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Populations of Araneae (Arachnoidea) and Staphylinidae (Coleoptera) on the floor of a primeval forest in Mäntyharju, southern Finland

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The spider and staphylinid populations of the forest floor in a coniferous forest in the primeval state were studied by sieving, and with dry funnels and pitfall traps. The results for spiders are compared with Palmgren's studies on spider populations in forests of spruce and pine in other parts of Mäntyharju. The forestry methods hitherto employed have apparently not altered the spider community.

The dry funnel technique gives much higher values for the population density of spiders than sieving. The two methods catch adult and subadult spiders with equal efficiency, however, and the youngest stages that escape sieving form only a small part of the biomass.

Although the majority of staphylinid beetles are predators, the population density does not correlate with that of the spiders. This implies that spiders (chiefly small Linyphiidae) and staphylinids occupy different niches.

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1. Introduction

In summer 1976 members of the Society for the Conservation of Nature in southern Savo were alarmed by the news that a big pulp- and sawmill company planned lumbering operations in a forest block at Kolmikanta near Vanonen, a village in the commune of Mäntyharju, southern Finland (61°15'N, 27°10'E). This block, 1000 × 400 m, had remained in an absolutely primeval state. It had never been cut and apparently not burned for more than 150 years, which is very rare in this part of Finland. (Later an agreement was reached to save the forest.)

It is of obvious interest to know the composition of the fauna of primeval forests, and this paper is a report of the results of a study of the spiders and staphylinids in the forest in question.

2. Study area and methods

A. Collecting of material

Palmgren paid a short visit to the place on 1 September 1976, and collected samples by sieving from five plots, 0.5 m² each (Palmgren 1977:13—14). Biström made six collecting trips to the forest during the following summer, on 22—23 May, 2—3 and 20 June, 8—9 July, 12 August and 9 September (Biström 1978). The following material was procured: 74 sieve samples from plots of 25 × 25 cm, depth 10 cm, 69 "dry funnel" samples 25 × 25 × 10 cm and samples from 25 pitfall traps with 4.5 cm diameter, distributed in a line with 3—4 m between the traps, which were emptied at every visit. Insects were also picked from dead tree trunks. Although Biström was chiefly interested in beetles, he collected spiders quantitatively from the dry funnel samples. From the pitfall traps only a minor part of the spider catch was collected.

B. Study area

In parts of the forest, the canopy consists only fo spruce and pine, height about 20 m. In other parts, which are a little moister, these are intermixed with birch and aspen (some particularly big). Fallen trunks in various stages of decay form almost a network on the ground. The forest is largely of the Myrtillus type according to the Finnish forest classification, i.e. it is of medium productivity. In the parts dominated by conifers the floor is covered by a continuous moss carpet (dominant species *Pleurozium schreberi*), with patches of *Vaccinium myrtillus* and *V. vitis-idaea*. Where deciduous trees occur, the moss carpet is more or less intermingled with dead leaves and remnants of twigs. Palmgren's samples 1—3 represent the former, samples 4—5 the latter type. Biström considered all his samples to represent only one habitat.

3. Comparison of methods for estimating spider populations

Fig. 1 shows the density of the spider population according to Palmgren's five sample plots on 1 September 1976 and Biström's dry funnel catches, separately for the spring season (May — 15 June), summer (July — August) and autumn (September). Great differences are apparent between Palmgren's and Biström's samples. Repeat counts made by Palmgren (1972) revealed that about 10—15 % of the spiders were lost during his sieving procedure, but could be found on renewed sieving of the material. However, he did not attempt to estimate how many spiders of the youngest stages (especially Micryphantinae) may have been crushed to immobility and invisibility during the rather crude handling of the sample, or what number of them inhabits interstices in the deeper, permanently moist soil layers which were not removed for sieving.

