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THE COMMUNITY OF SPIDERS OF THE GROUND FLORA OF PINE FOREST

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I. PURPOSE OF WORK AND METHODS

The research work on the communities of spiders of the ground flora of a pine forest (herbaceous layer) was carried out in Lemansk near Częstochowa (chief-forester's post Łobodno) in the spring, summer and autumn of 1954. Comparative collections were made in 1955 from July to October inclusive.

The purpose of work was to investigate the community of spiders of the ground flora of a pine forest as to its specific composition and changes of numbers in the vegetation season, and to compare the composition and numbers of spiders of the ground flora in various types of pine forest situated in one locality. Two types of the ground flora of a pine forest were chosen: 1) consisting mainly of bilberry (*Vaccinium myrtillus*) — 3 stations marked with letters V_1, V_2, V_3 and 2) consisting of heather (*Calluna vulgaris*) — 2 stations marked with letters C_1 and C_2. The stations of *Vaccinium myrtillus* are more humid; they are situated in a 70-year old pine forest: V_1 is half a kilometre distant from V_2; V_3 — 4 kilometres distant from V_2. The station V_1 is characterised by almost a complete lack of undergrowth and very uniform carpet of *Vaccinium myrtillus* with addition of fern *Pteridium aquilinum*. The station V_2 is more humid and has a richer undergrowth. Station V_3 has the richest undergrowth (young oaks, birches and numerous shrubs) and floristically the most differentiated carpet. The heather stations (about 3 kilometres distant from each other) are situated in a younger pine forest (C_1 — 50 years old, C_2 — 30 years old); they

differ also in the greater degree of sunlight operation on the ground flora at station C_2 and the presence of fern at station C_1. The carpet of heather is not uniform on either of the stations; it rather forms patches of heather separated by spaces without vegetation, covered with fallen pine needles.

Individuals caught in all:	1954	1955
Scoop method	11645	3226
Quadrate method	1315	1043

At particular stations

	Year	V_1	V_2	V_3	C_1	C_2
Caught by scoop	1954	3065	1865	1701	2903	2111
	1955	1399	176	153	111	1387
Caught by quadrate method	1954	214	229	184	236	452
	1955	259	250	31	223	280
Series of collections	1954	31	25	24	34	8
with scoop	1955	14	2	2	2	7
Series of observations made	1954	8	7	6	7	8
	1955	8	6	1	6	6

Quantitative samples were collected with the scoop and a series of 10 collections constituted a comparative unit, each collection consisting of 25 strokes of scoop. It was found that the selectivity of the scoop method is always of a similar type and does not give differentiated deformations in the picture of the quantitative dynamics of the communities of the ground flora spiders. It was determined by catching spiders by fast and slow strokes of the scoop at the same time and at all stations and comparing the spider material caught (Łuczak 1958). It was also stated that quantitative material collected by means of a scoop gives in uniform environments a true picture of changes in numbers of all spiders of the ground flora, their ecological groups and particular dominating species (Łuczak 1958, Kontkanen 1950 for *Homoptera*). Apart from the main method — by means of a scoop, time observations were made by means of the quadrate method, placing on the ground flora a square metal frame measuring 50 × 50 cm, and noting for 4 minutes all spiders of the ground flora observed during that time. A series of 20 observations constituted a comparative unit.

Both the above methods facilitated the orientation in variability of quantitative relations of spiders occurring on the ground flora.

II. QUALITATIVE COMPOSITION AND DISTRIBUTION OF THE SPECIES OF THE GROUND FLORA SPIDERS

In all, 91 species of spiders were caught, belonging to 15 families, in this 56 species of web-spiders and 35 wandering species (tab. I). A similar number of species occurred at all stations (58, 58, 52, 59, 53). 4 families dominate: *Argiopidae, Linyphiidae, Theridiidae* and *Thomisidae* (62 species).

1. QUALITATIVE COMPOSITION

The forest spiders distribute themselves in various layers of the forest: some species are characteristic of the litter, others of the layer of shrubs, tree trunks or tree-top layer (Charitonow 1953).

The community of spiders on the ground flora of forest is very heterogeneous. Beside species characteristic of low vegetation one can also meet there species, which occurring generally in other layers, come here probably mainly in search of prey (Vité 1953). These are: litter spiders (e.g. *Oxyptila brevipes, O. trux,* genus *Lepthyphantes*), spiders of higher layers of vegetation (shrubs, branches of trees) (e.g. *Theridion lunatum, Th. pinastri, Anyphaena accentuata*), spiders peculiar to one type of habitat, for example from under tree bark (*Araneus umbraticus, Clubiona subsultans*), from under roots of plants (*Trochosa terricola*).

On the ground flora of a pine forest species are also found finding their optimum conditions in other type of environment (e.g. species of the genus *Pachygnatha*. The ground flora is a place where representatives of different strata meet forming a very heterogeneous, mixed community.

37 species were common to all stations: this makes from 63 to 71 per cent of species occurring at particular stations (tab. I). Many of them are characteristic not only of the ground flora but also, or solely, of other strata of pine forests.

There are 8 species of spiders, in this 5 web-spider species and 3 wandering species (tab. I) which occur in abundance and are characteristic of the ground flora of all investigated stations, namely both of the carpet of *Vaccinium myrtillus* and the carpet of *Calluna vulgaris.*

List of spiders caught on the ground flora according to their numbers (systematic arrangement according to Locket and Millidge 1951—1953)

Spis złowionych na runie gatunków pająków według ich liczebności (układ systematyczny według Locketa i Millidge'a 1951—1953)

Tab. I

No. Lp.	Name of species Nazwa gatunku	Percentage of the total number of spiders caught on stations with Procent ogółu pająków złowionych na stanowiskach z	
		Vaccinium myrtillus	*Calluna vulgaris*
	Basic group of spiders of the ground flora (species occurring numerously on all stations investigated) Podstawowa grupa pająków runa (gatunki występujące licznie na wszystkich badanych stanowiskach)		
*1.	*Dictyna arundinacea* (L.)	2,4	2,6
*2.	*Xysticus cristatus* (Cl.)	2,8	4,4
*3.	*Philodromus collinus* C. L. Koch	4,0	2,8
*4.	*Evarcha falcata* (Cl.)	10,6	3,2
*5.	*Tetragnatha pinicola* L. Koch	12,4	7,1
*6.	*Mangora acalypha* (Walck.)	20,1	36,3
*7.	*Maso sundevalli* (Westr.)	11,7	3,2
*8.	*Linyphia triangularis* (Cl.)	7,2	7,7
	Species occurring more numerously on stations with *Vaccinium myrtillus* Gatunki występujące liczniej na stanowiskach z *Vaccinium myrtillus*		
*9.	*Philodromus dispar* Walck.	4,1	0,1
*10.	*Theridion ovatum* (Cl.)	9,0	0,2
*11.	*Araneus sturmi* (Hahn)	2,8	1,0
*12.	*Araneus cucurbitinus* Cl.	1,0	0,6
*13.	*Tetragnatha obtusa* C. L. Koch	1,6	0,2
*14.	*Linyphia pusilla* Sund.	1,1	0,9
*15.	*Linyphia marginata* C. L. Koch	1,2	0,4
°16.	*Pachygnatha listeri* Sund.	1,1	0,0
*17.	*Heliophanus flavipes* C. L. Koch	1,0	0,5

Tab. I (cont.)

