NS	NS	S(0.02)	S(0.05)	NS	NS
	Oct.	NS	NS	NS	S(0.001)	S(0.001)	NS	NS

NS — non significant, S — significant.

3.4. DISTRIBUTION OF SPIDERS IN FOREST ISLANDS

The uniformity of distribution of spiders, and spatial distribution of spiders biomass in forest islands were studied; coefficient of variability was calculated from ten subsamples of spider numbers obtained at the same time from all sampling sites (Figs. 4, 5). Generally each site has a different distribution of spiders. The results showed a greater range of the seasonal variability in distribution of spiders in birch-aspen islands, as compared to mixed forest islands. The ranges are similar in mixed forests, and the sizes of the coefficient of variability in numbers, at the time of maximum spider numbers (September), are even the same. This indicates very similar distributions of individuals in space, which is in contrast to birch-aspen sites, where the range of this coefficient is much greater, and the distribution of individuals in space in September more variable (Fig. 4).

Island No. 5 has the lowest range of the coefficient of variability; it is more stabilized with respect to spider distribution than other islands (Fig. 4). Islands No. 8 has the highest range of the coefficient.

Seasonal coefficients of spider biomass variability are more equalized, which shows similar distributions of biomass in the environment. Mixed forest No. 4, a small island among cultivated fields, located far from forests or forest islands, differs most from the other sites (Fig. 5).

spider communities of site pairs acc. to Student's *t*-test

presence of water at varying sizes of the birch-aspen forest islands; 9 and 10 — comparison of woodlot and a small forest island of the same Pino-Quercetum vegetation type; 12 — comparison of two differing in water presence; 14 — comparison of even-sized Pino-Quercetum islands (one isolated amidst complex of other forest islands)

8	9	10	11	12	13	14
5-6	5-7	5-8	2-3	7-8	6-7	3-4
S(0.001)	NS	NS	NS	S(0.02)	S(0.05)	NS
S(0.02)	NS	NS	NS	NS	NS	NS
NS	NS	NS	NS	S(0.05)	NS	S(0.05)
S(0.05)	S(0.001)	S(0.001)	NS	S(0.05)	NS	NS
NS	NS	S(0.001)	NS	S(0.02)	NS	NS
NS	NS	S(0.05)	S(0.001)	S(0.05)	S(0.05)	NS
NS	NS	S(0.01)	NS	S(0.02)	NS	S(0.05)
NS	NS	S(0.02)	NS	S(0.05)	NS	NS
NS	NS	NS	NS	NS	NS	NS
NS	S(0.05)	NS	NS	NS	NS	NS
NS	NS	S(0.001)	NS	S(0.05)	NS	NS
NS	S(0.05)	S(0.001)	S(0.02)	NS	S(0.05)	NS

3.5. QUALITATIVE STRUCTURE OF SPIDERS IN FOREST ISLANDS; SPECIES RICHNESS, SPECIES COMPOSITION, ECOLOGICAL GROUPS, COMMON AND EXCLUSIVE SPECIES OF FOREST ISLANDS, DOMINANT SPECIES

3.5.1. Species richness

In 1987, 76 species were identified; 65 in mixed forest islands, and 55 in birch-aspen woodlots (Table 3). The highest numbers of species occurred on islands 2 and 4 of mixed forest. The highest numbers of species in the season (21 – 25) were found at all sites in September, and at some also in October; on island 8 in May, September, and October (Table 3).

Table 3. Total number of spider species found at individual sites in 1987

Site	Apr.	May	June	July	Aug.	Sept.	Oct.	Number of species at particular sites
1	12	16	16	10	19	23	17	38 } 58
2	12	19	20	16	14	18	25	
3	11	19	20	13	13	22	16	
4	12	14	19	13	12	25	20	
5	9	12	16	15	15	21	13	32 } 54
6	6	15	14	19	16	24	25	
7	7	17	12	13	11	21	22	
8	4	16	12	13	9	16	16	
Total of species	26	41	41	36	34	43	42	75

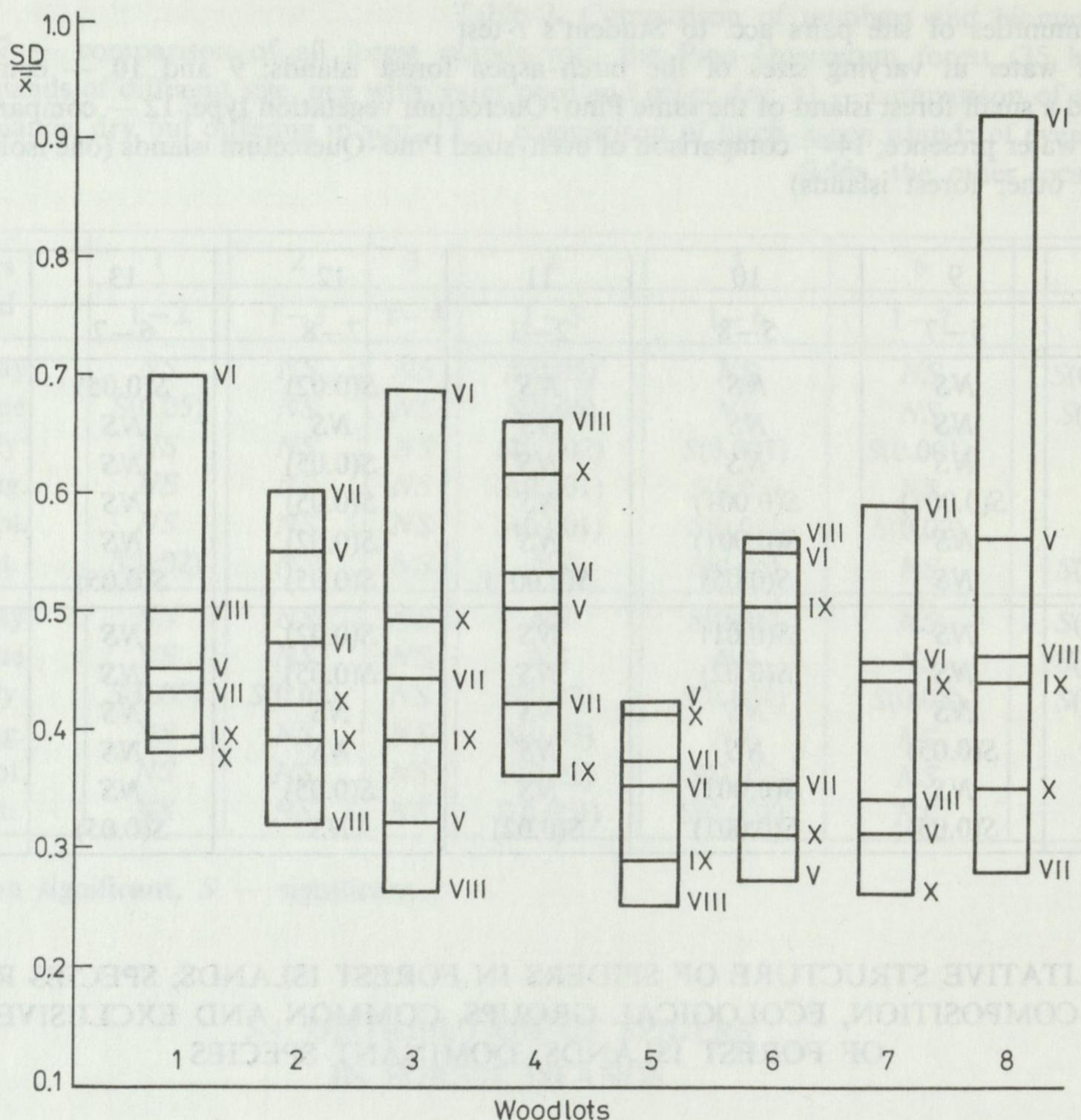


Fig. 4. Values of the coefficient of variation in numbers in particular forest islands
Roman numerals signify particular months in 1987

Explanation: coefficient of variation = $\frac{SD}{\bar{x}}$, where SD — standard deviation, \bar{x} — arithmetic mean

In the season investigated, the highest numbers of species in all the islands, occurred in September (43), in October (42), and in May and June (41). The least numbers of species in all the sites were found in April (26), and in November (15), in relation to the seasonal disappearance of species (dying, wintering) (Table 3).