Huhta (1972) observed differences in population density between sieve samples and dry funnel samples of the same order of magnitude, but did not propose a definite explanation. The following causes have to be considered: 1) Very small and slow-moving spiders escape detection among the material passing through the sieves, even if it is spread out on a white sheet. 2) Small, soft-bodied individuals are crushed and probably become glued to the debris. 3) The youngest stages, especially of Linyphiinae and Micryphantinae, live deeper than the soil layers removed. This seems very probable in respect of *Crustulina guttata* (Theridiidae), a species whose youngest stages are easily identified and have a fairly hard chitinized surface, but nevertheless are very rarely met with in sieve samples (cf. Palmgren 1977). 4) During a week a number of eggs may hatch in the dry funnels, and practically immobile stages develop into stages with greater mobility. This hypothesis was put forward by Huhta.

The following comparison of densities (ind./m^2) may throw some light on the question (P = Palmgren, B = Biström):

	Autumn		Summer	Spring
	P-76	B-77	B-77	B-77
Total sample area (m^2)	2.5	0.7	1.75	1.25
Adult spiders	93	96	146	85
Ad. + juv.	143	400	600	224

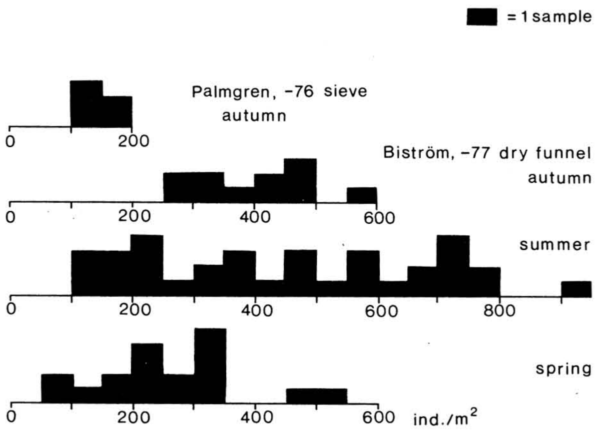

Fig. 1. Number of spiders on Kolmikanta primeval forest floor per m^2 according to Palmgren, sieve samples, and Biström, dry funnel samples.

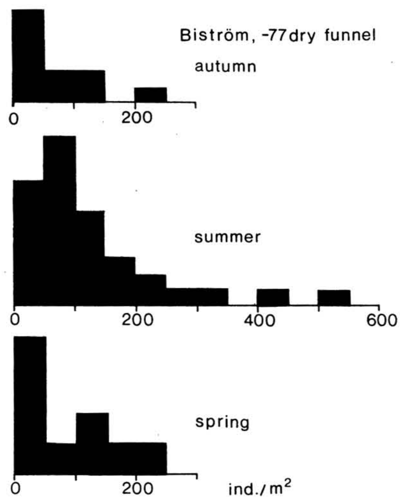

Fig. 2. Number of Staphylinid beetles on Kolmikanta primeval forest floor per m^2 according to Biström, dry funnel samples.

The values may be compared with Palmgren's values for spruce forest or spruce-pine forest of Myrtillus type: spring, Tvärminne 190, Mäntyharju 90; summer, Tvärminne 155, Mäntyharju 100; autumn, Tvärminne 170, Mäntyharju 130. (The above-mentioned correction of + 15 % not applied!).

The comparison justifies the conclusion that sieve samples, especially after the correction of 15 %, result in values quite comparable to dry funnel samples in regard to adult spiders and probably also to young spiders of the same size as small adult Micryphantinae (*Minyriolus*, *Tapinocyba*).

In terms of energy flow the biomass is, of course, a more important parameter than the number of individuals. Biomass is here expressed as volume (in mm^3), for which an approximate measure is afforded by the third power of the length of the cephalothorax. Some results of such calculations are presented in Table 1.