No. Lp.	Name of species Nazwa gatunku	Percentage of the total number of spiders caught on stations with Procent ogółu pająków złowionych na stanowiskach z	
		Vaccinium myrtillus	*Calluna vulgaris*
	Species occurring more numerously on stations with *Calluna vulgaris* Gatunki występujące liczniej na stanowiskach z *Calluna vulgaris*		
□18.	*Oxyopes ramosus* (Panz.)	0,0	9,6
*19.	*Pisaura mirabilis* (Cl.)	0,2	6,7
*20.	*Erigoninae gen. sp.*	0,1	2,8
	Species constituting less than 1 percent of the community of the ground flora spiders Gatunki stanowiące mniej, niż jeden procent zgrupowania pająków runa		
°21.	*Clubiona compta* C. L. Koch		
22.	*Clubiona trivialis* C. L. Koch		
°23.	*Clubiona subsultans* Thor.		
□24.	*Chiracanthium oncognathum* Thor.		
*25.	*Zora spinimana* (Sund.)		
26.	*Anyphaena accentuata* (Walck.)		
*27.	*Micrommata virescens* (Cl.)		
*28.	*Diaea dorsata* (Fabr.)		
*29.	*Misumena vatia* (Cl.)		
30.	*Pistius truncatus* (Pall.)		
31.	*Xysticus erraticus* (Blackw.)		
32.	*Xysticus ulmi* (Hahn)		
33.	*Xysticus luctuosus* (Blackw.)		
34.	*Oxyptila trux* (Blackw.)		
35.	*Oxyptila brevipes* (Hahn)		
36.	*Oxyptila horticola* (C. L. Koch)		
37.	*Philodromus sp.*		
38.	*Heliophanus patagiatus* Thor.		
°39.	*Euophrys frontalis* (Walck.)		
□40.	*Evarcha arcuata* (Cl.)		

Tab. I (cont.)

No. Lp.	Name of species Nazwa gatunku	Percentage of the total number of spiders caught on stations with Procent ogółu pająków złowionych na stanowiskach z	
		Vaccinium myrtillus	*Calluna vulgaris*
41.	*Lycosa lugubris* (Walck.)		
□42.	*Lycosa sp.*		
43.	*Tarentula fabrilis* (Cl.)		
44.	*Trochosa terricola* Thor.		
*45.	*Dolomedes fimbriatus* (Cl.)		
46.	*Agelena labyrinthica* (Cl.)		
47.	*Ero aphana* (Walck.)		
48.	*Episinus angulatus* (Blackw.)		
49.	*Episinus truncatus* Latr.		
50.	*Euryopis flavomaculata* C. L. Koch		
51.	*Dipoena tristis* (Hahn)		
□52.	*Theridion lunatum* (Cl.)		
53.	*Theridion sisyphium* (Cl.)		
*54.	*Theridion simile* C. L. Koch		
55.	*Theridion pictum* (Walck.)		
*56.	*Theridion varians* Hahn		
*57.	*Theridion tinctum* (Walck.)		
*58.	*Theridion bimaculatum* (L.)		
59.	*Theridion sp.*		
*60.	*Theridion pinastri* L. Koch		
61.	*Enoplognatha thoracica* (Hahn)		
*62.	*Tetragnatha extensa* (L.)		
63.	*Pachygnatha clercki* Sund.		
64.	*Pachygnatha degeeri* Sund.		
°65.	*Meta segmentata* (Cl.)		
°66.	*Meta segmentata mengei* (Blackw.)		
67.	*Araneus angulatus* Cl.		
*68.	*Araneus diadematus* Cl.		
69.	*Araneus alsine* (Walck.)		
70.	*Araneus umbraticus* Cl.		
*71.	*Zilla diodia* (Walck.)		
*72.	*Singa pygmaea* (Sund.)		
73.	*Singa hamata* (Cl.)		
°74.	*Cercidia prominens* (Westr.)		
*75.	*Cyclosa conica* (Pall.)		

Tab. I (cont.)

No. Lp.	Name of species Nazwa gatunku	Percentage of the total number of spiders caught on stations with Procent ogółu pająków złowionych na stanowiskach z	
		Vaccinium myrtillus	*Calluna vulgaris*
*76.	*Cyclosa oculata* (Walck.)		
77.	*Pocadicnemis pumila* (Blackw.)		
78.	*Minyriolus pusillus* (Wid.)		
79.	*Erigone dentipalpis* (Wid.)		
80.	*Meioneta rurestris* (C. L. Koch)		
81.	*Centromerus silvaticus* (Blackw.)		
□82.	*Centromerus incilium* (L. Koch)		
83.	*Centromerus bicolor* (Blackw.)		
°84.	*Floronia bucculenta* (Cl.)		
*85.	*Labulla thoracica* (Wid.)		
86.	*Lepthyphantes cristatus* (Menge)		
°87.	*Lepthyphantes tenebricola* (Wid.)		
88.	*Lepthyphantes angulipalpis* (O. P. Cambr.).		
89.	*Linyphia montana* (Cl.)		
90.	*Linyphia clathrata* Sund.		
91.	*Linyphia furtivą* O. P. Cambr.		

Species marked with a star occurred on all five stations.
Species marked with a circle occurred exclusively on stations with *Vaccinium myrtillus*.
Species marked with a square occurred exclusively on stations with *Calluna vulgaris*.
Gatunki oznaczone gwiazdką występowały na wszystkich pięciu stanowiskach.
Gatunki oznaczone kółkiem występowały wyłącznie na stanowiskach z *Vaccinium myrtillus*.
Gatunki oznaczone kwadratem występowały wyłącznie na stanowiskach z *Calluna vulgaris*.

It must be pointed out that many species (e.g. *Cyclosa conica, Araneus cucurbitinus, A. diadematus, Tetragnatha obtusa)* live on the ground flora a short time, only in very early development stages, and as they grow, they build webs on shrubs or between trees in the same environment; Petrusewicz (1938a) states that for example for the species *Cyclosa conica* the lower part of the layer of shrubs is characteristic. Many species (e.g. *Mangora acalypha, Tetragnatha extensa, Theridion varians, Th. pinastri, Th. tinctum)* even in the early stages of development may distribute

themselves or generally distribute themselves in addition to the ground flora, also on shrubs and branches of trees (W i e h l e 1937); some species live in the forest environment analysed only in the early stages of development and then move to another environment (e.g. *Dolomedes fimbriatus,* whose adult forms live only in environment on the banks of stretches of water (B o n n e t 1930, P e t r u s e w i c z 1937).

