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Originally published in:
Mitteilungen der Schweizerischen Entomologischen Gesellschaft 61

MITTEILUNGEN DER SCHWEIZERISCHEN ENTOMOLOGISCHEN GESELLSCHAFT
BULLETIN DE LA SOCIÉTÉ ENTOMOLOGIQUE SUISSE
61, 21–28, 1988

Spiders inhabiting the field layer of a dry meadow near Zurich, Switzerland[1]

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In a dry grassland (*Bromus* meadow) located in the protected "Katzensee" area (eastern Switzerland) the composition of foliage-dwelling spiders was studied by taking sweep net samples during one summer season. The total number of immature plus adult spiders per 100 single sweeps increased (quadrupled) from June to August (egg-laying of many adults in spring followed by hatching of the spiderlings in summer). A yearly total of 234 adult specimens – composing > ⅔ females and representing 21 identified species – was collected by sweeping (based on more than 3000 single sweeps). Immature stages (overall, 82%) outnumbered the adult spiders in the sweep net samples. Thirteen spider families were found in the dry meadow. The seven families Thomisidae, Salticidae, Micryphantidae, Tetragnathidae, Pisauridae, Theridiidae, and Araneidae prevailed in the yearly total of collected spiders (combined 89% of the 1295 immature plus adult specimens, 96% of the adults). Six species – *Enoplognatha ovata* (CLERCK), *Evarcha arcuata* (CLERCK), *Heliophanus flavipes* (HAHN), *Hylyphantes nigritus* (SIMON), *Tetragnatha pinicola* L. KOCH, and *Xysticus cristatus* (CLERCK) – combined made up > 80% of all collected adult spiders. The non-webbuilding spiders *E. arcuata* and *X. cristatus* considered to be insectivorous generalist predators were the two most frequently collected species. The results are compared with data of the foliage-dwelling spider community of another grassland habitat located in the same geographic area.

INTRODUCTION

Spiders represent an essential component of grassland biocoenoses (BONESS, 1953; KAJAK, 1971; VAN HOOK, 1971; SCHAEFER, 1974; PERTERER & THALER, 1976, a. o.). In the past several studies were conducted on the faunistic composition and/or ecology of grassland spiders in Switzerland (MAURER, 1974, 1975; BENZ & NYFFELER, 1980; GONSETH, 1985; HAENGGI, 1987; NYFFELER & BENZ, 1978, 1979, 1987, 1988a). Since in most of the previous faunistic studies spiders were collected by means of pitfall traps, ground surface-dwelling species were recorded primarily and little is known yet about the foliage-dwelling spider faunas (= field layer spiders) of Swiss grasslands (see also NYFFELER & BENZ, 1987). In this paper we present data on spiders assessed by sweeping the foliage of a dry meadow in eastern Switzerland. The habitat is located in the protected "Katzensee" area largely consisting of wetland and woodland, which, because of its great variety of species (e. g. over 600 species of Spermatophytae occurring in a relatively small area), is valued as a landscape of national scientific importance (LEIBUNDGUT et al., 1961).[2] With the exception of a note on a rare, conspicuous

[1] This research was supported by the Swiss National Science Foundation, grant 3.0020.76.

[2] So-called "Landschaftsschutzgebiet" in German literature.

crab spider discovered in a wetland of that area (see NYFFELER & BENZ, 1982)[3], this study is the first report on the spider fauna of the "Katzensee" area.

MATERIALS AND METHODS

From June to September spider samples were taken by sweeping the vegetation of a habitat which is part of the protected "Katzensee" area, located near Regensdorf (Canton Zurich, national grid coordinates: 678.70/253.57). The habitat consists of a rarely mown dry grassland (*Bromus* meadow) located on the hillside of the castle "Altregensberg", which at the foot of the hill turns into a small wet grassland. The habitat is separated by a road and intensively mown grassland from nearby woodland.

For the collection of spiders a sweep net with an upper diameter of 40 cm and a length of 75 cm was used. Sweep net collections were made on June 10+11, June 26, July 16+18, August 9+13, and September 17 with a total of more than 3000 single sweeps. By using tweezers the collected spiders were carefully removed from the sweep net, killed, preserved in 70% ETOH, and later on identified under a dissecting microscope. Genital preparations were made in the case of female spiders that could not definitely be identified by the morphology of the epigyne alone (for details see NYFFELER & BENZ, 1987). For identification of spiders we used the following keys: BLANKE (1976), DAHL & DAHL (1927), HARM (1971), LOCKET & MILLIDGE (1951/53), and WIEHLE (1931, 1937, 1956, 1960, 1963). The nomenclature was based on MAURER's (1978) catalogue of Swiss spiders. Of each spider species described in this paper, at least one specimen was deposited in the Entomological Collection of the Swiss Federal Institute of Technology (ETH) Zurich.