3.5.2. Species composition and ecological groups

Ecological groups of spiders are distinguished on the basis of their differing role as predators in the biocoenosis of invertebrates. The role is in hunting for different sets of prey. Generally, these are families of spiders which differ in building of their webs, or the mode of hunting for prey (Post and Riechert 1977, Łuczak 1984, 1987). This is an important problem, because more and more often the role of spiders in nature is estimated on the basis of the entire arachnofauna in a given ecosystem. The fauna consists of different functional groups, characterized by

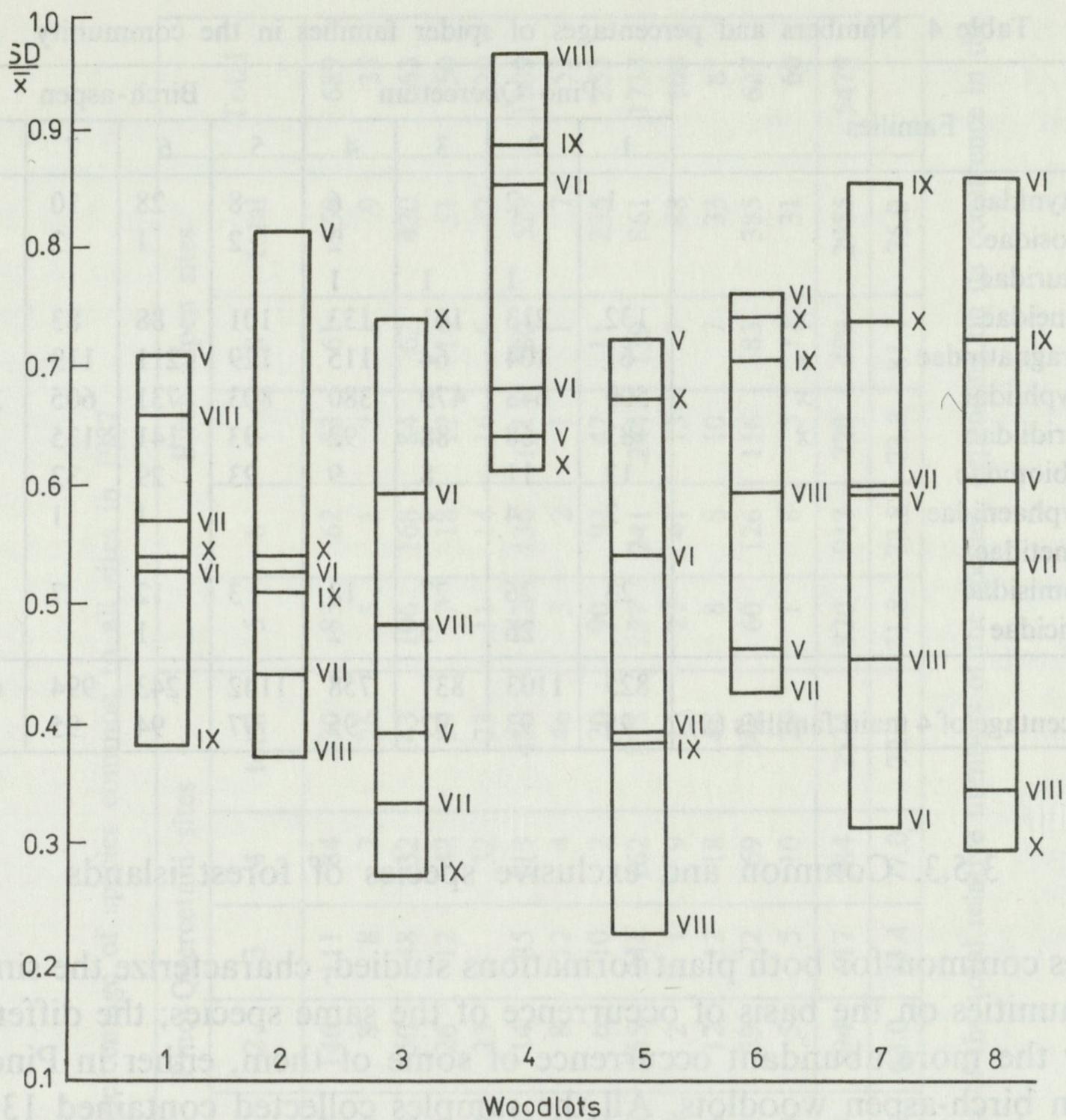


Fig. 5. Values of the coefficient of variation of biomass in particular forest islands in 1987

Explanations as in Figure 4

defined functions. Considering all spiders in an environment, their pressure on insects in all ecosystems is very strong.

Description of families which include most of the spiders of the herb layer, is given by Łuczak (1987). In 1987, 12 spider families were found in 8 forest islands (Table 4). Five of them, Araneidae plus Metidae, Tetragnathidae, Theridiidae and Linyphiidae make 93% (site No. 8) to 97% (No. 5) of all spider communities. Abundance of these families varies at different sites. In mixed forest islands, the Metidae dominate by 80% compared with birch-aspen sites, while the remaining three families dominate in birch-aspen islands; Tetragnathidae by 60%, Theridiidae 33%, Linyphiidae 21%. The family Linyphiidae is most abundant, followed by Araneidae + Metidae, Tetragnathidae, and Theridiidae (Table 4). The Linyphiidae exceed in numbers, by 66%, the sum of three other most numerous families; they prevail in the herb layer. The numbers refer to relative abundance. Dictynidae were mostly represented on island No. 6, Clubionidae on island No. 7, Thomisidae on islands 2 and 3, and Salticidae on island 2 (Table 4).

Table 4. Numbers and percentages of spider families in the community

Families	Pino-Quercetum				Birch-aspen			
	1	2	3	4	5	6	7	8
Dictynidae	1	2		6	8	28	10	7
Lycosidae				2	2	1	2	
Pisauridae		1	1	1				
Araneidae	<i>x</i>	132	213	161	133	101	88	83
Tetragnathidae	<i>x</i>	61	104	64	115	129	211	119
Linyphiidae	<i>x</i>	509	648	479	380	803	731	605
Theridiidae	<i>x</i>	83	68	88	92	73	141	135
Clubionidae		13	11	8	9	23	29	32
Anyphaenidae		2	4	4			1	1
Mimetidae		1						
Thomisidae		23	26	27	18	3	12	7
Salticidae			26	5	2		1	
		825	1103	837	758	1142	1243	994
Percentage of 4 main families (<i>x</i>)		95	93	92	95	97	94	95

3.5.3. Common and exclusive species of forest islands

Species common for both plant formations studied, characterize the similarity of the communities on the basis of occurrence of the same species; the differences are shown by the more abundant occurrence of some of them, either in Pino-Quercetum, or in birch-aspen woodlots. All the samples collected contained 13 common species (Table 5). They make up 20% of species occurring in Pino-Quercetum woodlots, and ca. 24% of species found in birch-aspen islands.