9 species occurred exclusively on bilberry sites (tab. 1), some of which (*Pachygnatha listeri, Meta segmentata, M. segmentata — mengei, Floronia bucculenta)* require considerable humidity of environment. P e t r u s e w i c z (1938a) states, that in *Pinetum* and *Picetum vacciniosum* there are few adult forms of *Meta segmentata,* but young spiders repeatedly occur in abundance on the *Vaccinium.* 3 of these 9 species (*Clubiona subsultans, Floronia bucculenta, Lepthyphantes tenebricola)* are not characteristic of the ground flora, occurring mainly in other strata of the forest.

6 species occurred exclusively on heather sites (tab. 1), 2 of which (*Evarcha arcuata, Oxyopes ramosus*) require environments on which the operation of heat and light is more intense. *Oxyopes ramosus* occurred very abundantly on C_1, others occurring only as single individuals. Two species (*Theridion lunatum, Centromerus incilium*) rarely occur on the ground flora, living mainly in other strata. The species *Pisaura mirabilis* occurred on heather sites in greater numbers (257 in all) than on bilberry sites (9).

In March, on sites V_1 and V_2 when collections were made by scoop, the species *Tetragnatha obtusa* occurred fairly abundantly, while on the ground flora of stations V_3 it was very scarce (6 individuals). After May it did not occur on any of the investigated stations because it is a species which lives higher, in the stratum of shrubs (P e t r u s e w i c z 1938b). Most probably this species, having more suitable conditions on station V_3 (site on which shrubs are most numerous) moved to the more suitable stratum of shrubs quicker than on other sites.

Only on the station V_1 (the driest) did *Cyclosa oculata* and *Linyphia pusilla* occur fairly abundantly in November (9.6% and 8% of the total number of spiders caught at that time) and *Heliophanus flavipes* (6%) in September.

Only on station V_2 did *Theridion bimaculatum* occur fairly numerously in September (5%), and *Linyphia marginata* in October (10%). On the same site the presence was noted of the species

Pachygnatha clercki and *Theridion pictum* which require considerable humidity of environment. It is situated in a slightly but distinctly lower-lying site and even "at sight" it seems more humid than the surrounding pine forest which grows on slightly higher ground.

Only on station V_3 did young individuals of *Araneus diadematus* occur fairly numerously in June (10%) and *Philodromus dispar* in July (15%). The species found on one site only — at most (8) — were noted to be also on this site, the most differentiated floristically.

2. ECOLOGICAL GROUPS OF SPIDERS

Among spiders may be distinguished two large ecological groups differentiated as to the manner in which they capture their prey. One of them is formed by web-spiders, which build web-traps for the purpose of capturing their victims, the second group being wandering spiders which catch their victims actively. This second group is less homogeneous than the first one, because here belong the running, jumping and lurking forms which move and capture their prey in a very different manner. Both ecological groups occurred abundantly on the ground flora of pine forest.

The species of wandering spiders (mainly lurking forms) occur in the surface layer of the ground flora from June to September, fairly uniformly on all sites, constituting in all analysed periods of time from 30 to 50 per cent of the total number of species caught by means of a scoop (tab.II). The greatest numbers of individuals of wandering species occur on the ground flora, dependent on the site — in May, June or July. In the peak period of their occurrence on particular sites they constitute from 44 to 85 per cent of spiders caught. The least number of wandering spiders occur in April, and on some sites in May — from 3 to 19 per cent of the whole community of spiders of the ground flora.

The greatest numbers of individuals of wandering species occur on the heather site C_1. At the end of June and in the middle of July they constitute there 78 and 75 per cent of the spider fauna of the ground flora. One of the contributory causes is the presence of considerable numbers of the dominant species *Oxyopes ramosus* (which does not occur on bilberry sites, and on site C_2 in small numbers only) which from the middle of May to the middle of July constitutes from 24 to 42 per cent of the total number of spiders of

the carpet C_1. Web spiders occurred in the greatest numbers in April, constituting in this period 70 per cent of the total community.

Relation of the number of wandering species to the total number of species of the ground flora spiders – percentage (June – September)

Stosunek ilości gatunków pająków wędrujących do ogółu gatunków pająków runa – w procentach (czerwiec – wrzesień)

Tab. II

Station Stanowisko	Collection period – Czas połowu						
	14–16. VI.	21–23. VI.	7–16. VII.	22–27. VII.	18–23. VIII.	3–11. IX.	22–27 IX.
V_1	33	40	50	41	46	40	39
V_2	50	56	48	47	48	46	37
V_3	42	47	44	55	32	46	30
C_1	47	50	53	50	40	50	41
C_2	–	42	44	43	38	42	40

Numbers of web-spiders species occurring in April and May on stations with Vaccinium myrtillus

Ilości gatunków sieciowych, występujących w kwietniu i w maju na stanowiskach z Vaccinium myrtillus

Tab. III

Stations Stanowiska	Collection period – Czas połowu		
	27.IV.	13.V.	25.V.
V_1	14	8	16
V_2	12	7	11
V_3	5	3	9

On the ground flora of the station V_3, where shrubs are most numerous, a smaller quantity of web-spiders occur in April and

May than on V_1 and V_2 (tab. III). It seems that some web-species, which make their webs on the *Vaccinium myrtillus,* might occupy on station V_3 ecological niches situated in a higher layer than the layer of the ground flora and distribute themselves on shrubs and small trees (birches, young oaks). In autumn, on the other hand, the majority of spiders descend to lower strata of vegetation and therefore at this time similar numbers of species may be observed on the ground flora of all three stations of which bilberry is predominant.

3. VERTICAL DISTRIBUTION

Vertical distribution of spiders of the stratum of the ground flora was examined by observing the surface of the ground flora, its internal and lower layers (by the quadrate method); for this purpose quantitative collections were made from *Vaccinium myrtillus* (on station V_1), from *Calluna vulgaris* (on station C_1) and from *Pteridium aquilinum* growing on these sites.

Observing the spacial distribution of spiders on the ground flora it may be noted, that some spiders are distributed on the surface parts of the ground flora and some in the lower layers. For example *Linyphia pusilla* and *Linyphia clathrata* do not on the whole make their webs in the upper layers of the ground flora and on the layer of shrubs. Książek-Mikulska (1936) investigating litter spiders of the beech forest on Podgórze Cieszyńskie, points out that the species of spiders characteristic of the given layer occur in each layer of litter. Similar relations may sometimes be observed among the spiders of the ground flora. One should not, however, overestimate the role of a particular stratum as influencing the distribution of spiders. Many species are distributed on very different heights: on the ground flora, on shrubs, on branches of trees (of the common species — *Linyphia triangularis, Mangora acalypha, Araneus cucurbitinus).* It may be supposed that the distribution of a species in one stratum only or in several strata is a characteristic of the species in question and depends on its ability to utilise the environment and on environmental requirements. Bristowe (1929) and Knülle (1953) declare that physical characteristics of plants (such as height, morphology) are of great importance to the distribution of spiders.

