The spider fauna of a marginal agricultural field
(Araneae)

Claus Vangsgaard, Ejgil Gravesen & Søren Toft

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Spiders were collected in pitfall traps on two transects running from a forest, through a strip of unmanaged grass, into a field grown with mixed peas, barley and grass. The field was only 2 ha in size, surrounded on all sides by forest, and the soil was sandy. Species diversity along the transects and through the season is described. The family composition differs from the usual agricultural situation by its high content of non-webbuilding spiders. The diversity of Linyphiidae and Lycosidae was found to respond to habitat gradients in opposite ways. Two species, *Pardosa lugubris* and *Pachygnatha degeeri*, showed population movements into the field from surrounding forest and grassland habitats, respectively.

C. Vangsgaard, E. Gravesen & S. Toft, Zoological Laboratory, University of Aarhus, DK-8000 Århus, Denmark.

Introduction

Recent reviews on spiders of agricultural fields testify an increasing interest in spiders as natural control agents of crop pest insects (Luczak, 1979; Riechert & Lockley, 1984; Sunderland, 1987). Another aspect concerns the potential of spiders as indicators of environmental quality (e.g. Ruzicka, 1986, 1987; Clausen, 1986) and thus their use in the field of environmental conservation and management. From both viewpoints, the diversity of the spider fauna and the exchange of faunal elements between different habitats are of central importance. This study analyses the spider fauna of a small area of agricultural land on a rather poor soil in a region of forest and bogs. In the years to come large areas of marginal agricultural land like this will be taken out of use and subjected to management of one kind or another. Very little is known about the arthropod fauna of such areas, even less about the impact of various management schemes on that fauna. Our aim here is to contribute to the knowledge about the dependence of the agricultural fauna in such areas on that of adjacent habitats.

Study area and methods

Field work was carried out near the village Tustrup on Djursland, Jutland, Denmark (UTM coordinates NH 96). The field under investigation was an isolated patch of agricultural land, about 2 ha (80 m x 250 m) in size, surrounded on all sides by mixed forest, mostly spruce, pine and birch. The crop was a mixture of different peas and barley, undersown with Italien ryegrass. In 1983, the year of the study, it was sown on the first days of May, and cut for green forage in mid-July. The soil is sandy, as the area was formed as a melt water plain at a temporary halt during the retreat of the ice after the last glacial period. The surrounding landscape is rich in moors and bogs. After periods of rain, shallow depressions become waterlogged, depicting a high water table. The field had received no pesticide treatment for at least eight years. However, during this study half of the area was sprayed with parathion on June 9. We will not go into detail with the impact of this on the fauna, as the part of the study reported here was not designed specifically for this purpose.

Spiders were collected by means of pitfall traps - double plastic beer beakers, 7 cm in diameter, half filled with a benzoic acid solution with detergent. Traps were placed in two parallel transects, running perpendicular to the long side of the field, one in each of the sprayed and unsprayed areas. Each transect consisted of ten traps, lined up in relation to the long western side of the field as follows: One was placed about 2 m into the forest (position - 2 m); one in the unmanaged grass strip between forest and field (-0.5 m); the remaining in the field at 0.5, 1, 2, 4, 8, 15, 30, and 50 m from the field edge. The traps were emptied approximately weekly between May 5 and July 17, when the crop was harvested. Data for the period May 19 to 26 have been omitted from seasonal graphs because several of the traps were flooded.

For visual comparison of faunas in different habitats, dominance-diversity curves have been drawn (Whittaker, 1975; Southwood, 1978). Southwood (1978: 420) in his discussion of diversity indices pointed out that dominance-diversity curves should be used as basis for choosing among indices. As our curves are nearly straight lines the underlying distribution is logarithmic and the α-index then gives the best description of diversity in this study. This is mainly because the α-index reflects the moderately abundant species most and has been found superior to other indices in reflecting environmental changes, which is important in agricultural habitats (Taylor et al., 1976). The α-index is given by $S = \alpha \ln(1 + N/\alpha)$, where S = number of species in sample, N = number of individuals in sample, and ln denotes the natural logarithm.