Contributions of common species numbers to spider communities range between 63% on island No. 2, which is most diversified with respect to species, and 81% on the least diversified island No. 8. In all the sampling materials collected, the common species make 73% (Table 5); they include species with a small number of individuals, such as *Cyclosa conica* (35 indiv. during season), and very abundant ones, e.g. *Linyphia triangularis* (1009 indiv.) and *Gongylidium rufipes* (1734 indiv.).

The common species of all the forest islands studied can be divided into three following groups.

1. Species much more numerous in a mixed forest. The group of 6 species include: *Meta segmentata*, *Cyclosa conica*, *Tetragnatha extensa*, *Pachygnatha listeri*, *Linyphia emphana*, and *Theridion varians*. Most specific for the mixed forest are: *Linyphia emphana* (87% of its numbers is found in a mixed forest), and *Cyclosa conica* (74%) (Table 5).

2. Species much more abundant in birch-aspen woodlots. The four species include: *Tetragnatha montana*, *Linyphia montana*, *Bolyphantes alticeps*, and *Enoplognatha ovata*. Most specific for birch-aspen woodlots are *Linyphia montana* (making 92% of all numbers of this species) and *Bolyphantes alticeps* (85%), (Table 5).

Table 5. Numbers and percentage of species common to all sites in 1987

Species	% of total numbers of the species*	Pino-Quercetum sites					Birch-aspen sites					Total
		1	2	3	4	total	5	6	7	8	total	
<i>Meta segmentata</i>	P-Q 62.4	89	146	111	84	430	83	62	53	61	259	689
<i>Cyclosa conica</i>	P-Q 74.3	3	8	8	7	26	5	1	2	1	9	35
<i>Tetragnatha montana</i>	b-a 74.6	13	50	48	32	143	106	168	84	62	420	563
<i>T. extensa</i>	P-Q 66	19	26	12	42	99	7	18	12	14	51	150
<i>Pachygnatha listeri</i>	P-Q 61	18	23		32	73	11	14	16	6	47	120
<i>Linyphia triangularis</i>	similar	168	114	85	113	480	182	136	131	80	529	1009
<i>L. emphana</i>	P-Q 86.8	22	8	12	4	46	3	2	1	1	7	53
<i>L. montana</i>	b-a 92	2	6	10	2	20	90	92	42	11	235	255
<i>Gongylidium rufipes</i>	similar	215	255	241	162	873	237	241	244	139	861	1734
<i>Bolyphantes alticeps</i>	b-a 85.4	3	2	1	9	15	27	41	13	7	88	103
<i>Theridion varians</i>	P-Q 59	6	12	12	18	48	8	8	10	7	33	81
<i>Enoplognatha ovata</i>	b-a 61.4	62	39	72	69	242	60	126	116	83	385	627
<i>Philodromus aureolus</i>	similar	9	5	5	10	29	1	8	5	17	31	60
Total		629	694	617	584	2524	820	917	729	489	2955	5479
% of community total		76.2	63.0	73.4	77.0	72.3	71.8	73.8	73.3	81.1	75.0	

* In this column are specified higher percentages of the total relative numbers of the species, depending on its occurrence in the mixed forest (P-Q), or birch-aspen islands (b-a).

3. Species of similar abundance in both types of woodlots. These are: *Linyphia triangularis*, *Gongylidium rufipes* and *Philodromus aureolus* (Table 5).

21 species exclusive for the Pino-Quercetum islands, contributed only 1.4% to the spider numbers in a mixed forest; species exclusive for birch-aspen woodlots made up 0.7% of spiders on these islands. All of them belong to less abundant

Table 6. A list and abundance of the exclusive species found in two habitat types (7 samples per season)

Pino-Quercetum	Numbers	Birch-aspen	Numbers
<i>Araneus sturmi</i>	6	<i>Araneus patagiatus</i>	7
<i>Mangora acalypha</i>	6	<i>Erigone dentipalpis</i>	2
<i>Centromerus silvaticus</i>	4	<i>Maso sundevalli</i>	4
<i>Philodromus dispar</i>	2	<i>Achacaranea simulans</i>	3
<i>Misumena</i> sp.	3	<i>Clubiona lutescens</i>	5
<i>Pisaura mirabilis</i>	3	<i>Bathyphantes concolor</i>	1
<i>Tetragnatha nigrita</i>	1	<i>Achacaranea lunata</i>	1
<i>Pachygnatha clercki</i>	2	<i>Clubiona germanica</i>	1
<i>P. degeeri</i>	1	<i>Oxyptila</i> sp.	1
<i>Linyphia peltata</i>	8	<i>Philodromus aureolus caesp.</i>	1
<i>L. marginata</i>	1		
<i>Bolyphantes</i> sp.	3		
<i>Erigonidium graminicola</i>	1		
<i>Ceratinella scabrosa</i>	1		
<i>Lepthyphantes alacris</i>	1		
<i>Episinus angulatus</i>	1		
<i>Clubiona coerulescens</i>	1		
<i>Xysticus luteolus</i>	1		
<i>Heliophanus</i> sp.	1		
<i>Ero</i> sp.	1		
Total of species	20	Total of species	10
Numbers	48	Numbers	26
% of total	1.4	% of total	0.7

species in the herb layer (Table 6), and for this reason, play an insignificant role as predators. Except for the common species (73%) and exclusive ones (2.1%), the other 31 species occur in both plant communities, but not at each sampling site, and make 25% of the total. Among this group, the species which predominate in mixed forests include: *Linyphia pusilla*, *Trematocephalus cristatus*, *Diaea dorsata*, and the spider of higher bushes *Anyphaena accentuata*. In birch-aspen woodlots more common are: *Linyphia clathrata*, *Helophora insignis*, and *Floronia bucculenta*. These differences are due to the variation in the structure of vegetation in both communities, and the resulting microclimatic conditions.

Detailed analysis of species dispersion and distribution of individuals, in the forest islands studied, even when environmental data are not considered, suggests differences in environmental conditions between mixed forests and birch-aspen woodlots, which lead to the variations in species distribution.

3.5.4. Dominant species

Dominant species being the major predators, define the role of spider community in the biocoenosis even more strongly, than the ecological groups. These are the most active species within distinct functional groups. They are the leading species of the functional ecological group, and characterize its mode of preying. As the most abundant, they hunt for prey of a defined type size, behaviour, and the ecosystem stratum which they inhabit. Groups of dominant species, although partly they include the same species as groups of common species, contain different sets of species composition.

Among the spiders collected at all the forest islands during the vegetative season, eight dominant species (above 5% of the total numbers) have been distinguished (Table 7). They all make up 63% of the total spider numbers. They also contribute more to the communities found in birch-aspen woodlots (59–70%), than in the mixed forest (62–66%).

