European Arachnology 2005

Editors: Christo Deltshev and Pavel Stoev
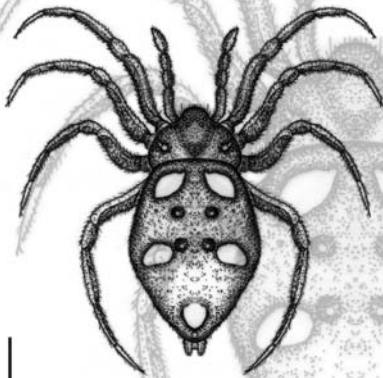
Institute of Zoology and National Museum of Natural History

Bulgarian Academy of Sciences

Dedicated to Konrad Thaler

Foreword

The 22nd European Colloquium of Arachnology was held in the Bulgarian town of Blagoevgrad, from 1–6 August 2005, accommodated in the buildings of the American University. The meeting was organized by the Institute of Zoology and the National Museum of Natural History (both part of the Bulgarian Academy of Sciences), under the aegis of the European Society of Arachnology (ESA). Participations from 28 countries – 96 scientific delegates and 19 accompanying persons attended the colloquium, which was officially opened by Dr Søren Toft – President of ESA, in the presence of the university authorities. The traditionally week-long meeting involved four full scientific days and a mid-week colloquium excursion. Including plenary sessions, there were 49 oral scientific presentations and 36 posters on display. The invited speakers gave thorough lectures on fields such as paleoarachnology (Jason Dunlop), ecology (Jean-Piere Maelfait), systematics (Matiaz Kuntner) and biogeography (Carles Ribera). The colloquium excursion took the participants to the region of the picturesque Melnik town and Rozhen Monastery, where except for the cultural program, all delegates were given opportunities to collect spiders and other arachnids in sandy and xerothermic sites. At the end of the excursion there was a reception in the wine cellar of a house with typical Bulgarian architecture. The colloquium dinner took place in a traditional Bulgarian restaurant where the guests tasted typical Bulgarian meals and listened (and danced) to Bulgarian folk music. During Friday's closing session prizes for the best student presentations were handed out, and ESA representatives thanked the organizers for their work. The General Assembly Meeting of ESA decided the next 23rd Colloquium of Arachnology to be held in Barcelona, Spain in 2006.

The present volume presents the proceedings of the 22nd European Colloquium of Arachnology. It comprises 32 scientific articles by 61 authors and covers the following topics: paleontology, morphology, taxonomy and systematics, ecology, biogeography, faunistics and parasitology. We are very thankful to all referees for providing professional and timely reviews of all manuscripts submitted for publication to *Acta zoologica bulgarica*. We hope that the diverse topics of the articles and their high scientific quality will make this issue pleasant, interesting and useful reading not only for all arachnologists but also to general ecologists and biologists.

The Organizing Committee members (Christo Deltshev, Petar Beron, Stoyan Lazarov, Plamen Mitov, Gergin Blagoev, Pavel Stoev, Boyan Petrov, Toshko Ljubomirov, Mario Langourov, and Silviya Tosheva) took on the task of all colloquium related duties. The logo and the web site were created by Stanislav Abadjiev, to whom the organizers are especially indebted. Very important for the social program and the accommodation was the help of Vlada Peneva (Central Laboratory of General Ecology, BAS), Velin Radenkov (St Kliment Ohridsky Sofia University), Rayka Georgieva, Alexander Pulev (Blagoevgrad Regional Museum of History) and Nadya Afendova (American University, Blagoevgrad). We express our gratitude to all that helped in the meeting's organization and proceedings publishing, as well as to the invited speakers and session leaders for making the colloquium interesting and smoothly running. We especially acknowledge the financial and kind support of the following companies and NG organizations: European Society of Arachnology, Gradus – Panagyuriste, Amarea Ylsor – Sofia, Optics – Panagyuriste, Asen Nikolov Foundation – Sofia, Bulgare Foundation – Sofia, Rajna Knyaginya – Panagyuriste, and Nikola Kaymakov – Panagyuriste. To all those who attended the meeting we express our thanks for the presentation of interesting lectures and posters, and for the all unforgettable moments that we shared together. We look forward to meeting you again at the 23rd Colloquium of Arachnology in Spain.

Christo Deltshev

COLLOQUIUM PHOTO
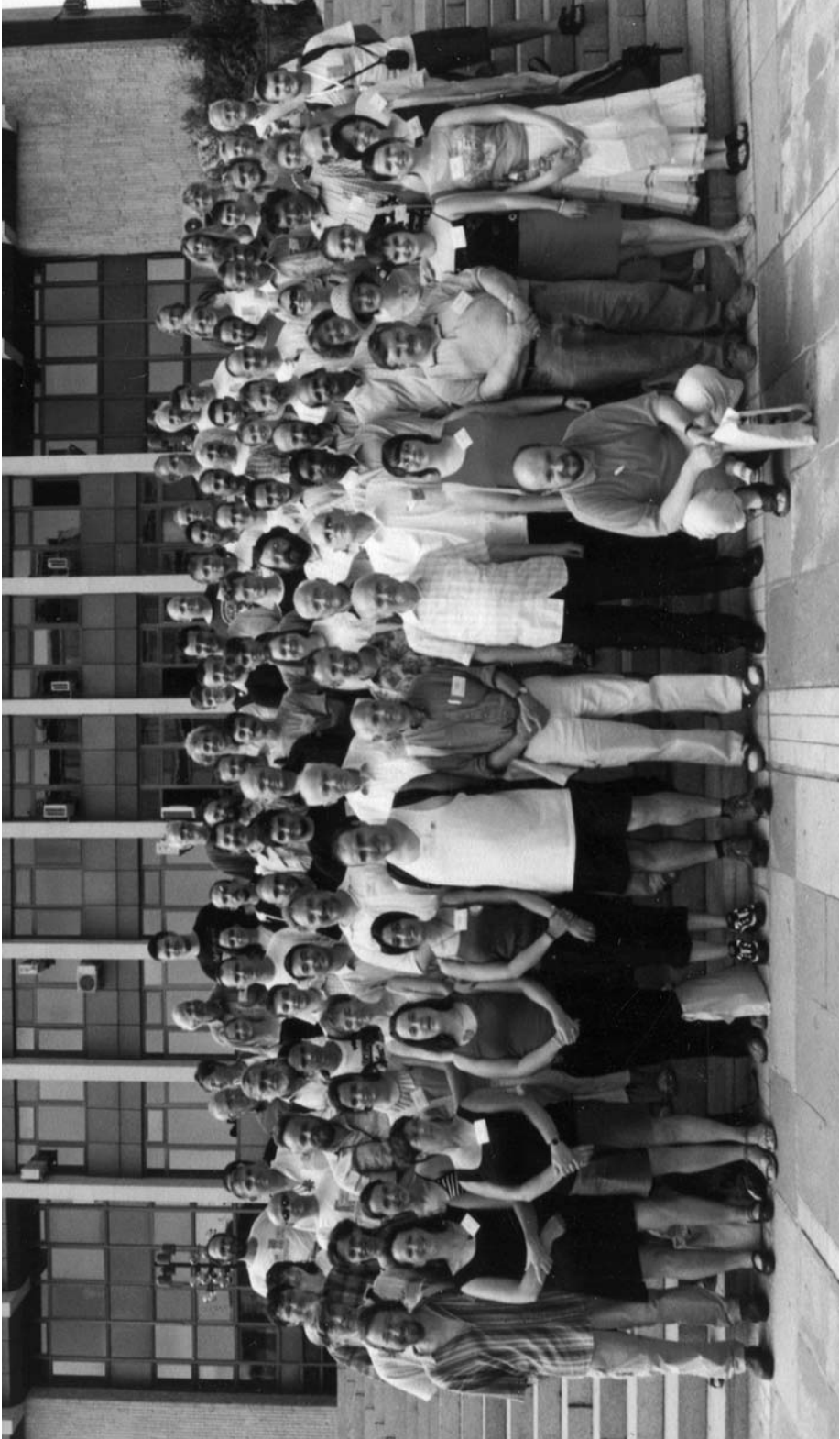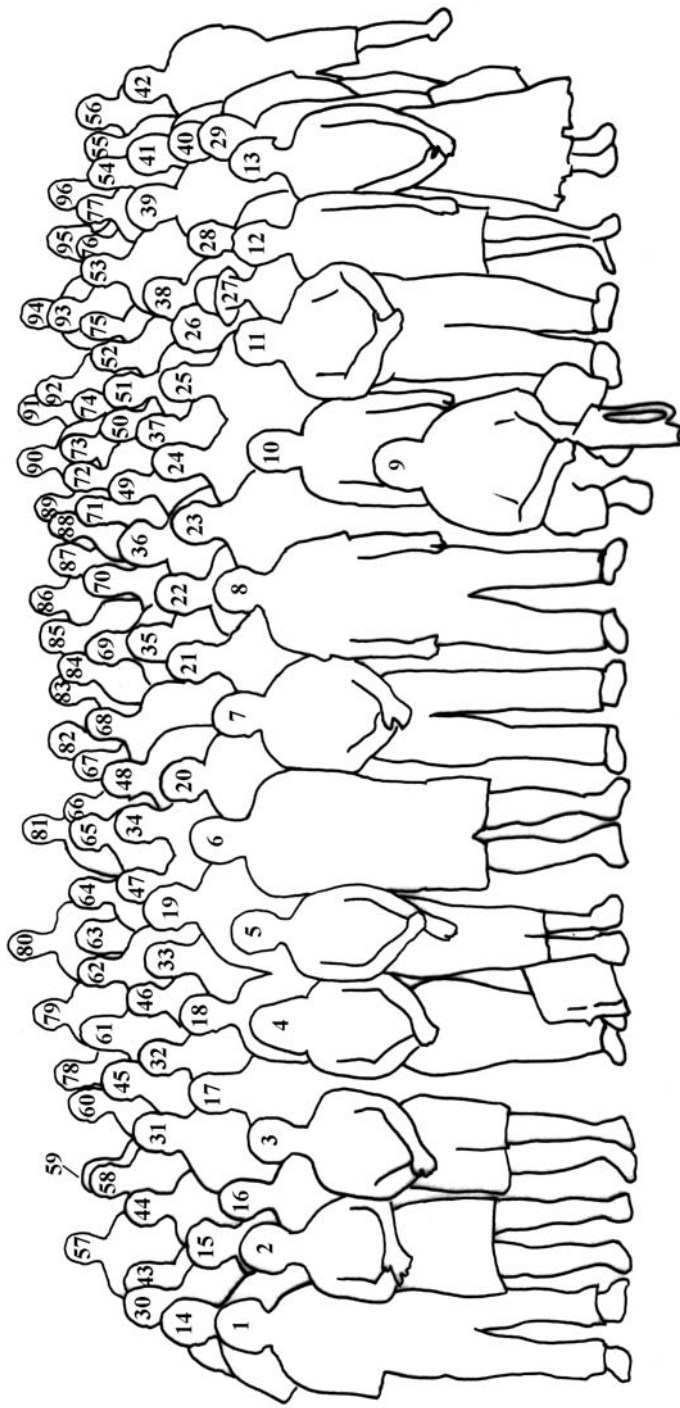
1. Leon Baert 2. Christine Rollard 3. Lut Maelfait 4. Emma Shaw 5. Zahida Bibi 6. David Penney 7. Joachim Haupt 8. Jan Buchar 9. Yuri Marusik 10. Rimma Seyfulina 11. Vladimir Ovtsharenko 12. Tatyana Piterkina 13. Elena Logunova 14. Robert Bosmans 15. Marij Decleer 16. Veerle Versteirt 17. Borbála Szinetár 18. Teréz Szinetár 19. Plamen Mitov 20. Jaroslav Svatoň 21. Vlastimil Růžička 22. Christo Deltshev 24. Ambalaparambil V. Sudhikumar 25. Pothalil A. Sebastian 26. Alena Gajdošova 27. Larisa Logunova 28. Andreea Tatole 29. Galina Azarkina 30. Marjan Komnenov 31. Csaba Szinetár 32. Márton Szinetár 33. Christoph Muster 34. Velin Radenkov 35. Heli Koponen 36. Seppo Koponen 37. Rudy Jocqué 38. Susan Bennett 39. Peter Gajdoš 40. Dirk Kunz 41. Nina Polchaninova 42. Pavel Stoev 43. Rajka Georgieva 44. Toshko Lyubomirov 45. Jean-Pierre Maelfait 46. Angelo Bolzern 47. Holger Frick 48. Ralf Platen 49. Valerio Vignoli 50. Sandra Öberg 51. Peter Jäger 52. Jan Mahnert 53. Alain Canard 54. Julien Petillon 55. Anka Mahnert 56. Folker Mahnert 57. Mario Langourov 58. Stoyan Lazarov 59. Aleksandar Pulev 60. Peter J. van Helsdingen 61. Anja Klan 62. Matiaz Kuntner 63. Clara Gaspar 64. Pedro Cardoso 65. Valery Gnelitsa 66. Dmitri Logunov 67. Johan Van Keer 68. Aleksandar Gromov 69. Stano Pekar 70. Milan Řezáč 71. Jason Dunlop 72. Tuncay Türkeş 73. Aydin Topçu 74. Hakan Demir 75. Tom Gheysens 76. Christophe Herve 77. Geneviève Canard 78. Ingrid Alberti 79. Gerd Alberti 80. Peter Michalik 81. Søren Toft 82. Ward de Spiegelaere 83. Philip Pearson 84. Herman De Koninck 85. Danny Vanacker 86. Theo Blick 87. Kevin Lambeets 88. Osman Seyyar 89. Cathleen Barby 90. Gernot Bergthaler 91. Jakob Walter 92. Christian Kropf 93. Peter Horak 94. Siegfried Huber 95. Filomeen Jocqué 96. Elisabeth Tybaert

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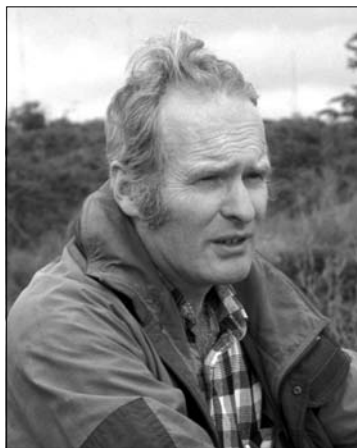
IN MEMORIAM

KONRAD THALER

19th December 1940 - 11th July 2005

In the middle of the summer of 2005 we received the sad and unexpected news of the death of our colleague and friend Konrad Thaler. He died on the 11th of July 2005 when leading a student excursion in the Alps near Innsbruck, the region he knew so well and which was so much "his" territory. He was born in Innsbruck and has lived there whole his life. He was preparing for his retirement early 2006 and making plans how to continue with his work on spiders.

With Konrad Thaler we have lost not only a dear friend and good colleague but also a leading arachnologist. His earliest publication on an arachnological subject dates from 1963. It grew into a steady stream of papers on taxonomical and zoogeographical subjects, some of which still are appearing posthumously. It shows how much he was taken in the middle of active life. The Alpine fauna had his deep interest and he studied the spiders of that mountain range as well as the harvestmen, myriapods and flies. He liked to work together with others and thus his list of publications, recently published in the *Arachnologische Mitteilungen* 21, comprises 220 papers many of which were written in cooperation with other arachnologists. His "oeuvre" covers many different subjects which reflects his broad interest in biology. He strongly contributed to the knowledge of the spider fauna of his own homeland Austria in the first place, directly by studying the spiders himself as well as indirectly by inspiring students and others to work on this group of animals. Gradually he was aiming at a complete overview of the Austrian spider fauna which early this century resulted in his contribution to the checklist of the spiders of several countries in central and western Europe on the internet. Konrad hated to simply repeat old records and was only willing to include data when he was convinced of their correctness. With his wife Barbara he undertook many trips to Greece and published on the species they found there. His taxonomic work was also not restricted to Austria but focussed on the European fauna. He also showed much interest in the history of arachnology and loved to unravel ancient publications and carry out a thorough exegesis of what the old masters wrote. He would be the last person to deny that he wanted to work on spiders every available hour on every available day for as long as he could.

We all have loved Konrad with his gentle manners, such a gentleman and always help-full. We could always rely on his enormous experience and knowledge of spiders and his willingness to share it with others. He loved to work with students and train them to carry out research properly. When visiting his office in the Zoological Institute in Innsbruck it soon

became clear how many people were in frequent contact with him and sought his advice or help. His laboratory always had that warm and pleasant atmosphere and was the inspiring place for many projects. We will not easily forget him. Konrad participated in most colloquiums of the European Arachnological Society and also of the International Arachnological Society, the former Centre International d'Arachnologie (C.I.D.A.), of which he acted as president from 1986-1989.

At the General Assembly of the European Society of Arachnology during the 22nd Colloquium on Arachnology in Blagoevgrad, Bulgaria, he was commemorated and a moment of silence was duly respected as a farewell.

P. J. van Helsdingen

New ideas about the euchelicerate stem-lineage

Jason A. Dunlop[1]

Abstract: Historically, various early Palaeozoic arthropods have been assigned to the fossil stem-lineage of Chelicerata. These include Trilobita and/or a number of extinct taxa belonging to the Arachnomorpha; most of which resemble Xiphosura (horseshoe crabs). However, many of the characters supporting Arachnomorpha fail when applied to Arachnida or Pycnogonida (sea spiders). Pycnogonida resolve either as basal Chelicerata or as sister-group to all other Euarthropoda. Furthermore, a new palaeontological hypotheses is reviewed here which identifies an assemblage of Cambrian 'great-appendage' arthropods (alternatively named protochelicerates or megacherians) as potential stem-group chelicerates. Significantly, these fossils have a robust pair of anterior head appendages and show a possible trend by which they became increasingly raptorial – approaching the condition of the chelate chelicerae. Homology of appendages at the 'head' end of arthropods remains highly controversial, but recent data suggests that chelicerae are homologous with the (a1) antennae. Thus in the scenario presented here euchelicerates did not lose (and indeed never had) long, sensory antennae, but probably evolved their chelicerae from a leg-like pair of uniramous appendages. The head region of the 'great-appendage' arthropods is not a prosoma, but may be segmentally homologous with an anterior body region associated with four pairs of appendages occurring in pycnogonids, many mites (Acari) and in arachnids with a divided carapace, or propeltidium.

Key words: Arthropoda, Chelicerata, stem-lineage, fossil, phylogeny, tagmosis

Introduction

Textbook accounts of Chelicerata usually recognise three major clades (or classes): Arachnida, Merostomata and Pycnogonida. Arachnids and merostomes together form the Euchelicerata WEYGOLDT, PAULUS, 1979; the monophyly of which seems to be one of the most stable and convincing results in arthropod phylogeny (GIRIBET, RIBERA 2000). Resolving euchelicerate ancestors from the fossil record has proven more challenging. Extinct arthropods like trilobites, and a number of other early Palaeozoic fossils which resemble both trilobites and horseshoe crabs, have often been proposed either as the oldest record of chelicerates, or as members of their immediate stem-lineage. Well preserved examples of these fossils often bear antennae – as opposed to chelicerae – leading to the assumption that chelicerates must have lost their antennae in the course of evolution (e.g. STÜRMER, BERGSTRÖM 1978). These putative stem-lineage chelicerates include Trilobita (in particular the Olenellida group), Aglaspidida and Cheloniellida (see below). Some of these fossils were traditionally grouped with chelicerates under the names Arachnomorpha HEIDER, 1913 or Arachnata LAUTERBACH, 1980. Nevertheless, the monophyly of Arachnomorpha has proven difficult to justify, since many of its putative synapomorphies are at best only applicable to trilobites (and similar-looking creatures) and horseshoe crabs – and not to arachnids and pycnogonids (SCHOLTZ, EDGECOMBE 2005).

Euchelicerata must have a sister-group. Among living taxa, Pycnogonida (sea spiders) remain the strongest candidate by virtue of their chelate chelifores. However, recent studies (summarised by DUNLOP, ARANGO 2005) have reduced the number of synapomorphies supporting the traditional

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concept of Chelicerata (see below). Other authors resolved pycnogonids as sister-group to all other (living) arthropods (e.g. Zrzavý *et al*. 1998). With respect to fossil arthropods, an important new hypothesis – reviewed here – has emerged (Bousfield 1995, Chen *et al*. 2004, Cotton, Braddy 2004) which recognises a number of so-called 'great-appendage' fossil arthropods as potential members of the chelicerate stem-lineage. The attractiveness of this new proposal is that if recent data (see e.g. Scholtz 2001, Mittmann, Scholtz 2003) showing the chelicerae and (a1) antennae to be homologous appendages is correct, there is no need to invoke the loss of antennae during chelicerate evolution. Nor must we assume the transformation of a long, flagelliform, sensory limb into a short, claw-like feeding limb. Starting from an ancestor with a fairly generalised anterior head limb (cf. Walozsek *et al*. 2005), a logical sequence can be traced among these 'great-appendage' fossils whereby the first (a1) head limb reduces or consolidates the number of articles and becomes more compact and raptorial; eventually approaching the chelate condition seen in horseshoe crabs and (basal) arachnids.

Results and Discussion

Major Issues in Arthropod Phylogeny

Arthropoda sensu lato is conventionally divided into the Euarthropoda and their stem. This stem-lineage includes the Recent Onychophora (velvet worms), Tardigrada (water bears) and, probably, Pentastomida (tongue worms). It also includes large, predatory extinct animals usually called anomalocaridids (cf. Hou *et al*. 1995, Collins 1996) and early onychophoran-like fossils usually known as lobopodians; see e.g. Ramsköld, Chen (1998) for an overview of the latter. Relationships among these stem-taxa remain largely unresolved, but there is clearly an accumulation of arthropod characters grading towards the euarthropod condition: i.e. a fully sclerotised body with legs attaching via a well-developed coxa (or basipod) and the beginnings of a recognisable head; see e.g. Budd (2002), Bergström, Hou (2003) and Waloszek *et al*. (2005) for recent discussions and alternative evolutionary scenarios. Euarthropoda thus includes Chelicerata, Myriapoda, Hexapoda and Crustacea, as well as many extinct, fossil forms. Of these, Trilobita are the most familiar by virtue of their high diversity (over 10,000 described species), long geological range (ca. 275 million years) and easily preserved, calcified exoskeleton. However, they are only one branch of a much wider group of extinct euarthropods, most of which lack a mineralised exoskeleton and are known primarily from a handful of localities yielding extraordinary preservation. Numerous names have been applied to trilobites plus these similar-looking forms, of which Trilobitomorpha Størmer, 1944 is probably the most widespread. The sub-group Arachnomorpha (see above) largely encompass the most horseshoe crab-like of these trilobitomorphs. Indeed some arachnomorphs were initially regarded as chelicerates and referred explicitly to Merostomata in their original description (see e.g. Walcott 1912).

     Three main hypotheses concerning relationships among the Euarthropoda can be found in the current literature. In brief, a number of studies drawing heavily on palaeontological data have supported (Chelicerata + Crustacea). This TCC (trilobite-chelicerate-crustacean) or Schizoramia hypothesis (Fig. 1) (e.g. Hou, Bergström 1997, Emerson, Schram 1997, Wills *et al*. 1998) recognises the biramous limbs of chelicerates (and trilobitomorphs in general) and crustaceans, as well as some similarities in their embryological development. Alternatively, some molecular data supports (Chelicerata + Myriapoda). This Myriochelata or Paradoxopoda hypothesis (Fig. 2) (e.g. Mallatt *et al*. 2004 and references therein) has been recovered in a number of studies, but so far has relatively little morphological support. Probably the most widely accepted recent result based on combined morphological and molecular data (e.g. Edgecombe *et al*. 2000, Giribet *et al*. 2001) recognises (Euchelicerata + Mandibulata) (Fig. 3). The mandibulates encompass myriapods,
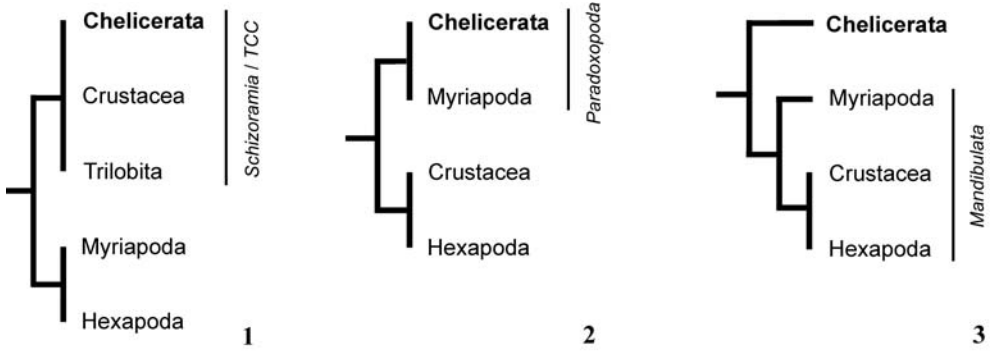
Figs 1-3. Alternative hypotheses in the recent literature for the position of the Chelicerata (see text for details): 1 - Trilobita + Chelicerata + Crustacea, (= Schizoramia or 'TCC' clade); 2 - Chelicerata + Myriapoda (= Paradoxopoda or Myriochelata); 3 - Chelicerata + Mandibulata. Hypothesis 3 seems to have the most widespread support based on current data, although its proponents have, in most cases, not tried to integrate fossil taxa into their analyses.

hexapods and crustaceans – all of which are united by a putatively homologous mandible (see e.g. SCHOLTZ 2001). The position of the Pycnogonida (sea spiders) relative to this scheme is discussed below, but it is also worth noting that most of the studies yielding (Euchelicerata + Mandibulata) or Myriochelata/Paradoxopoda have not tried to integrate fossil arthropods.

Trilobita and Chelicerata

Superficial similarities between trilobites (Fig. 4) and horseshoe crabs (Xiphosura) are self-evident. The fact that both the early instars of living horseshoe crabs and the adults of many fossil xiphosurans express trilobite-like segmentation has also long been recognised (e.g. LOCKWOOD 1870). Even today the hatching instar of horseshoe crabs is called the 'trilobite larva'. LANKESTER's (1881) classic paper firmly established the fact that horseshoe crabs were related to arachnids – and not crustaceans. In LANKESTER's studies, both xiphosurans and trilobites were included within Arachnida; which he divided into a Nomomeristicia grade (euchelicerates and subsequently also pycnogonids) where the segmentation is fairly stable, and Anomomeristicia (trilobites) where segmentation is highly variable. LANKESTER's scheme was not widely adopted, but trilobites continue to be implicitly grouped with chelicerates – even in modern zoological textbooks (e.g. GRÜNER 1993). Some cladistic analyses have also recovered (Chelicerata + Trilobita) (e.g. WHEELER *et al.* 1993), albeit when the diversity of fossil arthropods was ignored and trilobites were the only fossil terminal included.

Olenellid Trilobites

RAW (1957) considered chelicerates to be derived from a hypothetical ancestor of the so-called olenellid trilobites. Olenellids (olenellines is some classifications) (Fig. 4) are a Cambrian group whose most distinctive feature is the fact that the moulting, or facial, sutures of the cephalon (= head shield) run around its margin, and not across the cephalon to form the so-called free cheeks characteristic for other trilobite heads. Much of Raw's evidence for his hypothesis has been superseded by recent work on head segmentation and the homology of the anterior appendages. His paper also relied on a rigid concept of 'merocyclism' in which the postcephalic regions of both trilobites and chelicerates could be characterised into regular patterns of either fifteen, twelve, nine or six segments. Enough deviations from this scheme can be observed among both euchelicerates and trilobites to regard this hypothesis with suspicion, but Raw did make some valid
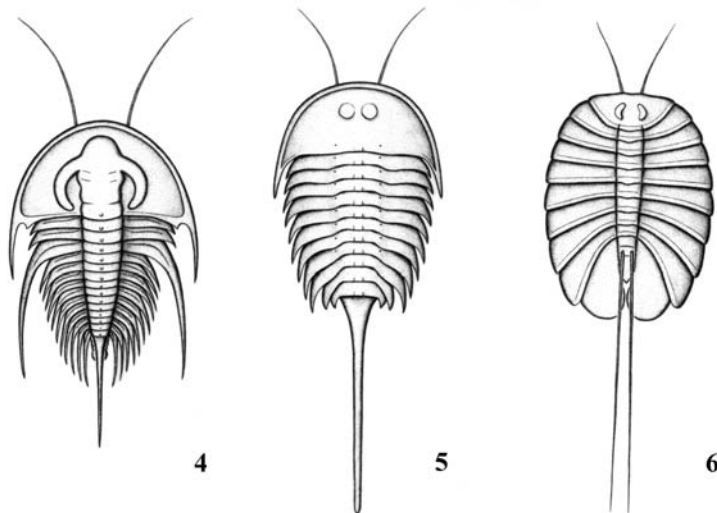
Figs 4-6. Sketch reconstructions of some of the putative members of the chelicerate stem-lineage previously suggested in the literature: 4 - *Olenellus thompsoni* (Trilobita, Olenellida) after LAUTERBACH (1980, fig. 5a); 5 - *Aglaspis spinifer* (Aglaspidida) after HESSELBO (1992, fig. 26-1); 6 - *Cheloniellon calmani* (Cheloniellida) after STÜRMER, BERGSTRÖM (1978, fig. 2). Not to scale. These taxa form part of a wider group of arthropods usually referred to as Arachnomorpha or Arachnata; the monophyly of which has recently been drawn into question (SCHOLTZ, EDGECOMBE 2005).

observations, such as the fact that chelicerates are more 'primitive' than mandibulate arthropods by virtue of the fact that they still use most of their head appendages for walking.

LAUTERBACH (1980, 1983, 1989) recognised an Arachnata clade comprising chelicerates and trilobites. Most controversially here, Trilobita was no longer considered monophyletic. Again the olenellids were the key group and were separated off from the remaining trilobites. LAUTERBACH's Chelicerata was thus divided into (Olenellida + Chelicerata sensu stricto). Three rather complex synapomorphies were proposed in support of this hypothesis: (1) a 'prothorax' of 15 segments behind the cephalon, whereby if thoracic segments 1-2 have become incorporated into the chelicerate prosoma then this character could effectively be scored as a 13-segmented opisthosoma, (2) a macroplural third thoracic segment, i.e. the first opisthosomal segment in chelicerates should be noticeably wider, and (3) a long, median spine on the 15th trunk segment of these trilobites, implicitly homologous with the chelicerate telson. Lauterbach's scheme – heavily based on his own hypothetical groundplan constructs – has found little support in the literature; but see AX (1987) and WEYGOLDT (1998). It was explicitly rejected by HAHN (1989), FORTEY, WHITTINGTON (1989) and RAMSKÖLD, EDGECOMBE (1991), all of whom articulated numerous autapomorphies for Trilobita while drawing attention to the weakness of Lauterbach's synapomorphies, such as the fact that axial spines and macropleural segments have evolved in different places in different trilobite taxa.

From a chelicerate perspective, the three proposed synapomorphies also deserve discussion. A thorax of 15 segments (= an opisthosoma of 13 segments) has some merit in that there are chelicerates, such as scorpions, apparently with 13 opisthosomal segments (DUNLOP, WEBSTER 1999). However, segment numbers are variable across the different euchelicerate orders and we have no obvious way to determine which of these patterns represents the ancestral condition. The median spine/telson homology is conceivable, but lacks explicit morphological support. Lots of arthropods have a telson. A macroplural third segment (= opisthosomal segment 1) is by far the weakest character. The trend, if anything, among chelicerates is to reduce or modify this segment;

the narrow pedicels of spiders and some other arachnids being a case in point. Lauterbach offered no clear example of an unequivocally 'macroplural' euchelicerate. In summary, none of his ole-nellid/chelicerate characters are particularly convincing and better evidence for a monophyletic Trilobita has been presented.

Aglaspidida

Aglaspidida (Fig. 5) are a group of mostly Cambrian arthropods, which (like trilobites) at least superficially resemble horseshoe crabs. HESSELBO (1992) provided a valuable overview. The monograph of RAASCH (1939) referred Aglaspidida to Merostomata based on one well-preserved specimen interpreted as showing six pairs of prosomal appendages, the first of which was suppos-edly chelate. For this reason it is still possible to read about horseshoe crabs being classic 'living fossils', unchanged since the Cambrian. In fact there are no unequivocal Cambrian horseshoe crabs and a putative Ordovician stem-xiphosuran (or stem-chelicerate according to DUNLOP, SELDEN 1998) turned out not to be an arthropod at all (MOORE, BRADDY 2005). The oldest unequivocal Xiphosura are Silurian in age (e.g. MOORE *et al.* 2005), while the oldest modern-looking crown-group examples – assignable to the extant clade Xiphosurida – come from the Carboniferous (ANDERSON, SELDEN 1997). On current evidence some arachnid orders (Acari, Opiliones, Pseudo-scorpiones) with modern-looking Devonian representatives are better examples of 'living fossils' than horseshoe crabs.

Raasch's merostome interpretation of Aglaspidida was widely accepted in the subsequent literature (e.g. STØRMER 1944). The hypothesis that Aglaspidida are specifically the sister-group of the remaining chelicerates owes much to the influential cladogram of WEYGOLDT, PAULUS (1979). In this paper they broadly accepted Lauterbach's hypothesis (see above), recognising a scheme of the form (Trilobita (Olenellida (Aglaspidida + Euchelicerata)))). Aglaspidids and euchelicerates were grouped together based on four putative synapomorphies: (1) reduced antennae, (2) chelate chelicerae, (3) two thoracic segments fused to the head to form a prosoma and (4) a predatory mode of life. However, in the same year BRIGGS *et al.* (1979) re-examined the key specimen of *Aglaspis spinifer* RAASCH, 1939 from the Late Cambrian of Wisconsin, which was supposed to show chelicerate characters. BRIGGS *et al.* concluded that in fact it had only four, or at most five, pairs of head appendages and that the first pair was not demonstrably chelate. HESSELBO (1992) confirmed this view, suggesting that the first pair of appendages were probably antenniform in life. These studies thus undermine the first three synapomorphies, while the fourth relates to behaviour and cannot be adequately tested in a fossil. Weygoldt and Paulus's hypothesis still commands some support in the literature (AX 1987, WEYGOLDT 1998), while other authors have resolved aglaspidids fairly close to the chelicerates (e.g. WILLS 1996, WILLS *et al.* 1998, DUNLOP, SELDEN 1998). Despite this apparent consistency in phylogenetic analysis, robust and unequivocal synapomorphies exclusive to (Aglaspidida + Euchelicerata) are lacking.

Cheloniellida

Cheloniellida (Fig. 6) encompasses at least six Ordovician–Devonian arthropods which have also been resolved as possible members of the chelicerate stem-lineage (e.g. STÜRMER, BERGSTRÖM 1978, WILLS 1996, WILLS *et al.* 1998, DUNLOP, SELDEN 1998). All are oval arthropods which superficially resemble isopod crustaceans. Well preserved examples have both anterior antennae and posterior furcal rami. The best known example is *Cheloniellon calmani* BROILI, 1932 from the Early De-vonian Hunsrück slates of Germany. It was redescribed in detail by STÜRMER, BERGSTRÖM (1978) who used radiographic techniques to reveal previously hidden characters, and who discussed its possible affinities. In brief, the anterior head region of *C. calmani* includes antennae, a pair of leg-like postantennal appendages and four pairs of strongly gnathobasic head limbs. This is fol-

lowed by a trunk of biramous limbs with well-defined exopods, presumably acting as gills. Thus *C. calmani* seems to approach the chelicerate condition of functional tagmosis into a 'prosoma' dominated by gnathobasic food-processing limbs and an 'opisthosoma' including respiratory appendage branches. However, *C. calmani* lacks chelicerae and in the homology scheme of Stürmer and Bergström has only five pairs of 'prosomal' limbs, not six as per euchelicerates, leading these authors to suggest that it may be late representative of the trilobitomorph branch which gave rise to the chelicerates.

Arachnomorphs and Their Antennae

Other arachnomorphs have also been proposed, usually rather speculatively, either as early chelicerates or their relatives; see e.g. COTTON, BRADDY (2004) for a review. Yet there are difficulties with the general Arachnomorpha / Arachnata concept. First, the limits of what actually belongs within this group are not particularly stable. RAMSKÖLD *et al.* (1997, p. 19) attempted to resolve this by defining Arachnata as "…the most inclusive clade including Chelicerata but not Crustacea." while WILLS *et al.* (1998, p. 74) stated that Arachnomorpha "…accommodates most non-bivalved Cambrian problematica in addition to trilobites and chelicerates". This leads neatly into the second problem. For the most part arachnomorphs have not been characterised by unequivocal synapomorphies and were effectively defined as 'not being crustaceans'. BRADDY, COTTON (2004) did recover Arachnomorpha as a clade (rather than a paraphyletic grade), recognising three potential synapomorphies (their characters 12, 17 and 48). The first was absence of a multiannulate shaft of the exopod limb branch, with each article bearing setae; a reductive apomorphy, scored as present in crustaceans. Second, was the lack of medially directed exopod setae, scored as an arachnomorph plesiomorphy relative to their presence in crustaceans. Their final character was an anus opening at the base of the arachnomorph telson, rather than within the telson itself. An anus opening within the telson is, however, present in at least one fossil pycnogonid (cf. DUNLOP, ARANGO 2005), thus the latter character does not encompass all chelicerates as they are traditionally recognised.

Another problem is the fact that, unlike chelicerates, many fossil arachnomorphs preserve very obvious antennae. A widespread assumption in the older literature was that trilobites were the most 'primitive' arthropods, thus chelicerate ancestors were predicted to have had long, flagelliform, trilobite-like antennae. As part of this hypothesis, it was also assumed that the chelicerae represent the second (so-called a2) head appendage, innervated from the tritocerebrum of the brain, and that chelicerates had simply lost their (a1) antennae. All this changed in 1998 with studies of the distribution of Homeobox (Hox) genes in the head region of arthropods (DAMEN *et al.* 1998, TELFORD, THOMAS 1998, review by SCHOLTZ 2001). By lining up segmental expression patterns of homologous genes, these papers demonstrated that both the chelicerae and (first) antennae of mandibulate arthropods are in all likelihood expressions of the same (a1) head appendage. MITTMANN, SCHOLTZ (2003) found further evidence in the horseshoe crab brain to support this hypothesis. They described the commissure of the cheliceral ganglion as running primarily in front of the stomodaeum, which strongly implies that the chelicerae are innervated from the deuterocerebrum – like the (a1) antennae of insects and crustaceans – and not the tritocerebrum as previously assumed. BOXSHALL (2004: 257-261) provided a further detailed review of the diversity of character states (and terminologies) observed for the uniramous (a1) appendage (ranging from antennae to chelicerae) in fossil and Recent arthropods, and current controversies in their interpretation. Further palaeontological work supports the idea that it is most parsimonious to assume that stem-chelicerates did not have antennae (MOORE 2005).

WALOSZEK, DUNLOP (2002) and COTTON, BRADDY (2004) noted pycnognid and arachnomorph fossils bearing putative precheliceral structures which might represent vestiges of the 'missing' (a1) antennae. However, SCHOLTZ (2001) mentioned potentially homologous frontal processes in front

of the (a1) antennae in some crustaceans. Developing this line of thought, SCHOLTZ, EDGECOMBE (2005) questioned the interpretation of at least some of the fossils reported to have precheliceral appendages while proposing a novel, but controversial, scheme of 'primary' and 'secondary' antennae. Here the 'primary antennae' are interpreted as homologous with the protocerebral antennae of Onychophora, which in their scheme became largely lost in the evolution towards the euarthropods. The 'secondary' (a1) antennae or chelicerae are, by contrast, demonstrably deuterocerebral in origin (see above) and thus not homologous with onychophoran antennae. If Scholtz and Edgecombe are correct, structures like crustacean frontal processes and precheliceral structures in fossil chelicerates and their stem-lineage could (when present) potentially be vestigial remnants of these protocerebral 'primary' antennae. Further discussion is beyond the scope of the present paper, but on current data the chelicerae = (secondary) antennae model appears the more robust hypothesis.

The End of Arachnomorpha?

SCHOLTZ, EDGECOMBE (2005) explicitly rejected Arachnomorpha as a clade, outlining arguments against the features traditionally used to ally trilobites (and certain other trilobitomorphs) with chelicerates; see these authors for details. In summary, they argued that most of the proposed arachnomorph characters – including trilobation, a broad head shield with genal spines and a rather soft ventral side to the body – are at best relevant only to trilobites and horseshoe crabs and are largely absent (or inapplicable) in arachnids and pycnogonids. On these grounds trilobites, aglaspidids, cheloniellids, etc. would have to be excluded from the stem-lineage of Chelicerata; an opinion which the present author largely supports. Scholtz and Edgecombe proposed (like BOUDREAUX 1979) that trilobites, and related forms, actually belong on the mandibulate stem-lineage, whereby their sensorial (a1) antennae offers a potential synapomorphy for (Trilobita + Mandibulata); differing, in their hypothesis, from the short, raptorial (a1) chelicerae of the euchelicerates and pycnogonids.

Pycnogonida

Pycnogonid affinities were reviewed by DUNLOP, ARANGO (2005) who summarised the literature to date and recognised three main historical hypotheses: (1) chelicerates, (2) crustaceans, or (3) unrelated to all other arthropod groups. Affinities with crustaceans were mostly based on crude similarities in the larvae, and in detail the crustacean nauplius larva and pycnogonid protonymphon are evidently rather different. There are no convincing synapomorphies for (Pycnogonida + Crustacea) and this relationship has not been recovered in any recent analyses. Other authors (e.g. HEDGPETH 1947) emphasised the uniqueness of pycnogonid morphology, using this as evidence against affinities with any other arthropod group. Characters like the pycnogonid proboscis and the reduced body with organ systems displaced into the legs are indeed unusual, but they are autapomorphies and tell us nothing about sister-group relationships.

Recent studies, including both morphological and/or molecular data, essentially favour one of two competing hypotheses. The first is the traditional (Pycnogonida + Euchelicerata) (Fig. 7), which was supported by three synapomorphies: (1) chelate chelicerae, (2) loss of antennae and (3) a body divided into a prosoma and opisthosoma. There are also further potential synapomorphies in the circulatory system and in embryology. Yet of the traditional characters, only chelicerae stand up to scrutiny; see e.g. WALOSZEK, DUNLOP (2002) for details. Loss of antennae is just an alternative character state for presence of chelicerae (see above). Yet even the homology of chelicerae (euchelicerates) and chelifores (in pycnogonid terminology) has recently been questioned based on neuroanatomical data (MAXMEN *et al.* 2005). These authors suggested that the pycnogonid chelifores are innervated from the protocerebrum and are thus topologically anterior
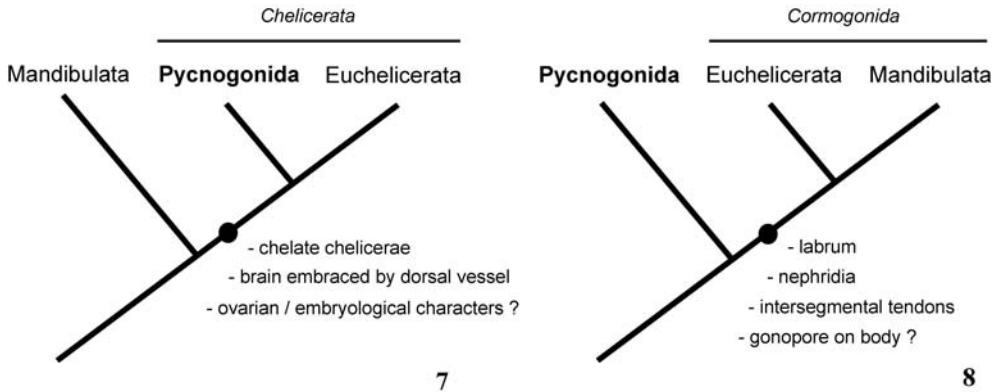
Figs 7-8. Alternative positions for the Pycnogonida (sea spiders) recovered in recent cladistic analyses: 7 - sister-group of Euchelicerata; 8 - sister group of Euarthropoda. Synapomorphies potentially supporting each of these models were discussed in detail by DUNLOP, ARANGO (2005).

to the position of the (a1) chelicerae (see above) which are innervated from the deuterocerebrum, as shown by MITTMANN, SCHOLTZ (2003). If Maxmen *et al.* are correct, one of the key characters supporting Chelicerata in its traditional sense would fail and pycnogonid chelifores would be in a homologous position to the 'primary' antennae postulated by SHOLTZ, EDGECOMBE (2005) and/or the protocerebral antennae of Onychophora (see above). Nevertheless, a recent test identifying Hox gene distributions in pycnogonids (JAGER *et al.* 2006) does not support the Maxmen *et al.* scenario, but rather supports the hypothesis that chelifores = chelicerae; both in the a1 position as elaborated above. Further comments on this controversial and rapidly evolving field are beyond the scope of the present paper.

The puzzling 'extra' (7th) limb pair in the pycnogonid prosoma is resolved by a simple count of appendages. This reveals that the 'prosoma' and 'opisthosoma' of pycnogonids are not segmentally homologous to those of euchelicerates (VILPOUX, WALOSZEK 2003, and references therein). Pycnogonids have a cephalosoma bearing four pairs of appendages (chelifores, palps, ovigers, walking leg 1) plus a trunk with three (rarely four or five) pairs of walking legs and a short tail end (abdomen) bearing the anus. Some fossil forms retain a few limbless segments, and in one case a telson, behind the legs. Thus a simple prosoma-opisthosoma division, in which the prosoma has six pairs of limbs, also fails to support the traditional concept of Chelicerata.

The alternative model (Fig. 8) is (Pycnogonida + (Euchelicerata + Mandibulata)), a scheme first articulated by ZRVARÝ *et al.* (1998), who united euchelicerates and mandibulates in a clade called Cormogonida ZRVARÝ, HYPSA, VLÁSKOVÁ, 1998. This they defined on the synapomorphy of a gonopore on the body, rather than on the leg bases as in pycnogonids. The problem here is that appendicular gonopores have long been accepted as a convincing sea spider autapomorphy. Nevertheless, other studies have also recovered pycnogonids in a basal position relative to all other (living) euarthropods (EDGECOMBE *et al.* 2000, GIRIBET *et al.* 2001). Characters absent from pycnogonids and potentially synapomorphic for euchelicerates and mandibulates include a labrum, nephridia and intersegmental tendons. Yet, identifying 'missing' characters as plesiomorphic or apomorphic in pycnogonids is complicated by the numerous reductive trends seen in their body and organ systems.

VILPOUX, WALOSZEK (2003) also noted that the three-limbed protonymphon of pycnogonids is shorter than the four-limbed 'head larva' interpreted by these authors as characteristic for early Euarthropoda. This head larva is observable in, for example, trilobites and stem-group crustaceans, whereby the shorter nauplius is a later development of the crustacean crown-group. Perhaps pycno-

gonids represent a more plesiomorphic grade of organisation, hatching with a three-limbed larva? In this hypothesis the remaining, more derived, euarthropods would have in their ground pattern the synapomorphy of a four-limbed head larva – which was subsequently modified in modern arthropod groups. For example euchelicerates hatch more precociously. Their first instar closely resembles the adult form, thus they no longer express a true larval stage of development.

In summary, it is presently difficult to resolve between pycnogonids being basal chelicerates or basal euarthropods and further studies directed specifically at this question would be welcome.

‘Great-Appendage’ Arthropods: Stem-Chelicerates?

So what is the sister-group of Euchelicerata? Using a construction morphology approach GRASS-HOFF (1978, p. 277) argued that the chelicerate grade of organisation must have arisen when their ancestors transformed the first appendage into something able to both detect and grasp food. In a rather obscure and poorly-known paper, BOUSFIELD (1995) compared feeding appendages in early fossil arthropods. He proposed that the distinctly raptorial head limbs in some specific arachnomorphs (see above) like *Yohoia tenuis* WALCOTT, 1912 (Fig. 9) from the famous Burgess Shale of Canada and *Jianfengia multisegmentalis* HOU, 1987 (Fig. 10) from the slightly older Chengjiang (or Maotianshan-Shale) fauna of China were effectively precursors of the chelicerae. These two genera were reassigned by Bousfield to the higher taxon Protochelicerata STØRMER, 1944 – although this name was originally proposed to encompass some quite different genera – redefined as animals with semi-chelate, preoral appendages composed of 4-5 articles, plus three more pairs of biramous head limbs used for walking. Protochelicerates sensu Bousfield were effectively placed on the lineage leading up to chelicerates (BOUSFIELD 1995, Fig. 7.), and indeed something similar was found by BRIGGS, FORTEY (1989) when one compares those arthropods which resolved close to chelicerates in their early cladistic analysis.

CHEN *et al.* (2004) and COTTON, BRADDY (2004) recently arrived independently at essentially the same hypothesis. They recognised a series of so-called ‘great-appendage’ arthropods which they resolved cladistically on the direct stem-lineage leading towards chelicerates. Their examples of these ‘great-appendage’ arthropods include (as in Bousfield’s scheme) *Yohoia* and *Jianfengia* as well as other Maotianshan-Shale fossils like *Parapeytoia yunnanensis* HOU *et al.*, 1995, *Fortiforceps foliosa* HOU, BERGSTRÖM, 1997 (Fig. 11) and *Haikoucaris ercaiensis* CHEN *et al.*, 2004 (Fig. 12). It should be noted that interpretations of *Fortiforceps* are controversial, specifically in the Hou and Bergström description explicit antennae in front of the great-appendage were recognised; an interpretation not accepted by e.g. CHEN *et al.* (2004) who found no such structures in the nevertheless similar-looking *Haikoucaris*.

Yet, what these remarkable creatures all have in common is a ‘head’ region apparently bearing at least four pairs of appendages, the (?) first of which has around five articles and is relatively robust, somewhat raptorial and presumably played an active role in grasping prey. The other head limbs, and the limbs of the segmented trunk, are biramous with a leg-like endopod and a flap-like expopod bearing marginal spines or setae (Figs. 9-12). Chen *et al.* and Cotton and Braddy differed slightly in the details – the latter also using the name Megacheria HOU, BEGSTRÖM, 1997 for these taxa – but their main conclusion was that these arthropods can be arranged in such a way on the chelicerate stem-lineage that they show a general trend towards a more claw-like head limb (Fig. 13). Thus ‘protochelicerates’ or ‘megacherians’ would probably represent a paraphyletic series of stem-taxa, rather than a monophyletic clade. Implicit in this hypothesis is of course the homology of the ‘great-appendage’ with the chelicera – but see BUDD (2002) and MAXMEN *et al.* (2005) for an alternative perspective whereby the ‘great-appendage’ and perhaps also the pycnogonid chelifore are effectively ‘precheliceral’. If the ‘great-appendage’ is homologous with the chelicera
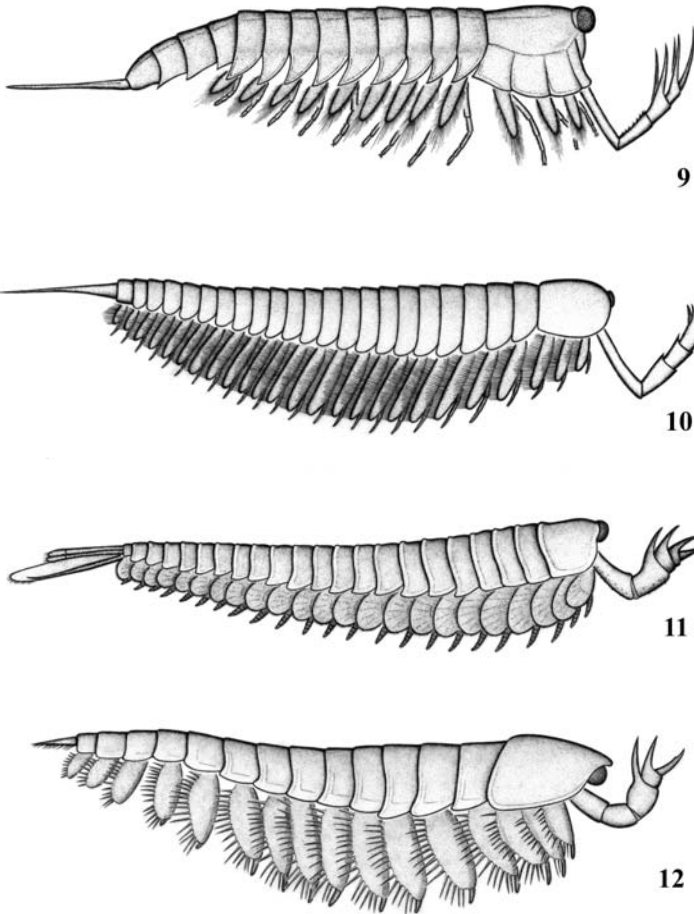
Figs 9-12. Sketch reconstructions of selected 'great-appendage', 'protochelicerate' or 'megacherian' arthropods recently suggested as members of the chelicerate stem-lineage: 9 - *Yohoia tenuis* after DUNLOP, ARANGO (2005, fig. 6); 10 - *Jianfengia multisegmentalis* modified from HOU 1987 (fig. 10); 11 - *Fortiforceps foliosa* modified from HOU, BERGSTRÖM (1997, figs 33C, 35); 12 - *Haikoucaris ercaiensis* after CHEN *et al.* (2004, fig. 3). Not to scale. Note that in some cases earlier descriptions were quite poor and/or other authors have reconstructed these taxa slightly differently; sometimes even with 'precheliceral' appendages. Nevertheless a large, probably raptorial head appendage does seem to be a consistent and genuine feature of all of them.

then Chen *et al*. regarded the chelicerae and their forerunners as the (a1) appendage, while Cotton and Braddy preferred the traditional, but now less well-supported, (a2) interpretation.

The advantage of this 'great-appendage' = chelicerae hypothesis is that if the Hox gene and (most) neuroanatomical data is accepted, we have a scenario whereby the chelicerae evolved through a series of ancestors with increasingly chelate anterior head appendages. There is no need to invoke either the loss of antennae or the transformation of a long, sensory appendage into a short claw. Chelicerae need not be "…profoundly modified antennules." sensu BOXSHALL (2004, p. 260) if they evolved from ambulatory rather than a sensorial first head limbs. This remains an area of much controversy since we do not know for sure what the original (a1) limb was like in the (eu)arthropod common ancestor: a leg, an antenna or a claw? The fossil data can be ambiguous or open to alternative interpretations. As a possible outgroup, the Maotianshan-Shale arthropod
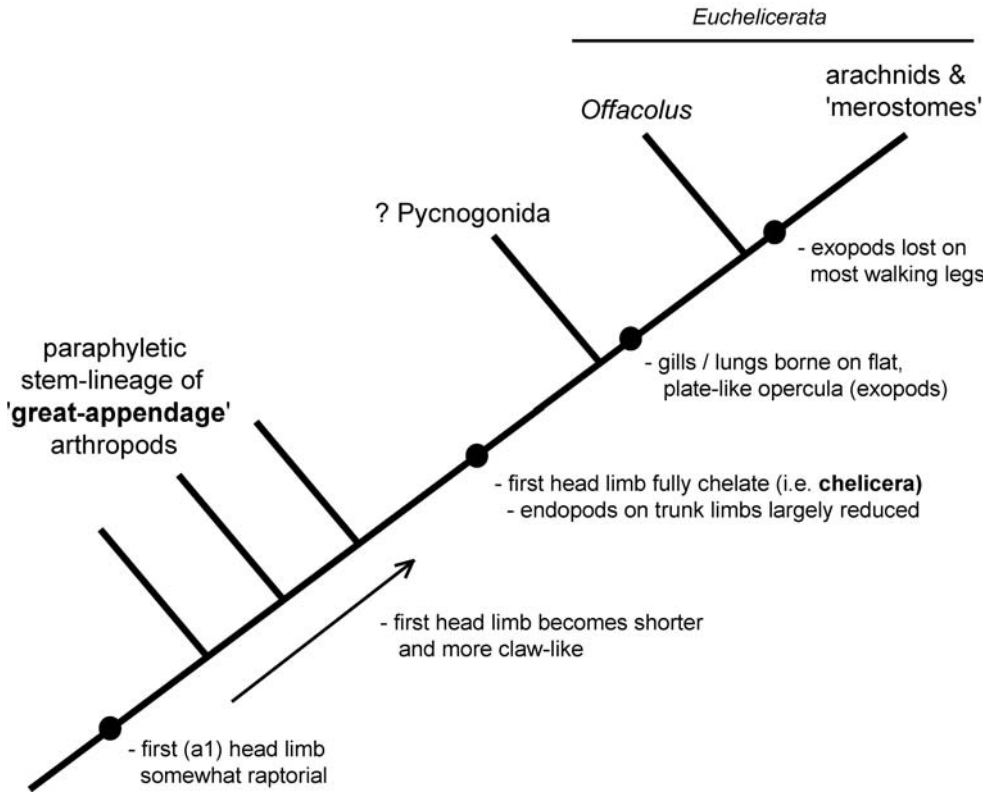
Fig. 13. A tentative scenario for euchelicerate origins illustrating the major transformations in limb morphology implied by the new 'great-appendage' arthropod hypothesis. See text for details.

Fuxianhuia protensa Hou, 1987 – itself once considered an early chelicerate (Wills 1996) – was recently restudied by Waloszek *et al.* (2005) in combination with some similar fossils. These *Fuxianhuia*-like fossils may resolve just below the euarthropod grade of organisation, although different authors have disagreed quite fundamentally on the number and position of its head appendages (cf. Wills 1996, Hou, Bergström 1997, Scholtz, Edgecombe 2005, Waloszek *et al.* 2005).

 Fuxianhuia and its relatives have, at least in the Waloszek *et al.* (2005) hypothesis, a relatively short, somewhat leg-like (a1) appendage. If the same were true of the last common ancestor of the Euarthropoda, this fairly simple anterior limb could conceivably evolve in various directions: including a long, sensory structure, as per trilobites, or a more raptorial one, via the 'great-appendage' arthropods, to the chelicerae. Thus whether antennae evolved once (Scholtz, Edgecombe 2005) or multiple times (Waloszek *et al*. 2005) remains to be resolved. Likewise, it is too early to rule out the possibility that claw-like limbs also developed in more than one lineage since this is clearly an adaptive character with a clear functional advantage – witness the almost certainly parallel development of (sub)raptorial pedipalpal claws for prey-capture in groups like scorpions and whipscorpions. Yet in the 'great-appendage' arthropods we now have one group of early fossil arthropods which (probably) lack antennae, which have raptorial feeding limbs instead, and thus appear to be excellent candidates for the animals which ultimately gave rise to the arachnids.

Missing Links?

These 'great-appendage' arthropods still differ in significant ways from euchelicerates, retaining for example plesiomorphic features like biramous limbs along the entire length of the body. If the

hypothesis that they are stem-lineage chelicerates is correct we would still expect to find some 'missing links' bridging this morphological gap, whereby the more anterior limbs lose the exopod and become primarily adapted for walking while the posterior ones are either lost completely or modified into plate-like, gill-bearing opercula. The enigmatic Silurian fossil *Offacolous kingi* ORR *et al*., 2000 might be such a missing link. These authors reconstructed this probable early chelicerate from computer images of serial sections through the nodules which encase them and discovered that most of its prosomal appendages are still biramous. This suggests a more basal grade of organisation than xiphosurans which have only one biramous limb pair (the 6th) bearing the flabellum (Fig. 12).

Interestingly, the 'great-appendage' arthropods lack clear tagmosis into a prosoma and opisthosoma and express a head region probably bearing four pairs of appendages, including the raptorial pair. This 'head' in the chelicerate stem-lineage associated with four limb pairs is potentially segmentally homologous with the cephalosoma of pycnogonids (VILPOUX, WALOSZEK 2003, see also above), to the propeltidium of the carapace in some arachnids and the proterosoma region characteristic for many mites (see also DUNLOP, ARANGO 2005, fig. 5). Thus the 'great-appendage' hypothesis might alter interpretations of polarity for a number of arachnid characters.

A Final Word: *Sanctacaris*

Finally, one of the most famous candidates for the oldest chelicerate is *Sanctacaris uncata* BRIGGS, COLLINS, 1988 from the Burgess Shale; a fossil which has entered the popular literature (e.g. GOULD 1989) as an arachnid ancestor. In the original description it was specifically referred to Chelicerata on account of: (1) a head with at least six pairs of appendages, (2) a cardiac lobe, i.e. a swelling on the head shield such as that seen in horseshoe crabs, (3) division of the body into a putative prosoma and opisthosoma and (4) an anus on the last trunk segment. A common criticism of this interpretation is the fact that it lacks chelicerae (or antennae for that matter), although BOXSHALL (2004) suggested that chelicerae might be present, but indistinct. BUDD (2002) has even proposed that the 'six' pairs of prosomal limbs are just outgrowths from the articles comprising a single pair of 'great-appendages' (see above). Arachnomorph cladograms (e.g. WILLS *et al.* 1998) generally did not resolve *Sanctacaris* as sister-group of Chelicerata, drawing its affinities into question. Interestingly, what Wills *et al*. did recover was *Sanctacaris* close to *Yohoia*. Bearing in mind the new position proposed for *Yohoia* on the chelicerate stem-lineage, and the possibility that *Sanctacaris* has 'great-appendages' too, a new look at the affinities of *Sanctacaris* is clearly warranted. Its interpretation as a stem-lineage chelicerate may yet prove to be correct, albeit for different reasons to those proposed in the original description.

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Нови идеи за предшествениците на еухелицератите

Дж. Дънлоп

(Резюме)

В исторически план различни раннопалеозойски артроподи са били смятани за предшественици на хелицератите (Chelicerata). Сред тях са трилобитите (Trilobita) и фосилни видове, принадлежащи към Arachnomorpha, повечето от които наподобяващи ксифозурите (Xiphosura). Въпреки това, много от белезите, подкрепящи таксона Arachnomorpha, не издържат на проверка, когато са приложени към Arachnida и Pycnogonida (морските паяци). Пикногонидите се оказват или в основата на хелицератите или като сестринска група на всички останали еуартроподи (Euarthropoda). В настоящата статия е представена нова палеонтологична хипотеза, определяща групата от камбрийски „голямоиздатъчни" (great-appendage) артроподи (носещи наименованието протохелицерати или мегахериани), като потенциални предшественици на хелицератите. От значение е, че тези животни са имали двойка големи издатъци на предната част на главата, като се наблюдава тенденция, при която те се превръщат все повече в хватателни, така приближавайки се до състоянието на хелатните хелицери. Хомоложността на различните издатъци на края на главата на артроподите е много дискусионен въпрос, но последните данни показват, че хелицерите са хомоложни с *a1* антените. В представения модел, еухелицератите никога не са загубвали дълги, сензорни антенни (всъщност не са имали такива), а най-вероятно са развили хелицерите си от двойка кракоподобни, еднораменни издатъци. Главовата част на голямоиздатъчните артроподи не е прозома, а е вероятно сегментно хомоложна на тази предна част на тялото, която носи четирите двойки израстъци при пикногонидите, повечето акари и при арахнидите с разделен карапакс или пропелтидиум.

Assembling the Tree of Life—Phylogeny of Spiders: a review of the strictly fossil spider families

David Penney[1], *Paul A. Selden*[1]

Abstract: The project Assembling the Tree of Life (AToL)—Phylogeny of Spiders is an ambitious, collaborative, six-year project, which aims to construct a robust cladogram for all spider families. The resulting phylogeny will be based on morphological, molecular, behavioural and palaeontological data. Fossil spiders are not considered in current systematic catalogues. As a first step to compiling the required palaeontological data for the AToL project, this paper reviews all previously described fossil spider families. To date, twenty strictly fossil spider families have been described. One has subsequently had extant species discovered (Archaeidae), others have been synonymized with extant families (Acrometidae, Adjutoridae, Arthrodictynidae, Mithraeidae, Mizaliidae), some are valid taxa (Permarachnidae, Juraraneidae, Lagonomegopidae, Baltsuccinidae, Ephalmatoridae, Insecutoridae, Protheridiidae, Spatiatoridae) and others are in need of revision (Arthrolycosidae, Arthromygalidae, Pyritaraneidae, Inceptoridae, Parattidae). None of the fossil specimens attributed to Archaeometidae are spiders.

Key words: amber, Araneae, fossil record, palaeontology

Introduction

The project Assembling the Tree of Life (AToL)—Phylogeny of Spiders is an ambitious six-year project funded by the US National Science Foundation (NSF), which aims to construct a robust cladogram for all spider families (HORMIGA *et al*. 2004; http://research.amnh.org/atol/files/index.html). The resulting phylogeny will be inferred from a character matrix of unprecedented dimensions (>20 million cells) and will consist of morphological, molecular, behavioural and palaeontological data. Including fossils in such a large-scale and multi-disciplinary approach sets an important precedent for future projects on other groups. Although taxonomically subequal to Recent specimens, some fossils, particularly those in amber, are often preserved with life-like fidelity. Strictly fossil families may share character states with extant families and help resolve their correct placement in the resulting phylogeny. The fossil taxa from extinct families will be scored as far as possible and included in the data matrix. More importantly, fossils form a means by which the final tree can be calibrated over geological time, by providing minimum dates for the observed phylogenetic dichotomies. The age–clade congruence of the tree can be used to provide additional support for the final phylogeny.

As a first step to compiling the required palaeontological data, this paper reviews all previously described strictly fossil spider families. Early reviews of the spider fossil record (SCUDDER 1886, 1891, PETRUNKEVITCH 1955) were based on different classification schemes to that which exists at present. In addition, the taxonomy of many earlier workers clearly warrants reassessment (see discussion in SELDEN 1993a). Since these earlier works, many more fossil spiders have been described and recent reviews (e.g. SELDEN 1993b, 1996, SELDEN, PENNEY in prep.) included fossils from both extant and extinct families but at most provided 'first and last' occurrence data, and thus

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did not provide complete species listings for each family. The aim here is to update these works by presenting a complete list of all species (including holotype repository data) originally placed in strictly fossil spider families and by commenting on their current taxonomic status.

The Strictly Fossil Spider Families

Occasionally, fossil spiders are described that do not show enough features to assign them to extant families, yet new genera are erected e.g. *Palaeouloborus* SELDEN, 1990, *Macryphantes* SELDEN, 1990, *Attercopus* SELDEN, SHEAR, 1991 (in SELDEN *et al.* 1991), *Triassaraneus* SELDEN, 1999 (in SELDEN *et al*. 1999) and *Argyrarachne* SELDEN, 1999 (in SELDEN *et al*. 1999). The temptation might be to assign these taxa to new fossil families based on plesiomorphic characters as was done for example by ESKOV (1984) with the family Juraraneidae. Because of a lack of autapomorphic features, the temptation then is to synonymize these metataxa (sensu SMITH 1994) with the closest available extant taxa, thus generating an awkward circular argument, not to mention unnecessary feeble names. For geologically old fossils, synonymizing these metataxa with extant taxa will increase the hypothesized range extensions for related taxa when constructing evolutionary trees (see PENNEY *et al*. 2003: Fig. 2), thus reducing the overall parsimony of the tree, whereas metataxa can be placed as 'ancestral' lineages. New material examined in light of previously described specimens may demonstrate that previously unplaced genera belong in extant families, e.g. *Palaeouloborus* belongs in Uloboridae and *Macryphantes* in Tetragnathidae (SELDEN, PENNEY 2003). Thus, the authors are happy to retain the currently unplaced (in terms of family) fossil spider taxa as *incertae sedis* within the systematic limits of their original taxonomic assignment.

Abbreviations: AMNH = American Museum of Natural History, New York; BA = Baltic amber; BSPHGM = Bayerische Staatssammlung für Paläontologie und Historische Geologie, Münich; CCU = Crosby Collection of Cornell University; Fl = Florissant Shales, Colorado; G = Institute and Museum of Geology and Palaeontology of the Georg-August-University, Göttingen; LUM = Lille University Museum; MCZ = Museum of Comparative Zoology, Harvard; MfN = Museum für Naturkunde Institut für Paläontologie, Humboldt Universität zu Berlin; MGUH = Mineralogical and Geological Museum, Copenhagen; NHM = Natural History Museum, London; NMP = Prague National Museum; PCFK = personal collection of F. Kernegger, Hamburg; PCJW = personal collection of Jörg Wunderlich, Hirschberg-Leutershausen; PIN = Palaeontological Institute of the Russian Academy of Sciences, Moscow; PIP = Palaeontological Institute, Paris; SMUC = Sedgwick Museum, University of Cambridge, UK; UMMP = University of Michigan Museum of Paleontology; YPM = Peabody Museum of Yale University; * = type species of the genus.

Palaeozoic Families

Remarks: All verifiable Palaeozoic spiders belong to the suborder Mesothelae or show more plesiomorphic character states (ESKOV, SELDEN 2005). A monograph on Palaeozoic spiders is in preparation by PAS, in which the taxonomy of the numerous genera used for Palaeozoic mesotheles will be clarified. Therefore, the taxonomic status of these families has yet to be challenged.

Family ARCHAEOMETIDAE PETRUNKEVITCH, 1949
(Fig. 1)

Age: Carboniferous (Westphalian B–Westphalian C)

Current status: Not valid, the fossils are not spiders

Species originally included: *Archaeometa nephilina* POCOCK, 1911* (Fig. 1), Coseley, Dudley, UK (holotype sex not mentioned, originally described from the personal collection of Mr W. Egginton, current specimen location NHM In. 31259); *A.? devonica* STØRMER, 1976, Alken-an-

der-Mosel, Germany (holotype sex unknown SMF); *Arachnometa tuberculata* Petrunkevitch, 1949*, Coseley, Dudley, UK (holotype sex not mentioned NHM I. 13917); *Eopholcus pedatus* Fritsch, 1904*, pyrite of Nýřaný, Czech Republic (holotype sex not mentioned NMP CGH 3184, Inv. 835). Each of the above species is known from a single specimen.

Remarks: Petrunkevitch's (1949, p. 107) diagnosis of this family – 'Arachnomorph spiders with prograde legs, and segmented abdomen' seems bizarre, considering the former character is widespread in araneomorphs [arachnomorphs] and the latter is plesiomorphic in Araneae and lost in Opisthothelae. The diagnosis and composition of the family was repeated in the *Treatise* (Petrunkevitch 1955), and no formal changes have yet been made. However, Selden and Shear studied *A. nephilina* and *A.? devonica*, and concluded (Selden *et al*. 1991) that they are not spiders, let alone araneomorphs. Subsequent study of *Arachnometa* and *Eopholcus* (PAS, unpublished) has indicated that these, too, show no diagnostic characters of Araneae, and the latter genus shows none of the diagnostic characters of the family.

Family ARTHROLYCOSIDAE Fritsch, 1904

Age: Carboniferous (Westphalian B)–Permian (Capitanian)

Current status: Valid, but poorly defined and in need of revision

Species currently included: *Arthrolycosa antiqua* Harger, 1874* (holotype sex indeterminate YPM No. 161), Francis Creek Shale, Mazon Creek, USA; *A. danielsi* Petrunkevitch, 1913 (holotype sex not mentioned, originally described from the personal collection of Mr L.E. Daniels, current specimen location UMMP 7219), Francis Creek Shale, Mazon Creek, USA; *Eocteniza silvicola* Pocock, 1911*, Coseley, Dudley, UK (holotype sex not mentioned, originally described from the personal collection of Mr W. Egginton, current specimen location NHM In. 31245). See also remarks under Arthromygalidae.

Remarks: Considered a family in the suborder Mesothelae by Petrunkevitch (1949: 275), and accepted by Eskov, Selden (2005) who described an isolated carapace, which they assigned to *Arthrolycosa*. Petrunkevitch rediagnosed this family as mesotheles with a distinct eye tubercle; modern mesotheles have an eye tubercle, so the family is poorly defined.

Family ARTHROMYGALIDAE Petrunkevitch, 1923

(Fig. 3)

Age: Carboniferous (Westphalian B–Stephanian)

Current status: Valid, but poorly defined and in need of revision

Species currently included: *Arthromygale fortis* (Fritsch, 1904)*, Rakovnik, Czech Republic (holotype sex not mentioned NMP CGH 1937, Inv. 804); *A. beecheri* (Fritsch, 1904), Rakovnik, Czech Republic (holotype sex not mentioned NMP CGN 1939, Inv. 805); *Protocteniza britannica* Petrunkevitch, 1949*, Coseley, Dudley, UK (holotype sex not mentioned NHM In. 14015); *Protolycosa anthracophila* Roemer, 1866, Upper Silesia (holotype sex unknown; this specimen was in Wrocław but is now lost [since WWII]); *P. cebennensis* Laurentiaux-Vieira, Laurentiaux, 1963, couche Le Pin, La Grand'Combe, Cévennes, France (holotype sex unknown LUM); *Palaranea borassifoliae* Fritsch, 1873*, Bohemia, Czech Republic (holotype sex not mentioned NMP); *Geralycosa fritschi* Kusta, 1888* (Fig. 3), Rakovnik, Czech Republic (holotype sex not mentioned NMP CGH 1943 and 1945, Inv. 811); *Kustaria carbonaria* (Kusta, 1888)*, Rakovnik, Czech Republic (holotype sex not mentioned NMP CGH 1933, Inv. 806); *Rakovnicia antiqua* Kusta, 1884*, Rakovnik, Czech Republic (holotype sex not mentioned NMP CGH 610, Inv. 810); *Eolycosa lorenzi* Kusta, 1885*, Rakovnik, Czech Republic (holotype sex not mentioned NMP CGH 1941 and 1948, Inv. 809).