The transect trap design allows calculation of a relative "mean position" of a species population in a trapping period. It is computed relative to the field edge by the expression

$$P = \frac{\Sigma (N_i \cdot P_i)}{N_{tot}}$$

where N_i is number of individuals of a given species in trap *i*, P_i is the position of trap *i* as indicated above, and N_{tot} is the total number of individuals of that species. Changes in the "mean position" of a species from one trapping period to another is taken to reflect a movement of the population along the transect, i.e. differences in mortality or relative activity at the trapping sites are considered negligible.

Results

Species composition

Appendix 1 presents the full list of species collected in the two transects. These have been divided into three "habitats" relative to the field edge, as indicated in the table. A total of 81 species was found, among 1298 identified individuals.

Sunderland (1987) reviewed the spider fauna in European cereal fields, and found that a few species dominated the cereal field fauna in large part of Europe. However, only a few of these species were numerous in our study area, e.g. *Pardosa prativaga, Pachygnatha degeeri, Oedothorax apicatus* and *Erigone dentipalpis*. Surprisingly small numbers were found of *Erigone atra, Meioneta rurestris, Bathyphantes gracilis* and *Lepthyphantes tenuis*. Several species common in woods were found in the field, e.g. *Pardosa lugubris, Pachygnatha listeri* and a few less numerous ones. Others like *Gnaphosa leporina, Pirata piraticus, P. uliginosus* and *Pachygnatha clercki* are common members of the spider communities in swampy areas. Others again like *Phrurolithus*

Table 1.

Comparison of family contributions to total catch of individuals and species between the field at Tustrup and barley fields at Torup. Zoridae included in Clubionidae.

Sammenligning af forskellige edderkoppefamiliers relative betydning mellem marginaljord ved Tustrup og bygmarker ved Torup. Zoridae inkluderet i Clubionidae.

	Individuals/Individer				Species/Arter			
	Tustrup		Torup		Tustrup		Torup	
	Number/ Antal	%	Number/ Antal	%	Number/ Antal	%	Number/ Antal	%
Gnaphosidae	7	0.5	5	0.1	4	4.9	3	3.8
Clubionidae	13	1.0	-	-	4	4.9	-	-
Thomisidae	5	0.4	15	0.2	3	3.7	2	2.5
Salticidae	-		1	0.0	-	-	1	1.3
Lycosidae	515	39.7	267	4.1	14	17.3	13	16.3
Pisauridae	5	0.4	-	-	l	1.2	-	-
Hahniidae	3	0.2	3	0.0	1	1.2	1	1.3
Mimetidae	1	0.1	-	-	1	1.2	-	-
Theridiidae	31	2.4	19	0.3	5	6.2	4	5.0
Tetragnathidae	260	20.0	72	1.1	3	3.7	1	1.3
Metidae	1	0.1	-	-	1	1.2	1	1.3
Linyphiidae	457	35.2	6142	94.1	44	54.3	54	67.5
	1298		6524		81		80	
Total non-web-spinning spp. (Total ikke-net-spindende arter)	806	62.1	360	5.5	30	37.0	20	25.0
Total web-spinning spp. (Total net-spindende arter)	492	37.9	6164	94.5	51	63.0	60	75.0

festivus, Pardosa monticola and *Alopecosa cuneata* are normally found on sun exposed heaths.

Family composition

The relative contribution of different spider families to the total catch appears from the table 1, which also compares to similar data from a more normal agricultural situation at Torup in Central Jutland (data in Toft, 1989). It is seen that at Tustrup non-webbuilding spiders, in particular Lycosidae, make up about two thirds of the fauna, while at Torup they constitute only a few per cent. If numbers of species are compared, we also find that non-webbuilders are favoured at Tustrup, though clearly the difference relates to families other than lycosids.

Diversity

We have analysed the changes in the α-index along the transects by pooling the catches for each trap position and computed the index on the whole-season catch for each pair of traps. Fig. 1 shows that total spider diversity is high at the forest, grass, and field edge positions compared to the interior of the field. Similar computations for the Lycosidae alone show the opposite pattern. Because of this, figs. 2 and 3 give dominance-diversity curves for Lycosidae and Linyphiidae separately. Fig. 2 shows curves for the three "habitats" of the transects at Tustrup. In the Lycosidae there is a high dominance in the forest-and-grass and the field margin as seen from the very steep curve, and a more even (less steep curve) and richer fauna out in the field. In the Linyphiidae evenness is high in the forest-and-grass, dominance is high in the field, while the field margin is intermediate.