Table 7. Abundance of species dominant in the period April–November 1987

Species	Site	Pino-Quercetum				Total	Birch-aspen				Total	Grand total
		1	2	3	4		5	6	7	8		
<i>Meta segmentata</i>		89	146	111	84	430	83	62	53	61	259	689
<i>Linyphia triangularis</i>		168	114	85	113	480	182	136	131	80	529	1009
<i>Gongylidium rufipes</i>		215	255	241	162	873	237	241	244	139	861	1734
<i>Enoplognatha ovata</i>		62		72	69	203	60	126	116	83	385	588
<i>Tetragnatha montana</i>			50	48		98	106	168	84	62	420	518
<i>Trematocephalus cristatus</i>			111			111						111
<i>T. extensa</i>					42	42						42
<i>Helophora insignis</i>							53				53	53
Total		534	676	557	470	2237	721	733	628	425	2507	4744
% of community total		64.7	61.3	66.3	62.0		63.1	58.9	63.2	70.5		

Three dominant species occurred in all the islands: *Meta segmentata*, *Linyphia triangularis*, and *Gongylidium rufipes*. The species *Enoplognatha ovata* was found on almost all islands with the exception of woodlot No. 2, where it did not dominate; also *Tetragnatha montana* was present almost everywhere, but it was more abundant in birch-aspen woodlots. *Trematocephalus cristatus* was only dominant in forest No. 2; *Tetragnatha extensa* only in island No. 4; and *Helophora insignis* exclusively in island No. 5 (Table 7). The species *Gongylidium rufipes* was the most numerous. It was followed by *Linyphia triangularis*, or *Meta segmentata* and *Tetragnatha montana*. A group of species dominating in birch-aspen woodlots No. 5 and 6 had the highest relative abundance (733 and 721 indiv.) and the lowest (425 indiv.) on island 8. The highest contribution to spider community had the species dominating in the smallest island No. 8. In island 6 there was the lowest contribution of dominant species to the entire spider community of the herb layer, which means the highest species diversity.

If we consider not as much the total spider collections of the season, but rather dominant species in individual islands in particular periods of time, we obtain 19 dominant species. In addition to those shown earlier, these are: *Evarcha falcata* (only island No. 2), *Linyphia emphana* (only No. 2), *Linyphia peltata* (only island No. 1), *Linyphia clathrata* (only No. 6), *Philodromus aureolus* (only No. 8), *Pachygnatha listeri* (only No. 1 and 4), *Dictyna uncinata* (islands No. 2 and 6), *Theridion varians* (islands 4 and 8), *Meta mengei*, the spider of a mixed forest (islands 1, 2, 3, 4) and *Linyphia montana* (islands No. 3, 5, 6, 7, 8), and *Bolyphantes alticeps* (islands 5, 6, 8). The two latter spiders occur mainly in birch-aspen woodlots.

As shown in the present analysis, both plant formations differ by the group of dominant species, although a few species occur as periodical dominants in all eight islands. In mixed-forest islands, there is a core of dominant species common to every island, but in addition, there are species occurring only in one of the islands. The same refers to birch-aspen woodlots, where the compositions of dominant species are more similar than in mixed forest islands.

3.6. AGE STRUCTURE OF SPIDER COMMUNITIES

Age structure is expressed as percentage of adult individuals in a spider community from each sampling site and period (Fig. 6). At mixed forest sites maxima of mature spiders contribution (50–61%) occur in different months from May to August; minima (0–4.6%) always in April. At birch-aspen sites maxima are found always in May (38–60%), minima (8–21%) in different months. This may mean that in mixed forests, the timing of the development cycle of spiders depends on the ecological character of the environment, which enables mass maturing of different species at various times; maxima of young forms always occur in early spring. On the other hand, in birch-aspen islands, best conditions for the development of adult forms occur everywhere for species maturing in spring, May, while maxima of young forms are found in different months, in April, June and October.

Maxima of adult individuals have similar values in both plant communities, while minima are much higher in birch-aspen forest islands, than in mixed forest (Fig. 6). Thus spiders inhabiting the birch-aspen woodlots, probably have better conditions for young individuals followed by stronger biocoenotical regulation. Detailed seasonal analysis shows the following: in April the highest percent of adult forms is observed in island 8 (33%); in May in islands 5, 6 and 7 (above 50%), but also in islands 2 and 3; in June, above 50%, only on island 2; in July in island 4; in August in islands 1 and 2; in September in island 1; in October in island No. 4.

Contributions of adult individuals are generally somewhat lower in dry small islands No. 3, 7 and 8 than in the other islands. In general, the percent contributions of adult individuals at four sites of mixed forest in 1987, were about 10% higher than at the birch-aspen sites. A comparison with 1986 (samples were taken in July, September, October, and November and thus, in the second half of the vegetative season) showed, that in the drier and warmer year, percent contributions of adult