Species no longer included: *Palaeocteniza crassipes* Hirst, 1923*, Rhynie Chert, Scotland (Devonian) (holotype sex not mentioned NHM In. 24670) (=?trigonotarbid exuvium).

Remarks: Considered a family in the suborder Mesothelae (e.g. Petrunkevitch 1949: 275). Petrunkevitch (1913) referred all Carboniferous spiders to Arthrolycosidae Fritsch, 1904 but, in 1923, he erected Arthromygalidae to accommodate the Carboniferous taxa listed above, and distinguished them from Arthrolycosidae by their eye arrangement. Petrunkevitch (1953) placed *Palaeocteniza crassipes* and *Eolycosa lorenzi* in 'Aranei incertae sedis', but in the *Treatise* (Petrunkevitch 1955) he listed both under Arthromygalidae, the former doubtfully. Subsequent work (Selden *et al.* 1991) has shown that *Palaeocteniza crassipes* Hirst, 1923 is most likely a moulted exoskeleton of a juvenile trigonotarbid and hence removed it from Araneae. The other genera can mostly be considered as spiders belonging to Mesothelae, but study of the specimens (PAS, unpublished) shows that Petrunkevitch's eye characters are quite fictitious.

Family PERMARACHNIDAE Eskov, Selden, 2005

Age: Permian (Cisuralian)

Current status: Valid

Species currently included: *Permarachne novokshonovi* Eskov, Selden, 2005*, Koshelevka Formation, Russia (holotype ?exuvium part and counterpart, PIN 4909/12).

Remarks: Easily distinguished from all other mesotheles by the presence of an elongated, cylindrical, multisegmented, distal article of one of the spinnerets (Eskov, Selden 2005).

Family PYRITARANEIDAE Petrunkevitch, 1953
(Fig. 2)

Age: Carboniferous (Westphalian B–Westphalian C)

Current status: Valid, but poorly defined and in need of revision

Species currently included: *Dinopilio parvus* Petrunkevitch, 1953, Chislet Colliery, Canterbury, UK (holotype sex not mentioned NHM In. 37101); *D. gigas* Fritsch, 1904* (Fig. 2), Rakovnik, Czech Republic (holotype sex not mentioned NMP CGH 1949, Inv. 816); *Pyritaranea tubifera* Fritsch, 1899*, Nýřaný, Czech Republic (holotype sex not mentioned NMP CGH 3170, Inv. 775).

Remarks: Petrunkevitch (1953) erected this family for supposed araneomorphs with laterigrade legs (cf. Archaeometidae, above) and segmented abdomens. The former character is widespread in Araneae, whilst the latter is plesiomorphic in spiders and would suggest Mesothelae. More recent study of these specimens (PAS, unpublished) indicates that *Dinopilio parvus* and *Pyritaranea tubifera* could be spiders but are too poorly preserved to assign to family, whilst *D. gigas* is most likely a large mesothele.

Mesozoic Families

Family JURARANEIDAE Eskov, 1984

Age: Jurassic (Middle?)

Current status: Valid, but possibly synonymous with Araneidae

Species currently included: *Juraraneus rasnitsyni* Eskov, 1984*, Buryat, Siberia (holotype, male part and counterpart, PIN 3000/3000).

Remarks: Wunderlich (1986: 95, 138) proposed that this family might be synonymous with Araneidae, but did not formally synonymize them. The original diagnosis of the family was not
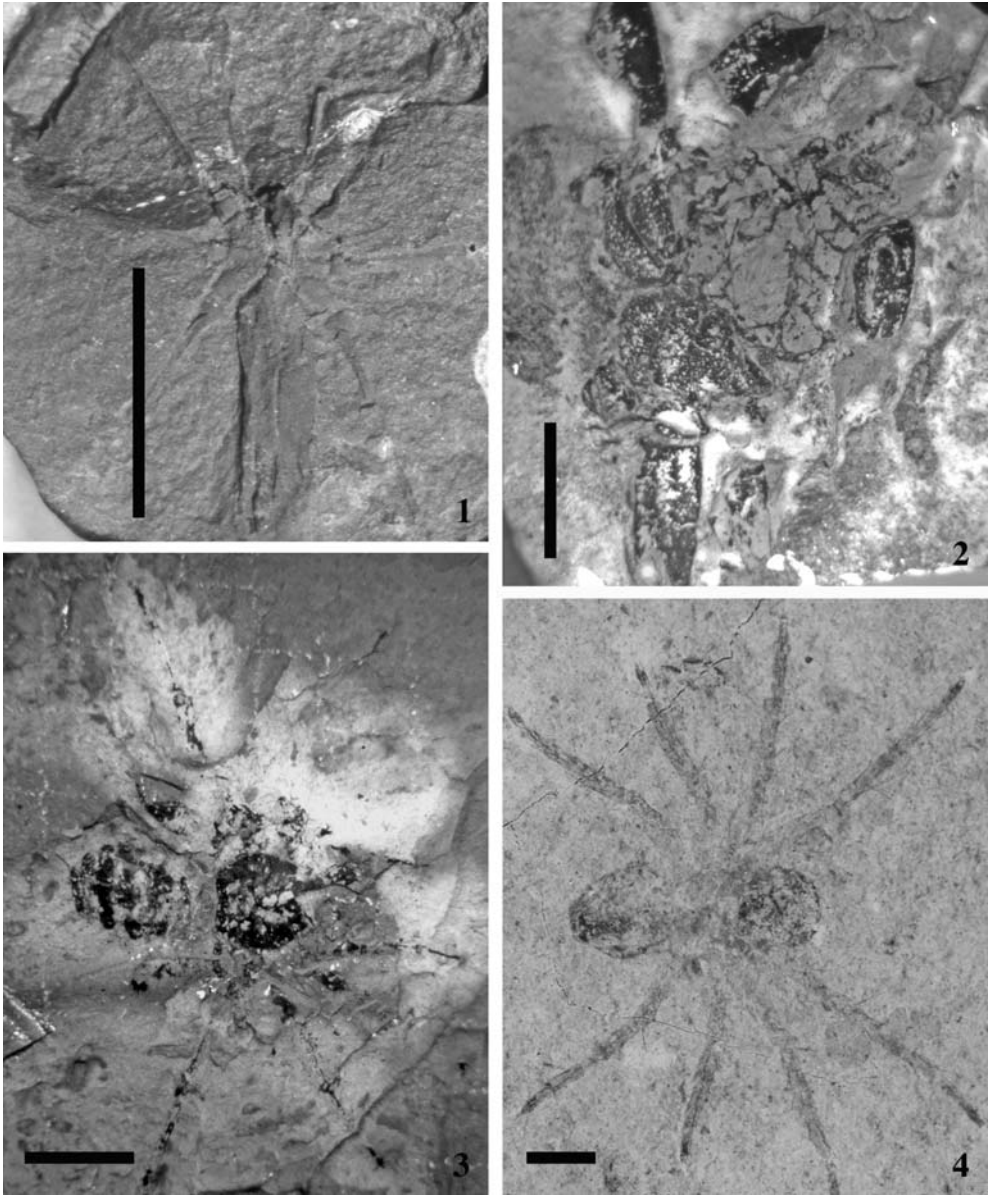
Figs 1-4. Holotypes of non-amber fossil spiders: 1 – *Archaeometa nephilina* Pocock, 1911 (Archaeometidae); 2 – *Dinopilio gigas* Fritsch, 1904 (Pyritaraneidae); 3 – *Geralycosa fritschi* Kusta, 1888 (Arthromygalidae); 4 – *Parattus resurrectus* Scudder, 1890 (Parattidae). Scale lines: approximately 1 mm.

based on unique apomorphies but on a combination of morphological characters found in other araneoid families (Eskov 1984).

Family ARCHAEIDAE Koch, Berendt, 1854

Age: Jurassic (Callovian–Kimmeridgian)–Recent

Current status: Valid

Species originally included (i.e., when known from fossil species only): *Archaea hyperoptica*

Menge, 1854 (holotype female lost, possibly in MfN [Keilbach 1982: 180]); *A. incompta* Menge, 1854 (holotype female lost); *A. laevigata* Koch, Berendt, 1854 (holotype juvenile MfN MB.A 1083); *A. paradoxa* Koch, Berendt, 1854* (holotype male/female lost); *A. sphinx* Menge, 1854 (holotype juvenile lost); *Baltarchaea conica* (Koch, Berendt, 1854)* (holotype juvenile lost).

Remarks: Although no longer a strictly fossil family Archaeidae is included here because it was first described from fossils in Baltic amber, with extant species discovered in Madagascar and South Africa a quarter of a century later (Pickard-Cambridge 1881). Wunderlich (2004: 780) considered *A. incompta*, *A. laevigata* and ?*A. sphinx* to be synonyms of *A. paradoxa*. *A. hyperoptica* was placed as the type species of *Eoarchaea* Forster, Platnick, 1984 (not accepted by Eskov 1992, but accepted by Wunderlich 2004). *A. conica* was transferred to the new genus *Baltarchaea* Eskov, 1992 in the family Mecysmaucheniidae by Eskov (1992). This genus was placed in Archaeidae: Archaeinae by Wunderlich (2004). Fossil species are also known in Cretaceous amber from Burma (Penney 2003), from the Jurassic of Kazakhstan (Eskov 1987), and the family has been recorded in Tertiary amber from Paris (Penney 2006a). Wunderlich (2004) described new fossil taxa from Baltic amber and reported the presence of this family in Eocene amber from the Ukraine (Rovno).

Family LAGONOMEGOPIDAE Eskov, Wunderlich, 1995

Age: Cretaceous (Aptian–Campanian)

Current status: Valid

Species currently included: *Burlagonomegops eskovi* Penney, 2005*, Burmese amber (holotype juvenile AMNH Bu–707, paratype juvenile AMNH Bu–1353); *B. alavensis* Penney, 2006, Spanish amber (holotype juvenile MCNA 8635 [CRLV 03]); *Grandoculus chemahawinensis* Penney, 2004*, Canadian amber (holotype juvenile, MCZ A 5000); *Lagonomegops americanus* Penney, 2005, New Jersey amber (holotype juvenile, AMNH NJ–556 [KL–297]); *L. sukatchevae* Eskov, Wunderlich, 1995*, Siberian amber (holotype juvenile, PIN 3311/564, location currently unknown, K. Eskov, pers. comm. 2004).

Remarks: This family is currently known only from juvenile specimens and is characterized by having cheliceral peg teeth and large eyes situated antero-laterally. *G. chemahawinensis* has such an eye arrangement, but is sufficiently different from the other genera in many other features that it may belong to a new fossil family (Penney 2004).

Cenozoic Families

Family ACROMETIDAE Wunderlich, 1979

Age: Tertiary (Eocene)

Current status: Not valid, a synonym of Nesticidae or Synotaxidae

Species originally included: *Acrometa cristata* Petrunkevitch, 1942*, BA (holotype male NHM In. 18724 [Klebs 481, No. 13408], four paratype males NHM In. 18713 [Klebs 467, No. 13430], In. 18728 [Klebs 485, No. 13458], In. 18750 [Klebs 508, No. 13453], In. 18752 [Klebs 510, No. 13461]; *A. samlandica* (Petrunkevitch, 1942), BA (holotype juvenile female NHM In. 18943, one exuvium NHM In. 17629); *A. minutum* (Petrunkevitch, 1942), BA (holotype juvenile SMUC No. C 6650); *A. robustum* (Petrunkevitch, 1942), BA (holotype juvenile CCU No. 8); *A. setosus* (Petrunkevitch, 1942), BA (holotype male NHM In. 18118); *A. succini* (Petrunkevitch, 1942), BA (holotype female NHM In. 18943); *Anandrus inermis* (Petrunkevitch, 1942), BA (holotype male NHM In. 18743 [Klebs 501, No. 13441]; *A. infelix* (Petrunkevitch, 1950)*, BA (holotype male MCZ 7002); *A. quaesitus* (Petrunkevitch, 1958), BA (holotype male MfN [zoology] no number assigned); *A. redemptus* (Petrunkevitch, 1958), BA (holotype male MGUH

9995); *Cornuanandrus maior* WUNDERLICH, 1986, BA (holotype male PCJW no number assigned): *Pseudoacrometa gracilipes* WUNDERLICH, 1986, BA (holotype male BSPHGM no number assigned, paratype male PCJW no number assigned).

Remarks: *Acrometa* PETRUNKEVITCH, 1942 and *Anandrus* MENGE, 1856 (sub *Elucus* PE-TRUNKEVITCH, 1942) were originally placed in Araneidae (Metinae) and Theridiosomatidae respectively by PETRUNKEVITCH (1942). PETRUNKEVITCH (1958) placed both genera in Araneidae. WUNDERLICH (1979) considered *Acrometa* a tetragnathid and to be synonymous with the extant genera *Metella* FAGE, 1931, *Pimoa* CHAMBERLIN, IVIE, 1943 and *Louisfagea* BRIGNOLI, 1971. This synonymy was rejected by BRIGNOLI (1979) and *Metella* and *Louisfagea* are now considered junior synonyms of *Pimoa* (Pimoidae) (e.g. PLATNICK 2006). WUNDERLICH (1986) revised *Acrometa* and *Anandrus* and synonymized *Theridiometa* PETRUNKEVITCH, 1942, *Liticen* PETRUNKEVITCH, 1942, *Eogonatium* PETRUNKEVITCH, 1942 and *Viocurus* PETRUNKEVITCH, 1958 with *Acrometa* (WUNDERLICH 1986: 131). WUNDERLICH (1986: 124) suggested Acrometidae might be closely related to Nesticidae or Malkaridae. The family was considered a synonym of the former by ESKOV, MARUSIK (1992) and of Synotaxidae (separated from Theridiidae by FORSTER *et al.* 1990) by WUNDERLICH (2004: 1195) based on the structure of the male pedipalp. WUNDERLICH (2004: 1822) reported the presence of *A. cristata* in Eocene amber from the Ukraine (Rovno).

Family ADJUTORIDAE PETRUNKEVITCH, 1942
(Fig. 5)

Age: Tertiary (Eocene)

Current status: Not valid, synonymous with Zodariidae and Sparassidae

Species originally included: *Adjutor mirabilis* PETRUNKEVITCH, 1942* (Fig. 5), BA (holotype juvenile female NHM In. 18945); *A. deformis* PETRUNKEVITCH, 1958, BA (holotype juvenile female PIP no number assigned); *Adjunctor similis* PETRUNKEVITCH, 1942*, BA (holotype juvenile female NHM In. 18085); *Admissor aculeatus* PETRUNKEVITCH, 1942*, BA (holotype juvenile female NHM In. 18946).

Remarks: LEHTINEN (1967: 397) proposed araneoid affinities for this family based on the figures and descriptions of Petrunkevitch, all of which were based on juvenile specimens. WUN-DERLICH (1984), without elaboration, placed the subfamily Adjutorinae in Zodariidae: ?Zodariinae (see also WUNDERLICH 1986: 23, 2004: 1702), and the subfamily Adjunctorinae in Sparassidae: Eusparassinae (see also WUNDERLICH 1986: 29, 2004: 1702). *Adjunctor* PETRUNKEVITCH, 1942 is not a junior synonym of *Sosybius* KOCH, BERENDT, 1854 as proposed by WUNDERLICH (1986: 29) (WUNDERLICH 2004: 1702).

Family ARTHRODICTYNIDAE PETRUNKEVITCH, 1942
(Fig. 6)

Age: Tertiary (Eocene)

Current status: Not valid, synonymous with Dictynidae

Species originally included: *Arthrodictyna segmentata* PETRUNKEVITCH, 1942* (Fig. 6), BA (holotype juvenile NHM In. 18950).

Remarks: The holotype and only known specimen is juvenile, incomplete and poorly preserved (PETRUNKEVITCH 1942). Based on the figures and description by PETRUNKEVITCH (1942), LEHTINEN (1967: 397) considered the correct placement of this taxon problematic. The family was synonymized with Dictynidae by WUNDERLICH (1984); see also WUNDERLICH (1986: 24). This synonymy was considered tentative by WUNDERLICH (2004: 1428). A formal redescription of the type material is in preparation by DP.
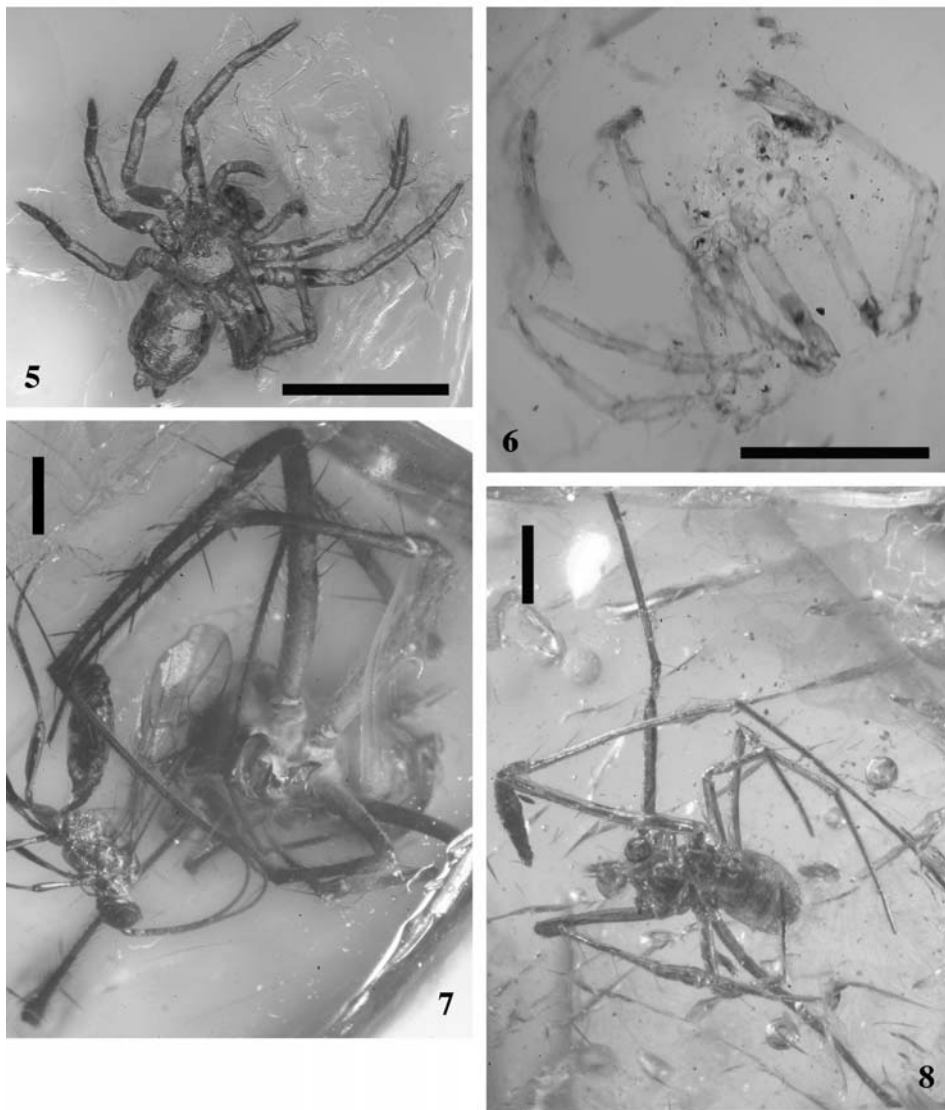
Figs 5-8. Holotypes of amber fossil spiders: 5 – *Adjutor mirabilis* Petrunkevitch, 1942 (Adjutoridae); 6 – *Arthrodictyna segmentata* Petrunkevitch, 1942 (Arthrodictynidae); 7 – *Baltsuccinus flagellaceus* Wunderlich, 2004 (Baltsuccinidae); 8 – *Praetheridion fleissneri* Wunderlich, 2004 (Protheridiidae). Scale lines: approximately 1 mm.

Family BALTSUCCINIDAE Wunderlich, 2004
(Fig. 7)

Age: Tertiary (Eocene)

Current status: Valid, but warrants independent assessment (original publication not peer-reviewed)

Species currently included: *Baltsuccinus flagellaceus* Wunderlich, 2004* (Fig. 7), BA (holotype male PCJW F40/BB/AR/BAL; *B. similis* Wunderlich, 2004, BA (holotype male G 359).

Remarks: Placed in the Araneoidea, but its systematic position within this superfamily is

unclear (WUNDERLICH 2004: 1130). The original diagnosis was primarily a list of plesiomorphic characters. A diagnostic apomorphy may be the bipartite paracymbium with a large, heavily sclerotized, trough-shaped portion and a separate long, slender setose branch (WUNDERLICH 2004).

Family EPHALMATORIDAE PETRUNKEVITCH, 1950

Age: Tertiary (Eocene)

Current status: Valid

Species currently included: *Ephalmator bitterfeldensis* WUNDERLICH, 2004, BA (Bitterfeld) (holotype male MfN 569); *E. calidus* WUNDERLICH, 2004, BA (holotype male PCFK 8/38); *E. debilis* WUNDERLICH, 2004, BA (holotype male PCJW F337/BB/AR/EPH); *E. distinctus* WUNDERLICH, 2004, BA (holotype male PCJW F338/BB/AR/EPH, paratype male PCJW F592/BB/AR/EPH); *E. ellwangeri* WUNDERLICH, 2004, BA (holotype male PCJW F557/BB/AR/EPH); ?*E. eximius* PETRUNKEVITCH, 1958, BA (holotype juvenile female MGUH 9988); *E. fossilis* PETRUNKEVITCH, 1950*, BA (holotype male MCZ 7882, paratype male MCZ 7188); *E. kerneggeri* WUNDERLICH, 2004, BA (holotype male PCFK 196/94); *E. petrunkevitchi* WUNDERLICH, 2004, BA (*Eophalmator* a lapsus calami) (holotype male PCJW F322/BB/AR/EPH); *E. ruthildae* WUNDERLICH, 2004, BA (holotype male PCJW F321/BB/AR/EPH, paratype male F336/BB/AR/EPH); *E. trudis* WUNDERLICH, 2004, BA (holotype male PCJW F339/BB/AR/EPH, three paratype males in a single piece of amber F340/BB/AR/EPH); *E. turpiculus* WUNDERLICH, 2004, BA (holotype male PCJW F325/BB/AR/EPH).

Remarks: WUNDERLICH (1986: 26) provided a revised diagnosis of this monogeneric family and WUNDERLICH (2004: 1559) revised Ephalmatoridae suggesting that *E. eximius* PETRUNKEVITCH, 1958, described from a juvenile, was misplaced in this family. Unfortunately, WUNDERLICH (2004) did not provide a distinct diagnosis based on autapomorphic characters, but gave a combined diagnosis and description, which was based on the combination of a large number of different characters. LEHTINEN (1967: 397) was unable to place this family, but WUNDERLICH (2004) proposed that it might be most closely related to Corinnidae, Zodariidae, Nicodamidae or Chummidae. The only known female specimen from this family was described, but not named by WUNDERLICH (2004: 1570).

Family INCEPTORIDAE PETRUNKEVITCH, 1942

Age: Tertiary (Eocene)

Current status: Not valid, possibly synonymous with Agelenidae

Species originally included: *Inceptor aculeatus* PETRUNKEVITCH, 1942*, BA (holotype juvenile CCU number 5); *I. dubius* PETRUNKEVITCH, 1946, BA (holotype female AMNH 26267).

Remarks: The original description of this family was based on a single juvenile specimen with no unusual outstanding features. LEHTINEN (1967: 397) was unable to place this family, but WUNDERLICH (1984) synonymized it with Agelenidae: Ageleninae. WUNDERLICH (1986) retained this view but suggested these fossils may also have affinities with Zodariidae. This family was not mentioned by WUNDERLICH (2004) and is in need of revision.

Family INSECUTORIDAE PETRUNKEVITCH, 1942

Age: Tertiary (Eocene)

Current status: Valid, but possibly synonymous with Pisauridae

Species currently included: *Insecutor aculeatus* PETRUNKEVITCH, 1942*, BA (holotype juvenile female NHM In. 18741 [Klebs 499, No. 13456], paratype juvenile/?female NHM In. 18723 [Klebs 480, No. 13447]); *I. mandibulatus* PETRUNKEVITCH, 1942, BA (holotype juvenile female NHM In. 18742 [Klebs 500, No. 13456], paratype juvenile female NHM In. 18721 [Klebs 478,

No. 13434]); ?*I. pecten* Wunderlich, 2004, BA (holotype male PCJW F644/BB/AR); *I. rufus* Petrunkevitch, 1942, BA (holotype juvenile female NHM In. 18123) ?*I. spinifer* Wunderlich, 2004, BA (holotype male PCJW F642/BB/AR, paratype male PCJW F643/BB/AR).

Remarks: Petrunkevitch (1942) considered this family most closely related to Pisauridae. Additional specimens were described/mentioned by Petrunkevitch (1956, 1958), including a mature male of *I. mandibulatus* (AMNH 26258: 2), but its conspecificity is uncertain (Wunderlich 2004: 1526). Lehtinen (1967: 397) was unable to place this family, but Wunderlich (1984, 1986: 25) synonymized it with Agelenidae: Ageleninae and Wunderlich (2004: 1524) provided a revised diagnosis, without discernable autapomorphies and proposed that it might be synonymous with Pisauridae, but nonetheless maintained it as a separate family. The males described by Wunderlich (2004) were only tentatively placed in *Insecutor*. Wunderlich (2004: 1525) suggested that *Thyelia* Koch, Berendt, 1854 may be a senior synonym of *Insecutor* Petrunkevitch, 1942 but was unable to locate the type material of Koch and Berendt required to confirm this. The systematic status of this family is unclear.

Family MITHRAEIDAE Koch, Berendt, 1854

Age: Tertiary (Eocene)

Current status: Not valid, synonymous with Uloboridae

Species originally included: *Androgeus militaris* Koch, Berendt, 1854, BA (holotype male MfN MB.A 1111 [cabinet P1287, drawer 115]); *A. triqueter* Koch, Berendt, 1854*, BA (holotype male MfN MB.A 1112 [cabinet P1287, drawer 115]).

Remarks: Petrunkevitch (1955: 152) was unable to place *Androgeus* Koch, Berendt, 1854 in any known family, but later considered Mithraeidae to be synonymous with Uloboridae (Petrunkevitch 1958). Wunderlich (1986: 27) synonymized *Androgeus* with the extant uloborid genus *Hyptiotes* Walckenaer, 1837 and transferred *A. militaris* to *Eomysmena* Petrunkevitch, 1942 (Theridiidae).

Family MIZALIIDAE Thorell, 1870

Age: Tertiary (Eocene)

Current status: Not valid, synonymous with Oecobiidae

Species originally included: *Mizalia rostrata* Koch, Berendt, 1854*, BA (holotype male lost, not found in collection of MfN). *M. truncata* Menge, 1854, BA (holotype sex and location unknown).

Remarks: The family was erected for the genus *Mizalia* Koch, Berendt, 1854, which had originally been placed in Theridiidae. The only species formally listed in this family by Thorell (1870) was *M. rostrata*. Some other species listed in *Mizalia* by Koch, Berendt (1854) had been transferred from this genus by Menge (1854) prior to the erection of the new family. Petrunkevitch (1955: 152) was unable to place *Mizalia* Koch, Berendt, 1854 in any known family. Mizaliini was considered a tribe in Oecobiidae: Urocteinae by Wunderlich (1986) and as a subfamily of Oecobiidae by Wunderlich (2004: 831). Wunderlich (1986) synonymized *Paruroctea* Petrunkevitch, 1942 with *Mizalia* and Wunderlich (2004) described the new Baltic amber species *M. gemini* Wunderlich, 2004 and *M. spirembolus* Wunderlich, 2004.

Family PARATTIDAE Petrunkevitch, 1922

(Fig. 4)

Age: Tertiary (Eocene)

Current status: Valid, but probably synonymous with a lycosoid family

Species currently included: *Parattus evocatus* Scudder, 1890, Fl (holotype female MCZ Scudder Coll. No. 12005 [renumbered 66]); *P. latitatus* Scudder, 1890, Fl (holotype sex not mentioned MCZ Scudder Coll. No. 9823 [renumbered 67]); *P. oculatus* Petrunkevitch, 1922, Fl (holotype female MCZ Scudder Coll. No. 118); *P. resurrectus* Scudder, 1890* (Fig. 4), Fl (holotype male MCZ Scudder Coll. No. 1081 [renumbered 64], paratype female MCZ Scudder Coll. No. 8459 and 8282 [renumbered 65]).

Remarks: Because the specimens are poorly preserved, this ecribellate, entelegyne family was originally diagnosed by the 'unusual' eye arrangement as follows: eyes round, in two rows of four, anterior subequal and fairly equidistant, posterior eyes considerably smaller, with PME between and slightly behind the AME (see Petrunkevitch 1922: Fig. 19). Petrunkevitch did not consider that taphonomic processes may have may have caused these specimens to be preserved in a manner requiring a careful interpretation of the eye arrangement. Re-examination of the type species demonstrated that what Petrunkevitch considered to be the anterior eyes are actually the posterior eyes and vice versa. Although currently considered a valid family, these spiders are actually lycosoids; a revision is in preparation.

Family PROTHERIDIIDAE Wunderlich, 2004
(Fig. 8)

Age: Tertiary (Eocene)

Current status: Valid, but warrants independent assessment (original publication not peer-reviewed)

Species currently included: *Praetheridion fleissneri* Wunderlich, 2004* (Fig. 8), BA (holotype male PCJW F42/BB/AR/PRO); *Protheridion bitterfeldensis* Wunderlich, 2004, BA (Bitterfeld) (holotype male PCJW F250/BB/AR/PRO); *P. detritus* Wunderlich, 2004, BA (holotype male PCJW F44/BB/AR/PRO); *P. obscurum* Wunderlich, 2004, BA (holotype male PCJW F252/BB/AR/PRO); *P. punctatum* Wunderlich, 2004, BA (holotype male PCJW F251/BB/AR/PRO); *P. tibialis* Wunderlich, 2004*, BA (holotype male PCJW F38/BB/AR/PRO).

Remarks: Wunderlich (2004: 1134) was unsure of the correct systematic placement of this family but suggested it might be most closely related to Theridiidae, based on leg autotomy (coxa–trochanter), palpal structure and the presence of a tarsal comb on leg 4.

Family SPATIATORIDAE Petrunkevitch, 1942

Age: Tertiary (Eocene)

Current status: Valid

Species currently included: *Spatiator praeceps* Petrunkevitch, 1942*, BA (holotype female NHM In. 18760 [Klebs 518, no. 3761], an additional male NHM In. 18761 [Klebs 519, no. 3764]).

Species no longer included: *Adorator brevipes* Petrunkevitch, 1942, BA (holotype male NHM In. 18716 [Klebs 474, No. 13455]); *A. samlandicus* Petrunkevitch, 1942, BA (holotype male NHM In. 18144) (=Zodariidae).

Remarks: Wunderlich (1984) placed Spatiatorini as a tribe in Palpimanidae *s.l.* Stenochilinae, but Wunderlich (1986: 21) considered it a valid family and provided a revised diagnosis. Spatiatorids are easily identifiable by the following combination of characters: carapace long with a distinctly raised caput, cheliceral peg teeth, spineless legs and spatulate setae on the tarsi and metatarsi of legs 1 and 2. However, these characters are widespread in Palpimanoidea and a formal diagnosis based on distinct apomorphies is warranted. Wunderlich (2004: 767) proposed that this family was most closely related to the New Zealand family Huttoniidae which had a

broader distribution in the past, evident from fossils in Cretaceous Canadian amber (PENNEY, SELDEN 2006). The genus *Adorator* was misplaced in Spatiatoridae because of the presence of leg spines and the lack of spatulate setae, and based on pedipalp structure it belongs in Zodariidae (WUNDERLICH 2004: 1592).

Concluding Remarks

To date, twenty strictly fossil spider families (including Archaeidae which was originally described as a fossil family) have been described and the expectation is that more await discovery and description. Of these families, one (Archaeidae) had extant species discovered subsequently and it is not unreasonable to expect that a similar situation may occur again, highlighting the need for neontologists to consider palaeontological data when describing new higher taxa because they may already be known as fossils. Of the Palaeozoic families, none of the specimens attributed to Archaeometidae are spiders and of the remaining families all but Permarachnidae are poorly defined and in need of revision. However, at this stage it would appear that they consist solely of primitive mesothele spiders. The Mesozoic families as currently delimited are acceptable, although the discovery of new material may demonstrate that *Juraraneus* belongs in Araneidae.

The majority of strictly fossil spider families described from the Cenozoic, were established primarily by Petrunkevitch, who often based his new taxa on juvenile specimens. This is the case for the families Adjutoridae, Arthrodictynidae, Inceptoridae and Insecutoridae and the type specimens require formal systematic scrutiny before the validity of these families (including their proposed synonymies) can be determined. Ephalmatoridae and Spatiatoridae, also established by Petrunkevitch have been revised by WUNDERLICH (1986, 2004) and are currently considered valid, although the systematic affinities of the former are unclear. The families Baltsuccinidae and Protheridiidae were recently described by WUNDERLICH (2004) and have not yet been critically assessed. The following fossil families have been synonymized with extant taxa: Acrometidae = Synotaxidae, Mithraeidae = Uloboridae, Mizaliidae = Oecobiidae; and recent unpublished data have shown that Parattidae are lycosoid spiders.

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Съставяне дърво на живота – филогения на паяците: преглед на изцяло фосилните семейства

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(Резюме)

"Assembling the Tree of Life (AToL): Phylogeny of Spiders" е амбициозна, шестгодишна програма, целяща изясняването на филогенията на паяците чрез съставяне на родословно дърво, включващо всички известни семейства. За осъществяването на проекта е изготвена таблица, съдържаща морфологични, молекулярни, поведенчески и палеонтологични данни. Тъй като досега фосилните паяци не са били разглеждани в съвременните систематични каталози, настоящата статия прави преглед на описаните до момента от фосилната летопис 20 семейства. От тях, семейство Archaeidae е наскоро открито с рецентен представител, а Acrometidae, Adjutoridae, Arthrodictynidae, Mithraeidae и Mizaliidae са синонимизирани със съвременни семейства. Според авторите валидни таксони са: Permarachnidae, Juraraneidae, Lagonomegopidae, Baltsuccinidae, Ephalmatoridae, Insecutoridae, Protheridiidae, Spatiatoridae, а Arthrolycosidae, Arthromygalidae, Pyritaraneidae, Inceptoridae, Parattidae трябва да бъдат преразгледани. Нито един от фосилните видове, причислени към семейство Archaeometidae не е паяк.

Ultrastructure of dermal and defence glands in *Cyphophthalmus duricorius* Joseph, 1868 (Opiliones: Sironidae)

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Abstract: The structure of dermal glands and defence glands is described in a species of Cyphophthalmi. The dermal glands consist of different cell types that discharge their secretion into a microvilli bordered cavity before reaching the cuticle-lined duct system. The paired sac-like defence glands are composed of an excretory channel, a non-secretory area and a secretory area. These three parts are characterized by a different arrangement of cells. The secretory area includes a number of glandular units, probably derived from dermal glands, producing a heterogeneous secretion that is discharged via numerous small ducts into the wide cuticle-lined lumen.

Key words: Cyphophthalmi, defence gland, dermal gland, ozophore

Introduction

The Cyphophthalmi represent a subgroup of small, „mite-like" Opiliones of about 115 species living in caves and leaf litter (Moritz 1993, Giribet 2000, Giribet, Boyer 2002). They are regarded by some authors as closely related to Palpatores (Cyphopalpatores; e.g., Martens *et al*. 1981, Martens 1986), whereas others consider them as the most early derivative Opiliones constituting the sister group to all other Opiliones (Giribet *et al*. 1999, 2002, Karaman 2005). The first view was mainly based on morphological characteristics of the ovipositor and penis. In contrast the second interpretation used aside of numerous morphological characters also molecular data sets. Furthermore, Opiliones are placed differently in cladograms depicting arachnid phylogenies. For example, some authors consider them closely related to Acarinomorpha (Ricinulei and Acari; e.g., Weygoldt, Paulus 1979a, b, Paulus 2004), whereas others suggested a more or less close relationship to Scorpiones (e.g., Hammen 1989, Shultz 1990, Wheeler, Hayashi 1998, Giribet *et al*. 2002). Evidently, much more has to be learnt about these arachnids until it is possible to reach generally accepted conclusions.

In the frame of a general study on cyphophthalmic ultrastructure we present here preliminary results on two glandular systems using *Cyphophthalmus duricorius* (Sironidae): dermal glands and defence glands. Further glands such as coxal glands (nephridia) and the male tarsal glands are currently under investigation and further opilionid taxa will also be included.

Material and Methods

The individuals of *Cyphopthalmus duricorius* Joseph, 1868 were collected from leaf litter in Styria (Austria) by R. Schuster in May 2005. The study is based on 10 adult specimens of both sexes. For

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transmission electron microscopy (TEM) examinations the cyphophthalmids were cut between prosoma and opisthosoma with a razor blade in buffered glutaraldehyd (2.5% glutaraldehyd in 0.1M phosphate buffer, pH 7.2). The tissues remained in the fixative for one night. After washing the material in 0.1M phosphate buffer (two times), it was postfixed in osmium tetroxide (2%), and then washed in phosphate buffer (three times) again. Before embedding in Spurr`s resin (Spurr 1969) the material was dehydrated in graded ethanols (from 60 up to 100%). Ultrathin sections were made with a Leica Ultracut UCT, and then stained with uranyl acetate and lead citrate. Observations were done with a transmission electron microscope Zeiss EM 10 A.

For scanning electron microscopy (SEM) one animal was dissected in a phosphate buffer (same as above) for studying the defence glands. The sample was then transferred into the fixative (see above), and then treated like the material for TEM until the dehydration in pure ethanol. Afterwards the sample was transferred in amylacetate and critical point dried with a BAL-TEC CPD. Subsequently, the material was covered with palladium-gold by using the Polaron Mini Sputter Coater SC 7620. The sample was studied with a scanning electron microscope LEO DSM 940 A.

Results

No structural differences between the sexes were observed with regard to the glands studied.

1. Dermal glands

The integument of *C. duricorius* is richly invested with small dermal glands on the dorsal side of the body as well as on the ventral side. The gland openings are distributed irregularly with a maximum density of 8 openings per 100 μm^2. These glands consist of a set of three types of cells: secretory, collar and canal cells which are surrounded by intercalary cells (Fig. 1A).

The secretory cells (Fig. 1A-C), are rather large, containing a prominent nucleus, which is surrounded by numerous cisternae of rough endoplasmic reticulum, free ribosomes and mitochondria. The mitochondria (0.1–0.4 µm in diameter) are round, sometimes elongated, located mainly in the distal part of cells. Small lipid droplets were also observed. Golgi bodies produce distinct, densely staining granules (0.5-2.1 µm in diameter). A different distribution of granules was found depending on the secretory activity of the cell. In early stages there are round or oval granules differing in their electron density. In late stages a number of the electron lucent granules merge and fill almost the whole cell. The apex of the secretory cell bears microvilli (1.0 -1.8 µm long), which extend into a funnel-shaped cavity, called secretory reservoir, where the secretion accumulates (Fig. 1A, B).

The collar cell surrounds the secretory cells of each gland and a small part of the proximal part of the canal cell (Fig. 1A). The collar cell contains rough endoplasmic reticulum, mitochondria and granules. Its nucleus is situated at the base. Golgi bodies and lipid droplets are present as well. The granules (0.5-0.7 µm in diameter) of the collar cell are surrounded by a distinct membrane. Similar to the secretory cells, also the collar cell bears microvilli (Fig. 1A, B). However, in contrast to the secretory cells, the microvilli are shorter (0.2-0.4 µm long). A distinct marginal fold is connecting the secretory cells and the collar cell (Fig. 1A, B). This fold stabilises this area as it anchors the glandular cells (secretory cells + collar cell). The fold includes densely packed microtubules encircling this area of the reservoir (Fig. 1B).

The microvilli border encloses the secretory funnel-shaped reservoir. The contents of the reservoir pass through a canal formed by a canal cell. Although the canal can be divided in two strikingly different parts, it seems that the duct is composed of one canal cell only. The proximal part of the canal cell (0.1 µm long) has a thick but less dense cuticle of a peculiar fine structure.
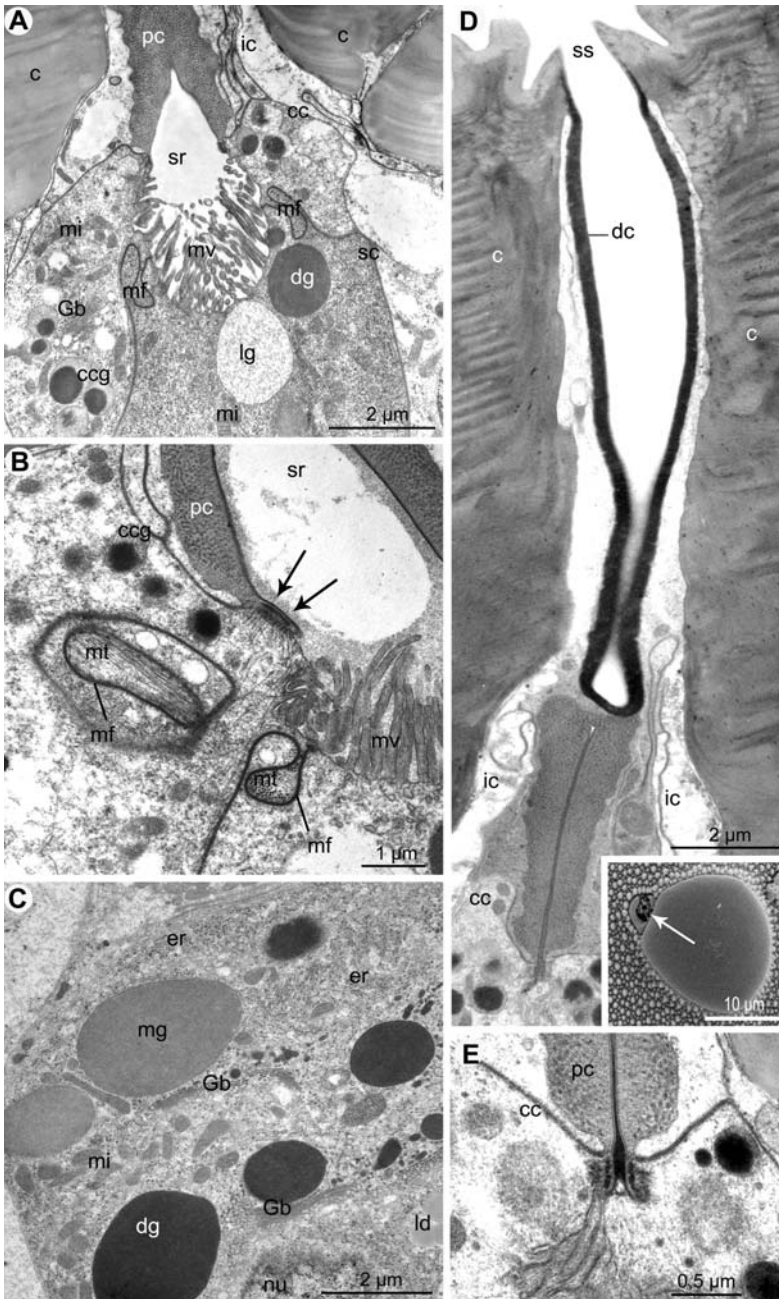
Fig. 1. The dermal glands. **A:** Glandular unit of a gland. Both, the secretory and the collar cell form a microvilli border, which extends into the secretory reservoir. **B:** The connection between the secretory cell and the collar cell is characterized by marginal folds provided with many microtubules. The linking of the collar cell to the proximal canal cuticle is provided by a peculiar attachment zone (arrows). The proximal beginning of the duct is wide open. **C:** Detail of the secretory cell. Note the Golgi bodies and secretions. **D:** Longitudinal section through the canal of a dermal gland. The canal cell is surrounded by intercalary cells. The proximal beginning of the duct is closed. Inset: SEM figure of the orifice of a dermal gland (arrow) in the surface cuticle next to a smooth tubercle. **E:** The proximal beginning of the canal with the collar cell linked to the canal cell by septate junctions.

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Its electron-lucent inner (i.e., adjacent to the lumen) layer projects into the reservoir lumen. The canal cell is proximally linked by septate junctions with the collar cell (Fig. 1E). The collar cell attaches to the cuticle by a peculiar junction (comparable to hemidesmosomes) (Fig. 1B). The distal part of the canal cell (length about 0.3 µm) is provided with a thin but dense cuticle. It seems that the thin cuticle of the distal part is interlocked in the thick cuticle of the proximal part composing a valve like structure. The canal surrounded by the canal cell is distinctly narrowed in this region before extending to the surface. Near the orifice, the cuticle of the distal canal merges with the integument cuticle. The duct terminates at the surface with a small opening surrounded by tiny cuticular lips arranged in a rosette like manner (Fig. 1D).

2. Defence glands

In *C. duricorius*, as in other Cyphophthalmi, the openings of the sac-like defence glands are located on dorsolateral elevations, the ozophores (Fig. 2A). They are approximately 110 µm high. The slit-like opening is located under a small lid-like protuberance (Fig. 2B, C) and measures about 20 µm. The glands are composed of a short excretory canal, a distal non-secretory part and a proximal secretory part.

Examined by TEM, the secretory slit is bordered by a cuticle forming a thick and externally smooth dorsal lid that overhangs the ventral border (Fig. 2B). Starting from the secretory slit, the cuticle becomes thinner towards the excretory canal (Fig. 2 D). At this part muscles are attached to the canal (Fig. 2E, F). Likely, the muscles play an important role for the opening of the glands and consequently for the expulsion of the secretory products. The excretory canal continues to the non-secretory part and finally to the secretory part. Both regions are composed of an epithelium, covered by a thin cuticle. The flat epithelium of the non-secretory area is composed of cuticle-supporting cells only. Characteristic for the non-secretory part are the foldings of the wall. Because of this feature we propose a division of the non-secretory area in to three parts. In the first part the intima shows simple ridges (Fig. 2F); in the second part regular folds are present (Fig. 2G) and, finally, in the third part close to the secretory area the intima is strongly and irregularly folded (Fig. 2H). These differences may reflect the different rigidity of the cuticle of the three regions. The cuticle-supporting cells of the non-secretory part are provided with ovoid nuclei and glycogen granules. Other cell organelles like small mitochondria (0.2 µm in diameter) were more obvious in the second and third part of the non-secretory area. In the last part of the non-secretory area muscles are also present (Fig. 2H). The secretory part extends into the interior of the body as a rather wide large sac (Fig. 2A). This part of the gland is more complex. Like the non-secretory part, the secretory part of the defence glands is also characterized by many folds of the wall (Fig. 2I). These folds are stronger here than in the non-secretory part. Contrary to the excretory canal and the third part of the non-secretory area, no muscles have been observed in the secretory area. The wall of the secretory part consists of secretory cells and duct cells, forming glandular units, and cuticle-supporting cells. The secretory cells consist of an ovoid nucleus (0.4 µm in diameter), numerous cisternae of rough endoplasmic reticulum, many mitochondria, lipid droplets and granules. The mitochondria are elongated and are mostly concentrated at base and at apex of the cell. The granules are either electron-lucent or electron-dense. The lucent granules are smaller (0.07 µm in diameter) while the dark granules (0.07-0.1 µm in diameter) are larger. The dark granules were more often observed and sometimes appeared in groups of two or three granules. Furthermore, lysosomes were observed in the secretory cells. The cells of the secretory part are connected to each other by interdigitations and bear many microvilli projecting into an elongated cavity (Fig. 2J). The duct cells begin at this cavity (Fig. 2J, K). The duct cells are similar to those of the dermal glands. But the thick, less dense cuticle is not seen. The cuticle-supporting cells of the secretory area contain an elongated nucleus, some small mitochondria and glycogen granules. The lumen of the defence gland may contain sometimes a heterogeneous secretion (Fig. 2I).
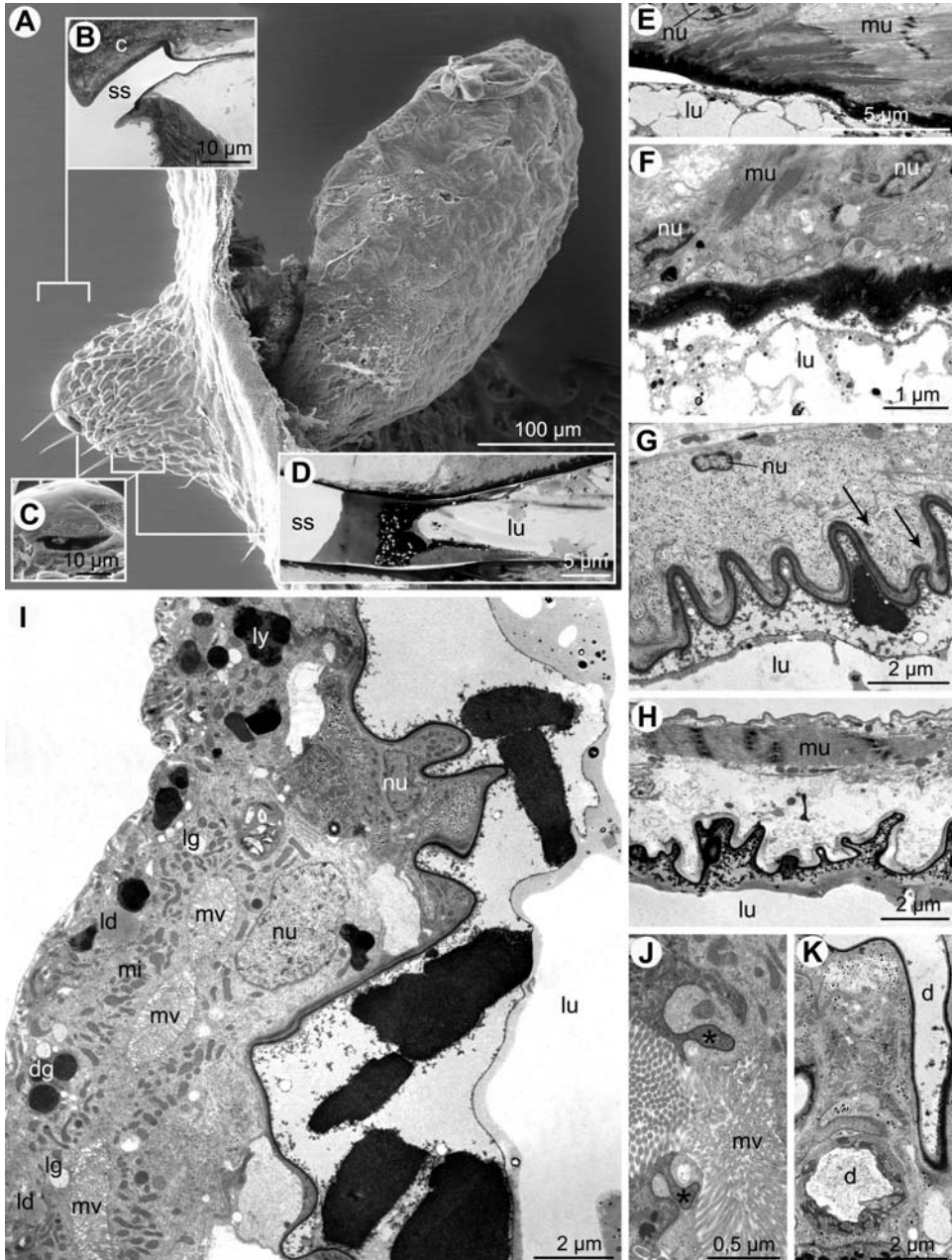
Fig. 2. The defence gland. **A:** SEM figure of the ozophore with the defence gland. **B:** Lid-like structure of the opening of the ozophore.**C:** SEM view of the secretory slit of the defence gland. **D:** Secretion in the excretory canal next to its exit. **E:** Longitudinal section through the excretory canal showing the muscle attachment. **F:** Wall of the first part of the non-secretory area. **G:** The second part of the non-secretory area with regular folds. Mitochondria (arrows) are located under the folds. **H:** Third part of the non-secretory area with irregular folds. Note the muscles under the epithelium. **I:** The secretory part of the glandular sac with some microvilli bordered cavities of the glandular units. **J:** The secretory cells are linked to each other by interdigitations (asterisks). **K:** Ducts are also observed in the secretory epithelium.
Abbreviations: c = cuticle, d = duct, dg = dense granules, lg = lucent granules, ld = lipid droplets, lu = lumen, ly = lysosomes, mi = mitochondria, mu = muscles, mv = microvilli, nu = nucleus, ss = secretory slit.

Discussion

1. Dermal glands

Numerous dermal glands are known from a number of Opiliones. They may help to modify integumental properties. Sometimes these secretions serve for camouflaging (e.g., Trogulidae). In Cyphophthalmi these glands are very frequent but rather inconspicuous because their openings are very tiny and usually covered by a thin film of secretion. Hence they have not been often recognised (e.g., MARTENS 1979, HAMMEN 1989). In Sironidae it seems likely that the secretions help to keep the surface hydrophobic.

The dermal glands correspond to the class 3 glands according to the classification of NOIROT, QUENNEDY (1974). This type of glands is composed by different cells. The secretory cell is extruding its secretion products into a microvilli bordered cavity from where the secretion passes within the cuticle-lined duct towards the exterior. The similarity of the ultrastructure of these dermal glands with the glands of the male adenostyle (tarsal gland) described by MARTENS (1979) from the same species is remarkable. The occurrence of secretion in the secretory and collar cells demonstrate that both cell types have a secretory activity. Their products are released into a funnel-like cavity lined by microvilli, which are formed by the secretory and collar cells. In the secretory cells, the formation of the granules runs through different stages. Before extrusion into the secretory reservoir, the granules merge into larger granules, which are electron-lucent. The proximal beginning of the duct is provided with a distinct probably sealing structure which may be involved in the control of the expulsion of the secretions.

2. Defence glands

The defence, repugnatory or scent glands are present in all Opiliones. In the Cyphophthalmi these glands are located between the second and third pair of legs on the dorsolateral side of the body on specific elevations, called the ozophores (JUBERTHIE 1970, GIRIBET *et al.* 2002). The defence glands are considered first to provide chemical defence against putative predators. It is possible that their secretion is released as fine sprays or as a droplet (JUBERTHIE 1976, MARTENS 1978, HOLMBERG 1986). In some studies the secretions have been suggested to be used for territorial marking (JUBERTHIE 1976) or as alarm pheromones (MACHADO *et al.* 2002). The chemical composition of the defence secretion was known for the Laniatores and Palpatores (EKPA *et al.* 1985, JONES *et al.* 1976). In a recent study the composition of the gland secretion of *Cyphophthalmus duricorius* was reported by RASPOTNIG *et al.* (2005) for the first time of a species of Cyphophthalmi.

It seems evident that the defence glands are derived from dermal glands: The lid-like structure covering the opening is simply an enlarged tubercle of the surface cuticle, the body of the gland is provided with a (cuticular) intima, and the glandular units found in the secretory part correspond largely in structure with the dermal glands. Discharge of the secretion may be achieved by an increase of haemolymphic pressure. Alternatively, it could be that the gland is kept constantly under pressure and the muscles attaching to the non-secretory part may serve as dilators of this part releasing the secretions when stimulated. No sphincter muscles have been seen. Thus cuticle properties may be responsible for keeping the opening closed when undisturbed. The appearance of a huge number of mitochondria is probably evident for the high activity of the defence glands. Together with the presence of the microvilli bordered cavities in the secretory part, an effective transport of secretions may be assumed.

The defence glands of Cyphophthalmi, described by JANCZYK (1956) and JUBERTHIE (1961) by light microscopy, are ultrastructurally rather similar to those of Phalangiidae (CLAWSON 1988), a family belonging to the Palpatores, a taxon regarded by GIRIBET *et al*. (1999, 2002) as paraphyletic.

The similarity of these glands in Cyphophthalmi and "Palpatores" may seem to support a taxon "Cyphopalpatores" as suggested by Martens *et al*. (1981) and Martens (1986). However, since the peculiarities of these glands of other Opiliones than Cyphophthalmi and Phalangiidae are not known, such a conclusion would be overhasty and further studies have to be awaited.

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Ултраструктура на дермалните и защитните жлези при *Cyphophthalmus duricorius* JOSEPH, 1868 (Opiliones: Sironidae)

М. Гутяр, Р. Шустер, Г. Алберти

(Резюме)

В статията се описва устройството на дермалните и защитните жлези при сенокосеца *Cyphophthalmus duricorius*. Дермалните жлези се състоят от различни по тип клетки, които изпразват секретите си в периферни кухини с микровили, преди да достигнат кутикулната канална система. Двойката защитни жлези с торбовидна форма са съставени от един екскреторен канал, една несекреторна и една секреторна области. Тези три части се характеризират с различна подредба на клетките. Секреторната област включва няколко жлезисти участъка, които произвеждат хетерогенни секрети и по всяка вероятност произлизат от дермалните жлези. Тези жлези отделят секретите си чрез малки канали, водещи в широкия кутикулен лумен.

Lengthening of embolus and copulatory duct: a review of an evolutionary trend in the spider family Sparassidae (Araneae)

Peter Jäger[1]

Dedicated to Dr Manfred Grasshoff on occasion of
his 70th anniversary and in memory of
his contributions to the functional morphology of
the spider family Araneidae

Abstract: The phenomenon of lengthening copulatory structures in the spider family Sparassidae is reviewed. One can distinguish between a diversifying type and a lengthening type, but admitting that there may be combinations and transitions between these cases. Some 55% of 662 species examined show clearly that the embolus and/or copulatory ducts are lengthened in comparison with the ancestral species, whereas only in 8% there is no noteworthy lengthening of these structures. Different types of lengthening are recognised: 'tegular coil', 'distal coil', 'distal screw', the irregular or combination type, and the so-called 'functional lengthening'. In these types uniformity of the copulatory structures prevails, although diversifying elements may occur albeit rarely. Combined morphological changes, occurring in the course of evolutionary lengthening, are considered as being dependent on functional constraints. The position of the embolus' tip may play an important role in this context. Understanding of functional and evolutionary aspects may enlighten possible mechanisms which trigger the phenomenon.

Key words: spider genitalia, copulatory organs, tip of embolus, evolutionary mechanisms, types of lengthening, functional constraints, huntsman spiders

Introduction

In spiders, as in other terrestrial arthropods, copulatory structures have been developed which allow direct sperm transfer (in contrast to indirect sperm transfer in marine or fresh water organisms). Male spiders exhibit copulatory organs on their second pair of appendages: the pedipalpi are modified as gonopods. Females have either rather simple receptacula seminis (Mygalomorphae and haplogyne Araneomorphae) or frequently a complex duct system in front of the genital opening (entelegyne Araneomorphae). Considering the fact that copulatory organs are present only in the last stage of an individual and used for a short time only, and for a restricted purpose, it seems to be most likely that the evolution of these structures may be largely independent from external conditions, e.g. such as climate, habitat, prey animals or others. Both structures in males and females are acting during copulation as one functional unit and are therefore dependent on each other with respect to evolutionary changes of their parts (as in upper and lower jaws in vertebrates) (GRASSHOFF 1975; see also KRAUS 1995, 1998). Apparently, this also seems to be true, if the structures (embolus, copulatory ducts) are in the process of changing their length in the course of evolution, as the lengths of these structures in males and females are changed accordingly. This length-changing occurs, among others, in the spider family Sparassidae, which is represented by about 1000 species worldwide (PLATNICK 2005). Representatives of one subgroup of this family, the Deleninae from the Australasian region, exhibit extremely long emboli and copulatory

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ducts (Figs 1-2). From examination of these copulatory organs, several questions arise, e.g. which mechanisms are responsible for such a trend of lengthening[1], what is the proximate and what the ultimate causation? What advantages or what functional economisation could lengthening genitalia provide for animals of lineages with such an evolutionary trend, such that these have been selected in the evolutionary processes? Have modifications of the mating behaviour been established, as known from e.g. Staphylinidae (GACK, PESCHKE 2005)?

The phenomenon of lengthening genitalia has been addressed only by few authors in the past: COMSTOCK (1910) simply described different types of spider pedipalps and gave standardised names for individual parts. WIEHLE (1961) suggested that for longer female ducts, the emboli would stay for a longer time during the copulation and, by this delay, the transfer of sperm would be secured. Wiehle recognised different types of emboli ('Einführungs-Embolus' and subtypes, 'Anschluss-Embolus') whereas looking for this phenomenon in different spider families. HELS-DINGEN (1972) put this subdivision into perspective and considered it an 'oversimplification'. This author dealt with a striking case of lengthening copulatory structures in the family Linyphiidae. He investigated functional aspects of male palp and female epigyne in fixed copulae and used the results for a systematical re-classification of four genera (HELSDINGEN 1965, 1969, 1970). JOCQUÉ (1998) claims that lengthening of the embolus (as described in e.g. JOCQUÉ 1990, JOCQUÉ, BAEHR 1992, JOCQUÉ, SZÜTS 2001, JOCQUÉ, BOSSELAERS 2005) is one of the possibilities for spiders to increase their complexity of the genitalia, in what he calls the "mating module", implying that genital complexity is linked to ecological specialisation.

Before addressing the questions mentioned above, the trend of length-changing genital structures within a particular group (here: Sparassidae) should be investigated for comparison purposes, in order to get an idea of its importance and structural influence on the evolutionary history of the recent species composition.

Material and Methods

During the past ten years, 662 of the 793 Sparassidae species, with male sex known, were examined, i.e. about 83%. Some 546 (69%) with known male sex, have been used here. Legends of drawings or indications in the text should be a sufficient reference. Male and female copulatory organs were investigated and drawn, using stereomicroscopes (Leica MZ 16, Wild M8) and compound microscopes (Zeiss, Leica DMLS), all with camera lucida attachments. Female epigynes were cleared with 96% lactic acid if necessary; epigynes with membranous parts were either cleared very carefully or not treated with lactic acid, since it can change the position of individual parts. Only male copulatory organs were used for taking measurements (length of embolus, position of tip of embolus). Female epigynes are only referred to in a more general manner or in single cases (e.g. *Heteropoda* LATREILLE, 1804). Relative length of emboli and lengthening respectively were measured in comparison to a reference length of an assumingly basal state (short embolus). An arising point in a 6-o'clock-position, for instance, is considered plesiomorphic for many taxa within Sparassidae. To make positions of the embolus' tip comparable, i.e. to compensate for differently shaped pedipalps, the tegulum including all its appendices were fitted into a rectangle as in Fig. 29. The relative position of the tip was calculated with: co-ordinates of the embolus' tip being the relative length and width of the rectangle. Additional measurements were taken from suitable original drawings, i.e. if the cymbium was drawn in a ventral view and the parts were unambiguously identifiable. All measurements were carried out only for those emboli being in the resting position (i.e. bulbs were not expanded). Single females were assigned to one of the

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[1] For evidences supporting the hypothesis that copulatory structures lengthen and do not shorten in the process of evolution, see first paragraph of discussion.

categories, when the internal duct system showed evidence of belonging to one of the lengthening types, even though a conspecific male was not known (e.g. in *Heteropoda*).

A species was identified as belonging to the lengthening type, when either the gradual character states of the embolus or of the copulatory ducts with respect to their length in different, related species appeared (Fig. 1), or if in a single species a distinctly elongated embolus pointed to a derived state. In contrast, emboli with different shapes or with new features such as apophyses and without any evidence of lengthening, were assigned to a so-called diversifying type (Figs 3-6). These assignments are partly supported by females with copulatory ducts of the same or of a similar length. Species without characters of one or other group were noted as questionable.
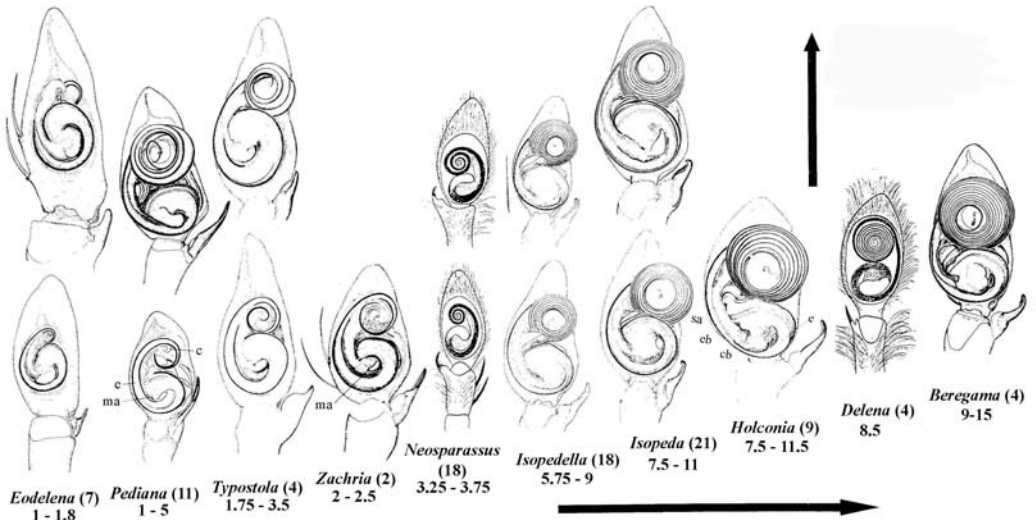
Fig. 1. Male pedipalps of different species of the subfamily Deleninae from Australia, showing different lengths of distal coils of the embolus, here interpreted as 'lengthening type'. All illustrations by Hirst (1989, 1990, 1991a, 1991b, 1992, 1993, 1995, 1997, 1999), exception: *Neosparassus* and *Delena* (by Hickmann 1967). Arrows point to lengthening within the subfamily (horizontal) and within the particular genus (vertical), but are not interpreted as direct detector of phylogenetic relationship. Numbers in parentheses behind genus names indicate species numbers, ranges below genus names number of coils observed within the particular genus.
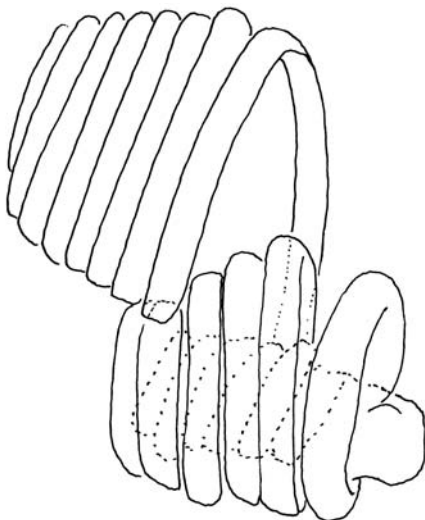
Fig. 2. Distal coils of the embolus of an undescribed *Neosparassus* sp., lateral view, showing organisation of the twenty coils in three spirals. The outer coil was compassed to make inner coils visible.
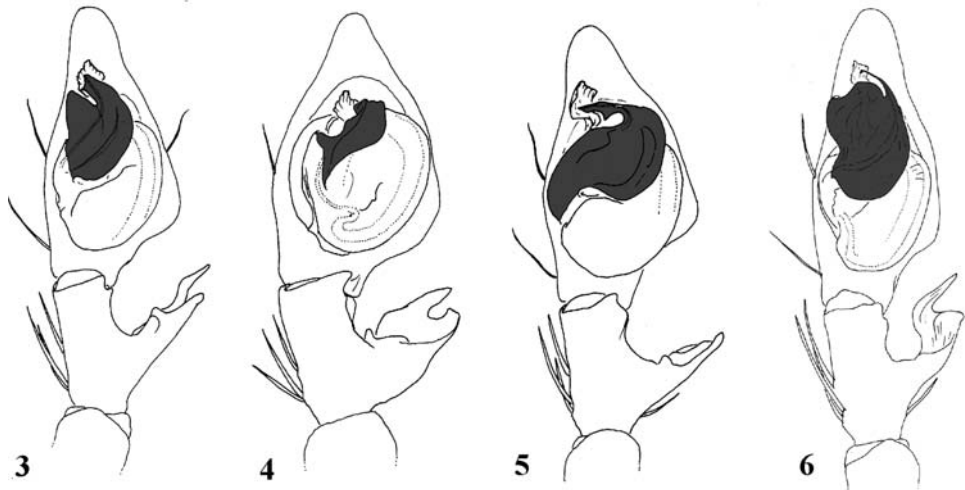
Figs 3-6. Male pedipalps of different undescribed *Pseudopoda* species from Yunnan, showing different shapes and sizes of emboli, here interpreted as 'diversifying type'. Emboli shaded.

Results

In total 364 species (55%) of 662 species examined were considered belonging to a lengthening type of copulatory structures. In contrast only 54 species (8%) exhibit a clearly diversifying type of emboli (e.g. *Pseudopoda* JÄGER, 2000 cf. Figs 3-6, *Anaptomecus* SIMON, 1903, *Sparianthina* BANKS, 1929, *Prusias* O.-P. CAMBRIDGE, 1892 ad part., *Olios* WALCKENAER, 1837 ad part.). Two hundred forty-five species could not be assigned to one of the two categories and remain questionable until further work. Generally, lengthening can take place at the tip (e.g. in *Holconia* THORELL, 1877) or at the base (e.g. in *Heteropoda*) of the embolus. Moreover, both types can occur together (e.g. in *Pandercetes* L. KOCH, 1875; compare JÄGER 2002: fig. 173). Beside these, different types of lengthening were also recognised.

Different types of lengthening

In the **'tegular coil'**- type the base of the embolus is shifted in the course of evolution around the tegulum, the tip of the embolus remains almost in the same position (Figs 7-8). This type occurs in *Heteropoda* (180 species), *Barylestis* SIMON, 1910 (9), *Yiinthi* DAVIES, 1994 (8), *Polybetes* SIMON, 1897 ad part. (8), *Damastes* SIMON, 1880 (17), *Gnathopalystes* RAINBOW, 1899 ad part. (7), *Tychicus* SIMON, 1880 (5) and *Prychia* L. KOCH, 1875 (4) (total number of species: 238). Maximal lengthening of the embolus constitutes 200% additional length. The **'distal coil'**- type is characterised by a lengthening at the tip of the embolus, which during the process remains in almost the same position, with the embolus tightly circling around a central point (Figs 11-12). It is realised in the Deleninae (11 genera, 105 species), *Clastes* WALCKENAER, 1837 (1), *Palystes* L. KOCH, 1875 ad part. (6), *Remmius* SIMON, 1897 (5), *Rhitymna* SIMON, 1897 ad part. (10), *Sarotesius* POCOCK, 1898 (1) (total number of species: 128). Emboli exhibit a maximal lengthening of 900%. Representatives of one genus (*Olios* ad part., i.e. former *Pelmopoda* KARSCH, 1879 spp.; 10 species) exhibit a **distal screw** with a maximum of 120% additional length (Figs 14-15). The embolus' tip is circling around its straight length axis and the embolus is lengthened at its tip retrolaterad. In *Pseudopoda* ad part. (20), *Pandercetes* (18), *Olios* ad part. (10), *Palystella* LAWRENCE, 1928 (4)*, Microrchestris* LAWRENCE, 1962 (2)*, Cebrennus* SIMON, 1880 (13) the embolus is lengthened at the base and at its tip **irregularly** (i.e. with no distinct shape, such as a circle, spiral, etc.) or **in combination** (Figs 18-19; total species number: 67; maximal lengthening: 350 % additional length).
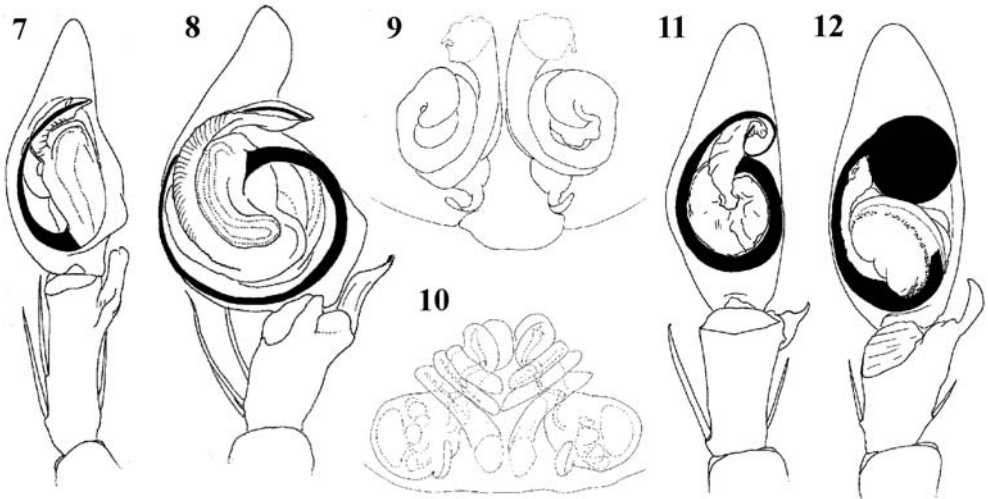
Figs 7-12. 7-8 - Male pedipalps of *Heteropoda* species representing the 'tegular coil' type; 7 - *Heteropoda* sp., 8 - *Heteropoda cyperusiria* BARRION, LITSINGER, 1995. 9-10 Female internal duct systems of *Heteropoda* species belonging to the same lengthening type of males (tegular coil) but show different pattern of lengthening: 9 - *Heteropoda lunula* (DOLESCHALL, 1857), 10 - *Heteropoda cyperusiria* BARRION, LITSINGER, 1995. 11-12 Male pedipalps of Deleninae species representing the 'distal coil' type: 11 - '*Olios*' *coccineiventris* (SIMON, 1880), syntype, 12 - Deleninae sp. Note the shorter tibia in males with longer embolus in both types and the shape of cymbium changed in *Heteropoda cyperusiria*. Emboli shaded. 8, 10 from JÄGER, BARRION (2001).
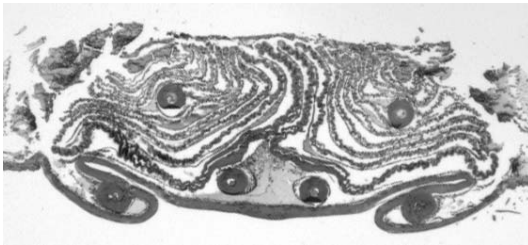
Fig. 13. Cross section through female copulatory organ of *Holconia* sp. from Australia (stained with Azan-Heidenhain, 8μm) showing space saving type of windings in membranous copulatory ducts (ducts arranged in tiers partly folded). Preparation and photo by M. Reinke.