On the bilberry covered site (V_1) in the period from July to September 38 species of spiders occurred on fern, and 47 species on

bilberry. 33 species were found to be common to both these layers of the ground flora; i.e. 60 % of the species occurring in bilberry vegetation. On site C_1 36 species were noted on ferns and 45 on heather. There were 29 species, common to the both strata, that is 64 % of all species occurring on the heather. Thus more species occur on the *Vaccinium myrtillus* and on *Calluna vulgaris* than on the ferns. It may be accepted that the scoop method gives a correct picture in this case, because the scoop catches only animals of the upper part of the bilberry or heather plants, whereas the whole of the fern plants come within the reach of its catching action.

Thus on the whole, the same species occur on ferns as on other plants of the ground flora (*Vaccinium* or *Calluna*). The following belong to species occurring more numerously on the ferns: *Araneus sturmi, Heliophanus flavipes, Evarcha falcata, Philodromus dispar;* to species occurring more numerously on bilberry and heather belong: *Mangora acalypha, Tetragnatha pinicola.* I caught *Oxyopes ramosus* solely and *Pisaura mirabilis* almost exclusively on heather.

My observations and quantitative results confirm the thesis made by arachnologists some time ago, that layers of forest above the litter have no separate groups of spiders, strictly detached from one another; many species are distributed on various layers. On the other hand, there is a clearer boundary between groups living in the litter and groups in the higher layers of vegetation (Tretzel 1954). According to Tretzel (1952) and to Vité (1953) the size of a spider is a factor which to a large degree determines its appartenance to some defined forest strata; small spiders are mainly distributed in the litter, medium spiders on herbaceous plants and big spiders in upper layers of vegetation (shrubs, trees). This, however, is only relatively right, because for example the individuals of the *Theridion* genus (mainly small spiders) are often distributed high up on trees.

III. THE QUANTITATIVE DYNAMICS OF THE SPIDERS OF GROUND FLORA

1. MAXIMUM AND MINIMUM OCCURRENCE OF SPIDERS ON THE GROUND FLORA

On all five stations the quantitative variability of the community of spiders of the ground flora was similar. The most general rules of the quantitative dynamics of the spiders investigated, common to all stations, will be described mainly on the basis of data

from station V_1, on which the greatest number of series of collections was made.

Numbers of spiders of the ground flora of pine forest on stations investigated

Dynamika liczebności pająków runa boru sosnowego na badanych stanowiskach

Tab. IV

Dates of collections Daty połowów	Stations – Stanowiska				
	V_1	V_2	V_3	C_1	C_2
22 – 23.III.	113	50	37	63	–
8 – 9.IV.	155	58	60	91	–
27 – 28.IV.	142	54	37	81	–
13 – 14.V.	47	17	21	69	–
25 – 27.V.	47	33	33	53	–
14 – 15.VI.	96	64	98	80	–
21 – 23.VI.	62	80	101	89	90
7 – 16.VII.	89	111	110	85	115
22 – 27.VII.	90	99	70	128	234
18 – 23.VIII.	157	163	143	173	352
3 – 11.IX.	247	208	183	327	333
22 – 27.IX.	204	172	201	203	410
23 – 26.X.	132	115	92	219	408
15 – 17.XI.	83	–	–	35	169
Total – Razem	1664	1224	1186	1698	2111

Two maximum periods in the numbers of spiders of the ground flora, occurring in the spring and early autumn, may be distinguished and one minimum period in May (tabl. IV, V). On other stations the spring maximum is not clearly marked, while the autumn maximum occurs everywhere very markedly. As seen from the data of table V the maximum periods do not depend on the number of species occurring at a given time in an environment,

because, for example, in July, August and in the beginning of September the average number of individuals for one species (the quantity of species occurring being the same — 27) amounts to: 3.3, 5.8, 9.0.

Numbers of spiders of the forest ground flora on station V_1

Dynamika liczebności pająków runa leśnego na stanowisku V_1

Tab. V

Date of taking quantitative samples Data pobierania prób ilościowych	Number of species occurring in a series of samples Ilość gatunków występujących w serii prób	Number of individuals occurring in a series of samples Ilość osobników występujących w serii prób	For 1 species average number of individuals Na 1 gatunek średnio osobników
22.III.	20	113	5,65
8.IV.	26	155	6,00
27.IV.	22	142	6,45
13.V.	20	47	2,35
25.V.	23	47	2,00
14.VI.	23	96	4,2
22.VI.	15	62	4,1
7.VII.	20	89	4,05
22.VII.	27	90	3,3
18.VIII.	27	157	5,8
3.IX.	27	247	9,00
22.IX.	33	204	6,3
23.X.	29	132	4,5
15.XI.	17	83	5,0

The autumn maximum is caused by the hatching out of numerous young individuals of many species, which spread over the ground flora; they hibernate in their early stage of development and come out of their winter shelters in early spring producing the spring maximum which is lower than the autumn maximum (winter mortality). Before and during the period of sexual maturity

(for many species this is the period of early summer — May, June, middle of July) the numbers of the various species on the ground flora, on the whole diminish rapidly (tab. V). Several supposed causes of this phenomenon may be mentioned: migration of spiders to other layers of environment as the individuals develop and increase their body size, migration of adult spiders during the period of copulation and formation of cocoons, to other layers of their environment (Petrusewicz 1938a, Tretzel 1955) or even to other environments (Petrusewicz 1938a, Mikulska 1955), increased mortality during the period of the last moult before reaching sexual maturity (Deevey G. and E. in Gertsch 1949).

Changes of numbers of Mangora acalypha on the ground flora of pine forest (8.IV. – 25.V.)

Zmiany liczebności Mangora acalypha na runie boru sosnowego (8.IV. – 25.V.)

Tab. VI

Date Data	Number of individuals – Ilość osobników			
	Stations – Stanowiska			
	V_1	V_2	V_3	C_1
8 – 9.IV.	80	24	36	53
27 – 29.IV.	104	34	25	46
13.V.	33	4	13	26
25.V.	9	0	1	1

The autumn maximum of the occurrence of spiders is much higher on stations with heather owing to great numbers of the species *Mangora acalypha,* which finds here its environmental optimum (Petrusewicz 1938b, Tretzel 1955). The autumn maximum occurs on the heather as late as October, whereas on stations with bilberry a marked decrease of the number of ground flora species may be observed in this month. The highest maximum occurs on the station C_2 which is drier and more exposed to the sun (tab. VII).