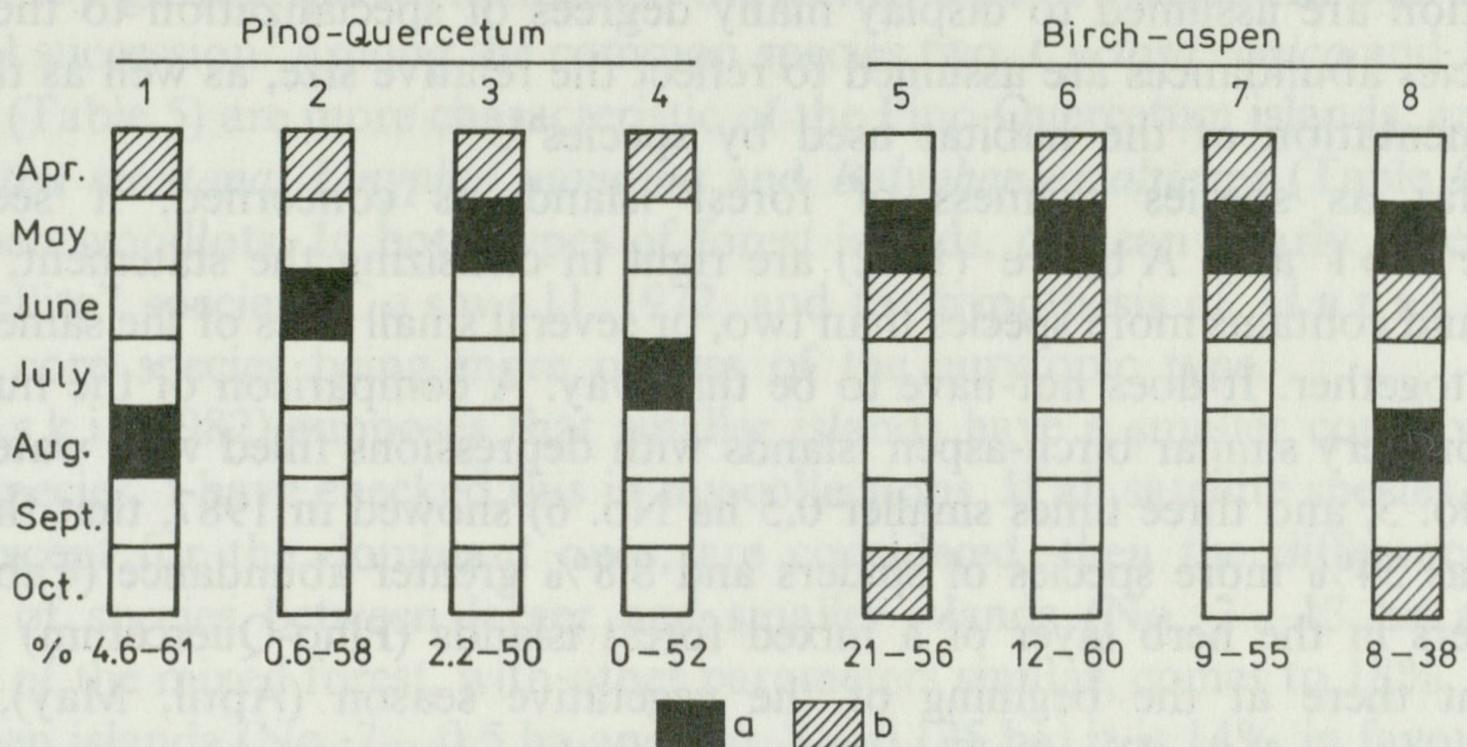


Fig. 6. Periods of maximum and minimum percentages of mature individuals in the spider community of forest islands (after Łuczak 1990)

a — periods of maximum percentages of mature individuals,

b — periods of minimum percentages of mature individuals

individuals in spider communities, were about 8% higher at the birch-aspen sites. These differences are not large, and probably depend on the meteorological conditions in a given year, favouring different plant formations.

4. DISCUSSION

When comparing ecologically different forest islands in an agricultural landscape, one must remember, that our considerations pertain not as much to the characteristics of the chosen animal group in the entire habitat mosaics, but to these properties in chosen, defined, environmental spots, that is in the herb layer of the whole woodlots. The open space of the cultivated field which surrounds the forest islands studied is very weakly inhabited by the representatives of the Araneae, especially those living on plants. Such species are quite diversified, but their numbers in fields are low (Raatikainen and Huhta 1968, Łuczak 1979, Sechterova-Špičakova 1987). It should also be emphasized, that the mosaic effect of the forest islands has not been investigated, except for the ecotone and the interior in 1988 and 1989. The islands were treated integrally in relation to spiders, particularly in 1987. This is why, it is difficult to comment the statement of Baker (1989), that increasing fragmentation of environment results in an increase of “disturbance value” of biocoenosis, which is expressed as the ratio of eurytopic species to all the species, or to those specialized in a given habitat. It is as difficult to relate to the thesis of Kolas (1989), according to whom, the abundance of species reflect the extent and degree of habitat fragmentation, that is its division into subunits. Discussing eurytopic species and specialized ones, he writes (Kolas 1989) about the hierarchical structure of each environmental unit where “species in

a collection are assumed to display many degrees of specialization to the habitat. The species abundances are assumed to reflect the relative size, as well as the degree of fragmentation of the habitat used by species”.

As far as species richness of forest islands is concerned, it seems that Simberloff and Abele (1982) are right in criticizing the statement, that one large island contains more species than two, or several small ones of the same size may contain together. It does not have to be that way. A comparison of the numbers of species on very similar birch-aspen islands with depressions filled with water (1.5 ha island No. 5, and three times smaller 0.5 ha No. 6) showed in 1987, that the smaller island has 34% more species of spiders and 8.8% greater abundance (Tables 3, 4).

Spiders in the herb layer of a mixed forest islands (Pino-Quercetum) are more abundant there at the beginning of the vegetative season (April, May), than in birch-aspen woodlots (Fig. 2). This suggests that they overwinter there more easily. In June the numbers are similar in both environments, and from July to the end of the season, the total numbers of spiders, and also their biomass, are greater in birch-aspen islands (Figs. 2, 3). This indicates good ecological conditions for spiders living there on vegetation; greater variation of the numbers and biomass of spiders in seasonal dynamics points out to the higher individualization of these forest islands (Figs. 2, 3). Being young in the ecological succession (Wójcik 1991), they are not as uniform as the older mixed forest environments, including even small islands (No. 3), or those located far from forests and surrounded by cultivated fields (island No. 4). Similar, and probably for the same reason, is the situation with the greater variability of general spider numbers in individual birch-aspen islands. It seems, that we are dealing with a “non-steady state mosaic” in relation to spiders, according to Baker (1989) designation, in contrast to more stabilized mixed forest islands.

Mean individual spider weight is higher on birch-aspen islands (Table 1); this suggests the occurrence of larger species, or better fed, heavier individuals. In both types of islands, forest spiders predominate. It is similar for the group of epigeic spiders. These spiders caught in the midfield woodlots in Chechoslovakia contain mainly the common species of Micryphantidae and Linyphiidae, and the entire group resembles arachnofauna of forests (Sechterova-Špičková 1987, 1989).

In both plant communities investigated presently, there are variations in distribution of different ecological groups of spiders. More of the Metidae (*Meta segmentata* and *Meta mengei*) live in mixed forest islands, and generally more representatives of the families Tetragnathidae (mainly *Tetragnatha montana*), Linyphiidae, and Theridiidae, inhabit birch-aspen woodlots. Post and Riechert (1977) have distinguished ecological groups of spiders (guilds) based on the mode of building webs and hunting for prey. Spider families in the present work, are treated the same way. Four families cited above make up 93–97% of the spider communities on forest islands.

Both types of forest islands differ, apart from the exclusive species represented by small numbers (Table 6), also in the quality, quantity and contribution of dominant species (Table 7), as well as in the abundance of common species. Among the exclusive species 20 occur in Pino-Quercetum islands, and 10 in birch-aspen islands,

thus there is a greater species richness in the former type of islands more advanced in ecological succession. Among the common species two, *Cyclosa conica* and *Linyphia emphana* (Table 5) are more characteristic of the Pino-Quercetum islands, and three, *Tetragnatha montana*, *Linyphia montana* and *Bolyphantes alticeps* (Table 5) of the birch-aspen woodlots. In both types of forest islands, one can clearly observe core and “satellite” species (C a s w e l l 1972, and the hypothesis of H a n s k i 1982), with the core species being more or less of the eurytopic type.

H a n s k i (1982) supposes that smaller islands have a smaller contribution of satellite species. I have checked this in my collections. If all satellite species, thus all species except for the dominant ones, are considered, then the difference in the numbers of species between larger and smaller islands (No. 2—13 ha and No. 3—1 ha) of the mixed forest, with other parameters similar, comes to 18%, while in birch-aspen islands (No. 7—0.5 ha and No. 8—0.125 ha) it is 14% in favour of the larger island. However, the difference is much greater in the quantities of the satellite species; 76% in birch-aspen islands and 74% in mixed forest islands, in favour of the larger islands. It is interesting to note, that it does not refer to rare species, represented by 1–3 individuals in the season, neither to “accidental” ones (one indiv. in a season). As it happened, these species occurred in the same numbers in both small and large islands. Thus, species more or less accidental, might be represented by the same numbers, independently of the size of the island. The principle of smaller number of species and individuals of the satellite species, occurring in a smaller island refers only, in our case, to quantitatively intermediate species between dominant and very rare ones. Therefore, it might happen, that an island may have a greater number of species, than an island which is three times as large. Rare species are decisive in this respect.