A special type of lengthening occurs in the *okinawana*-group of the genus *Sinopoda* JÄGER, 1999: the embolus is reduced in its width, the embolic apophysis is reduced and the shape of the embolus changes from an '*S*' to a semi-circle (Figs 20-24). Since it is assumed that the reduction of hindering parts (i.e. broad base, distal embolic apophysis, *S*-shaped tip) allows an insertion of longer parts, this type is called **functional lengthening**. This assumption is slightly supported by the internal duct system of the female spiders: in the species with functionally longer emboli the ducts are more strongly bent to the dorsal side (Figs 25-26), which could be explained as a better accommodating the longer emboli. However, this group exhibits some apomorphies (reduced ventral part of RTA, distinct brush of hairs at the base of RTA, body size reduction; JÄGER, ONO 2002) which polarise the gradual change in direction to the reduced embolus and thus an assumed functional lengthening. Species with assumed derived structures occur in the most eastern part of the distribution range (Japan) of this species-group (see also legend of Figs 22-26).

Lengthening may occur in a group exhibiting generally diversifying copulatory structures as e.g. in the genus *Pseudopoda* (Figs 3-6). In this case only parts of the embolus are lengthened (e.g. *Pseudopoda martensi*-group, see JÄGER 2001: 124, fig. 84) and it is called here **secondary lengthening**.
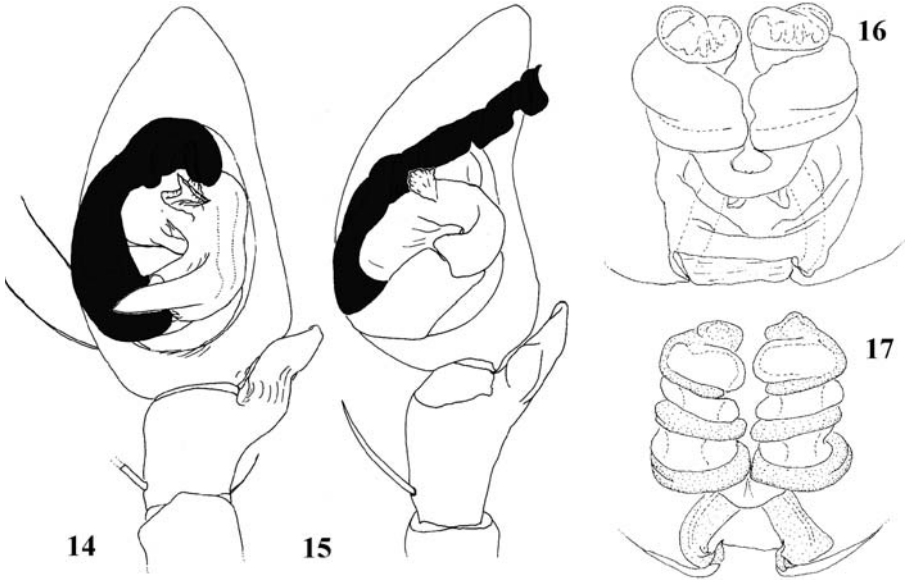
Figs 14-17. 14-15 - Male pedipalps of *Olios* species representing the 'distal screw' type: 14 - *Olios* sp., 15 - *Olios punctipes* SIMON, 1884; 16-17 - Female internal duct systems of *Olios* species belonging to the same lengthening type: 16 - *Olios nigrifrons* (SIMON, 1897), 17 - *Olios* sp. Note that a straight (functionable) screw is only realisable in the distal part of the pedipalp. Emboli shaded.
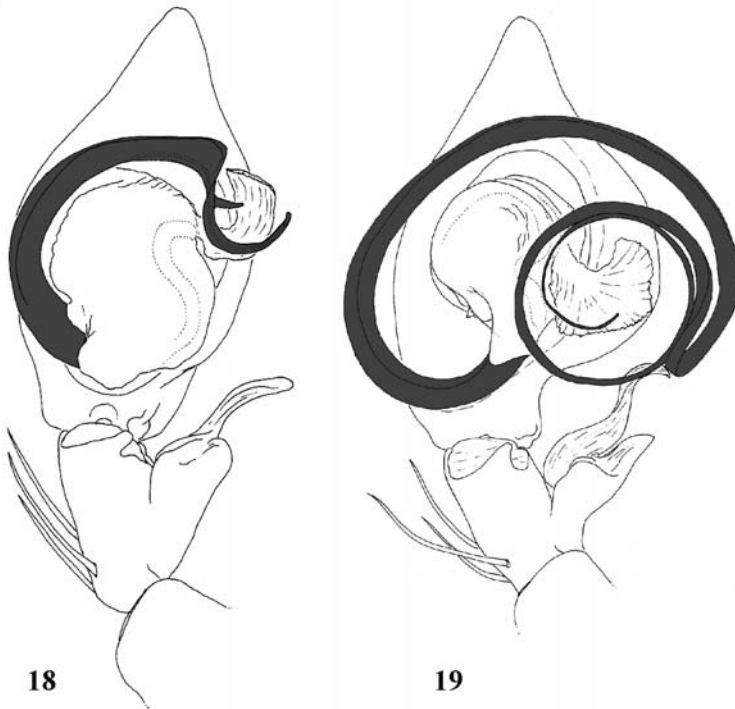
Figs 18-19. Male pedipalps of *Pseudopoda* spp. from Japan representing an irregular type of lengthening: 18 - *Pseudopoda kasariana* JÄGER, ONO, 2002; 19 - *P. spirembolus* JÄGER, ONO, 2002. Emboli shaded. 18-19 after JÄGER, ONO (2002).
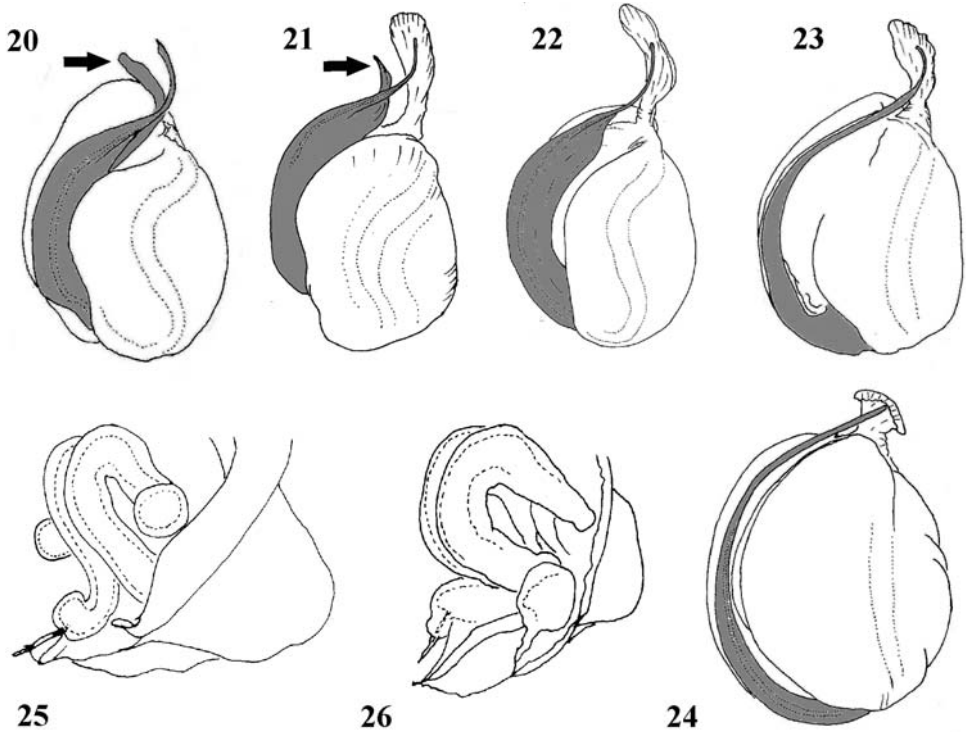
Figs 20-26. 20-24 - Male tegula with appendices of *Sinopoda* species of the *okinawana*-group representing the 'functional lengthening' type: 20 - *S. hamata* (Fox, 1937), holotype from Sichuan Prov. (China), conductor omitted, 21 - *S. fasciculata* Jäger, Gao, Fei, 2002, holotype from Guizhou Prov. (China), 22 - *S. wangi* Song, Zhu, 1999, syntype from Jiangxi Prov. (China), 23 - *S. albofasciata* Jäger, Ono, 2002, holotype from Tokashiki Isl. (Japan), 24 - *S. derivata* Jäger, Ono, 2002, holotype from Tokara Isl. (Japan). Note that embolic apophysis (arrows) and basal width of embolus are reduced and shape of embolus is changed from *s*-shaped to semi-circular, and note the geographic gradient (reduction from West to East). Emboli shaded. 25-26 - Female internal duct system of *Sinopoda* spp. of the *okinawana*-group: 25 - *S. hamata* (Fox, 1937), 26 - *S. tanikawai* Jäger, Ono, 2000. Note that the right vulva is more strongly bent and could accommodate theoretically a longer embolus inserted. 21-22 after Jäger *et al.* (2002), 23-24, 26 after Jäger, Ono (2002).

Uniformity within one type

Within one type of lengthening the copulatory organs appear rather uniform, i.e. without diversifying elements. Only in relatively rare cases are new structures found, such as new apophyses at the tegulum, conductor or embolus. One such example occurs in the genus *Heteropoda*: *H. javana* Simon, 1880 and some related species (Fig. 27; Jäger 2002: fig. 61), which exhibit an apophysis arising from the conductor in conjunction with an unusually shaped RTA (in comparison with the common form of the RTA in *Heteropoda* spp. which is supposed to be plesiomorphic for this genus). Other examples occur in *Heteropoda boiei* (Doleschall, 1859) with an additional tegular apophysis (Fig. 28), and the different genera of the Deleninae in Australia, which are distinguished among other characters by their differently shaped tegular apophyses and embolic sclerites (Hirst 1990).

In females, usually the same type of lengthening of copulatory ducts were observed within one type of lengthening of the corresponding embolus (e.g. *Olios* spp., Figs 16-17). Only within *Heteropoda* were different types recognised (Figs 9-10). Thus, females apparently may provide a morphological basis for recognising subgroups (sublineages) within one trend of lengthening emboli of males.

Combined morphological changes

Within a certain lineage, species with longer emboli exhibit additional morphological features which changed either in size or shape. In several cases the tibia is often shorter than in species with longer emboli (*Heteropoda* spp., Figs 7-8; Deleninae, Figs 11-12; *Pseudopoda* spp., Figs 18-19). Moreover the shape of the cymbium also changed, e.g. is transformed from having more straight or slight concave retrolateral margins, to having strongly concave retrolateral margins in a ventral view for *Heteropoda* species (Figs 7-8). When the embolus is lengthened and requires more space, the tegulum is reduced or shifted mostly in direction of the basal half of the palp (Deleninae, Figs 11-12). The latter phenomenon may also occur in cases of species with a diversifying type of embolus (*Bhutaniella*, JÄGER 2001: fig. 54b; *Sparianthina* spp., unpubl. observations).

Figs 27-28. Male pedipalps of *Heteropoda* spp. showing diversifying elements within the otherwise uniformly developed bulbs of the 'tegular coil'-type: 27 - *Heteropoda dagmarae* JÄGER, VEDEL, 2005, holotype, with apophysis at the base of the conductor (arrow), from JÄGER, VEDEL 2005; 28 - *Heteropoda boiei* (DOLESCHALL, 1859) with a tegular apophysis (arrow), from JÄGER 2001.

In a few cases the RTA becomes longer in species with longer emboli, either by shifting the RTA base proximad, or by increasing the length at the tip distad (e.g. Deleninae, Figs 11-12; *Cebrennus rungsi* JÄGER, 2000, *C. aethiopicus* SIMON, 1880, see JÄGER 2000: figs 34, 49). Furthermore, in few cases, the membranous part of the tibia-tarsus joint is extended more onto the tibia part (Deleninae: *Eodelena* HOGG, 1902 => *Beregama* HIRST, 1990, Figs 11-12, *Heteropoda*, Figs 7-8, *Olios* ad part., Figs 14-15).

Position of embolus' tip

In male copulatory organs the position of the embolus' tip appears, in many lineages, to be strikingly constant. To check this first impression, the position of this tip in different species (n = 546) within the Sparassidae, were measured. Results are shown in Figs 29-30. The tip of the embolus is situated, in most cases (95.4%) in the distal half of the constructed rectangle, and also in most species (72%), is situated in the retrolateral distal quarter (e.g. in *Heteropoda*). In contrast, there are only 4.6% of the species with the embolus ending in the basal half, and just 0.4% in the prolateral basal quarter. In fact, in the latter case there is a large area, in which no tip of an embolus was situated, i.e. in general the emboli end more to the distal or retrolateral directions.

Discussion

In the opinion of the author copulatory structures are lengthening in the process of evolution. It arises the question, why it should not run the opposite way, i.e. evolve from long to short. Here, some evidences are listed, which support the 'lengthening-hypothesis'. One of the main arguments is that it seems unlikely that species in different (sub)lineages (e.g. in the Deleninae, Fig. 1) with

Figs 29-30. 29 - Rectangle constructed for measuring position of embolus' tip; 30 - Position of embolus' tip from 546 species of Sparassidae (of 793 with males known). Prolateral half 130 spp. (24%), retrolateral half 416 spp. (76%), basal half 25 (4.6%), distal half 521 (95.4%); Basal prolateral quarter 2 spp. (0.4%), basal retrolateral quarter 23 spp. (4.2 %), distal prolateral quarter 128 spp. (23.4%), distal retrolateral quarter 393 spp. (72.0%).

long emboli and long copulatory ducts have evolved independently and then have been shortened and resulted by chance in species with very similar, convergently developed short structures. In contrast, it seems more likely that those species with shorter structures are derivatives of one stem species and represent the initial point for lengthening in different lineages. There exist more such examples from further subfamilies, e.g. Heteropodinae, and Sparassinae. Another example, supporting the idea of lengthening copulatory structures, is the *Sinopoda okinawana*-group (for details see paragraph 'functional lengthening' in subchapter 'Different types of lengthening'). A further strong argument is of more hypothetical nature: considering the high percentage of species with long copulatory structures, it seems likely that there are mechanisms - yet unknown - triggering this kind of evolutionary process. If so, it would wonder, when this process could be reversed by the same mechanisms. One could ask, why species with short emboli are still present in the recent fauna, if the trend of lengthening and its mechanisms are so strong. But species composition is not a question of evolution alone, but also of post-evolutionary, ecological mechanisms, e.g. such as competition. However, for most of the aspects and thoughts presented here, it does not matter, whether the embolus and the copulatory ducts are lengthening or shortening in the evolution. For instance, the assumed combined morphological changes seem to be present anyway, no matter whether structures have been lengthened or shortened, and should be considered in future research, e.g. in phylogenetic analyses.

When considering the more derived states, i.e. those with a definitely long embolus and copulatory ducts, e.g. in the Deleninae, it is surprising that so little attention has been paid to this

striking phenomenon. No attempt has been made as yet, to explain the mechanisms behind the trend, either by looking for immediate or long-term causes. Although the present paper cannot provide any explanations in this respect, it does bring the phenomenon into sharp focus. The simple recognition of the trend is important for taxonomic descriptions, systematic sorting as well as for phylogenetic analyses, regarding the secondary effects it might have (see under 'combined morphological changes').

Because the phenomenon occurs in different spider families, the results obtained in the Sparassidae may serve as an example and may help to understand evolutionary mechanisms in these other families. I do not think that the results of one analysis may apply to all spider families as was done by WIEHLE (1961), as longer emboli and the corresponding structures in female spiders may have different causations. It may be useful for an organism to shift the spermathecae away from the close contact with the outside environment as it occurs in some Mygalomorphae, to prevent dehydration, bacteria infection or simply leakage. However, it is not likely that the same cause can be called upon to explain the development of more than 10 coils as is the case in the Deleninae. Moreover, it makes more sense to look at causal effects within one group with a large range of embolus types (here: Sparassidae), since the same structures may be used differently in non-related groups (RTA anchored in epigastric furrow in Sparassidae, but in epigyne in Gnaphosidae; pers. observ., SENGLET 2004).

Different types of lengthening

Different types of lengthening structures which occur in different, but not closely related taxa, may point to general constraints, which, in the course of evolution, are effective and stabilise such a type of "increasing complexity" (sensu JOCQUÉ 1998). Apparent differences in species numbers and maximal lengthening of copulatory structures among the Sparassidae, lead to the question, whether the recent diversity of this family can be explained by this phenomenon? The example of the distal screw may show that, at least, part explanations can be found looking for functional constraints of the different types: the screw of *Olios* species is lengthened by circling around its length axis and by extending the length of the embolus in a retrolateral direction. The space for doing so is limited to the dorsal half of the bulb, as the embolus length axis has to remain straight, as only then a screw is functionable. According to the females' genitalia, the male screw is indeed screwed into the copulatory ducts of the female. In this case a bent screw could not work, neither for a real screw, nor for a screw in spiders' copulatory organs. We can presume that the bauplan of the ancestors of copulatory structures - once established in the course of evolution of a spider - restricts the subsequent evolutionary events in their evolutionary changes. Even if there was a strong evolutionary pressure for long copulatory structures in these *Olios* species-group, the development of a screw cannot be reversed. Thus, the development of a screw in the copulatory organ of this species group delimits its relative evolutionary output - i.e. results a fewer number of species – in comparison with other lineages without such (morphological) restrictions, e.g. with a distal coil and a higher maximal lengthening as e.g. in Deleninae.

The maximum length of a male embolus can also be delimited by restrictions in the particular female: a male embolus with a potential of maximal lengthening of for instance 200%, cannot lengthen further if the female duct system is restricted to 100% and could not accommodate the additional lengthened structures of the male. On the other hand, one explanation for the strongly lengthened emboli and ducts in the Deleninae may be a combination of two different factors: **1**. the male distal coil of the embolus provides a system of lengthening which has no strong structural restrictions (i.e. tip of the embolus remains almost in the same position, while evolutionary lengthening and space saving type of coiling, backed up by the similar-shaped conductor, allow for a high number of coils; in comparison with the distal screw of *Olios* spp., the distal coil is

also restricted in its shape [only a circular coil is insertable in the case of several windings]. But this restriction does not decrease but increase the output with respect to the number of possible coils). **2**. Additionally, the female duct system represents the rare case of being membranous and thus space saving, facilitating strong coiling within a restricted space (Fig. 13). The same number of coils would need a lot more space in the sclerotised form as in e.g. *Heteropoda* spp., as these cannot be folded, apart from the fact that sclerotised coils have thicker walls per se.

Uniformity within one type

Within one type of lengthening, the copulatory organs were distinctly uniform (e.g. Deleninae, *Heteropoda*). Diversifying appears, but apparently in fewer cases in comparison with lengthening events. In Deleninae, genera are distinguished by the shape of the tegular apophysis and the basally situated embolic sclerite (e.g. HIRST 1990). Based on the fact that Hirst distinguished genera by means of these diversifying elements, a ratio of about 1:10 is observed (11 genera, 105 species). This means that lengthening events occur 10 times more frequently than diversifying ones. A similar ratio is present in *Heteropoda*: from the total number of species (n=180) less than 10% (n=14) show diversifying elements, i.e. tegular apophyses, conductor apophyses or embolus modifications. A scenario which would explain this ratio is that the lengthening type develops faster than the diversifying one, i.e. produces more functionable variants within a specified time period. The apparent higher degree of freedom with respect to evolutionary changes in the copulatory traits in females of *Heteropoda* species, may be explainable by proximate causations of the individiual development of these structures in the ontogeny. Investigations in this field would be interesting, but may be also complex to carry out.

Combined morphological changes

The observed morphological changes, in combination with an elongation of an embolus, may be explained by functional constraints based on copulatory mechanics. No investigations were conducted, so far, for this topic in the Sparassidae, whereas results of 'frozen copulations' were described in Gnaphosidae (SENGLET 2004) and Pholcidae (UHL *et al.* 1995, SENGLET 2001, HUBER 2002). In the latter cases investigated, exclusively diversifying types were present, i.e. no conclusions about the phenomenon on lengthening can be drawn. In respect of combined changes in tibia length, or different cymbium shapes, the observations made in the Sparassidae are backed up by observations in e.g. Zodariidae (*Palfuria panner* JOCQUÉ, 1991, *P. spirembolus* SZÜTS, JOCQUÉ, 2001: SZÜTS, JOCQUÉ 2001a; *Australutica moreton* JOCQUÉ, 1995, *A. quaerens* JOCQUÉ, 1995: JOCQUÉ 1995), Salticidae (*Bacelarella tentativa* SZÜTS, JOCQUÉ, 2001, *B. tanohi* SZÜTS, JOCQUÉ, 2001: SZÜTS, JOCQUÉ 2001b, JOCQUÉ, SZÜTS 2001) and Lamponidae (*Asadipus humptydoo* PLATNICK, 2000, *A. yundamindra* PLATNICK, 2000: PLATNICK 2000). Although a thorough analysis for each family or genus or even species group would be necessary for making statements, the examples may by seen as evidence for this trend of combined changes in other families (at least within the RTA-clade). However, the results shown here for the Sparassidae indicate that similar combined changes found in other taxa and their utilisation for systematical purposes may be viewed in a different perspective.

Position of embolus' tip

A similar position for the embolus' tip within one type of lengthening, and also among less closely related taxa, may point to a functional constraint, which inhibits a considerable shifting of the tip, since the behavioural, as well as morphological changes, to accommodate this shifting may be too intricate. Distinctly different positions within an assumed monophyletic lineage (e.g. in the subfamily Sparianthinae) on the other hand may point to a polyphyly or to different sublineages. The

position of the tip is considered here as just providing indications for further investigations.

A similar result, in respect of the position of the embolus' tip, is observed in other spider families, especially those from the RTA-clade: Philodromidae, Gnaphosidae, Lamponidae, Thomisidae, Salticidae, Corinnidae, etc. Constraints, in respect to functional morphology of the particular pedipalps or copulatory mechanics in male-female interaction, may explain why an embolus tip obviously cannot be situated in certain positions. It may have something to do with the fact that the RTA is fixed during the copulation and subsequent movements are possible only in a mechanically restricted frame, due to the automatic haemolymph pressure driven expansion of the haematodochae (as described in HUBER 2004). The typical embolus tip position for particular taxa, may act as additional diagnostic character, e.g. in *Sinopoda* and *Pseudopoda*, mostly in the prolateral distal quarter of cymbium, in *Heteropoda*, Deleninae, etc. in the retrolateral distal quarter of cymbium and so on. Once recognised as typical for a group an unusual position of an embolus tip can indicate a special systematic position for a particular species, e.g. basal or derived within the stem group.

Future studies should focus on a broad-range comparison within the family, i.e. to fix couples during copulation, and to show where the spermatophor opening is situated during copulation, which glandular parts of the female duct system are secreting to which part of the copula, and where the sperm mass is deposited. Results may enlighten mechanisms in the course of the evolution which are responsible for the process of lengthening, described above, and, partly, for the recent composition of species.

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Удължаване на емболуса и копулаторния канал: преглед на еволюционна тенденция при паяците от семейство Sparassidae (Araneae)

П. Йегер

(Резюме)

Разгледан е феноменът на удължаване на копулаторните структури при паяците от семейство Sparassidae. Определени са различни типове на модифициране и на удължаване, но се допускат и комбинации и преходи между тях. При 55% от изследваните 662 вида ясно се вижда, че емболусът и/или копулаторните канали са удължени в сравнение с прародителските видове, докато само при 8% не е установена елонгация на тези структури. Разграничени са следните типове на удължаване: "тегуларна спирала", "дистална спирала", "дистално витло", неправилен или комбиниран тип, и така нареченото "функционално издължаване". Комбинираните морфологични изменения, ставащи в процеса на еволюционното нарастване, вероятно зависят от функционалните ограничения. В тази връзка, положението на края на емболуса може да играе важна роля. Изясняването на функционалните и еволюционни аспекти на разглеждания феномен може да разкрие механизмите, които го отключват.

Four new species of the genus *Aelurillus* SIMON, 1884 (Araneae: Salticidae)

Galina N. Azarkina[1]

Abstract: Four new species of *Aelurillus*, *A. afghanus* sp. n. (northeastern Afghanistan), *A. balearus* sp. n. (Balearic and Canary islands), *A. bosmansi* sp. n. (Spain) and *A. cypriotus* sp. n. (Cyprus) are diagnosed, illustrated and described. A new combination, *A. stanislawi* (PRÓSZYŃSKI, 1999) (ex *Rafalus*), is proposed, and *A. minutus* AZARKINA, 2002 is synonymized with *A. stanislawi*. The unknown female of *A. stanislawi* is also described. Distributional maps are provided for all species.

Key words: spiders, *Aelurillus*, *Rafalus*, taxonomy, new species, synonymy

Introduction

Five species of the spider genus *Aelurillus* from the Mediterranean region, Levant and Central Asia are treated in this paper. Four of them are described as new to science. One species, *A. afghanus* sp. n., is described from a single female from northeastern Afghanistan; both *A. bosmansi* sp. n. and *A. cypriotus* sp. n. are described from single males; and *A. balearus* sp. n., is described from both sexes. Very problematic in taxonomic respect is the group of *A. v-insignitus* (CLERCK, 1757) comprising a lot of synonyms. The species *Aranea punctata* OLIVIER, 1789 (from France), *Aranea litterata* WALCKENAER, 1802 and *Attus quinquepartitus* WALCKENAER, 1805 (both from France), *Aranea navaria* MARTINI, GOEZE: In LISTER (1778) and *Salticus nidicolens* O. P.-CAMBRIDGE, 1861 (from England), are considered as junior synonyms of *A. v-insignitus* (THORELL 1869, see pp. 377-381), but the type material of these species is yet to be re-examined. The material of *A. cypriotus* sp.n. has been previously identified as *A. v-insignitus* (CLERCK, 1757).

Material and Methods

This paper is based on both museums' collections and on the material newly collected from Spain. A total of 19 specimens were examined. Specimens for this study were borrowed from and after the study housed in the following museums and personal collections: AMNH = American Museum of Natural History, New York, USA (N. Platnick); CBAR = Centro di Biologia Ambientale, Baixa da Banheira, Portugal (P. Cardoso); HECO = Hope Entomological Collection, Oxford, UK (J. Hogan); HUJI = The Hebrew University of Jerusalem (Zoological Department), Israel (G. Levy); MHNG = Museum d'Histoire Naturelle, Genève, Switzerland (P. Schwendinger); NMP = National Museum of Prague, Czech Republic (A. Kurka); PCJM = the personal collection of J. Murphy, Hampton, UK; RBINS = Royal Belgian Institute of Natural Sciences, Brussels, Belgium (L. Baert); SNHM = Senckenberg Natural History Museum, Frankfurt am Main, Germany (P. Jäger); ZMTU = Zoological Museum of the Turku University, Turku, Finland (M. Saaristo). Abbreviations used in the text: AME - anterior median eyes, ALE - anterior lateral eyes, PLE - posterior lateral eyes,

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Fm - femur, Pt - patella, Tb - tibia, Mt - metatarsus. The measurements of leg segments are in the following sequence: femur+patella+tibia+metatarsus+tarsus. All measurements are in mm. The leg spination is after Ono (1988).

Taxonomy

Aelurillus afghanus sp. n.

Figs 1-5

Material examined: Holotype ♀ (NMP), Eastern Afghanistan, Prov. Nergrahar, 12-20 km SE of Jalalabad, 600 m a.s.l., 7 March 1966, Coll. Povolný & Tenora; – Paratype: 1 ♀ (NMP), Afghanistan, Prov. Nergrahar, Jalalabad Nimla, 2 May 1963.

Diagnosis: This species is similar to *A. nenilini* Azarkina, 2002, but differs in having smaller epigynal wings, which are situated markedly below the upper part of the copulatory pores, also in having a compact and small epigynal pocket (Fig. 3) and stronger meandering spermathecae (Figs 1, 4) (cf. Azarkina 2002, and Figs 1, 3-4).

Etymology: The species is named after Afghanistan, the type locality.

Description: Female (Holotype): Carapace 2.0 long, 1.8 wide, 1.0 high at PLE. Ocular area 1.0 long, 1.1 wide anteriorly and 1.0 wide posteriorly. Diameter of AME 0.4. Abdomen 3.9 long, 2.5 wide. Cheliceral length 0.7. Clypeal height 0.2. Length of leg segments: I 0.9+0.6+0.6+0.4+0.4; II 0.9+0.6+0.6+0.5+0.4; III 1.5+0.7+0.9+0.9+0.6; IV 1.4+0.7+0.9+1.1+0.7. Leg spination: I: Fm d 1-1-3; Tb pr 1-1, v 2-2-2 ap; Mt pr and rt 1-1, v 2-2 ap. II: Fm d 1-1-4; Tb pr 1-1, v 2-2-2 ap; Mt pr and rt 1-1, v 2-2 ap. III: Fm d 1-1-4; Pt pr and rt 1; Tb d 1-0-0, pr and rt 0-1-1, v 1-0-2 ap; Mt d 1-1-0, pr and rt 1-0-2, v 1-1-2 ap. IV: Fm d 1-1-1; Pt pr and rt 1; Tb d 1-0-0, pr and rt 0-1-1, v 1-0-2 ap; Mt d 1-1-0, pr 1-1-2, rt 1-0-2, v 1-1-2 ap. Coloration: carapace brown, with dark brown eye field, covered with adpressed white scales and without a colour pattern (Fig. 2). Hairs around eyes white. Clypeus and cheeks yellow-brown, covered with short white hairs. Chelicerae
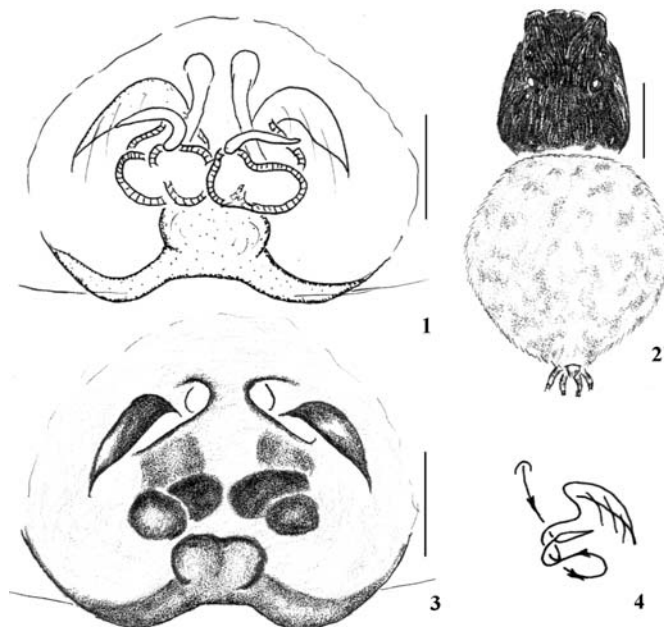
Figs 1-4. *Aelurillus afghanus* sp. n.: 1 – spermathecae, dorsal view; 2 – female, body pattern; 3 – epigyne, ventral view; 4 – diagrammatic course of the insemination ducts. Scale lines: 0.1 mm (1, 3), 1 mm (2).

Fig 5. Distribution map of *Aelurillus afghanus* sp. n.

and sternum yellow-brown. Abdomen grey-yellow, dorsum yellow, covered with silvery hairs and thin brown spines and with an indistinct pattern of brown spots. All legs brown-yellow, with brown stains and half rings, covered with white hairs. Palps yellow, covered with long white hairs. Structure of epigyne and spermathecae as in Figs 1, 3-4.

Remarks: Only one species of *Aellurillus*, *A. logunovi*, has hitherto been recorded from Afghanistan (LOGUNOV, ZAMANPOORE 2005). From Afghanistan neighbour territories - Himachal Pradesh (North India), two further species have been recorded. All of them are clearly different from the new Afghan species.

Aelurillus balearus sp. n.

Figs 6-16

Material examined: Holotype ♂ (AMNH), Spain, Balearic Islands, Mallorca, Arta, Cala Estreta, rocky, pine scrub, 8 April 1985, Coll. J. A. Murphy; – Paratypes: 2 ♂ 1 ♀ (AMNH), same locality as holotype; 1 ♀ (PCJM), 1 ♂ (AMNH), Albutera marsh, 8-16 April 1975, Coll. J. A. Murphy; 1 ♂ (PCJM), Ibiza Island, Puig de Sabina, 200 m a.s.l., dry scrub hillside, 16 April 1980, Coll. J. A. Murphy; 1 ♀ (MHNG, JC-98/11), Canary Islands, Fuerteventura, Morro Jable (S of the island), 80 m a.s.l., on the ground in the port, desert slope with sandy vegetation, under stones, 18 November 1998, Coll. C. Lienhard.

Diagnosis: This species is close to *A. lucasi* but the male has different body coloration: the carapace has a clear pattern of short white scales (Fig. 6). The terminal apophysis has poorly extended teeth (Figs 10, 12-13, 15) vs. well-extended teeth in *A. lucasi* (WUNDERLICH 1995); epigyne with wide epigynal pocket (Figs 11, 14), vs. narrow and small epigynal pocket (SCHMIDT 1977a, see Fig. 11; SCHMIDT 1977b, see Fig. 17; SCHMIDT 1980, see Fig. 6).

Etymology: The species is named after Baleares.

Description: Male (paratype from Arta, Mallorca): Carapace 2.5 long, 1.9 wide, 1.5 high at PLE. Ocular area 1.15 long, 1.5 wide anteriorly and 1.4 wide posteriorly. Diameter of AME 0.4. Abdomen 2.0 long, 1.6 wide. Cheliceral length 1.0. Clypeal height 0.2. Length of leg segments: I 1.1+0.7+0.7+0.6+0.5; II 1.2+0.8+0.75+0.4+0.5; III 1.6+0.9+0.9+1.0+0.65; IV 1.5+0.7+1.0+1.2+0.6. Leg spination: I: Fm d 1-1-5; Pt pr 1; Tb pr 1-1-1, rt 1, v 1-1-2 ap; Mt pr
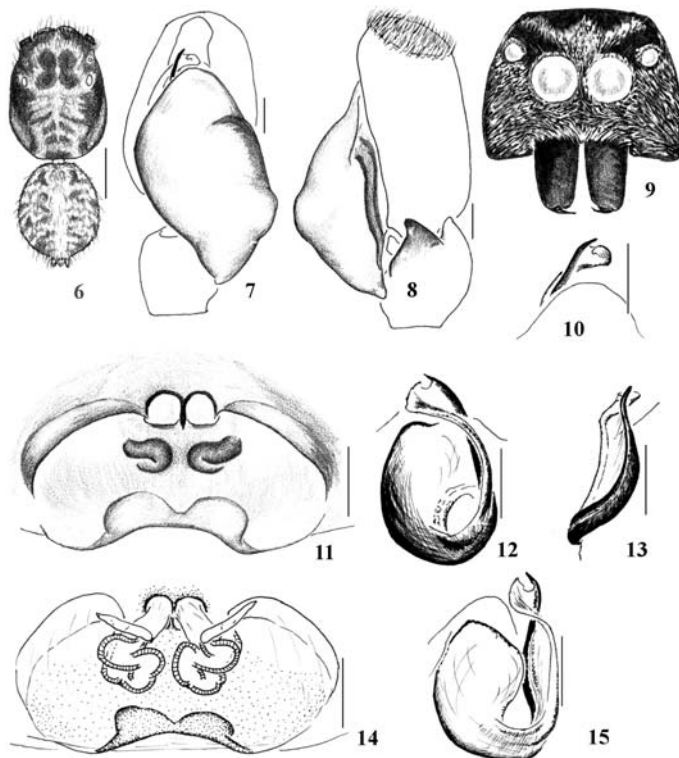
Figs 6-15. *Aelurillus balearus* sp. n.: 6 – male, body pattern; 7 – male palp, ventral view; 8 – same, lateral view; 9 – male face; 10 – embolic division, ventral view; 11 – epigyne, ventral view; 12 – embolic division, dorsal view; 13 – same, prolateral view; 14 – spermathecae, dorsal view; 15 – embolic division, retrolateral view. Scale lines: 0.1 mm (7-8, 10-15), 1 mm (6).

and rt 1-1, v 2-2 ap. II: Fm d 1-2-5; Pt pr and rt 1; Tb d 1-0-0, pr 1-1-1, rt 1-1-0, v 1-1-2 ap; Mt pr and rt 1-1, v 2-2 ap. III: Fm d 1-3-5; Pt pr and rt 1; Tb d 1-0-0, pr and rt 1-1-1, v 1-0-2 ap; Mt d 1-1-0, pr and rt 1-0-2, v 2-2 ap or 1-1-2 ap. IV: Fm d 1-2-2; Pt pr and rt 1; Tb d 1-0-0, pr and rt 1-1-1-1, v 1-0-2 ap; Mt d 1-1-0, pr 1-1-2, rt 1-0-2, v 1-1-2 ap. Coloration: carapace brown, with dark brown eye field and with a pattern of white adpressed scales (Fig. 6). Clypeus brown, covered with short thick brown-yellowish hairs (Fig. 9). Chelicerae dark brown. Abdomen yellow-grey; dorsum black, with a pattern of brown, brownish and white hairs. Legs yellow-brownish, with brown stains and half-rings, covered with dense short white hairs. Femur I ventrally with long dense white hairs and a bunch of black hairs, retrolaterally with two bunches of black hairs. Palpal femur without ventral knob, yellow, proximally brown, densely covered with white hairs. Palpal structure as in Figs 7-8, 10, 12-13, and 15.

Female (paratype from Albutera, Mallorca): Carapace 3.0 long, 2.3 wide, 1.5 high at PLE. Ocular area 1.2 long, 1.6 wide anteriorly and 1.5 wide posteriorly. Diameter of AME 0.4. Abdomen 3.1 long, 2.7 wide. Cheliceral length 1.0. Clypeal height 0.2. Length of leg segments: I 1.4+0.8+0.9+0.5+0.5; II 1.4+0.8+0.75+0.5+0.5; III 2.2+1.0+1.0+0.9+0.9; IV 1.9+0.9+1.0+1.3+0.8. Leg spination: I: Fm d 1-1-2; Tb rt 1-1-0, v 1-1-2 ap; Mt v 2-2 ap. II: Fm d 1-1-2; Tb rt 0-1, v 1-1-2 ap; Mt v 2-2 ap. III: Fm d 1-2-3; Pt pr 1; Tb pr and rt 0-1-1-0, v 0-1-2 ap; Mt d 0-1-0, pr and rt 1-0-2, v 2-2 ap. IV: Fm d 1-1-1; Pt rt 1; Tb pr and rt 0-1-1-0, v 1-0-2 ap; Mt pr and rt 1-1-2, v 1-1-2 ap. Coloration: carapace brown, dorsum densely covered with short white scales and dark spines, without specific pattern or similar to those of males but paler. Clypeus dark brown covered
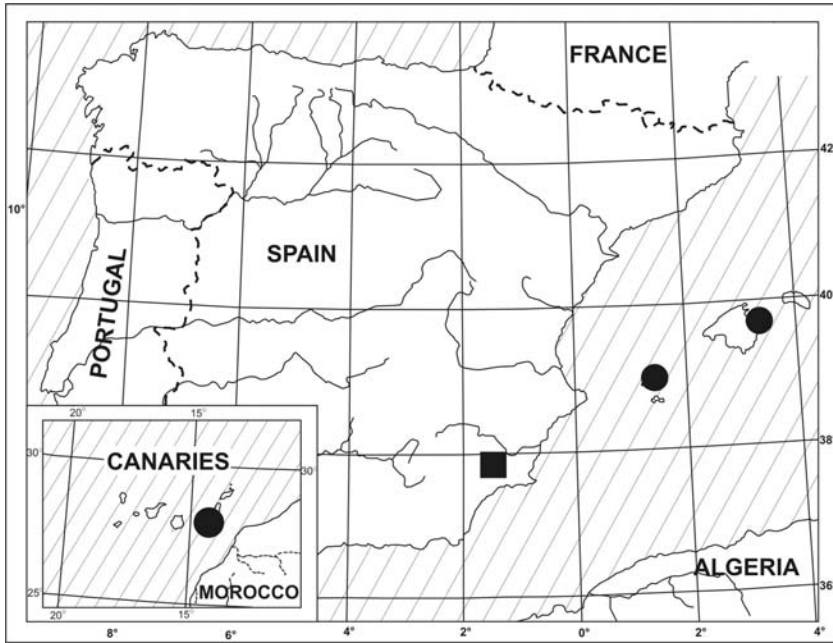
Fig. 16. Distribution map of *Aelurillus balearus* sp. n. (circle) and *A. bosmansi* sp. n. (square).

with short white scales. Sternum brown. Abdomen grey-yellow, dorsum with a variegated pattern of brown, brownish and white hairs. All legs yellow, densely covered with white scales, with brown stains and half-rings. Palps yellow, covered with white hairs. Epigyne and spermathecae as in Figs 11, 14.

Remark: This is the first record of genus *Aelurillus* for the Balearic Islands.

Aelurillus bosmansi sp. n.

Figs 16-26

Material examined: Holotype ♂ (RBINS), Spain, Murcia, Totana W., Sierra de la Tercia, 300 m a.s.l., stones in maquis, 4 April 1996, Coll. R. Bosmans.

Other materials: *Aelurillus blandus*: 1 ♂ (CBAR, № 1756) Portugal, Porto Prov., Recarei, ca. 41°09'N, 8°24'W, 22.10.1944 (collector unknown). 2 ♂ 2 ♀ (ISEA) Spain, Perales de Tajuña, Madrid, ca. 40°14'N, 3°21'W, 24.09.2003 (A. Jiménez-Valverde). 1 ♂ (ZMTU) Greece, Rhodes City, on dry field along seashore, 28.05.1973 (P.T. Lehtinen); 1 ♀ (SNHM, № 2043) Crete, "Ebene von Akrotiri", 26.05.1930 (C.F. Roewer).

Diagnosis: This species is close to *A. blandus* described from Spain (material examined), but differs in the following set of characters: coloration of clypeus and cheeks (white cheeks and clypeus (Fig. 20) vs. brown clypeus and white cheeks in *A. blandus* (Fig. 27)); smaller body (Fig. 17), and specific shape of embolic division (cf. AZARKINA 2002).

Etymology: The species is named after the collector, R. Bosmans.

Description: Male: Carapace 2.5 long, 1.7 wide, 1.2 high at PLE. Ocular area 0.9 long, 1.4 wide anteriorly and 1.3 wide posteriorly. Diameter of AME 0.4. Abdomen 1.9 long, 1.8 wide. Cheliceral length 0.6. Clypeal height 0.2. Length of leg segments: I 1.2+0.8+0.8+0.6+0.5; II 1.2+0.7+0.7+0.6+0.5; III 1.7+0.8+0.9+0.9+0.6; IV 1.4+0.7+0.8+1.1+0.5. Leg spination: I: Fm d 1-1-5; Pt pr and rt 1; Tb pr 1-1-1, rt 1, v 2-2-2 ap; Mt pr and rt 1-1, v 2-2 ap. II: Fm d 1-2-5;
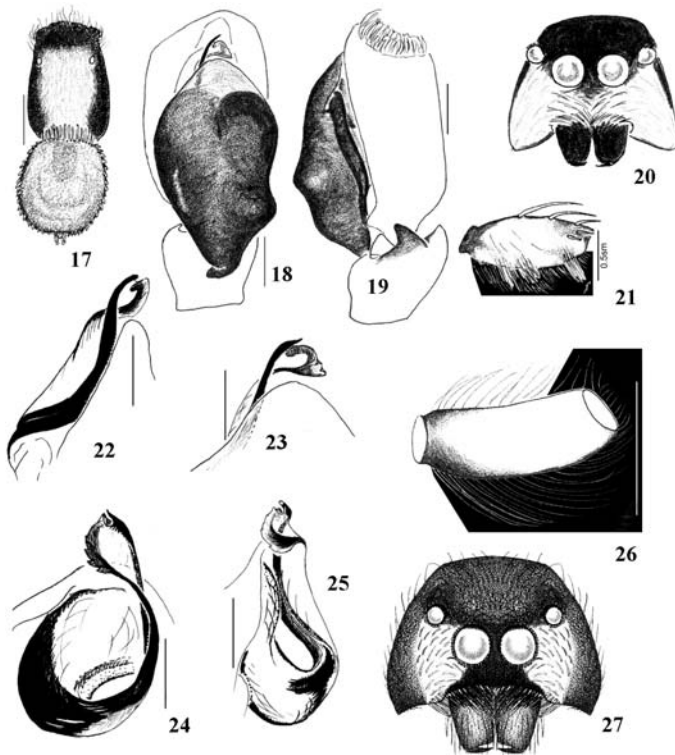
Figs 17-26. *Aelurillus bosmansi* sp. n.: 17 – male, body pattern; 18 – male palp, ventral view; 19 – same, lateral view; 20 – male face; 21 – femur of leg I, retrolateral view; 22 – embolic division, prolateral view; 23 – same, ventral view; 24 – same, dorsal view; 25 – same, retrolateral view; 26 – palpal femur, retrolateral view. Scale lines: 0.1 mm (18-19, 22-25), 0.5 mm (26), 1 mm (17), 5 mm (21). *Aelurillus blandus* (SIMON, 1871): 27 – male face.

Pt pr and rt 1; Tb pr 1-1-1, rt 1, v 1-1-2 ap; Mt pr and rt 1-1, v 2-2 ap. III: Fm d 1-3-5; Pt pr and rt 1; Tb d 1-0-0, pr and rt 1-1-1-1, v 1-1-2 ap; Mt d 1-1-0, pr and rt 1-0-2, v 1-1-2 ap. IV: Fm d 1-2-5; Pt pr and rt 1; Tb d 1-0-0, pr and rt 1-1-1-1, v 1-0-2 ap; Mt d 1-1-0, pr 1-1-2, rt 1-0-2, v 1-1-2 ap. Coloration: carapace black, dorsally covered with white scales, posterior part of the eye field (about one-forth) with white scales (Fig. 17). Clypeus and chelicerae dark brown. Clypeus and the lateral sides of carapace covered with long white hairs (Fig. 20). Abdomen brown-grey, dorsum brown-black, covered with yellowish silver scales (Fig. 17). Legs yellow-brownish, with brown stains. Femur I ventrally with long dense yellowish hairs, retrolaterally with two bunches of brown hairs (Fig. 21). Tibia, metatarsus and tarsus I brown. Tibia with two pairs of pro- and retrolateral dark brown stains. Femur II ventrally covered with dense yellow hairs, retrolaterally and distally with a bunch of dark brown hairs. Palpal femur yellow, proximally dark brown, covered with long white hairs (Fig. 26). Patella and tibia yellow, cymbium light brown, with white hairs. Palpal structure as in Figs 18-19, 22-25.

Aelurillus cypriotus sp. n.

Figs 28-37

Material examined: Holotype: ♂ (AMNH), Cyprus, 27-29 April 1982, Coll. A. Stubbs. The exact locality is not specified on the label. On the map (Fig. 37) it is indicated with a question mark in the center of the island.
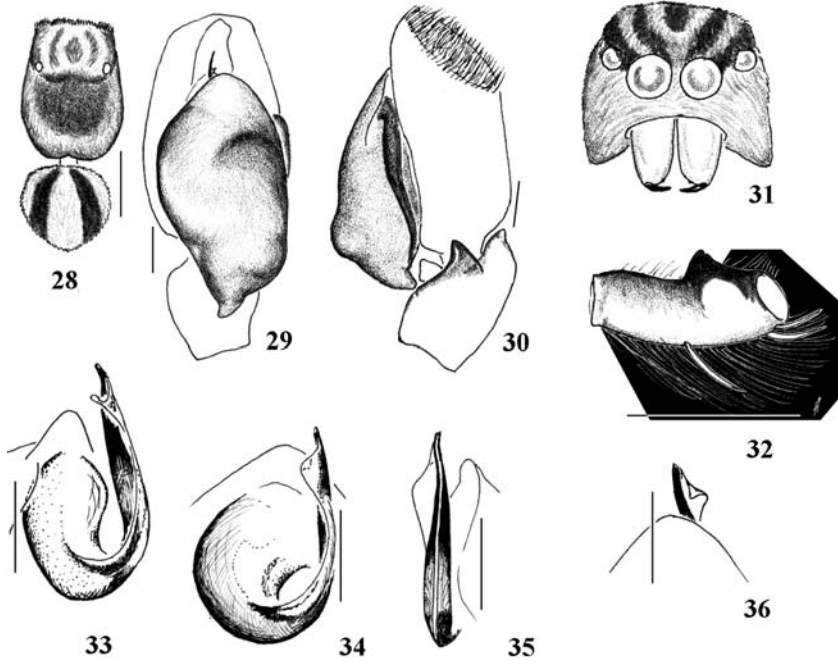
Figs 28-36. *Aelurillus cypriotus* sp. n.: 28 – male, body pattern; 29 – male palp, ventral view; 30 – same, lateral view; 31 – male face; 32 – palpal femur, retrolateral view; 33 – embolic division, retrolateral view; 34 – same, dorsal view; 35 – same, prolateral view; 36 – same, ventral view. Scale lines: 0.1 mm (29-30, 33-36), 0.5 mm (32), 1 mm (28).
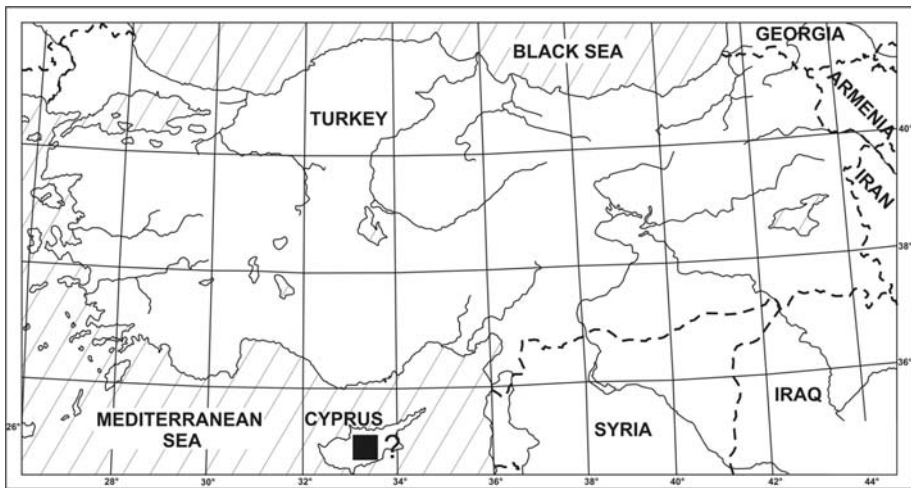
Fig. 37. Distribution map of *Aelurillus cypriotus* sp. n.

Diagnosis: Having similar body coloration the new species resembles *A. v-insignitus* (Fig. 28), but differs from it in the absence of two longitudinal white stripes (the carapace of holotype is in poor condition). By the structure of the embolic division, the new species is close to *A. m-nigrum*, but differs in having a simpler apical part of the terminal apophysis, without the top membrane (Figs 33-36).

Etymology: The species is named after Cyprus, the type locality.

Description: Male: Carapace 1.9 long, 1.5 wide, 1.0 high at PLE. Ocular area 0.9 long, 1.2 wide anteriorly and 1.2 wide posteriorly. Diameter of AME 0.35. Abdomen 1.6 long, 1.3 wide. Cheliceral length 0.7. Clypeal height 0.15. Length of leg segments: I 1.0+0.65+0.6+0.4+0.4; II 1.0+0.6+0.55+0.4+0.4; III 1.4+0.7+0.7+0.8+0.6; IV 1.3+0.6+0.7+0.8+0.55. Leg spination: I: Fm d 1-1-5; Pt pr 1; Tb d 1-0-0, pr 0-1-2-0, rt 1, v 1-1-2 ap; Mt pr and rt 1-1, v 2-2 ap. II: Fm d 1-2-5; Pt pr and rt 1; Tb d 1-0-0, pr 1-1-1, rt 0-1-1-0, v 1-1-2 ap; Mt pr and rt 1-1, v 2-2 ap. III: Fm d 1-2-5; Pt pr and rt 1; Tb d 1-0-0, pr and rt 1-1-1, v 1-0-2 ap; Mt d 1-1-0, pr and rt 1-0-2, v 1-1-2 ap. IV: Fm d 1-1-4; Pt pr and rt 1; Tb d 1-0-0, pr 1-1-1, rt 1-1-1-1, v 1-0-2 ap; Mt d 1-1-0, pr 1-1-2, rt 1-0-2, v 1-1-2 ap. Coloration: carapace brown, with dark brown eye field. Eye field covered with brown and whitish scales, having the same pattern as in *A. v-insignitus* (Fig. 28). Carapace in poor condition therefore its dorsal colour pattern is not clear. Lateral parts of carapace covered with thin white hairs. Clypeus and cheeks covered with thin transparent-white hairs (Fig. 31). Hairs around anterior eyes yellowish-white. Abdomen yellow-grey, dorsum dark brown, with a broad medial white stripe (Fig. 28). Legs yellow. Femora of all legs with dark brown stains apically. Patella, tibia, metatarsus and tarsus brownish. Palpal femur with a ventral knob, covered with white hairs (Fig. 32). Palpal structure as in Figs 29-30, 33-36.

Remarks: The eye field of *A. cypriotus* has a double *V* pattern similar to that in *A. v-insignitus*. However, the new species has a different shape of the embolic division (like that in *A. m-nigrum*) and tibial apophysis (see Fig. 30). Prószyński (1971) described two forms of *A. v-insignitus* – "black" and "grey", both having a visible double *V* pattern on the eye field and high dorsal lateral tibial apophysis (Prószyński 1971, see Figs 8-10, 13, 16, 18-21), but the structure of the embolic division and the shape of tibial apophysis are also different in *A. cypriotus* sp. n.

Aelurillus stanislawi (Prószyński, 1999) comb. n.

Figs 38-41

Rafalus stanislawi Prószyński, 1999: 96-98, Figs 22-26; 2003: 162-163, Figs 659-666.

Aelurillus minutus Azarkina, 2002: 258-259, Figs 64-71 (D♂) **New Synonym**

Material examined: *Rafalus stanislawi*: Holotype ♂ (HUJI, No. 15193), Israel, Be'er Sheva [= Beer Sheva, = Beersheba], Mash'abbim [= Mashabbim, = Mashabbe Sade], ca. 31°01'N, 34°47'E, pitfall traps, 15 May 1991, Coll. Y. Lubin. – Paratypes: 3 ♂♂ (HUJI, No. 15413) Israel, Be'er Sheva [=Beer Sheva, = Beersheba], Mash'abbim [= Mashabbim, = Mashabbe Sade], ca. 31°01'N, 34°47'E, pitfall traps, 12 June 1991, Coll. Y. Lubin; 1 ♂ (HUJI, No. 15414) Israel, Be'er Sheva [= Beer Sheva, = Beersheba], Mash'abbim [=Mashabbim, = Mashabbe Sade], ca. 31°01'N, 34°47'E, pirfall traps, 12 June 1991, Coll. Y. Lubin. *Aelurillus minutus*: Holotype ♂ (NHBS), Syria, 3 August 1989, Coll. T. Blick. Non type material: 1 ♂ (ISEA), Syria, 07 April – May 1907; 1 ♂, 1 ♀ (HECO, 19/9/6034), Ethiopia, Eloa Dancalia, on rocks and grass.

Diagnosis: The male is diagnosed in Prószyński (1999, sub *Rafalus s.*) and Azarkina (2002, sub *Aelurillus minutus*). The female of this species is similar to *A. improvisus*, but differs in

Figs 38-40. *Aelurillus stanislawi* comb. n.: 38 – epigyne, ventral view; 39 – spermathecae, dorsal view; 40 - diagrammatic course of the insemination ducts. Scale lines: 0.1 mm (38-39).

having epigyne with a broader medial plate (Fig. 38) and spermathecae with more curved insemination ducts (Figs 39-40).

Description: Female (Ethiopia): Carapace 3.7 long, 2.6 wide, 1.7 high at PLE. Ocular area 1.3 long, 1.9 wide anteriorly and 1.85 wide posteriorly. Diameter of AME 0.6. Abdomen 3.6 long, 2.7 wide. Cheliceral length 1.1. Clypeal height 0.3. Length of leg segments: I 1.8+1.1+1.1+0.7+0.6; II 1.7+1.1+1.1+0.75+0.6; III 2.4+1.2+1.3+1.4+0.8; IV 2.2+1.1+1.4+1.7+1.0. Leg spination: I: Fm d 1-1-4; Tb pr 1-0, v 2-2-2 ap; Mt pr 1-0, v 2-2 ap. II: Fm d 1-2-4; Tb pr 1-1, v 1-1-2 ap; Mt pr 1-1, v 2-2 ap. III: Fm d 1-2-4; Pt pr and rt 1; Tb d 1-0-0, pr 1-1-1-1, rt 1-1-1, v 1-0-2 ap; Mt d 1-1-0, pr and rt 1-0-2, v 1-1-2 ap. IV: Fm d 1-1-2; Pt pr and rt 1; Tb d 1-0-0, pr 1-1-1, rt 1-1-1-1, v 1-0-2 ap; Mt d 1-1-0, pr 1-1-2, rt 1-0-2, v 1-1-2 ap. Coloration: carapace brown, with dark brown eye field, covered with adpressed white scales and thin brown setae, which are more dense on the eye field. Clypeus and cheeks brown-

Fig. 41. Distribution map of *A. stanislawi* comb. n.

yellow, covered with white hairs. White hairs around anterior eyes. Chelicerae brown. Sternum yellow. Abdomen yellow, dorsum brown, covered with yellowish hairs and brown setae, with an indistinct pattern: a yellow medial stripe and brown transversal and yellow stripes. Legs brownish-yellow, covered with white hairs. Palps yellow, with white hairs and brown setae. Epigyne and spermathecae as in Figs 38-40.

Distribution: Levant and Ethiopia (Fig. 41, Azarkina, 2002, Fig. 71, sub *A. minutus*).

Remarks: *Rafalus stanislawi* was described from male specimens collected in Israel, while *A. minutus* from a single male found in Syria (cf. Prószyński, 1999, Azarkina, 2002). After careful examination of the type specimens of *R. stanislawi* and direct comparison with the type of *A. minutus* and the non-typical specimens from Syria and Ethiopia it became clear that *R. stanislawi* should be transferred to the genus *Aelurillus*, whereas *A. minutus* is undoubtedly its junior synonym. We propose here the following new taxonomic alteration: *Aelurillus stanislawi* (Prószyński, 1999) comb. n. = *A. minutus* Azarkina, 2002 syn. n. The female of *A. stanislawi* is herewith described for the first time.

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Четири нови вида паяци от род *Aelurillus* Simon, 1884 (Araneae: Salticidae)

Г. Азаркина

(Резюме)

Описват се четири нови вида салтицидни паяци от род *Aelurillus* Simon, 1884: *A. afghanus* от Североизточен Афганистан, *A. balearus* от Балеарските и Канарските острови, *A. bosmansi* от Испания и *A. cypriotus* от Кипър. Предложена е нова комбинация – *Aelurillus stanislawi* (Prószyński, 1999) (ex *Rafalus*), а видът *A. minutus* Azarkina, 2002 от Сирия, е синонимизиран. За първи път се описва женската на вида *A. stanislawi*. Всички нови таксони са илюстрирани, а разпространението им е представено на карти.

Typhochrestus longisulcus sp. n., a new spider species from the Crimean Peninsula, Ukraine (Araneae: Linyphiidae)

Valery A. Gnelitsa[1]

Abstract: A new linyphiid spider, *Typhochrestus longisulcus* sp.n., found in broad-leaved forests in the Crimean Peninsula, Ukraine, is described and illustrated. The new species is most closely related to *Typhochrestus digitatus* (PICKARD-CAMBRIDGE, 1872) and *Typhochrestus inflatus* THALER, 1980 but it is well distinguished from both by the peculiar form of the palps, epigyne and vulva.

Key words: spiders, taxonomy, *Typhochrestus longisulcus* sp.n., Ukraine

Introduction

The genus *Typhochrestus* SIMON, 1884 is currently known to comprise 29 species distributed mainly in the Mediterranean region with some exceptions in Central Europe and North America (PLATNICK 2006). Here, we describe a new, quite distinct species found in forest habitats in the Crimean Peninsula, SW Ukraine, thus increasing the number of the species to 30.

Materials and Methods

The specimens were collected using a hand-held suction sampler. The determination was made using binocular microscope MBS-10, drawings were made using camera lucida. The material is currently preserved in the Zoology Department of the Sumy Teacher's Training University (STTU). Abbreviations of the names of the palpal structures follow HORMIGA (2000): ARP – anterior radical process, E – embolus, EM – embolic membrane, P – paracymbium, PT – protegulum, R – radix, St – subtegulum, T – tegulum, Tp – radical tailpiece. Other abbreviations in the text are: Fe – femur, Pt – patella, Ti – tibia, Mt – metatarsus, Ta – tarsus, Tr – position of the metatarsal trichobothria. All measurements are in mm.

Taxonomic part

Typhochrestus longisulcus **sp. n.**

Material examined: Holotype: male, Ukraine, Crimea, Pheodosia Distr., Caradag Nature Reserve, 20° northwest slope, 15.10.2003, V. Gnelitsa leg.; - Paratype: female, Kirov Distr., ravine to the north of the Big Agarmysh mount 01.05.2003, V. Gnelitsa leg. (STTU).

Etymology: to emphasize the presence of long postocular sulci on the carapax.

Diagnosis: *Typhochrestus longisulcus* sp. n. is most closely related to *Typhochrestus digitatus* (PICKARD-CAMBRIDGE, 1872) and *Typhochrestus inflatus* THALER, 1980 based upon the morphology of the palp. The males of the new species clearly differ in their palp area especially by the short and heavy anterior radical process with skew cut apex; wide and flat distal piece of embolus;

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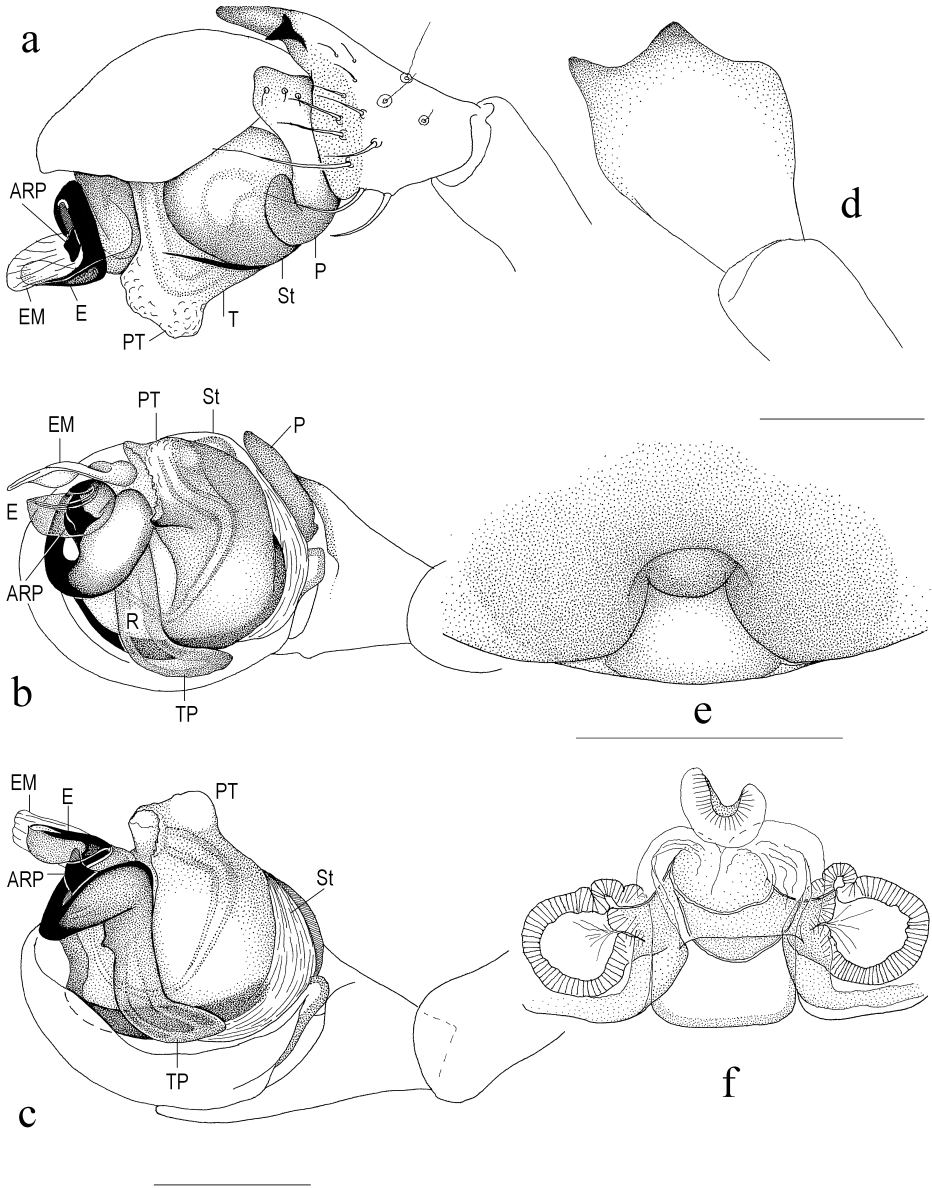
Fig. 1. *Typhochrestus longisulcus* sp.n.: a-c - male palp, lateral, ventral and median views, respectively; d - palpal tibia, dorsal view; e - epigyne, ventral view; f - vulva. Scale lines: 0.1 mm.

palpal tibia configuration and the form of carapace with unusually elongated postocular sulci. The female is distinguished by the peculiar shape of the epigyne and vulva.

Description: Male: Total length: 1.30. Carapace (Fig. 2 c, d): yellow-grey, length: 0.66; width: 0.49. Chelicerae with 4 teeth on their promargins, retromargin with 3 closely-spaced teeth. Sternum with shiny surface, dark grey; length: 0.36; width: 0.32; distance between the posterior median eyes is more than the PME diameter; Tibial spines 2: 2: 2: 1. Abdomen: dark grey, monotonous. Palp: see Fig. 1 a, b, c, d.
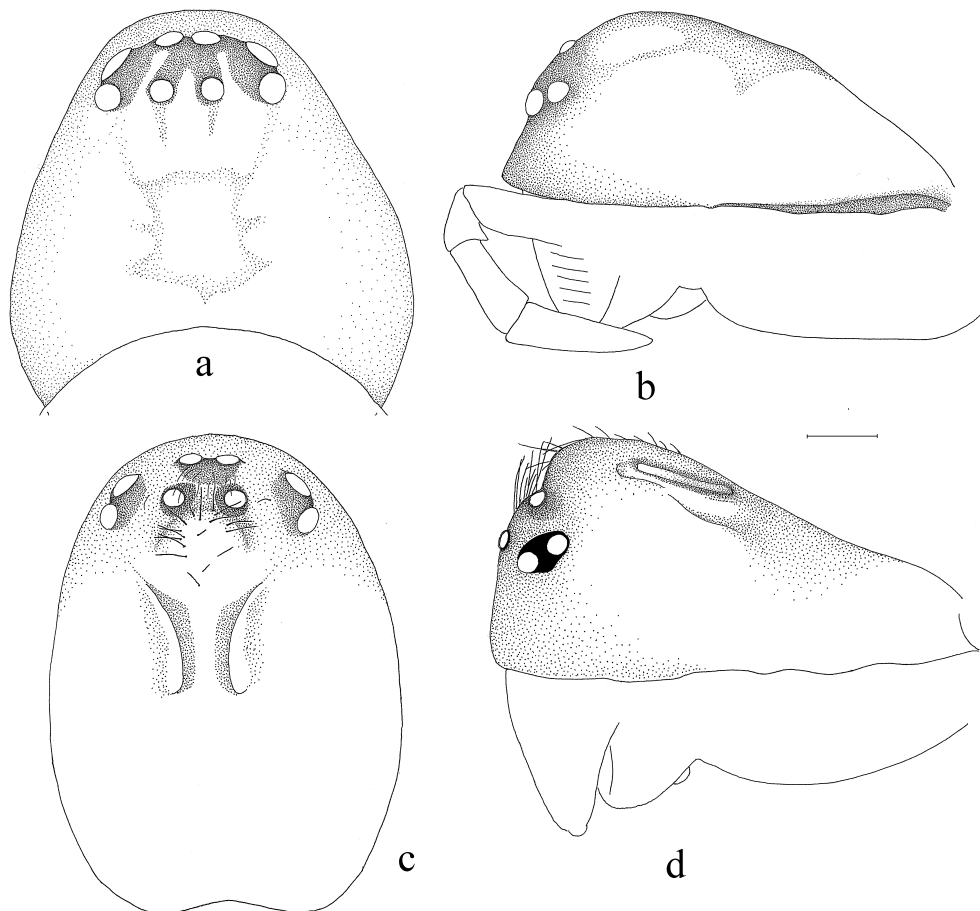
Fig. 2. *Typhochrestus longisulcus* sp.n.: a–b - female carapace, dorsal and lateral views; c–d – male carapace, dorsal and lateral views. Scale line: 0.1 mm.

Legs	Fe	Pt	Ti	Mt	Ta	Tr
I	0.47	0.15	0.43	0.31	0.27	0.43
II	0.41	0.15	0.38	0.28	0.24	0.43
III	0.34	0.14	0.28	0.26	0.22	0.37
IV	0.49	0.15	0.49	0.34	0.25	-

Female: Total length: 1.47. Carapace (Fig. 2 a, b): dark yellow-grey; length: 0.66, width: 0.51. Sternum yellow-grey with darker margins; length: 0.31, width: 0.28. Chelicerae with 5 teeth on their promargins; posterior median eyes is the PME diameter apart. Tibial spines 2: 2: 2: 1. Abdomen black, monotonous. Epigyne and vulva are presented in Figs 1 e and 1 f, respectively.

Legs	Fe	Pt	Ti	Mt	Ta	Tr
I	0.48	0.17	0.42	0.29	0.27	0.46
II	0.43	0.15	0.35	0.27	0.25	0.42
III	0.36	0.15	0.27	0.25	0.19	0.40
IV	0.55	0.18	0.48	0.34	0.25	-

Ecology: The male was found in the soil and grass of broad-leaved forests of *Quercus pubescens*, *Fraxinus* sp., *Pyrus elaeagnifolia* with *Jasminum fruticans*, while the female was collected in the same habitat in forests of *Quercus petraea*, *Carpinus* sp., *Fagus* sp., *Populus* sp. with *Corylus* sp., *Sambucus* sp. and *Euonimus* sp.

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Typhochrestus longisulcus – нов вид паяк от Кримския полуостров, Украйна (Araneae: Linyphiidae)

В. Гнелица

(Резюме)

В статията се описва новият за науката линифииден паяк *Typhochrestus longisulcus*, намерен в широколистни гори на Кримския полуостров. Видът е близък до видовете *T. digitatus* (PICKARD-CAMBRIDGE, 1872) и *T. inflatus* THALER, 1980, но се различава от тях по характерната форма на палпите, епигината и вулвата.

On the taxonomic position of the East Asian species of the genus *Ummidia* Tʜᴏʀᴇʟʟ, 1875 (Araneae: Ctenizidae)

Joachim Haupt[1]

Abstract: Original webspiders like Mygalomorphae or Mesothelae may cause some taxonomical problems, because the morphological characters usually used among Araneomorphae may not allow a clear distinction of these species. This is the case even in female receptacula where differences may be slight or a great variability may exists in a single population. A critical review on the history of synonymization and a comparison of the biology of East Asian *Ummidia* species leads to a new classification: The two species known from Japan and from Taiwan are members of the genus *Conothele*. The way they construct their short, superficial burrow is entirely identical with the species of *Conothele*. Members of the genus *Ummidia* differ considerably in their behaviour: they dig burrows in the soil.