RESULTS

The total number of immature plus adult spiders per 100 single sweeps increased (quadrupled) from June to August. A yearly total of 234 adult specimens – composing > ⅔ females and representing 21 identified species – was collected by sweeping (based on totally more than 3000 single sweeps). Immature stages (82%) outnumbered the adult spiders in the sweep net samples. Thirteen spider families were found in the dry meadow. The seven families Thomisidae, Salticidae, Micryphantidae, Tetragnathidae, Pisauridae, Theridiidae, and Araneidae prevailed in the yearly total of collected spiders (combined 89% of the 1295 immature plus adult specimens, 96% of the adults) (Table 1). Thomisidae and Salticidae combined constituted ca. 50% of all spiders collected. Five medium sized species – *Enoplognatha ovata* (CLERCK), *Evarcha arcuata* (CLERCK), *Heliophanus flavipes* (HAHN), *Tetragnatha pinicola* L. KOCH, and *Xysticus cristatus* (CLERCK) – as well as the small sized *Hylyphantes nigritus* (SIMON) combined made up > 80% of all adult spiders collected (Table 1). The non-web-building spiders *X. cristatus* and *E. arcuata* considered to be insectivorous generalist predators (see NYFFELER & BENZ, 1979; NENTWIG, 1986) were the two

[3] According to a letter of A. LOERBROKS, Hamburg, the species is *Heriaeus graminicola* (DOLESCHAL); it is characterized by its dilating opisthosoma.

Tab. 1. Foliage-dwelling spiders of a dry meadow near Zurich, eastern Switzerland, assessed by sweep sampling. Data which are not listed under imm. (= immature stages) are all relating to adults.

Spider family and species	June 10–11	June 26	July 16–18	August 9–13	Sept. 17	Total
Non-webbuilding spiders:						
THOMISIDAE (imm.)	39	21	151	83	22	316
Xysticus cristatus	25	3	2	1	0	31
Xysticus kochi	1	0	0	0	0	1
SALTICIDAE (imm.)	32	26	29	52	72	211
Evarcha arcuata	23	22	8	13	18	84
Heliophanus flavipes	9	6	0	2	0	17
PISAURIDAE (imm.)	8	3	31	33	16	91
Pisaura mirabilis	2	5	1	0	0	8
CLUBIONIDAE (imm.)	2	0	1	5	1	9
LYCOSIDAE (imm.)	0	0	1	0	2	3
Pardosa amentata	1	0	0	0	0	1
Pardosa pullata	1	1	0	0	0	2
PHILODROMIDAE (imm.)	0	0	0	0	0	0
Philodromus rufus	1	0	0	0	0	1
Webbuilding spiders:						
MICRYPHANTIDAE (imm.)	0	0	4	54	71	129
Hylyphantes nigritus	13	5	4	1	0	23
TETRAGNATHIDAE (imm.)	4	0	24	57	10	95
Tetragnatha pinicola	15	4	0	0	0	19
THERIDIIDAE (imm.)	34	8	1	0	2	45
Enoplognatha ovata	1	0	14	5	1	21
Neottiura bimaculata	4	2	0	1	0	7
Theridion boesenbergi	1	0	0	0	0	1
Theridion impressum	0	1	0	0	0	1
ARANEIDAE (imm.)	9	3	6	6	20	44
Aculepeira ceropegia	6	0	0	0	0	6
Araniella cucurbitina	0	0	0	1	0	1
Argiope bruennichi	0	0	0	0	1	1
Mangora acalypha	3	0	0	0	0	3
Meta segmentata	0	0	0	0	1	1
DICTYNIDAE (imm.)	0	0	1	11	13	25
LINYPHIIDAE (imm.)	1	3	2	4	0	10
Linyphia triangularis	0	0	0	2	1	3
Linyphia spec.	0	0	1	0	0	1
Meioneta rurestris	0	0	1	0	0	1
AGELENIDAE (imm.)	0	0	1	1	0	2
UNIDENT. SPIDERS	1	2	12	36	30	81
TOTAL	236	115	295	368	281	1295

species dominating the yearly total of adults collected (combined ca. 50% of all adults). On the whole non-webbuilding spiders constituted ca. 60% of all spiders collected in the field layer of this dry meadow.

DISCUSSION

The 21 spider species recorded in the dry meadow have already been known to occur in Switzerland (BENZ, 1969; MAURER, 1978; MAURER & WALTER, 1980, 1984), 16 of them [*A. ceropegius, Araniella cucurbitina* (CLERCK), *E. ovata, E. arcuata, H. flavipes, H. nigritus, Linyphia triangularis* (CLERCK), *Mangora acalypha* (WALCK.), *Meioneta rurestris* (C. L. KOCH), *Neottiura bimaculata* (L.), *Pardosa amentata* (CLERCK), *Philodromus rufus* (WALCK.), *T. pinicola, Theridion impressum* L. KOCH, *X. cristatus,* and *Xysticus kochi* THORELL] being collected by sweeping the field layer of hay meadows near Zurich, Switzerland (NYFFELER, 1982).