Movements

Some species showed seasonal changes in their occurrence along the transects, indicating movements between the habitats. This is most evident in *Pardosa lugubris* and *Pachygnatha degeeri.* Fig. 4 shows the seasonal variation in catches of these two species as changes in mean population position along the transects. Both populations move outwards into the field in the early part of their activity period, and a backward trend were found later in the season, but this is less certain as numbers are low at that time. It is possible to compute the speed of movement of the populations simply by the slope of the lines in fig. 4. In the outgoing phase *P. lugubris'* mean position was displaced by 12.1 m in three weeks, i.e. about 0.6 m per day. In *P. degeeri* the figure is 0.4 m per day.

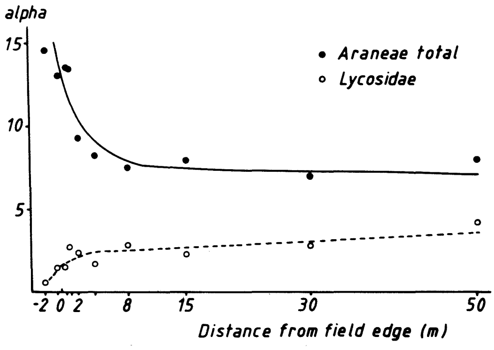

Fig. 1. Pattern of species-diversity (α-index) along the transects. Curves drawn by eye.
Variation i arts-diversitet (α-indeks) langs transekterne. Kurverne tegnet på øjemål.

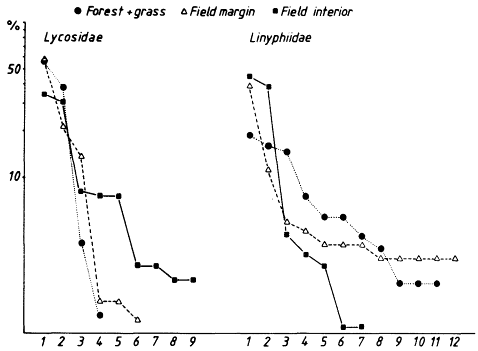

Fig. 2. Dominance-diversity curves for total catches in three parts of the transects.
Dominans-diversitetskurver (relativ hyppighed i forhold til hyppighedsrangfølge) for totalfangsten i tre afsnit af transekterne . Bemærk logaritmisk ordinat-akse.

Discussion

Species and family composition

The species and family composition of the Tustrup field differs substantially from that of European agricultural fields in general (Sunderland, 1987). The main reason for this certainly lies in the small size of the field and its isolation from other agricultural fields. Thus the field contain several species not normally found in agriculture, particularly species associated with the surrounding forest or swampy habitats. On the other hand, the Tustrup field did have a substantial element of agricultural spiders. Thus, Tustrup had 46 species in common with the barley fields at Torup (Toft, 1989).

Among some of the species normally found in agricultural fields, numerical abundance at Tustrup was far lower than expected (Sunderland, 1987; Toft, 1989). This was the case with *Erigone atra* as well as *Bathyphantes gracilis, Meioneta rurestris* and *Lepthyphantes tenuis.*

The richness and abundance of non-web-building species were clearly unusual and this might be a result of the more diverse and less managed surrounding landscape. According to Tischler (1955), lycosids and other hunting spiders are much more vulne-

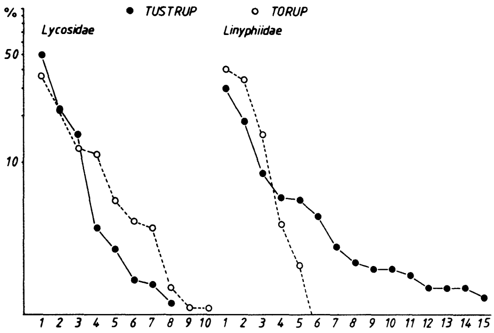

Fig. 3. Dominance-diversity curves for total catches at Tustrup compared to similar data from barley fields at Torup.
Dominans-diversitetskurver for totalfangsten ved Tustrup, sammenlignet med tilsvarende fangster fra bygmarker ved Torup.

rable to the kinds of disturbances applied during agricultural practices, whereas several linyphiids even can withstand ploughing to a surprising extent (Duffey, 1978).