It should be added that in young individuals with a cephalothorax of adult length the opisthosoma is always much less bulky than in full-grown females. This has not been taken into account in the table. We do not know when the smallest stages (cephalothorax length 0.50—0.35) hatched, i.e. how long it takes for immobile individuals to become active. It seems clear, however, that the difference between the sieve samples and the dry funnel samples is due partly to the appearance of new individuals in the latter. But despite allowance for this source of error, the other sources enumerated above remain unknown quantities. From the point of view of energy flow, the stages not covered by the sieve method represent hardly more than 0.25—30 % of the biomass. The whole problem should, of course, be studied by comparing sieve samples from habitats as homogeneous as possible and taken on the same date. From a practical point of view it must be stressed that the dry funnel technique is unsuitable for use in a research programme which deals with large numbers of habitats (Palmgren 1972, 25 different habitats, 1977 23 ground habitats), especially if the study area is far from laboratory resources.

Table 1. Calculation of biomass (expressed as volume, V), of spiders for some dry funnel samples. (l = length of cephalothorax in mm, n = number of individuals, $V = n \times l^3$

	Length class		Adults		Juv. of ad. size		Smaller juv.	
		l^3	n	V	n	V	n	V
Tapinocyba,	0.70	0.34	4	1.36				
sample 26	0.65	0.27	2	0.54	1	0.27		
	0.60	0.22	1	0.22	2	0.44		
	0.55	0.17					1	0.17
	0.50	0.13					3	0.39
	0.45	0.09					2	0.18
	0.40	0.06					4	0.24
	0.35	0.04					1	0.04
			Total	2.12		0.71		1.02
					2.83			
Tapinocyba, sample 44					1.72			0.86
» » 21					1.58			0.85
Minyriolus, » 26					0.65			0.54
			Grand total		6.78			3.27

4. The spider and staphylinid faunas

A. Spiders

The differences between successive years are generally considerable. The total number of individuals (ad. + juv.) per unit area had not, however, increased very greatly, as seen if Palmgren's sieve samples for September 1976 are compared with Biström's funnel samples for the following spring (143 against 224, which might be well within natural variation); the number of adults had in fact decreased (93 against 85). It is possible that in the habitat studied the summer of 1977 was unusually favourable for the propagation of small ground spiders.

Table 2 summarizes the species composition of the spider population of the ground habitat in Kolmikanta forest. Some differences between the samples collected by Palmgren and by Biström require attention. *Diplocentria bidentata* had decreased between autumn 1976 and the following autumn. On the other hand, Palmgren's catch of *Tapinocyba pallens*, generally the most numerous of our forest floor spiders, was much smaller than would be expected (cf. Palmgren 1977!). *Pocadicnemis pumila*, not a very typical species of moss carpets, was unusually numerous in the samples for autumn 1977. *Robertus scoticus* was not present in Palmgren's samples for September 1976, but was numerous in Biström's funnel catches the following spring. We are unable to relate the changes to any particular ecological factors. A necessary conclusion is that local spider faunas should always be based upon material from more than one year!

Table 2. Spider community of Kolmikanta forest. *n* = total number of specimens, %j = percentage of young specimens, %*D* = dominance of the species as % of the total catch. P- 1977 Hab. 4 = species dominance values in spruce-pine forests of medium productivity (habitat 4) in other parts of Mäntyharju according to Palmgren 1977. P = Palmgren, B = Biström.