Numbers of individuals of Mangora acalypha in the autumn period on stations investigated

Ilości osobników Mangora acalypha w okresie jesiennym na stanowiskach badanych

Tab. VII

Stations Stanowiska / Date of collection Data połowów	Number of individuals Ilość osobników				
	C_1	C_2	V_1	V_2	V_3
3 - 11.IX.	70	174	61	43	15
22 - 27.IX.	48	198	42	20	14
23 - 26.X.	80	291	36	21	8
15 - 17.XI.	14	114	38	-	-

Numbers of mature species and individuals in the period V–VI

Ilości dojrzałych gatunków i osobników w okresie V–VI

Tab. VIII

Station Stanowisko	Species - Gatunki			Individuals - Osobniki		
	Total Ogółem	Mature Dojrzałe	% of mature Procent dojrzałych	Total Ogółem	Mature Dojrzałe	% of mature Procent dojrzałych
V_1	15	9	60	62	24	40
V_2	16	7	44	80	19	24
V_3	15	8	53	33	14	42
C_1	15	9	60	69	16	23
C_2	19	13	68	90	33	37

2. AGE STRUCTURE

A great majority of the spiders caught on the ground flora in various periods of the vegetation season were sexually immature individuals, often very young. This phenomenon is characteristic of the community of the ground flora spiders. On all stations the greatest number of species with adult individuals occurs in June (tab. VII), and the greatest number of adult individuals occurs in May and June (tabl. VIII). In the period from April to July 64% (58 out of 91) of all species collected, reach maturity; Tretzel (1955) states that in this period 75% of species reach maturity; he has however collections of species from various strata and environments (tab. IX).

Relation of mature species to the total number of species caught – percentage

Stosunek gatunków dojrzałych do ogółu złowionych gatunków w procentach

Tab. IX

Month Miesiąc	Mature species from different strata and environments (according to Tretzel) Gatunki dojrzałe z różnych synuzji i środowisk (wg Tretzela)	Mature species from herbaceous layer of pine forest Gatunki dojrzałe z synuzji runa boru sosnowego
IV	21	2
V	26	12
VI	19	35
VII	9	15

3. DOMINATION RELATIONS

I have called those species dominant which show the greatest frequency and density (in the sense used by Braun Blanquet) and the highest degree of domination (relation of the number of individuals of the investigated species to the number of all spiders caught — given as percentage). When investigating the community of spiders of the forest ground flora, variations in domination may be observed; some dominant species die out, others migrate to other

strata disappearing from the investigated site, and their place is taken by young individuals of some other species developing at that period (tab. X, fig. 1).

Frequency, density and degree of domination of the most numerous species on station V_1 in the period of maximum numbers

Frekwencja, gęstość i stopień dominacji najliczniejszych gatunków na stanowisku V_1 w okresie maksymalnej liczebności

Tab. X

Name of species Nazwa gatunku	Periods of peak numbers Okresy szczytu liczebności	Frequency Frekwencja	Density Gęstość	Degree of domination in % Stopień dominacji w %
Mangora acalypha	April Kwiecień	100	8,0	52
Theridion ovatum	June Czerwiec	70	1,3	21
Linyphia triangularis	Beginning of July Początek lipca	90	3,0	34
Evarcha falcata	August Sierpień	90	2,4	15
Mangora acalyphy	Beginning of September Początek września	90	6,1	25
Tetragnatha pinicola	End of September Koniec września	100	6,5	32

If we tabulate the species according to the class of frequency (tab. XI), we shall find the known regularity of biocenotic systems: only certain species occur in all samples of a series of collections (dominants); numerous species (16—22) occur in only a few samples of a series. The former are the most numerous species, the latter occur only in the form of single individuals. Such a system may suggest the existence of biocenotic connections between them, but it is not sufficient evidence in itself.

The species dominating at certain periods on the ground flora of all stations are: *Mangora acalypha, Tetragnatha pinicola* and

Linyphia triangularis. Other species occur as periodical dominants dependent on the type of ground flora and station.

In 1954 individuals of the species *Mangora acalypha* came out of their winter shelters in March. In the first quantitative collections

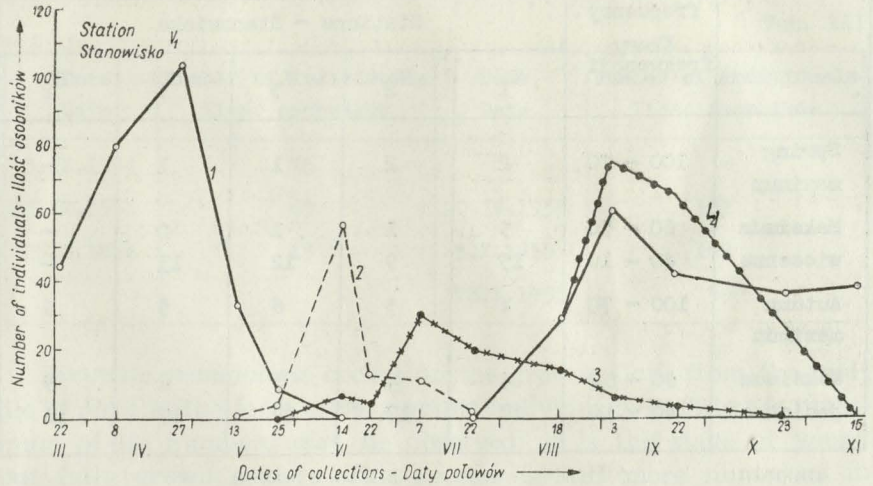

Fig. 1. Variations in the domination of web-spiders on the ground flora with *Vaccinium myrtillus*

Zmienność dominacji pająków sieciowych na runie z *Vaccinium myrtillus*

1 — *Mangora acalypha*; 2 — *Theridion ovatum*; 3 — *Linyphia triangularis*; 4 — *Tetragnatha pinicola*

on station V_1 (22. III.) they already occurred numerously (40 in a series of collections). In April their numbers on the ground flora increased (8.IV.—80, 27.IV.—104). In May they decreased rapidly and their number on the ground flora fell considerably (13.V.—33 individuals, 25.V.—9). In June in quantitative collections only one adult male was caught. Only at the end of July (22.VII.—2 individuals) very small numbers of young spiders freshly hatched from cocons begin to occur on the ground flora. In August the number of this species increases rapidly and in September it reaches its autumn maximum (61 individuals in a series of collections). Probably it so happens because from cocoons laid by the females more and more small spiders come out at different times and accumulate on the ground flora. Through October and half of November a great number of spiders continue to persist on the ground flora.

Distribution of the number of species in classes of frequency

Rozmieszczenie ilości gatunków w klasach frekwencji

Tab. XI

	Classes of frequency Klasy frekwencji	Numbers of species – Ilości gatunków				
		Stations – Stanowiska				
		V_1	V_2	V_3	C_1	C_2
Spring maximum	100 – 70	2	2	1	1	–
Maksimum	60 – 50	3	1	1	0	–
wiosenne	40 – 10	15	9	12	13	–
Autumn maximum	100 – 70	4	3	6	5	6
Maksimum	60 – 50	4	4	3	4	5
jesienne	40 – 10	17	17	22	17	16

Tetragnatha pinicola appears in very small numbers on the ground flora in March, during April its numbers do not increase much, in May and June (months of its sexual maturity) decrease to the minimum, disappearing from the stratum of the ground flora in July. In August (18.VIII.—29 individuals) newly hatched individuals begin to lead an active life building small webs on the bilberry plants. In September their numbers exceed even the numbers of the species *Mangora acalypha*. On the 15th of November no individuals of this species were found on the ground flora.