In a wet grassland (megaphorbe meadow: Valeriano-Filipenduletum, *Carex acutiformis* EHRH. type) located ca. 7 km east of the dry grassland described in this paper, an analogous study had been conducted by NYFFELER & BENZ (1987). Investigations both in the wet meadow (NYFFELER & BENZ, 1987) and in the dry meadow (this paper) being conducted in the same geographic area, in the same year (identical sampling dates and weather conditions), and by the same investigator using the same method (standardized sweeping technique), the results of the two studies are comparable. The following analogies were found for the foliage-dwelling spider communities of the two meadows:

- Adults of slightly more than 20 identifiable spider species were recorded in the course of one summer season.
- The following twelve species were found: *A. bruennichi, E. arcuata, E. ovata, H. flavipes, H. nigritus, L. triangularis, Meta segmentata* CLERCK, *N. bimaculata, P. mirabilis, T. pinicola, X. cristatus,* and *X. kochi.*
- About a dozen spider families were found, about half of them (respectively 6 and 7) prevailing in the sweep net samples (combined ca. 90% of the yearly total of immatures plus adults).
- Basically the same spider families were found, but in differing proportions.
- Predominance of species with at least a medium adult body size, whereas small sized species prevailed in the ground surface-dwelling spider community of a grassland in the same geographic area as reported by NYFFELER & BENZ (1988a).
- More than two thirds of the adult spiders collected were females, which agrees well with the results of HUHTA (1965) who found the sex ratio in most spider species to be 1 male to 3 females because of the males' shorter life-span (comp. NYFFELER & BENZ, 1987).
- Immature stages (> 80%) outnumbered the adults.
- A significant increase of the total number of immature plus adult spiders per 100 single sweeps from June to August was noticed (compared to June four times as many spiders per 100 single sweeps were found in August). The high density increase is considered to be primarily due to egg-laying of many females in spring followed by hatching of the spiderlings in the course of the summer, which is evidenced by the seasonally changing age structure of the collected specimens (increasing proportion of immatures with the progressing season).

However, there were also some significant differences between the foliage-dwelling spider communities of the two habitats:

- Several spider species could only be found – or were dominating – in either the one or the other habitat. For instance, in accordance with the differing levels of humidity, the hygrophilous *T. extensa* was prevailing in the wet

meadow, while in the dry meadow only the euryhygric *T. pinicola* occurred; this is in agreement with WIEHLE's (1963) observations on the habitat preference of these two species.

- To assess the "community similarity" of the foliage-dwelling spider faunas of the two meadow types, the "overlap index" (C_{jk}) after SCHOENER (1970) was calculated by means of the following formula:

$$C_{jk} = 1 - 0.5 \sum \mid p_{ij} - p_{ik} \mid ,$$

where p_{ij} and p_{ik} are the proportions of species i of the spider communities in the locations j (dry meadow) and k (wet meadow). This index ranges from 0 (no overlap) to 1 (total overlap). The comparison of the yearly totals of adult spiders collected in the two grassland habitats results in an "overlap index" C_{jk} of 0.32, indicating that the two foliage-dwelling spider communities differ considerably.

- Diversity (H') and evenness (J) of the collected spiders were higher in the dry meadow than in the wet meadow (based on yearly totals of adults, Table 2). The difference between the diversity indices in the two habitats is statistically significant ($p < 0.05$, t-test after POOLE, 1974). The diversity difference can be explained by the fact that in the dry meadow four species combined constituted two thirds of all adult spiders collected, while in the wet meadow only two species combined composed two thirds of all collected adults.
- In the dry meadow a total of only 1295 spiders were collected, based on more than 3000 single sweeps (ca. 430 spiders/1000 single sweeps), whereas in the wet meadow a total of 3756 spiders were collected, based on ca. 2000 single

Tab. 2. Comparison of diversity H' (SHANNON-WEAVER index) and evenness J (sensu PIELOU, 1966) of the foliage-dwelling spiders of two grassland habitats in eastern Switzerland. The calculation was based on the yearly totals of adults collected by sweeping. The two diversity values are significantly different ($p < 0.05$).