Contributions of mature individuals to spider communities inhabiting vegetation are generally similar, but their numbers in islands 5 and 6 in 1987 are 20–110% higher than in other islands. They are birch-aspen woodlots with large pools of water. In the warm year of 1986, many mature individuals occurred also in the dry forest island No. 7. An interesting phenomenon is the occurrence of a maximum abundance of mature spiders in all birch-aspen woodlots in May, followed immediately by a minimum in June (Fig. 6). This might be the result of preying on larger (mature) spiders by predators, such as birds inhabiting different types of woodlots (G r o m a d z k i 1970).

Among the parameters investigated in the present work, only the island origin (differing plant communities), and perhaps also the small threshold size of a forest island may affect the quantitative dynamics of spiders. L o v e j o y and O r e n (1981) state, that the size of a forest island may have an influence on the numbers and biomass of invertebrates which live there. The influence of the size of an island on species is also discussed by L e v e n s o n (1981). The problem of the size of an island in relation to species, is partly discussed in the present paper. Raatikainen investigated distribution and population abundance of *Philaenus spumarius* (L.) on different sizes islands of the Finnish Bay, and found a positive effect of the size of the habitat area on population numbers (H a l k k a et al. 1971).

In the present research, variable location of a forest island in a landscape, did not make a difference in the general numbers and biomass of spiders. However, earlier investigations showed, that this parameter may be important for the quantitative differences between entire communities or individual species of spiders which occur in fields surrounded by other cultivated fields, or in fields located near forests (Łuczak 1984). Similarly other landscape systems, e.g. a forest neighbouring with another type of forest, or with a meadow, also show different distributions of spider numbers in the ecotones of these ecosystems (Dąbrowska-Prot and Łuczak 1968, Dąbrowska-Prot et al. 1973), from those found in the forest-cultivated field ecotone in 1986–1989. In the two former cases, that is forest — forest and forest — meadow configurations, their ecotones are quantitatively richer in spider individuals than the forest interior, and in the case of forest islands neighbouring with cultivated fields, the ecotones of islands are generally poorer quantitatively (Table 8).

Table 8. Surroundings-related differences in numbers between the spiders of the forest interior and its ecotone (in %)

Alder forest adjacent to a mixed forest	
Ecotone	> by 18% from the alder forest interior
Ecotone	> by 31% from the mixed forest interior
Alder forest adjacent to a mid-field meadow	
Ecotone	> by 15% from the alder forest interior
Mixed forest (forest island) adjacent to a cropfield	
Ecotone	< by 2% from the mixed forest interior
Birch-aspen forest (forest island) adjacent to a cropfield	
Ecotone	< by 56% from the birch-aspen forest interior
Birch-aspen forest (forest island) adjacent to a cropfield	
Ecotone	< by 17% from the birch-aspen forest interior

Thus, configuration of ecosystems in a landscape has a very important meaning for the numbers of the Araneae, and one example of the lack of significant differences in island No. 4, remote from other forest areas, may have resulted from an increased number of eurytopic species from the group of aeronauts entering the island by flight. Sechterova-Špičková (1989) from Czechoslovakia emphasizes the role of the surrounding space for mid-field woodlots, and their colonization by aeronautic spiders, in the abundance and species composition of epigeic spiders. Meijer (1971) in his work on colonization by spiders, of a new polder in Netherlands not yet inhabited by animals, stated, that in the period of four weeks, he had caught 1526 spiders representing 27 species.

The lack of the influence of the presence of water in an island on the numbers and biomass of spiders, (islands of the same size and origin were compared; No. 6 with water, No. 7 without water) has not been unexpected, since the difference might be shown in another way, e.g. by the presence of hygrophilic species in a humid environment, and xerothermic species in a dry environment (Table 2). In spite of the greater floristic richness (Wójcik 1991) of both dry birch-aspen

woodlots (not having water pools) than the humid ones (with water reservoirs), the numbers and biomass of spiders are greater on the latter. In this case the presence of water is a more important factor for spiders than floristic richness. This refers especially to island No. 6, since on the annual basis, the numbers of spiders in dry island No. 7 are 25% lower, and the biomass is 33% lower than in the humid island No. 6, however, during individual months these differences are not statistically significant (Table 2). On the other hand, within the same type of islands containing water pools, a higher abundance of spiders is found in island No. 6 having a richer herb layer as compared to island No. 5.

Forest islands of the Masurian Lakeland landscape were rich in spiders. The older and more stabilized, and thus with probably a strongly reduced species competition forest islands of the Pino-Quercetum type, were characterized by a greater species richness of spiders, but generally lower numbers and biomass. Spider communities inhabiting vegetation of these islands differing in size and location, were more similar to one another, than the spider communities of birch-aspen woodlots.

The birch-aspen forest islands, except for the differences from the mixed forest in dominant species composition and quantities of common species, were characterized by higher and more individualized levels of spiders numbers and biomass in the vegetative season.

All forest islands in an agricultural landscape are substitutes for forests and act as reservoirs for many species and ecological groups of spiders (Ł u c z a k 1987). Spiders accumulate there and only rarely inhabit the neighbouring crop fields. For this reason, the preying activity of spiders living on vegetation is weaker on cultivated fields, than in forests, forest islands, or meadows. S e c h t e r o v a - Š p i č a k o v a (1989) found that epigeic spiders of midfield woodlots ("groves") do not play an important role in the colonization of fields; in the fields of sugar beets the most abundant are Micryphantidae, which belong to the major aeronautic species. Species of spiders differ by their aeronautic dispersal capacity (R i c h t e r 1971).

Forest islands which are characterized by different and much richer communities of spiders than the surrounding crop fields, serve as reservoirs of this group of predator arthropods; from there young spiders may migrate, via air, to many suitable environments in the entire landscape.

5. SUMMARY

An estimate has been made of the role and influence of forest islands on communities of spiders inhabiting vegetation of the herb layer. The islands considered are remnants of the Pino-Quercetum forest, and also birch-aspen woodlots which develop naturally on farm waste lands, in the agricultural landscape of the Masurian Lakeland (Mazury). The spiders studied represented a mixture of different ecological groups. It was found that the island origin (and thus a difference in vegetation) is important for the numbers and biomass of spiders (Table 2, Fig. 2). Particularly, the general spiders biomass and that of a statistical individual, was greater on birch-aspen islands than on mixed forest islands (Table 1). The size

of an island (35 ha, 13 ha, 1.5 ha, 1 ha, 1 ha, 0.5 ha, 0.5 ha, 0.125 ha) was meaningful only at a small threshold size (0.125 ha) of the island where numbers and biomass of spiders were the lowest (Table 2, Fig. 3).

Location of the sampling sites within forests and forest islands, or their isolation among cropfields did not, in this case, influence the numbers or biomass of spiders (Table 2). An isolated island is probably more inhabited by aeronautic species. Similarly, the presence of water reservoirs in an island of the same size and vegetation in comparison with a dry island, did not affect these parameters either. One island had more hydrophilic species, another more xerothermic ones. Quantitative dispersion of spiders in the period of their highest abundance in September, was more similar at different sites of the mixed forest, than at the birch-aspen sampling sites (Fig. 4), where the range of the coefficient of variability values was much greater.