The results of scoop collections in 1955 confirm in general outlines the picture of quantitative variations of both the above mentioned species. It must be emphasised, however, that in the autumn period of 1955 considerable numbers of individuals of *Tetragnatha pinicola* were being caught. Besides, the maximum of their occurrence in 1955 compared with 1954 is moved to a somewhat later period, which probably has a connection with the delay of the whole cycle of development by the late spring in 1955 (tab. XII).

I confirm the supposition of Petrusewicz (1938a), that this species, in dry environments is a vicarious form of the species

Tetragnatha extensa which is closely related, and which occurred very scantily in the environment analysed.

Numbers of Tetragnatha pinicola on station V_1 in years studied

Liczebność Tetragnatha pinicola na stanowisku V_1 w badanych latach

Tab. XII

Date Data	Number of individuals Ilość osobników	Date Data	Number of individuals Ilość osobników
3.IX.1954	75	-	-
22.IX.1954	65	20.IX.1955	102
23.X.1954	13	5.X.1955	169
		28.X.1955	39

Linyphia triangularis occurs on the ground flora from the middle of June in the form of very young individuals. In July the maximum of its numbers may be observed: it is the stage of young but fully grown spiders. This species is still more numerous in August and September, when almost exclusively mature individuals may be found. *Linyphia triangularis,* contrary to the two above mentioned species, occurs numerously in adult form on the same stratum in which young individuals weave their webs. However it can be found in strata above the ground flora, for example on young firs, pines or on the high withered stems of *Sarothamnus scoparius*. On these plants and on many others I observed the stratified distribution of webs of this species. The forest ground flora (heather or bilberry plants) is covered with the large horizontal webs of this spider, often distributed close to one another. The role of *Linyphia triangularis* as the hunter of small insects must be comparatively significant in the biocenosis of forests. Bristowe (1941) writes, that the zone of temperate climate is the most suitable for the species of the *Linyphiidae* family, which is most numerously represented in our country.

The data obtained by means of the scoop do not indicate the real numerical wealth of this species, as is indicated by observations, because although *Linyphia triangularis* does not readily leave its own web, nevertheless when it is frightened, it jumps out of the web to the ground, hiding below the reach of action of the scoop; it

is also defended by the upside down position which it takes up on the horizontal web.

The period of maximum occurrence of individuals of this species does not on the whole coincide with maximum occurrence of the species *Mangora acalypha* and *Tetragnatha pinicola*. Something like temporary sharing of environment occurs here. First the *Linyphia triangularis* takes possession of the environment (July), and then later, when its numbers gradually decrease, other dominants occur more and more numerously — *Mangora acalypha* and *Tetragnatha pinicola* (September and beginning of October).

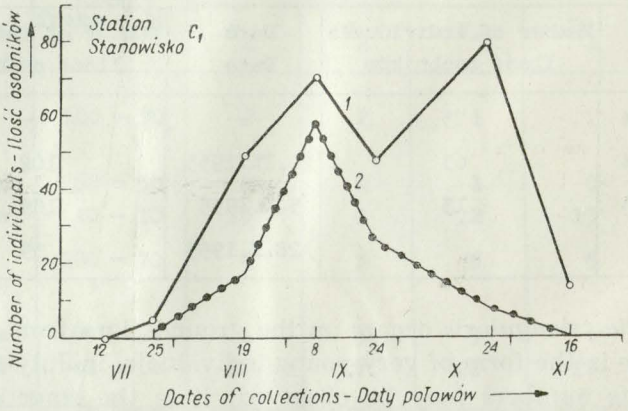

Fig. 2. Simultaneous domination of *Mangora acalypha* and *Tetragnatha pinicola* on the ground flora with *Calluna vulgaris*, with predominance of *Mangora acalypha*

Równoczesna dominacja *Mangora acalypha* i *Tetragnatha pinicola* na runie z *Calluna vulgaris*, z przewagą *Mangora acalypha*

1 — *Mangora acalypha*; 2 — *Tetragnatha pinicola*

The bilberry sites differ from the heather sites by the occurrence of various periodical dominants (great numbers on the ground flora for a short period of time). *Theridion ovatum* dominates in June on bilberry sites, and on heather only the wandering species *Oxyopes ramosus* (C_1) and *Evarcha falcata* (C_1 and C_2). In July on C_1 *Maso sundevalli* occurred in great numbers, and *Pisaura mirabilis* — from July to October on C_1 and C_2.

In August and in September on station V_2 a characteristic arrangement is formed of simultaneous domination of three web-species: *Mangora acalypha, Tetragnatha pinicola, Linyphia triangu-*

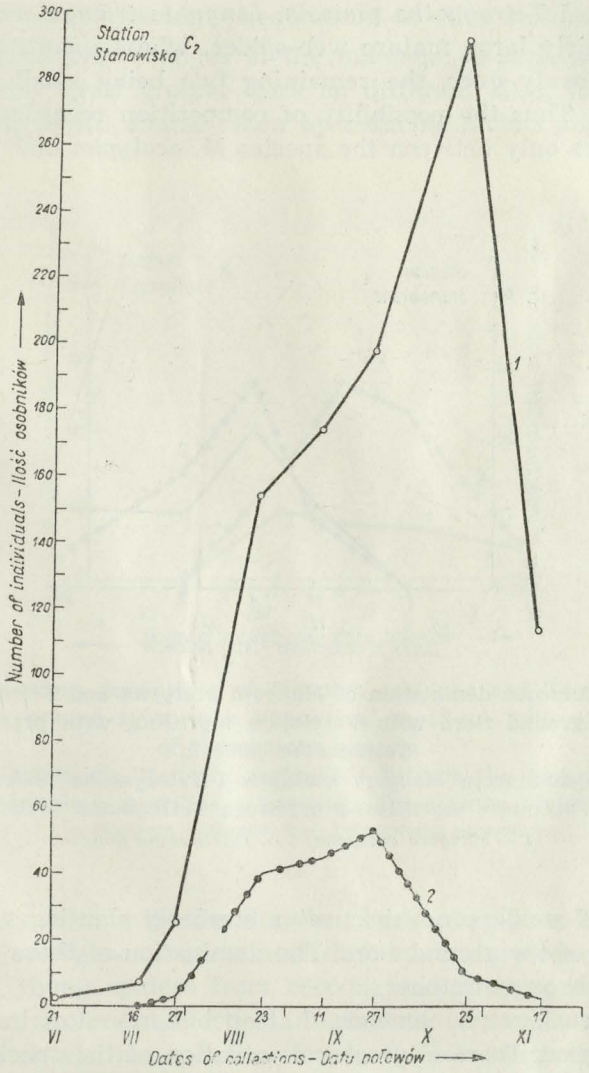

Fig. 3. Simultaneous domination of *Mangora acalypha* and *Tetragnatha pinicola* on the ground flora with *Calluna vulgaris*, with great predominance of *Mangora acalypha*