Diversity

Comparing the fields at Tustrup and Torup (Fig. 3), we find that lycosids produce a steeper curve (i.e. they have a more prominent dominance structure) at Tustrup than at Torup, while for the linyphiids the opposite is true. The opposite response of lycosid and linyphiid assemblages to habitat gradients is probably the most surprising result of this study. In a study of a successional strip of land, including a recently planted hedgerow and adjacent agricultural fields, Mader et al. (1986) found lowered diversity and richness in the latter. This was true not only for the spiders as a whole, but also for lycosids in particular. We refrain from elaborating on the possible causes of our findings, as this would only be guesswork, except for noting that the very diverse crop growing on our field may have created a favourable environment.

However, these data indicate that the taxon Araneae is not an ecologically homogenous entity, rather it consists of subgroups showing different trends in relation to habitat gradients.

Faunal exchange

The question to what extent the agricultural spider fauna relies on yearly recruitment from surrounding habitats is still not fully answered. Most of them are active aeronauts, but their ballooning activity may not represent movements between different kinds of habitats, but rather a mixing of animals from different fields.

Several groups probably invade the fields by walking, but few previous studies have documented this process directly. Krause (1987) found evidence for movements away from a hedgerow by using pitfall traps fenced by barriers, so that they caught animals coming from one side only. Her results, as well as our own, come short of the question whether immigration is directional or only results from passive diffusion due to differences in density. Hallander (1967) measured the speed of movement in *P. lugubris* on individually marked animals and estimated speed to 0.67 and 1.14 m/day for females and males respectively, which are somewhat higher than our estimate of 0.6 m/day (both sexes). However, considering that his figures are mean individual displacements in all directions, while ours are net unidirectional population displace-

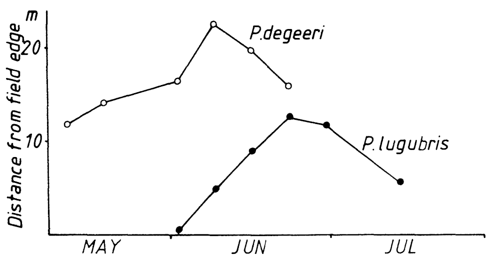

Fig. 4. Changes of mean "population position" (cf. STUDY AREA AND METHODS) of two species during the study period.
Gennemsnitlig "position af populationen" i forhold til transekterne for to arter gennem undersøgelsesperioden.

ments, the difference in estimates is surprisingly small.

Previous studies by Nørgaard (1945) and Edgar (1971) have demonstrated that egg-sac carrying females of *P. lugubris* as a regular part of their life-cycle moves into clearings or adjacent meadows. Our own results show this to be the case for males too. Thus, in the last week of May males showed much higher activity in the forest than in the field, whereas all through June the opposite was true. Our estimate of speed of movement of the *P. degeeri* population (0.4 m/day) is unexpectedly high. Though the species is a non-webbuilding wanderer in the adult stage it is in no way known as a fast runner. It is hard to imagine a population displacement of this magnitude otherwise than by directed individual movements. Documentation for this is missing, however.

Conclusion

The spider fauna of our study site seems to be a mixture. It is not a typical agricultural one, though with a substantial agricultural element as well as with elements of several different surrounding habitat types. Such a fauna is likely to be more peculiar to a specific site than a typical agricultural fauna and less influenced by the crop grown in a particular year. The whole study area has an ecotone character and compared to the number of individuals caught, species richness and diversity is higher than that of an agricultural monoculture, and several families, especially of non-webbuilding spiders, are much better represented.

Acknowledgements

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Dansk sammendrag

Edderkopper blev indsamlet ved hjælp af fangfælder på en lille mark (2 ha) dyrket med ærter, byg og græsudlæg, samt i omgivende græskant og skov. Fælderne var anbragt som to transekter gående fra skoven vest for marken og ind til midten af denne. Jordbunden i området er sandet og noget vandlidende efter regnskyl. Omgivelserne omfatter tillige et større moseområde og flere mindre vandhuller.

Faunaen viste sig sammensat af flere elementer. Foruden en egentlig markfauna, repræsenteret ved *Pachygnatha degeeri, Erigone dentipalpis, Oedothorax apicatus* m. fl. fandtes et element hidrørende fra skov (*Pardosa lugubris, Pachygnatha listeri,* m. fl.), et element hidrørende fra mosehabitater (*Gnaphosa leporina, Pirata piraticus, P. uliginosus, Pachygnatha clercki* m. fl.), og endelig et varmeelskende element stammende fra områdets bare solbeskinnede sandflader (*Phrurolithus festivus, Pardosa monticola, Alopecosa cuneata* m. fl.). Ikke netspindende former viste langt større hyppighed end man normalt finder det i nordeuropæiske landbrugssystemer (Tabel 1) (Sunderland, 1987).