Key words: spiders, Mygalomorphae, *Conothele fragaria* new comb., *Conothele taiwanensis* new comb.

Introduction

In many studies on the Japanese spider fauna the ctenizid *Ummidia fragaria* (Dönɪᴛᴢ, 1887) is mentioned (Cʜɪᴋᴜɴɪ 1989, Kɪᴍ *et al*. 1995, Yᴀɢɪɴᴜᴍᴀ 1986, Yᴏsʜɪᴋᴜʀᴀ 1987). But does this species really belong to the genus where it is placed now? The original genus name *Pachylomerus* was changed into *Pachylomerides* by Sᴛʀᴀɴᴅ (1934) in cause of preoccupation (Bᴏɴɴᴇᴛ 1954-1959) and was synonymized with *Ummidia* by Dᴇɴɪs (1938). On this occasion the type material of *U. fragaria* may not have been checked.

Material and Methods

East Asian species of *Ummidia fragaria* (Dönɪᴛᴢ, 1887) (type material) and *U. taiwanensis* Tsᴏ, Hᴀᴜᴘᴛ, Zʜᴜ, 2003 from Nantou county (Taiwan) were studied and compared to undescribed material from Thailand (Thanboke Khoranee Nat. Park) and material of *Conothele arboricola* from Neu-Pommern / New Britain, i.e. an island close to the East coast of New Guinea. For comparative purposes representatives of *Ummidia aedificatoria* (Wᴇsᴛᴡᴏᴏᴏᴅ, 1840) and *U. audouini* (Lᴜᴄᴀs, 1835) were examined. *U. fragaria*, *U. aedificatoria*, *U. audouini*, *U. taiwanensis* and *Conothele arboricola* are deposited in the Zoological Museum of Humboldt University (Berlin). *U. taiwanensis* is also deposited in the National Museum of Natural Science (Taichung, Taiwan).

Results

Originally a new Japanese ctenizid species was described under the name of *Pachylomerus fragaria* Dönɪᴛᴢ, 1887. This genus name still exists as the subfamily name 'Pachylomerinae (Rᴀᴠᴇɴ, 1985)'. Rᴏᴇᴡᴇʀ (1954) states that all species of the genus *Pachylomerus* are found under the name *Pachylomerides* since Sᴛʀᴀɴᴅ (1934) changed the name in that way in cause of preoccupation. It has to

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be kept in mind, that this genus was synonymized with *Ummidia* by Denis (1938) (Bonnet 1954-1959), a fact which was not mentioned by Roewer. In the past, various characters were pointed out to distinguish the genera *Ummidia* and *Conothele*. Raven (1985, p. 145) lists that trochanters I and II should be distinctly notched in *Ummidia*, but not in *Conothele*. This character was used by recent authors to classify a new species from Taiwan (Tso *et al.* 2003).

When observing the living spiders, it is quite obvious that certain habits are entirely different: The representatives of the genus *Conothele* construct a rather durable and short superficial home. It is always parallel to the surface of the ground and its silken sheet is covered with items of the surrounding, i.e. bark, moss, soil and debris. Instead, representatives of the genus *Ummidia* dig a burrow inside the soil, which is generally vertical to the soil surface and is several centimeters long.

Discussion

It has been questioned whether the establishment of two genera '*Ummidia*' and '*Conothele*' is necessary at all, as characters used to distinguish the two genera proved to be variable (Main 1985). Besides, both genera also have some characters in common, i.e. the dorso-distal bristles on the third metatarsus are situated in a row. Moreover, they are allopatric, *Conothele* being confined to South East Asia, New Guinea and the islands East of New Guinea, as well as Australia, while *Ummidia* appears in the New World and in the Mediterranean region.

The biology of *Conothele* was described by Main (1957), its burrow also by Pocock (1898) and Crome (1962). By no means representatives of *Conothele* are rare spiders. Otto Heinroth collected plenty of specimens between December 1900 and May 1901 in what was at that time Herbertshöh, Neu-Pommern (now Gazelle Peninsula, New Britain). Main (1985) states that "within Australia, *Conothele* is the most widespread genus of Ctenizidae...".

Observations on the burrow digging behaviour of *Ummidia* were published by Moggridge (1873), Pickard-Cambridge (1908), Bacelar (1927, 1933), Buchli (1962) and Coyle (1981). In all cases members of the genus *Ummidia* are described to dig a burrow in the soil. At present, the behavioural difference in burrow construction between the genera *Ummidia* and *Conothele* seems to be the best means to distinguish both genera. Herewith, I propose the following taxonomic alterations: *Ummidia fragaria* (Dönitz, 1887) = *Conothele fragaria* (Dönitz, 1887) comb. n. and *U. taiwanensis* Tso, Haupt, Zhu, 2003 = *Conothele taiwanensis* (Tso, Haupt, Zhu, 2003) comb. n. Moreover, this also fits to the geographic distribution of the genus which extends from Japan through Taiwan, South East Asia and New Guinea to Australia.

Key for identification of the two genera

1. Posterior opisthosoma soft and normal, Tibia III dorsally excavate……............................……2

2. Burrow in the soil, Mediterranean region and America…………………….................*Ummidia*

- Short superficial burrow, parallel to the surface, on trunks, etc. Paired claws of legs I-III with one short tooth. Indo-Pacific region……………………………………………...................*Conothele*

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Върху таксономичния статус на източноазиатските видове от род *Ummidia* Thorell, 1875 (Araneae: Ctenizidae)

Й. Хаупт

(Разюме)

Статията разглежда някои съществуващи таксономични проблеми при мигаломорфните паяци от род *Ummidia*. След критичен преглед на историята на синонимизирането на източноазиатските видове от рода и особено след изследване на тяхната биология, авторът стига до извода, че видовете *Ummidia fragaria* и *Ummidia taiwanensis* всъщност принадлежат към род *Conothele* и предлага новите комбинации - *Conothele fragaria* comb. n. и *Conothele taiwanensis* comb. n. Основание за това му дава най-вече фактът, че и двата вида конструират къси, повърхностни дупки, което е характерно за представителите на този род.

A new spider species, *Harpactea samuili* sp. n., from Bulgaria (Araneae: Dysderidae)

Stoyan Lazarov[1]

Abstract: A new species, *Harpactea samuili* sp. n. (Araneae: Dysderidae), is described and illustrated with male and female specimens collected in Bulgaria (South Pirin Mountain, Kresna Gorge, Rupite). The male palps of this species are similar to these of *H. srednogora* DIMITROV, LAZAROV, 1999 but embolus is long, falcate and apically pointed.

Key words: *Harpactea samuili* sp. n., maquis, South Pirin Mountain, Rupite

Introduction

The Dysderidae, a rather species-rich spider family in the Mediterranean countries, shows remarkable diversity in southeastern Europe, and especially on the Balkan Peninsula (PLATNICK 2006, DELTSHEV 1999). However, in terms of the taxonomy and faunistics, there are still quite a few regions remaining insufficiently investigated. One of these is Bulgaria, where in the last decade several new species were discovered and described (see e.g. DIMITROV, LAZAROV 1999, LAZAROV 2006). This process is very likely to continue also in the future. The current paper provides a description of a new species of *Harpactea*, which was recently discovered in southwestern Bulgaria, in the frames of a scientific project aiming at the inventory of the maquis habitats.

Material and Methods

The material was collected by pitfall trapping. The traps were filled with 4 % formalin and emptied once a month. The colour of the new species is taken from alcohol and formalin preserved specimens. All measurements used in the description are given in mm. The measurements of the legs are taken from the dorsal side. The total length of the body includes chelicerae.

Taxonomy

Harpactea samuili sp. n.

Figs 2-6

Material examined: Bulgaria: South Pirin Mountain, Sveti Iliya Hill near Kalimantsi Village, 450-510 m alt., maquis (*Quercus coccifera* association), male holotype, 5 male and 1 female paratypes, 10 May - 1 June 2002; male paratype, 1 - 22 June; male and female paratypes, 5 May - 4 June, leg. M. Langourov & S. Lazarov. – Struma Valley, Rupite near Kozhuh Hill, 120 m alt., male paratype, 24 May 1997, leg. M. Serafimova. – Kresna Gorge, May 1997, leg. Ch. Deltshev, male paratype (Fig. 1).

Depository: The holotype, 1 male and 2 female paratypes are deposited in the Muséum d'histoire naturelle, Genève, 1 male paratype - in the National Museum of Natural History, Sofia.

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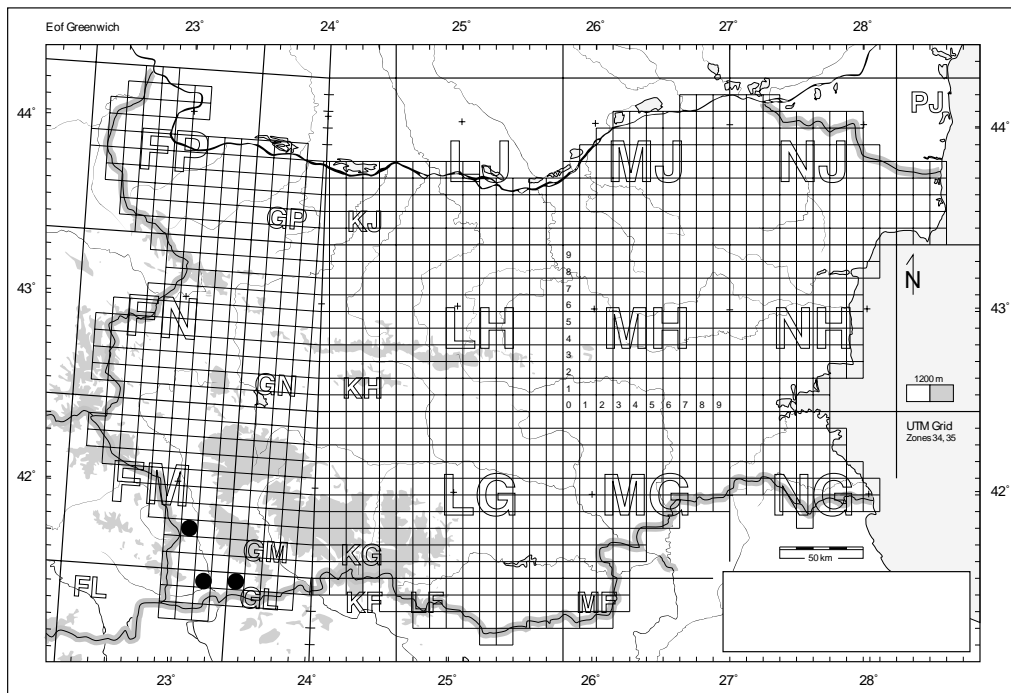
Fig. 1. Distribution map of *H. samuili* sp.n.

The remaining 5 male and 2 female paratypes are preserved in the collection of the Institute of Zoology, Sofia.

Etymology: Named in honour of the Great Bulgarian Tsar Samuil.

Diagnosis: The new species is morphologically close to *H. srednogora* DIMITROV, LAZAROV, 1999 but differs in having long, falcate and apically pointed embolus (Figs 2-5, 7, 8). Females are very similar to the other *Harpactea* species but there are differences in the shape of epigyne (Fig. 6).

Description: Male: Total length 5.9; prosoma length - 2.9, width - 2.2; abdomen length - 3.0. Carapace and chelicerae - red-brown, sternum - red-orange; abdomen - whitish. Legs - red-orange. Legs' measurements:

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	1. 13	0.9	1.33	1.14	0.6	5.1
II	1.39	1.1	1.39	1.0	0.54	5.42
III	1.39	0.5	1.48	1.1	0.5	4.97
IV	1.8	0.6	1.82	1.6	0.6	6.42

Legs' spines: Coxae: I, II - without spines, III - 3 dorsal, IV - 4-5 dorsal. Femora: I - 4 prolateral, II - 4-5 prolateral, III - 4 pairs dorsal, IV - 10 dorsal. Patellae: I, II - without spines, III-IV - 1 dorsal. Tibiae: I, II - without spines, III-IV - 2-3 whorls of spines. Spines on metatarsi as on tibiae; all tarsi without spines.

Palp (Figs 2-5): Bulbus - globular, conductor - lamellate, embolus - long, falcate and apically pointed.

Female: Total length 6.25; prosoma length - 2.15, width - 1.6; abdomen length - 4.1. The vulva is illustrated in Fig. 6.

Legs' measurements:

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	1.15	0.9	1.35	1.15	0.6	5.15
II	1.45	1.1	1.4	1.0	0.55	5.5
III	1.45	0.6	1.5	1.1	0.5	5.15
IV	1.9	0.7	1.85	1.6	0.6	6.65
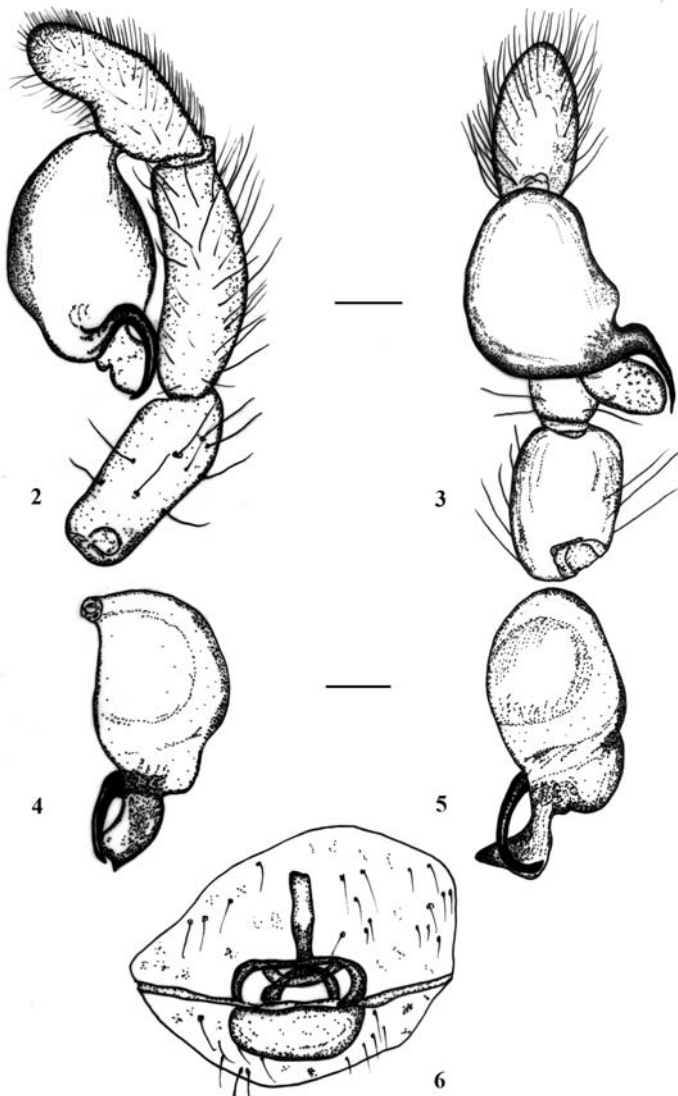
Figs 2-6: *Harpactea samuili* sp. n.: male palp: 2 – retrolateral view; 3 – retroventral view; 4-5 – bulb, retroventral view; 6 - vulva, dorsal view. Scale lines: 0.4 mm.
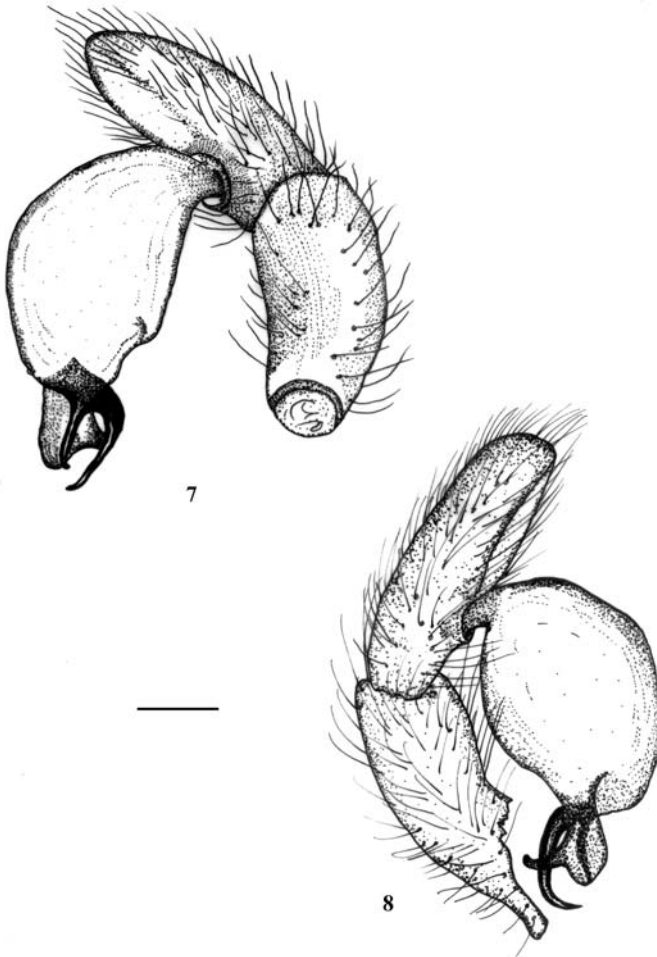
Figs 7-8: *H. srednogora* Dimitrov, Lazarov, 1999 (specimen from Zemen gorge, Bulgaria): male palp: 7 – retrolateral view; 8 – retroventral view. Scale line: 0.2 mm.

Discussion

According to the classification of Deeleman-Reinhold (1993), *H. samuili* sp.n. belongs to the group *D*, i.e. the *H. rubicunda* (C.L. Koch, 1838) species complex. The new species is most similar to *H. srednogora* but differs in the shape of the embolus.

Distribution and habitats: The new species has been found in SE Bulgaria, inhabiting screes and dry stony areas covered with bushes at 270-510 m alt.

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Нов вид паяк - *Harpactea samuili*, от България (Araneae: Dysderidae)

С. Лазаров

(Резюме)

В статията се описва новият за науката паяк *Harpactea samuili*, уловен на хълма Свети Илия близо до с. Калиманци в Пирин, в Кресненското дефиле и в местността „Рупите" до вулкана Кожух. Той е морфологично близък до *H. srednogora,* но се различава от него по формата на емболуса – сърповидно извит и заострен апикално, вместо базално раздвоен. Видът предпочита открити, сухи и обрасли с храсталаци скали и сипеи.

Ground spiders of the genus *Taieria* Forster, 1979 in New Zealand: taxonomy and distribution (Araneae: Gnaphosidae)

Vladimir I. Ovtsharenko[1]*, Mariya M. Fedoryak*[2]*, Boris P. Zakharov*[1]

Abstract: The genus *Taieria* Forster, 1979 includes six species: *T. erebus* (L. Koch, 1873); *T. elongata, T. kaituna, T. obtusa* and *T. miranda* - found in New Zealand and described by Forster (1979); and *T. titirangia,* a new species from the South Island, New Zealand. For the first time *T. erebus* has been found on the South Island (recorded previously only on the North Island), and for the first time *T. elongata* has been recorded on the North Island (known before only on the South Island). Maps with the distribution of six species of *Taieria* on the South and North Islands are included.

Key words: spiders, Gnaphosidae, *Taieria titirangia,* new species, New Zealand

Introduction

The genus *Taieria* was described by R. Forster (1979). Earlier, two species, *Drassus erebus* and *Drassus achropus,* were described from New Zealand by L. Koch (1873). Forster (1979) showed that the two species were actually a male and a female of the same species and he chose a valid name *Taieria erebus* (L. Koch, 1873). Additionally, Forster (1979) described four new species of the genus *Taieria* from New Zealand: *T. elongata, T. kaituna, T. obtusa* and *T. miranda*. Currently six species are found in New Zealand: *Taieria erebus* (L. Koch, 1873), *T. elongata* Forster, 1979, *T. kaituna* Forster, 1979, *T. obtusa* Forster, 1979, *T. miranda* Forster, 1979 and *T. titirangia,* new species.

Methods

For the distribution of *Taieria* in New Zealand we have used materials provided by major museums of New Zealand and Florida State Collection of Arthropods, Gainesville. Materials used by Forster (1979) have been also included. Maps have been prepared with the program ArcView GIS 3.2. The format of a new species description and the standard abbreviation of morphological terms follow those used in Ovtsharenko, Platnick (1995). All measurements are in millimeters.

Collection Examined
AMNZ - Auckland Institute and War Memorial Museum, Auckland
OMD - Otago Museum, Dunedin
MONZ - Museum of New Zealand
LUNZ - Lincoln University, Lincoln
NZAC - New Zealand Arthropod Collection, Auckland
FSCA - Florida State Collection of Arthropods, Gainesville

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Taxonomic Part

Genus *Taieria* Forster, 1979

Diagnosis: The genus *Taieria* includes medium-sized spiders, total body length 4.5 to 9.6 mm. Carapace is pear-shaped, narrowed anteriorly, usually reddish brown, orange brown or yellow with brown or yellow setae. Eight eyes in two rows; anterior row is straight, posterior row - procurved; anterior median eyes - circular, dark; others are oval and light. Abdomen is from yellowish to gray brown covered by plumose hairs; male abdomen has shiny brown anterior scutum. Legs are usually yellow brown. Tibia has a double row of spines on the ventral surface and a basal ventral pair of spines on metatarsus. Male palps have very distinctive retrolateral tibial and retrolateral patellar apophysis, with or without dorsal tibial apophysis. Embolus laminar, conductor vestigial or absent. Median apophysis relatively large, hooked. Epigynum ventrally with prominent median scape and distinctive lateral pockets located posteriorly; epigynum dorsally with one pair of oval receptacula.

Biology: The biology of the genus *Taieria* is almost unknown except for *T. erebus*, the unique behavior of which has recently been described by Jarman, Jackson (1986). *T. erebus* has been found to be a versatile predator: it captures insects both cursorially (away from webs) and kleptoparasitically (on alien webs) and it also eats the eggs of host spiders (oophagy). When *T. erebus* invades webs, it has an aggressive mimic, performing a repertoire of vibratory behaviors to lure a host spider. Ground spiders (Gnaphosidae) are traditionally referred to as hunting spiders, but *T. erebus* builds a small prey-capture web. It also preys on segestriid spiders, then uses their webs to catch more prey. This being an unusual example of a spider using as a tool for predation the web of another species from an unrelated family.

Habitat preferences of *Taieria*: we have found that some species are notably more adaptable than others. They occupy a greater variety of habitats while others are singularly less plastic and are restricted to a narrower range of habitat types. An example of more plastic species is *T. erebus*, which occurs in forests, gardens, rocky hillsides, sand dunes, beaches, and in the houses. A lifespan of adults is relatively short, particularly for males (Forster 1979). Revision of additional material shows, that in New Zealand adult specimens of *Taieria* occur mostly from October till February. As to the species *T. erebus*, females of this species occur all year long and males occur from August till May.

Distribution: Currently there are six species of *Taieria* in New Zealand. Analysis of additional materials of the genus *Taieria* demonstrates much wider distribution of the genus throughout New Zealand than it has been known before (Forster 1979). Thus we have found *T. erebus* also on the South Island (recorded previously only on the North Island) and *T. elongata* has been found on the North Island (earlier known only on the South Island). A new species, named *T. titirangia*, has been found in the northern part of the South Island. Therefore the South Island is more diverse and presented by five species of *Taieria*. *T. titirangia* and *T. obtusa* occur only on this island. The North Island is presented by four species, and only one species *T. miranda* is endemic of the Island.

Taieria erebus (L. Koch, 1873)

Drassus erebus L. Koch, 1873: 387, pl. 30, fig. 5 (male holotype from Canterbury, New Zealand, in O. P. Cambridge Coll., Oxford, not seen).
Drassus ochropus L. Koch, 1873: 390, pl. 30, fig. 7 (female holotype from Canterbury, New Zealand, in O. P. Cambridge Coll., Oxford, not seen).
Taieria erebus (L. Koch, 1873): Forster 1979: 49.

Material examined: **North Island**: Flat Point, 41°14'S, 175°57'E, Sept. 5, 1970, coastal plain (C. Wilton; OMD), 1♂; Houhora, Northland, 34°47'S, 173°06'E, July 23, 1975 (C. Wilton; MONZ, 102), 1♀, 2 juv.; Kaingaroa Forest, Ngapuketurua, Rotorua area, 38°08'S, 176°15'E, Dec. 30, 1965, elev. 2000' (M. Neill; MONZ), 1♀; Karori Hills, 41°17'S, 174°44'E, July 6, 1940 (R. Forster; OMD), 1F; Orongorongo Valley, 41°14'S, 175°03'E, Dec. 23, 1983, Dec. 1, 16, 1991, Jan. 1, 1993, Jan., Feb., Dec. 1995, Feb. 1996, hard beech, log trap, emergence trap, pitfall (A. Moeed, M. Meads, B. Fitzgerald, P. Berben, J. Alley; MONZ), 3♂, 6♀; Red Rocks, Wellington, 41°21'S, 174°43'E, May 31, 1941 (F. Bodley; OMD), 1♂; Wellington, 41°17'S, 174°46'E, Apr. 1993, inside house (P. Sirvid; MONZ), 1♂; Wellington, Signal Hill, 41°17'S, 174°46'E, June 10, 1941 (F. Bodley; OMD), 1♀; Wellington, Waikanae, 40°52'S, 175°03'E, Feb. 6, 1943 (R. Forster; OMD), 1♂. **South Island**: Mt. Algidus, Canterbury, 43°14'S, 171°21'E, Mar. 11, 1946 (R. Forster; OMD), 1♀; Allans Beach, 45°52'S, 170°41'E, Nov. 6, 1965 (C. Wilton; OMD, 1149), 1♂; Balclutha Plant Reserve, 46°13'S, 169°44'E, Apr. 21, 1966 (C. Wilton; OMD, 1179), 1♀; Broken River near Castle Hill Station, 43°11'S, 171°25'E, Sept. 29, 1966 (C. Wilton; OMD, 1140), 1♀; Christchurch, 43°35'S, 172°38'E, 1940, Dec. 12, 1943, Nov. 1950, Sept. 10, 1954, Sept. 23, 1991, in house, in garden (T. Lomas, R. Pilgrim, R. Forster, S. Thomson; OMD, MONZ, LUNZ), 3♂, 5♀, 1 juv.; Christchurch, Deans Bush, 43°04'S, 172°37'E, Dec. 20, 1949 (J. Dugdale; OMD), 1♀; Christchurch, Victoria Park, 43°35, 172°38'E, Oct. 26, 1960 (R. Leech; OMD), 1♀; Christchurch, Harewood Airport, 43°28'S, 172°32'E, Oct. 22, 1959 (E. Young; OMD), 1♀; Coopers Creek, 43°57'S, 171°15'E, Dec. 1, 1948 (R. Forster; OMD), 1♀; Deepdell, 45°48'S, 169°15'E, Dec. 6, 1967, Jan. 27, Nov. 20, 1968, pitfall (C. Wilton; OMD), 2♂, 1♀; Dunback Hill overlooking, McRaes Flat Road, 45°24'S, 170°32'E, Jan. 7, 1967 (C. Wilton; OMD), 1♀; Dunedin, Baldwin Street, 45°52'S, 170°30'E, Oct. 15, 1952, Aug. 10, 1958, Oct. 6, 31, Dec. 1961, Feb. 20, Mar. 31, Nov. 1962, Oct. 23, 1965, Oct. 28, 1966, in house (W. Poppelwell, B. Marples, R. Forster; OMD, 1163), 6♂, 5♀; Evansdale Glen, 45°43'S, 170°34'E, Oct. 21, 1973 (R. Forster; OMD), 2♀, 4 juv.; Filly Burn Bridge, 45°20'S, 170°17'E, Dec. 26, 1968, Jan. 27, 1969, pitfall (C. Wilton; OMD), 2♀; Flagstaff, 45°05'S, 168°40'E, Dec. 20, 1983 (R. Forster; OMD), 1♂; Golden Bay, Stewart Island, 46°54'S, 168°07'E, Nov. 1959 (H. Watt; OMD), 1♀; Golden Point, Macraes Flat, 45°22'S, 170°24'E, Jan. 7, 1967 (C. Wilton; OMD), 1♀; near Hindon, 45°43'S, 170°18'E, Nov. 30, 1969 (C. Wilton; OMD, 2021), 1♂; Kaiapoi, 15 km N of Christchurch, 43°23'S, 172°38'E, Feb. 7, 1960 (R. Leech; OMD), 1♀; Kaitorete Spit, 43°49'S, 172°35'E, Nov. 19, 1992, sand dune, under driftwood (C. Vink; LUNZ), 2♀; Kowhai Bush, 46°16'S, 169°47'E, Dec. 29, 1974 (OMD), 1♀; corner Little Kyeburn Naseby-Dansey Pass Roads, 45°08'S, 170°14'E, Jan. 6, 1968, Jan. 15, 1969, pitfall (C. Wilton; OMD), 2♀; Logan Burn, 45°28'S, 169°54'E, Dec. 15, 1982 - Jan. 12, 1983, Jan. 26 - Feb. 11, 1983, elev. 900 m, pitfall (B. Barratt; OMD), 4♂; Maniototo Road, near Patearoa, 45°16'S, 170°03'E, Oct. 25, 1967, Oct. 6, 1969, pitfall (C. Wilton; OMD), 1♂, 1♀; Manuherikia Road, St. Bathans Road, 45°05'S, 169°37'E, Jan. 15, 1966 (C. Wilton; OMD, 1141), 1♀; Motunau Island, 43°03'S, 173°04'E, Dec. 1 - 5, 1967, pitfall (A. Whiltaker; NZAC, 92170), 1♀; Naseby, mid Kyeburn Road, 45°01'S, 170°08'E, Feb. 21, Nov. 20, 1968, pitfall (C. Wilton; OMD), 1♂, 1♀; Oban, Stewart Island, 46°50'S, 167°52'E, Feb. 23, 1972 (C. Wilton; OMD), 1♀; Okuti Valley, 43°47'S, 172°49'E, Nov. 22, 1975 (R. Forster; OMD), 1♀; Omarama, MacKenzie Country, Otago, 44°29'S, 169°57'E, Oct. 1962 (W. Popplewell; OMD), 1♀; Opoho Bush, Dunedin, 45°51'S, 170°31'E, Jan. 1946 (T. Smith; OMD), 1♀; Patearoa, 45°16'S, 170°03'E, Jan. 16, 1968, Jan. 15, Mar. 6, 1969, pitfall (C. Wilton; OMD), 1♂, 4♀; Peel Forest, Canterbury, 43°54'S, 171°15'E, Sept. 30, 1966 (R. Forster, C. Wilton; OMD), 1♂; Portobello, 45°49'S, 170°39'E, Jan. 9, 1969 (R. Forster, C. Wilton; OMD), 1♀; Purau Stream, Cantenbury, 43°39'S, 172°45'E, Sept. 16, 1962 (R. Bigelow; OMD), 1♂; Rangitata Bridge, Canterbury, 44°04'S, 171°22'E, Dec. 10, 1955, Oct. 31, 1966, under stone (B. Marples, R. Forster; OMD, 1166), 1♂, 2♀; Riverton, 46°21'S, 168°01'E, Nov. 24, 1970 (R. Forster, C. Wilton; OMD), 1♀; Roaring Meg, Kawarau

Gorge, 45°03'S, 169°08'E, Nov. 19, 1974 (J. Dugdale; OMD), 1♀; Rock and Pillar Ecological Survey, 2 km S of Summit Rock, Ski Hut, 44°46'S, 170°18'E, Jan. 18, Feb. 28 1969, elev. 1368 m, edge of bog, pitfall (J. Child; OMD), 2♀; Rock and Pillar Ecological Survey, W of Middlemarch, 45°30'S, 170°07'E, Dec. 31, 1968, elev. 608 m, rocky hillside, pitfall (J. Child; OMD), 1♂; Rock and Pillar Ecological Survey, Lug Creek, Matagouri Scrub, 45°25'S, 170°07'E, Dec. 18, 1968, pitfall (J. Child; OMD), 1♀; The Sentinel, Cook, 44°43'S, 168°01'E, Dec. 3, 1953 (B. Holloway; OMD), 2♀; Southland, Orepuki, 46°16'S, 167°43'E, May 9, 1944, under log (R. Forster; OMD), 1♀; Spencer Park, Spencerville, Christchurch, Mar. 1983 (R. Jackson; OMD), 1♀; Stewart Island, 46°50'S, 167°52'E, Jan. 1956 (H. Watt; OMD), 1♀; Stewart Island, Halfmoon Bay, 46°53'S, 168°09'E, Mar. 10, 1951 (O. Allan; OMD), 1♀; Swinburn Bridge, 45°24'S, 169°07'E, Dec. 16, 1968, Mar. 6, 29 1969, pitfall (C. Wilton; OMD), 3♀; Taieri, 45°23'S, 170°18'E, Jan. 26, 1951, Oct. 10, 1973, dead cabbage tree leaves (R. Forster; OMD), 2♂, 1♀; Taieri Ridge, Deep Dell-Fillyburn, 45°23'S, 170°18'E, Dec. 12, 1968, summit (C. Wilton; OMD), 2♂; Taitapu, 43°40'S, 172°32'E, Nov. 1980 (A. W. P.; OMD, 28/91), 1♀; Te Anau, 45°25'S, 167°41'E, Feb. 12, 1983 (R. Forster; OMD), 2♀; N of Tiroiti, 45°15'S, 170°15'E, Dec. 12, 1968, summit, steep grade (C. Wilton; OMD), 1♂; near Waipiata, 45°10'S, 170°09'E, Oct. 14, 1968, pitfall (C. Wilton; OMD), 1♀; Waipori, 45°49'S, 169°52'E, Nov. 7 - 21, Dec. 5 – 19, 1978, elev. 520 m, tussock, pitfall (B. Barratt; OMD), 3♂; Wakari, Dunedin, 45°51'S, 170°28'E, Nov. 10, 1982 (D. J. H.; OMD), 1♂; Wedderburn, 45°02'S, 170°00'E, Oct. 15, 1967, Nov. 20, 1968, Feb. 16, 1969, pitfall (C. Wilton; OMD), 1♂, 1♀; Weka Pass, Canterbury, 43°00'S, 172°41'E, Jan. 12, 1947 (B. Marples; OMD), 1♀; Whale Island, Bay of Plenty, 43°53'S, 172°48'E, Aug. 27, 1970 (OMD), 1♂; Wooden Beach, Canterbury, 43°20'S, 172°42'E, Dec. 26, 1957, Oct. 25, 1992, beach, amongst maram grass (R. Pilgrim, C. Vink; OMD, LUNZ), 1♂, 1♀.

Distribution: the North and the South Islands, New Zealand (Fig. 1).

Ecology: forests, beaches, rocky hillside, gardens, inside houses, sand dunes, edge of bog; can be found under logs, stones, deans bushes, dead cabbage tree leaves, maram grass, inside buildings.

Taieria elongata FORSTER, 1979

Taieria elongata FORSTER, 1979: 50 (female holotype from Otago, Balclutha Plant Reserve, 46°13'S, 169°44'E, New Zealand (South Island) (Nov. 20, 1958; R. Forster) and male allotype taken on bank above tide level, between Taieri Mouth and Brighton, 45°56'S, 170°19'E, New Zealand (South Island) (Sept. 27, 1968; C. Wilton), in OMD, examined).

Other material examined: **North Island**: Poor Knights Islands, Tawhiti Rahi Island, 35°27'S, 174°43'E, Dec. 8, 1980, northern slopes near lighthouse, Pohutukawa leaf litter (K. Wise; AMNZ, 6000), 1♀. **South Island**: Allans Beach, Otago, 45°52'S, 170°41'E, Jan. 2, 1952 (B. Marples; OMD), 1♀; Bull Creek, 43°27'S, 170°00'E (R. Forster; OMD),

Fig. 1. Distribution of *Taieria erebus* (L. KOCH) (circles) and *T. titirangia*, new species (triangle).

1♀; Chatham Island, 45°33'S, 166°52'E, Feb. 11, 1969, litter (A. Wriah; OMD), 1♂, 1♀, 1 juv.; Cromwell, 45°02'S, 169°12'E, Nov. 7, 1958, under stone (R. Forster; OMD), 1♂, 1♀; Lake Manapouri, Fiorland, 45°30'S, 167°30'E, Feb. 6, 1946 (R. Forster; OMD), 1♀; Manuka Gully, 43°52'S, 170°11'E, Jan. 16, 1955 (B. Marples; OMD), 1♀; Pounawea E of Owaka, 46°28'S, 169°41'E, Jan. 18, 1978, sifted litter (B. Kuschel; NZAC, 92170), 1♀; Waipori Gorge, 45°49'S, 169°52'E, Nov. 26, Dec. 11, 1965, Dec. 8, 1966, Nov. 13, 1970 (R. Forster, C. Wilton; OMD, 1167, 1168), 6♀; Wanaka district, 44°42'S, 169°07'E, Jan. 1955 (B. Marples; OMD, 55.16), 1♀.

Distribution: the South Island and the Poor Knights Islands, New Zealand (Fig. 3).

Ecology: hillsides, on bank above tide level; can be found under stones and leaf litter.

Taieria kaituna FORSTER, 1979

Taieria kaituna FORSTER, 1979: 52 (male holotype and female allotype from Kaituna Valley, Canterbury, 43°44'S, 172°41'E, New Zealand (South Island) (Nov. 1, 1966; R. Forster, in OMD, examined).

Other material examined: **North Island**: Feilding, 40°13'S, 175°32'E, Dec. 26, 1949 (R. Forster; OMD), 1♀. **South Island**: Birdlings Flat, 43°49'S, 172°41'E, Nov. 17, 1976, litter (J. Dugdale; OMD), 1♀; Boulder Bank, Nelson, 41°09'S, 173°24'E, May 29, 1973 (G. Ramsay, K. Bonnington, A. Walker; OMD), 1♀; Christchurch, 43°35'S, 172°38'E, Nov. 2, 1994, in house (C. Vink; LUNZ), 1♂; Governors Bay, Canterbury, 43°37'S, 172°39'E, Jan. 4, 1949, under stones (I. Creswell; OMD), 2♀; Kennedys Bush, 43°37'S, 172°36'E, Nov. 30, 1946 (R. Forster; OMD), 1♀; Kowhai Bush, 46°16'S, 169°47'E, Dec. 29, 1974 (OMD), 1♀; Lincoln College, 43°38'S, 172°27'E, pitfall (P. Campbell; OMD), 1♂, 1♀; Long Creek, Hapuka River, 43°57'S, 168°53'E, Dec. 26, 1974, under stone (OMD), 1♀; Orongorongo Valley, 41°14'S, 175°03'E, Feb. 1, 1995, under sheet of fin on moss in Kanuka Green Station (B. M. F.; MONZ), 1♀; Palmers Bush, Waimea West, Nelson, 41°49'S, 171°34'E, Oct. 20, 1971, litter (G. Ramsay; OMD), 1♀; Ship Cove, 41°05'S, 174°14'E, Nov. 30, 1972, litter (J. Dugdale; OMD), 1♂.

Distribution: the North and the South Islands, New Zealand (Fig. 2).

Ecology: bays, under stones, on bushes, in litter, under sheet of fin in moss, inside houses.

Taieria obtusa FORSTER, 1979

Taieria obtusa FORSTER, 1979: 53 (male holotype and female allotype taken under stones on ground, Cromwell, Otago, 45°02'S, 169°12'E, New Zealand (South Island) (Oct. 21, 1950; R. Forster), in OMD, examined).

Other material examined: **South Island**: Christchurch, 43°31'S, 172°38'E (FSCA), 1♂, 1♀; Christchurch, Spencers Beach, 43°31'S, 172°38'E, Oct. 10, 1973, sand beach, under log (OMD), 1♂; Cromwell, 45°02'S, 169°12'E, Oct. 21, 1959 (R.

Fig. 2. Distribution of *Taieria obtusa* FORSTER (circles) and *T. kaituna* FORSTER (triangles).

Forster; OMD), 1♂, 4 juv.; Cromwell, Beetle Reserve Cemetery Road, 45°02'S, 169°12'E, Nov. 15, 17, 1977, tussock, litter, dead *Poa* sp. leaves (J. Watt; NZAC, 92170), 3♀, 18 juv.; Cromwell, Sandflat Road, 45°02'S, 169°12'E, Nov. 19-28, 1974, pitfall (J. Watt; OMD), 1♀; Cromwell Gorge, 2 km SE of Cromwell, E bank of Clutha below Dunston Gold monument, 45°06'S, 169°18'E, Nov. 21-27, 1974, pitfall (J. Watt; OMD) 1♂, 1♀; East Branch Eweburn, Otago, 45°09'S, 170°06'E, Nov. 20, 1968, Jan. 27, 1969, pitfall (C. Wilton; OMD), 1♂, 1♀; Flagstaff, 45°05'S, 168°40'E, Dec. 27, 1979 (R. Forster; OMD), 1♀; Hokitika, 42°42'S, 170°57'E, Oct. 4, 1974, under log (OMD), 1♀; Kaikoura, 42°24'S, 173°41'E, May 16, 1974 (OMD), 6♀; Opoho Bush, Cemetery Road, Dunedin, 45°51'S, 170°31'E, Nov. 17-23, 1970, pitfall (C. Wilton; OMD), 1♂; Waipori, 45°49'S, 169°52'E, Nov. 5 - Dec. 21, 1978, Jan. 16-31, Feb. 28 - Mar. 14, 1979, elev. 520 m, tussock, pitfall (B. Barratt; OMD), 1♂, 2♀.

Distribution: the South Island, New Zealand (Fig. 2).

Ecology: sand beaches, tussock grass, under logs, stones, and leaf litter.

Taieria miranda Forster, 1979

Taieria miranda Forster, 1979: 54 (female holotype from Ohope Beach, Auckland, 37°57'S, 177°02'E, New Zealand (the North Island) (Oct. 1, 1969; C. Wilton) and male allotype from Hawkes Bay, Cape Kidnappers, 39°38'S, 177°06'E, New Zealand (the North Island) (Jan. 21, 1954; J. Dugdale), in OMD, examined).

Other material examined: **North Island**: Auckland, Red Mercury Island, 36°38'S, 175°56'E, Sept. 1971 (D. Court; OMD), 1♀; Hawkes Bay, Taradale, 39°32'S, 176°50'E (R. Hutton; OMD), 1♀; White Pine Bush, 37°59'S, 176°57'E (R. Forster; OMD), 1♀.

Distribution: the North Island, New Zealand (Fig. 3).

Ecology: beaches.

Taieria titirangia, new species

Type: Male holotype taken in litter, Titirangi, Marlborough, 41°23'S, 174°03'E, New Zealand (Oct. 22, 1969; F. Alack) deposited in OMD (69/177).

Etymology: The specific name is a noun in apposition taken from the type locality.

Diagnosis: Male palp differs from all New Zealand species of *Taieria* in the lack of dorsal apophysis on the tibia, small, almost undeveloped retrolateral apophysis on patella, and relatively short and hooked retrolateral tibial apophysis (Fig. 4 A-C).

Male: Total length 4.75. Carapace 2.25 long, 1.60 wide. Femur II 1.55. Carapace yellow brown with dark brown reticulation and borders; abdomen yellow gray with dark brown transverse stripes and reddish antero-

Fig. 3. Distribution of *Taieria miranda* Forster (circles) and *T. elongata* Forster (triangles).
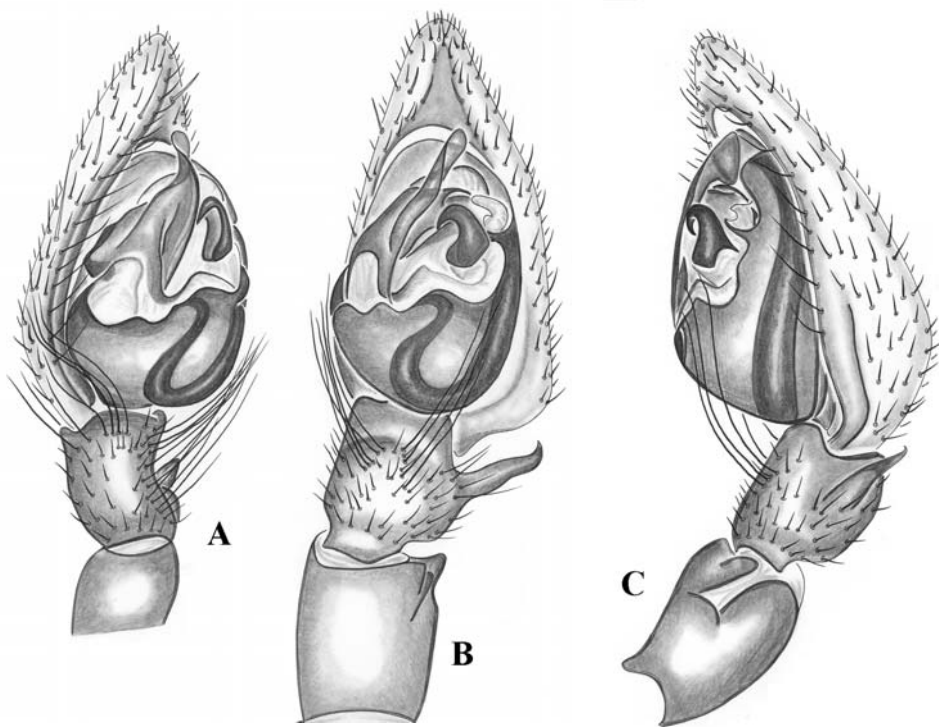
Fig. 4. *Taieria titirangia*, new species: A - left male palp, prolateral view; B - same, ventral view; C - same, retrolateral view.

median triangular spot; legs yellow. Eye sizes and interdistances: AME 0.09, ALE 0.11, PME 0.14, PLE 0.11, AME-AME 0.06, AME-ALE 0.02, PME-PME 0.01, PME-PLE 0.07, ALE-PLE 0.06; MOQ length 0.39, front width 0.24, back width 0.24. Leg spination: femora: I d1-1-0, p0-0-1; II d1-1-0, p0-0-1; III d1-3-3; IV d1-1-1-2; patella: III p0-1-0, r0-1-0; IV p0-1-0, r0-1-0; tibia: I v0-1-0; II v0-1-1; III p0-1-1, r0-1-1, v1-2-2; IV d0-1-0, p0-2-2, r0-1-2, v2-2-2; metatarsus: I v2-0-0; II v2-0-0; III d0-1-2; p1-1-1, r1-1-1, v2-1-2; IV d0-2-2, p1-1-1, r1-1-1, v2-1-2. Palp: retrolateral tibial apophysis short (but not tiny) and slender, hooked on the tip, dorsal tibial apophysis lacking, retrolateral apophysis on patella small, almost undeveloped, and look like as tubercles, embolus slightly twisted on the top, medial apophysis large and hooked (Fig. 4 A-C).

Female: Unknown.

Other material examined: None.

Distribution: Known only from type locality on the South Island, New Zealand (Fig. 1).

Ecology: in litter.

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Паяците от род *Taieria* FORSTER, 1979 в Нова Зеландия: таксономия и разпространение (Araneae: Gnaphosidae)

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(Резюме)

До момента родът *Taieria* е познат с пет вида: *T. erebus* (L. KOCH, 1873), *T. elongata* FORSTER, 1979, *T. kaituna* FORSTER, 1979, *T. obtusa* FORSTER, 1979 и *T. miranda* FORSTER, 1979, всичките обитаващи Нова Зеландия. В статията се описва шести вид – *T. titirangia*, намерен на Южния остров, и се съобщават нови находища за останалите видове. *T. erebus* е установен за пръв път на Южния остров, а *T. elongata* – на Северния. Представени са множество нови данни за хабитатните предпочитания на видовете, както и подробни карти на разпространението им.

On the harvestman fauna of Absheron-Gobustan zone (Azerbaijan), with a description of a new species (Opiliones)

Nataly Snegovaya[1]

Abstract: Seven harvestmen of family Phalangiidae are found in the Absheron-Gobustan zone of Azerbaijan. One of them, *Phalangium bakuensis* sp.n., is newly described and illustrated. It is most closely related to *Ph. staregai* Sɴᴇɢᴏᴠᴀʏᴀ, 2005 but differs from it in having smaller chelicerae, shorter penis and 2-3 rows of tubercles on ocularium. The species *Opilio afghanus* Rᴏᴇᴡᴇʀ, 1960 is recorded for the territory of Caucasus for the first time.

Key words: faunistics, harvestman, new record, *Phalangium bakuensis* sp.n., Azerbaijan

Introduction

The Absheron-Gobustan region is located in the eastern part of Azerbaijan and includes Absheron Peninsula and the neighbouring territories of the Gobustan Hills. The harvestman fauna of the region has hitherto remained unknown. The recent collecting activities carried out in the area revealed the following species: *Opilio parietinus* (Dᴇ Gᴇᴇʀ, 1778), *O. lederi* Rᴏᴇᴡᴇʀ, 1911, *O. absheronicus* Sɴᴇɢᴏᴠᴀʏᴀ, 2005, *O. shirvanicus* Sɴᴇɢᴏᴠᴀʏᴀ, 2004, *O. afghanus* Rᴏᴇᴡᴇʀ, 1960, and *Phalangium punctipes* C.L. Kᴏᴄʜ, 1878. A new species, *Phalangium bakuensis*, is herewith described and illustrated. The find of *O. afghanus* in Absheron-Gobustan represents the first formal record of the species in Caucasus.

Taxonomy

Phalangium bakuensis **sp. n.**

Figs 1-16.

Type material: Holotype: 1♂ (Zoological Institute RAN, St.-Petersburg, Russia; V. A. Krivokhatski), Azerbaijan, Absheron, Volchi Vorota (vicinities of Baku), 7-12.V.2005, collected under stones and in grass, Ilham Alekperov and Nataly Snegovaya leg.; Paratypes: 1♀ (Zoological Institute RAN, St.-Petersburg, Russia; V. A. Krivokhatski), 1♂, 6♀ (Institute of Zoology, Baku; N. Yu. Snegovaya, No. 276), same locality, data and collectors.

Diagnosis: The new species is close to *Phalangium staregai* Sɴᴇɢᴏᴠᴀʏᴀ, 2005 but differs from it by the characters given in Table 1.

Etymology: The species is named after Baku City, the type locality.

Description (all measurements are in mm): Male (Holotype) (Figs 1-10): Body: length 5.0; width 3.2; Chelicera: basal segment 1.5, distal segment 3.1, horn 1.4; Penis: length 1.88; length of glans: 0.33, stylus 0.15. Length of palp and leg segments: see Table 2.

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Table 1. Diagnostic characters of *Phalangium bakuensis* sp.n. and *Ph. staregai*.

	Ph. bakuensis sp.n.	*Ph. staregai* SNEGOVAYA, 2005
Body	Quadrangular, oval; not very large, 5.0 mm long (Figs 1-2)	Quadrangular, widening to caudal end; large, 5.6 mm long (SNEGOVAYA 2005: Fig. 46)
Chelicerae	Relatively small (Figs 5-6)	Relatively large (SNEGOVAYA 2005: Figs 53-54)
Legs	Fm I slightly thickened	Fm I strongly thickened
Penis	Relatively short (1.88 mm) (Figs 7-10)	Relatively long (2.8 mm); "wings" long (SNEGOVAYA 2005: Figs 47-50)
Ocularium	With 2-3 rows of black-tipped tubercles	With a single row of small tubercles

Table 2. *Phalangium bakuensis* sp.n., male (Holotype). Length of palp and leg segments (mm).

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Palp	1.85	0.8	1.0	---	2.1	5.75
Legs						
I	2.55	0.9	2.45	3.1	3.9	12.9
II	4.0	1.1	3.3	2.3	9.2	19.9
III	2.6	0.8	2.0	2.6	5.6	13.6
IV	7.0	1.0	3.0	3.5	7.4	21.9

Body: rounded–quadrangular, anterior margin of carapace smooth; there are groups of tubercles situated at corners and directed anteriorly. Each of the supra-cheliceral lamellae with a single setae. Saddle is clearly visible. On the cephalothorax all tergites bear a longitudinal row of small tubercles. There are 8-9 small tubercles in front of the ocularium, with each branch of the longitudinal stripe. Lateral sides of the cephalothorax with tubercles and setae between coxae. Ocularium contently high, with a group of 14-15 spine-tipped tubercles on each side, forming double/triple rows. There is a group of 8-9 tubercles on each sides of the ocularium. Abdominal sternites and coxae of legs covered with hairs. Palp not very long. Femur covered with small tubercles and setae. Patella also covered with tubercles and setae and bears hardly visible apophysis densely covered with micro-denticles. Tibia with setae and small and dark grains and tubercles. Tarsus with setae and grains. Chelicera rather robust. Cheliceral segment I covered with setae, segment II covered anteriorly with black micro-denticles and hairs and bearing a horn, covered with micro-denticles and hairs; the horn' size is variable. Legs not very long, femur I thicker and shorter than others. Legs I covered ventrally with denticles. Other legs covered with setae. Penis: the corpus penis is short, narrowing in the middle and then widening towards the glans. Glans long and thin with two pairs of setae on each side. Stylus long, hooked at its tip.

Female (Paratype) (Figs 11-16): Body: length 5.6; width 4.2; Chelicera: basal segment 1.3, distal segment 1.7. Length of palp and leg segments: see Table 3. Ovipositor: length 3.4, width

Table 3. *Phalangium bakuensis* sp.n., female. Length of palp and leg segments.

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Palp	1.3	0.8	0.7	---	1.6	4.4
Legs						
I	2.1	1.0	1.75	2.0	3.25	10.1
II	3.25	1.1	3.0	2.8	6.35	16.5
III	2.3	1.1	1.9	2.9	3.9	12.1
IV	3.25	1.1	2.7	4.1	5.6	16.75
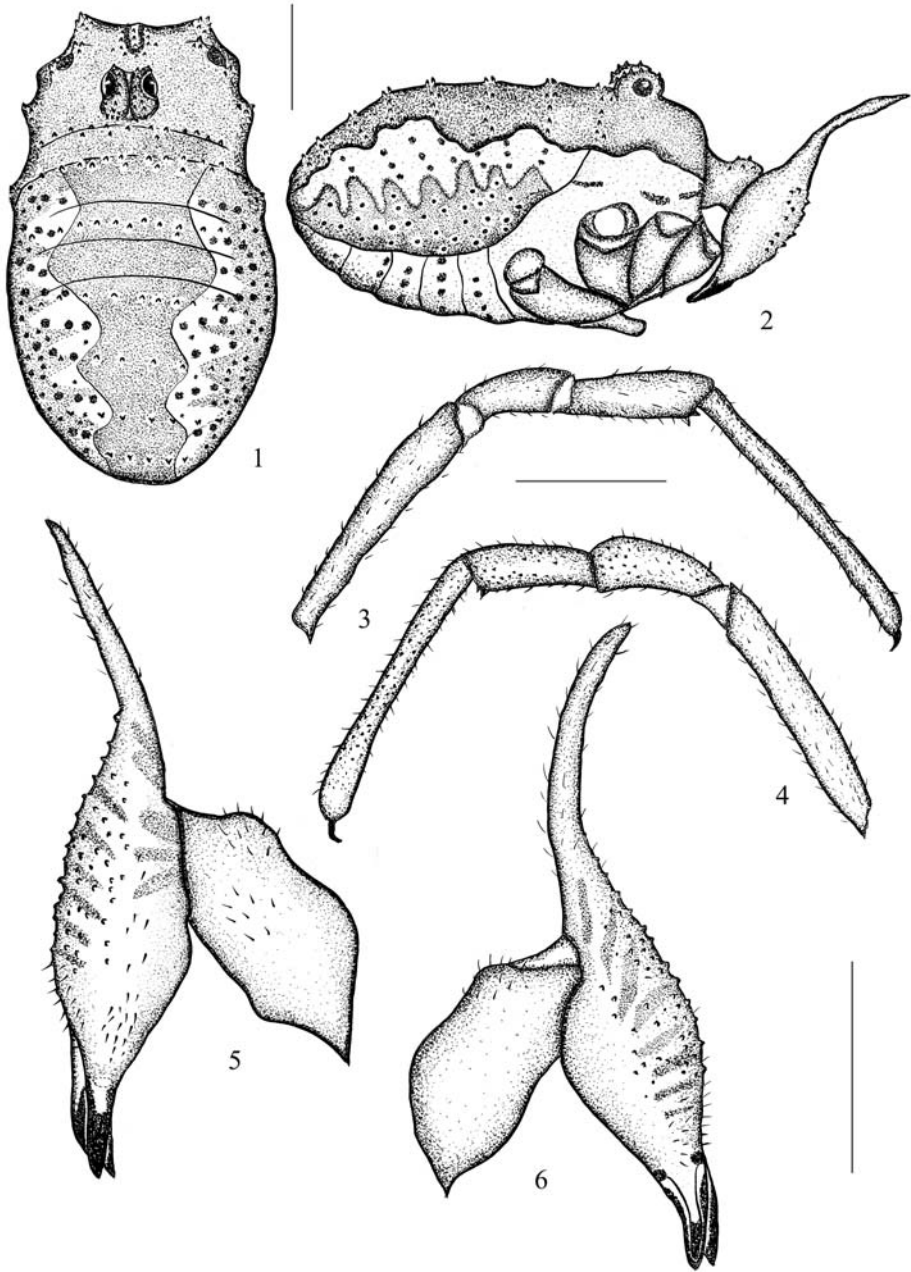
Figs 1-6. *Phalangium bakuensis* sp.n., male (Holotype): 1 – body, dorsal view; 2 – body, lateral view; 3-4 – palp, lateral view; 5-6 – chelicerae, lateral view. Scale lines: 1 mm.

0.4. Female longer and wider than the male; the second cheliceral segment without a process. Femora I not thickened. Palps and legs entirely covered with setae. Seminal receptacles situated between 2-5 segments.

Coloration: In both sexes, body light brown, with numerous dark brown and light yellow spots. Abdomen light brown, with dark spots. Palp light brown, with dark longitudinal spots. Legs light brown, with large and small dark brown spots.
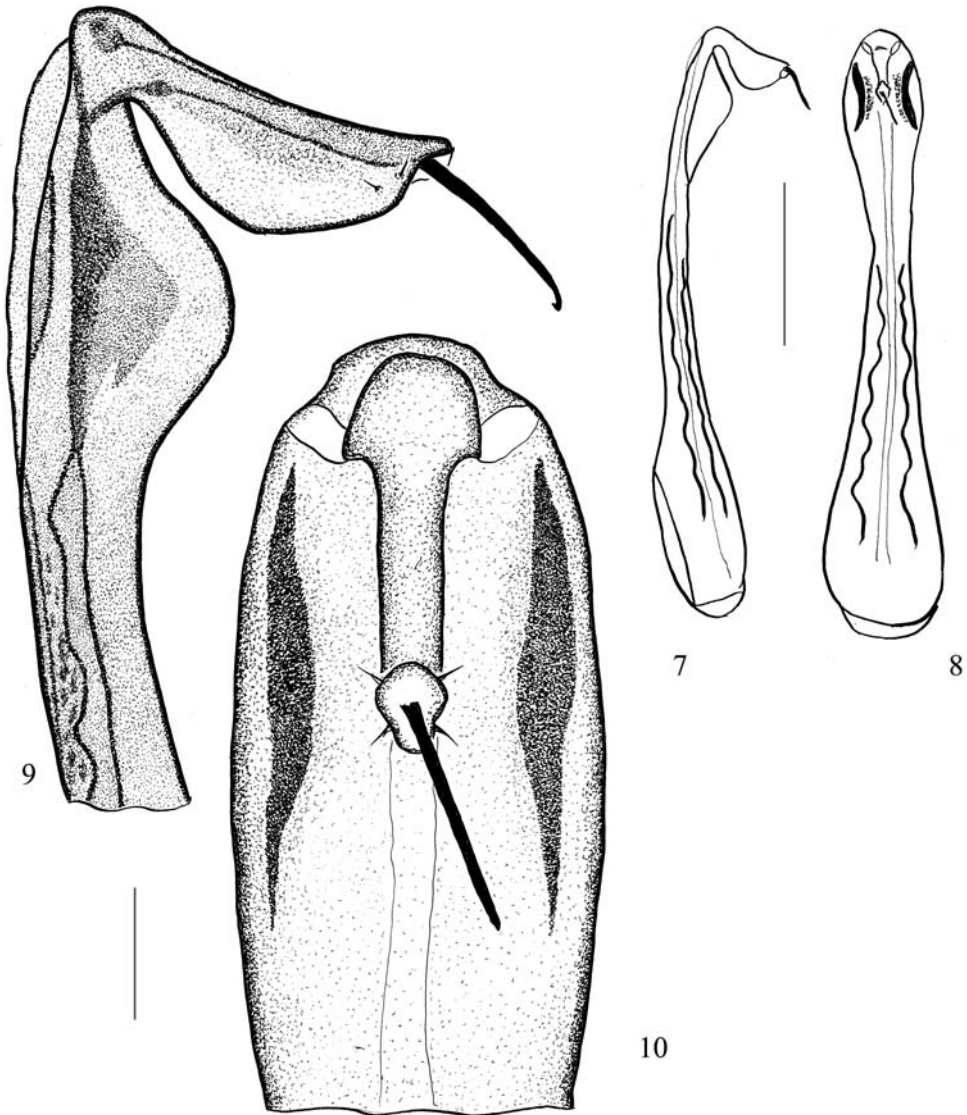
Figs 7-10. *Phalangium bakuensis* sp.n., male (Holotype): 7 – penis, lateral view; 8 – penis, dorsal view; 9 – glans penis, dorsal view; 10 – glans penis, lateral view. Scale lines: 0.5 mm (7, 8), 0.1 mm (9, 10).

Remark: The genus *Phalangium* LINNAEUS, 1758 is hitherto known with five species in Azerbaijan: *Phalangium punctipes* (L. KOCH, 1878), *Ph. armatum* SNEGOVAYA, 2005, *Ph. zuvandicum* SNEGOVAYA, 2005 and *Ph. staregai* SNEGOVAYA, 2005, and *Ph. bakuensis* sp.n. (ROEWER 1911, 1923, 1956, STARĘGA 1978, SNEGOVAYA 1999, 2004, 2005, present study).
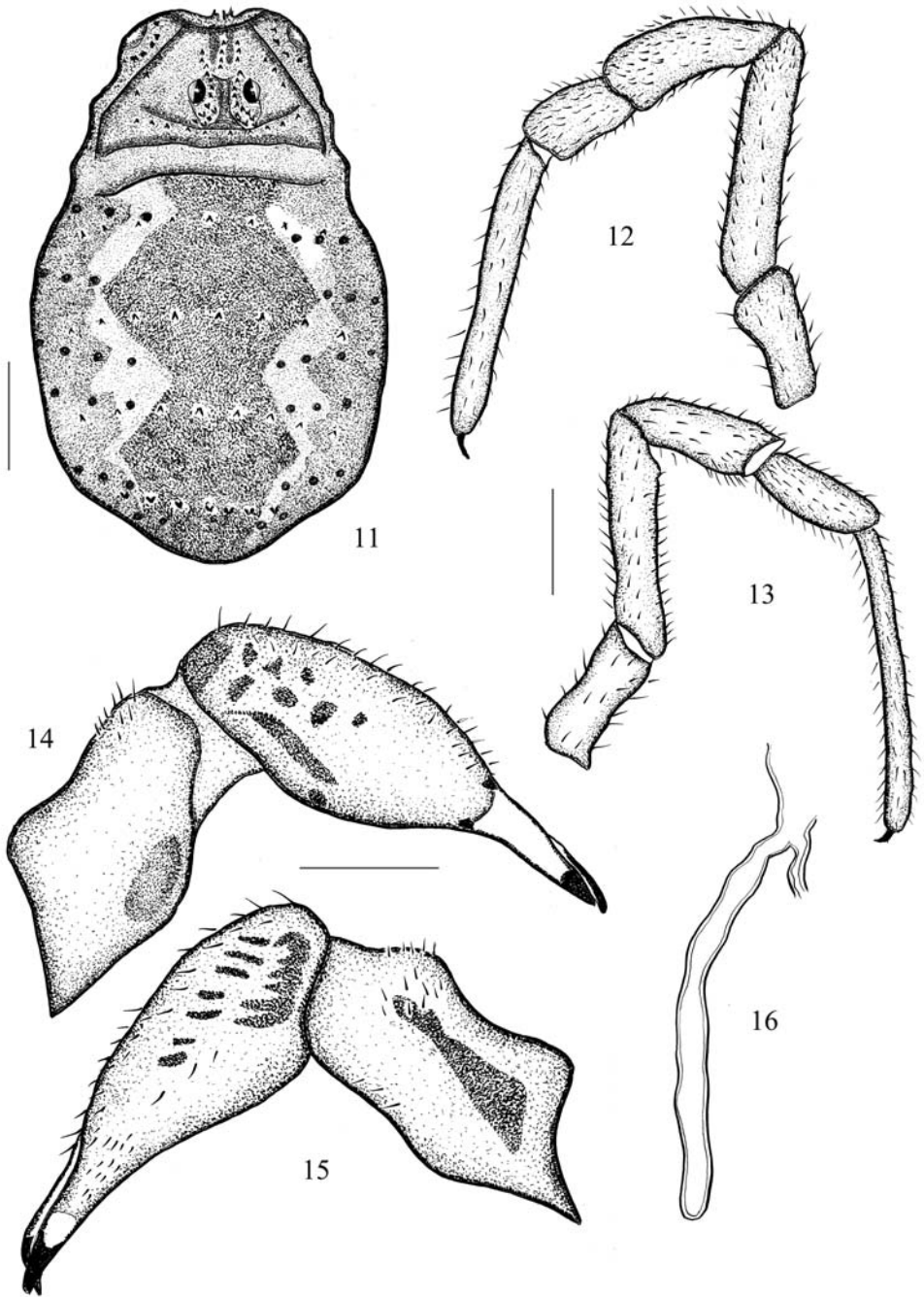
Figs 11-16. *Phalangium bakuensis* sp.n., female (Paratype): 11 – body, dorsal view; 12-13 – palp, lateral view; 14-15 – chelicerae, lateral view; 16 – seminal receptacle. Scale lines: 1 mm (11), 0.5 mm (12-15).

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Сенокосци от Абшерон-Гобустан (Азербайджан) с описание на нов вид (Opiliones)

Н. Снеговая

(Резюме)

Седем вида сенокосци от семейство Phalangiidae са установени в района на Абшерон-Гобустан, Източен Азербайджан. Един от тях – *Opilio afghanus* Roewer, 1960, е нов за фауната на Кавказ. Описва се новият за науката вид *Phalangium bakuensis*, намерен в околностите на Баку. Видът е морфологично близък до *Ph.* s*taregai*, но се различава от него по малките хелицери и пенис, както и по наличието на 2-3 реда туберкули на окулариума.

Spiders of the Domica drainage area (Slovak Karst Mts.): community composition and habitat evaluation (Araneae)

Peter Gajdoš[1]

Abstract: In 2003 and 2004 a research of araneofauna and spider communities of the Domica drainage area was performed on 27 study sites (on 12 of them by pitfall trapping). Altogether, more than 2,712 specimens belonging to 198 species were captured. The species diversity in the Domica drainage area is rather high, representing approximately 23% of the Slovak araneofauna. Of the identified species, 15 are listed in the Red List of Spiders of Slovakia. The occurrences of *Centromerus capucinus* (EN), *Diaea livens* (CR), *Hahnia picta* (EN) and *Sintula spiniger* (EN) are of great importance since these species had been reported in Slovakia only a few times before. The great richness of the spider fauna and the occurrence of rare and threatened species for Slovakia confirm the high biotic value of the investigated areas. Ten study sites (sites 1-10) investigated by means of pitfall traps for a period of one year were assessed according to their biological importance based on the occurrence of endangered and rare spider species. Three of the study sites, such as dry calcareous pasture in lime sink (site 6), dry calcareous grassland in the karren area of the National Nature Reserve Domicke Škrapy (Domica Karren) (site 3) and an old extensively used orchard near Kečovo (site 7) have been assigned to the biologically most valuable areas (territories with the highest proportion of endangered and rare species).

Key words: spiders, nature conservation, Domica, karst, southeastern Slovakia

Introduction

The Domica drainage area, one of the areas of the Slovak Karst Mts., having well-preserved dry calcareous grasslands and other xerothermic habitats, is a suitable model area for research of animal communities of karst habitats including also spider communities. Dry calcareous grasslands belong among the endangered types of biotopes in Europe and they are listed in the Annex 1 of the Habitat Directive (COUNCIL 1992). The area is important not only for national nature conservation but also for the whole of Europe, as part of the investigated area is National Nature Reserve and also a Natura 2000 site. Spiders, an important component of xerothermic fauna, are used as bio-indicators of environmental quality (BUCHAR 1983, 1991, CLAUSEN 1986, MAELFAIT 1996, RŮŽIČKA 1986, 1987) and for evaluation of biota changes in relation to the land management (MAELFAIT *et al*. 1990, MAELFAIT, SEGHERS 1986, MAELFAIT, DE KEER 1990, MAELFAIT *et al*. 1997, SVATOŇ 1987, SVATOŇ, MAJKUS 1994). This type of bio-indication, which is based on the investigation of species diversity and community composition is called ecological indication (BLANDIN 1986).

From the point of view of arachnological research, insufficient attention has been devoted to the territory of the Domica drainage area. Only a few papers with sporadic records (CHYZER, KULCZYŃSKI 1891, 1894, 1897, 1899, MILLER, KRATOCHVÍL 1940, MILLER 1971, SVATOŇ 1994, KŮRKA 1996, BUCHAR 1999 and GAJDOŠ *et al*. 1999) present the spider fauna of the region. Up to the present only 42 spider species have been published from the Domica drainage area. This fact initiated an arachnological research on this territory in the period 2003-2004. The aim of this study was to describe the spider species composition, to characterise the spider communities of

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the Domica drainage area and to classify the study sites according to their importance from the point of view of nature conservation.

Material and Methods

Study area

The Domica drainage area is situated around Domica cave on the south-western edge of the Silická Plateau in Slovak Karst (the largest karst region in Central Europe), 10 km to the southwest of Plešivec, near the borders with Hungary. It represents a typical landscape of the Slovak Karst Mountains. Centrally situated, Domica Cave (World Heritage Site) is a pearl of the National Nature Reserve Domické škrapy (Domica Karren), which is part of investigated area. The drainage area is covered with sunny, rocky and forest-steppe habitats, dry calcareous meadows and pastures, orchards, dry oak forests, wet depressions, arable fields with typical karst formations as lime sinks, karren, karst plateaus, abysses, caves, etc. The selected study sites present the different habitat types characteristic of this territory. The mosaic of habitats creates good conditions for high biodiversity of the spider fauna and occurrence of many rare and threatened spider species.

Sampling and study sites

Research on the spider fauna was carried out in 2003 and 2004. The spiders were collected mainly by pitfall traps on 10 study sites (1-10) in 2003-2004 during the whole research period (from August 21, 2003 to November 26, 2004) and on two additional sites (study sites 11-12) in 2004 (from beginning of May to November) on dry calcareous habitats. As pitfall traps 0.7 liter jars - 9 cm in diameter, were used, one-third filled with a 4 % formaldehyde solution with a drop of added detergent, during winter season - with antifreeze liquid. The traps were emptied approximately once a month during the vegetation season and once in every three months during winter time. The traps were placed in pairs at site *ca.* 10 m apart on the 12 following study sites:

St. 1 – abandoned wet meadow on the top of a small hill surrounded by arable land

St. 2 – willow (*Salix cinerea*) stand on the top of a small hill surrounded by arable land

St. 3 – dry calcareous grassland with shrubs in the karren area near Domica cave

St. 4 – hornbeam forest at the bottom of a lime sink near hill top

St. 5 – Veľký Polder, abandoned polder overgrown with sparse poplar trees in herbal layer with mesophilous grasses

St. 6 – dry calcareous pasture at the bottom of a lime sink near Kečovo

St. 7 – mown old extensively used orchard near Kečovo

St. 8 – oak-hornbean forest

St. 9 – extensively used mesophilous meadow

St. 10 – wet grassland (*Molinietum*) with solitary birch trees near St. 9

St. 11 – dry calcareous pasture above Kečovo

St. 12 – dry calcareous grassland with shrubs in the karren area near Domica cave (100 m above St. 3)

At the other 15 study sites the spiders were collected sporadically by sweeping (sw), sifting of detritus and dead leaves (si), beating from trees and shrubs (be) and by individual collection under stones and in grass and leaves (ic):

St. A – Domica, shrubby margin of the mesophilous meadow on a hill top near st. 1 (be)

St. B – Domica - small polder opposite the Domica cave entrance overgrown with shrubs and tall sedges (be)

St. C – Domica, dams of the Domický Potok stream overgrown with poplars (sw, ic)

St. D – Domica, pastured dry calcareous grassland in the margin of the lime sink near Kečovo - near st. 6 (be, ic)

St. E – Domica, Veľký polder, litoral zone overgrown with *Carex* sp. and *Phragmites* sp. near St. 5 (ic)

St. F – Domica, wetlands overgrown with willow trees near main road, undergrown with *Urtica dioica* (sw)

St. G – Domica, dry calcareous grassland on the hill top of the National Nature Reserve Domické Škrapy (ic)

St. H – Domica, mesophilous meadows fallow among the arable land near study site 1 (sw)

St. I – Domica, pastured dry calcareous grassland near Kečovo (near St. 11) (sw, ic)

St. J – Domica, dry calcareous grassland near a cave between study sites 3 and 12 (si)

St. K – Domica, shrubby and tree margin in a dry calcareous grassland near a cave (near st. 12)

St. L – Domica, rocky slope of the lime sink near Kečovo (near St. 6) (ic)

St. M – Domica, shrubby and tree margin of the dry calcareous grassland in the margin of the lime sink near st. 4 (be)

St. N – Domica, shrubby and tree margin of the dry calcareous grassland near a cave (near St. 3) (be)

St. O – desolate buildings of the camp opposite cave entrance (ic)

Evaluation of the study sites was performed only on ten study sites (study sites 1-10) in which pitfall traps were situated during a whole year. The study sites have been assigned to three categories of biological importance on the basis of species composition (the presence of threatened and rare spider species): **category I** – the biologically most valuable sites – sites with high species diversity and with the highest proportion of the threatened/rare species; **category II** – biologically valuable sites – sites with high or average species diversity and with lower proportion of threatened/rare species than in category I; **category III** – sites of low biological importance – sites with lower or average species diversity and a low number of the threatened/rare species. The nomenclature and systematic order of species follow Platnick (2005). A comparison of the epigeic spider communities of the individual study sites was done according to Ward's clustering method. This method was chosen as the most proper for this type of data.