On the other hand, the ranges of the seasonal coefficients of spider biomass variability are more similar to each other, which shows more uniform biomass distribution in the environment. Mixed forest island No. 4, located among fields, far from forests and forest islands, is different in this respect from the other sites (Fig. 5).

76 spider species have been identified; more of them occurred in the mixed forest areas (Table 3). The highest number of species in the season, 21–25, was observed in September (Table 3). Altogether 12 spider families were found; the majority of the communities was represented by the Linyphiidae, Araneidae + Metidae, Tetragnathidae, and Theridiidae (Table 4). Spider communities of all the islands were similar to one another. Common spiders made up the majority (Table 5). Spiders exclusive for a given plant formation, contributed only an insignificant percent to the total numbers (Table 6). However, the mixed forest sites contained generally twice as many exclusive species than the birch-aspen woodlots. Differences were found also in the composition of dominant species. Among spider species common to both plant communities there was a group occurring mainly in the mixed forest, and another one, more abundant in birch-aspen woodlots (Table 5). Eight dominant species were distinguished in the whole vegetative season (Table 7); when particular periods of the season were considered, 19 such species were found.

The range of the contribution of dominant species to the community is higher (54–70%) in birch-aspen islands than those of a mixed forest (62–66%). Three species, *Meta segmentata*, *Linyphia triangularis*, and *Gongylidium rufipes* were dominant in all forest islands. There are differences between both plant formations with respect to the remaining dominant species. Both plant communities differed also in the age structure of spiders, taken here as the percent of mature individuals in the community (Fig. 6). Maxima of mature spiders in mixed forests were found at different times of the season, while minima were always observed in April. In birch-aspen islands such maxima occurred in May, and minima always in June (Fig. 6). Ecotones of forest islands bordering with cultivated fields were found to be generally poorer in the numbers of spiders, than the interior of the islands (Table 8).

In summary, a considerable influence of forest islands on the group of Araneae has been ascertained. Besides a high similarity between the communities of spiders living on vegetation in the two types of forest islands, there are many characteristic differences between these communities. The discussion includes many ecological problems concerning the landscape ecology, size, origin and location of forest islands and the influence of these factors on communities of invertebrates, especially on different ecological groups of spiders.

6. POLISH SUMMARY

W pracy oceniono znaczenie i wpływ wysp leśnych (pozostałości boru Pino-Quercetum i zadrzewienia brzożowo-osikowe powstające samorzutnie na nieużytkach rolnych) w krajobrazie rolniczym Mazur na zgrupowania pajaków naroślinnych runa. Pajaki stanowiły mieszanekę różnych grup ekologicznych. Okazało się, że pochodzenie wysp leśnych (a więc i różnice roślinności) miało największe znaczenie w ustalaniu i różnicach liczebności (tab. 2, rys. 2) i biomasy pajaków. Szczególnie biomasy były większe

na wyspach brzożowo-osikowych — ogólna i statystycznego osobnika (tab. 1). Wielkość wysp leśnych (35 ha, 13 ha, 1,5 ha, 1 ha, 1 ha, 0,5 ha, 0,5 ha, 0,125 ha) miała znaczenie tylko przy krytycznym, małym obszarze wyspy (0,125 ha), na której liczebność i biomasa pajaków były najmniejsze (tab. 2, rys. 3).

Położenie badanych obszarów w obrębie lasów i wysp leśnych lub izolacja wśród pól, nie miały w tym przypadku wpływu na liczebność i biomasa pajaków (tab. 2) Izolowaną wyspę zasiedlają zapewne w większym stopniu gatunki aeronautyczne. Podobnie obecność zbiorników z wodą na wyspie o tej samej wielkości i roślinności także nie miała na te parametry wpływu w porównaniu z wyspą suchą. Na jednej było więcej gatunków wilgociolubnych, na drugiej sucholubnych. Rozkład liczebności pajaków na stanowiskach boru mieszanego w okresie największej liczebności pajaków (wrzesień) jest bardziej podobny niż na stanowiskach brzożowo-osikowych (rys. 4), gdzie zakres różnic współczynnika zmienności jest znacznie większy.

Sezonowe współczynniki zmienności biomasy pajaków są bardziej wyrównane (jeśli chodzi o zakres), co oznacza bardziej podobne rozmieszczenie biomasy w środowisku. Wyróżnia się wyspa boru mieszanego nr 4, położona wśród pól, z dala od lasów i wysp leśnych (rys. 5).

Oznaczono 76 gatunków, więcej na terenach boru mieszanego (tab. 3). Największa liczba gatunków w sezonie (21–25) występowała we wrześniu (tab. 3). Znalaziono 12 rodzin pajaków, z których znaczną większość zespołu stanowią Linyphiidae, Araneidae + Metidae oraz Tetragnathidae i Theridiidae (tab. 4). Zespoły pajaków wszystkich wysp były podobne do siebie. Pajaki wspólne stanowiły znaczną większość zespołów (tab. 5). Pajaki wyłączne dla określonej formacji roślinnej stanowiły znikomy procent liczebności zespołów (tab. 6), ale w borze mieszanym znalaziono ogółem dwa razy więcej gatunków wyłącznych niż na stanowiskach brzożowo-osikowych. Różnice wystąpiły również w składzie grup gatunków dominujących. Z gatunków wspólnych obu formacjom roślinnym wyróżniono gatunki występujące głównie w borze mieszanym i takie, które były dużo liczniejsze w zagajnikach brzożowo-osikowych (tab. 5). W całym sezonie wegetacyjnym wyróżniono osiem gatunków dominujących (tab. 7), a biorąc pod uwagę poszczególne okresy sezonu wyróżniono ich dziewiętnaście.

Zakres udziału gatunków dominujących w zespole jest większy na wyspach brzożowo-osikowych (54–70%) niż na wyspach boru mieszanego (62–66%). Trzy gatunki: *Meta segmentata*, *Linyphia triangularis* i *Gongylidium rufipes* wystąpiły jako dominanty na wszystkich wyspach leśnych. Co do pozostałych gatunków dominujących występują różnice między obu formacjami roślinnymi. W obu typach roślinności różniła się również struktura wiekowa pajaków rozumiana jako procent osobników dojrzałych w zespole (rys. 6). Okresy maksimum pajaków dojrzałych przypadają na różne terminy sezonu w borach mieszanych, a minima występowały tam w kwietniu. Natomiast na wyspach brzożowo-osikowych okresy maksimum dojrzałości osobniczej pajaków przypadają w maju, a okresy minimum w czerwcu (rys. 6). Ekotony badanych wysp leśnych graniczących z polami uprawnymi okazały się na ogół uboższe, jeżeli chodzi o liczebność pajaków, od wnętrza wysp leśnych (tab. 8).

Reasumując stwierdzono duże znaczenie wysp leśnych dla grupy Araneae. Przy dużym podobieństwie zespołów pajaków naroślinnych badanych wysp leśnych z dwoma zgrupowaniami roślinnymi jest wiele charakterystycznych różnic w ich zespołach. W dyskusji poruszono szereg problemów ekologicznych stawianych przez autorów zagranicznych zainteresowanych mozaikowością środowiska, stosunkiem wielkości wysp leśnych do zespołów zwierzęcych, prawidłowościami biocenotycznymi zespołów bezkręgowców i ich grupami ekologicznymi.