Równoczesna dominacja *Mangora acalypha* i *Tetragnatha pinicola* na runie z *Calluna vulgaris*, z wielką przewagą *Mangora acalypha*

1 — *Mangora acalypha*; 2 — *Tetragnatha pinicola*

laris, and on all stations the domination of two species: *Mangora acalypha* and *Tetragnatha pinicola*. *Linyphia triangularis* is at this period a fairly large mature web-spider, whose quantitative maximum is already over, the remaining two being small and young web forms. Thus the possibility of competition regarding food and space occurs only between the species *M. acalypha* and *T. pinicola*,

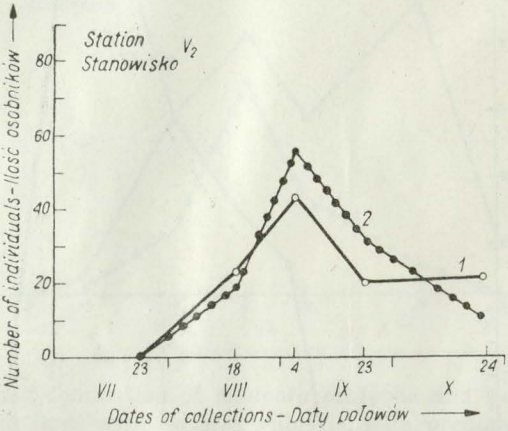

Fig. 4. Simultaneous domination of *Mangora acalypha* and *Tetragnatha pinicola* on the ground flora with *Vaccinium myrtillus*, with predominance of *Tetragnatha pinicola*

Równoczesna dominacja *Mangora acalypha* i *Tetragnatha pinicola* na runie z *Vaccinium myrtillus*, z przewagą *Tetragnatha pinicola*

1 — *Mangora acalypha*; 2 — *Tetragnatha pinicola*

which build small, concentric, often similarly slanting webs on the same level of the ground flora. The domination of these two species continues through October.

It is a curious phenomenon that on bilberry sites in the period of late summer there is greater domination of the species *T. pinicola*, and on heather sites *M. acalypha* dominates considerably as to quantity (fig. 1—5). It is well known fact that heather is the most suitable environment of this eurytopic species. It may be supposed that the cause of these inverted systems of domination are the abiotic differences of the environments analysed. The fact that the quantitative level of the species *Mangora acalypha* in the autumn period is much higher on station C_2 (more open to sun operation)

than on station C_1 seems to confirm this (tab. VII). The domination of *M. acalypha* on station C_2 is so intensive, that this phenomenon has no correspondent phenomenon on other stations (tab. III).

The similarity of changes in the numbers of various species of spiders of the forest ground flora on different sites, results from the similarity of the course taken by reducing factors and from the

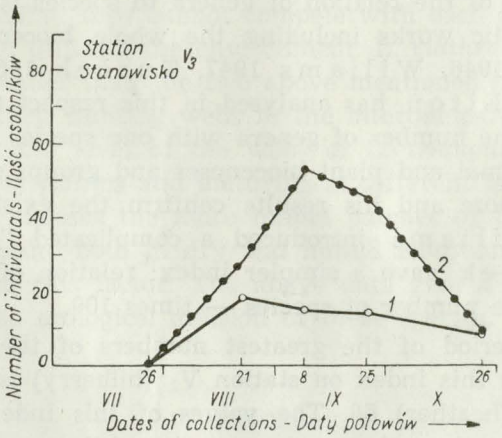

Fig. 5. Simultaneous domination of *Mangora acalypha* and *Tetragnatha pinicola* on the ground flora with *Vaccinium myrtillus*, with predominance of *Tetragnatha pinicola*

Równoczesna dominacja *Mangora acalypha* i *Tetragnatha pinicola* na runie z *Vaccinium myrtillus*, z przewagą *Tetragnatha pinicola*

1 — *Mangora acalypha*; 2 — *Tetragnatha pinicola*

regularities governing the development cycle of spiders. These regularities are: emergence from winter shelters, maturescence, breding, hatching of young spiders from cocoons and their spreading over a suitable environment, vertical migrations in search of suitable places to catch victims and form cocoons, descending to the litter for the winter — all in definite times of the season. They condition the variations in numbers, which in addition are influenced by the action of processes of biocenotic reduction and regulation. All these processes give, as a result, a definite type of quantitative dynamics, varying (different quantitative level on similar sites), but exhibiting certain general regularities above mentioned.

IV. THE RELATION OF GENERA TO SPECIES IN A COMMUNITY OF GROUND FLORA SPIDERS

In biocenotic groups the occurrence was often noted of only one species of a given genus; the so called vicarious species occurring in different environments in the same ecological niches. It may be supposed that this is the evolutionary result of the spacial division of related species, eliminating competition between close forms. The analysis of the relation of genera to species is applied in various biocenotic works including the whole biocenosis or part of it (Elton 1946, Wiliams 1947, Turček 1951, 1956, Tretzel 1955). Elton has analysed in this respect (calculating percentage of the number of genera with one species only) the whole series of animal and plant biocenoses and groups distinguished by various authors and his results confirm the existence of spacial division. Wiliams introduced a complicated "index of diversity". Turček gave a simpler index: relation of the number of genera to the number of species — times 100.

In the period of the greatest numbers of the species on the ground flora this index on station V_1 (bilberry) is 63, and on the station C_1 (heather) 50. The values of this index are not very high and they show that various species of the same genus meet on the ground flora. This very general index, of value in works comparing different analysed biocenoses or groups, is of no great importance in concrete ecological works of the same type as this paper. Only a closer ecological analysis of particular species could show the existence of spacial, time and ecological isolation between the species of the same stratum. An example of the penetrating analysis of the ecological division of spider species is the work of Tretzel (1955) on intrageneric time isolation (non-concurrence of the periods of maturing or periods of copulation) of closely related species of spiders. As an example I shall analyse from this angle the genus *Linyphia*, whose four species occur on the ground flora of sites with *Vaccinium myrtillus*. They are: *Linyphia triangularis*, *Linyphia marginata*, *Linyphia clathrata*, *Linyphia pusilla*. The first two species are of similar size and occupy the same spacial niche in the biotope in which they live, but whereas *L. triangularis* is one of the commonest species, *L. marginata* occurs more rarely and more locally; they differ also as to the period of maturing and hatching of the young. *L. marginata* matures in the spring (May,

June), when the individuals of *Linyphia triangularis* are not yet visible on the ground flora. In the period of domination of the environment by young individuals of *L. triangularis* (July, August), *L. marginata* disappears from the ground flora, probably descending to the litter for the period during which the cocoons are formed and the young hatched. In the period of sexual maturity of *L. triangularis,* the tiny individuals of *L. marginata* begin to appear on the ground flora. In these circumstances in spite of occurring in the same habitat, they cannot compete with each other or obstruct each other in utilising the environment. *L. clathrata* and *L. pusilla* are much smaller than the two above mentioned species of spiders and set up their hunting webs in the internal parts of the ground flora, below the level of the webs of *L. triangularis*, feeding on other types of victims and maturing at different times of the year. *L. clathrata* chooses the more humid patches of the environment, *L. pusilla* occurs both in dry and humid environments and seems indifferent to this factor. The above data give a certain concrete picture of the ecological division of these species.