	P autumn			B autumn			B summer			B spring			P 1977
	n	%j	%*D*	*n*	%j	%*D*	*n*	%j	%*D*	*n*	%j	%*D*	Hab. 4
Micryphantinae													
Maso sundevalli	15	74	4	9	89	3	11	55	1	8	88	3	3
Ceratinops pectinata	3	0	0.4										0.3
Abacoproeces saltuum	1	0	0.3				1	0	0.1				<0.1
Wideria antica	6	33	2	3	33	1							1.2
W. cucullata										1	0	0.4	0.7
W. melanocephala							1	0	0.1				—
W. picetorum							1	0	0.1				<0.1
Cornicularia karpinskii	2	0	0.5				4	50	0.4				<0.1
Zornella cultrigera							1	100					0.5
Minyriolus pusillus	75	7	21	48	60	18	140	78	13	41	64	15	22
Micrargus apertus	1	0	0.3	1	0	0.4	2	50	0.2				<0.1
Silometopus incurvatus				1	0	0.4	1	0	0.1				<0.1
Pocadicnemis pumila	5	100	1	32	97	12				4	50	1	2
Diplocentria bidentata	104	24	29	6	33	2	222	80	21	29	73	10	9
Microcentria pusilla	1	0	0.3				14	45	1.3				<0.1
Diplocephalus picinus										2	0	1	<0.1
Tapinocyba pallens	17	45	5	78	80	29	419	73	39	78	54	28	6
Micryphantinae sp.juv.	5	100	1	11	100	4	13	100	1.2	9	100	1	4
Linyphiinae													
Centromerus arcanus				3	0	1	48	83	5	17	53	6	5
Macrargus rufus	12	17	3				38	95	4	8	88	3	7
Agyneta subtilis	2	0	0.5	2	0	0.7							0.5
A. conigera										1	0	0.4	0.2
A. ramosa	3	0	0.8										0.2
A. sp. juv.	2	100	0.5	2	100	0.7	2	100	0.2	1	100	0.4	3
Meioneta gulosa				1	0	0.4							—
Microneta viaria	13	8	4				2	50	0.2	12	25	4	0.5
Porrhomma pallidum	7	57	2	9	89	3	14	86	1	15	53	5	1.4
Bolyphantes sp.										1	100	0.4	0.1
Tapinopa longidens	12	0	3	2	0	0.7	1	100	0.1				—
Lepthyphantes alacris							9	56	1	1	0	0.4	0.4
L. tenebricola	4	25	1	2	50	0.7	2	100	0.2	3	66	1	0.2
L. antroniensis							4	50	0.4				<0.1
L. mengei	4	0	1	3	0	1							0.6
L. angulipalpis				2	0	0.7	2	100	0.2	4	100	1	—
L. sp. juv.	12	100	3	2	100	0.7	22	100	2	6	100	2	2
Poeciloneta globosa										1	100	0.4	—
Stemonyphantes lineatus	1	100	0.3										<0.1
Helophora insignis	2	0	0.5										<0.1
Neriene clathrata				1	100	0.4							<0.1
Linyphiinae sp. juv.	2	100	0.5	3	100	1	19	100	2	4	100	1	0.3

	P autumn			B autumn			B summer			B spring			P 1977
	n	%j	%*D*	*n*	%j	%*D*	*n*	%j	%*D*	*n*	%j	%*D*	Hab. 4
Theridiidae													
Crustulina guttata				2	50	0.7							0.3
Theridion varians				2	100	0.7							<0.1
Robertus lividus	6	83	2	3	33	1	6	10	0.6	2	50	0.7	0.9
R. scoticus							21	44	4	54	33	18	0.3
R. sp. juv.							44	100	5	10	100	4	0.3
Argiopidae													
Araneus omoedus	1	100	0.3										0.2
A. alsine										1	100	0.4	<0.1
Hahniidae													
Hahnia ononidum										2	100	0.7	—
Agelenidae													
Cryphoeca silvicola							1	0	0.1	1	0	0.4	0.6
Dictynidae													
Dictyna sp.				1	100	0.4				1	100	0.4	<0.1
Gnaphosidae													
Haplodrassus soerenseni	5	100	1	20	100	7	5	100	0.5	3	66	1	0.2
Clubionidae													
Clubiona sp.										1	100	0.4	0.4
C. subsultans	1	100	0.3										0.1
Liocranidae													
Agroeca brunnea	7	100	2				1	100	0.1				<0.1
Zoridae													
Zora spinimana	5	100	1	1	100	0.4				2	50	0.7	1.2
Z. nemoralis				2	0	0.7							1.2
Salticidae													
Neon reticulatus	12	83	3	6	100	2	3	0	0.3				3
Xysticidae													
Xysticus obscurus	1	100	0.3				1	100	0.1	4	100	1	0.8
X. luctuosus				2	100	0.7				1	100	0.4	0.4
Oxyptila trux	2	100	0.5	2	50	0.7	12	75	1	5	20	1	1.1
Lycosidae													
Alopecosa aculeata							4	100	0.4				0.8
A. pinetorum							1	100	0.1				—
Trochosa terricola	4	100	1	5	100	2	1	100	0.1	5	100	2	0.7
Pardosa lugubris				5	100	2							1.1