Results

Species and family composition

Altogether 2,712 specimens belonging to 198 species from 28 families were captured in the Domica drainage area (Appendix 1). The majority of spiders come from pitfall traps (2,556 specimens belonging to 155 spider species from 27 families). The species diversity in the Domica drainage area is rather high, representing approximately 23% of the Slovak araneofauna. From the identified species, fifteen are included in The Red List of Spiders of Slovakia (Gajdoš, Svatoň 2001) (Tables 2-3). The occurrences of the critically endangered (CR) species *Diaea livens* and the endangered (EN) species *Centromerus capucinus*, *Hahnia picta* and *Sintula spiniger* (EN) are of great importance since these species had been reported in Slovakia only a few times before. In the epigeic communities of all sites, the Lycosidae were eudominant (D = 15.08 – 63.7%). From the other families, the Linyphiidae were eudominant on sites 2-8 and 10 (D = 12.9 – 25.8%), Amaurobiidae - on sites 4 and 8 (D = 34.2 and 16.8%), Liocranidae - only on site 2 (D = 12.5%) and Gnaphosidae - on sites 1, 3, 6, 7 and 9 (D = 13 – 15.8%). The majority of other families is defined as recedent and subrecedent (Table 1). The composition of spider communities on individual study sites differs depending on habitat types.

Table 1. Dominance (in %) of spider families in epigeic communities on study site 1-10.

Family	Study site (St.)									
	St. 1	St. 2	St. 3	St. 4	St. 5	St. 6	St. 7	St. 8	St. 9	St. 10
Pholcidae	-	-	0.4	-	-	-	-	-	-	-
Dysderidae	-	4.0	0.4	1.8	0.8	2.8	2.1	4.4	-	-
Mimetidae	0.3	0.4	-	0.9	-	-	0.3	-	-	0.4
Eresidae	-	-	0.4	-	-	-	-	-	-	-
Theridiidae	0.3	1.8	1.2	-	0.5	0.9	0.7	0.9	0.7	1.3
Linyphiidae	3.4	15.4	25.9	18.4	18.9	23.1	13.4	13.3	2.2	12.9
Tetragnathidae	2.5	-	-	-	5.2	-	-	-	1.8	1.3
Araneidae	0.8	-	1.2	-	-	-	-	-	-	-
Lycosidae	63.2	50.4	27.5	15.8	58.6	46.3	31.2	42.5	63.7	45.3
Pisauridae	1.4	1.8	0.4	-	0.8	0.9	2.7	-	2.2	2.2
Oxyopidae	-	-	-	-	-	-	-	-	-	-
Zoridae	-	1.1	-	-	0.5	-	0.7	0.9	-	9.8
Agelenidae	0.6	-	4.7	7.0	0.3	0.9	1.0	0.9	-	-
Cybaeidae	-	-	-	-	-	0.9	-	-	-	-
Hahnidae	2.0	1.1	0.4	-	0.3	-	0.7	-	1.4	1.3
Dictynidae	0.8	4.4	-	11.4	3.0	4.6	-	8.0	2.2	3.6
Amaurobiidae	-	-	9.4	34.2	0.5	0.9	7.5	16.8	-	-
Miturgidae	-	-	-	-	-	-	-	0.9	0.4	-
Anyphaenidae	-	-	-	1.8	-	-	0.3	-	-	-
Liocranidae	2.8	12.5	2.7	4.4	3.8	3.7	9.9	0.9	0.7	11.6
Clubionidae	0.3	-	-	-	0.3	-	-	-	-	0.4
Corinnidae	-	-	-	-	0.8	-	1.4	-	1.1	0.9
Zodariidae	-	-	-	-	-	-	-	2.7	-	-
Gnaphosidae	14.3	4.0	14.9	2.6	4.4	13.0	19.2	5.3	15.8	6.2
Sparassidae	-	-	0.4	-	-	-	-	-	-	0.4
Philodromidae	0.6	-	1.2	-	-	-	-	-	0.4	0.9
Thomisidae	4.8	2.9	7.5	1.8	0.5	1.9	7.9	1.8	6.5	0.9
Salticidae	2.0	-	1.6	-	0.5	-	1.0	0.9	1.1	0.4
Number of specimens	**356**	**272**	**255**	**114**	**365**	**108**	**292**	**113**	**278**	**225**

Evaluation of study sites 1-10 on the basis of epigeic spider communities

The spider communities of the investigated study sites (1-10) consist of various coenoses, which are characterised by different plant communities in the Domica drainage area. On the basis of the chosen criteria, three of the sites (3, 6 and 7) have been assigned to category I as the biologically most valuable areas (Table 3). They present sites with high species diversity, with a high number of threatened and rare species. Open dry calcareous grasslands found on sites 3 and 6 seems to be the most valuable habitats in the area. The spider communities found in these study sites are composed mainly of species, which have high claims on stable environmental conditions (light, soil humidity and vegetation structure). The low soil humidity, high intensity of solar radiation and sparse vegetation, which characterize both study sites, provide conditions for the occurrence of many xerothermophilous threatened species. It is interesting that besides the characteristic karst habitats also old extensively used fruit orchards (st. 7) belong among the habitats important for conservation of threatened and rare species. The communities of the sites 1, 2, 4, 8 and 10 were classified to category II as biologically valuable. In this category, the spider communities of

Table 2. Dominance (in %) of the threatened species in epigeic communities on study site 1- 10 and their presence in the other sites (rest). RL – Red list of spiders of Slovakia (GAJDOŠ, SVATOŇ 2001). Categories of threat: CR - critically endangered, EN – endangered, VU – vulnerable, LR - lower risk (nt - near threatened, lc - least concern), DD - data deficient.

RL	Threatened species	Study site										
		St. 1	St. 2	St. 3	St. 4	St. 5	St. 6	St. 7	St. 8	St. 9	St. 10	Rest
CR	*Diaea livens*											M.N
EN	*Centromerus capucinus*			13.33								
EN	*Sintula spiniger*		0.74	10.59			8.33	7.19				
EN	*Hahnia picta*										0.44	
EN	*Agroeca lusatica*	0.84		0.39			1.85	3.77		0.72		
VU	*Dysdera hungarica*		4.04	0.39	0.88	0.27	2.78	2.05	4.42			
VU	*Gnaphosa modestior*						8.33					st.12
VU	*Xysticus lineatus*	2.25									0.44	
LR.lc	*Cheiracanthium punctorium*											H
LR.lc	*Tmarus stelio*											N
LR.lc	*Marpissa nivoyi*					0.27						
LR.lc	*Pseudicius encarpatus*											M.N
LR.nt	*Kishidaia conspicua*						0.93					
DD	*Megalepthyphantes pseudocollinus*				2.63				0.88			
DD	*Pocadicnemis juncea*										0.89	
	Totally	**3.09**	**4.78**	**24.71**	**3.51**	**0.54**	**22.2**	**13.0**	**5.31**	**0.72**	**1.77**	

Table 3. Evaluation of epigeic communities of the study sites (St.) 1-10 D – dominance, SI – category of the site importance.

	Study site									
	St. 1	St. 2	St. 3	St. 4	St. 5	St. 6	St. 7	St. 8	St. 9	St. 10
Number of species	57	37	46	29	41	25	45	25	41	47
Number of threatened species (category EN)	1	1	3			2	2		1	1
Number of threatened species (category VU)	1	1	1	1	1	2	1	1		1
Number of threatened species (cat. LR. DD)				1	1	1		1		1
Total number of threatened species	2	2	4	2	2	5	3	2	1	3
Dominance of threatened species (D%)	3.1	4.8	24.7	3.5	0.5	22.2	13.0	5.3	0.7	1.8
Category of SI	**II**	**II**	**I**	**II**	**III**	**I**	**I**	**II**	**III**	**II**

forest habitats (St. 4, 8), of shaded wet habitats (St. 2, 10) and of open or semi-open wet habitats (St. 1) were included. In this category the main attention in terms of protection should be paid to wetland habitats, the occurrence of which is very rare in this generally very dry territory. The forest habitats have lower species richness.

The other two evaluated study sites (5 and 9) have been classified as sites with lower biological importance and were assigned to category III. In this category an extensively used site (St. 9) and a site considerably disturbed by man (St. 5) are listed. Although the spider communities on the mentioned sites are rich in species, they consist mainly of species which are widespread and common or expansive. Occurrence and proportion of rare and threatened species is low (Table 3).

Comparison of the epigeic spider communities in the individual study sites

The majority of the compared spider communities is highly dissimilar (Fig. 1). On the basis of the hierarchical classification, spider epigeic communities were divided into two main clusters. The first cluster (I) represents spider communities of the forest sites (St. 4, St. 8), shaded willow stand (St. 2) and poplar stand (St. 5). They are relatively dissimilar (values of their dissimilarity are about 56%) and characterized by the eudominant representation of the species *Pardosa lugubris* (Appendix 1). The similarity of the communities of sites 2 and 8 was the highest (about 76%). Both sites have similar conditions for ground living spiders – shaded ground covered by detritus and dead leaves without low vegetation. The second cluster (II) represents epigeic communities of non-forest habitats which are open or only partly shaded. The compositions of these communities are very dissimilar with values of dissimilarity of more than 60%. At this level the cluster is divided into two subclusters. Subcluster IIa demonstrates considerable similarity between site 6 (dry calcareous pasture at the bottom of a lime sink) and site 10 (wet grassland *Molinietum* with solitary birch trees). In both communities the same common widespread species occur abundantly (e.g. *Centromerus sylvaticus* and *Alopecosa trabalis*). Subcluster IIb combines four habitats with different spider communities. Within this subcluster similarity of the communities of sites 1 and 7 was the highest (about 60%). The similarity of 2 other communities (dry calcareous grassland - St. 3 and cultivated meadow - St. 9) was evidently lower than what corresponds to different habitat types of the compared sites.

Discussion

The recording of 198 spider species in a sixteen-month research programme in a restricted area indicates a very rich spider fauna of this karst ecosystem. This is approximately 23% of the Slovak araneofauna, in spite of the fact that a relatively small part of Slovakia and a limited set of habitats were studied. The compositions of the studied spider communities in the study area showed great variation depending mainly on vegetation structure, as well as on environmental factors and land use. The vegetation of the habitats modifies microclimatic factors such as moisture, intensity of sunshine, and also determines its spatial structure (WISE 1993). More authors (ABRAHAM 1983, ROBINSON 1981, UETZ 1975, etc.) have demonstrated narrow relationships between spider and plant communities. Of the investigated habitats, the open dry calcareous grasslands with threatened spider communities are especially interesting from a nature conservation point of view. The area of these types of habitat is continually decreasing as the result of natural succession after grazing has been reduced or stopped. At present their spider communities are bound to only small fragments of habitat which are spatially limited and into which some forest species have spread from surrounding forest and shrubby habitats, such as *Pardosa lugubris, Cicurina cicur*, etc. In the case that this negative trend continues, the typical karst habitats will disappear and with them also numerous stenotopic, rare and threatened species will be lost. For this reason it will be necessary very soon to suggest and to realize management activities insuring the efficient protection of
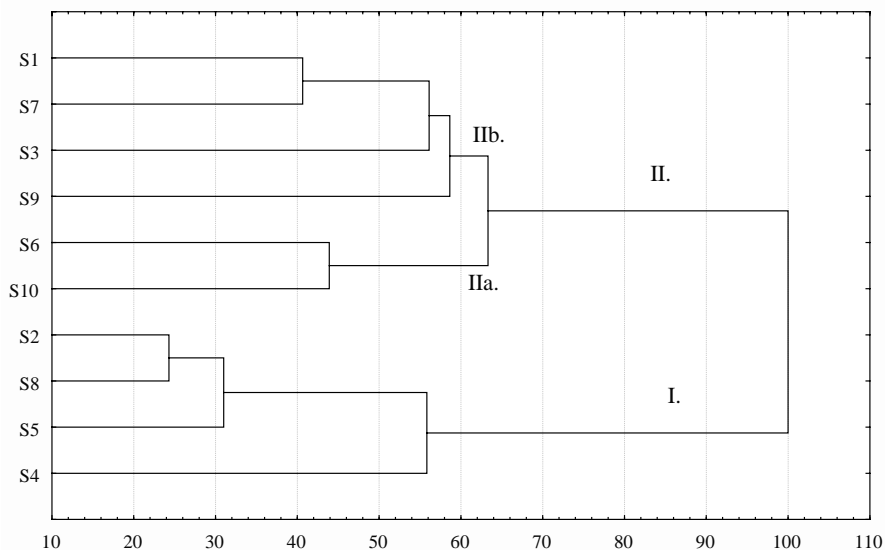
Fig. 1. Hierarchical classification of epigeic spider communities of the sites 1-10 according to Ward´s clustering method.

these rare habitats. Suggested management activities might consist of cutting of shrubs and trees, grazing, mowing and burning of the selected parts, respectively.

Also the sites of the mown old extensively used orchard show high spider species richness and present a habitat for some threatened species, such as *Dysdera hungarica*, *Sintula spiniger*, *Agroeca lusatica*, etc. This type of habitat is relatively numerous in the area, therefore has a great importance from a protection point of view. Because this type of habitat is vulnerable, it is also necessary to consider/include protection of these semi-natural habitats in the management programmes.

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Паяците на Домица (Словашки Карстови планини): състав на съобществата и оценка на хабитатите (Araneae)

П. Гайдош

(Резюме)

Статията представя резултатите от изследване на съобществата от паяци в района на Домица (Словашки Карстови планини), състояло се в периода 2003-2004 г. Проучването е проведено в 27 площадки, като в 12 от тях са заложени земни капани. Уловени са над 2712 екземпляра от 198 вида, което показва високото видово разнообразие на изследвания район – приблизително 23% of цялата словашка аранеофауна. Петнадесет вида са включени в Червения списък на Словакия, а намирането на видове като *Centromerus capucinus* (EN), *Diaea livens* (CR), *Hahnia picta* (EN) and *Sintula spiniger* (EN) е от голямо значение, тъй като тези паяци са много редки в страната. Голямото видово богатство и наличието на редки видове показва голямата консервационна значимост на района на Домица. Сравнителният анализ на отделните хабитати, направен въз основа на уловените редки и застрашени паяци показва, че най-консервационно значими са сухите варовикови пасища в понори (площадка No. 6), сухите варовикови поляни в карстовите райони на резервата Домицке шкарпи (площадка No. 3) и старата, интензивно използвана градина в близост до Кечово (площадка No. 7).

Appendix 1. List of species and number of specimens collected from study sites of the Domica drainage area. See text for explanation of classification numbers and letters for individual study sites.

Family / species	Study sites												
	1	2	3	4	5	6	7	8	9	10	11	12	Other
PHOLCIDAE													
Pholcus opilionoides (SCHRANK, 1781)			1										
DYSDERIDAE													
Dysdera hungarica KULCZYŃSKI, 1897		11	1	1	1	3	6	5					
Harpactea rubicunda (C.L. KOCH, 1838)				1	2								
MIMETIDAE													
Ero furcata (VILLERS, 1789)	1	1		1			1			1			
ERESIDAE													
Eresus cinnaberinus (OLIVIER, 1789)			1									1	
THERIDIIDAE													
Achaearanea sp. (*lunata*)						1							
Dipoena melanogaster (C.L. KOCH, 1837)													K, M, N
Enoplognatha ovata (CLERCK, 1757)		2											
Episinus angulatus (BLACKWALL, 1836)		2								1			
E. truncatus (LATREILLE, 1809)										1			
Euryopis flavomaculata (C.L. KOCH, 1836)												4	
Lasaeola tristis (HAHN, 1833)													B
Neottiura bimaculata (LINNAEUS, 1767)							2				1		J
N. suaveolens (SIMON, 1879)	1								1				K
Robertus lividus (BLACKWALL, 1836)		1			2			1	1	1			
Simitidion simile (C.L. KOCH, 1836)													N
Steatoda phalerata (PANZER, 1801)			1								1		
Theridion impressum (L. KOCH, 1881)			1										
T. nigrovariegatum (SIMON, 1873)													K,N
T. sisyphium (CLERCK, 1757)													
T. tinctum (WALCKENAER, 1802)													E,K,N
Theridion sp. ? *neglectum*			1										
LINYPHIIDAE													
Anguliphantes angulipalpis (WESTRING, 1851)			1					1		1			
Bathyphantes parvulus (WESTRING, 1851)					1					6			
Centromerus capucinus (SIMON, 1884)			34										
C. incilium (L. KOCH, 1881)	1												
C. sylvaticus (BLACKWALL, 1841)	5	7	1	1	31	16	9	4		15			
Ceratinella brevis (WIDER, 1834)	1	7	2		1					1		1	
C. scabrosa (O. P.-CAMBRIDGE, 1871)										1			
Dicymbium brevisetosum LOCKET, 1962					1								
Diplostyla concolor (WIDER, 1834)		2	1	1	19		3	1	1				
Erigone dentipalpis (WIDER, 1834)									1				
Floronia bucculenta (CLERCK, 1757)													D,E
Gnathonarium dentatum (WIDER, 1834)								1					D
Palliduphantes insignis (O. P.-CAMBRIDGE, 1913)						1							
Lepthyphantes minutus (BLACKWALL, 1833)				1									
Macrargus rufus (WIDER, 1834)				1									
Megalepthyphantes pseudocollinus (SAARISTO, 1997)				3				1					
Meioneta rurestris (C.L. KOCH, 1836)	1								4				N
Microneta viaria (BLACKWALL, 1841)		3		2	2			2					

Appendix 1. Continued.

Family / species	1	2	3	4	5	6	7	8	9	10	11	12	Other
													Study sites
Neriene clathrata (Sundevall, 1830)		1			2					1			E
N. montana (Clerck, 1757)													D
Panammomops fagei Miller, Kratochvíl, 1939					1								
Pocadicnemis juncea Locket, Millidge, 1953										2			
P. pumila (Blackwall, 1841)										1			
Sintula spiniger (Balogh, 1935)		2	27			9	21						
Stemonyphantes lineatus (Linnaeus, 1758)	1												
Syedra gracilis (Menge, 1869)		2											
Tenuiphantes flavipes (Blackwall, 1854)				6			5						
T. mengei (Kulczyński, 1887)		1	1		1		1						
Trematocephalus cristatus (Wider, 1834)													K,N
Walckenaria alticeps (Denis, 1952)	2	14			6								
W. antica (Wider, 1834)			2										
W. capito (Westring, 1861)	1						4						
W. cucullata (C.L. Koch, 1836)			2							1			
W. dysderoides (Wider, 1834)		2			3								
W. mitrata (Menge, 1868)			1										
W. obtusa (Blackwall, 1836)					1								
TETRAGNATHIDAE													
Metellina segmentata (Clerck, 1757)													C,E
Pachygnatha degeeri (Sundevall, 1830)	9								5				
Pachygnatha listeri Sundevall, 1830					19					3			
Tetragnatha pinicola L. Koch, 1870													C
ARANEIDAE													
Aculepeira ceropegia (Walckenaer, 1802)													C
Agalenatea redii (Scopoli, 1763)													C,I
Araneus quadratus Clerck, 1757	1												A,C
A. triguttatus (Fabricius, 1793)													B
Araniella sp. (*cucurbitina – opisthographa*)													K,M
Argiope bruennichi (Scopoli, 1772)	1		1										
Cercidia prominens (Westring, 1851)			1										
Cyclosa conica (Pallas, 1772)													C, I,M
Hypsosinga sanquinea (C.L. Koch, 1844)													I
Gibbaranea bituberculata (Walckenaer, 1802)													C
Mangora acalypha (Walckenaer, 1802)			1										C,K,N
Singa hamata (Clerck, 1757)	1												D,E
Zilla dioda (Walckenaer, 1802)													K
LYCOSIDAE													
Alopecosa accentuata (Latreille, 1817)			6			5						6	
A. cuneata (Clerck, 1757)	12		1				8		11	1	1		
A. pulverulenta (Clerck, 1757)	26	1	1			1			23	1			
A. sulzeri (Pavesi, 1873)			3										
A. trabalis (Clerck, 1757)	12	9	3	2	10	18	16	1	8	26	29		L,M
Hogna radiata (C.L. Koch, 1838)												2	
Pardosa amentata (Clerck, 1757)	1	2			62								

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Appendix 1. Continued.

Family / species	1	2	3	4	5	6	7	8	9	10	11	12	Other
	Study sites												
P. bifasciata (C.L. Koch, 1834)	2		38			4	2		3		3	4	
P. hortensis (Thorell, 1872)							2		26				
P. lugubris (Walckenaer, 1802)	6	92		11	102	4	4	42	1	22		8	
P. monticola (Clerck, 1757)										5			
P. paludicola (Clerck, 1757)	10	5			7		1		3	18			
P. palustris (Linnaeus, 1758)	2								45		8		
P. prativaga (L. Koch, 1870)										1			
P. pullata (Clerck, 1757)	16								23				
P. riparia (C.L. Koch, 1833)	20					10	13		1				
Pardosa sp.	2		5			1	2		12	2	1		
Pirata hygrophilus Thorell, 1872		1		1									
P. latitans (Blackwall, 1841)	2								1				
Trochosa ruricola (De Geer, 1778)	14	2			7		8						
T. terricola Thorell, 1856	7	19		5	24	6	7	5	5	13	1	1	D
Trochosa sp.	4												
Xerolycosa nemoralis (Westring, 1861)									8				
PISAURIDAE													
Pisaura mirabilis (Clerck, 1757)	5	5	1		3	1	8		6	5			B,C,H
OXYOPIDAE													
Oxyopes ramosus (Martini, Goeze, 1778)													C,F
ZORIDAE													
Zora spinimana (Sundevall, 1833)		3		2		2	1		22				
AGELENIDAE													
Agelena gracilens C.L. Koch, 1841	2			1	1						1		C,E,H
Tegenaria agrestis (Walckenaer, 1802)			12				3					4	
T. campestris C.L. Koch, 1834				3				1					
T. ferruginea (Panzer, 1804)													C,O
T. silvestris L. Koch, 1872				5									
CYBAEIDAE													
Cybaeus angustiarum L. Koch, 1868						1							
HAHNIDAE													
Cryphoeca silvicola (C.L. Koch, 1834)			1										
Hahnia nava (Blackwall, 1841)	7	3			1		2		4	2	3	1	
H. picta Kulczyński, 1897										1			
DICTYNIDAE													
Argenna subnigra (O. P.-Cambridge, 1861)										1			
Cicurina cicur (Fabricius, 1793)	3	12		13	11	5		9	6	8			
Lathys humilis (Blackwall, 1855)													N
AMAUROBIIDAE													
Coelotes inermis (L. Koch, 1855)			37			1		19					
Urocoras longispinus (Kulczyński, 1897)		24	2	2			22				14		
MITURGIDAE													
Cheiracanthium elegans Thorell, 1875							1						
C. punctorium (Villers, 1789)													H
Cheiracanthium sp.									1				
ANYPHAENIDAE													
Anyphaena accentuata (Walckenaer, 1802)				2			1						B,E,K
LIOCRANIDAE													
Agroeca brunnea (Blackwall, 1833)		4		3	10	1	1	1		25			

Appendix 1. Continued.

Family / species	1	2	3	4	5	6	7	8	9	10	11	12	Other
							Study sites						
A. lusatica (L. Koch, 1875)	3		1			2	11		2				
Scotina celans (Blackwall, 1841)	2					1							
CLUBIONIDAE													
Clubiona caerulescens C.L. Koch, 1839													M
C. comta C.L. Koch, 1839													K,M
C. diversa O.P.-Cambridge, 1862	1												
C. neglecta O.P.-Cambridge, 1862													E,H
C. pallidula (Clerck, 1757)										1			
Clubiona sp.					1								
CORINNIDAE													
Phrurolithus festivus (C.L. Koch, 1835)			3				4		3	2		1	L
ZODARIIDAE													
Zodarion germanicum (C.L. Koch, 1837)								3				2	
GNAPHOSIDAE													
Drassodes lapidosus (Walckenaer, 1802)			3									6	
D. pubescens (Thorell, 1856)	3				1					2			
Drassodes sp.							16		1				
Drassyllus praeficus (L. Koch, 1866)	5		8			2	4		9		3	2	
D. pumilus (C.L. Koch, 1839)							9						
D. pussilus (C.L. Koch, 1833)	18	1		1			13		28	2	5	1	
D. villicus (Thorell, 1875)												1	
Gnaphosa lucifuga (Walckenaer, 1802)			9									3	L
G. modestior Kulczyński, 1897						9						1	
Gnaphosa sp.										1			
Haplodrassus signifer (C.L. Koch, 1839)	3						8		3	2		1	
H. silvestris (Blackwall, 1833)		5		1			3	1					
Micaria pulicaria (Sundevall, 1831)					2								
Kishidaia conspicua (L. Koch, 1866)						1							
Trachyzelotes pedestris (C.L. Koch, 1837)	7	1	2			2	1			2	2	1	
Zelotes apricorum (L. Koch, 1876)	1	3			8			2		1		1	
Z. erebeus (Thorell, 1871)			1										
Z. latreillei (Simon, 1878)	11			1	1		3		2	3			
Z. petrensis (C.L. Koch, 1839)	1	1	11				1	1		1	3	6	J
Zelotes sp.	2		4		4		1					2	
SPARASSIDAE													
Micrommata virescens (Clerck, 1757)			1							1			C
PHILODROMIDAE													
Philodromus aureolus (Clerck, 1757)													M,N
P. dispar Walckenaer, 1826													
P. margaritatus (Clerck, 1757)													F,K
Thanatus arenarius L. Koch, 1872									1		5		
T. formicinus (Clerck, 1757)	1		3								2		
Tibellus maritimus (Menge, 1875)										1			
T. oblongus (Walckenaer, 1802)	1									1			C
THOMISIDAE													
Diaea livens Simon, 1876													M,N
Misumena vatia (Clerck, 1757)													C,N
Misumenops tricuspidatus (Fabricius, 1775)	1		1										A,B,C,E, K,M,N

Appendix 1. Continued.

Family / species	Study sites												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Other**
O. nigrita (THORELL, 1875)			6										
O. praticola (C.L. KOCH, 1837)		8		2	1		5	1					
O. pullata (THORELL, 1875)	2		9				2		2			3	
O. scabricula (WESTRING, 1851)			1				2		9		3		
O. trux (BLACKWALL, 1846)	1												
Pistius truncatus (PALLAS, 1772)			1										A,B,K,M
Synema globosum (FABRICIUS, 1775)	1												A,B,C,G,H,K,M,N
Tmarus piger (WALCKENAER, 1802)			1										B,C,G,K
T. stelio SIMON, 1875													N
Xysticus audax (SCHRANK, 1803)									1	2			
X. bifasciatus C.L. KOCH, 1837	2				1	3							
X. cristatus (CLERCK, 1757)	1								1				
X. lanio C.L. KOCH, 1835													K
X. lineatus (WESTRING, 1851)	8									1			
X. luctator L. KOCH, 1870)				1			1						
X. ninni THORELL, 1872												4	
X. striatipes L. KOCH, 1870									4		2		
X. ulmi (HAHN, 1831)													N
Xysticus sp.						1	6			1			
SALTICIDAE													
Asianellus festivus (C.L. KOCH, 1834)			1		1							2	
Ballus chalybeius (WALCKENAER, 1802)													A,B,K,M
Sibianor aurocinctus (OHLERT, 1865)									1				
Carrhotus xanthogramma (LATREILLE, 1819)													M,N
Dendryphantes rudis (SUNDEVALL, 1833)													F
Euophrys frontalis (WALCKENAER, 1802)													M,N
Evarcha arcuata (CLERCK, 1757)	4												C,H
E. falcata (CLERCK, 1757)	1		1										
E. laetabunda (C.L. KOCH, 1846)													L
Heliophanus flavipes (HAHN, 1832)									2				
H. kochii SIMON, 1868													
Macaroeris nidicolens (WALCKENAER, 1802)													M,N
Marpissa muscosa (CLERCK, 1757)								1					
M. nivoyi (LUCAS, 1846)				1									
Myrmarachne formicaria (DE GEER, 1778)							1						
Pellenes nigrociliatus (SIMON, 1875)											1		
Phlegra fasciata (HAHN, 1826)	2		1				2			1	1		
Pseudeuophrys obsoleta (SIMON, 1868)			1								1		
Pseudicius encarpatus (WALCKENAER, 1802)													M,N
Salticus sp. (? *cingulatus* or *zebraneus*)													N

Characteristic spider species of peat bog fenlands in the Netherlands (Araneae)

Peter J. van Helsdingen[1]

Abstract: Peat bogs in the Netherlands passed through a dynamic history over the centuries from developing in the wet river delta, exploitation by man for energy purposes, filling-in again by natural forces and vegetation succession, and recent dragging for nature management purposes in the remaining larger reserves. Seepage of mineral-rich water from deep underground water layers is a prerequisite. For the present semi-natural habitat condition the term "peat bog fenland" is used. The spider fauna composition of the ecotone land–water, usually the margins of quaking bogs, was investigated. The typical fauna comprises relatively rare species on the international scale often in large numbers, such as *Dolomedes plantarius* (CLERCK), *Tetragnatha striata* L. KOCH, *Enoplognatha caricis* (FICKERT), *Theridion hemerobium* SIMON, *Entelecara omissa* O.P.-CAMBRIDGE, and *Clubiona juvenis* SIMON. The microhabitats of the different species was described. Environmental threats are numerous and very strict management measures are necessary to keep the ecological conditions and the populations in good condition.

Key words: ecotone land-water, filling-in, habitat restoration, peat bog fenland, quaking bogs, water management

Introduction

The aim of the present study was to investigate the spider fauna composition of the ecotone land-water of the peat bog fenlands in the Netherlands, as part of a general and still ongoing inventory of the spider fauna of the Netherlands. The work in the field was carried out dispersed over the last decade of the 20th century and mainly in spring and summer. Twelve different reserves have been visited several times each and at different parts so as to get an overall picture of each reserve.

The spider fauna of the peat bog fenlands in the Netherlands was poorly known. This may have been partly caused by unsuitable collecting methods in a hardly accessible habitat in the past. The floating vegetation at the margins of a quaking bog is inaccessible from the land side without destroying or at least disturbing the habitat. The only profitable method to investigate this zone is to collect by hand from the waterside, which can be done best from a boat.

History

The general geological structure of the Netherlands is that of the margin of the continent. Sand deposits in the south and east were put down by the rivers and remodelled by glaciers from the north. With the rising of the sea-level at the end of the Würm Glaciation the western part of the country was remodelled into a river delta area because the larger rivers, such as the Rhine, Meuse and Scheldt, now ended in the enlarged North Sea and not farther to the north. From then onwards the Netherlands had major drainage problems because the fresh water from the rivers could not

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flow off to the sea at all times. Behind the range of dunes, constructed out of the sand deposits through the forces of tide and wind, a lowland area developed into marshland, intersected by river arms and local higher areas.

In this marshy region in some places the forming of peat bog started through a succession of floating vegetation (filling-in) towards quaking bog, subsequently towards more solid soil and finally carr with alder (*Alnus*) and birch (*Betula*). At many places there existed a special condition: mineral rich ground water from higher areas seeping in through the deeper soil created mesotrophic conditions in which the typical vegetation of fenlands could develop. Where the sea broke through, which happened from time to time, clay was deposited and salt was absorbed by the existing peat soil.

Land use

The land became inhabited on the drier areas along the rivers and the dune range and at local higher places, and the area was brought under cultivation for agricultural purposes by cutting down the forested parts. Ditches and small canals were made for managing the water level and for transport. From 13th century onwards the wet marshes were also used as a source of energy. Peat was extracted, dried and used as fuel for household purposes and even exported to energy-poor countries. We sold our country! The peat extraction resulted in open water surfaces and set back the succession of the vegetation. When most of the peat had been harvested the filling-in restarted as a natural process. As a result many of the open water bodies (lakes, fenlands) became smaller again over the centuries. This is what I call peat bog fenlands: man-made fenlands caused by the extraction of peat.[1]

Land used for agriculture underwent a different development. Farmers made polders by building a dike around an area and lowering the water table by pumping water away with the aid of windmills, thus making the land accessible for farming. The unforeseen consequence was the oxydation of the soil and subsequent lowering of the surface level or land subsidence. One had to pump quicker and deeper with more mills following the sinking soil, but in fact the surface followed the water table. Through cultural history we inherited an inverted profile, an inversion of the relief: the canals into which the water is pumped now lie higher than the polder water table and at the same level as the fenlands which remained after the extraction of peat.

Restoration of the historical landscape

The remaining fenlands all became nature reserves in the 20th century. In the last decades of that century the nature management decided to restore some of the former open water areas by enlarging the remaining open water surfaces through cutting the carr and dragging out the peat soil to a depth of about two metres in order to restart the filling-in process. This is a cultural development which was initiated by nature protection societies and became possible through the relative wealth of the country. In the case of the fenlands, the former peat bogs, one faced two major problems, viz. the leaking away of water from the reserve to the lower surrounding agricultural land, the polders, and the loss of the inward seepage from higher areas. As to the leaking, the area loses more water than the rain can supplement and in a dry summer the fenland starts to dry out. One then has to choose between two evils: let the area suffer from drought, let animals die, let the

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[1] In my opinion the traditional definitions for bog and fen are not applicable here. Bog is usually defined as a wet oligotrophic organic deposit. Fen is described as a eutrophic organic deposit or mire with the winter water table at ground level (modified after Lincoln *et al.* 1982). Peat bog fenland is man-made through the extraction of peat and mesotrophic in combination with inward seepage of mineral rich water from higher areas.

ecosystem suffer; or pump in water from a strange source which necessarily is always of lesser quality in the Netherlands. The only answer is to acquire a buffer area around the reserve and bring up the water level in this buffer and thus at least partly stop the leaking.

To solve the second problem one had to restore the inward seepage from far-off filter areas. The original seepage often appeared to have stopped because of the excessive extraction of water by watersupply companies on the higher grounds; this had to be restored first by convincing the watersupply companies to obtain their water from other sources (e.g. the central inland sea Ijsselmeer). In many cases the mineral rich seepage thus could be restored, at least partly.

Characteristic vegetation of the floating and filling-in stage

Filling-in starts with the development of floating vegetation in which plants such as watersoldier (*Stratiotes aloides* L.) and frogbit (*Hydrocharis morsus-ranae* L.) are characteristic. Together with deep-rooting waterlily (*Nymphaea alba* L.) and different species of pondweed (*Potamogeton* spec.) they soon form layers of floating vegetation in which common reed (*Phragmitis australis* (Cav.) Trin. ex Steud.) and sedges (*Carex* spec.) soon invade. Marsh fern (*Thelypteris palustris* (Salisb.) Schott) becomes one of the common species on the borders of the vegetation. Slowly the layer of vegetation gets thicker and develops carrying capacity and one can walk on a quaking bog.

Importance of the peat bog fenlands on the European level

The Netherlands form only a marginal chip of the European mainland. It does not have mountains, rocks or stony areas, it is poor in old forest and has nothing which comes near to ancient forest. The historical development has been too dynamic for the survival of original landscapes. Peat bog fenlands are man-made out of lowland peat bog and presumably many former biota have survived there which originally were more widespread over the extensive wet and marshy areas in the river delta. All the important peat bog fenlands now have the status of reserves and are managed by one of the nature conservation organisations, the private society Natuurmonumenten or the semi-independent State Forestry Service (Staatsbosbeheer). The peat bog fenland reserves are concentrated in two chains, locally interrupted but, nevertheless, more or less contiguous, one in the western part of the country and one in the northeast (Fig. 1). All reserves are part of the National Ecological Network, which is presently being developed and should connect all the main sites with characteristic biota. With the two chains we contribute proportionally very well to the conservation of this type of wetland habitat in Europe. Most of the characteristic spider species mentioned are found in the surrounding countries, but they appear to be rare and are often restricted to few smaller reserves.

Characteristic spider fauna composition

Investigations of the spider fauna composition of the ecotone land-water of the peat bog fenlands resulted in a short list of characteristic spider species of the different (micro)habitat types, such as tussocks of sedge, mixed vegetation of marsh fern and common reed, or marsh fern and cowbane (*Cicuta virosa* L.) mixed with bittersweet (*Solanum dulcamara* L.), both shaded and unshaded. This border of vegetation is very rich in biota, probably because it is well-structured and provides large supplies of food. Investigations were made from a boat and the vegetation was sampled by hand.

In the fenlands the following characteristic species were found which appear to be rare in other areas and habitats. They are not completely restricted to peat bog fenland habitats but the main populations in the Netherlands clearly occur there. The distribution of the species in the
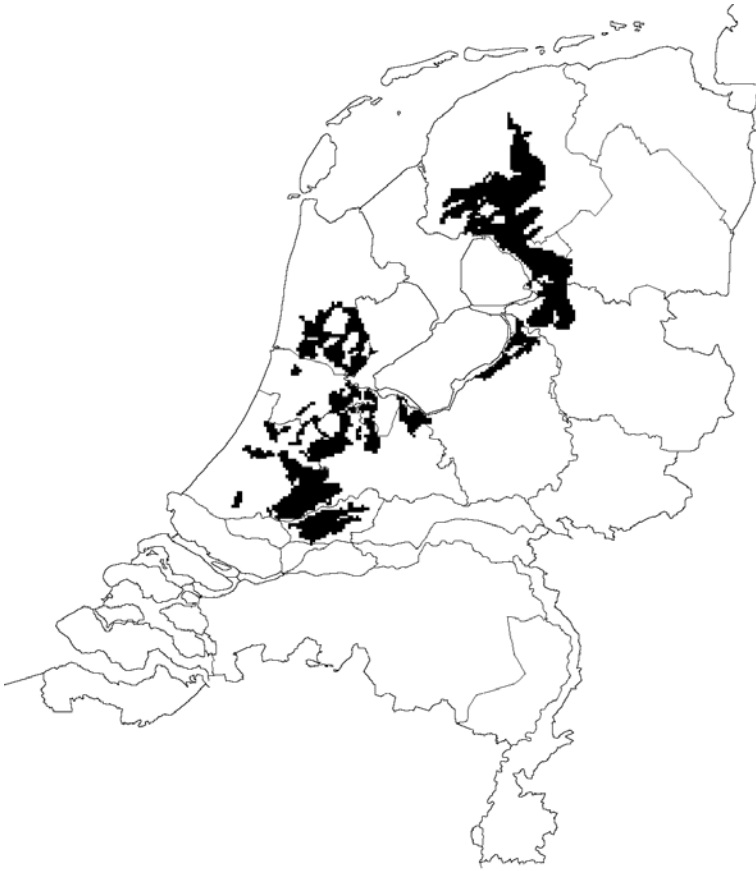
Fig. 1. Distribution of peat bog fenlands in the Netherlands. The fenlands in the northwestern part are too brackish because of relatively recent flooding by the sea and lack of seepage of mineral-rich water to develop into peat bog fenlands.

Netherlands is indicated and compared with those in the surrounding countries Great Britain, Belgium, Germany and Denmark. For a complete distribution per country one is referred to the Fauna Europaea Database (VAN HELSDINGEN 2005).

Dolomedes plantarius (CLERCK, 1757) (Pisauridae)

The larger raft spider appears to be very common on and near the water in the peat bog fenlands (Fig. 2). The young leave the egg sac in the female web on the vegetation, often watersoldier (*Stratiotes aloides*), after some days and disappear into the lower vegetation close to the water level, inside the vegetation or at the border of the vegetation mat. They prey on insects and other spiders, overwinter in the same vegetation, live through the next summer and overwinter a second time. They reach adulthood in the following month of May and thus show a two-year life-cycle.

One gets a good impression of the density of the *Dolomedes plantarius* populations at the different sites by counting the nursery webs on the floating *Stratiotes* armada's, often completely covering the water surface of a ditch, or on the shore vegetation. The number of juvenile and subadult specimens (of two different year classes) in the shore vegetation, e.g. between the marsh ferns and below the overhanging sedges, at some sites can be quite impressive. At one site I counted over 50 specimens of last years egg batches over a stretch of three metres!
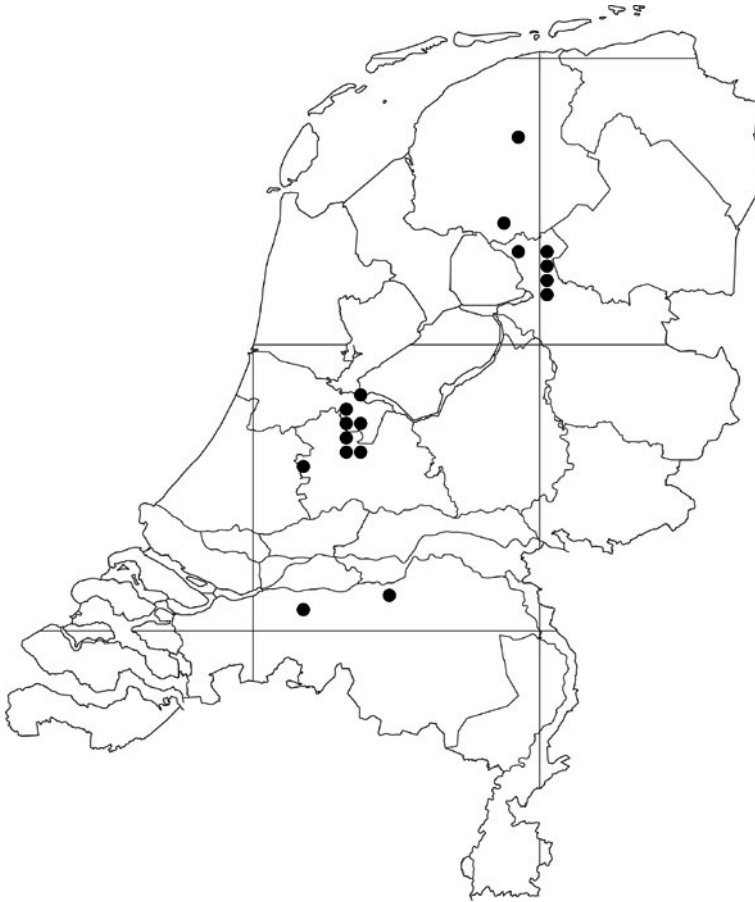
Fig. 2. Distribution map of *Dolomedes plantarius* (Clerck, 1757) in the Netherlands.

In the Netherlands *D. plantarius* also used to occur in oxbows of rivers but there are no recent records known from such places. In the United Kingdom *D. plantarius* occurs at four localities (three of which are mentioned in Harvey *et al*. 2002: 265). In Belgium it is known from one site in the East. In Germany a few older records are known besides some from the second half of last century from the northern Bundesländer (see also Fründ *et al*. 1994 for records from the North German plain) and a recent capture in Rheinland-Pfalz (Kitt, Nährig 2002). But there are no actual confirmations for Nordrhein-Westfalen and Bayern (see Renner 1987). In Denmark it was rediscovered recently (Gajdos *et al*. 2000). In the literature artificial fishponds are frequently mentioned as habitat (Ruzicka, Holec 1998, Bosmans, Janssen 1979). This demonstrates that the species is able to reach such places or manages to survive where natural wetlands are converted into fishponds.

In many countries the species has become rare or has disappeared, probably because of changes on the original sites, e.g. changes in the water conditions or pressure from touristic developments. It has always been rare in Mediterranean Europe and more common in the north where it still is represented by sizable populations (Sweden, Finland) (see Van Helsdingen 2005). In most neighbouring countries this species is protected by law or put on a Red List. In Great Britain one is actively implementing a Species Action Plan. The second *Dolomedes* species in Europe, *D. fimbriatus* (Clerck, 1757), does not occur in the peat bog fenlands but is restricted to the oligotrophic peat-moors and wet forests in the eastern part of the Netherlands.

Tetragnatha striata L. Koch, 1862 (Tetragnathidae)

It is generally indicated that this species inhabits the flowerheads of common reed. This is true, but adult specimens are very frequently found low in the shore vegetation where they seek cover or prey, or both. Numbers are not very high, but the species is common in the peat bog fenlands and characteristic for the peat bog fenland sites, in reeds as well as in other vegetation. In the Netherlands it is hardly found outside this type of habitat. In the United Kingdom this species is well represented in reed-beds around lakes (Harvey *et al*. 2002: 218). In Belgium the species is known from a number of localities throughout the country (Decleer 1988, Alderweireldt 1992). Known from Germany and Denmark and in fact recorded from most European countries except the Mediterranean Region (Van Helsdingen 2005).

Enoplognatha caricis (Fickert, 1876) (Theridiidae)

This species was usually found hanging below stems and leaves of sedges and marsh fern and overhanging the water in their web just above the water level. Usually a number of specimens were hanging together with their egg sacs (from July onwards). It is also found in tussocks of sedge in the shore vegetation. It certainly can be called a common species in the shore vegetation, although densities are never very high.

Known from only two sites in the South of the United Kingdom in association with common reed and sedge (Harvey *et al*. 2002: 61, as *E. tecta*). Recorded from Germany (Platen *et al*. 1999: 57). From Belgium mentioned by Bosmans (1980), Alderweireldt, Selys (1990). Known from most other European countries but missing in Fennoscandia, Denmark, Ireland and Spain (Van Helsdingen 2005). Apparently it is nowhere else a common species. All authors refer to wetland conditions. I am convinced that a proper survey of the available habitats will yield many more records. It has been pointed out (Ruzicka, Holec 1998) that in North America (*Enoplognatha tecta*) and East-Asia the habitat preferences seem to be different (drier situations).

Theridion hemerobium Simon, 1914 (Theridiidae)

This species is very common where tussocks of sedge provide spatial structure and microhabitat with shelter, shade and food. In such places it occurs in large numbers together with many other spider species, among which another theridiid, *Rugathodes instabilis* (O.P.-Cambridge, 1871). Other common species in this microhabitat are *Clubiona phragmitis* C. L. Koch, 1843, *Hypomma fulvum* (Bösenberg, 1902), and *Microlinyphia impigra* (O.P.-Cambridge, 1871). *T. hemerobium* is a common species in the peat bog fenlands. In the Netherlands *T. hemerobium* up to now has been collected only in peat bog fenland areas.

In the United Kingdom *T. hemerobium* is known from four sites near water, such as marshes and flood-plains (Harvey *et al*. 2002: 51). Daws (2003) has found this species to inhabit fishing complexes in the flood-plains of rivers in England where it could easily be traced under bridges, wooden walks and fishing platforms, but also farther away from rivers (Daws 2004). In Belgium the species is known from at least three localities (Decleer 1990, Vanuytven *et al*. 1991) which are all described as reed vegetations. There are many records from Germany. Not recorded from Denmark. In the Czech Republic "it is quite common in all littoral vegetation, in sedge grass and reed-mace growth." In Europe occurring in most countries but not in Spain and Greece and not (yet) found in Norway and Finland, where I expect it to turn up when looked for in the proper habitat. Also known from North America. The distribution is mapped by Anthes (2000) and available in database format (Van Helsdingen 2005).

Entelecara omissa O.P.-Cambridge, 1902 (Linyphiidae)

So far in the Netherlands this species has been found only in peat bog fenland. It is a rare species in this type of habitat. It has not been found outside these areas. It was found in low numbers in

the tussocks of sedge. In the United Kingdom the species is recorded from a number of marshy areas, mostly in East-Anglia (HARVEY *et al*. 2002: 83). In Belgium it is recorded for the first time on the European mainland (DECLEER 1992) and is said to be threatened now with extinction (http://www.instnat.be/docupload/1593.xls). In Germany a first record dates from 1994 (SCHIKORA 1994, Niedersachsen) from peat-moor. In Denmark it is on the Red List. The species apparently prefers wet habitats, either in peat bog or on peat-moor. The European distribution is summarised by VAN HELSDINGEN (2005).

Clubiona juvenis SIMON, 1878 (Clubionidae)

C. juvenis in our inventories was found to be associated with reed. They were often hiding in old stems of last years reed present in the shore vegetation. Specimens can easily be found by opening old reed stems along the water border. Apparently they use the stems for hiding during the daytime. In the Netherlands the species appears to be present exclusively in peat bog fenlands, although specimens are never collected in large numbers at one site.

In the United Kingdom *C. juvenis* is established in East-Anglia "in reeds and ground vegetation" (HARVEY *et al*. 2002: 310). DECLEER, BOSMANS (1989) have presented an overview of all European records then available. Apart from the Neusiedler See in Austria, where the species is said to be abundant (NEMENZ 1967), there are very few records from other European countries, while it is absent, again, from Fennoscandia and Denmark. DECLEER, BOSMANS (1989) mention the same ecological niche. In the Netherlands it has not been found, so far, outside the peat bog areas. However, in most cases the species was found in any reed vegetation bordering ponds and lakes. In Ireland and Germany *C. juvenis* has been found in coastal dunes where it was collected in the densest parts of tussocks of grass, far away from the water (BOCHMANN 1941). In the Netherlands *C. juvenis* has never been found in the dune area, where instead *C. diversa* O.P.-CAMBRIDGE, 1862 and *C. subtilis* L. KOCH, 1867 are found in the tussocks of maram grass. The species occurs in most European countries, the Mediterranean Region excepted (VAN HELSDINGEN 2005).

Other frequently found species

A number of other interesting species was found to be common but are not typical for such peat bog fenlands since they can also occur in other wet habitats.

Donacochara speciosa (THORELL, 1875) (Linyphiidae)

A species of wet places, also outside the peat bog fenlands. Quite frequently found in the leaf-sheath of reedmace (*Typha* spec.) and in dry old reed stems. In the United Kingdom recorded from a number of sites in East Anglia (HARVEY *et al*. 2002: 147). In nearly all European countries found in wet places but absent from Portugal, Spain and Greece (VAN HELSDINGEN 2005).

Hypomma fulvum (BÖSENBERG, 1902) (Linyphiidae)

A common species in wet habitats, such as peat bog fenlands, lowland marshes and vegetation along ditches. It is, therefore, not typical for peat bogs. In the United Kingdom again most frequently found in East Anglia "in fens and marshes, on *Phragmites* or in the litter beneath, sometimes in *Cladium* marshes" (HARVEY *et al*. 2002: 89). The European distribution has been summarised by VAN HELSDINGEN (2005).

Rugathodes instabilis (O.P.-CAMBRIDGE, 1871) (Theridiidae)

This species occurs in large numbers along the border of the peat bog fenlands in the vegetation also inhabited by *Theridion hemerobium*, and equally abundant. The occurrence of these two species together in the same habitat is also mentioned by RUZICKA, HOLEC (1998). Common in

southern England in wetland habitats (Harvey *et al*. 2002: 57). The species is present in Belgium and Germany, but has not been recorded from Denmark. There are records from most European countries and one gets the impression that it forms dense populations in the preferred habitat (Van Helsdingen 2005).

Microlinyphia impigra (O.P.-Cambridge, 1871) (Linyphiidae)

One of the common species in lowland Netherlands. It builds extensive webs close to or above the water surface in dense, taller vegetation. In the United Kingdom mostly restricted to England (Harvey *et al*. 2002: 213). Recorded from Belgium, Germany, Denmark, and most European countries (Van Helsdingen 2005).

Theridiosoma gemmosum (L. Koch, 1877) (Theridiosomatidae)

In the peat bog fenlands it was usually found in the more shaded places in the structures offered by dead branches of trees lying in and above the water and the vegetation of sedges and other grasses. At such places they have been found in large numbers. The spiders were often seen gliding or sailing down a slightly sloping line without any leg movement. In the Netherlands it has also been found in swampy forest in the East, e.g. at the margin or in depressions in peat-moors. In the United Kingdom restricted to southern England and "often abundant where found, but very local" (Harvey *et al*. 2002: 67), which agrees with my own observations above. Known from Belgium, Germany, Denmark, and most European countries (Van Helsdingen 2005).

Ozyptila brevipes (Hahn, 1826) (Thomisidae)

This species occurs in low densities at places where the filling-in process is in an advanced stage and soil has formed between the plants. Specimens of this species are regularly found in small depressions in the soil under moss and detritus. In the Netherlands *O. brevipes* has been found regularly in peat bog fenlands, but it is also known from the Frisian Islands in the north. In the United Kingdom it occurs "in fens and marshy places", but also in drier habitats (Harvey *et al*. 2002: 365). Recorded from most European countries (Van Helsdingen 2005).

Conclusion

Peat bog fenland reserves in the Netherlands appear to be a stronghold for a number of otherwise rare spider species, in the Netherlands as well in most of Europe. The peat bog fenlands offer the habitat requirements for these species. This is also the case for a number of other taxa (the waterbeetle *Graphoderus bilineatus* (De Geer, 1774), the dragonfly *Aeshna viridis* Eversmann, 1836 some birds such as the black tern *Chlidonias niger* (Linnaeus, 1758)). The occurrence of such a special fauna certainly justifies the costly restoration and management of the peat bog fenland reserves.

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Характерни паяци в изкуствените торфени блата на Холандия (Araneae)

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(Резюме)

Торфените блата в Холандия имат динамична история през вековете. През Средновековието те са експлоатирани от хората за енергийни нужди, по-късно е последвало естественото им запълване с вода и сукцесия на растителността. В съвремието, блатата, които се намират на територията на по-големите резервати, се драгират, което е част от мерките, заложени в плановете им за управление. В статията са представени резултатите от изследване на видовия състав на паяците, обитаващи динамично променящия се екотон между сушата и водата. Типичната фауна обхваща сравнително редки видове, като например: *Dolomedes plantarius*, *Tetragnatha striata*, *Enoplognatha caricis*, *Theridion hemerobium*, *Entelecara omissa* и *Clubiona juvenis*, които в изследваната територия са с висока численост. Описани са микрохабитатите, обитавани от установените паяци. Авторът смята, че поради големия брой заплахи са необходими стриктни управленски мерки за поддържане на екологичното равновесие и жизнеността на популациите в тези екосистеми.

Lycosidae: the grassland spiders

Rudy Jocqué[1], Mark Alderweireldt[1]

Abstract: The hypothesis is formulated that the Lycosidae co-evolved with grassland and dispersed with the expansion of this type of habitat. Arguments that sustain this view are the abundance of Lycosidae in open habitats with low vegetation and their relative rareness in dense forest, the lack of typical hunter adaptations to achieve grip on smooth surfaces and the fact that the family is only known in the fossil record from the Miocene onwards, which is in synchronization with the spreading of grassland.

Key words: adaptation, grip, Miocene, Araneae, Pisauridae

Introduction

Lycosidae or wolf spiders are a clearly delimited and well defined spider family both on somatic and behavioural characteristics. They have a unique eye pattern and a typical egg sac and spiderlings carrying behaviour. However, their systematics are particularly problematic because of the often faint distinctions between the different taxa, on specific as well as generic level. It has been suggested (Aʟᴅᴇʀᴡᴇɪʀᴇʟᴅᴛ, Jᴏᴄǫᴜᴇ́ 1992, Wᴜɴᴅᴇʀʟɪᴄʜ 2004) that Lycosidae are a family of recent evolutionary origin. Taxonomic revisions have in several cases been problematic as confronted with particular difficulties in species and genus delimitations and diagnoses (e.g. Aʟᴅᴇʀᴡᴇɪʀᴇʟᴅᴛ 1996, 1999, Aʟᴅᴇʀᴡᴇɪʀᴇʟᴅᴛ, Jᴏᴄǫᴜᴇ́ 1992, 2005). From these studies ample indications are found that at least certain groups of Lycosidae apparently demonstrate recent speciation processes.

But apart from these indications resulting from the taxonomic approach, no data have been put forward to support this opinion. The present paper is the first one that gathers a series of arguments to defend the recent origin of the family mainly based on the indications that Lycosidae are particularly well adapted to grassland habitats. It is hypothesised that Lycosidae have co-evolved with that type of vegetation.

Habitat preferences

The idea of promoting Lycosidae to the "grassland spiders" par excellence comes mainly from our experience with soil dwelling spiders in tropical as well as temperate habitats. Especially during field work in tropical Africa, some striking observations were made that asked for explanation. An example:

During our sampling campaigns (Jᴏᴄǫᴜᴇ́ *et al.* 2005) in the frame of a forest rehabilitation project in Ivory Coast (West Africa), we were confronted with the fact that Lycosidae, despite being a very widespread and very speciose spider family in Africa, are particularly scarce to even absent in dense (primary) forest. We were at first looking for a representative of the Lycosidae as indicator species in monitoring for several reasons. Many Lycosidae are diurnal and very active and therefore easy to spot and observe. As the females carry the egg sacs attached to the spin-

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nerets, these are easily collected during the reproductive season. The number and the size of the eggs can be used as good parameters to estimate the fitness and general condition of the parents and their populations (e.g. ALDERWEIRELDT, MAELFAIT 1988, BONTE, MAELFAIT 2001, HENDRICKX *et al*. 2003). However, surprisingly, Lycosidae appeared to be rather rare in the forests of eastern Ivory Coast in contrast to the nocturnal Ctenidae, which proved to be absolutely ubiquitous. In areas where the forest canopy was opened, even locally, and were grasses (Poaceae) had formed a thin herb layer, Lycosidae (mainly *Pardosa injucunda* O.P-CAMBRIDGE) made their appearance. In locations devoid of grasses, Lycosidae remained absent. Several pitfall trap studies demonstrate that Lycosidae have been found to be the dominating spider group in a wide range of habitats. RUSSELL-SMITH *et al*. (1987, 1999), VAN DER MERWE, DIPPENAAR-SCHOEMAN (1996), WARUI *et al*. (2005) found them to be the dominating family in African savanna habitats. They are also abundant in other herb dominated vegetations such as swamps, but are particularly scarce in densely forested habitats.

Similar observations were made in forests in Congo D.R. near Kisangani (Juakaly, pers. comm.), Gabon (Pauwels, pers. comm.), Malawi, Comoros, Rwanda, Guinea and Equatorial Guinea (own observations). More or less the opposite seems to be true for Ctenidae. Figs 1 and 2 summarise some pitfall data for Lycosidae in a gradient of different habitat types. In nocturnal transects, along which spiders with grate-shaped tapeta were caught according to a distance sampling protocol (JOCQUÉ *et al*. 2005), lycosids were so rare in the dense forest patches, that it was decided to concentrate on Ctenidae alone. Lycosidae numbers increase with the area covered by the herb layer which is negatively correlated with the degree of canopy closure. The tendency in Ctenidae is exactly the opposite. The less degraded the forest, the more abundant they become. Lycosidae and Ctenidae thus seem to counterbalance each other in a habitat gradient. The proportion of Lycosidae/Ctenidae might therefore be an excellent and easy to use indicator for forest quality (see JOCQUÉ *et al.* 2005).

About webs, claws and claw tufts

Lycosidae versus Ctenidae

JOCQUÉ (1995) and DIPPENAAR-SCHOEMAN, JOCQUÉ (1997) attracted the attention to the fact that there is a tendency in spiders to abandon the habit of webbing and return to the hunting strategy. The majority of spider species are indeed hunters. In almost all spider families consisting of mainly web building spiders, there are taxa that have switched to a hunting way of life (e.g. AL-DERWEIRELDT 1994; overview in JOCQUÉ 1995). As far as known, these almost invariably belong to the more derived taxa. Lycosidae are an excellent example of this tendency. The more ancestral taxa in the family are purely web-inhabiting. Among these are *Hippasa, Aulonia* and *Amblyothele*. But the majority of the wolf spiders have turned into a purely hunting life style. Typical for web building spiders is the presence of three tarsal claws: one dorsal pair of large claws, and one smaller, more ventrally inserted, unpaired claw. This is shown on the scanning EM picture in Fig. 3a. The third tarsal claw appears to be an adaptation for life on a web and is present in almost all webbing spiders.

Most hunting spiders on the other hand have lost the third claw and many have developed extensive scopulae and well developed claw tufts, as shown in Fig. 3b. The latter provide the owners with a perfect grip on smooth surfaces (Fig. 3d) thanks to the so called "Van der Waals forces" (KESEL *et al*. 2003). These forces are based on the dipole-dipole attraction between large molecules provided there is close contact between them. The tips of claw tuft setae are finely divided, resulting in several hundreds of thousand of contact points between the leg tip and the substrate.

Ctenidae are a perfect example of a family with very well developed claw tufts. This adaptation makes them very well equipped to move over very smooth surfaces such as forest tree
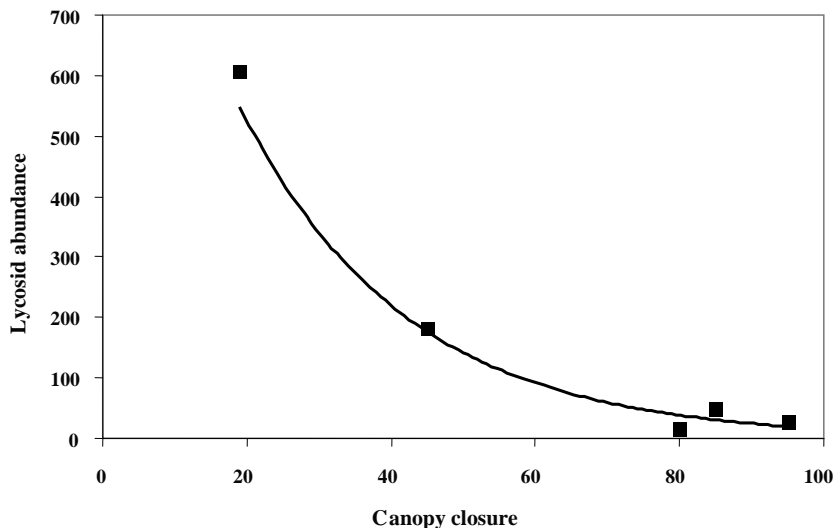
Fig. 1. Number of Lycosidae captured during a two-year trapping cycle in five stations with different tree density in eastern Ivory Coast (Jocqué, unpublished).
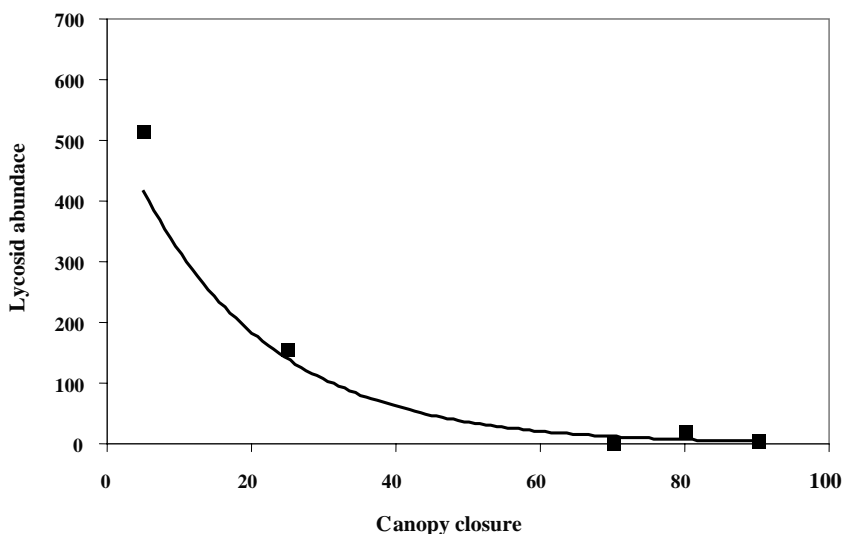
Fig. 2. Number of Lycosidae captured during a one-year trapping cycle in five stations with different tree density in eastern Congo D.R. (Juakaly, unpublished)

leaves. For some species, e.g. *Petaloctenus* (see JOCQUÉ, STEYN 1997), the leaves of forest tree saplings is their preferred substrate. In these tropical forests, tree leaves are very smooth (Fig. 3d) and provided with a drip tip to evacuate excess of water in order to prevent algal growth (WOLFE 1985, WOLFE, UPCHURCH 1986, 1987). Lycosidae on the other hand, are not equipped with such an adaptation like claw tufts and are as a consequence rarely seen on forest leaves. However, most grasses and many herb species have either a rough surface (Fig. 3c) or are provided with an extensive layer of hairs. In many cases this is an adaptation to prevent excessive transpiration. But on such a surface a claw tuft is useless for good grip. In contrast to this, claws provide a much better adherence and it is therefore easily understood why Lycosidae move remarkably easy over herbs and grasses.

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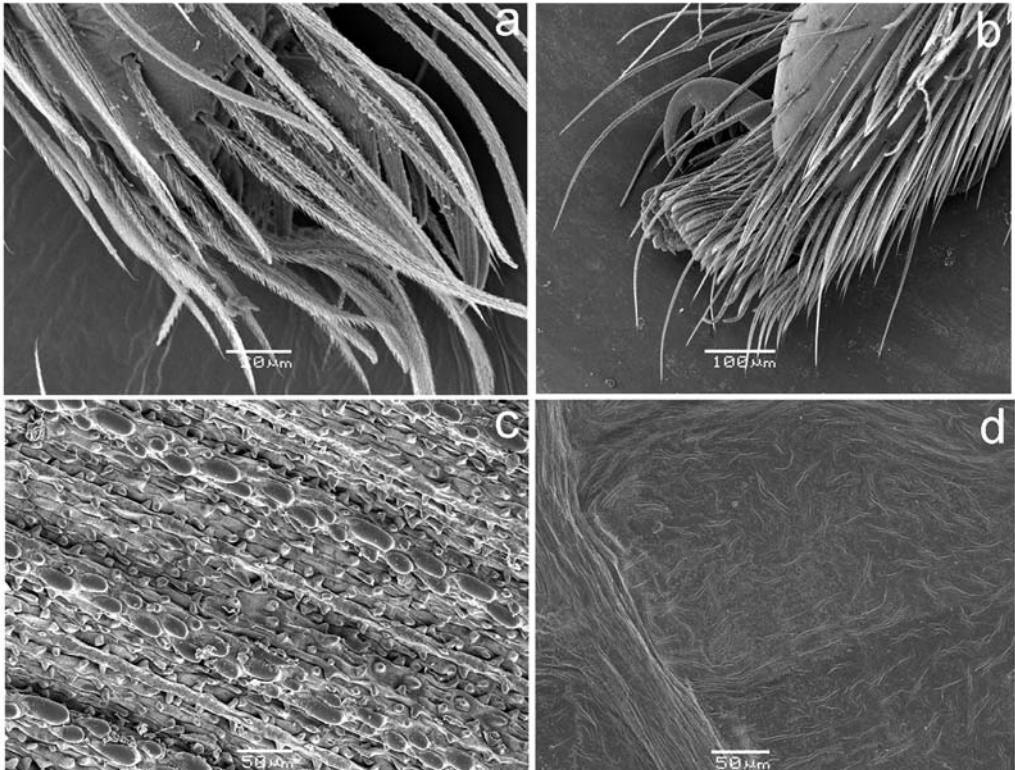
Fig. 3. a – tip of tarsus of a three clawed spider; b – claw tufts and scopulae; c – rough surface; d – smooth surface.

This reasoning is confirmed by observing actively hunting, non-web building members of the Pisauridae (e.g. *Charminus*, *Cispius*, *Pisaura*). They also have retained the third claw and wander around on herbs, grasses and lower bushes. Pisauridae are indeed spiders of the lower shrub and upper herb layer par excellence although one clade including *Thalassius, Dolomedes, Hygropoda* and *Hypsithylla*, appears to have developed fishing behaviour. However, they also hide in high shrubby vegetation during periods of inactivity. This explains why Pisauridae are rare or absent in pitfalls but are frequently caught in pan traps and Malaise-traps. The nursery webs of *Pisaura* for instance are most often constructed in high grasses or between branches of low bushes with rough surfaces. Claw tufts are useless in these conditions, while the third claw proves crucial to move easily through this kind of vegetation. Just like Lycosidae they are absent in higher strata and only very exceptionally found in canopy fogging samples (De Bakker, pers. comm.).

The fossil record

Recent studies of the presence of the spider families in the fossil record are particularly instructive. The fascinating study of PENNEY (2004) shows that the first records of Lycosidae are as recent as the Miocene. As illustrated in his cladogram Lycosidae seem to have evolved far more recently than most other spider families. The striking observation however is that the Miocene period is exactly the period in which grassland habitats dominated by Poaceae have become a major habitat occupying by now a large proportion of the surface of continents. CREPET, FELDMANN (1991) summarise data about the earliest remains of grasses in the fossil record. Although grass pollen occurs sporadically since the Eocene (SALARD-CHEBALDAEFF 1981), evidence of grassland communities in Africa does not appear until the mid-Miocene, about 14 million years ago (JONES 1997,

RETALLACK 1992). PICKFORD (1985) provides evidence for co-evolution of some elements in the fauna with grasses dating back from that period. Similarly, the synchronisation of lycosid radiation and the expansion of grassland habitats can therefore be regarded as a plausible phenomenon.

The hypothesis

Combining all the observations explained above, we emit the following hypothesis: Lycosidae originated fairly recently in the evolutionary history of spiders and were exclusive web spiders until the Miocene. As far as the habitat structure is concerned, they had fairly simple demands as they were providing their own substrate in the shape of a sheet web. The spreading of grasslands from the Miocene onwards provided the Lycosidae with an excellent habitat that gave them the possibility to spread as hunters without particular new adaptations: the combination of acute vision and their perfect grip on rough surfaces were the perfect requisites to become the grassland hunters par excellence. Thanks to this, they were able to radiate quickly to become today one of the most speciose families on the African continent (ALDERWEIRELDT, JOCQUÉ 1994) and beyond. It is therefore stated that Lycosidae have co-evolved with the expansion of grassland habitats and by extension in all kinds of open habitats with short vegetation, since the Miocene.

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Lycosidae – тревните паяци

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(Резюме)

В настоящата статия е изказана хипотезата, че паяците от семейство Lycosidae са произлезли съвместно с тревните съобщества и са разширили ареала си заедно с експанзията на този тип хабитат. Аргументите, които подкрепят тази хипотеза са: обилието от представители на това семейство в открити местообитания с ниска растителност, сравнително рядкото им присъствие в гъсти гори, липсата на типичните ловни приспособления за улавяне на жертва на гладка повърхност, както и фактът, че семейството е известно във фосилната летопис едва от миоцена насам, което е в синхрон с появата и експанзията на тревната растителност.

Spiders along a pollution gradient (Araneae)

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Abstract: Thirty-one species were found during a study of the ground-living spiders at a distance of 2.5-30 km from a smelter, in Monchegorsk (Kola Peninsula, Russia). Three species were found in an industrial barren 2.5-5 km from the smelter. Two of them, *Steatoda phalerata* and *Agyneta gulosa*, were caught at the 2.5 km site. Eight species were collected in a heavily polluted area, 10 km from the smelter. Eighteen species were found both at the 20 km and 30 km sites. The spider assemblage in a slightly damaged spruce forest, 30 km S of the smelter complex, was more or less typical for the northern taiga forest-floor. Spider densities were very low (3-6 ind./sq.m.) at heavily polluted sites, and close to normal magnitude of northern conifer forests (60 ind./sq.m) at the 30 km site.

Key words: industrial barren, heavy metals, smelter, sulphur dioxide, taiga, Kola Peninsula

Introduction

In the late 1980's, news on heavy pollution loads from the Russian smelters in the Kola Peninsula and their possible effect on needle losses of pine in northern Finland, were the starting point for active studies on forest vegetation health. Connected with or included in this project, a great number of research groups studied pollution and monitored its effects on the nature in northern Finland, Russia and Norway (TIKKANEN, NIEMELÄ 1995). Many Russian scientists studied the pollution and its effects in the Kola Peninsula, especially in Monchegorsk but also in Nikel, Pechenga (e.g. KOZLOV *et al.* 1993, CHERNENKOVA *et al.* 1995).