	Dry meadow (this study)	Wet meadow (NYFFELER & BENZ, 1987)
Number of families a/	13	12
Number of species S b/	22 c/	23 d/
Diversity $H' = -\sum_{i=1}^{S} p_i \ln p_i$ e/	2.14	1.85
Evenness $J = H'/\ln S$	0.69	0.59

a/ based on immatures plus adults
b/ adults only
c/ 21 identified species plus 1 unid. species
d/ 22 identified species plus 1 unid. species
e/ p_i = proportion of total individuals in species i

sweeps (ca. 1880 spiders/1000 single sweeps). Since the investigations in the two habitats were conducted under very similar conditions (see above), the estimated relative densities are comparable, at least indicating a trend. Thus, it follows that based on the same number of sweeps more than four times as many spiders were caught in the wet meadow, suggesting that the wet meadow may have been populated by a higher number of spiders per space unit. This hypothesis, however, needs verification with a method permitting absolute density estimates.–HAEFELFINGER & DUELLI (1987) developed a sampling method for absolute population estimates of invertebrate communities, which they tested by assessing invertebrate densities in various habitats in northwestern Switzerland. Using this sampling method the authors estimated an average density of 4 spiders/m^2 in semi-dry meadows and of 44 spiders/m^2 in wetlands, which basically indicates the same trend towards density discrepancy as found by us with the sweeping technique.[4]

- A major difference between the spider communities of the two habitats shows up in the different proportions of webbuilders. In the wet meadow ca. 60% of the collected spiders were orb-webbuilding spiders and ca. 16% were irregular-webbuilding spiders (combined ca. 76% webbuilding spiders), while in the dry meadow ca. 60% of the collected spiders were non-webbuilding spiders. Hence, foraging by spiders seems to operate differently in the two meadows. While orb-weavers with their large webs kill prey in excess leading to high prey capture rates of up to > 100 insects killed/web/day (see NATON, 1976; NYFFELER, 1982), non-webbuilding spiders are known to feed rarely, often capturing less than 1 prey/spider/day (see JACKSON, 1977; NYFFELER *et al.*, 1987a, b; NYFFELER & BENZ, 1979, 1988b). The predominance of rarely feeding non-webbuilding spiders and the evidence of lower spider densities in the drier grassland suggest that the predation pressure exerted by the foliage-dwelling spider community may be much lower in dry meadows than in wet grasslands.

This is the first investigation of the foliage-dwelling spiders in a dry meadow of eastern Switzerland. Since dry meadows are characterized by a great variety of rare plant species and very rich invertebrate faunas (WILDERMUTH, 1978), and since the total area of this meadow type in the Swiss midland has been shrinking drastically (KLEIN, 1977), it is obvious that faunistic surveys in these habitats are of vital importance from the point of view of nature conservation.

ACKNOWLEDGEMENTS

We would like to thank Doz. Dr. K. Thaler, Department of Zoology, University of Innsbruck, Austria, for checking our spider identifications and Professor Dr. A. Gigon, Geobotanical Institute, The Rübel Foundation, ETH Zurich, for informations on the habitat described in this paper. Spiders collected with permission of the Fachstelle für Naturschutz, Zurich.

ZUSAMMENFASSUNG

Die pflanzenbewohnenden Spinnen eines im Landschaftsschutzgebiet «Katzensee» (Ostschweiz) gelegenen Trockengraslandes (*Bromus*-Wiese) wurden von Juni bis September mit der Käscher-

[4] Density discrepancy was also observed by comparing the dry meadow of this study with wetland of the "Katzensee" area (data for July): 295 spiders/500 single sweeps in dry meadow, and 484 spiders/500 single sweeps in wetland (nature reserve "Chrähenried").

methode untersucht. Die Gesamtzahl aller Spinnen (Jung- plus Adulttiere) pro 100 einfache Käscherschläge stieg vom Juni bis August signifikant an. Basierend auf total mehr als 3000 einfachen Käscherschlägen wurden 234 Adulttiere gekäschert, die 21 identifizierte Spinnenarten repräsentierten und wovon mehr als zwei Drittel Weibchen waren. Die Mehrzahl (82% des Totals) der gesammelten Spinnen waren Jungtiere. Unter den insgesamt 1295 gekäscherten Spinnen (Jung- plus Adulttiere) herrschten die sieben Familien Thomisidae, Salticidae, Micryphantidae, Tetragnathidae, Pisauridae, Theridiidae und Araneidae vor (zusammen 89% aller Spinnen, 96% der Adulttiere). Sechs Arten – *Enoplognatha ovata* (CLERCK), *Euarcha arcuata* (CLERCK), *Heliophanus flavipes* (HAHN), *Hylyphantes nigritus* (SIMON), *Tetragnatha pinicola* L. KOCH und *Xysticus cristatus* (CLERCK) – stellten zusammen > 80% des Totals gesammelter Adulttiere. Die netzlos jagenden Spinnen *E. arcuata* und *X. cristatus* – zwei mutmasslich polyphage Insektenfresser – waren die beiden am häufigsten gefangenen Spinnenarten. Die Resultate dieser Arbeit wurden verglichen mit Daten über die pflanzenbewohnende Spinnengemeinschaft eines anderen, 7 km entfernt gelegenen Graslandhabitates.

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(received January 27, 1988)