7. REFERENCES

1. Baker W. L. 1989 — Landscape ecology and nature reserve design in the Boundary Waters Canoe Area, Minnesota — Ecology, 70: 23–35.
2. Burgess R. T., Sharpe D. M. (Eds.) 1981 — Forest island dynamics in man-dominated landscape — Ecol. Stud. 41: 1–310.
3. Caswell H. 1972 — Predator-mediated coexistence: a non-equilibrium model — Am. Nat. 112: 127–154.

4. Dąbrowska-Prot E. (Ed.) 1984 — Biocoenosis in an industrial landscape — Pol. ecol. Stud. 10: 5–230.
5. Dąbrowska-Prot E. (Ed.) 1987 — Biocoenotical processes in the industrial regions — Pol. ecol. Stud. 13: 5–168.
6. Dąbrowska-Prot E. 1991 — Forest islands in the landscape of the Masurian Lakeland; origin, location in space, research problems — Introduction — Ekol. pol. 39: 431–436.
7. Dąbrowska-Prot E. 1991 — The role of forest islands in the shaping of the structure and functioning of entomofauna in an agricultural landscape — Ekol. pol. 39: 481–516.
8. Dąbrowska-Prot E., Łuczak J. 1968 — Spiders and mosquitoes in the ecotone of alder forest (*Carici-elongatae-Alnetum*) and oak-pine forest (*Pino-Quercetum*) — Ekol. pol. 16: 461–483.
9. Dąbrowska-Prot E., Łuczak J., Wójcik Z. 1973 — Ecological analysis of two invertebrate groups in the wet alder wood and meadow ecotone — Ekol. pol. 21: 754–812.
10. Gromadzki M. 1970 — Breeding communities of birds in mid-field afforested areas — Ekol. pol. 18: 307–350.
11. Halkka O., Raatikainen M., Halkka L., Lokki J. 1971 — Factors determining the size and composition of island populations of *Philaenus spumarius* (L.) (Hom.) — Acta entomol. fenn. 28: 83–100.
12. Hanski I. 1982 — Dynamics of regional distribution: the core and satellite hypothesis — Oikos, 38: 210–221.
13. Kolaszka J. 1989 — Ecological systems in hierarchical perspective: breaks in community structure and other consequences — Ecology, 70: 36–47.
14. Kondracki J. 1978 — Geografia fizyczna Polski [Physical geography of Poland] — Państwowe Wydawnictwo Naukowe, Warszawa.
15. Levenson J. B. 1981 — Woodlots as biogeographic islands in Southeastern Wisconsin (In: Forest island dynamics in man-dominated landscape, Eds. R. T. Burgess, D. M. Sharpe) — Springer-Verlag, New York–Heidelberg–Berlin, 13–39.
16. Lovejoy T. E., Oren D. C. 1981 — The minimum critical size of ecosystems (In: Forest island dynamics in man-dominated landscape, Eds. R. T. Burgess, D. M. Sharpe) — Springer-Verlag, New York–Heidelberg–Berlin, 7–12.
17. Łuczak J. 1958 — O metodyce badania pajaków runa lasu sosnowego [Methods of investigation of spiders in the field layer of a pine forest] — Ekol. pol. B, 4: 283–292.
18. Łuczak J. 1979 — Spiders in agrocoenoses — Pol. ecol. Stud. 5: 151–200.
19. Łuczak J. 1984 — Spiders of industrial areas — Pol. ecol. Stud. 10: 157–185.
20. Łuczak J. 1986 — The distribution of spiders and the structure of their communities under the pressure of agriculture and industry — Les Colloques de l'INRA, 36: 85–96.
21. Łuczak J. 1987 — Spiders of woods and woodlots in an industrial landscape — Pol. ecol. Stud. 13: 113–137.
22. Łuczak J., Wierzbowska T. 1959 — Analysis of the likelihood of material in relation of the length of a series in the sweep-net method — Bull. Acad. Pol. Sci, Cl. II, Sér. Sci. biol. 8: 313–318.
23. Meijer J. 1971 — Immigration of arthropods into the new Lauwerszee Polder (In: Dispersal and dispersal power of carabid beetles, Ed. P. J. Boer) — Landbouwhogeschool, Wageningen, The Netherlands, 53–64.
24. Post W. M., Riechert S. E. 1977 — Initial investigation into the structure of spiders communities I. Competitive effects — J. anim. Ecol. 46: 729–749.
25. Raatikainen M., Huhta V. 1968 — On the spider fauna of Finnish oat fields — Ann. zool. fenn. 5: 254–261.
26. Richter C. J. J. 1971 — Some aspects of aerial dispersal in different populations of wolf spiders, with particular reference to *Pardosa amentata* (Araneae, Lycosidae) (In: Dispersal and dispersal power of carabid beetles, Ed. P. J. Boer) — Landbouwhogeschool, Wageningen, The Netherlands, 17–150.
27. Simberloff D., Abele L. G. 1982 — Refuge design and island biogeographic theory: effects of fragmentation — Am. Nat. 120: 41–50.

28. Sechterova-Špičakova E. 1987 — Zpravy Krajskeho Vlastivedneho Muzea w Olomouci — 247: 1–20.
29. Sechterova-Špičakova E. 1989 — Spiders (Araneae) and harvestmen (Opiliones) in the groves II — Acta Univ. Palacki Olomuc., Fac. Rerum Nat. Biol. 96: 165–184.
30. Wójcik Z. 1991 — The vegetation of forest islands in the agricultural landscape of the Jorka river reception basin in the Masurian Lakeland (north-eastern part of Poland) — Ekol. pol. 39: 437–479.

Mirosława TARWID

Department of Biodynamics, Institute of Zoology, Polish Academy of Sciences,
Dzikańów Leśny (near Warsaw), 05-093 Lemonski, Poland

FERILITY OF THE SPIDER *ENOPLIGNATHA OVATA* CL IN WOODLOTS OF THE AGRICULTURAL LANDSCAPE OF NORTH-EASTERN POLAND

ABSTRACT. Fecundity of females and reproduction rate of a population of the spider were examined in woodlots situated in different agricultural landscapes of the Masurian Lakeland. For each woodlot the following variables were determined: seasonal changes in the rate of reproduction, population density, fecundity of females in terms of these indices such as the size, viability, and viability of cocoons, also physical and relative productivity of the population, and percentage losses as a result of egg and young mortality.

It has been found that birch-aspens woodlots as compared with pine-oak woodlots provide more suitable conditions for survival and reproduction of *Enoplognatha ovata* populations. Also small forest islands, or those located close to other islands or large forests, are more suitable for reproduction of the spider.

KEY WORDS: spiders, fecundity, woodlots, landscape.

1. INTRODUCTION

Enoplognatha ovata is a common spider living in the herb layer and even in the litter layer of many forests in Poland. It is one of the dominant species in spider communities of these habitat types. With respect to the way of reproduction, this is a suitable object for the study of fecundity. Females lay only one cocoon (Selys 1875) thus it represents the total fecundity of an individual. Moreover, cocoons are very marked as females lay them on leaves folded in a characteristic way, and stay nearby. Due to their blue colour, it is easy to distinguish them from the cocoons of other spiders. Thus, this spider can be used as a model species in the studies of the effects of various factors such as site conditions, food, and man-produced disturbances on the reproduction of individuals.