Spiders, as some other predator groups, have been found at heavily polluted sites near the smelters (BENGTSSON, RUNDGREN 1984, KONEVA 1993, KOPONEN, NIEMELÄ 1993, 1995). Therefore spiders have often been used as indicators in monitoring of effects of pollution (see e.g. CLAUSEN 1987). In the present paper, we will give information on spider assemblages near the Severonikel smelter complex, Monchegorsk, based on materials collected by the second author in the early 1990s. For general data on the nature and degree of pollution in the area, see KOZLOV *et al.* (1993). For the spider fauna of natural forests in the northern boreal taiga zone, see e.g. KOPONEN (1977, 1999) and RYBALOV (2003).

Material and Methods

The study area lies near Monchegorsk (about 68°N, 33°E), in the spruce forest zone (Fig. 1). A pollution gradient was investigated from an eroded industrial barren, 2.5 km N of the smelter, to a little damaged spruce-dominated forest, 30 km S of the smelter, at five study sites (Table 1). Three of them, 2.5 km to 10 km, are situated in the most seriously damaged area found in satellite surveys by MIKKOLA, RITARI (1992) and classified as "forest dead area". The shrub and ground layers (including herb, moss and lichen vegetation) at a 20 and 30 km distance from the smelter resemble those in natural forests, although marks of decline are seen on spruce trees.

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Fig. 1. Location of the study area.

The Severonikel smelter complex is one of most severe pollution sources in northern Europe. The SO$_2$ emission at the turn of 1980/90s was about 210 000 tn/year, and the amount of Ni and Co 2500 and 1700 tn/year, respectively (BARCAN 2002). The sites are described in Table 1. The main heavy metals, Ni and Cu, drastically diminished in soil along the distance from the smelter (at 30 km only about 2% of that at 2.5 km; cf. also BARCAN 1992). The same declining trend was true for Pb and Co, while values of Mn and Zn did not show such a trend (Table 1). For comparison, sulphate fallout at 10 km was 2-3 kg /sq m and at 30 km 0.1-0.3 kg /sq m (GILYASOVA 1993).

Table 1. Content of heavy metals in horizon A$_0$ (mg/ kg) along the pollution gradient around the Monchegorsk smelter (from STEPANOV *et al*. 1991).

Distance (km)	Cu	Ni	Mn	Zn	Pb	Co	Description of the site
2.5 N	2290	6220	36	32.3	18.2	35.1	badly eroded industrial barren
10 S	674	2068	160	22.4	15.9	15.5	forest vegetation almost vanished
20 S	52	332	82	28.9	9.1	5.7	marks of forest declination
30 S	46	115	325	24.9	8.2	4.4	first signs of forest declination

Ground-living spiders were collected from 25 x 25 cm squares, taken to the depth of mineral soil. Samples were sorted by hand in a laboratory. The number of replicates varied from 8 to 32 (Table 2). Field work was done during the summers of 1991-1992**.** The material is deposited in the Zoological Museum, University of Turku, Finland.

Table 2. Structure of spider assemblages along the pollution gradient; sites 2.5-30 km from the Monchegorsk smelter (1991-1992).

	2.5 km	5 km	10 km	20 km	30 km
Species found	2	2	8	18	18
Families found	2	1	6	8	6
% of Linyphiidae (ind.)	66.6	-	26.3	67.5	66.7
% of Theridiidae (ind.)	33.3	100.0	10.5	12.5	16.7
% of Lycosidae (ind.)	-	-	15.8	10.0	12.2
Ind./sq. m	6.0	3.0	10.5	34.5	59.5
SD	8.29	8.70	22.48	36.37	43.25
N	8	16	32	32	32

Results and Discussion

Altogether 31 species of spiders from nine families were collected. The density of spiders (Table 2) was very low (3-6 ind./sq m) in the eroded industrial barren area (2.5-5 km from the smelter), low (10 ind./sq m.) in the heavily polluted area (10 km) and rather low (35 ind/sq.m.) also at the slighly polluted site (20 km). The density of spiders in an area with some marks of degradation of trees (30 km apart from the smelter) was close to normal magnitude in northern conifer forests (60 ind./sq m; cf. KOPONEN 1977, RYBALOV 2003). Near the smelter (2.5-5 km distance), only theridiids and linyphiids were found. At a distance of 10 km or more, 6-8 families were observed.

Only three species were found in the most heavily polluted areas (black, dead barren; 2.5-5 km from the smelter), theridiids *Steatoda phalerata* (PANZER, 1801) and *Robertus scoticus* JACKSON, 1914, and the linyphiid *Agyneta gulosa* (L. KOCH, 1869) (Table 3). Of these *S. phalerata* is known to be a thermophilous species (e.g. HÄNGGI *et al*. 1995) and *Agyneta* species are well-known ballooning pioneer species (KOPONEN, NIEMELÄ 1993). *R. scoticus* is a rather eurytopic grounddweller, commonly found in northern taiga forests (RYBALOV 2003). Availability of food near the smelter may be an important limiting factor. According to KONEVA (1993), only predators (spiders, centipedes, ground and rove beetles) were found in low numbers at the present heavily polluted sites. The gnaphosids *Micaria alpina* L. KOCH, 1872 and *Gnaphosa* sp., and the philodromid *Thanatus formicinus* (CLERCK, 1757), all thermophilous species (cf. HÄNGGI *et al*. 1995), were found at a 10 km distance (still a heavily destroyed site) as well as the salticid *Evarcha falcata* (CLERCK, 1757). The lycosids, often found in open forests, *Alopecosa aculeata* (CLERCK, 1757) and *Pardosa hyperborea* (THORELL, 1872) were found starting at 10 and 20 km distance, respectively.
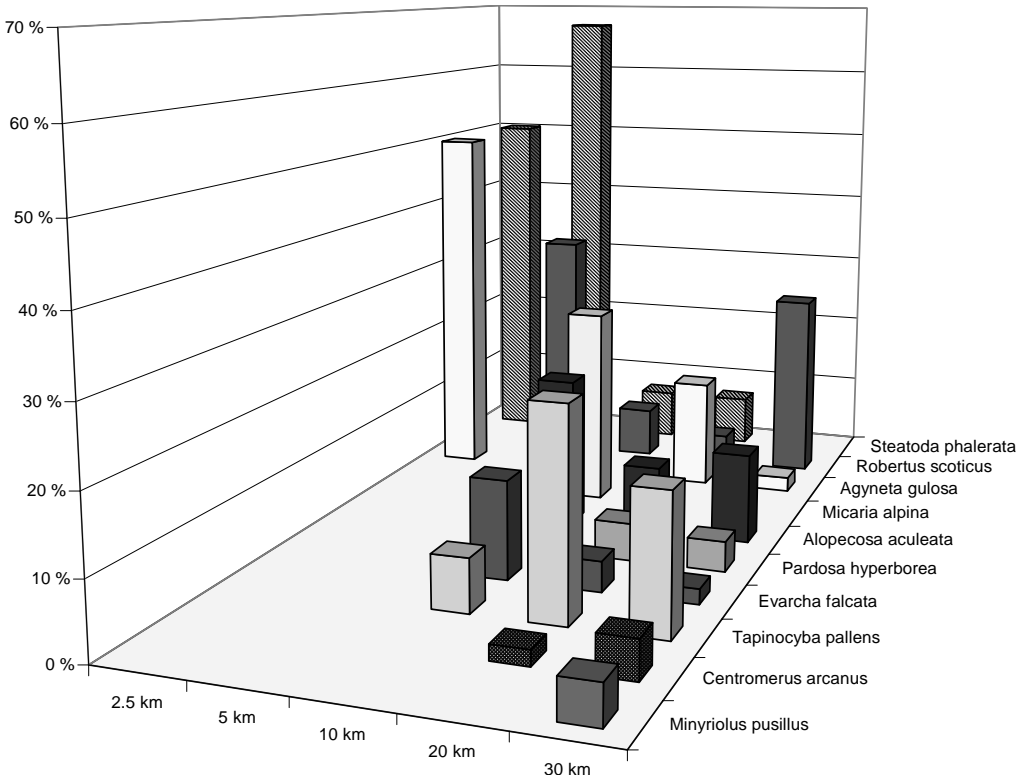
Fig. 2. Distribution of spider species along the pollution gradient, sites 2.5-30 km from the Monchegorsk smelter. Percentages of the identifiable specimens at each site.

The closest distance from the smelter for the typical forest-floor linyphiids (e.g. HUHTA 1965) *Tapinocyba pallens* (O.P.-CAMBRIDGE, 1872), *Centromerus arcanus* (O.P.-CAMBRIDGE, 1873) and *Minyriolus pusillus* (WIDER, 1834) was 10 km, 20 km and 30 km, respectively (Table 3, Fig. 2). Other typical taiga forest species (cf. HUHTA 1965, KOPONEN 1999), found in low numbers 20-30 km from the smelter, included *Hahnia ononidum* SIMON, 1875, *Robertus lividus* (BLACKWALL, 1836), *Macrargus rufus* (WIDER, 1834), *Maso sundevalli* (WESTRING, 1851), *Palliduphantes antroniensis* (SCHENKEL, 1933), and *Walckenaeria dysderoides* (WIDER, 1834) (Table 3). Of the field layer species, *Evarcha falcata* was found at a distance of 10 km and *Xysticus audax* (SCHRANK, 1803) and *Singa* sp. at 20 km from the smelter.

In general, more or less typical ground-layer fauna of northern coniferous forests was observed at a 30 km distance from the Severonikel smelter, in an area where some marks of pollution can still be seen, especially in spruce trees, and where marked concentration of heavy

Table 3. Distribution of spider species along the pollution gradient, sites 2.5-30 km from the Monchegorsk smelter (1991-1992). Percentages of the identifiable specimens at each site are given for 12 abundant species.

Species	2.5 km	5 km	10 km	20 km	30 km
Steatoda phalerata (PANZER, 1801)	50%	67%	7%	7%	-
Robertus scoticus JACKSON, 1914	-	33%	7%	4%	26%
Agyneta gulosa (C. L. KOCH, 1869)	50%	-	-	15%	2%
Micaria alpina L. KOCH, 1872	-	-	27%	-	-
Alopecosa aculeata (CLERCK, 1757)	-	-	20%	9%	12%
Evarcha falcata (CLERCK, 1757)	-	-	13%	4%	2%
Tapinocyba pallens (O. P.-CAMBRIDGE, 1872)	-	-	7%	27%	18%
Robertus lividus (BLACKWALL, 1836)	-	-	-	7%	-
Pardosa hyperborea (THORELL, 1872)	-	-	-	5%	4%
Centromerus arcanus (O. P.- CAMBRIDGE, 1873)	-	-	-	2%	5%
Maro sublestus FALCONER, 1915	-	-	-	-	5%
Minyriolus pusillus (WIDER, 1834)	-	-	-	-	5%
Gnaphosa sp.	-	-	+	-	-
Thanatus formicinus (CLERCK, 1757)	-	-	+	-	-
Gonatium rubens (BLACKWALL, 1833)	-	-	-	+	-
Hahnia ononidum SIMON, 1875	-	-	-	+	-
Haplodrassus sp.	-	-	-	+	-
Macrargus multesimus (O. P.- CAMBRIDGE, 1875)	-	-	-	+	-
Maso sundevalli (WESTRING, 1851)	-	-	-	+	-
Scotinotylus alpigena (L. KOCH, 1869)	-	-	-	+	-
Singa sp.	-	-	-	+	-
Walckenaeria dysderoides (WIDER, 1834)	-	-	-	+	-
Xysticus audax (SCHRANK, 1803)	-	-	-	+	-
Agyneta decora (O. P.- CAMBRIDGE, 1871)	-	-	-	-	+
Macrargus rufus (WIDER, 1834)	-	-	-	-	+
Palliduphantes antroniensis (SCHENKEL, 1933)	-	-	-	-	+
Pardosa palustris (LINNAEUS, 1758)	-	-	-	-	+
Pocadicnemis pumila (BLACKWALL, 1841)	-	-	-	-	+
Ozyptila arctica KULCZYŃSKI, 1908	-	-	-	-	+
Tenuiphantes mengei KULCZYŃSKI 1887	-	-	-	-	+
Xysticus obscurus COLLET, 1877	-	-	-	-	+

metals was found in the ground (Table 1). The amount of sulphur dioxide and heavy metal pollution has decreased markedly since completion of the field work on this paper. Ten years later, the SO_2 emission was one fifth and that of Ni and Cu about half of the amount at the turn of the 1980/90s (Barcan 2002). However, the contamination in this area has increased all this time, much greater decrease of pollutants would be needed to stop it. So the present situation in the area is worse than it was in 1991-1992.

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Паяци по градиент на екологично замърсяване (Araneae)

С. Копонен, Г. Конева

(Резюме)

При изследване на района около металургичния комбинат в град Мончегорск (Колски полуостров, Русия) са установени тридесет и един вида наземно живеещи паяци. Три вида са намерени в силно замърсена индустриална зона на 2,5-5 km от комбината, като два от тях – *Steatoda phalerata* и *Agyneta gulosa* – са уловени на 2,5 km. Осем вида са установени в силно замърсен район на разстояние от 10 km, а по единадесет вида на съответно 20 и 30 km. Комплексът от видове, който е регистриран в слабо повлияна от замърсяването смърчова гора, намираща се на 30 km от завода, е приблизително еднакъв с този на незамърсени гори в северната тайга. В силно замърсените райони плътността на паяците е ниска (3-6 инд./m²), а на 30 km от комбината е приблизително близка до нормалната за северните иглостни гори (60 инд./ m²).

Synecology of spiders (Araneae) of gravel banks and environmental constraints along a lowland river system, the Common Meuse (Belgium, the Netherlands)

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Abstract: Gravel banks along the Common Meuse (Belgium) were sampled for epigeal invertebrates in order to investigate how assemblages are structured in relation to gravel bank characteristics (size, degree of isolation, vegetation cover, silt and periodic flooding). The spider species composition was dominated by Linyphiidae and Lycosidae. Species having short life cycles and well-developed aerial dispersal, litter-dependent hygrophiles and agrobionts were collected on all sites. The presence of xerothermic species and gravel-bank specialists was limited to scarcely covered, less dynamic gravel banks. By means of an ordination, we were able to reveal important characteristics that relate to invertebrate predator assemblage structure on the different gravel banks. Besides isolation and the level of flooding disturbance, the vegetation density and the presence of silt appeared to affect general diversity patterns, but also the diversity of species belonging to different ecological groups. The influence of the number and area of the banks in the vicinity can be interpreted as an ecological landscape effect. To preserve riparian specialists, river management along the Common Meuse should maintain disturbances caused by regular inundations of the riverine habitats. Overall we can state that there is not an univocal definition of "the" gravel bank. Therefore the aims of the current and future conservation policy should imply both dynamic and more elevated banks, in order to guarantee a high degree of local and regional heterogeneity throughout the river system.

Key words: spider assemblages, river banks, flood disturbance, landscape structure, river ecosystem

Introduction

Assemblages can be seen as local snapshots of a spatiotemporal continuous system, having no status as distinct biological entities and hence dependent of species' life history patterns, dispersal capacities and environmental constraints (HENGEVELD, HEMERIK 2002, BONTE *et al*. 2003). The understanding and structure of terrestrial predator assemblages from exposed riverine sediments along lowland river systems and their correlations with local habitat structure is poorly documented (ADIS, JUNK 2002, HENSHALL 2003). In these studies assemblages are characterized by fluvial dynamics and local habitat properties. Recent research of invertebrate assemblages focused upon upland and low mountainous stretches (BONN, KLEINWÄCHTER 1999, MANDERBACH, FRAMENAU 2001, ARMBRUSTER 2002, 2002, FRAMENAU *et al*. 2002, SADLER *et al*. 2004). The amount of litter and other micro-environmental factors were found to influence spider assemblages from riparian habitats like tidal marshes (HENDRICKX *et al*. 1998, PÉTILLON *et al*. 2004). With regard to the species-specific requirements of spiders, MAELFAIT *et al*. (2004) state that slight changes in habitat quality can cause important changes in the spider assemblage composition, making them useful indicators for nature conservation, comparable in that respect with carabid beetles (DESENDER, MAELFAIT 1999, JOCHEMS, VAN LOOY 2001, SADLER *et al*. 2004).

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The Common Meuse, forming both the natural and geographical border between Flanders (Belgium) and The Netherlands, is denominated as a lowland gravel river. In general riparian habitats (alluvial floodplains, gravel banks, etc.) are mostly characterized by a patchy spatial distribution along the river trajectory (PLACHTER, REICH 1998, SADLER *et al*. 2004). The main differentiating processes are related to the rain dependable water level fluctuations and the microclimatological circumstances of the gravel banks *in se* (RENÖFALT *et al*. 2005). Habitat fragmentation and in general landscape configuration, can have drastic consequences for all living organisms. At the moment it is one of the central themes regarding nature management and conservation (HEINO, HANSKI 2001, WIENS 2001). Gravel banks along the Common Meuse have always been present. Though from 1860 onwards dikes along the River Meuse were fortified to secure safe navigation, to improve flood protection and to allow agriculture on the fertile floodplain soils (VAN WINDEN *et al*. 2001). By consequence natural river dynamics became suppressed and natural riverine habitats were fragmented (VAN LOOY *et al*. 2002). Nowadays, following the "Living River"-concept (NAGELS *et al*. 1999), the natural river dynamics of the Common Meuse are being restored. The present habitat management attempts to re-establish the natural character of the Common Meuse and its surroundings (JOCHEMS, VAN LOOY 2001). Dikes are being removed, banks are lowered and the summer bed is widened (VAN LOOY, DE BLUST 1998) in order to restore the contact between the river and its winter bed and to re-create riverine habitats (NAGELS *et al*. 1999).

We investigated whether gravel banks under restoration support a typical spider fauna and if ecological species groups are evenly spread over all gravel banks or if they only occur in a selection of banks with distinct environmental properties.

Material and Methods

The Common Meuse (45 km) is the shallow, less diked or dammed part of the River Meuse (LIEFVELD *et al.* 2001). It marks the border between The Netherlands and Flanders (Belgium) (Fig. 1). The strong river flow fluctuations, coarse gravel and sharp sand characterize the watercourse (LIEFVELD *et al.* 2001). The gravel banks situated along the trajectory of the Common Meuse can be defined as a top layer of coarse shingle with between a sharp sand-gravel fraction, mostly covered with a thin layer of silt (VAN LOOY, DE BLUST 1998), shifting into steep loamy banks towards the dike. It is the only gravel river in Flanders, and one of the few lowland gravel rivers in Europe (VAN LOOY, DE BLUST 1998). The extreme microclimatic conditions of the gravel banks are caused by the bare gravel (LOMMELEN 2000). Besides irregular spring and summer inundations, all sites are permanently flooded during autumn and winter. Only when the river discharge drops below 200 m^3/s, the gravel banks are exposed (VANACKER 2000). Patch size and relative height of the gravel banks varies from day to day and depends of the water level fluctuations (PLACHTER, REICH 1998). The degree of vegetation succession depends both on the silt deposition (SLUIS, TANDARICH 2004, NEUMEIER 2005), the river dynamics (FRANKLIN *et al*. 2001) and the morphological structure of the substrate (BONN, KLEINWÄCHTER 1999, EYRE *et al*. 2002). A species-poor and scarce pioneer vegetation appears some meters from the waterline (SCHAMINÉE *et al*. 1998), changing into brushwood towards the dike (VANACKER 2000). Flooding offers new habitats for succession of terrestrial plants and animal communities (BONN, KLEINWÄCHTER 1999). Yet many riparian species, e.g. *Pardosa wagleri, Pirata knorri* (MANDERBACH, FRAMENAU 2001), *Bryodema tubercultata* (STELTER *et al*., 1997), depend on inundations so that specific habitat characteristics are provided. The temporary nature of gravel banks makes them unique habitats for several highly specialized invertebrates of great conservational value (HENSHALL 2003, SADLER *et al*. 2004). Gravel banks along the Common Meuse are surrounded by a variety of biotopes, enclosing both arable land and alluvial grasslands.
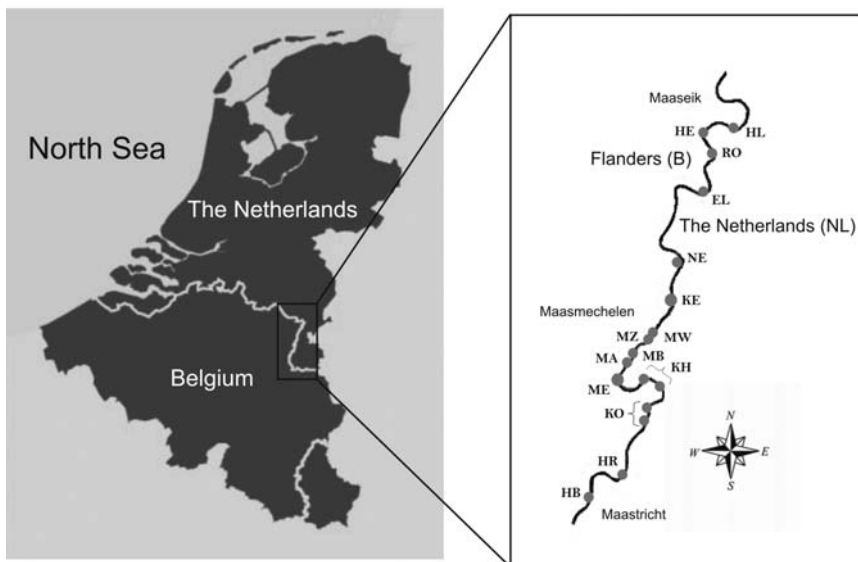
Fig. 1. Location of the gravel banks along the Common Meuse trajectory in 1998. Sampled gravel banks are indicated by dots.

In total 17 gravel banks, situated both on Belgian and Dutch side of the river, were sampled along the 45 km long trajectory of the Common Meuse (Fig. 1). At each sample site, three or more pitfalls (Ø = 9.5 cm, 4% formalin solution) were placed from the end of May until the end of August, spaced ca. 10 meter apart, which should suffice to avoid interference between traps for spider catches (TOPPING, SUNDERLAND 1992, PÉTILLON et al. 2004). During the field survey several parameters were measured: 1) vegetation cover, 2) substrate structure (mean gravel size, presence of sand and/or silt), 3) relative height of the gravel banks (inverse measure; calculate as the slope of the regression line that symbolizes the relation between the discharge of the river at the moment of each pitfall collecting (X) and the distance of the pitfalls to the waterline (Y), troughout the sample period), 4) gravel bank dimensions (area, circumference, length) and 5) distance to and total area of nearest banks. Pitfall traps register arthropod activity patterns, and are affected by both population density and species-specific movement rates (MAELFAIT, BAERT 1975). Furthermore microhabitat structure and movement behaviour could also affect trappability in spiders (TOPPING, SUNDERLAND 1992).

Community structure and reaction of the species to environmental gradients were indirectly explored by means of an unconstrained indirect gradient analysis (DCA = Detrended Correspondence Analysis (HILL 1979)). Only the more abundant species were taken into account for the ordination analysis (BONTE et al. 2002). Thereby a multidimensional ordering of the traps is revealed based on their species composition similarity. Sample sites, in this case gravel banks, with a similar assemblage are closely ordered, while those with a completely different species composition are ordered distantly (BONTE et al. 2002). Ecological characteristics of spiders were mainly derived from HÄNGGI et al. (1995), MAELFAIT et al. (1998), ROBERTS (1998), NENTWIG et al. (2002) and HARVEY et al. (2002).

Results

After Bonferroni-correction, only the presence of silt and both the vegetation cover (r = 0.61; p<0.05), and the total area of banks in the vicinity (r = -0.63; p<0.05) showed a significant cor-

relation. In total 11.438 spiders (not standarized numbers) were collected from 14 gravel banks along the Common Meuse, divided over 82 species and 11 families (Table 1). About half of the catches belonged to the Linyphiinae and Erigoninae. The linyphiid *Oedothorax retusus* was the most common species, representing over 25% of the grand total of the catches. *Pardosa agricola* as well as *Erigone dentipalpis* took up about 12% of the catches. Both linyphiids occurred on all the sites, whereas *P. agricola* only appeared on 9 of the gravel banks.

Ordination of spider data revealed an axis 1 (eigenvalue 0.423), showing a clear relationship with the environmental factors and the spreading of the gravel banks and explaining 22.67% of the total variance in the species data (Fig. 2). Less isolated gravel banks ($r(2)12 = 0.746$, $p<0.05$), thus with higher extent of connectivity, were situated more towards the left side of the ordination plot. Furthermore a landscape effect is signified by the number of gravel banks in the vicinity of the bank under consideration ($r(2)12 = -0.587$, $p<0.05$). On the left of the plot banks situated relatively lower in respect to the water level ($r(2)12 = -0.560$, $p<0.05$) could be found, as well as banks with a denser vegetation ($r(2)12 = -0.606$, $p<0.05$) and mostly covered with a layer of silt ($r(2)12 = -0.529$, $p<0.05$). Eurytopic, frequently ballooning species were centered in the ordination, and thus present on all gravel banks, just as several ubiquitous ground dwelling grassland species. Hygrophiles cluster together on the left of the output (gravel banks HB, KO, MB). Specialized xerophiles and psammophiles cluster together on the right side of the ordination (HL, KE, ME). Additionally typical xerothermic species are found in high abundance on KE in comparison with the other banks. Typical riverine species can be found on both frequent flooded as rather elevated gravel banks (resp. EL, HE, HL, RO and KE, ME). Moreover axis 2 (eigenvalue 0.126) explained 6.79% of the scattering of species. Along axis 2 perennial species with a short life-cycle are found on the right and on the left side long-lived species with an annual life-cycle. These eurytopic species probably colonize the gravel banks from the adjacent habitats, comparable with source-sink dynamics (JOHNSON 2004). Overall axis 2 probably accounts for a landscape-effect, though no clear explanation could be restrained.

Discussion

Spider synecology

The total number of spider species is rather low in comparison with other studies concerning recently fragmented and dynamic biotopes (BONTE *et al*. 2003, HENDRICKX *et al*. 1998). Possible reasons could be the long-lasting winter inundations, making the gravel banks unsuitable for colonization (BONN *et al*. 2002), and the large-scale fluctuations in temperature. Frequent balloon-ers and cursorial meadow species can be considered as typical pioneers of gravel banks as well as other terrestrial habitats which are regularly flooded (cf. WOHLGEMUTH - VON REICHE, GRUBE 1999). Though when looking at the ordination a clear distinction can be made between annual and perennial pioneer species. Former, for instance cursorial lycosids, seem to be present once gravel bank stability increases, thus probably colonizing the banks from the adjacent habitats, which seem to be mostly grasslands under nature management (source-sink dynamics (cf. JOHNSON 2004)). While frequent ballooning, short-living species colonize the banks from the first moment on (SCHMIDT, TSCHARNTKE 2005). Overall many of the habitat specialists show a limited distribution, at least in Flanders (MAELFAIT *et al*. 1998) or even in Europe (HÄNGGI *et al*. 1995, HARVEY *et al*. 2002), thus representing high values for regional conservation or even on European scale (PLACHTER, REICH 1998).

Hygrophiles clearly prefer denser vegetated habitats, consequently characterized by a more stable microclimate with regard to temperature and humidity (PHILLIPS, COBB 2005). Xerophiles and psammophiles can be found on scanty vegetated banks with a lower extent of connectivity.

Table 1. Relative number of spider species from gravel banks along the Common Meuse (standarized for 6 pitfall traps per sample site), and classification as listed in the Red List of Flanders (MAELFAIT *et al.* 1998) (in concordance with IUCN-categories; **CR**: critical, **EN**: endangered, **IN**: indeterminate, **RG**: rare geographically, **VU**: vulnerable).

Abbreviation	Species	EL	HB	HE	HL	HR	KE	KH	KO	MA	MB	ME	MW	MZ	RO	Total	Red list
Agynsubt	*Agyneta subtilis* (O. P.-CAMBRIDGE, 1863)	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	
Arctcine	*Arctosa cinerea* (FABRICIUS, 1777)	0	0	0	0	0	0	0	0	0	0	37	0	4	0	41	CR
Arctleop	*Arctosa leopardus* (SUNDEVALL, 1833)	0	2	0	0	0	0	0	0	0	3	0	0	0	0	5	VU
Baryprat	*Baryphyma pratense* (BLACKWALL, 1861)	2	0	0	0	0	0	0	0	0	2	0	0	0	0	4	VU
Bathgrac	*Bathyphantes gracilis* (BLACKWALL, 1841)	2	2	10	4	3	0	4	30	6	8	0	5	1	1	75	
Bathparv	*Bathyphantes parvulus* (WESTRING, 1851)	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	
Cerabrev	*Ceratinella brevis* (WIDER, 1834)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	
Cerascab	*Ceratinella scabrosa* (O. P.-CAMBRIDGE, 1871)	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	
Clubfris	*Clubiona frisia* WUNDERLICH, SCHUETT, 1995	0	0	2	0	0	0	1	2	0	2	1	0	1	3	13	VU
Clubnegl	*Clubiona neglecta* O. P.-CAMBRIDGE, 1862	0	0	1	0	0	0	0	1	0	0	0	1	1	0	4	
Clubphra	*Clubiona phragmitis* C.L. KOCH, 1843	0	2	0	0	0	0	1	0	0	3	0	0	0	0	6	
Clubpseu	*Clubiona pseudoneglecta* WUNDERLICH, 1994	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	IN
Diplconc	*Diplostyla concolor* (WIDER, 1834)	6	36	10	82	3	2	88	14	0	21	2	13	14	16	307	
Diplconn	*Diplocephalus connatus* BERTKAU, 1889	0	0	0	0	0	0	1	0	0	0	0	0	0	1	2	IN
Diplcris	*Diplocephalus cristatus* (BLACKWALL, 1833)	0	0	4	48	3	4	5	0	0	1	4	0	3	2	74	
Dipllati	*Diplocephalus latifrons* (O. P.-CAMBRIDGE, 1863)	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	
Diplperm	*Diplocephalus permixtus* (O. P.-CAMBRIDGE, 1871)	1	0	4	12	1	0	4	0	0	0	0	0	5	0	27	
Enopthor	*Enoplognatha thoracica* (HAHN, 1833)	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0.4	
Erigarct	*Erigone arctica* (WHITE, 1852)	0	0	3	16	0	0	2	2	0	1	0	2	0	2	27	
Erigatra	*Erigone atra* BLACKWALL, 1833	53	50	100	150	14	36	66	91	6	139	34	58	36	26	859	
Erigdent	*Erigone dentipalpis* (WIDER, 1834)	61	72	156	254	23	88	105	116	2	142	55	133	57	52	1316	
Eriglong	*Erigone longipalpis* (SUNDEVALL, 1830)	4	8	13	18	0	6	2	13	0	4	4	5	4	3	84	
Euopaequ	*Talavera aequipes* (O. P.-CAMBRIDGE, 1871)	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2	VU
Euopfront	*Euophrys frontalis* (WALCKENAER, 1802)	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0.4	
Halodist	*Collinsia distincta* (SIMON, 1884)	2	2	0	0	2	0	3	11	0	12	1	7	1	4	45	EN
Heliaura	*Heliophanus auratus* C.L. KOCH, 1835	2	0	0	0	1	0	0	0	0	1	0	0	0	0	4	EN
Hypobitu	*Hypomma bituberculatum* (WIDER, 1834)	0	8	1	1	0	0	0	0	0	3	0	2	0	0	14	
Laricorn	*Larinioides cornutus* (CLERCK, 1757)	0	0	0	0	0	2	0	0	0	1	0	0	0	0	3	
Leptflav	*Tenuiphantes flavipes* (BLACKWALL, 1854)	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0.4	

Table 1. Continued.

Abbreviation	Species	EL	HB	HE	HL	HR	KE	KH	KO	MA	MB	ME	MW	MZ	RO	Total	Red list
Leptpall	*Pallidaphantes pallidus* (O. P.-Cambridge, 1871)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	
Leptrobu	*Leptorhoptrum robustum* (Westring, 1851)	5	2	0	0	1	0	2	3	0	2	0	0	1	1	16	VU
Lepttenu	*Tenuiphantes tenuis* (Blackwall, 1852)	2	4	4	0	0	0	2	18	2	20	1	1	0	2	56	
Linyhort	*Linyphia hortensis* Sundevall, 1830	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0.4	
Meiorure	*Meioneta rurestris* (C.L. Koch, 1836)	0	0	3	8	0	10	5	5	2	3	1	18	32	1	88	
Micapuli	*Micaria pulicaria* (Sundevall, 1831)	0	0	2	6	0	8	0	0	0	1	1	0	1	4	23	
Micrimpr	*Microlinyphia impigra* (O. P.-Cambridge, 1871)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	VU
Micrsuba	*Micrargus subaequalis* (Westring, 1851)	0	0	0	0	0	2	0	1	0	0	0	0	0	0	4	
Milliner	*Collinsia inerrans* (O. P.-Cambridge, 1885)	1	0	2	0	1	0	4	7	0	1	1	0	1	0	16	
Nereclat	*Neriene clathrata* (Sundevall, 1830)	0	0	0	0	0	0	1	0	0	2	0	0	0	0	3	
Oedoapic	*Oedothorax apicatus* (Blackwall, 1850)	195	36	131	100	15	22	69	76	8	119	65	51	51	123	1060	
Oedofusc	*Oedothorax fuscus* (Blackwall, 1834)	101	80	210	260	15	28	68	90	18	124	66	81	95	87	1323	
Oedoretu	*Oedothorax retusus* (Westring, 1851)	306	122	398	226	82	82	194	151	24	540	196	206	82	185	2793	
Ostemela	*Ostearius melanopygius* (O. P.-Cambridge, 1879)	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	
Ozypprat	*Ozyptila praticola* (C.L. Koch, 1837)	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	
Ozypsimp	*Ozyptila simplex* (O. P.-Cambridge, 1862)	0	0	0	2	0	0	0	0	0	1	0	0	0	0	3	
Pachcler	*Pachygnatha clercki* Sundevall, 1823	11	12	46	8	5	2	9	19	0	75	16	7	5	10	224	
Pachdege	*Pachygnatha degeeri* Sundevall, 1830	1	8	5	8	1	2	2	2	0	0	0	1	1	8	39	
Pardagre	*Pardosa agrestis* (Westring, 1861)	0	0	0	6	0	2	2	0	0	2	0	0	0	1	13	EN
Pardagri	*Pardosa agricola* (Thorell, 1856)	327	0	110	106	0	2	4	1	0	6	40	0	0	939	1534	CR
Pardamen	*Pardosa amentata* (Clerck, 1757)	28	48	27	50	1	12	13	5	0	71	22	21	16	64	378	
Pardpalu	*Pardosa palustris* (Linnaeus, 1758)	3	0	1	6	0	0	1	2	0	2	1	0	1	2	19	
Pardprat	*Pardosa prativaga* (L. Koch, 1870)	4	18	0	4	0	0	6	0	0	15	0	4	1	5	57	VU
Pardprox	*Pardosa proxima* (C.L. Koch, 1847)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	RG
Pardpull	*Pardosa pullata* (Clerck, 1757)	0	0	0	2	0	0	1	0	0	0	0	0	0	0	3	
Pelepara	*Pelecopsis parallela* (Wider, 1834)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	
Phlefasc	*Phlegra fasciata* (Hahn, 1826)	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2	VU
Phrufest	*Phrurolithus festivus* (C.L. Koch, 1835)	1	0	1	30	0	14	4	1	0	0	2	2	5	5	65	
Pirahygr	*Pirata hygrophilus* Thorell, 1872	0	0	0	0	1	0	1	1	0	2	0	0	0	0	5	
Piralati	*Pirata latitans* (Blackwall, 1841)	2	8	0	2	0	0	1	1	0	2	0	2	0	0	17	

Table 1. Continued.

Abbreviation	Species	EL	HB	HE	HL	HR	KE	KH	KO	MA	MB	ME	MW	MZ	RO	Total	Red list
Pirapira	*Pirata piraticus* (CLERCK, 1757)	0	2	0	0	0	4	0	1	0	0	0	0	0	0	7	
Porrconv	*Porrhomma convexum* (WESTRING, 1851)	2	0	0	0	0	2	1	0	0	1	1	0	0	0	7	
Prinvaga	*Prinerigone vagans* (AUDOUIN, 1826)	5	2	19	10	4	0	4	31	2	4	2	5	3	6	97	
Robelivi	*Robertus lividus* (BLACKWALL, 1836)	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0.4	
Steaalbo	*Steatoda albomaculata* (DE GEER, 1778)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	VU
Steaphal	*Steatoda phalerata* (PANZER, 1801)	0	0	0	0	0	8	0	1	0	0	1	0	0	0	10	VU
Stemline	*Stemonyphantes lineatus* (LINNAEUS, 1758)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
Synavena	*Synageles venator* (LUCAS, 1836)	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2	
Tegeagre	*Tegenaria agrestis* (WALCKENAER, 1802)	0	0	0	2	0	20	0	0	0	0	0	0	0	0	22	
Tetrexte	*Tetragnatha extensa* (LINNAEUS, 1758)	0	0	1	0	0	0	0	0	0	1	0	0	0	0	2	
Trichack	*Trichoncus hackmani* MILLIDGE, 1956	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0.4	CR
Trocruri	*Trochosa ruricola* (DE GEER, 1778)	29	24	30	44	1	86	2	11	2	64	19	29	3	33	378	
Trocterr	*Trochosa terricola* THORELL, 1856	0	4	1	0	0	2	0	0	0	0	0	0	0	0	7	
Troxscab	*Troxochrus scabriculus* (WESTRING, 1851)	0	4	0	2	0	0	0	0	0	1	0	0	0	0	7	
Xeromini	*Xerolycosa miniata* (C.L. KOCH, 1834)	0	0	0	0	0	8	0	3	0	2	0	0	0	0	13	EN
Xystcris	*Xysticus cristatus* (CLERCK, 1757)	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2	
Xystkoch	*Xysticus kochi* THORELL, 1872	0	0	0	0	0	6	0	0	0	0	0	0	0	1	7	
Zeloaene	*Zelotes aeneus* (SIMON, 1878)	0	0	0	10	0	0	0	0	0	0	0	0	0	0	10	RG
Zelolatr	*Zelotes latreillei* (SIMON, 1878)	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	
Zelolute	*Drassyllus lutetianus* (L. KOCH, 1866)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	EN
Zelopede	*Trachyzelotes pedestris* (C.L. KOCH, 1837)	3	0	1	4	0	6	0	0	0	1	0	0	0	0	15	EN
Zelosubt	*Zelotes subterraneus* (C.L. KOCH, 1833)	1	0	0	0	0	10	0	0	0	0	0	0	0	0	11	EN
	Total	1164	558	1297	1482	177	482	678	710	72	1407	572	653	426	1588	11266	23
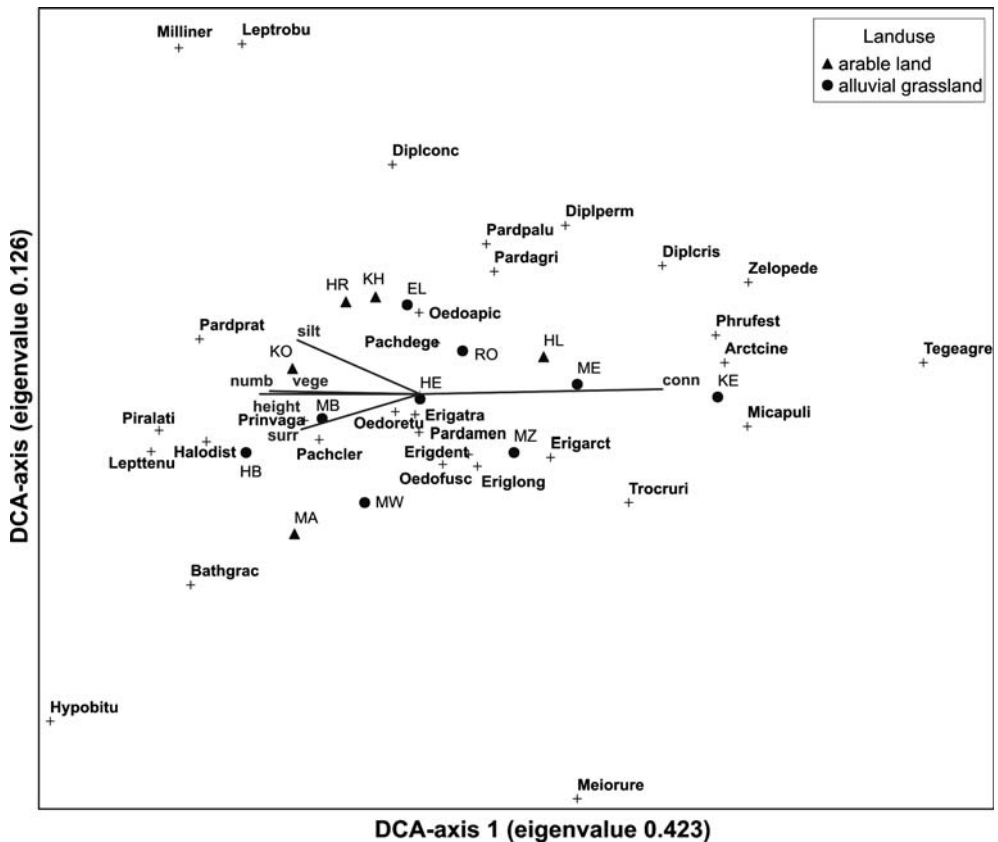
Fig. 2. DCA-ordination of spider pifall data, after standardization for 6 pitfalls per site. Only most abundant species are taken in consideration. Species are listed by respectively first 4 letters of genus and species epitheton. Gravel banks are grouped by means of surrounding land-use (gravel bank characteristics: height - flooding disturbance measure, i.e. relative height ot the gravel bank; silt - absence or presence of a silt layer; connectivity measure, i.e. nearest neighbour distance; numb and surr - respectively number and area of gavel banks in the vicinity; vege - amount of vegetation cover.

A. cinerea and *P. agricola* are considered as stenotopic riparian species having a clear preference for sandy and shingly soils (ALBERT, ALBERT 1976, FRAMENAU *et al.* 1996), just as *Diplocephalus connatus*. In Belgium *Halorates distinctus* only occurs in freshwater marshes along large rivers (HENDRICKX *et al.* 1998), consequently can be considered as a riparian species. Still *A. cinerea* is markedly isolated within the DCA-output from *P. agricola*. This niche-differentiation appears to be in concordance with a field survey along the Common Meuse of 2005 (K. Lambeets, unpubl. data). *A. cinerea* occurs on more elevated, sandy gravel banks with rather scarce vegetation cover and a relative high amount of coarse gravel. This in contrary to *P. agricola* which inhabits more loamy, denser vegetated gravel banks with a silt layer present. *P. agricola* is almost absent from high gravel banks (KE), thus not in direct contact with the river (VAN LOOY, DE BLUST (1998), while *Zelotes subterraneus* and *Xysticus kochi,* both occurring in rather dry and non-shaded habitats (ROBERTS 1998), are only found on KE. Furthermore, we can state that the adjacent habitat plays a role in the survival of both *A. cinerea* and *P. agricol*a because former seems to hibernate in natural alluvial grasslands (FRAMENAU *et al.* 1996) and *P. agricola* is found in pitfalls situated in yearly mown meadows from September onwards (K. Lambeets, unpubl. data).

Overall gravel banks where habitat specialist species occur in rather high numbers, can be considered of being of great conservational value for future nature management. Taken into consideration the different habitat requirements of these species, several types of gravel banks and ecological managed alluvial grasslands have to be preserved during future nature management and restoration of the Common Meuse.

Spider assemblage responses

Overall we can state that the spider assemblages are influenced by local environmental factors and in some degree by the landscape configuration. This is consistent with similar studies from exposed riverine sediments (EYRE *et al*. 2002) and other dynamic habitats, like agricultural landscapes (JEANNERET *et al*. 2003). The high supply of allochtonous organic matter by the river is posed by ADIS, JUNK (2002) and FRAMENAU *et al*. (2002) as another explanation for the high abundance of more mobile groups (e.g. ground beetles and spiders) on river banks. BONN *et al*. (2002) studied riparian habitats along several river systems in Germany and concluded that mainly vegetation heterogeneity, rather than different flood regimes, influenced spider assemblages. PERNER, MALT (2003) showed that vegetation structure indirectly explained most of the variance in the spider data-set along a decreasing management gradient of grasslands. In our study, the separation of araneid groups is less apparent. Nevertheless from the spider data onwards an obvious difference between the characterisation of gravel banks is noticeable, pointing out their singularity. Once the water level drops, gravel banks become exposed and quickly are colonized by a pioneer vegetation, with a characteristic vertical zonation pattern (SCHAMINÉE *et al*. 1998, NEUMEIER 2005). Gravel banks situated lower above the water level are more susceptible to flooding disturbance, thus getting covered with a silt layer more often. This in turn enhances vegetation succession. Stronger vegetated banks are able to accumulate a higher amount of silt, which has a self-reinforcing effect upon the vegetation *in se* (SLUIS, TANDARICH 2004). Due to the denser vegetation cover, relative lower banks can maintain a more stable micro-climate concerning humidity, temperature etc. (SOUZA, MARTINS 2004).

Pioneer spider species like *Oedothorax* spp. and *Erigone* spp. clearly dominate gravel banks, just as outlined by a study considering several river-floodplains in Germany (BONN, KLEINWÄCHTER 1999, WOHLGEMUTH - VON REICHE, GRUBE 1999). Next to vegetation density, gravel size increases from the sharp sand fraction along the water line, onwards to the coarse gravel of the dike, where a ruderal and dense vegetation is found. Thus gravel banks enclose a wide range of small-scale microclimatological differences, causing a more heterogeneous habitat with varying substrate structure and vegetation cover, both in time and space (BONN, KLEINWÄCHTER 1999). Former authors noticed that the narrow niche separation in Araneae and Carabidae assemblages was due to the high heterogeneity, enhancing general biodiversity. PHILLIPS, COBB (2005) found proof that micro-scale differences of vegetation type and substrate structure around pitfalls can obscure trapping of certain species. In contrary to carabid beetles (grand total of 98 species, K. Lambeets unpubl. data), only some spider species are able to survive the extreme conditions met on gravel banks, which can serve as one of the main reasons of the poor species richness. Next to the long-lasting winter and regular springtime flood events, possibly most of the spider species are more sensitive to desiccation due to a non-adapted morphology and behaviour (FOELIX 1996). Certain types of gravel and other substratum (e.g. sand, loam and silt), with regard to physical composition, size and ability to restrain heat, can play a decisive role in the thermal balance of river bank habitats. But if vegetation succession on sandy gravel banks would proceed, due to a decrease in river dynamics, typical riverine species would disappear and on the other hand an increase in habitat generalists could be noticed (WOHLGEMUTH - VON REICHE, GRUBE 1999). Furthermore connectivity, considered as the interpatch distance between consecutive banks, can be looked at as an isolation effect, while secondly the patch area contributes to the degree of fragmentation

(PIESSENS *et al*. 2005). Within our study, only the degree of isolation had a significant effect upon species distribution, especially habitat specialists seem susceptible to an increase of fragmentation (landscape effect).

Conservation and restoration issues

For conservational purposes, one can state, in order to preserve specialist species within a river-ecosystem, regular disturbance by inundation within the ecosystem should be maintained. In order to enhance natural water dynamics, present river management should be revised. In other words the human impact, e.g. river bed modifications, damming, stone embankments, etc., should be minimized (BONN *et al*. 2002). Yet it is important to account for flood protection measures, like is the case along the Common Meuse (NAGELS *et al*. 1999). But rather small-scale habitat restoration would be beneficial for conservational purposes (LIN, XIE 2005), otherwise the initial amplitude of species adjustment could be too large, and species would ultimately face extinction. This can be a reason for the slow reaction of spider assemblages after habitat restoration, like BONTE *et al*. (2003) pointed out for dune landscapes. Further research will reveal if this is also the case along the Common Meuse (K. Lambeets, unpubl. data). Although not measured in this study, other properties of exposed riverine sediments such as grazing intensity, surrounding land-use or exposure to environmental factors as wind, shadowing, water chemistry or pollution may also influence communities of cursorial predators (FRAMENAU *et al*. 2002).

In conclusion we can state that there isn't a unequivocal definition of "the" gravel bank. In order to preserve typical riverine species by means of river ecosystem restoration, both dynamic and more elevated gravel banks should be taken in consideration. Overall promoting heterogeneity in local gravel bank characteristics and landscape composition, e.g. surrounding land-use, could be one of the keys promoting spider diversity along a river system, just as CLOUGH *et al*. (2005) have shown for spider diversity in cereal fields. Thereby a variety in local habitat characteristics should be retained, especially by means of a differentiating substrate structure and a vertical zonation pattern in vegetation succession, caused by natural flooding of the gravel banks. River management should be adjusted in order to maintain a natural river corridor and surrounding riverine landscape, as well as the conservation of natural river flow regimes.

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(Резюме)

Чакълестите брегове на речната система Мюз са изследвани за епигейни безгръбначни животни, с цел да се установи как са структурирани съобществата по отношение на характеристиките на речния бряг (размер, степен на изолираност, растителност, наличие на наноси и периодичност на заливанията). Семействата Linyphiidae и Lycosidae доминират сред установените при изследването паяци. Видове с кратки жизнени цикли и по-добри възможности за разпространение по въздуха, както и подстилъчно живеещи хигрофили и агробионти са установени във всички изследвани стации. Присъствието на ксеротермни видове и такива, специализирани за живот в чакълести крайречни брегове, са регистрирани само на места с рядка растителност и по-малко динамични брегове. Чрез ординационен анализ са установени факторите, които определят структурата на хищните безгръбначни животни в различните чакълести брегове. Изолацията, степента на заливност, гъстотата на растителната покривка и наличието на наноси са сред факторите, които определят основните типове на разпространение. Според авторите, за да се опазят видовете, живеещи само в чакълестите брегове на реките, е необходимо да бъдат поддържани естествените процеси на периодичното им заливане. Тъй като няма еднозначна дефиниция на това, какво е речен чакълест бряг, предлага се при природозащитни действия терминът да се прилага в по-широк смисъл, като по този начин бъдат включени по-динамичните и по-издигнатите речни брегове, за да се гарантира опазването на хетерогенността по дължината на речната система.

The diel vertical migrations of herbage-dwelling spiders in clayey semi-desert of the northern Caspian Sea basin, West Kazakhstan (Araneae)

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Abstract: The diel periodicity of vertical migrations of the herbage-dwelling spiders in the natural biotopes of the clayey semi-desert in the northern Caspian Sea basin (West Kazakhstan) is investigated. Steppe biotopes (microdepressions) and desert ones (microelevations) are shown to have much in common: the abundance and the family composition of the spider population of both biotopes are similar, they differ a bit only in summer. The amplitude of diel fluctuations in the spider abundance is rather significant. In spring and autumn the peaks of abundance in both types of biotopes are at night, when the temperature of the air is minimal. In summer, in addition to night peaks of abundance there are daytime rises due to increase of activity of "southern" taxa – Thomisidae in desert associations, and Thomisidae+Salticidae in steppe ones. The diel rhythmic of vertical migrations of hortobiotic spiders is a complicated phenomenon which is determined by a number of factors. Partly it is conditioned by environmental factors, and partly – by the vertical migrations of their preys – phytophagous insects. So, the ecological niches of different spider taxa are separated in time according to their adaptations to climate conditions. It brings about a decrease of the competition between taxa.

Key words: desert, steppe, herbage-dwelling spiders, diel activity, temporal distribution

Introduction

The characteristic feature of invertebrates inhabiting the herbage layer is their extremely high diel mobility. This mobility is determined by their regular vertical migrations whereas the character of movements in the species remains individual (CHERNOV, RUDENSKAYA 1975). In most papers devoted to the diel dynamics of spiders, the main attention is paid to herpetobionts (DONDALE *et. al*. 1972, SEYFARTH 1980, GRAMOTENKO 1984, FUJII 1997). The diel activity of hortobiotic spiders has been poorly studied (MIKHAILOV 1985).

Different anthropogenic effects that disturb natural succession processes and the complexity of ecosystem elements themselves make investigations of dynamic processes difficult. We analyzed the diel and seasonal dynamics of herbage-dwelling spiders in the clayey semi-desert of the northern Caspian Sea Lowland. It is situated in the interfluve of the Volga and Ural rivers. The semi-desert of the Volga River basin is especially appropriate for such investigations due to vast areas of virgin lands, which are exposed to a constant but very weak and thus reversible anthropogenic impact; and the zonal ecosystems are rather simply organized here because of severe and contrasting conditions and plain relief. In addition, the hydrological, soil and geobotanical conditions of this territory are well studied (KAMENETSKAYA 1952, RODE 1971, DOSKACH 1979 and others). Besides, we have preliminary data of spider population on this territory (MIKHAILOV 1985). So, we consider that the semi-desert of the northern Caspian Sea basin is a quite suitable model territory for investigating the dynamics of spiders.

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This work is only a part of a project investigating the fauna and ecology of spiders of clayey semi-desert of the northern Caspian Sea Lowland.

Study Area

The region of our investigation is located in the flat plain of the northern Caspian Sea Lowland (an altitude of 21-25 m a.s.l.) at the border between Russia and Kazakhstan (49º23'N; 46º47.5'E). It is the most arid territory in the Caspian Sea semi-desert, despite its northernmost location. Groundwater, at a depth of 5-10 m, is highly mineralized. The main part of the plain has a complex soil-vegetable cover. This cover is related to the microrelief, and its components have an area of no more than some tens of square meters. Microelevations are occupied by solonetzic soils, which have nonpercolative type of water regimes (it means that water never percolates through the soil and gets to the ground water, i.e. salts and different nutrients are never washed out from the soil to the ground water) (RODE 1971). A plant cover of desert type is developed here (*Kochia prostrata* and *Artemisia pauciflora* associations), so microelevations are desert biotopes. Microde-pressions (up to 0.4 m depth) are with dark-chestnut and meadow-chestnut soils, they periodically have percolative type of water regimes (salts and nutrients are periodically washed out from the soil). Microdepressions are occupied by motley grass (*Stipa* spp., *Festuca valesiaca, Agropyron cristatum*, etc.) - these are steppe biotopes.

Materials and Methods

Sweeping was done in different seasons (spring, summer and autumn) so as to reveal seasonal particularities of vertical migrations of grass-dwelling spiders. Sweeping (4x25 sweeps) was done every 4 hours, i.e. at 0, 4, 8, 12, 16 and 20 o'clock during 2 consecutive days. Two types of zonal biotopes were investigated: steppe and desert ones, i.e. microdepressions and microel-evations. Seventy-two samples per 100 sweeps were analyzed, about 3700 specimens of spiders were collected. The majority of the spiders were immature which is quite typical for the spider community of the herbage layer (VESELOVA, MIKHAILOV 1986). So, the identification of species was not always possible.

Results

Spiders of 13 families were caught by sweeping (Table 1). Spiders of 5 main families and 21 species were identified (Table 2). The total abundance of spiders in different seasons varied greatly but seemed to be similar in both biotopes: it was low in the spring and autumn but two or three times higher in the summer (Fig. 1). The family composition of spider communities of the herbage in both biotopes was also quite similar (Table 1). Namely, the basis of the spring population was Oxyopidae (only immature spiders were caught) and Araneidae with the domi-nating species *Gibbaranea bituberculata* (WALCKENAER, 1802). The autumn population of both biotopes had also much in common. It mostly consisted of Clubionidae (*Cheiracanthium* sp. 1) on microelevations; on microdepressions only immature specimens were caught. Araneidae with *Cercidia levii* MARUSIK, 1985 were abundant on microdepressions (the immature individu-als were found on microelevations). The Thomisidae with *Xysticus marmoratus* THORELL, 1875 and *X. striatipes* L. KOCH, 1870 dominated in both biotopes. The summer population of the two biotopes had some differences: besides the common prevailing families Thomisidae (on microelevations immatures only; on microdepressions *Thomisus albus* (GMELIN, 1789) and *X. cristatus* (CLERCK, 1758) were caught) and Clubionidae (immatures only), in steppe biotopes Salticidae were also abundant – one third of the population, with *Evarcha michailovi* LOGUNOV, 1992 dominating.

Table 1. Correlation (%) of the families of hortobiotic spiders collected by sweeping (May – September 2004).

Family	Spring		Summer		Autumn	
	Microeleva-tions	Microde-pressions	Microel-evations	Microde-pressions	Microel-evations	Microde-pressions
Thomisidae	3.2	0.7	65.0	36.9	11.4	23.1
Philodromidae	5.7	3.9	5.0	6.7	5.4	11.6
Araneidae	18.8	20.6	6.9	3.3	27.3	16.8
Oxyopidae	33.4	33.9	0.2	0.1	5.9	7.3
Clubionidae	2.4	9.3	12.2	15.6	32.5	23.6
Salticidae	1.1	7.4	6.2	32.4	-	3.4
Linyphiidae	10.7	8.6	1.9	1.9	1.6	1.0
Dictynidae	5.1	4.9	0.9	1.2	5.0	3.9
Theridiidae	5.1	5.6	0.9	1.5	9.6	8.7
Uloboridae	14.2	5.1	0.1	0.3	0.9	0.3
Gnaphosidae	-	-	0.5	0.1	0.4	-
Lycosidae	-	-	0.1	-	-	0.3
Titanoecidae	0.3	-	0.1	-	-	-

Table 2. List of hortobiotic spiders in five dominating families collected by sweeping (May – September 2004).

Family, species	Microelevation	Microdepression
Araneidae		
Argiopa lobata (Pallas, 1772)	+	-
Cercidia levii Marusik, 1985	-	+
Gibbaranea bituberculata (Walckenaer, 1802)	+	+
Mangora acalypha (Walckenaer, 1802)	+	-
Neoscona adianta (Walckenaer, 1802)	-	+
Oxyopidae		
Oxyopes globifer Simon, 1876	+	-
O. lineatus Latreille, 1806	-	+
Clubionidae		
Cheiracanthium pennyi O. P.-Cambridge, 1873	-	+
Cheiracanthium sp. 1	+	+
Cheiracanthium sp. 2	+	+
Clubiona genevensis L. Koch, 1866	-	+
Thomisidae		
Ozyptilla pullata (Thorell, 1875)	+	-
Thomisus albus (Gmelin, 1789)	-	+
Xysticus cristatus (Clerck, 1757)	+	+
X. marmoratus Thorell, 1875	+	+
X. striatipes L. Koch, 1870	+	+
Xysticus sp.	+	-
Salticidae		
Evarcha michailovi Logunov, 1992	-	+
Heliophanus flavipes (Hahn, 1832)	-	+
H. koktas Logunov, 1992	-	+
H. lineiventris Simon, 1832	-	+
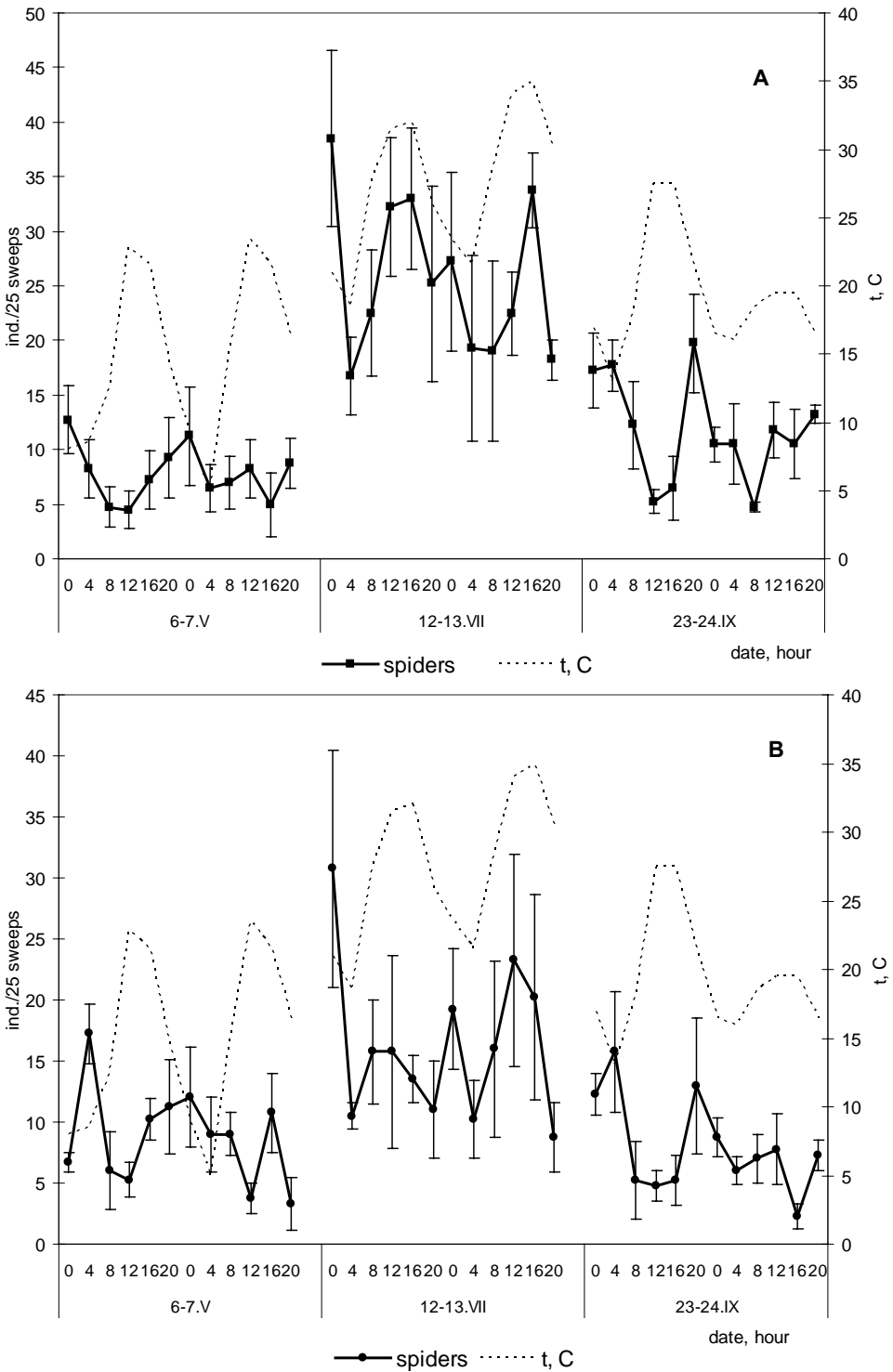
Fig. 1. Diel fluctuation of the abundance of hortobiotic spiders and air temperature in microelevations (A) and microdepressions (B).

Sweeping is known to record the abundance of individuals that have migrated to the upper layers of the herbage and thus have become available for catching (Beklemishev 1934). The plants growing on microelevations are very short and scattered. In this case, we suggest that spiders migrate (in vertical direction) to the herbage from soil cracks. In the dense grass cover of microdepressions, spiders may migrate both from soil cracks and the lower part of the herbage. The results of the sweeping in both biotopes are rather similar (Fig. 1). In the spring and autumn, the diagram of dynamics of diel vertical migrations had a peak at night hours and a decrease in the daytime. It is quite typical for many components of the herbage complex (Chernov, Rudenskaya 1970) especially under arid and semi-arid climatic conditions (Avanesova 1983). The comparison of abundance and temperature curves shows some inverse relationship (Fig. 1): the abundance of spiders is maximal at minimal night temperatures, and vice versa. But in the summer, the hottest period, when the day temperatures reach up to 40°C and night temperatures are about 20°C, there are daytime peaks in the abundance of spiders. These peaks are restricted to the hottest hours (12-16) of the day. The abundance of spiders in daytime was not less than that at night (Fig. 1). Night peaks were quite expected. It worth emphasizing that the amplitude of diel fluctuations in the spider abundance was rather significant, which is typical for cenoses of open space. The investigations of activity of arachnids in the herbage under the forest canopy showed that the fluctuations in their abundance were more even because of the more stable microclimatic conditions there (Williams 1962).

The analysis of the diel activity rhythms of each family has revealed the following results (Fig. 2). Oxyopidae, which were dominant in the spring, were active at night on microelevations and in the early morning and late evening, on microdepressions. Very likely, this is related to the fact that different species inhabited these sites, but we cannot firmly state it, since all the spiders caught in the spring were immature. However, adult Oxyopidae caught in the summer and autumn were different in different biotopes: *Oxyopes globifer* Simon, 1876, on microelevations and *O. lineatus* Latreille, 1806, on microdepressions. The Araneidae, abundant in spring and autumn, had no distinct peaks in their activity (they are the only non-wandering spiders) but nevertheless, their catching efficiency was higher during daytime. The Clubionidae are abundant only at night. They were almost absent during daytime, which confirms some previous observations about their nocturnal activity (Dondale *et. al.* 1972, Marc 1990 and others). The Thomisidae are diurnal but their abundance rose somewhat at night. All salticids are distinctively diurnal. In the summer, in the herbage of the microdepressions they were abundant from 8 till 16 o'clock.

The typical ground-dwelling spiders such as Lycosidae, Gnaphosidae and Titanoecidae were found to be also capable of vertical migrations to the grass layer. Probably, when sampling on microelevations we could catch them accidentally from the ground surface because of the sparse vegetation. However, representatives of these families were also collected in the microdepressions, and besides, most of them were caught only during night hours. We think that these facts prove the vertical migrations of herpetobiotic species. Moreover, some other authors also showed night rises of herpetobiotic spiders to the herbage (Chernov, Rudenskaya 1975, Kupershtein, Egorova 1978, Mikhailov 1985).

Discussion

The vertical migrations of invertebrates in the herbage layer have not still been sufficiently explained. Following Mikhailov (1985), we suggest that the spider migrations are a display of their activity. Another question – what determines such an activity? Very likely, the diel activity rhythms are an endogenous feature of a taxon, which has been formed during the evolution process (Tshernyshov 1960). But these rhythms are certainly controlled by the environment and modified depending on the needs of the species. Differences in diel activity of spiders of different taxa is conditioned by their morphological or ethological features.
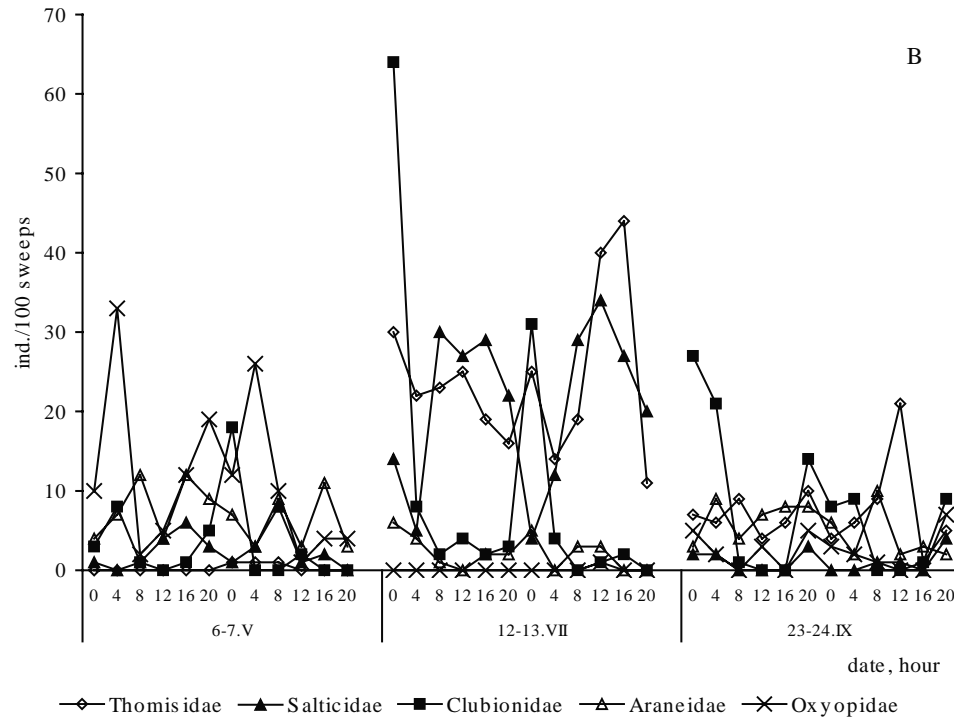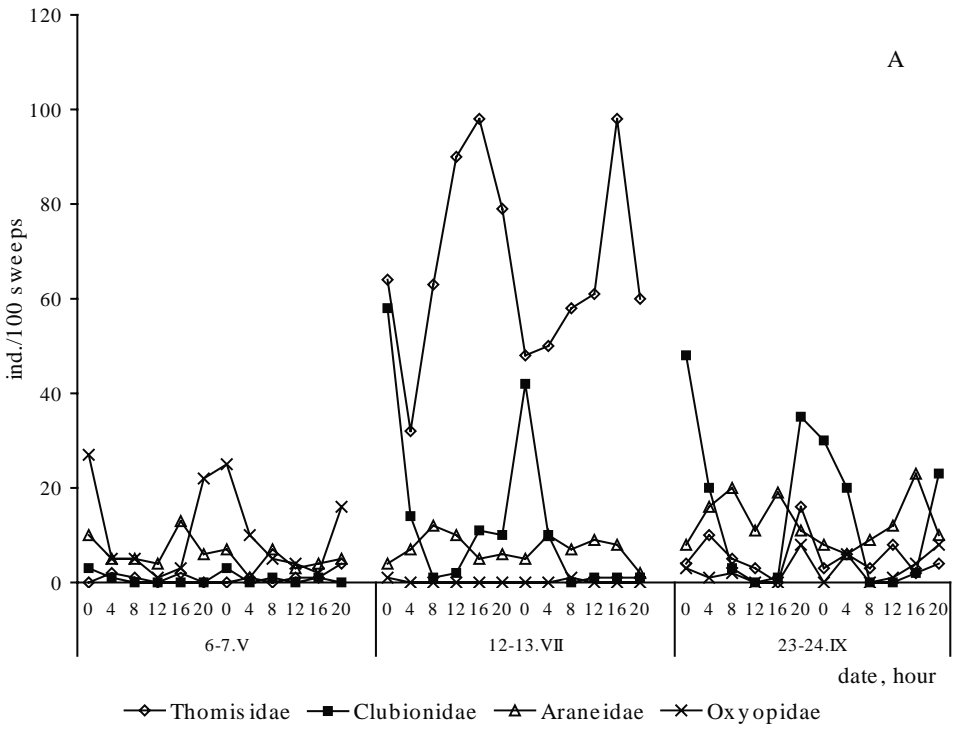
Fig. 2. Temporal distribution of the dominating families of hortobiotic spiders in the microelevations (A) and microdepressions (B).

The Thomisidae and Salticidae are "southern" elements in the araneofauna. Their high abundance and diversity are especially typical for arid and semi-arid conditions (CLOUDSLEY-THOMPSON 1983). They have a diurnal type of activity and have developed some adaptive features against overheating. Namely, Thomisidae have a thick chitinous-cloth and an intensive coloration of the body. Salticidae's bodies usually have even more expressed pigmentation and glitter scales that protect them from harmful solar radiation. Darkling beetles (Tenebrionidae), the most adapted and abundant group of Coleoptera under arid conditions, are known to have similar adaptive features. They were described as having some special structure of their skin coverings and physiological mechanisms that protect their body from overheating (GHILAROV 1964, TOMS 1993). The salticids probably have similar adaptive features. The Clubionidae and Oxyopidae have pale coloration and thin chitin, which cannot protect them from overheating and water loss. They are mostly nocturnal. Araneidae didn't show distinct diel rhythms. It's the only family whose representatives spin webs and stay on them. So, to avoid overheating they hide in the shadow or in special shelters not far from their webs.

As said before, environment conditions influence the diel activity of spiders. Thus, temperature is one of the main factors, especially in semi-arid zones, where the amplitude of its diel fluctuations is rather high. Fig. 1 shows that certain dependence exists. The activity of spider populations in the spring and autumn is inversely related to the temperature. In the summer, these two graphs almost follow each other. The second environmental factor affecting the diel spider activity is air humidity. As a rule, the invertebrates follow the maximum of moisture: in the daytime hours, it is near the ground surface and by night it goes up (HEIGER 1931, cit. in CHERNOV, RUDENSKAYA 1975, MELNICHENKO 1949). To our mind another very important factor which determines the activity of spiders, obligate predators, is the migration of their preys – phytophagous insects. Night rises in the abundance of phytophags were noted by numerous authors. The night activity of phytophags is specified by movements in search of the optimal combination of microclimatic conditions and is connected with the highest intensity of feeding (CHERNOV, RUDENSKAYA 1970, AVANESOVA 1983). Similar rhythmics of diel activity of preys and predators was found in the springtail *Isotoma violacea* and spiders of the genus *Pardosa* (Lycosidae) on the snow surface in Greenland (FOX, STROUD 1986). A relationship between the peaks of activity in predators and their prey of different taxa was also revealed in the meadows of Ontario (DONDALE *et. al.* 1972).