V. CONCLUSIONS

1. The community of spiders of the ground flora of a pine forest does not constitute a group of species differing qualitatively from other forest strata. It is very heterogenous because in addition to species characteristic of the ground flora, representatives of numerous species of spiders can be found there which distribute themselves mainly in other strata (litter, shrubs, trees), representatives of species whose adult forms are more stenotopic and can live only in environments other than those analysed and species for which the ground flora of pine forest does not provide optimal conditions.

The specific composition of the spiders of the ground flora changes partly according to the type of environment of pine forest (with ground flora of *Vaccinium myrtillus*, of *Calluna vulgaris*, with ground flora floristically richer and poorer) and according to abiotic conditions (greater or less intense sun operation and humidity), but the majority of species is common to all the sites analysed independent of their differentiation, and some species characteristic of the ground flora occur on all sites in great abun-

dance constituting about 60 % of the total number of spiders of the ground flora.

2. The quantitative dynamics of the ground flora spiders are above all formed in accordance with the regularity of development cycle of the dominating species. The migration from stratum of the ground flora of individuals before the period of sexual maturity (mainly of dominant species) causes the minimum of quantitative occurrence of spiders of the ground flora in May; the hatching of young spiders of the two most important dominants of the ground flora creates the autumn maximum. Many species of forest spiders lay their cocoons in the litter, and young web-spiders hatched from them take possession of the stratum of the ground flora; part of the species as they grow, move to higher layers. The above phenomena influence the formation of age structure of the community of spiders of the ground flora, the characteristic feature of which is the occurrence on the ground flora of mainly young forms of spiders.

3. Variation of domination of the species of spiders during the vegetation season occurs on the ground flora. The early spring aspect of the community of ground flora spiders is similar to the autumn aspect on account of the domination of the same species.

4. The species of genus *Linyphia* found on the ground flora of pine forest exhibit a certain degree of ecological isolation.

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ZGRUPOWANIE PAJĄKÓW RUNA BORU SOSNOWEGO

Streszczenie

W latach 1954 i 1955 prowadzono w Lemańsku pod Częstochową (nadleśnictwo Łobodno) badania nad pająkami runa boru sosnowego. Celem pracy było zbadanie występującego na runie *Vaccinium myrtillus* i *Calluna vulgaris* zgrupowania pająków, poznanie jego dynamiki liczebności oraz prawidłowości i zróżnicowania składu, ilości i dynamiki liczebności pająków, zależnie od zróżnicowania wybranych do badań stanowisk. Posługiwano się metodą czerpaka

ilościowego, metodą kwadratów oraz obserwacji. Złowiono ogółem 17 229 pająków należących do 91 gatunków, 15 rodzin.

1. Zgrupowanie pająków runa, poza występowaniem gatunków rozmieszczających się na niskiej roślinności, charakteryzuje się stałą obecnością licznych gatunków, występujących zasadniczo w innych synuzjach.

2. Liczne, charakterystyczne dla runa gatunki pająków występują na runie tylko w postaci młodych osobników; po dojściu do dojrzałości płciowej przechodzą do innych pięter swego biotopu lub nawet zmieniają środowisko.

3. Na pięciu stanowiskach runa boru sosnowego (3 stanowiska z *Vaccinium myrtillus* i 2 stanowiska z *Calluna vulgaris)* stwierdzono następujące prawidłowości:

a) podobny skład gatunkowy runa. Na wszystkich stanowiskach występuje zbliżona ilość gatunków; wyróżniono podstawową grupę pająków runa, charakterystyczną dla wszystkich pięciu stanowisk (tab. I); stwierdzono występowanie 37 gatunków wspólnych (tab. I);

b) jesienne maksimum i wiosenne minimum liczebności pająków (tab. IV, V, VI);

c) dojrzewanie największej ilości gatunków w czerwcu, występowanie największej ilości dojrzałych osobników (procentowo) w maju i w czerwcu (tab. VIII, IX);

d) równomierne na wszystkich stanowiskach występowanie gatunków pająków wędrujących (od czerwca do września 30—56% ogółu złowionych gatunków) (tab. II);

e) występowanie trzech wspólnych dominantów sieciowych: *Mangora acalypha, Tetragnatha pinicola, Linyphia triangularis;*

f) zmienność dominacji w czasie sezonu wegetacyjnego (tab. X, fig. 1);

4. Na tychże stanowiskach stwierdzono następujące różnice:

a) kilka gatunków występuje wyłącznie na runie z *Vaccinium myrtillus,* kilka wyłącznie na runie z *Calluna vulgaris* (tab. I);

b) jesienne maksimum występowania pająków jest znacznie wyższe na stanowiskach wrzosowych, dzięki silnej dominacji gatunku *Mangora acalypha* (tab. VII);

c) na obu typach runa występują inne okresowo dominujące gatunki (oprócz trzech wspólnych);

d) z obu dominujących na jesieni gatunków, *Mangora acalypha* wykazuje silniejszą dominację na stanowiskach z wrzosem *Tetragnatha pinicola* — na stanowiskach z borówką czernicą (fig. 1—5);

e) najbardziej florystycznie zróżnicowane i najbardziej zakrzewione stanowisko z borówką czernicą (V_3) ma na wiosnę uboższe gatunkowo zgrupowanie pająków runa (tab. III). Przyczyną tego jest najprawdopodobniej możliwość zajmowania przez różne, wielosynuzyjne gatunki pająków dogodniejszych dla nich wyższych pięter roślinności.

5. Pająki na runie rozmieszczają się piętrowo — niektóre gatunki są charakterystyczne dla wewnętrznych partii runa z *Vaccinium myrtillus* i runa *Calluna vulgaris*, inne dla warstw powierzchniowych, jeszcze inne liczniej występują na paprociach.

6. Współczynnik ilości rodzajów do ilości gatunków (według T u r č e k a 1951) w zgrupowaniu pająków runa wynosi 63 na stanowisku z *Vaccinium myrtillus*, 50 na stanowisku z *Calluna vulgaris*.

7. Stwierdzono izolację ekologiczną czterech gatunków rodzaju *Linyphia* spotykanych na runie boru sosnowego.