Artsdiversiteten (α-index) viste en interessant forskel mellem tæppespindere (Linyphiidae) og jagtedderkopper (Lycosidae), de to dominerende familier. Således viste jagtedderkopperne en stigende diversitet fra skov + græskant og ind over marken, mens mønstret var modsat for tæppespinderne (Fig. 2). Dominans-diversitetskurver for hver af tre transekt-afsnit (Skov + græs, markkant, mark-indre) viser den samme modsat gående tendens (Fig. 3), og det samme gør kurver, der sammenligner den her undersøgte mark med data fra et mere normalt landbrugssystem (bygmarker) (Fig. 4).

To arter, *Pardosa lugubris* og *Pachygnatha degeeri,* viste tydelige bevægelser i løbet af foråret: *P. lugubris* invaderede marken fra den omgivende skov, mens *P. degeeri* invaderede fra græskanten. Det kunne beregnes, at populationerne forskød sig langs transekterne med hastigheder på henholdsvis 0.6 m og 0.4

m pr. døgn. Disse tal er så høje, at man må formode de skyldes retningsbestemte vandringer. Det undersøgte område er et stykke typisk marginaljord. På grund af sin størrelse har det udpræget økotonkarakter, og faunaen er da også en blanding af elementer fra flere af områdets habitater. Marken ligger som en plet med en ganske betydelig diversitet. Selv om artsrigdommen ikke var væsentligt højere, end man iøvrigt kan finde i danske landbrugssystemer, var artsantallet højt i forhold til det samlede antal individer indsamlet (81 arter, 1300 individer).

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Appendix 1

Systematic list of spider species and their numbers caught in two transects of a forest-pea field ecotone. The transects have been divided into three main habitat categories: 1) Field surroundings (forest and grass; 4 traps), 2) Field margin (positions 0.5 m, 1 m, 2 m, 4 m, 8 traps), 3)Interior of field (positions 8 m, 15 m, 30 m, 50 m; 8 traps). Numbers in brackets are numbers caught in the three habitat categories and totals (1, 2, 3 and totals). For comparability, figures for the field traps have been divided by 2.

Systematisk fortegnelse over de fangne edderkoppearter og deres samlede antal i to transekter over en skoværtemark økoton. Disse er delt i tre habitatkategorier: 1) Omgivelser (skov og græs; 4 fælder), 2) Markkant (afstande 0.5 m, 1 m, 2 m, 4 m; 8 fælder), 3) Mark indre (afstande 8 m, 15 m, 30 m, 50 m; 8 fælder). Tallene i parentesen er fangststørrelser i de enkelte habitatkategorier (1, 2, 3 og ialt). For sammenlignelighedens skyld er tallene fra markfælderne divideret med 2.

Family GNAPHOSIDAE

Drassodes pubescens (Thor.) (0,1.5,1.0=5), Haplodrassus signifer (C.L.K.) (1,0,0,=1), Drassyllus pusillus (C.L.K.), (0,.5,0=1), Gnaphosa leporina (L.K.) (0,0,.5=1)

Family CLUBIONIDAE

Clubiona compta C.L.K. (1,0,0=1), C. diversa O.P.-C. (0,.5,0=1), Phrurolithus festivus (C.L.K.)(1, 1.0, 1.5=6)

Family ZORIDAE

Zora spinimana (Sund.) (1,1.5,.5=5)

Family THOMISIDAE

Xysticus kochi Thor. (0,0,.5=1), X. ulmi (Hahn) (0,.5,1.0=3), Oxyptila trux (Bl.) (0,.5,0=1)