The daytime peaks in spider activity are likely to be explained by trophic relations as well. In tundra forests spiders are known to keep their activity at minimal night temperature, whereas insects lose their agility. Under these conditions, spiders easily hunt unmoving preys (OL'SHVANG 1974). In the semi-arid zone, the situation might be quite similar: many insects spend the hottest hours torpid on plants. Thus, spiders of some taxa, being adapted to arid conditions, keep their activity and hunt slow-moving prey. Besides, there are some taxa of diurnal phytophags: some Diptera, Homoptera, etc. (CHERNOV, RUDENSKAYA 1970, DONDALE *et. al.* 1972). So, we can conclude that the high abundance of spiders and, hence the high competition between them, cause a differentiation of niches of different taxa according to their adaptation to climate conditions. Such a differentiation makes possible the use of habitat resources in full measure.

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Денонощната вертикална миграция при хербиколните паяци, обитаващи глинестата полупустиня на Северния Каспийски басейн в Западен Казахстан (Araneae)

Т. Питеркина

(Резюме)

Изследвана е денонощната вертикалната миграция на хербиколните паяци, обитаващи естествени биотопи в глинестата полупустиня на Северния Каспийски басейн в Западен Казахстан. Степните биотопи (малки падини) и пустинните биотопи (малки възвишения) имат редица общи черти: обилието и доминантната структура на семействата паяци и на двете места е еднакво, с незначителни разлики само през лятото. Денонощните флуктуации в числеността на паяците са значителни. През пролетта и есента пиковете в числеността на паяците в двата типа биотопи е през нощта, когато температурата на въздуха е най-ниска. През лятото има пик и през деня, дължащ се на увеличаването на активността на "южните таксони" – видове от семейство Thomisidae в пустинните съобщества и такива от семействата Thomisdae и Salticidae в степните съобщества. Денонощната ритмичност във вертикалната миграция при хортобионтните паяци е сложен феномен, който се определя от редица абиотични фактори, както и от миграцията на фитофагните насекоми, които са сред основните жертви на паяците. По този начин екологичните ниши на различните видове паяци са разделени във времето според тяхната адаптация към климатичните условия. Това води до намаляване на антагонизма между таксоните.

Microhabitat effect on spider distribution in winter wheat agroecosystem (Araneae)

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Abstract: The study was carried out in Moscow Area (central European part of Russia) in a winter wheat field and its grassy margins. A total of 151 spider species from 17 families and 89 genera were collected. In croplands, the families Linyphiidae, Tetragnathidae, Araneidae and Thomisidae were dominant among hortobiontous spiders, while Lycosidae, Linyphiidae and Tetragnathidae were dominant among epigeic ones. In the margins, Linyphiidae, Tetragnathidae and Araneidae prevailed among hortobiontous spiders, while Lycosidae and Linyphiidae prevailed among herpetobiontous spiders. The abiotic (soil acidity, soil moisture, organic matter content) and biotic (wheat ear height, weed abundance, plant biomass) factors studied have a different influence on the distribution of different spider groups. Their effect is diminished in the field margins. The distribution of most hortobiont web-building spiders depended on the characteristics of crop vegetation cover, as they preferred weeds. Hortobiont hunting spiders (crab spiders) were more sensitive to microclimate and preferred dry microhabitats. Herpetobiont spiders did not respond to soil characteristics in the field. The patterns of spider aggregation should be taken into account while carrying out ecological monitoring.

Key words: agrocoenoses, spider aggregation, spatial distribution, Russia

Introduction

Spider spatial distribution depends on prey availability and other factors such as vegetation cover, micro-landscape, microclimate (Samu *et al.* 1999). In contrast to insects, spiders do not tend to be concentrated on plants of certain species (Rypstra *et al.* 1999). It is the architecture of plants, which is the most important (Gibson *et al.* 1992, Balfour, Rypstra 1998, Basedov 1998, Halaj *et al.* 1998). Microclimate often correlates with architecture of plants (Cady 1984, White, Hassel 1994), nevertheless it is an independent factor of habitat when effecting spider distribution (Clausen 1986, Canard 1990). For example, the web location of Araneidae, Tetragnathidae, and Linyphiidae depends on humidity (Enders 1977, Gillespie 1987). Studies on distribution of spiders and their preys in agroecosystems are numerous (Yeargan 1975, Coll, Bottrell 1995, Yan *et al.* 1997, Halaj *et al.* 1998). However, which biotic and abiotic factors effect spider distribution remains unclear.

The study focuses on the uneven spider distribution within an agroecosystem. The main question to be answered is what are the effects of some abiotic (soil humidity, soil acidity, organic matter content) and biotic (vegetation height and biomass, weed abundance) factors on the spider distribution in the winter wheat agroecosystem.

Material and Methods

The investigation was carried out in a 12 ha winter wheat field and its margins during the vegetation season of 1996 from thawing until harvesting (April-August). The sampling site is situated

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in Moscow Area (central European part of Russia) 20 km NE of Moscow, on the territory of the Educational and Experimental Centre for Soil Ecology of Lomonosov Moscow State University (55°59′N, 37°24′E). The area is typical for the mixed forest zone of the European part of Russia. The relief of the experimental field is rather flat with slight depressions in the central and eastern parts of the field. The field is surrounded by several types of biotopes: a lime-trees alley with a drainage trench in-between, a mixed birch-fir forest, a potato field, and an uncultivated plot with a dirt road in-between the field. A small pond is located at a distance of 10-15 m from the sampling field.

Entomological sweeping and pitfall trapping were used to collect spiders in 81 sample plots. Forty-nine plots were evenly located over the cropland and 32 were determined in the surrounding grassy margins at a distance of 2-5 m from the field border (Fig. 1). On each plot, one trap was placed and 10 single sweeps were performed. Half-liter glass jars filled one-fourth with moist soil served as pitfall traps. The traps were exposed for 4 days and for the next 4 days they were closed. Sweepings were applied every 8 days. In total, 10,560 sweeps were made; the overall time of trap exposure was 4,540 trapping days; ca. 2,000 spider specimens were collected.

To measure soil moisture, pH and organic matter content samples were taken close to the pitfall traps to a depth of 10 cm both in the field and its grassy margins. The field moisture of soil (water content at a time of sampling) was measured by a weight method (ALEXANDROVA, NAYDE-NOVA 1976). Soil pH was estimated in a $CaCl_2$ extract by using a pH-340 potentiometer with glass electrode (ALEXANDROVA, NAYDENOVA 1976). Organic matter content (OMC) was measured by an appropriate method (ARINUSHKINA 1961, ORLOV, GRINDEL' 1967, NIKITIN 1972). Above-ground plant biomass of winter wheat vegetation and weeds from the studied plots was evaluated by weighing of the wet material collected over an area of 1 m² (DOSPEHOV 1973) in the place of soil sampling. Wheat ear height was estimated by direct measuring. Abundance of weeds was estimated with
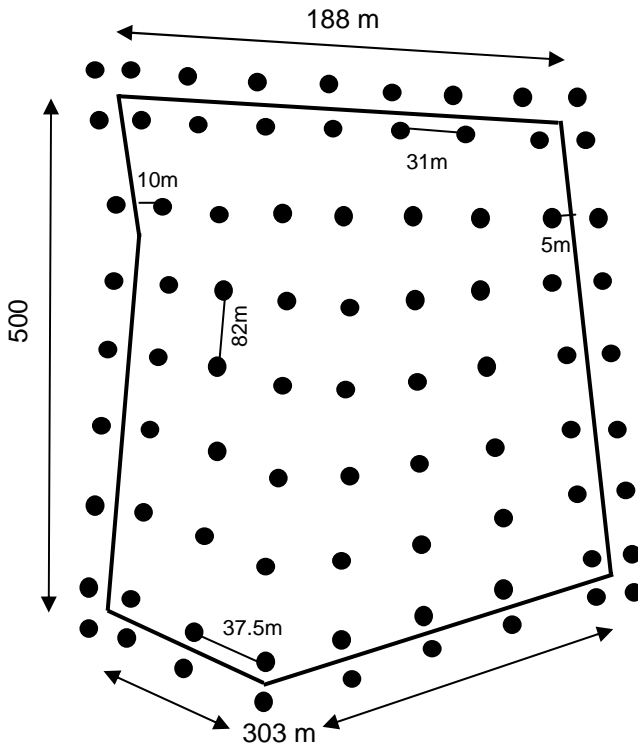
Fig. 1. Sampling plots in the studied area.

mark rating using five categories of weed-covering. Fifteen species of weeds were found within the field, 8 of which prevailed (occurred more than in 20 % of samples).

All mature spider individuals were identified to a species level. A spider family was considered dominant if it represented more than 8 % of the total catch. Statistical data analysis was performed by using MS STATISTICA 5.5. Correlation between the total year catch of the same family spiders and each sample plot (separately for sweeping and trapping) and soil characteristics (pH, organic matter content, moisture), vegetation characteristics (crop ear height, weed contents, plant biomass) on the same plots were calculated. The families encountered in more than 5 % of the total catch were used in the correlation analysis.

Results and Discussion

A total of 151 spider species from 17 families and 89 genera were collected in the winter wheat field and its grassy margins. Among them, 80 species (52 %) were found in the cropland (Table 1). The Linyphiidae had the highest species number (ca. 50 %) (Table 2). However, only a quarter of the total spider catch belongs to linyphiid spiders, hence there were many species with low abundance and single specimens among them. The other six main families (Araneidae, Dictynidae, Lycosidae, Tetragnathidae, Theridiidae, Thomisidae) accounted totally for over 30 % of the species number and 70% of the individuals' number.

The families Linyphiidae, Tetragnathidae, Araneidae, and Thomisidae dominated in the vegetation cover of cropland (Fig. 2a), while Lycosidae, Linyphiidae, and Tetragnathidae prevailed on the soil surface (Fig. 2b). Linyphiidae, Tetragnathidae, Araneidae, Lycosidae, Thomisidae, Theridiidae, and Dictynidae dominated among hortobiontous spiders in the field margins (Fig. 2c), while Lycosidae and Linyphiidae dominated among herpetobiontous ones (Fig. 2d). The correlation analysis between the studied factors and spider distribution in the field and its margins resulted as following.

Soil Moisture and OMC

These factors significantly correlate to each other within the field (Fig. 3). Within the cropland, they affected only the distribution of crab spiders, represented mainly by *Xysticus* spp. (Fig. 3). These typical for open areas spiders preferred dry microhabitats. Their correlation with OMC is probably indirect and was caused of soil moisture and OMC interdependence. In the field margins, the effect of soil humidity and of OMC on spiders has not been found (Fig. 4).

Soil pH

Within the cropland, pH varied from medium-acid to neutral (4.5-6.9), while in the margins from high-acid to neutral (3.9-7.0). Spider allocation in the cropland did not correlate with soil acidity (pH). However, in the field margins lycosid and thomisid spiders were usually found in the plots with higher acidity. The effect of pH on hortobiontous thomisids is most likely indirect, because they were more abundant in the margins adjacent to the mixed forests with higher soil acidity. Obviously, the effect has not been revealed in the cropland. The distribution of epigeic lycosids might be a result of the same factors, but on the other hand, the species dominating the cropland (*Pardosa agrestis*) and the margins (*P. fulvipes*) were different. The latter fact could be affected by soil acidity.

Weed Abundance and Wheat Ear Height

Fifteen species of weeds were found within the field, 8 of which prevailed. Some of them (especially *Agropyron repens* and *Matricaria inodora*) grew forming patches. Weed abundance and

Table 1. List of collected spiders: «+» – presence; «–» – absence.

No.	Taxon	Sampling method		Sample site	
		Sweeping	Pitfall trapping	Field	Margin
	Anyphaenidae				
1	*Anyphaena accentuata* (WALCKENAER, 1802)	+	–	–	+
	Araneidae				
2	*Araneus sturmi* (HAHN, 1831)	+	–	+	+
3	*Araniella cucurbitina* (CLERCK, 1758)	+	–	+	+
4	*Cyclosa conica* (PALLAS, 1772)	+	–	+	+
5	*Hypsosinga pygmaea* (SUNDEVALL, 1831)	+	–	+	+
6	*Larinioides cornutus* (CLERCK, 1758)	+	–	–	+
7	*L. patagiatus* (CLERCK, 1758)	+	–	+	+
8	*Neoscona adianta* (WALCKENAER, 1802)	+	–	–	+
9	*Singa hamata* (CLERCK, 1758)	+	–	–	+
10	*S. nitidula* C.L. KOCH, 1844	+	+	+	+
	Clubionidae				
11	*Cheiracanthium erraticum* (WALCKENAER, 1802)	+	–	–	+
12	*Clubiona caerulescens* L. KOCH, 1867	+	–	–	+
13	*C. reclusa* O. PICKARD-CAMBRIDGE, 1863	–	+	–	+
14	*C. stagnatilis* KULCZYŃSKI IN CHYZER ET KULCZYŃSKI, 1897	+	+	+	+
15	*C. subsultans* THORELL, 1875	+	–	–	+
	Dictynidae				
16	*Cicurina cicur* FABRICIUS, 1793	–	+	+	–
17	*Dictyna arundinacea* (LINNAEUS, 1758)	+	–	+	+
	Gnaphosidae				
18	*Drassylus lutetianus* (L. KOCH, 1866)	–	+	+	+
19	*D. pusillus* (C.L. KOCH, 1833)	–	+	+	+
20	*Haplodrassus umbratilis* (L. KOCH, 1866)	–	+	–	+
21	*Micaria pulicaria* (SUNDEVAL, 1831)	–	+	+	+
22	*Zelotes latreillei* (SIMON, 1878)	–	+	–	+
	Hahniidae				
23	*Cryphoeca silviciola* (C.L. KOCH, 1834)	+	–	–	+
24	*Hahnia nava* (BLACKWALL, 1841)	+	–	–	+
25	*H. pusilla* C.L. KOCH, 1841	–	+	+	+
	Linyphiidae				
26	*Agyneta rurestris* (C.L. KOCH, 1836)	+	+	+	+
27	*A. saxatilis* (BLACKWALL, 1844)	+	+	–	+
28	*A. subtilis* (O. PICKARD-CAMBRIDGE, 1863)	+	–	–	+
29	*Allomengea scopigera* (GRUBE, 1889)	–	+	–	+
30	*A. vidua* (L. KOCH, 1879)	–	+	–	+
31	*Anguliphantes angulipalpis* (WESTRING, 1851)	–	+	–	+
32	*Araeoncus humilis* (BLACKWALL, 1841)	–	+	+	+
33	*Bathyphantes approximatus* (O. PICKARD-CAMBRIDGE, 1871)	+	+	+	+
34	*B. gracilis* (BLACKWALL, 1841)	–	+	+	+
35	*B. nigrinus* (WESTRING, 1851)	–	+	+	+
36	*B. parvulus* (WESTRING, 1851)	–	+	+	+
37	*Bolyphantes alticeps* (SUNDEVALL, 1832)	–	+	–	+
38	*Centromerita bicolor* (BLACKWALL, 1833)	–	+	+	+

Table 1. Continued.

No.	Taxon	Sampling method		Sample site	
		Sweeping	Pitfall trapping	Field	Margin
39	*C. concinna* (THORELL, 1875)	–	+	–	+
40	*Centromerus sylvaticus* (BLACKWALL, 1841)	–	+	–	+
41	*Ceratinella brevis* (WIDER, 1834)	–	+	–	+
42	*Dicymbium nigrum* (BLACKWALL, 1834)	–	+	+	+
43	*D. tibiale* (BLACKWALL, 1836)	–	+	–	+
44	*Diplocephalus cristatus* (BLACKWALL, 1833)	–	+	–	+
45	*D. picinus* (BLACKWALL, 1841)	+	+	–	+
46	*Diplostyla concolor* (WIDER, 1834)	+	+	+	+
47	*Dismodicus bifrons* (BLACKWALL, 1841)	–	+	–	+
48	*D. elevatus* (C.L. KOCH, 1838)	+	+	–	+
49	*Erigone atra* (BLACKWALL, 1833)	+	+	+	+
50	*E. dentipalpis* (WIDER, 1834)	+	+	+	+
51	*Erigonella hiemalis* (BLACKWALL, 1841)	–	+	+	+
52	*E. ignobilis* (O. PICKARD-CAMBRIDGE, 1871)	+	–	–	+
53	*Erigonidium graminicola* (SUNDEVALL, 1830)	+	–	+	+
54	*Floronia bucculenta* (CLERCK, 1758)	+	–	–	+
55	*Gnathonarium dentatum* (WIDER, 1834)	+	+	+	+
56	*Gonatium rubellum* (BLACKWALL, 1841)	+	–	–	+
57	*Gongylidium rufipes* (LINNAEUS, 1758)	+	–	–	+
58	*Hypomma bituberculatum* (WIDER, 1834)	+	–	–	+
59	*H. cornutum* (BLACKWALL, 1833)	+	+	–	+
60	*Kaestneria dorsalis* (WIDER, 1834)	+	–	–	+
61	*K. pullata* (O. PICKARD-CAMBRIDGE, 1863)	+	+	+	+
62	*Leptorhoptrum robustum* (WESTRING, 1851)	–	+	–	+
63	*Linyphia triangularis* (CLERCK, 1758)	+	–	–	+
64	*Micrargus herbigradus* (BLACKWALL, 1854)	+	–	–	+
65	*Microlinyphia pusilla* (SUNDEVALL, 1830)	+	+	+	+
66	*Moebelia penicillata* (WESTRING, 1851)	+	–	+	+
67	*Neriene clathrata* (SUNDEVALL, 1830)	–	+	–	+
68	*N. emphana* (WALCKENAER, 1841)	+	+	–	+
69	*Oedothorax agrestis* (BLACKWALL, 1853)	–	+	–	+
70	*O. apicatus* (BLACKWALL, 1850)	+	+	+	+
71	*O. gibbosus* (BLACKWALL, 1841)	+	+	–	+
72	*O. retusus* (WESTRING, 1851)	–	+	+	+
73	*Palliduphantes alutacius* (SIMON, 1884)	–	+	–	+
74	*Pocadicnemis pumila* (BLACKWALL, 1841)	–	+	–	+
75	*Porrhomma convexum* (WESTRING, 1851)	+	+	+	+
76	*P. pallidum* JACKSON, 1913	–	+	+	+
77	*Savignya frontata* BLACKWALL, 1833	+	+	+	+
78	*Silometopus elegans* (O. PICKARD-CAMBRIDGE, 1872)	+	–	–	+
79	*S. reussi* JACKSON, 1913	–	+	+	+
80	*Tallusia experta* (O. PICKARD-CAMBRIDGE, 1871)	–	+	+	+
81	*Tapinocyba biscissa* (O. PICKARD-CAMBRIDGE, 1872)	–	+	+	+
82	*T. pallens* (O. PICKARD-CAMBRIDGE, 1872)	+	–	+	–
83	*Tenuiphantes mengei* KULCZYŃSKI, 1887	–	+	–	+

Table 1. Continued.

No.	Taxon	Sampling method		Sample site	
		Sweeping	Pitfall trapping	Field	Margin
84	*T. nigriventris* (L. Koch, 1879)	+	+	–	+
85	*T. tenebricola* (Wider, 1834)	+	+	–	+
86	*Tiso vagans* (Blackwall, 1834)	–	+	–	+
87	*Trematocephalus cristatus* (Wider, 1834)	+	–	–	+
88	*Troxochrus scabriculus* (Westring, 1851)	–	+	+	+
89	*Walckenaeria antica* (Wider, 1834)	–	+	–	+
90	*W. atrotibialis* O. Pickard-Cambridge, 1878	–	+	–	+
91	*W. cucullata* (C.L. Koch, 1836)	–	+	–	+
92	*W. dysderoides* (Wider, 1834)	–	+	–	+
93	*W. nudipalpis* (Westring, 1851)	–	+	+	+
94	*W. unicornis* O. Pickard-Cambridge, 1861	+	+	+	+
95	*W. vigilax* (Blackwall, 1853)	+	+	+	+
	Liocranidae				
96	*Phrurolithus festivus* (C.L. Koch, 1835)	–	+	+	+
	Lycosidae				
97	*Hygrolycosa rubrofasciata* (Ohlert, 1865)	–	+	–	+
98	*Pardosa agrestis* (Westring, 1861)	–	+	+	+
99	*P. amentata* (Clerck, 1758)	+	+	+	+
100	*P. fulvipes* (Collett, 1875)	+	+	+	+
101	*P. prativaga* (L. Koch, 1870)	+	+	+	+
102	*P. lugubris* (Walckenaer, 1802)	–	+	+	+
103	*P. paludicola* (Clerck, 1758)	–	+	+	+
104	*P. palustris* (Linnaeus, 1758)	+	+	+	+
105	*P. pullata* (Clerck, 1758)	–	+	+	+
106	*Pirata hygrophilus* Thorell, 1872	–	+	+	+
107	*P. piraticus* (Clerck, 1758)	–	+	–	+
108	*Tarentula aculeata* (Clerck, 1758)	–	+	–	+
109	*Trochosa ruricola* (De Geer, 1778)	–	+	+	+
110	*T. terricola* Thorell, 1856	–	+	+	+
111	*Xerolycosa miniata* (C.L. Koch, 1834)	–	+	+	+
	Mimetidae				
112	*Ero furcata* (Villers, 1789)	+	+	–	+
	Philodromidae				
113	*Philodromus cespitum* (Walckenaer, 1802)	+	–	–	+
114	*Thanatus striatus* C.L. Koch, 1845	–	+	+	–
115	*Tibellus maritimus* (Menge, 1875)	+	–	+	+
116	*T. oblongus* (Walckenaer, 1802)	+	–	+	+
	Pisauridae				
117	*Dolomedes* sp.	+	+	+	+
	Salticidae				
118	*Dendryphantes rudis* (Sundevall, 1832)	+	–	–	+
119	*Euophrys frontalis* (Walckenaer, 1802)	–	+	–	+
120	*Evarcha arcuata* (Clerck, 1758)	+	–	–	+
121	*E. falcata* (Clerck, 1758)	+	–	–	+
122	*Heliophanus auratus* C.L. Koch, 1835	+	–	–	+

Table 1. Continued.

No.	Taxon	Sampling method		Sample site	
		Sweeping	Pitfall trapping	Field	Margin
123	*H. flavipes* (Hahn, 1832)	+	–	–	+
124	*Marpissa radiata* (Grube, 1859)	+	–	–	+
125	*Sitticus floricola* (C.L. Koch, 1837)	+	–	–	+
	Tetragnathidae				
126	*Metellina segmentata* (Clerck, 1758)	+	+	+	+
127	*Pachygnatha clercki* Sundevall, 1823	+	+	+	+
128	*P. degeeri* Sundevall, 1830	–	+	+	+
129	*P. listeri* Sundevall, 1830	–	+	–	+
130	*Tetragnatha dearmata* Thorell, 1873	+	–	+	+
131	*T. extensa* (Linnaeus, 1758)	+	–	+	+
132	*T. obtusa* C.L. Koch, 1837	+	–	+	+
133	*T. pinicola* L. Koch, 1870	+	–	+	+
	Theridiidae				
134	*Dipoena torva* (Thorell, 1875)	+	–	+	–
135	*Enoplognatha ovata* (Clerck, 1758)	+	–	+	+
136	*Robertus arundineti* (O. Pickard-Cambridge, 1863)	–	+	+	+
137	*R. lividus* (Blackwall, 1836)	–	+	+	+
138	*R. neglectus* (O. Pickard-Cambridge, 1863)	–	+	+	+
139	*Steatoda bipunctata* (Linnaeus, 1758)	+	–	+	+
140	*Theridion bimaculatum* (Linnaeus, 1767)	+	–	+	+
141	*T. pictum* (Walckenaer, 1802)	+	–	–	+
142	*T. sisyphium* (Clerck, 1758)	+	–	–	+
	Thomisidae				
143	*Misumena vatia* (Clerck, 1758)	+	–	+	+
144	*Ozyptila praticola* (C.L. Koch, 1837)	+	+	–	+
145	*O. trux* (Blackwall, 1846)	–	+	–	+
146	*Xysticus audax* (Schrank, 1803)	+	–	+	+
147	*X. kochi* Thorell, 1872	+	+	+	+
148	*X. lanio* C.L.Koch, 1845	–	+	+	–
149	*X. ulmi* (Hahn, 1831)	+	+	+	+
	Zoridae				
150	*Zora nemoralis* (Blackwall, 1861)	–	+	–	+
151	*Z. spinimana* (Sundevall, 1832)	–	+	–	+

wheat ear height correlated to each other and to soil moisture and OMC (Fig. 3). Weeds sprouted largely at moist sites with high humus content and hence the crop was undersized in these plots. Hortobiontous web-building spiders (excl. Araneidae) were positively associated with weed abundance (Fig. 3). They tended to concentrate on weed plants and were less abundant on "clear" wheat with high ears. The similar conclusion was made by Jmhasly, Nentwig (1995), discovered that weed strips as intercropping diverted the spiders from wheat crop. But generally weed intercropping increase spider density in agriculture fields and orchards (Riechert, Bishop 1990, Wyss *et al.* 1995, Feber *et al.* 1998). In this connection Samu *et al.* (1999) considered the habitat diversification interspersed throughout the crop (e.g. crop mixture or small weed patches) to be more effective than spatially segregated (e.g. weed strips).

Table 2. Number of the species and individuals in the studied agroecosystem.

Family	Number of species	%	Number of individuals	%
Anyphaenidae	1	0.7	1	0.1
Araneidae	9	6.0	211	11.0
Clubionidae	5	3.3	31	1.6
Dictynidae	2	1.3	117	6.1
Gnaphosidae	5	3.3	9	0.5
Hahniidae	3	2.0	5	0.3
Linyphiidae	70	46.4	489	25.4
Liocranidae	1	0.7	2	0.1
Lycosidae	15	9.9	397	20.6
Mimetidae	1	0.7	2	0.1
Philodromidae	4	2.6	23	1.2
Pisauridae	1	0.7	3	0.2
Salticidae	8	5.3	41	2.1
Tetragnathidae	8	5.3	285	14.8
Theridiidae	9	6.0	134	7.0
Thomisidae	7	4.6	172	8.9
Zoridae	2	1.3	4	0.2
Total	**151**	**100**	**1926**	**100**
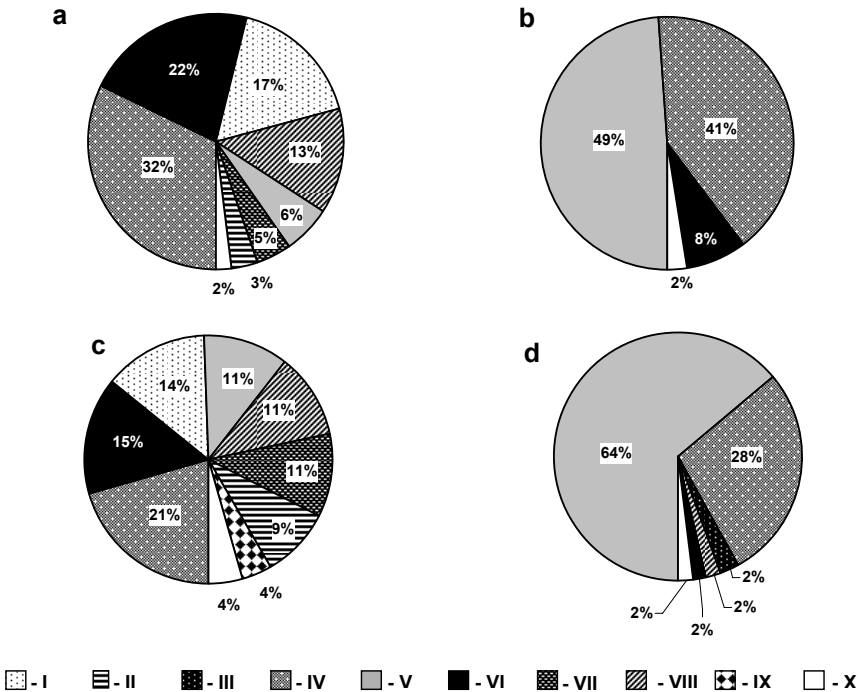
Fig. 2. Proportion of spider families in relative abundance (a, c) and in dynamic density (b, d) in the studied wheat agroecosystem: a, c - data obtained by sweeping, b, d - data obtained by pitfall traping, a, b - field centre, c, d - field margin, (I - Araneidae, II - Dictynidae, III - Gnaphosidae, IV - Linyphiidae, V - Lycosidae, VI - Tetragnathidae, VII - Theridiidae, VIII - Thomisidae, IX - Salticidae, X - other families).

In contrast, ambush crab spiders were more abundant in the plots with maximal wheat ear height and minimal weed abundance. This is likely to be accounted for by their preference for dry habitats (where crop was higher) rather than for the wheat itself. According to our data, these spiders are less numerous in crops as compared to margins (SEYFULINA, TSCHERNYSHEV 2001). Thomisid spiders choose dry microhabitats only within the cropland, but their distribution in the margins is affected by other factors (Fig. 4).

Plant Biomass

In plots rich in weeds the plant biomass was lower than in the other places probably because of the low mass of weeds as compared to wheat ears. The vegetation biomass in cropland did not correlate with the spiders' abundance within the field (Fig. 3), though in the field margins some spiders (Araneidae) preferred dense vegetation cover (Fig. 4).

Distribution Interdependency of Different Spider Groups

Within the cropland, only the distribution of two families (Tetragnathidae and Linyphiidae), which prefer weedy plots was interdependent (Fig. 3). There was no correlation between these families in the field margins (Fig. 4). The correlations between the allocations of the different spider families in the margins attracted attention, i.e. the distribution of all spiders was interconnected. At the same time, the correlations between many of the families with studied factors were insignificant, which suggests the presence of other factors not yet measured, for example, the vegetation type and the features of adjacent habitats. It is well known that spiders respond to the complexity and diversity of vegetation (BALFOUR, RYPSTRA 1998, RYPSTRA *et al.* 1999, SUNDERLAND, SAMU 2000).

Thus, both abiotic and biotic factors studied had different impact on the distribution of different spider groups. In the field margins these factors affected the spider distribution less than in the cropland probably due to the more complexity of the vegetation cover in the margins. The distribu-
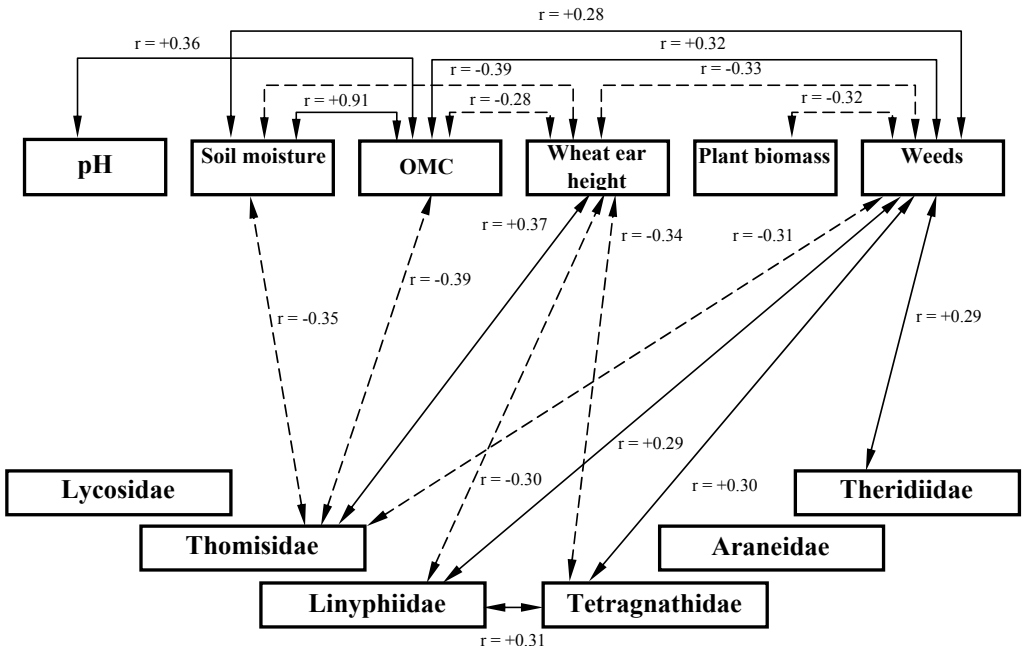
Fig. 3. Correlation between spider distribution and factors within the field: solid line represents significant positive correlation (p < 0.05), dashed line is significant negative correlation.
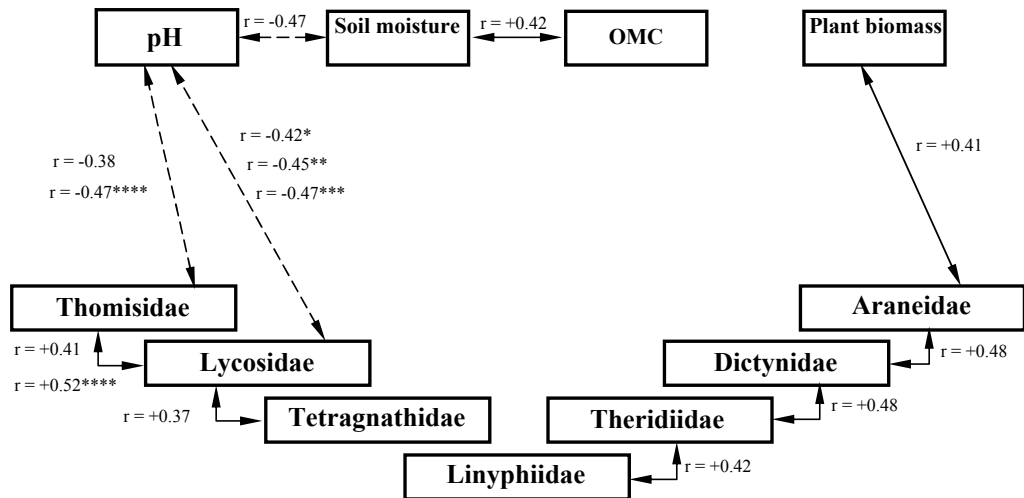
Fig. 4. Correlation between spider distribution and factors within the field margins: line notation are the same as in Fig. 3. * - data obtained by sweeping, ** - data obtained by pitfall traping, *** - *Pardosa* spp., **** - *Xysticus* spp.

tion of most hortobiont web-building spiders depended on the characteristics of crop vegetation cover, since they preferred weeds. At the same time, hortobiont hunting spiders were more sensitive to microclimate and preferred dry microhabitats. Herpetobiont spiders did not respond to soil characteristics in the field. The pattern of spider spatial distribution should be taken into account while carrying out ecological monitoring. Sampling over an entire field area is recommended to accurately estimate spider counts.

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Влияние на микрохабитатите върху разпространението на паяците в агроценоза от зимна пшеница (Araneae)

Р. Сейфулина

(Резюме)

Настоящето изследване е проведено в Московска област (Русия) в насаждение от зимна пшеница със затревена периферия. Събрани са 151 вида паяци от 17 семейства и 89 рода. В границите на агроценозата сред хортобионите паяци доминират семействата Linyphiidae, Tetragnathidae, Araneidae и Thomisidae, а сред епигейните – Lycosidae, Linyphiidae и Tetragnathidae. В периферията на насаждението хортобионтите са представени най-вече от видове от семействата Linyphiidae, Tetragnathidae и Araneidae, докато Lycosidae и Linyphiidae доминират сред херпетобионтите. Абиотичните (киселинност, влага, органика) и биотичните (височината на житните класове, обилието на бурените, растителната биомаса) фактори влияят различно върху разпространението на паяците. Като цяло въздействието им намалява в периферията на насаждението. Докато разпространението на хортобионтните мрежести паяци зависи основно от характеристиката на растителната покривка (установено е, че те предпочитат бурените), то паяците-ловци (крабовите паяци) са по-чувствителни към микроклимата и предпочитат сухи микрохабитати. Херпетобионтните паяци не зависят от почвената характеристика на полето. Авторът стига до извода, че при провеждането на мониторинг в бъдеще трябва да бъде взет под внимание моделът на пространствено разпределение на паяците.

The effects of cypermethrin on *Tenuiphantes tenuis* (Blackwall, 1852): development of a technique for assessing the impact of pesticides on web building in spiders (Araneae: Linyphiidae)

Emma M. Shaw[1], C. Philip Wheater[1], A. Mark Langan[1]

Abstract: The construction and design of webs are fundamental units of behaviour in spiders and can be used as an indicator of the impact of environmental stressors (for example pesticides) on their health. Very few studies have quantified web building by spiders that produce three dimensional webs, with the majority of published works concentrating on web building in orb weavers. An arena was developed to allow the filming of Linyphiidae to take place during the construction of sheet webs. The methods described are considered sensitive enough to detect the effects of exposure to different levels of the pesticide cypermethrin on *Tenuiphantes tenuis*. Exposure to high levels of cypermethrin resulted in increased mortality and reduced levels of activity detected through filming.

Key words: spiders, *Tenuiphantes tenuis,* cypermethrin, locomotion, mortality

Introduction

Spiders can be divided into two main categories in terms of foraging techniques; active hunting spiders and those that capture prey by means of a web. Web building spiders comprise a large proportion of spider species producing webs of many varying sizes, shapes and architectures. The construction and design of a web is one of the fundamental units of behaviour in spiders (Herbestein, Tso 2000) which can range from simplistic webs to some often highly complex structures. All web building spiders utilise their web in some way for prey capture and some spiders use it as a moulting or mating platform, as cocoon support, or as a sun shield (Zschokke 1994). Therefore, it is possible that exposure to environmental stressors, such as agrochemicals, may result in disturbances in the web building activity and web appearance. However, there is a current paucity of knowledge regarding the process of web building in many spider families which needs to be addressed before these more applied questions are examined.

Testing the effects of pesticides on web building behaviour is limited to a handful of works which mainly comprise of studies on two dimensional orb webs. Johansen (1967) was the first to describe the significant disruptions to web building associated with exposure to pesticide. The changes in the geometric pattern of the web were evident, even when low doses were sprayed directly onto the web (Johansen 1967) which has since been shown to be a particularly efficient collector of small droplets of pesticides (Samu *et al.* 1992). Subsequently, the sublethal effects of several pesticides were tested on *Larinioides sclopetarius* (Clerck, 1757) (Lengwiler, Benz 1994). This was the first time that pesticides had been applied topically to web building spiders to allow an exact amount of pesticide to be applied directly to the spiders. The effects varied

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with each pesticide, ranging from no effects with pirimicarb applications to increased mortality, delays to web building and a reduction in web size being associated with exposure to diazipon (Lengwiler, Benz 1994). However in European crops, orb weavers are generally not abundant and Linyphiidae are the dominant web building family.

Testing pesticide effects of web building behaviour in Linyphiidae spiders has yet to be documented, in part due to the complex nature of the web. Indeed, linyphiid web building per se had previously not been described prior to Benjamin *et al.* (2002), and Benjamin, Zschokke (2004). Benjamin, Zschokke (2004) were able to film web building by limiting the size that the spider was able to build the web in and thus were not able to quantify changes in behaviour.

The aim of the current study was to develop a protocol for assessing the impacts of commonly applied pesticides (e.g. cypermethrin) on the web building behaviour of *Tenuiphantes tenuis* (Blackwall, 1852) which is a common agricultural spider throughout Europe. The design had to allow spiders to build webs of differing sizes and enable the assessment of the changes in the size of those webs. Although filming would initially be used, subsequent monitoring was designed to be able to be conducted by eye. Thus the removal of part of the arena was required to allow this, and for feeding to take place.

Methods

Experimental Development

Initially an attempt was made to directly observe spiders beginning to build a web. This was to determine when web building took place (to allow accurate filming of the process) and what the best method of capturing this behaviour was and to gauge whether it was possible to collect data on web building by merely observation alone. However, spiders never initiated web building whilst an observer was present and often began building only several hours after the departure of the observer (this was assessed by returning to the arena at regular intervals). Therefore, it was concluded that to efficiently capture the process, filming would be required. It was also noted that during early developmental stages *T. tenuis* did not build a complete web for several days once placed in an arena. This was related to individuals building webs in the acclimation chambers during an initial starvation period. Those individuals that built webs within the acclimation chambers did not then build a web within the experimental arena. Spiders were therefore sequestered in small plastic vials during the acclimation and starvation period in order to limit the amount of web produced prior to experimentation. This resulted in individuals building connecting threads during the first evening in the arena and producing the beginnings of the sheet portion of the web during the second night.

On determining that filming would be required in order to compare behaviours successfully, a suitable arena in which spiders would build a web was required. A number of designs were attempted, many of which resulted in the spider not building a web or the spider building its' web on the roof of the arena or on the sides, but not in the middle of the arena where filming was possible. The type of arena used by Benjamin, Zshockke (2004) was deemed as unsuitable as it did not allow the spider to vary the size of the web that was built and would not allow the easy and continued monitoring of web size and development once filming had ceased.

Final Arena

Arenas (154 mm diameter) consisted of clear, plastic, circular containers with a transparent lid that allowed filming to take place (Fig. 1). A cardboard base, with a grid of 36 vertical, wooden uprights (60 mm high and set 20 mm apart), was inserted into the arena base. Approximately

Fig. 1. Final design of web building arena used to examine the effects of a pesticide on *T. tenuis*.

20 mm depth of silica sand was added to the arena and sprayed with distilled water to solidify the sand and provide moisture. In order to prevent spiders from attaching the web to the arena lid petroleum jelly was applied to the sides of the removable lid, allowing individuals to walk on that area but not allowing web points to be attached (S. Zschokke pers. comm.).

Treatments

All individuals (*n*=20) were collected from an area of grassland (Chorlton, Manchester, UK) that has not been sprayed with insecticides for over 10 years. An acclimation and starvation period of ten days was imposed on all individuals during which time they were sequestered in small plastic vials.

Spiders were exposed to a topically applied droplet (0.05 µl) of either distilled water or technical grade cypermethrin. All individuals were anaesthetised, using CO_2, prior to droplet application in order to reduce movement, thus ensuring all droplets were applied successfully. Following recovery from the effects of the CO_2, spiders were placed in the centre of the arena which was placed directly underneath a video camera.

Each spider was filmed, at an ambient temperature of 20°C (±1), over an 18 hour period in both light and dark (simulated by red light) conditions (3L/12D/3L). A time lapse video recorder (Panasonic Model AG-6010) was used to continuously record activity resulting in 24 hours film for every 1 hour of video tape. Filming took place in two dimensions only by placing the camera directly over the top of the arena (Fig. 2). Previous work has filmed spider movement from above and the side to allow a three dimensional view of the web building behaviour (Benjamin, Zschokke 2004). However, this was not possible in this experiment as it was necessary to be able to remove the arena lid to allow for accurate web size analyses throughout. Since this required petroleum jelly to be added to the arena walls, filming through the arena sides was not possible. As only one individual was filmed per night, the collection of spiders and the initiation of the starvation period were carried out in stages in order to ensure individuals were starved for similar lengths of time.

Fig. 2. Arena in position for filming showing the camera, red lights and time lapse recorder.

Each morning, once filming had ceased, the arena lid was removed and the amount of silk deposited, the position and the state of the spider were recorded and if a sheet portion of web had been produced, one prey item (*Sinella curriseta*) was introduced. Each individual was then monitored over a 30 day period assessing the changes in web size and spider condition, as well as recording the production of egg sacs and the number of hatchlings from those egg sacs.

Statistical analyses

Data were heavily skewed and transformation did not result in data meeting the assumptions of normality. Therefore, Mann Whitney U tests (StatView 5, SAS) were used to compare longevity after behavioural observations, the time spent moving, the distance travelled and the number of wooden uprights used in web building between treated and untreated individuals.

Results

Spiders exposed to cypermethrin died significantly earlier than individuals treated with distilled water ($U=13$, df=18, $P=0.0049$) with individuals in the treated cohort dying on average ten days after treatment and those in the control treatment surviving for the duration of the monitoring period (30 days; Fig. 3a). Exposure to cypermethrin also resulted in significantly reduced levels of movement during filming ($U=16.5$, df=18, $P=0.0199$); significantly shorter distances travelled ($U=13$, df=18, $P=0.0090$); and significantly lower numbers of uprights used in web building ($U=13$, df=18, $P=0.0053$). Treated individuals moved on average a distance of 1.14 m (±0.75) compared to control treated individuals that travelled a mean distance of over 3.25 m (±0.70) (Fig. 3b). This took place during a mean total movement time of 17.5 min (±12.4) for treated individuals and 32 min (±7.3) for control treated individuals (Fig. 3c). The size of web produced by the end of the trial, assessed by the number of uprights used in web attachment, was reduced to an average of ten uprights in the treated cohort whereas individuals in the control cohort used an average of 34 uprights (Fig. 3d).

Discussion

Exposure of *T. tenuis* to cypermethrin resulted in reductions in locomotor and web building behaviour and, as previously shown in *Pardosa amentata* (SHAW *et al.* 2004), culminated in high levels of mortality. The techniques used to assess these changes in behaviour were suitable for the current study but modifications are advised for future works in this area. The arenas allowed spiders to build webs of varying sizes, dependant on the exposure to pesticides. The results pro-
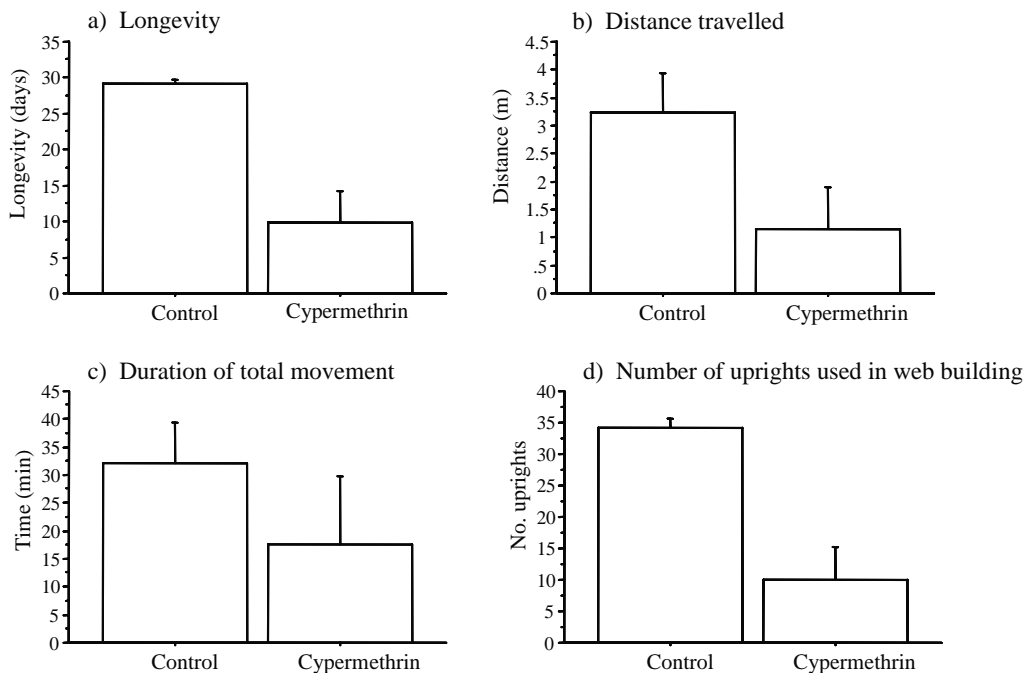
Fig. 3. Mean (± S.E.) responses of *Tenuiphantes tenuis* to droplets of cypermethrin or distilled water (Control).

duced detectable effects that were relatively easy to identify from the films produced. In future experiments it would be advised to increase the arena size in order to provide an area larger than the average size of the web of the particular spider species being studied. This may be a difficult assessment to make as the web building behaviour of many Linyphiidae is still unknown. However, the arena size that is currently being used may be sufficient for an initial assessment of web size for individual species prior to testing the effects of external stressors.

Filming of spiders gives an accurate assessment of the immediate impact of exposure to a pesticide and helps to give an insight into the sublethal changes in behaviour and, potentially the time scales over which these changes take place. The filming achieved only low levels of contrast between the spider and the background, mainly as a result of the small size of the spider. However, if a better contrast between the spider, the background and the wooden structures was achieved then a system such as Videomex-V (Columbus Instruments, Columbus, Ohio, USA) or Ethovision (Noldus Information Technology™) could be used in combination with the current arena. These are automated video based digital-data collection systems that allow the collection of data regarding activity patterns whilst filming is taking place. This system has been previously used to quantify the level of movement within a number of organisms including wolf spiders (Walker *et al*. 1999), mice (Murphy *et al*. 2001) and fish (Qian *et al*. 2001). The use of such a system would dramatically reduce the amount of time required for data extraction post filming. This could also facilitate the testing of exposure to pesticides via residual contact by treating some parts of an arena with pesticide and the remaining parts with distilled water. Videomex or Ethovision can then assess the levels of activity in each area of the arena to determine whether avoidance of treated areas occurs, as in true of some mites (Holland, Chapman 1994) and ladybirds (Singh *et al*. 2001) or how the level of effects are related to the time spent in treated areas.

Currently the impact of cypermethrin on the behaviour of *T. tenuis* is concurrent with effects observed in *P. amentata* (Baatrup, Bayley 1993, Shaw *et al*. 2004, 2006). This demonstrates that

despite pyrethroid pesticides being of a lower potency to non-target organisms than many other pesticides (e.g. organophosphates) there are still a high level of sublethal impacts of cypermethrin. This insecticide can potentially impact upon the feeding efficiency of individuals due to delays in web building (Shaw, unpublished data) and dispersal as a result of the paralysis of hind legs in *P. amentata* (Baatrup, Bayley 1993, Shaw *et al.* 2004, 2006).

The current work has highlighted a need to investigate the impact of repeated exposure to this, and other pesticides, and the effect of different modes of exposure (topical, residual and ingestion) in order to gain a more realistic view of what may occur in a treated crop. Furthermore, field based assessments are required to provide the most reliable results to be extrapolated into real environmental situations.

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Ефектът на циперметрина върху *Tenuiphantes tenuis* (BLACKWALL, 1852): разработване на техника за оценка на влиянието на пестициди върху изграждането на мрежи при паяците (Araneae: Linyphiidae)

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(Резюме)

Начинът на изграждане на мрежата и нейната структура са основни поведенчески характеристики на паяците и могат да бъдат използвани като индикатори за определяне влиянието на различни вредни вещества (например пестициди) върху тях. В настоящата статия е представен експеримент, при който в лабораторни условия паякът *Tenuiphantes tenuis* е третиран с разтвор с различна концентрация на пестицида циперметрин. Наблюдавана е по-висока смъртност и по-ниска двигателна активност сред тези екземпляри, които са изложени на действието на циперметрин с по-висока концентрация. Представена е методика за заснемане на линифиидни паяци по време на строежа на техните мрежи. За целта в лабораторни условия е построена специална арена, над която е монтирана камера.

Seasonal variation in spider abundance in Kuttanad rice agroecosystem, Kerala, India (Araneae)

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Abstract: The present study attempts to improve the understanding of resident spider population and seasonal variations in their diversity in the rice agroecosystem of Kuttanad, one of the "Rice Bowls of Kerala". The investigation was carried out for a period of 2 years from June 2001 to February 2003. Fortnightly sampling was done in four cropping seasons viz., Rabi 1 (June 2001 to September 2001), Kharif 1 (November 2001 to February 2002), Rabi 2 (June 2002 to September 2002) and Kharif 2 (November 2002 to February 2003). Spiders were collected from quadrates in 8 sites by hand-picking method. Different indices were calculated using the SPDIVERS.BAS programme. Spider population in Rabi and Kharif seasons exhibited slightly different species abundance and composition. Among the 94 species of spiders collected during the study, 70 species of 17 families were recorded in the Rabi season and 94 species of 20 families in the Kharif season. All families except Amaurobiidae, Pisauridae and Pholcidae were present in both seasons. A total of 68 species had common occurrence in both crop seasons. Results indicate that the interaction of seasons on spider abundance/assemblage was significant for Shannon, Richness and Evenness indices, but non-significant for Simpson's index. Population fluctuation of spiders showed insignificant difference between the two seasons.

Key words: diversity, abundance, spiders, rice agroecosystem, Kuttanad, India

Introduction

Spiders are potential biological control agents in agroecosystems (Rɪᴇᴄʜᴇʀᴛ, Lᴏᴄᴋʟᴇʏ 1984, Tᴀɴᴀᴋᴀ 1989, Bɪsʜᴏᴘ, Rɪᴇᴄʜᴇʀᴛ 1990). Many researchers have provided descriptions of spider species abundance or composition in a variety of agroecosystems (Wɪsɴɪᴇsᴡᴋᴀ, Pʀᴏᴋᴏᴘʏ 1997). Other researchers provided quantitative observations on the abundance of spiders (Cᴀʀʀᴏʟʟ, Hᴏʏᴛ 1984) or recorded spider predation events (Rɪᴇᴄʜᴇʀᴛ, Bɪsʜᴏᴘ 1990). A rice (*Oryza sativa* L.) field is a complex agroecosystem, containing many aquatic, semi-aquatic, and terrestrial species (Oʀᴀᴢᴇ *et al.* 1988). Spiders are well represented among the many predators found in this habitat. Numerous surveys of spiders have been conducted in the rice growing regions of Asia (Hᴇᴏɴɢ *et al.* 1991, Bᴀʀʀɪᴏɴ, Lɪᴛsɪɴɢᴇʀ 1995, Kɪᴍ 1995, Bᴀʀʀɪᴏɴ, Sᴄʜᴏᴇɴʟʏ 1999). The spider fauna of the rice fields in India has been studied by many authors. Basic studies were carried out by Pᴀᴛʜᴀᴋ, Sᴀʜᴀ (1999) and Bʜᴀᴛᴛᴀᴄʜᴀʀʏᴀ (2000). However, it is a less common practice among workers to compare spider abundance at different stages of crop growth with the exception of the work of Bᴀɴᴇʀᴊɪ *et al.* (1993). Aɴʙᴀʟᴀɢᴀɴ, Nᴀʀᴀʏᴀɴᴀsᴡᴀᴍʏ (1999) also analyzed the population fluctuation of spiders in paddy fields. Most of these studies were just limited to the identification of spiders and investigation of the dominant spider species. There has been no study on their seasonal variation and their ecological impact. Here we present the data that compare the abundance and richness of spiders between two cropping seasons and during different stages of the crop growth.

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Materials and Methods

Study Area: Kuttanad is rightly called one of the "Rice Bowls of Kerala", contributing nearly 20% of the total rice production of the Kerala state of India. This wetland rice agroecosystem extends from 9° 17' – 9° 40' N and 76° 19' – 76° 33' E. It is a low lying area of costal Kerala situated 0.6 – 2.2 m below mean sea level and formed by the confluence of 4 major river systems viz., Meenachil, Manimala, Pamba and Achancoil draining into the Vembanad Lake. It measures approximately 25 km east to west and 60 km north to south on the west coast of Kerala, in which about 53,639 hectares are used for rice cultivation. This is a warm, humid region and the seasonal variation in the temperature ranges from 21°C – 38°C. Humidity is also showing seasonal fluctuation and the average annual rainfall received is around 300 cm of which about 83% is received during monsoon period, from June to October.

Study Period: The investigation was carried out for a period of 2 years from June 2001 to February 2003. Sampling was conducted in four seasons; Rabi 1 (June 2001 – September 2001), Kharif 1 (November 2001 – February 2002), Rabi 2 (June 2002 – September 2002) and Kharif 2 (November 2002 – February 2003) at the following randomly selected 8 sites located in the same altitude: Krishnapuram, Vellisrakka, Edathua, Champakulam, Pallikoottuma, Pallathuruthy, Nedumudy and Moncompu. Rabi season is characterized by heavy rain (South-West Monsoon) and high humidity. More than 80% of the total annual rainfall is received during this season. Kharif season is characterized by low rainfall and dry weather (MENON *et al.* 2000).

Sampling: Sampling was done every 15 days after transplantation (DAT) from quadrates. Spiders were collected from 4 quadrates (1m × 1m) placed at four corners of 10m × 10m area by visual search method between 9.30 – 11.30 hours. A sufficient core area was left to avoid edge effects. All 4 quadrates were searched for a total of one hour. Seven visits were made per site per season. A total of 28 quadrates were studied in each season per site. Spiders were collected from the ground stratum and from the terminals of plants. Specimens from each quadrate were preserved in 75% alcohol in the field and counted under a stereo-zoom microscope (Leica-MS5) in the laboratory.

Identification of Spiders: The adult spiders were identified on species level and others on genus or family level using available literature (TIKADER 1987, BARRION, LITSINGER 1995). Monthly data were prepared for each season with detailed information on the occurrence of mature male, female and juvenile spiders. Voucher specimens were preserved in 75% alcohol and deposited in a reference collection housed with the Arachnology Division, Department of Zoology, Sacred Heart College, Cochin, Kerala, India.

Data Analysis: The diversity indices like the Shannon-Wiener index (H^1), which is sensitive to changes in the abundance of rare species in a community, and the Simpson index (λ), which is sensitive to changes in the most abundant species in a community, Margalef Richness index (R) and Evenness index (E) of spider communities were calculated using the SPDIVERS.BAS program of LUDWIG, REYNOLDS (1988). Shannon-Wiener index is defined as:

$H^1 = -\sum_i \log p_i$

Where: p_i = the observed relative abundance of a particular species (SOLOW 1993).

Simpson index is defined as:

$\lambda = \sum n_i (n_i\text{-}1)/ [N (N\text{-}1)]$

Where: n_i = the number of individuals of species i, and $N = \sum n_i$ (SOLOW 1993).

Margalef richness index is defined as:

$R = S\text{-}1/\text{In} (n)$.

Where: *S* = total number of species in a community, and *n* = total number of individuals observed.

Evenness index is defined as:

E = In (*N1*)/In (*N0*).

Where: *N1* = number of abundant species in the sample, and *N0* = number of all species in the sample. One tailed ANOVA tests were used to test the hypothesis that the crop growth stages and seasons resulted in different abundance and composition of spider assemblages. Feeding guild classification was done following UETZ *et al.* (1999).

Results

Species Composition: A total of 17,717 individuals belonging to 94 species, 64 genera and 20 families were collected during the study (Table 1). In the Rabi season 70 species of 17 families and in the Kharif season 94 species of 20 families were collected. The spider population in the Rabi and Kharif seasons exhibited a slightly different species composition. The family level composition also shows differences between the two seasons. All families except Amaurobiidae, Pisauridae and Pholcidae were present in both seasons and species that commonly appeared in both seasons numbered 68.

Table 1. List of spiders collected from the Kuttanad rice agroecosystem.

Family	No. of genera	No. of species	No. of individuals	Guild
Amaurobiidae	1	1	5	Sheet webs
Araneidae	5	11	2142	Orb weavers
Clubionidae	1	2	19	Foliage runners
Corinnidae	1	1	49	Ground runners
Gnaphosidae	1	1	11	Ground runners
Hersiliidae	1	1	8	Foliage runners
Linyphiidae	2	4	3576	Sheet webs
Lycosidae	4	9	3378	Ground runners
Miturgidae	1	1	11	Foliage runners
Oxyopidae	2	6	429	Stalkers
Philodromidae	2	2	14	Ambushers
Pholcidae	3	3	16	Space builders
Pisauridae	1	1	1	Ambushers
Salticidae	15	17	1625	Stalkers
Scytodidae	1	1	30	Ambushers
Sparassidae	2	3	42	Foliage runners
Tetragnathidae	6	12	4489	Orb weavers
Theridiidae	5	5	1760	Space builders
Thomisidae	6	6	75	Ambushers
Uloboridae	3	3	30	Orb weavers
Total	64	94	17717	

The spiders collected in the largest numbers were *Phycosoma martinae* (ROBERTS, 1983) (8.12% of total collection), *Pardosa pseudoannulata* (BÖSENBERG, STRAND, 1906) (7.13%), *Erigone bifurca* LOCKET, 1982 (7.07%), *Tetragnatha andamanensis* TIKADER, 1977 (7.05%). *Atypena adelinae* BARRION, LITSINGER, 1995 (6.75%), *Dyschiriognatha dentata* ZHU, WEN, 1978 (5.97%),

Araneus ellipticus (TIKADER, BAL, 1981) (5.26%), and *Tetragnatha cochinensis* GRAVELY, 1921 (4.77%). The major component of the spider population found in this ecosystem was the family Tetragnathidae composed mainly of *D. dentata*, *T. andamanensis*, *T. cochinensis* and the family Linyphiidae mainly composed of *Atyepena* and *Erigone*. Besides the above, Lycosidae and Araneidae were found in relatively large numbers. The families Tetragnathidae and Linyphiidae constituted 45%, while Lycosidae and Araneidae constituted 31% of the total collection.

In the Kharif season, Tetragnathidae and Lycosidae were the dominant families. However, in the Rabi season the second dominant family was Linyphiidae. Lycosidae constituted 20% of the Kharif spiders and 16.91% of the Rabi spiders. Eleven minor families constituted 1.163% of the total collected spiders. Theridiidae (9.93%), Salticidae (9.17%), Oxyopidae (2.42%), and Thomisidae (0.42 %) were also represented in the fauna from these sites.

Diversity, Evenness and Richness indices: There were some significant differences in Shannon index, Richness index and Evenness index between the two seasons. But the Simpson index was not significantly different in the two seasons. The highest Shannon index value of the Kharif season was 3.55 and the lowest was 2.95 with a mean of 3.32 ± 0.04. But in the Rabi season, it was 3.34 and 3.02 with a mean of 3.19 ± 0.02. The one way ANOVA showed that the Shannon index showed significant variation ($F_{1, 30} = 7.41$, $P = 0.01$) between the two seasons. In the case of the Simpson index, the maximum value of the Kharif season was 0.61 and the minimum was 0.37 with a mean of 0.46 ± 0.01. In the Rabi season, it was 0.56 and 0.37 and 0.47 ± 0.01. This showed no significant difference between the two seasons ($F_{1, 30} = 0.61$, $P = 0.04$). In the case of the Richness index, the Kharif maximum value was 9.88 and minimum 4.63 and mean 7.61 ± 0.40. However, in the Rabi season, it was 7.75 and 4.40 and 5.80 ± 0.27. This also showed a significant difference between the two seasons ($F_{1, 30} = 34.70$, $P = 0.08$). The average Evenness value of the Kharif season was 0.85 ± 0.01 with a maximum of 0.90 and a minimum of 0.82. In the Rabi season however it was 0.88 ± 0.01, 0.91 and 0.83 respectively. The ANOVA result showed a significant difference ($F_{1, 30} = 18.03$, $P = 0.01$). The above results indicated that the interaction of seasons on spider composition was significant for Shannon, Richness and Evenness indices, but was non-significant using the Simpson index.

Population: The population growth showed a gradual increase in the 15th, 30th and 45th DAT followed by a slight decrease in the 60th DAT. Then it continued to grow up to the 90th DAT and reached the peak and then showed a sudden decline (Fig. 1). The number of species obtained during the sampling showed a gradual increase in number as the growth of the plants advanced and the maximum number of 86 species was collected on the 90th DAT sampling. The number of individuals also increased as the crop growth advanced and the maximum number (5442) was collected in the 90th DAT. A doubling of individuals occurred between 60th and 75th DAT as shown in Table 2. The value of the Shannon index also showed a gradual increase except in the 60th DAT with an average of 3.05 during the entire growth. But the Simpson index value registered an irregularity and the maximum value was reached on the 15th DAT and the minimum on the 90th DAT with an average of 0.60. The richness index value showed the same tendency as number of individuals reached its peak during the 90th DAT. The value of evenness index showed more similarity in the 15th, 30th 45th and 60th DAT than 75th, 90th and 105th DAT. Spiders of the family Corinnidae appeared for the first time on the 45th DAT and Pholcidae with Pisauridae appeared in 75th DAT. No male spiders were collected in the 15th DAT and a peak of M: F ratio occurred in the 45th DAT and then declined. In the case of A: J ratio, peak value was obtained on the 30th DAT and then decreased. The fluctuation in the population density showed a difference between the web builders and the non-web builders. The density of web builders gradually increased and then decreased at the time of harvest. But hunters showed a trend of continuous increase in population density towards harvest (Fig. 1) and some families were present only at the final stage of crop growth. This study reveals that non-web builders outnumbered the web builders in this rice ecosystem.
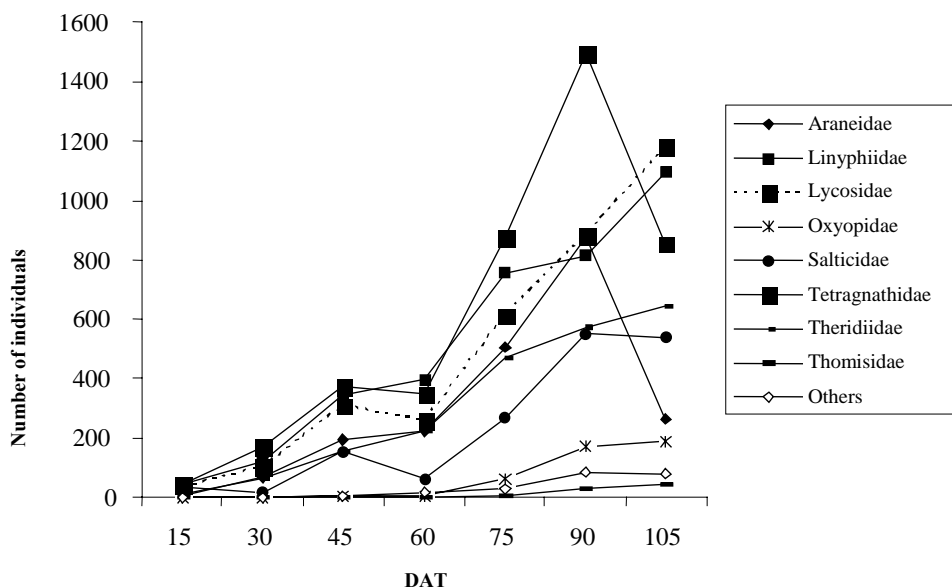
Fig. 1. Population fluctuation of individuals of dominant families during DAT of crop growth.

Table 2. N - Number of individuals, S - Number of species, H^1 - Shannon index, λ - Simpson index, R - Richness index, E - Evenness index, M:F - Male to Female ratio and A:J - Adult to Juvenile ratio during DAT of crop growth in Kuttanad rice agroecosystem during the study.

DAT	N	S	H^1	λ	R	E	M:F	A:J
15	0178	15	2.53	0.95	2.75	0.92	0.00	12.46
30	0544	19	2.68	0.76	2.95	0.89	6.33	23.81
45	1533	31	2.99	0.57	4.16	0.86	7.00	06.11
60	1542	38	2.96	0.64	5.10	0.80	2.38	02.21
75	3595	64	3.27	0.49	7.74	0.78	2.62	02.25
90	5442	86	3.56	0.37	9.92	0.79	2.21	01.77
105	4883	74	3.38	0.46	8.62	0.78	2.15	01.98
Total	17717	94	3.05	0.60	5.89	0.83	3.24	07.22

Discussion

Twenty spider families recorded from Kuttanad rice agroecosystem represent 43% of the families reported from the country (PLATNICK 2005). The number of families found here is as high as or higher than the number recorded for other biomes surveyed in India (JOSE *et al*. 2006). The numbers of taxa recorded are generally higher than those reported for other surveys of rice ecosystems. BARRION, LITSINGER (1984) collected 13,270 specimens belonging to 51 species under 64 genera and 16 families during a 3-year study. This difference in quantity and quality of spider fauna is related to the time of the collection and method of sampling. There are many environmental factors like seasonality, spatial heterogeneity, competition, predation, habitat type, environmental stability and productivity that can affect species diversity (RIECHERT, BISHOP 1990). We found overall significant differences in the diversity, evenness and richness between the two seasons. The results indicate that both seasons show different species composition. It might be expected that climatic changes through seasons would influence the abundance of spiders (KATO *et al*. 1995).

Studies of Russell-Smith (2002) established the importance of rain fall in the regional spider diversity. In the tropics, a continuum of species with extended seasonal ranges has been found (Basset 1991), which would give rise to variable samples at different times of the year. Most spiders are limited to a certain extent by environmental conditions. In general, different species have varying humidity and temperature preferences and are limited to those seasons which offer a microclimate within the range of their physiological tolerances. So the difference in species diversity between the two seasons is likely to be due to the difference in the amount of rainfall and temperature in the two seasons.

Diversity analysis determines the significance of observed differences in community structure between different crop growth stages and two seasons based on the species abundance distributions (Solow 1993). A diversity index incorporates both species richness and evenness in a single value (Magurran 1988). Two diversity indices used here are Shannon-Wiener index (H^1), which is sensitive to changes in the abundance of rare species in a community, and Simpson index (λ), which is sensitive to changes in the most abundant species in a community. In the present study, the value of H^1 increased as crop growth advanced. This indicates the presence of some rare species in the spider community as crop growth advanced. A decline in the value of λ as crop growth in the present study indicates the dominance of some spiders like tetragnathids and lycosids in the initial period of crop growth. A diversity index allows comparisons to be made between two conditions. This index is more easily interpreted than other diversity indices. If values for diversity indices are often difficult to interpret, species richness and evenness are often presented as separate values. In this form they provide important insights into the ecological changes that occur over time or the differences between ecological communities (Bisby 1995). It would appear that an unambiguous and straight forward index of species richness would be Richness index (R), the total number of species in a community. Species richness examines the number of species occurring in a habitat. Overall species richness is the most widely adopted diversity measure. However, since R depends on the sample size, it is limited as a comparative index. Hence, a number of indices have been proposed to measure species richness that is independent of the sample size. They are based on the relationship between R and total number of individuals observed, *n*, which increases with increasing sample size. When all species in a sample are equally abundant an evenness index will be at its maximum, decreasing towards zero as the relative abundance of the species diverges away from evenness. Probably the most common evenness index used by ecologists is E. An evenness index should be independent of the number of species in the sample. It has shown that the addition of a rare species to a sample that contains only a few species greatly change the value of E.

Additionally, there are many factors that determine the species composition. This may be related to the changes in the vegetation structure of the habitat. Kajak (1965) found that relative spider and prey densities were related to the structural diversity of the habitat, and Turnbull (1966) attributed similar relative predator and prey densities to environmental conditions operating in both groups. According to Turnbull (1973), most webs have specific attachment and space requirements. Cherrett (1964) found that adult orb weavers in a grass land habitat needed a vertical space of at least 25-30cm^2 for web placements, a factor which strongly limited those spiders to certain habitats. Other workers have also found the availability of specific structural features to limit the habitats occupied by various web-builders (Duffey 1962). Structurally complex crops, providing a wider assortment of resources, would be predicted to support a more diverse spider assemblage, thus increasing the chances of the "best" match between spiders and insect pests. The results of this study also indicate the influence of vegetation structure on the diversity of resident spider community. The web building and plant wandering spiders rely on vegetation for some part of their lives, either for finding food, building retreats or for web building. The structure of the vegetation is therefore expected to influence the diversity of spiders found in the habitat. Studies

have demonstrated that a correlation exists between the structural complexity of habitat and species diversity (UETZ 1979, ANDOW 1991). UETZ (1991) suggests that structurally more complex plants can support a more diverse spider community. DOWNIE *et al*. (1999) and NEW (1999) have demonstrated that the spiders are extremely sensitive to small changes in the habitat structure; including habitat complexity and microclimate characteristics. Thus the physical structure of the environments has an important influence on the habitat preferences of spider species especially web-building species (HURD, FAGAN 1992). Vegetation structure seems to influence the spider composition on family level because similar families cluster within a similar habitat type. The result also indicates that similar species are present at specific stage of crop growth. Thus, vegetation structure may be a more important determinant than the seasonal variation alone. This provides valuable insights as to why certain species may dominate at different times of the season. Vegetation architecture plays a major role in the species composition found within a habitat (GREENSTONE 1984, SCHEIDLER 1990), and vegetation which is structurally more complex can sustain higher abundance and diversity of spiders (HATLEY, MAC MAHON 1980). The final stage of the crop results in a habitat that is more complex and can support higher diversity. Surveys have demonstrated that spiders respond numerically to the diversity and complexity of the vegetation (RYPSTRA 1983, HALAJ *et al*. 1998). Difference in vegetation architecture during crop growth accounts for the different community structure of spiders in the present study. In addition, the difference in the seasonal abundance of spiders may be due to the variation in patterns of activity of individual spiders and the phenology of total spider community (COREY *et al*. 1998).