The last column of the table summarizes the dominance values (total ind. as a percentage of the total catch from the habitat) of spider species from the moss carpet in spruce or spruce-pine forest of Myrtillus type in Palmgren's paper on the spider populations of Mäntyharju. (In addition, he found the following species: *Erigonella hiemalis* 0.5, *Dicymbium tibiale* 0.5, *Tibioplus arcuatus* 0.6 and *Xysticus cristatus* 0.7.)

It seems justifiable to conclude that forest management of the type hitherto usual has left the spider fauna largely unchanged. The papers of Huhta (1965, 1971) and Palmgren (1964, 1972) afford additional background material. *Cornicularia karpinskii, Diplocentria bidentata* (both northern species) and *Alopecosa pinetorum* were perhaps more common at Kolmikanta than in forests of the usual — managed — type, but this is by no means certain.

As already mentioned, the spider catch of the pitfall traps was only partly preserved. Table 3 is thus of very limited value. The following species did not appear in the sieve or dry funnel samples: *Lepthyphantes kochiellus*, probably a northern species, but very few finds from Finland, the nearest from Hämeenkyrö (Palmgren 1975); *Ero furcata*; *Alopecosa pinetorum* (a dubious juv. in funnel sample). *Agroeca brunnea* is apparently unusually prone to fall into pitfall traps.

Table 3. Spiders from pitfall traps.

	♂	♀	juv.	Total
Maso sundevalli		1		1
Diplocentria bidentata		1		1
Wideria cucullata	1	1		2
Zornella cultrigera		1		1
Tapinocyba pallens	1			1
Macrargus rufus		6		6
Microneta viaria	6	4		10
Lepthyphantes alacris		2	1	3
L. kochiellus	1			1
L. tenebricola	1	2	1	4
Poeciloneta globosa	1			1
Ero furcata			1	1
Haplodrassus soerenseni	1	2	1	4
Zelotes subterraneus		1		1
Agroeca brunnea	6	11	2	19
Xysticus obscurus		1		1
Oxyptila trux		1		1
Dolomedes fimbriatus			1	1
Alopecosa aculeata	6	2	3	11
A. pinetorum	1	1	3	5
Pardosa lugubris	15	2		17
Trochosa terricola		2	3	5
Total	40	41	16	97

B. Staphylinids

Fig. 2 summarizes the population density values for the staphylinid beetles in Biström's dry funnel samples. Compared with the corresponding spider abundance values, the beetles appear less numerous, but only imagines were counted. The ratio of imagines to larvae is unknown. Pupae are not, of course, active consumers.

The dry funnel samples produced about 120 staphylinids/m^2, the sieve samples only 35. It is known that beetles often remain immobile ("feigning death") after violent treatment. They can hardly be as easily damaged as young spiders.

C. Comparison of spider and staphylinid faunas

The much narrower scatter of the density values of the beetles as compared with the spiders is very striking. The most probable interpretation seems to be a wider vertical distribution of the spiders in the layers of moss and litter. Small-scale differences in the vegetation ought thus to be more important as ecological factors for spiders than for beetles. Moreover, the dry funnel samples with the highest spider densities are probably from spots where spiderlings have recently hatched from egg groups in cocoons. No corresponding values could be calculated for the beetles, as the larvae and pupae were not accounted for.

The majority of Staphylinidae are predators, and thus at least to some extent compete with the small spiders. No significant correlations were found between the densities of spiders and beetles. This somewhat unexpected result is probably also due to the more diverse microhabitats of the spiders.

Biström (1978) has given a full list of the staphylinid species, with abundance values. The most common and regularly occurring species (in order of abundance) are *Atheta myrmecobia*, *Oxypoda annularis*, *Gyrohypnus myrmecophilus*, *Sipalia circellaris*. None of them is especially typical of forests in a primeval state.

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