Family LYCOSIDAE

Pardosa agricola (Thor.) (0,.5,.5=2), P. agrestis (Westr.) (0,0,7.0=14), P. monticola (Clerck) (0,2.0,7.5 =19), P. palustris (Linn.) (0,0,.5=1), P. pullata (Clerck) (0,2.0,2.0=8), P. prativaga (L.K.) (3,26.5, 28.5=113), P. amentata (Clerck) (0,.5,2.5=6), P. nigriceps (Thor.) (1,1.5,2.5=9), P. lugubris (Walck.) (44,74.0,31.5=255), Alopecosa pulverulenta (Clerck) (0,.5,.5=2), A. cuneata (Clerck) (0,1.0,2.0=6), Trochosa terricola Thor. (30,17.0,7.0=78), Pirata piraticus (Clerck) (0,.5,0=1), P. uliginosus (Thor.) (0,0,.5=1)

Family PISAURIDAE

Pisaura mirabilis (Clerck) (1,1.5,.5=5)

Family HAHNIDAE

Hahnia montana (Bl.) (1,1.0,0=3)

Family MIMETIDAE

Ero furcata (Villers) (0,.5,0=1)

Family THERIDIIDAE

Euryopis flavomaculata (C.L.K.) (0,0,1.0=2), Achaearanea riparia (Bl.) (0,0,1.5=3), Theridion bimaculatum (Linn.) (0,.5,0=1), Enoplognatha ovata (Clerck) (2,.5,0=3), Robertus lividus (Bl.) (19,1.5,0=22)

Family TETRAGNATHIDAE

Pachygnatha clercki Sund. (3,0,1.0=5), P. listeri Sund. (14,4.0,.5=23), P. degeeri Sund. (22,39.0, 66.0=232)

Family METIDAE

Metellina mengei (Bl.) (0,0,.5=1)

Family LINYPHIIDAE

Walckenaeria acuminata Bl. (3,2.0,0=7), W. antica (Wider) (0,0,.5=1), W. cucullata (C.L.K.) (1,0,0=1), W. cuspidata (Bl.) (1,0,0=1), Dicymbium tibiale (Bl.) (0,2.5,0=5), D. brevisetosum Locket (0,.5,0=1), Dismodicus bifrons (Bl.) (1,0,0=1), D. elevatus (C.L.K.) (1,.5,0=2), Maso sundevalli (Westr.) (1,.5,0=2), Pocadicnemis pumila (Bl.) (2,1.0,0=4), Oedothorax fuscus (Bl.)(0,.5,0=1), Oe. agrestis (Bl.) (0,0,.5=1), O. apicatus (Bl.) (0,7.5,36=85), Tiso vagans (Bl.) (0,0,.5=1), Minyriolus pusillus (Wider) (1,0,0=1), Tapinocyba praecox (O.P.-C.) (1,0,0=1), Micrargus herbigradus (Bl.) (0,2.0,0=4), M. subaequalis (Westr.) (1,0.5,1.0=4), Erigonella hiemalis (Bl.) (5,1.5,0=8), Diplocephalus latifrons (O.P.-C.) (21,2.5,.5=27), D. picinus (Bl.) (23,1.0,.5=26), Erigone dentipalpis (Wider) (1,26.0,42.0=137), E. atra (Bl.) (1,2.5,0- =6), Porrhomma lativela Tretzel (0,0,.5=1), Agyneta subtilis (O.P.-C.) (1,0,0=1), A. conigera (O.P.-C.) (1,0,0=1), A. cauta (O.P.-C.) (1,0,0=1), Meioneta rurestris (C.L.K.) (1,1.0,1.0=5), M. beata (O.P.-C.) (2,0,0=2), Microneta viaria (Bl.) (3,2.0,0=7), Centromerus sylvaticus (Bl.) (1,0,0=1), C. arcanus (O.P.C.) (1,0,0=1), Saaristoa abnormis (Bl.)(1,0,0=1), Bathyphantes gracilis (Bl.) (1,3.0,3.0=13), B. parvulus (Westr.) (27,2.0,4.0=39) Kaestneria dorsalis (Wider) (1,0,0=1), Diplostyla concolor (Wider) (11,2.0,2.5- =20) Lepthyphantes tenuis (Bl.) (8,0,.5=9), L. mengei Kulcz. (8,.5,.5=10), L. tenebricola (Wider), (6,.5, 0=7), L. ericaeus (Bl.) (3,0,0=3), L. pallidus (O.P.-C.) (0,1.0,0=2), Linyphia triangularis (Clerck) (1, .5,0=2), Linyphia (Neriene) clathrata Sund. (2,3.5,0=9).

Nomenclature after Merrett, Locket & Millidge (1985).
Nomenklatur efter Merrett, Locket & Millidge (1985).