An increase in the spider population according to the plant growth tends to depend on prey availability and, if the density of prey becomes higher, spiders are expected to increase proportionally to some extent. The peak of population density of spiders coincides with an increase of insect pests (KIRITANI *et al*. 1972). It has already been pointed out by KOBAYASHI (1961) that the values of correlation coefficients between the population density of insect pests and that of spiders tend to increase from negative to positive form as crop growth advanced. As no quantitative evaluation was done on the insect pest density during this study, further investigations should be carried out to reveal the influence of insect pests on the resident spider community. The amount of preys alone does not affect the density of spiders. What can be cited as other important factors is the number of surviving individuals after hibernation and other repair works related to agriculture. The halter often deals a heavy blow up on spiders because it destroys the vegetation on the ground surface. The growth of weeds quickens the time of draining water from paddy fields and this is considered to promote migration of spiders from dikes to paddy fields and dikes can act as an over wintering place of pests and as a source of spiders (VAN DEN BOSH, TELFORD 1964)

The changes noted in spider association with specific crop stage at different sampling times were related to the flowering state of the crop. A multiple regression analysis of prey density versus various conditions of the physical environment and habitat features revealed the presence of a significant relationship between high insect density and the presence of flowering herbs and shrubs in the vicinity of the web (RIECHERT 1981). Although it is reasonable to expect a significant influence of crop characteristics on structuring the resident spider community, the importance of adjacent habitats must also be considered (DUELLI *et al*. 1990). Selective forces of the crop environment can act only on "what is available" i.e., sets of species colonizing in the fields from the neighbouring habitats. Neighbouring habitats may also influence the composition of crop spider fauna indirectly by modifying the dispersal of potential spider prey and predators in the patchy agricultural landscapes (POLIS *et al*. 1998). The quality of the adjacent habitats influences the spider composition of the focal habitat via multitudes of direct and indirect channels. Since no data were collected from the adjacent habitats and bunds, more studies should be carried out to reveal the influence of these habitats on the occurrence of spiders in the rice field proper.

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Сезонна изменчивост на паяците (Araneae) в оризова агроекосистема в Кутанад (Керала, Индия)

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(Резюме)

Проучен е видовият състав и сезонната динамика на паяците в оризова агроекосистема в Кутанад. Изследването е проведено от юни 2001 до февруари 2003 г. Материалът е улавян чрез ръчен сбор два пъти в месеца по време на четири жътвени сезона – Раби 1 (юни - септември 2001), Кариф 1 (ноември 2001 - февруари 2002), Раби 2 (юни - септември 2002) и Кариф 2 (ноември 2002 - февруари 2003). От събраните 94 вида паяци, 70 вида от 18 семейства са установени през сезона Rabi, а 94 вида от 21 семейства през сезона Кариф. Наблюдават се незначителни разлики в плътността и видовия състав на популациите в сезоните Раби и Кариф. Всички семейства, без Amaurobiidae, Pisauridae и Pholcidae, или общо 68 вида паяци, са установени и в двата сезона. Резултатите, анализирани чрез програмата SPDIVERS.BAS и индексите на Shannon, Richness и Evenness показват, че влиянието на сезона върху плътността на популациите и видовото разнообразие е значително, докато прилагането на индекса на Simpson показва обратното. Авторите стигат до извода, че флуктуациите в популациите през двата основни сезона са незначителни.

Spiders of Gaderská and Blatnická Dolina valleys in the southern part of Veľká Fatra Mts., Slovakia (Araneae)

Jaroslav Svatoň[1]*, Peter Gajdoš*[2]

Abstract: During the years 1974-1976 and 1986-1990, a research of epigeic spiders of the Gaderská and Blatnická Dolina valleys was carried out in 71 study sites. Altogether, 3295 spiders belonging to 293 species and 28 families were captured in the non-forest, ecotones and forest habitats. Out of the identified species, 32 are listed in the Red List of Spiders of Slovakia and one species (*Centromerus semiater*) has not been previously reported from Slovakia. The occurrence of *Meioneta innotabilis* is faunistically very important because it was considered an extinct species in Slovakia. *Zelotes puritanus* has been reported from Slovakia only from this area. The family Linyphiidae was eudominant in species composition (101 species – D=34.5%). Specimens from the families Linyphiidae, Lycosidae and Cybaeidae were the most abundant (D=23.4%, 17.4% and 12.3%). Eurytopic psychrophilous and mesophilous spiders represented the highest number of species. Species diversity in the research area is rather high, consisting of approximately 32.5% of the Slovak araneofauna. Four of the study forest habitats (relict origin oak, beech, fir-beech and pine forests) and two non-forest habitats (dry calcareous grassland and subalpine meadows) were evaluated as important habitats for spider diversity conservation and conservation of threatened spider species (territories with high diversity of spiders, with the highest proportion of endangered and rare species).

Key words: spiders, faunistics, nature conservation, Veľká Fatra National Park, North Slovakia

Introduction

The Gaderská and Blatnická Dolina valleys form the southern part of the Veľka Fatra Mts., which are important orographical units in Slovakia. In the zoogeographical classification, the area of the Veľka Fatra Mts. represents the Western Carpathian part of the subprovince of the Carpathian Mountains and the Central European Mountains. There occur animals of steppe, forest-steppe, cultural steppe, agricultural land, synantropic species, and also species of wetland and marshy biotopes. The submontanous, montanous, boreoalpine, subalpine and alpine species predominate in the area with many rare species, which occur in Slovakia only here. For some species this is the northern border of their distribution in Europe. The Cosmopolitan, Holarctic, Palearctic, Euro-Siberian, Siberian, European, Caucasian, Pontic, Submediterian, Boreo-alpine and Boreal elements of our fauna are manifested here.

From the point of view of arachnological research, the territory of the Veľká Fatra Mts., as well as the Gaderská and Blatnická Dolina valleys had received only little attention until 2000. Only a few papers (Svatoň 1981, 1983, Franc 2002) describe the spider fauna of the region. The territory was included in the Natura 2000 network in 2003 and this fact initiated an evaluation of the unpublished araneological material collected from 71 localities in this area in the periods 1974-1976 and 1986-1990. The aims of this study are to present the results of this inventory and to propose a classification of the studied habitats according to their importance from a point of view of the spider fauna conservation.

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Material and Methods

Study area

The study area comprises the upper part of the Blatnica and Gader Creek catchments (the area of Gaderská and Blatnická Dolina valleys). These valleys lie in the south western part of Veľká Fatra Mts. In accordance with the orographic division of Slovakia (Hromádka 1956) Veľká Fatra Mts. belongs to a zone of the inner Western Carpathians with crystalline core and Mesozoic cover. A predominant part of its geological base consists of limestone and dolomite rocks. This geological substratum allows the occurrence of high number of species which are bound to rocky limestone and dolomitic biotopes with numerous caves, semi-caves, rock hollows and clefts that create suitable conditions for troglophilous and cavernicolous species. From a biological point of view, the most valuable habitats are inaccessible rock walls, steep slopes and sharp ridges undisturbed by human activities. Natural vertical zoning of the vegetation is here quite often disturbed by following geomorphological factors: inclination, orientation, relief, wideness and depth of both valleys. This causes species inversion, which means occurrence of cryophilic plant and animal species at the bottoms of valleys below the zone of beech and oak forest and occurrence of thermophilous species in the top zone of the hills which surround the Gaderská and Blatnická Dolina valleys.

Due to different climatic, morphological, geological and vegetation conditions in addition to forestry and farming activities in Veľká Fatra Mts, as well as in the adjacent Turčianska Kotlina basin, the valleys support a high plant and animal diversity. Altitudinal zoning ranges from 385 m to 1500 m above the sea level, segmentation of terrain, different terrain expositions and different substratum create a vivid mosaic of contrasting sites, biocoenosis with various animal communities bound to these habitat types.

Sampling

The spider fauna was studied by different methods such as pitfall trapping, sifting detritus and dead leaves, sweeping herbal layer, beating the trees and shrubs, as well as individual collection under stones, in grass and among leaves. Spiders were fixed in 80% ethanol.

Study sites and habitats

Sampling was carried out in 71 study sites of different types of habitats (Appendix 1). The sites were chosen as the most representative habitat types of this region. They represent non-forest habitats (debris and rock formations, caves, dry calcareous meadows, hygrophilous and forest meadows, fen meadows, peat-bogs, subalpine meadows and shrubby habitats) and forest habitats such as alder (*Alnetum incanae*) forests growing on gravel deposits near creeks, pioneer birch habitat, original azonal oak forests (*Quercetum*), virgin and secondary beech forests (*Fagetum typicum*), original fir-beech forests (*Abieto-Fagetum*), secondary mixed beech-spruce forests (*Fageto-Piceetum*), original and secondary pine forests (*Pineetum*), original and secondary spruce forests (*Piceetum*) and original dwarf pine habitat (*Pinion mughi*).

Analysis

The evaluation of the main studied habitats in the Gaderská and Blatnická Dolina valleys was done on the basis of spider species richness and diversity, mainly by the presence of threatened and rare spider species. For analysis of species data the program CANOCO (TerBraak, Šmilauer 2002) was used. Richness of samples (N^1) related to Shannon entropy statistics (H) using the relation $N^1 = e^H$, Shannon's diversity (H), the maximum achievable value of the diversity (H_{max}) ($H_{max} = \log(S)$, S = number of species) in samples and evenness (J) ($J = H/\log(S)$) were calculated (Table 3).

Table 1. List of families: number of captured species and specimens.

Family	Species		Specimens	
	Number	**D (%)**	**Number**	**D (%)**
Atypidae	2	0.68	34	1.03
Pholcidae	1	0.34	1	0.03
Segestriidae	1	0.34	27	0.82
Dysderidae	3	1.02	17	0.52
Mimetidae	1	0.34	6	0.18
Theridiidae	19	6.48	53	1.61
Linyphiidae	101	34.47	772	23.43
Tetragnathidae	9	3.07	141	4.28
Araneidae	19	6.48	125	3.79
Lycosidae	30	10.24	572	17.36
Pisauridae	1	0.34	1	0.03
Agelenidae	9	3.07	69	2.09
Cybaeidae	1	0.34	404	12.26
Hahniidae	5	1.71	15	0.46
Dictynidae	3	1.02	17	0.52
Amaurobiidae	6	2.05	342	10.38
Titanoecidae	1	0.34	17	0.52
Anyphaenidae	1	0.34	9	0.27
Liocranidae	3	1.02	61	1.85
Clubionidae	9	3.07	22	0.67
Corinnidae	1	0.34	19	0.58
Gnaphosidae	13	4.44	180	5.46
Zoridae	5	1.71	20	0.61
Heteropodidae	1	0.34	35	1.06
Zodariidae	1	0.34	42	1.27
Philodromidae	8	2.73	52	1.58
Thomisidae	20	6.83	110	3.34
Salticidae	19	6.48	132	4.01
Total	**293**	**100**	**3295**	**100**

Table 2. Thermo-preference of the spider fauna in the study area: S – number of species, Sp – number of specimens, D – dominance (after Buchar 1983, 1992).

Thermo-preference	S	D (%)	Sp	D (%)
Thermophilous (T)	47	16.04	419	12.72
Psychrophilous (P)	78	26.62	1405	42.64
Mesophilous (M)	78	26.62	374	11.35
Eurytopic (Non-specific) (N)	87	29.69	1081	32.81
Not determined (?)	3	1.02	16	0.49
Total	**293**	**100**	**3295**	**100**

Table 3. Evaluation of the forest, ecotone and non-forest spider faunas in the study area. Sp – number of specimens, S – number of species, categories of threat: see Appendix 2, (1) – new species for Slovakia, Σ – total number of threatened species, N₁ – richness of species in samples, (H) – Shannon's diversity of samples, H$_{max}$ – H maximum in samples, J – evenness of samples.

Habitat	Sp	S	Categories of threat							N$_1$	(H)	H$_{max}$	J
			EX	CR	EN	VU	LR	DD	Σ				
Origin forests (Or.f.)	**1336**	**190**	**1**	**1**	**4**	**4**	**8**	**1**	**19**				
Alder forest (*Aln*)	161	26						1	1	5.81	1.76	3.26	0.54
Oak forest (*Qu*)	307	70		1	1	3	2		7	37.16	3.62	4.25	0.85
Beech forest (*Fag.*)	327	69				1	3	1	5	28.06	3.33	4.23	0.79
Fir-beech forest (*AbF*)	190	49	1			1	3		6	26.61	3.28	3.89	0.84
Spruce forest (*Pic*)	38	8				1			1	5.13	1.63	2.08	0.79
Pine forest (*Pin*)	256	77		1	2		5		8	44.91	3.80	4.34	0.87
Dwarf pine forest (*Pm*)	57	18			1				1	8.79	2.17	2.89	0.75
Secondary forests (Se.f.)	**531**	**92**				**1**	**2**		**3 (1)**				
Birch forest (*Bet*)	96	35				1			1	27.25	3.31	3.56	0.93
Beech forest (*Fag*)	30	9							0	6.05	1.80	2.20	0.82
Spruce forest (*Pic*)	224	36					2		2	9.37	2.24	3.58	0.62
Pine forest (*Pin*)	130	40							(1)	26.47	3.28	3.69	0.89
Mixed forest (*Mix*)	51	13							0	8.09	2.09	2.56	0.81

Table 3. Continued.

Habitat	Sp	S	Categories of threat						Σ	N_I	(H)	H_{max}	J
			EX	CR	EN	VU	LR	DD					
Ecotones	**273**	**95**			**1**	**0**	**2**		**3**				
O.pine forest	16	12							0	11.31	2.43	2.48	0.98
S.beech forest	6	6							0	6	1.79	1.79	1
S.spruce forest	242	81			1		2		3	56.07	4.03	4.39	0.92
Non-forest habitats	**1140**	**192**		**1**	**4**	**6**	**9**	**2**	**22**				
Debris and rock-faces (*Deb*)	50	26				1	2		3	20.13	3.0	3.26	0.92
Caves (*Cv*)	88	13				1	1		2	3.81	1.34	2.56	0.52
Shrubby habitat (Shr)	31	20					1		1	18.02	2.89	3.0	0.97
Dry calcareous grassland (*Dry*)	189	64			3	1	2	1	7	37.15	3.61	4.16	0.87
Subalpine meadows (*S-alp*)	338	91		1	2	3	3	1	10	54.44	3.98	4.51	0.89
Forest meadows and mesophilous meadows (*Mes*)	283	68				1	2		3	30.87	3.43	4.14	0.83
Fen meadows (Fen)	103	30							0	17.03	2.84	3.4	0.83
Peat bog	71	34			1		2	1	4	23.68	3.16	3.53	0.9

Many habitats were not evaluated because of the low number of captured specimens and species. For evaluation of the thermo preference of captured species Buchar's classification (BUCHAR 1983, 1992) was used. The nomenclature and systematic order of spiders follow PLATNICK (2005).

Results

Species composition

Altogether 3295 spiders belonging to 293 species were captured in non-forest and forest habitats. The species number in the Gaderská and Blatnická valleys is rather high, representing approximately 32.5 % of the Slovak araneofauna. Of the identified species, 32 species are included in The Red List of Spiders of Slovakia (GAJDOŠ *et al*. 1999, GAJDOŠ, SVATOŇ 2001) and one species (*Centromerus semiater*) has not been previously reported from Slovakia. Also the occurrence of the species *Meioneta innotabilis* was documented, which is important from a faunistic point of view, because this species was considered extinct in Slovakia. *Zelotes puritanus* has previously been reported from Slovakia only from this area (GAJDOŠ, SVATOŇ 1993, GAJDOŠ et *al*. 1999, FRANC 2002). The composition of the spider fauna in the habitats depends on the habitat types (Appendix 2).

Family composition

Twenty eight families were recorded in non-forest and forest ecosystems of the Gaderská and Blatnická Dolina valleys. The families Linyphiidae and Lycosidae were eudominant in the species composition (101 species – D-34.5%, 30 species – D-10.2%). Specimens from the families Linyphiidae, Lycosidae, Cybaeidae and Amaurobiidae were the most abundant (D - 23.4%, 17.4% 12.3% and 10.4 %) (Table 1).

Thermo-preference

The psychrophilous component was represented by 78 species (26.62%) and 1405 specimens (42.64%), while the mesophilous component was represented by 78 species (26.62%). The thermophilic fauna was presented in the study area by 47 species (16.04%), occuring mainly in the extremely dry calcareous meadows and azonal oak forests with southern exposition. The largest component of the captured species (87 species) belongs to eurytopic species (29.69%). The remaining few species can not be categorized (1.02%) (Table 2).

Evaluation of the spider fauna of forest habitats and ecotones

In the forest habitats, classified in 7 typological groups (*Alnetum incanae, pioneer habitat with Betula pubescens, Quercetum, Fagetum typicum, Abieto-Fagetum, Fageto-Piceetum* and *Pinion mughi*), the species diversity was high (216 species or 73.72% of all captured species, Appendix 2). In these ecosystems we also recorded many species that are significant and important from a faunistic-ecological, as well as from a zoogeographical point of view. The most important captures are: *Dasumia carpatica*, *Evansia merens*, *Mecynargus morulus*, *Meioneta innotabilis*, *Tenuiphantes zimmermanni*, and *Trichoncus hackmani*. In the ecotones the most important species are: *Pardosa sordidata*, *Peponocranium praeceps*, *Sitticus zimmermanni*, and *Poeciloneta variegata* (Appendix 2).

On the basis of the criteria chosen for the habitat evaluation, four of the habitats (relict pine forest (*Pinetum dealpinum*), relict azonal oak forest (*Quercetum*), original fir-beech forest, and original beech forest) were considered as important habitats for the spider diversity and also for conservation of threatened species. Of these habitats the relict pine forest has the highest species

richness (N_1 - 44. 91) and the highest number of threatened species (8 species). Of the ecotone habitats the margin of the secondary spruce forests presents high species richness (N_1 - 56.07) with occurrence of 3 threatened species (Table 3).

Evaluation of the spider fauna of non-forest habitat

From the non-forest habitats 192 spider species (65.53%) were recorded (Appendix 2). Several spider species bound to the non-forest ecosystems of the Gaderská and Blatnická Dolina valleys, are very important from faunistic-ecological and zoogeographical points of view. Such species are: *Notioscopus sarcinatus, Xysticus luctuosus*, *Tapinocyba biscissa*, *Tapinocyba pallens*, etc. *Centromerus capucinus*, *Centromerus serratus*, *Incestophantes crucifer*, *Improphantes improbulus*, *Peponocranium praeceps* and *Zelotes puritanus* were very rare in the collected material. On the basis of the criteria which have been chosen for the habitat evaluation, two of the studied non-forest habitats (dry calcareous grasslands and sub-alpine meadows) were evaluated as important habitats for conservation of both spider diversity and threatened species. From non-forest habitats the sub-alpine meadows present the highest species richness (N_1 - 54.44) and also manifest presence of threatened species (10 species) (Table 3).

Discussion

The recording of 293 spider species from a restricted area indicates the richeness of the habitats in the studied area. This makes approximately 32.5 % of the Slovak araneofauna, in spite of the fact that still relatively small part of Slovakia has been studied. The compositions of the spider fauna in the studied habitats were quite different, depending mainly on vegetation structure and various environmental factors, as well as on recent utilisation of the landscape. From the investigated non-forest habitats the spider communities of the open dry calcareous grasslands and sub-alpine meadows are especially interesting from nature conservation point of view (areas with high spider species diversity, with the highest proportion of threatened species). The cover of these habitat types is continually decreasing as a result of natural succession, and there is a urgent need for preparation of management plans for their protection.

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Паяци (Araneae) от долините Гадерска и Блатницка в южната част на планината Велка Фатра (Словакия)

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(Резюме)

В периода 1974-1976 и 1986-1990 г. е проведено изследване на епигейните паяци в 71 стации в долините Гадерска и Блатницка, намиращи се в южната част на планината Велка Фатра (Словакия). Уловени са 3295 екземпляра от 293 вида и 28 семейства, установени в екотонни или изцяло горски хабитати. Тридесет и два вида присъстват в Червения списък на паяците на Словакия, а един вид – *Centromerus semiater* – е нов за фауната на Словакия. Видовото разнообразие в долините Гадерска и Блатницка е високо и представлява 32.5% от словашката аранеофауна. Важни фаунистични приноси са намирането на *Meioneta innotabilis* – вид, смятан за изчезнал, и *Zelotes puritanus*, който е намиран само в този район на страната. Семейство Linyphiidae е еудоминантно (101 вида – D=34.5%), а най-много екземпляри са уловени от семействата Linyphiidae, Lycosidae и Cybaeidae (съответно D=23.4%, 17.4% и 12.3%). Евритопните, влаголюбивите и мезофилните паяци са представени с най-много видове. Четири от изследваните горски хабитати – реликтни дъбови, букови и борови гори, както и сухите пасища и субалпийските ливади, са важни за опазването на високото видово разнообразие и на големият брой застрашени видове.

Appendix 1. List of the studied sites with habitat types.

Locality	Habitat	Altitude
Original forests		
Blatnická dolina	alder forest (*Alnetum*)	542
Dedošova dolina	beech forest (*Fagetum typicum*)	650
Gaderská dolina	alder forest (*Alnetum*), gravel sediment	512
Horné piesky	flowery beech forest (*Fagetum dealpinum*)	850
Horné piesky	relict pine forest (*Pinetum dealpinum*)	987
Chládkove úplazy	relict pine forest (*Pinetum dealpinum*)	1228
Kamenný úplaz	relict pine forest (*Pinetum dealpinum*)	725
Mohošov	flowery beech forest (*Fagetum dealpinum*)	750
Mohošov grúň	flowery beech forest (*Fagetum dealpinum*)	1136
Nad Ďurďášovou	relict pine forest (*Pinetum dealpinum*)	997
Nad Mažarnou	relict oak forest with lime trees	890
Ostrá	relict pine forest (*Pinetum dealpinum*)	1100
Padva	virgin beech-fir forest (*Fageto-Abietum*)	950
Pod Mažarnou	virgin debris beech forest	780
Smrekov	origin dwarf pine habitat	1441
Široká	beech forest (*Fagetum typicum*)	950
Veterné	beech forest (*Fagetum typicum*)	900
Zadná hubná	beech forest (*Fagetum typicum*)	1003
Secondary forests		
Dedošova dolina	secondary spruce forest	650
Gaderská dolina	secondary spruce forest	574
Ľubená	secondary spruce forest	1024
Nad Mažarnou	mixed beech and spruce forest	950
Plešovica	secondary pine forest	685
Pod Rovnou	pioneer birch growth (15-20 year old) after fire	870
Pod vôdkami	secondary spruce forest	650
Predná hubná	mixed spruce and pine forest	800
Príkra	secondary spruce forest	795
Široká	secondary spruce forest	902
Škap	secondary spruce forest	770
Žihľavná	secondary pine forest	752
Ecotone habitats		
Dedošova dolina	margin of secondary spruce forest	567
Dolné piesky	margin of beech forest (*Fagetum typicum*)	594
Gaderská dolina	margin of secondary spruce forest	574
Horné piesky	margin of relict pine forest (*Pinetum dealpinum*)	1005
Ostrá	margin of relict pine forest (*Pinetum dealpinum*)	1103
Rovná dolina	margin of beech forest (*Fagetum typicum*)	595

Appendix 1. Continued.

Locality	Habitat	Altitude
Shrubby habitat		
Mohošov	dry shrubby meadow	1050
Meadow habitats		
Horné piesky	dry calcareous meadow	1003
Horné piesky	xerotherm forest meadow	952
Horný Jasienok	xerotherm forest meadow	948
Kamenný úplaz	dry calcareous meadow	1203
Kozia skala	dry calcareous meadow	1162
Kozia skala	xerotherm forest meadow under summit	1121
Mohošov grúň	dry forest meadow	1136
Mohošovec	dry calcareous meadow	1050
Nad Ďurďášovou	dry calcareous meadows on the foot of rock formations	700
Pod Rovnou	dry shrubby meadow	879
Široká	dry calcareous meadows	950
Veľká Skalná	dry calcareous meadow	1297
Vrátna	dry forest meadow	785
Blatnica: amfiteater	forest meadow along creek	500
Blatnická dolina	forest meadow along creek	550
Dedošová, under summit	complex of forest meadows after fire	670
Dolné piesky	forest meadow	575
Kráľov grúň	subalpine meadow	1360
Kráľova studňa	subalpine meadow	1574
Kráľova studňa	mountain meadow	1574
Krížna	subalpine meadow	1574
Magura	mesophilous forest meadow	1142
Mohošov	peat bog	730
Ostrá, summit	subalpine meadow	1264
Pod Žihlavnou	mesophilous meadow	550
Selenec	mesophilous and wet forest meadows	675
Tlstá, summit	subalpine meadow	1370
Caves, debris and rock formations		
Gaderská dolina	rock formations	574
Konský dol	rock formations	620
Mažarná	cave	850
Nad vôdkami	rock formations	1200
Smrekov	debris in subalpine zone	1441
Široká	debris	951

Appendix 2. List of the species collected from different habitats in the Gaderská and Blatnická valleys. TP stands for the thermo preference classification of Buchar (Buchar 1992). For explanation of the classification letters see the text in Table 2; for the abbreviations of the habitat types see Table 3 Red List, categories of threat: EX – considered extinct, CR - critically endangered, EN - endangered, VU - vulnerable LR - lower risk, DD – data deficient.

FAMILY / Species	Red list	TP	Origin forests						Secondary forests						Ecoton Or.		Ecoton Se.			Rocky			Peat	Meadows				Σ
			Aln.	Fag	Qu	Pic	AbF	Pin	Pm	Bet	Fag	Pic.	Pin	Mix	Fag	Pin	Fag	Pic	Pin	Shr	Deb	Cv	bog	Dry	Mes	Fen	S-alp	
ATYPIDAE (2)																												
Atypus affinis Eichwald, 1830		T			6		17																		1			24
Atypus piceus (Sulzer, 1776)		T			10																							10
PHOLCIDAE (1)																												
Pholcus opilionoides (Schrank, 1781)		T			1																							1
SEGESTRIIDAE (1)																												
Segestria senoculata (Linnaeus, 1758)		P		3	1		1		4		2	4	1			1					5			3			1	27
DYSDERIDAE (3)																												
Dasumia carpatica (Kulczyński, 1882)	LR (nt)	M		1	5		1																	1			1	9
Dysdera erythrina (Walckenaer, 1802)		T			1																			6				7
Harpactea lepida (C. L. Koch, 1838)		M				1																						1
MIMETIDAE (1)																												
Ero furcata (Villers, 1789)		M							2															3	1			6
THERIDIIDAE (19)																												
Achaearanea lunata (Clerck, 1757)		M																3			1							4
Crustulina guttata (Wider, 1834)		M		1			1						1															3
Dipoena erythropus (Simon, 1881)		T																					1					1
Enoplognatha ovata (Clerck, 1757)		M					1						1					2										4

Appendix 2. Continued.

Red list	TP	FAMILY / Species	Origin forests							Secondary forests					Ecoton Or.		Ecoton Se.			Rocky			Peat		Meadows			Σ
			Aln.	Fag	Qu	Pic	AbF	Pin	Pm	Bet	Fag	Pic.	Pin	Mix	Fag	Pin	Fag	Pic	Pin	Shr	Deb	Cv	bog	Dry	Mes	Fen	S-alp	
	M	*Episinus angulatus* (BLACKWALL, 1836)																				1			2			3
	T	*Episinus truncatus* LATREILLE, 1809			1		2																					3
	M	*Euryopis flavomaculata* (C. L. KOCH, 1836)																			1							1
	M	*Neottiura bimaculata* (LINNAEUS, 1767)					1																		5			6
	M	*Robertus arundineti* (O.P.-CAMBRIDGE, 1871)				2																						2
	P	*Robertus lividus* (BLACKWALL, 1836)			2						1																	3
LR (nt)	N	*Robertus neglectus* (O.P.-CAMBRIDGE, 1871)				2																			1			3
	P	*Robertus truncorum* (L. KOCH, 1872)				1		1				1																3
	M	*Steatoda albomaculata* (DE GEER, 1778)																									1	1
	N	*Steatoda phalerata* (PANZER, 1801)																							1		1	2
	T	*Theridion betteni* WIEHLE, 1960			1																7							8
	N	*Theridion impressum* L. KOCH, 1881																									1	1
	M	*Theridion mystaceum* L. KOCH, 1870			1																							1
	N	*Theridion sisyphium* (CLERCK, 1757)										1																1
	N	*Theridion varians* HAHN, 1833																							3			3
		LINYPHIIDAE (101)																									
LR (lc)	P	*Agyneta subtilis* (O.P.-CAMBRIDGE, 1863)				5																	2					7

Appendix 2. Continued.

Red list	TP	FAMILY / Species	Origin forests						Secondary forests						Ecoton Or.		Ecoton Se.			Rocky			Peat		Meadows			Σ
			Aln.	Fag	Qu	Pic	AbF	Pin	Pm	Bet	Fag	Pic.	Pin	Mix	Fag	Pin	Fag	Pic	Pin	Shr	Deb	Cv	bog	Dry	Mes	Fen	S-alp	
LR (lc)	P	*Anguliphantes tripartitus* MILLER, SVATON, 1978										1									1							2
	N	*Bathyphantes nigrinus* (WESTRING, 1851)	2			10																2							14
	P	*Bolyphantes alticeps* (SUNDEVALL, 1833)					1												1					2		1	2		7
	P	*Centromerus arcanus* (O.P.-CAMBRIDGE, 1873)				2							1												1			6	10
EN	T	*Centromerus capucinus* (SIMON, 1884)																										1	1
	N	*Centromerus incilium* (L. KOCH, 1881)	1		6	1	4			6			2	1											3	2		4	30
	P	*Centromerus pabulator* (O.P.-CAMBRIDGE, 1875)					2		1			1																2	6
	P	*Centromerus sellarius* (SIMON, 1884)		3												1													4
new	M	*Centromerus semiater* (L. KOCH, 1879)											1																1
VU	N	*Centromerus serratus* (O.P.-CAMBRIDGE, 1875)																							1				1
	N	*Centromerus sylvaticus* (BLACKWALL, 1841)				1							2																3
	P	*Ceratinella brevipes* (WESTRING, 1851)											2																2
	N	*Ceratinella brevis* (WIDER, 1834)																							1			1	2
	M	*Ceratinella major* KULCZYNSKI, 1894					1																						1
	M	*Ceratinella scabrosa* (O.P.-CAMBRIDGE, 1871)																										1	1
	M	*Dicymbium brevisetosum* LOCKET, 1962	2			5																							7

Appendix 2. Continued.

Red list	TP	FAMILY / Species	Origin forests						Secondary forests						Ecoton Or.		Ecoton Se.			Rocky			Peat		Meadows			Σ
			Aln.	Fag	Qu	Pic	AbF	Pin	Pm	Bet	Fag	Pic.	Pin	Mix	Fag	Pin	Fag	Pic	Pin	Shr	Deb	Cv	bog	Dry	Mes	Fen	S-alp	
	N	*Dicymbium nigrum* (BLACKWALL, 1834)				6						1																7
	N	*Diplocephalus cristatus* (BLACKWALL, 1833)				4													2										6
	N	*Diplocephalus latifrons* (O.P.-CAMBRIDGE, 1863)		1		6		8				21							1									34	71
	N	*Diplocephalus picinus* (BLACKWALL, 1841)		2															4										6
	N	*Diplostyla concolor* (WIDER, 1834)		1		1																			1				3
	P	*Dismodicus bifrons* (BLACKWALL, 1841)																	1										1
	P	*Drapetisca socialis* (SUNDEVALL, 1833)												7								3						10
	M	*Entelecara acuminata* (WIDER, 1834)	2																										2
	M	*Entelecara congenera* (O.P.-CAMBRIDGE, 1879)																	2										2
	N	*Erigone atra* BLACKWALL, 1833			1														4							1		1	7
	N	*Erigone dentipalpis* (WIDER, 1834)	1				1							1					7										10
LR (nt)	T	*Erigonoplus globipes* (L. Koch, 1872)					1																						1
VU	P	*Evansia merens* (CLERCK, 1757)		1				1																				4	6
	M	*Gonatium paradoxum* (L. KOCH, 1869)		1																						2		1	4
	P	*Gonatium rubellum* (BLACKWALL, 1841)					1																			1		1	3
	P	*Helophora insignis* (BLACKWALL, 1841)	2																										2

Appendix 2. Continued.

Red list	TP	FAMILY / Species	Origin forests							Secondary forests					Ecoton Or.		Ecoton Se.			Rocky			Peat		Meadows			Σ
			Aln.	Fag	Qu	Pic	AbF	Pin	Pm	Bet	Fag	Pic.	Pin	Mix	Fag	Pin	Fag	Pic	Pin	Shr	Deb	Cv	bog	Dry	Mes	Fen	S-alp	
VU	M	*Improphantes improbulus* (Simon, 1929)								2											2	4						8
VU	M	*Incestophantes crucifer* (Menge, 1866)																							1			1
	M	*Kaestneria dorsalis* (Wider, 1834)					1																					1
	M	*Kaestneria torrentum* (Kulczyński, 1882)				4																						4
	M	*Lepthyphantes leprosus* (Ohlert, 1865)											2															2
	M	*Lepthyphantes minutus* (Blackwall, 1833)		1														1										2
N	N	*Linyphia triangularis* (Clerck, 1757)		1			12					2							7					2	1	44	4	4	77
	N	*Macrargus rufus* (Wider, 1834)		2																					2				4
	N	*Mansuphantes mansuetus* (Thorell, 1875)		1	1	1	1						1												1		1	7
DD	M	*Maso gallicus* Simon, 1894		1																								1
	P	*Maso sundevalli* (Westring, 1851)		15			4																		11				30
EN	P	*Mecynargus morulus* (O.P.-Cambridge, 1873)							1																			1
	P	*Meioneta affinis* (Kulczyński, 1898)																							1				1
	M	*Meioneta equestris* (L. Koch, 1881)											1									1					1	3
	T	*Meioneta fuscipalpa* (C. L. Koch, 1836)					1																					1
EX	M	*Meioneta innotabilis* (O.P.-Cambridge, 1863)			1																							1

Appendix 2. Continued.

Red list	TP	FAMILY / Species	Origin forests							Secondary forests					Ecoton Or.		Ecoton Se.			Rocky			Peat		Meadows			Σ
			Aln.	Fag	Qu	Pic	AbF	Pin	Pm	Bet	Fag	Pic.	Pin	Mix	Fag	Pin	Fag	Pic	Pin	Shr	Deb	Cv	bog	Dry	Mes	Fen	S-alp	Σ
	N	*Metioneta rurestris* (C. L. KOCH, 1836)					2		2	1								1	1		2			1		2		11	22
	M	*Micrargus georgescuae* MILLIDGE, 1976																					1					2	3
	P	*Micrargus herbigradus* (BLACKWALL, 1854)							2										1			1		1				11	16
	N	*Micrargus subaequalis* (WESTRING, 1851)						1																					1
	N	*Microlinyphia pusilla* (SUNDEVALL, 1830)	1	4	5	1									1		1	2											15
	N	*Microneta viaria* (BLACKWALL, 1841)																3									1	6	10
	N	*Minicia marginella* (WIDER, 1834)					1																						1
	M	*Minyriolus pusillus* (WIDER, 1834)																							2				2
	P	*Mughiphantes mughi* (FICKERT, 1875)		1		2		3										8											14
	P	*Mughiphantes pulcher* (KULCZYŃSKI, 1881)																										1	1
	M	*Neriene emphana* (WALCKENAER, 1842)					1							1			1								5	2		10
	M	*Neriene peltata* (WIDER, 1834)		1		4	2					1						10		1					2	8			29
	M	*Neriene radiata* (WALCKENAER, 1842)		1														1								1			3
LR (nt)	P	*Notioscopus sarcinatus* (O.P.-CAMBRIDGE, 1872)																					15						15
	P	*Obscuriphantes obscurus* (BLACKWALL, 1841)											1							2									3
	M	*Oedothorax agrestis* (BLACKWALL, 1853)			1																								1

Appendix 2. Continued.

Red list	TP	FAMILY / Species	Origin forests							Secondary forests					Ecoton Or.		Ecoton Se.			Rocky			Peat	Dry	Meadows			Σ
			Aln.	Fag	Qu	Pic	AbF	Pin	Pm	Bet	Fag	Pic.	Pin	Mix	Fag	Pin	Fag	Pic	Pin	Shr	Deb	Cv	bog	Dry	Mes	Fen	S-alp	
	M	*Oedothorax apicatus* (BLACKWALL, 1850)	1																									1
	P	*Oedothorax fuscus* (BLACKWALL, 1834)																								1		1
	P	*Oedothorax gibbifer* (KULCZYŃSKI, 1882)	1																									1
	P	*Oedothorax gibbosus* (BLACKWALL, 1841)				5																						5
	P	*Oedothorax retusus* (WESTRING, 1851)																								4		4
	M	*Palliduphantes alutacius* SIMON, 1884																				1						1
	N	*Palliduphantes pallidus* (O.P.-CAMBRIDGE, 1871)		2																								2
EN	?	*Peponocranium praeceps* MILLER, 1943					1											1		2							10	14
	N	*Pelecopsis radicicola* (L. Koch, 1872)																						2				2
	P	*Pityohyphantes phrygianus* (C. L. Koch, 1836)		1	1	1												4									3		10
	N	*Pocadicnemis pumila* (BLACKWALL, 1841)																					3		1			4
LR (lc)	P	*Poeciloneta variegata* (BLACKWALL, 1841)																2				1						3
	P	*Porrhomma pygmaeum* (BLACKWALL, 1834)					1																			1		2
	P	*Saloca diceros* (O.P.-CAMBRIDGE, 1871)											1															1
LR (lc)	P	*Saloca kulczynskii* MILLER, KRATOCHVIL, 1939				2						2																4
LR (nt)	P	*Sauron rayi* (SIMON, 1881)		1	5	2	1																		1			8

Appendix 2. Continued.

Red list	TP	FAMILY / Species	Origin forests							Secondary forests					Ecoton Or.		Ecoton Se.			Rocky			Peat		Meadows			Σ
			Aln.	Fag	Qu	Pic	AbF	Pin	Pm	Bet	Fag	Pic.	Pin	Mix	Fag	Pin	Fag	Pic	Pin	Shr	Deb	Cv	bog	Dry	Mes	Fen	S-alp	
	P	*Sintula corniger* (Blackwall, 1856)			16																1								17
	P	*Tapinocyba affinis* Lesseri, 1907				1																							1
DD	M	*Tapinocyba biscissa* (O.P.-Cambridge, 1872)																										1	1
DD	M	*Tapinocyba pallens* (O.P.-Cambridge, 1872)																					1	1				2
	P	*Tenuiphantes alacris* (Blackwall, 1853)		5		13						4			2							1			1		1	27
	P	*Tenuiphantes cristatus* (Menge, 1866)		1						1		2						7						1	1		1	14
	N	*Tenuiphantes flavipes* (Blackwall, 1854)			2		1			2																1			6
	N	*Tenuiphantes mengei* (Kulczyński, 1887)																						1	3			3	7
	P	*Tenuiphantes tenebricola* (Wider, 1834)	4	19		4		12				9	4	1			1	9										4	67
LR (nt)	P	*Tenuiphantes zimmermanni* (Bertkau, 1890)	3	1		2	1																					1	8
	P	*Thyreosthenius parasiticus* (Westring, 1851)		1																									1
	N	*Trematocephalus cristatus* (Wider, 1834)				2																							2
VU	T	*Trichoncus hackmani* Millidge, 1956			3																								3
	N	*Walckenaeria antic* (Wider, 1834)				1																							1
	M	*Walckenaeria atrotibialis* (O.P.-Cambridge, 1878)																										1	1
	P	*Walckenaeria cucullata* (C. L. Koch, 1836)		3																									3

Appendix 2. Continued.

Red list	TP	FAMILY / Species	Aln.	Origin forests						Secondary forests					Ecoton Or.	Ecoton Se.				Rocky			Peat	Dry	Meadows			Σ
				Fag	Qu	Pic	AbF	Pin	Pm	Bet	Fag	Pic.	Pin	Mix	Fag	Pin	Fag	Pic	Pin	Shr	Deb	Cv	bog	Dry	Mes	Fen	S-alp	
N		*Walckenaeria furcillata* (Menge, 1869)		1	3		2						1														2	9
N		*Walckenaeria mitrata* (Menge, 1868)			1																1			2				4
P		*Walckenaeria nudipalpis* (Westring, 1851)																	2									2
P		*Walckenaeria obtusa* Blackwall, 1836																										3	3
		TETRAGNATHIDAE (9)																										
P		*Meta menardi* (Latreille, 1804)																				54						54
P		*Metellina mengei* (Blackwall, 1870)				1													6							2		1	10
P		*Metellina merianae* (Scopoli, 1763)				1	1																18						20
P		*Metellina segmentata* (Clerck, 1757)																	1							1			2
M		*Pachygnatha clercki* Sundevall, 1823																						1					1
N		*Pachygnatha degeeri* Sundevall, 1830																	8										8
M		*Pachygnatha listeri* Sundevall, 1830				11	1												3					2			9		26
M		*Tetragnatha extensa* (Linnaeus, 1758)	1																										1
N		*Tetragnatha pinicola* L. Koch, 1870				1	1					2	2						8							2	2	1	19
		ARANEIDAE (19)																										
P		*Aculepeira ceropegia* (Walckenaer, 1802)						3											3						2		5	1	14
M		*Araneus alsine* (Walckenaer, 1802)																	1								1		2

Appendix 2. Continued.

Red list	TP	FAMILY / Species	Origin forests							Secondary forests					Ecoton Or.		Ecoton Se.			Rocky			Peat		Meadows			Σ
			Aln.	Fag	Qu	Pic	AbF	Pin	Pm	Bet	Fag	Pic.	Pin	Mix	Fag	Pin	Fag	Pic	Pin	Shr	Deb	Cv	bog	Dry	Mes	Fen	S-alp	
	M	*Araneus angulatus* CLERCK, 1757																			1							1
	N	*Araneus diadematus* CLERCK, 1757		1	8		1			1		2							4			1		3	5	20	9		55
	M	*Araneus marmoreus* CLERCK, 1757										2							1					2	2		2		9
	N	*Araneus quadratus* CLERCK, 1757																	1								1		2
	P	*Araneus sturmi* (HAHN, 1831)		2															1					2					5
	P	*Araniella alpica* (L. KOCH, 1869)																							1	1		2	4
	N	*Araniella cucurbitina* (CLERCK, 1757)					1			1		1					1	5									2		11
	M	*Araniella inconspicua* (SIMON, 1874)	1																										1
	T	*Araniella opisthographa* (KULCZYŃSKI, 1905)										1																	1
	N	*Cercidia prominens* (WESTRING, 1851)																						1	1				2
	P	*Cyclosa conica* (PALLAS, 1772)										1							1										2
	N	*Hypsosinga sanguinea* (C. L. KOCH, 1844)		2																					1	1			4
	M	*Larinioides folium* (SCHRANK, 1803)					1																						1
	N	*Mangora acalypha* (WALCKENAER, 1802)		1															1									2	4
	M	*Nuctenea umbratica* (CLERCK, 1757)																	1										1
	T	*Zilla diodia* (WALCKENAER, 1802)		1															2										3

Appendix 2. Continued.

Red list	TP	FAMILY / Species	Origin forests					Secondary forests							Ecoton Or.		Ecoton Se.			Rocky			Peat	Meadows				Σ
			Aln.	Fag	Qu	Pic	AbF	Pin	Pm	Bet	Fag	Pic.	Pin	Mix	Fag	Pin	Fag	Pic	Pin	Shr	Deb	Cv	bog	Dry	Mes	Fen	S-alp	
P		*Zygiella montana* (C. L. Koch, 1834)										3																3
		LYCOSIDAE (30)																										
T		*Alopecosa accentuata* (Latreille, 1817)		2	2								5			2								7	17		5	40
M		*Alopecosa aculeata* (Clerck, 1757)			2																							18	20
N		*Alopecosa cuneata* (Clerck, 1757)																								2			2
M		*Alopecosa inquilina* (Clerck, 1757)		6	5		4			3		1	2			1		3					5		10		5	45
N		*Alopecosa pulverulenta* (Clerck 1757)				6									1			2									14	23
T		*Alopecosa sulzeri* (Pavesi, 1873)			6		8						16												2			32
P		*Alopecosa taeniata* (C. L. Koch, 1835)			1														1				28	28			58
T		*Alopecosa trabalis* (Clerck, 1757)			1											2											2	5
T		*Arctosa figurata* (Simon, 1876)										1			1												2
M		*Arctosa maculata* (Hahn, 1822)	6																									6
N		*Aulonia albimana* (Walckenaer, 1805)								2			1											2	1			6
P		*Pardosa amentata* (Clerck, 1757)	8															10	1						2		21
N		*Pardosa lugubris* (Walckenaer, 1802)	1	1	45		3			4		1	1					11	1				1	12	1		82
N		*Pardosa monticola* (Clerck, 1757)																						1		4	5
N		*Pardosa palustris* (Linnaeus, 1758)															7								4	11

Appendix 2. Continued.

Red list	TP	FAMILY / Species		Origin forests					Secondary forests						Ecoton Or.		Ecoton Se.			Rocky			Peat		Meadows			Σ
			Aln.	Fag	Qu	Pic	AbF	Pin	Pm	Bet	Fag	Pic.	Pin	Mix	Fag	Pin	Fag	Pic	Pin	Shr	Deb	Cv	bog	Dry	Mes	Fen	S-alp	
	P	*Pardosa prativaga* (L. KOCH, 1870)	2																									2
	N	*Pardosa pullata* (CLERCK, 1757)																3										3
	N	*Pardosa riparia* (C. L. KOCH, 1833)				13	1											1						1			3	19
	P	*Pardosa saltuaria* (L. KOCH, 1870)																									1	1
LR (nt)	P	*Pardosa sordidata* (THORELL, 1875)																1										1
	P	*Pirata hygrophilus* THORELL, 1872	2			2																					27		31
	M	*Pirata knorri* (SCOPOLI, 1763)	1														1											2
	M	*Pirata latitans* (BLACKWALL, 1841)	1																									1
	M	*Pirata piscatorius* (CLERCK, 1757)											1				1						1					2
	T	*Tricca luetiana* (SIMON, 1876)			16		2					3														1	22
	T	*Trochosa robusta* (SIMON, 1876)					1			1											2							4
	M	*Trochosa ruricola* (DE GEER, 1778)			1					5																1	7
	P	*Trochosa spinipalpis* (O.P.-CAMBRIDGE, 1895)																				1					1
	N	*Trochosa terricola* THORELL, 1856	1	16	18		2			3		6			2					2		2	10	3		4	69
	N	*Xerolycosa nemoralis* (WESTRING, 1861)		3	2	3	9			2		11				1	2	2				1	6		7	49
		PISAURIDAE (1)																										
	N	*Pisaura mirabilis* (CLERCK, 1757)																1									1

Appendix 2. Continued.

			Origin forests							Secondary forests					Ecoton Or.		Ecoton Se.			Rocky			Peat		Meadows			
Red list	TP	FAMILY / Species	Aln.	Fag	Qu	Pic	AbF	Pin	Pm	Bet	Fag	Pic.	Pin	Mix	Fag	Pin	Fag	Pic	Pin	Shr	Deb	Cv	bog	Dry	Mes	Fen	S-alp	Σ
		AGELENIDAE (9)																										
	M	Agelena labyrinthica (CLERCK, 1757)		1			7																		2	1	3	14
	P	Histopona torpida (C. L. KOCH, 1837)			6	1					3	2																13
	T	Tegenaria agrestis (WALCKENAER, 1802)											1															1
	?	Tegenaria atrica C. L. KOCH, 1843																							1			1
	M	Tegenaria campestris C. L. KOCH, 1834								1											1				2			4
	?	Tegenaria domestica (CLERCK 1757)					1																					1
	M	Tegenaria ferruginea (PANZER, 1804)										5						3										8
	N	Tegenaria silvestris L. KOCH, 1872			1	2				1	1	2						4			1	1					1	15
	N	Textrix denticulata (OLIVER, 1789)			1		1			3		1						2			4							12
		CYBAEIDAE (1)																										
	P	Cybaeus angustiarum L. KOCH, 1868	99	54		39		11	26			107		8				16		1		1		5	21	4	11	404
		HAHNIIDAE (5)																										
	P	Cryphoeca carpathica HERMAN, 1879		1																								1
	P	Cryphoeca silvicola (C. L. KOCH, 1834)		6		1			1														1		1			10
	T	Hahnia nava (BLACKWALL, 1841)																									1	1
	M	Hahnia ononidum SIMON, 1875			1																							2
	P	Hahnia pusilla C. L. KOCH, 1841			1																							1

Appendix 2. Continued.

Red list	TP	FAMILY / Species	Aln.	Origin forests					Secondary forests						Ecoton Or.		Ecoton Se.			Rocky			Peat		Meadows			Σ
				Fag	Qu	Pic	AbF	Pin	Pm	Bet	Fag	Pic.	Pin	Mix	Fag	Pin	Fag	Pic	Pin	Shr	Deb	Cv	bog	Dry	Mes	Fen	S-alp	
		DICTYNIDAE (3)																										
	N	*Cicurina cicur* (FABRICIUS, 1793)	1	3										2				1		1	1			1				10
	P	*Dictyna pusilla* THORELL, 1856	4	1																								5
	N	*Dictyna uncinata* THORELL, 1856					1																				1	2
		AMAUROBIIDAE (6)																										
	P	*Amaurobius fenestralis* (STROEM, 1768)		31	2	1						9		14				2						13				72
	M	*Amaurobius ferox* (WALCKENAER, 1830)												1														1
	T	*Amaurobius jugorum* L. KOCH, 1868				2																						2
	P	*Callobius claustrarius* (HAHN, 1833)	1	16	14	6	8			6	6	2	1	9	2			3					2	7	1		9	93
	P	*Coelotes atropos* (WALCKENAER, 1830)		15	1				1	1	12	13		1				1					1				7	53
	P	*Eurocoelotes inermis* (L. KOCH, 1855)	12	38	1	1	11		1	8	1	15	4			1		3			5		4	9	2	1	3	121
		TITANOECIDAE (1)																										
	T	*Titanoeca quadriguttata* (HAHN, 1833)			6							1	2											7			1	17
		ANYPHAENIDAE (1)																	1							5			9
	M	*Anyphaena accentuata* (WALCKENAER, 1802)		3														1							5			9
		LIOCRANIDAE (3)																										
	T	*Agroeca cuprea* MENGE, 1873		6	1		2						4												2		7	22
	N	*Apostenus fuscus* WESTRING, 1851		9	8		4							4	2				1			1						29

Appendix 2. Continued.

Red list	TP	FAMILY / Species	Origin forests							Secondary forests					Ecoton Or.		Ecoton Se.			Shr	Rocky		Peat	Dry	Meadows			Σ
			Aln.	Fag	Qu	Pic	AbF	Pin	Pm	Bet	Fag	Pic.	Pin	Mix	Fag	Pin	Fag	Pic	Pin		Deb	Cv	bog	Dry	Mes	Fen	S-alp	
	N	*Liocranum rupicola* (WALCKENAER, 1830)			1		1			4						1					3							10
		CLUBIONIDAE (9)																										
	P	*Clubiona alpicola* KULCZYNSKI, 1882				2	1	1	2			1												1			1	9
	N	*Clubiona comta* C. L. KOCH, 1839		1																				1				2
	M	*Clubiona corticalis* (WALCKENAER, 1802)											1											1				2
	N	*Clubiona diversa* O.P.-CAMBRIDGE, 1862																									1	1
LR (lc)	T	*Clubiona genevensis* L. KOCH, 1866					1														1							2
	N	*Clubiona neglecta* O.P.-CAMBRIDGE, 1862																1					1				1	3
	P	*Clubiona subsultans* THORELL, 1875																						1				1
	N	*Clubiona terrestris* WESTRING, 1851		1																								1
	N	*Clubiona trivialis* C. L. KOCH, 1843																								1		1
		CORINNIDAE (1)																										
	N	*Phrurolithus festivus* (C. L. KOCH, 1835)					10			2			3			1				1				2				19
		GNAPHOSIDAE (13)																										
	M	*Drassodes cupreus* (BLACKWALL, 1834)			1																							1
	N	*Drassodes lapidosus* (WALCKENAER, 1802)			15		3			1			7						1	3							4	34
	N	*Drassodes pubescens* (THORELL, 1856)			1				2										1	2				1	2		3	12
	T	*Gnaphosa bicolor* (HAHN, 1833)		2	3																1							6

Appendix 2. Continued.

Red list	TP	FAMILY / Species	Origin forests							Secondary forests					Ecoton Or.		Ecoton Se.			Rocky			Peat	Meadows				Σ
			Aln.	Fag	Qu	Pic	AbF	Pin	Pm	Bet	Fag	Pic.	Pin	Mix	Fag	Pin	Fag	Pic	Pin	Shr	Deb	Cv	bog	Dry	Mes	Fen	S-alp	
N		*Haplodrassus umbratilis* (L. Koch, 1866)			4																							4
	T	*Micaria fulgens* (Walckenaer, 1802)					1																	1			1	3
LR (lc)	T	*Phaeocedus braccatus* (L. Koch, 1866)																			1							1
	P	*Zelotes clivicola* (L. Koch, 1870)																									1	1
	T	*Zelotes erebeus* (Thorell, 1871)		1			5			1			8							1				1			1	18
	N	*Zelotes latreillei* (Simon, 1878)					1																		1			2
	T	*Zelotes petrensis* (C. L. Koch, 1839)		4	9		22			6			12							1				2	3		2	61
CR	T	*Zelotes puritanus* Chamberlin, 1922			2		3																				1	6
	N	*Zelotes subterraneus* (C. L. Koch, 1833)		1	14		4				2								1		3				3	2		1	31
		ZORIDAE (5)																										
VU	P	*Zora distincta* Kulczyński, 1915			1	1																						1	3
	T	*Zora manicata* Simon, 1878			3																								3
	N	*Zora nemoralis* (Blackwall, 1861)		2			1												1										4
	T	*Zora pardalis* Simon, 1878			1														1										2
	N	*Zora spinimana* (Sundevall, 1833)		1					1	1			1						3						1				8
		HETEROPODIDAE (1)															1		2		1			2	5	5	1	9	35
	N	*Micrommata virescens* (Clerck, 1757)		3	1		5									1			2		1			2	5	5	1	9	35
		ZODARIIDAE (1)																										
	T	*Zodarion germanicum* (C. L. Koch, 1837)			6		7		1	2			5								3	1	1		2	1		13	42

Appendix 2. Continued.

Red list	TP	FAMILY / Species	Origin forests							Secondary forests					Ecoton Or.		Ecoton Se.			Rocky			Peat		Meadows			Σ
			Aln.	Fag	Qu	Pic	AbF	Pin	Pm	Bet	Fag	Pic.	Pin	Mix	Fag	Pin	Fag	Pic	Pin	Shr	Deb	Cv	bog	Dry	Mes	Fen	S-alp	
		PHILODROMIDAE (8)																										
	M	*Philodromus aureolus* (CLERCK, 1757)																1										1
	M	*Philodromus cespitum* (WALCKENAER, 1802)								1																		1
	N	*Philodromus collinus* C. L. KOCH, 1835			1																							1
	M	*Philodromus margaritatus* (CLERCK, 1757)																1										1
	P	*Philodromus vagulus* SIMON, 1875		3																								3
	N	*Thanatus formicinus* (CLERCK, 1757)								8								1					1		1		1	12
EN	T	*Thanatus sabulosus* (MENGE, 1875)			4		15																		1		6	26
	M	*Tibellus oblongus* (WALCKENAER, 1802)																					1	1	4		1	7
		THOMISIDAE (20)																										
	M	*Coriarachne depressa* (C. L. KOCH, 1837)					1																					1
	M	*Diaea dorsata* (FABRICIUS, 1777)																6							2			8
	N	*Misumena vatia* (CLERCK, 1757)		1								1						1					1	1	6	1	5	17
	T	*Misumenops tricuspidatus* (FABRICIUS, 1775)																		2								2
	T	*Ozyptila atomaria* (PANZER, 1801)								1																		1
	M	*Ozyptila blackwalli* SIMON 1875			1		7			4																		12
	T	*Ozyptila claveata* (WALCKENAER, 1837)					11						6															17

Appendix 2. Continued.

Red list	TP	FAMILY / Species	Origin forests								Secondary forests				Ecoton Or.		Ecoton Se.			Rocky			Peat		Meadows			Σ
			Aln.	Fag	Qu	Pic	AbF	Pin	Pm	Bet	Fag	Pic.	Pin	Mix	Fag	Pin	Fag	Pic	Pin	Shr	Deb	Cv	bog	Dry	Mes	Fen	S-alp	
	T	*Ozyptila pullata* (THORELL, 1875)																									2	2
	P	*Ozyptila trux* (BLACKWALL, 1846)							3										1									8	12
	T	*Thomisus onustus* C. L. KOCH, 1805																							1			1
VU	P	*Xysticus alpicola* KULCZYŃSKI, 1882			1																						2	3
	N	*Xysticus audax* (SCHRANK, 1803)					1											1										2
	N	*Xysticus bifasciatus* C. L. KOCH, 1837																									4	4
	N	*Xysticus cristatus* (CLERCK, 1757)					1											2									8	11
	N	*Xysticus erraticus* (BLACKWALL, 1834)																						1				1
	M	*Xysticus gallicus* SIMON, 1875		4																				2	1	1		8
	M	*Xysticus kochi* Thorell, 1872				1																			1	1		3
	T	*Xysticus luctator* L. KOCH, 1870																							1			1
LR (lc)	N	*Xysticus luctuosus* (BLACKWALL, 1836)																							1		1	2
	T	*Xysticus robustus* (HAHN, 1832)					1																		1			2
		SALTICIDAE (19)																										
	T	*Ballus chalybeius* (WALCKENAER, 1802)			1																							1
	N	*Dendryphantes rudis* (SUNDEVALL, 1833)		2																							2	4
	N	*Euophrys frontalis* (WALCKENAER, 1802)		1	4		3		2	4			4			2				1				2			4	27

Appendix 2. Continued.

Red list	TP	FAMILY / Species	Origin forests							Secondary forests					Ecoton Or.		Ecoton Se.			Rocky			Peat		Meadows			Σ
			Aln.	Fag	Qu	Pic	AbF	Pin	Pm	Bet	Fag	Pic.	Pin	Mix	Fag	Pin	Fag	Pic	Pin	Shr	Deb	Cv	bog	Dry	Mes	Fen	S-alp	
	M	*Evarcha arcuata* (Clerck, 1757)		2			1			2													2		1	4		12
	N	*Evarcha falcata* (Clerck, 1757)					9											3					1	1	14	7	7	42
	M	*Heliophanus aeneus* (Hahn, 1831)			5																							5
	T	*Heliophanus cupreus* (Walckenaer, 1802)		1														2										3
	T	*Heliophanus flavipes* (Hahn, 1832)																1										1
	T	*Philaeus chrysops* (Poda, 1761)					1			4																		5
	T	*Phlegra fasciata* (Hahn, 1826)											1															1
	M	*Pseudeuophrys erratica* (Walckenaer, 1826)											2											2				4
	N	*Salticus scenicus* (Clerck, 1757)																									1	1
	N	*Salticus zebraneus* (C. L. Koch, 1837)			1																				1			2
	P	*Sitticus floricola* (C. L. Koch, 1837)										1																1
	P	*Sitticus rupicola* (C. L. Koch, 1837)				5			2			1		1							1		1		1	2		14
	M	*Sitticus saxicola* (C. L. Koch, 1846)																						1				1
EN	M	*Sitticus zimmermanni* (Simon, 1877)																1					3	1				5
EN	M	*Synageles lepidus* Kulczyński, 1897					2																					2
	N	*Talavera petrensis* (C. L. Koch, 1837)																									1	1
		T o t a l :	161	327	307	190	256	38	57	96	30	226	130	51	8	16	6	242	1	31	50	88	71	189	283	103	338	3295

A review of spiders on tree trunks in Europe (Araneae)

Csaba Szinetár[1], Roland Horváth[2]

Abstract: The present paper provides an overview of the European publications concerning bark-dwelling spiders. A total of 29 works have been investigated during the work: articles, M.Sc. theses and books. Collections on which the publications were based upon, demonstrated the presence of a total of 298 spiders on the bark of different tree species. This high species number can be attributed mostly to the species occurring randomly on the tree bark; however, it can unanimously be stated that there are facultative and exclusive bark-dwelling spider species as well**.** Among the species occurring randomly, a high proportion is constituted by the ground-dwelling linyphiid spiders of small body, which make up a large proportion in the species number, however, their abundance is low. Different authors used different sampling methods and efforts. In spite of this, several conclusions could be drawn concerning the bark-dwelling spider assemblages: i) within the total population in tree bark, the widespread bark-dwelling species were dominant, regardless of tree species and location; ii) in the case of a single tree species, significant differences may be present within a smaller region – even within a town – in the species composition of spider assemblages; iii) the altitude plays an important role in the formation of the bark-dwelling spider assemblages within a given area; iv) the occurrence frequency is characteristically changing with the geographical latitude; v) the composition of the bark-dwelling spider assemblages is seasonally changing even within a single tree species. A significant difference is shown between the summer and winter assemblages.

Key words: bark-dwelling spiders, coniferous trees, deciduous trees, urban habitats, seasonality

Introduction

Trees represent well-defined and unique habitats for animals. On the one hand, trees are structurally complex and include several microhabitats (foliage, branch, trunks). Thus, they provide ample opportunity for niche-segregation (LAWTON 1978). On the other hand, trees provide a stable food source for animals dwelling on them (SOUTHWOOD 1978). These characters are coupled with a large geographical range in most tree species (STRONG 1979). All these factors result in a high species richness and diversity of tree-living animal communities. Tree trunks, as a distinctive microhabitat of the tree, are characterised by numerous unique biotic and abiotic environmental factors, which explains why we can also discern a separate, so-called bark-dwelling arthropod assemblage. Spiders represent a dominant taxon of bark-dwelling predatory arthropods. Well-recognisable adaptation phenomena, which can be observed in bark-dwelling spiders, provide evidence for the evolution of species living on or under tree bark. Adaptations of bark-dwelling spiders can be seen in morphology, phenology, and physiology. Relatively few studies have been published on bark-dwelling-spiders to date, and most of them are of a rather faunistical nature (KOSLINSKA 1967, ALBERT 1976, WUNDERLICH 1982, NICOLAI 1986, HANSEN 1992, MALTEN 1994). Systematic surveys on bark-dwelling spiders were carried out in Hungary by the mid-nineties (SEBESTYÉN 1996, HORVÁTH, SZINETÁR 1998, 2002, BOGYA *et al*. 1995, HORVÁTH *et al*. 2001, 2004, 2005, SZINETÁR *et al*. 2002). Up to this date, primarily the black pine (*Pinus nigra*), Norway spruce (*Picea abies*), Scots pine (*Pinus sylvestris*), European beech (*Fagus sylvatica*), English

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oak (*Quercus robur*), London planetree (*Platanus hybrida*) and Apple tree (*Pyrus malus*) have been investigated for bark-dwelling spider species. In case of the Norway spruce, planetree and apple surveys were carried out in several Hungarian land regions while in the case of the other species, the surveys were carried out in Western Transdanubia only. Simultaneously with the Hungarian surveys, other countries in Europe also conducted similar studies recently (Simon 1995, Weiss 1995, Koponen 1996, 2004, Koponen *et al*. 1997, Rinne *et al*. 1998, Pekár 1999, Kubcová, Schlaghamerský 2002).

Our overview on European bark-dwelling spider fauna is based on the results of nearly fourteen years of our investigations and foreign literature data.

Overview and evaluation on the survey methods

The different authors employ various methods to collect spiders dwelling on the trunk and branches of the trees (parts covered by bark). Beyond the fact that all methods endeavour to capture the species dwelling on bark as efficiently as possible and provide the most comprehensive picture on the assemblages dwelling on bark, these methods resulted in very different samples that can be compared to each other in a very limited manner. The tree eclectors (various stammeclectors, modified pitfall trap, branch traps) of continuous operation, with killing liquid, and mounted on the trunk and the branches are in several aspects similar to the Barber pitfall trap. The animals get into the trap owing to their active movements. A number of similar, automated traps were employed by the authors (Nicolai 1986, Simon 1995, Weiss 1995, Koponen 1996, 2004, Koponen *et al*. 1997, Rinne *et al*. 1998, Kubcová, Schlaghamerský 2002). Different preservation liquids were used for the collecting containers e.g. NaCl solution, 4% formaldehyde, ethylene glycol. In this aspect too, the traps are similar to the Barber traps. The other widespread method of trapping from the bark is the trap band, differing significantly from the traps mentioned above. In Hungary and other countries too, one of the often-employed methods is the corrugated cardboard trap band (Bogya *et al*. 1995, Sebestyén 1996, Horváth, Szinetár 1998, 2002, Pekár 1999, Horváth *et al*. 2001, 2004, 2005, Kovács 2002). Bands are placed around the trunk, their waved surfaces facing the trunk and covering the whole perimeter of the tree, as if a kind of artificial bark. When sampling, the whole belt is removed from the trunk and placed into a plastic bag. The collection of the animals living on and under the bark is carried out in a laboratory. It can be considered that it is a difficulty (fault) of the method that the animals dwelling between the band and the bark – primarily in the summer period – can quickly escape when the belt is removed, therefore the fast and co-ordinated work of several collectors is needed when removing the trap bands. The vacuum sampler might be an efficient method for collection from the bark (Nicolai 1986), and the sifting as well (Sebestyén 1996).

Numerous collectors used the manual method, which means surveying the surface of the bark. This, of course is influenced by the structure of the bark (Nicolai 1986, Hansen 1992, Sebestyén 1996). Scraping the bark off the trunks and branches: the essence of this method is that by disbarking the tree, the spiders dwelling between the bark layers and in the bottom surface of the bark can be collected with little effort and in large number both in terms of specimen and species. In the case of some tree species (e.g. *Platanus hybrida*), the bark layers can easily be removed, placed in plastic bags, then the surface of the trunk can be brushed and it can be placed along with the bark layers into the bag. The height of collection from the bark also significantly influences the results, which is well demonstrated by the trunk trap captures carried out at different heights (Simon 1995). He was able to establish stratocoenoses or assemblage characteristics to a layer, from the soil to the canopy of Scots pine. The sampling methods, the studied tree species according to sampling sites and the publications by the referenced authors are presented in Table 1. No detailed description is provided on the individual trap types employed by the authors, this can be found in the given publications.

As an addition, it can be mentioned that in case of collection by the beating method often employed for collection from foliage, numerous spider species might be sampled, which primarily dwell on the bark of the branches, instead of the foliage. In the case of these samples, according to the microhabitat choice, it can be established (assumed) whether a species dwells on the bark. The canopy spraying is a similar method. Although it can be assumed that like the beating method, the bark-dwelling species are also under-represented in the samples, in a small number, however, they still might be present (Benfatto *et al.* 1992).

Table 1. Sampling methods in the individual publications, studied tree species and survey locations (details on methods and locations can be found in the given publications).

Publication	Sampling method(s)	Investigated tree(s)	Sampling site(s) Locality
Bogya *et al.* 1999	corrugated cardboard trap band	apple tree, pear tree	Nagykovácsi (Hungary)
Hansen 1992	hand colletion	london planetree	Venezia (Italy)
Horváth, Szinetár 1998, 2002 and Horváth *et al.* 2001, 2004, 2005	corrugated cardboard trap band	black pine	Szombathely, Velem, Bozsok, Debrecen, (Hungary)
Koponen 1996	"new" branch trap	english oak	7 different localities (SW-Finland)
Koponen *et al.* 1997	"new" branch trap	english oak	7 different localities (SW-Finland)
Koponen 2004	"new" branch trap and tree eclector	english oak	Ruissalo (SW-Finland)
Koslinska 1967	scraping the bark off the trunks and branches	apple tree	Kraków, Lódź (Poland)
Kovács 2002	corrugated cardboard trap band	english oak, european beech, scots pine	8 different localities in West Hungary
Kubcová, Schlaghamerský 2002	tree eclector	english oak	Lednice, Soutok (Czech Republic)
Malten 1994	tree eclector	white willow	Magdeburg (Germany)
Nicolai 1986	hand collection, vacuum sampler, arboreal photo-eclector	camperdown elm, english oak, european beech, planetree maple, silver birch, white willow	Marburg (Germany)
Pekár 1999	corrugated cardboard trap band	apple tree, pear tree	Horoměřice, Doksany (Czech Republic)
Rinne *et al.* 1998	"new" branch trap	english oak	7 different localities (SW-Finland)
Sebestyén 1996	corrugated cardboard trap band, hand collection, bark sifting	london planetree	12 different localities (Hungary)
Simon 1995	tree eclector	scots pine	Grunewald, Eberwalde (Germany)
Weiss 1995	"modified pitfall traps"	norway spruce	Nationalpark Bayerischer Wald (Germany)

Owing to the differences in the collection methods, the collections are comparable to a certain extent only. Endeavours were made to draw conclusions and make reference to works where the statistical evaluation of standardised samplings was ensured.

Results and Discussion

Evaluation and summary of the surveys carried out on the tree trunks and branches

According to the results of the publications hereby examined, a total of 298 spider species can be indicated as inhabiting the bark of different tree species in Europe. This accounts for about a quarter of the European spider fauna. This extremely high species number shows that although the majority of the spiders was of accidental occurrence, the spiders are present on the bark for shorter or longer periods, therefore the presence of species characteristic to other microhabitats should also be reckoned with. The more balanced microclimate, diverse bark structure and the high number of hiding places can also be considered an advantageous condition in the case of the trees. The tree trunks provide a willy-nilly landing strip for the ballooning species or those using the aerial dispersal. Certainly, this is the reason for the occurrence of mature forms of small species, dwelling mostly on the ground; however, this presence is presumably of a short duration only. Moreover, the bark is rich in potential prey animals, fulfilling by this the role of an advantageous feeding place in case of a temporary stay (Horváth *et al.* 2005). The fallen, decayed old trunks have to be mentioned separately. Such works were also examined (Weiss 1995, Kubcová, Schlaghamerský 2002). In such cases the trunks are in close proximity to the ground, their moss and lichen cover might be more developed than in the case of living and upright tree trunks, thence on these trunks the ground-dwelling species settle in a much greater number, which is well demonstrated by the work of Weiss (1995).

Classification the bark-dwelling spiders into types according to the strength (closeness) of the relationship

Wunderlich's (1982) study is still a determinant publication in the European literature. He used the categories on which our study is also based.

Real or exclusive bark-dwellers (E): spider species which, as microhabitat specialists, live on or under the bark. They can be found on the bark throughout the year. It is characteristic for them to have mature forms for most of the year or even continuously. Their adaptation to the microhabitat could result in well-distinguishable morphological signs.

Facultative bark-dwellers (F1, F2): species which use tree trunks and branches as typical but not exclusive microhabitats with permanent or seasonal character. Rocks, cracks in rocks, artificial walls may also be typical habitats of these species. Spider species dwelling on trees and choosing the bark as a dwelling place for the winter are also classified into this category. This is characteristic primarily for those dwelling in the foliage of deciduous trees. In the case of facultative bark-dwellers we considered it necessary to establish two further sub-categories in order to indicate the frequency of the facultative relationship. F1 is a closer relationship that can be observed more frequently, while F2 is a rarer one, however, it indicates spider-tree species relationships observed by several authors and in several instances.

Accidental species (A): The species are listed here regardless of their occurrence frequency. They are species for which other microhabitats mean the typical habitat or such which have no specific habitat preference. In the case of these species it is presumed that the time of stay on the bark is short, however, it is very difficult to study or demonstrate it.

These categories can certainly be stated more precisely based on new data gathered on the species. There are rare species for which – owing to the low population number – no reliable knowledge

on the microhabitat selection is at our disposal. Apendix 1. includes all species demonstrated from trees together with their short phenological, habitat selection characterisation as well as literature references. Data on 298 spider species were obtained while examining 29 publications, books, and theses. Based on the evaluation of the relationship between the spiders and the bark, the distribution of categories is as follows: 65% of the total species number was constituted by accidental species. In other species, a relationship of different strength and various habitat preferences can be stated. Twenty-four species were classified (8% of the total number of species) into the real bark-dwelling species. Seventy-nine species can be deemed as facultative bark-dwellers. Out of this, 50 species were ranked into the F1 type (17%), while 29 species (10%) were ranked into the F2 type according to the collections, reference literature and own experiences.

Taxonomic notes

Several authors draw attention to the great and striking morphological similarity between *Clubiona genevensis* L. Koch, 1866 and *Clubiona leucaspis* Simon, 1932, and to the possibility of a misidentification (Malten 1984, Nentwig *et al*. 2003, Weiss, oral communication). The habitats of the two species are largely different. *C. genevenis* is a ground-dwelling species of dry sandy lands, whereas *C. leucaspis* is a typical bark-dwelling species. Following Simon's (1932) description, Di Franco (1993) published a drawing of *C. leucaspis,* as well as on the biology of the species from lemon plantations in Sicily. In our opinion the drawing in Figure 12/b on page 56 in Sterghiu (1985), also published by Nentwig *et al.* (2003), is not of *C. genevensis* but of *C. leucaspis*. Likewise, we assume that the occurrence of *C. genevensis* on trunks and barks is mistakenly reported and stands for the rather similar *C. leucaspis*, cf. Sterghiu (1985), Heimer, Nentwig (1991), Simon (1995).

Spider assemblages

Based on survey results of other tree species and geographical locations, we can formulate the following statements concerning the bark-dwelling spider assemblages:

i) In samples from tree trunks, generally irrespective of the tree species and location, the widespread bark-dwelling spider species dominate (Appendix 1). Well-recognisable adaptation phenomena, which can be observed in bark-dwelling spiders, provide evidence for the evolution of species living on or under the bark. This process is a sequential evolution, in which the relationship between the plant and the arthropod living on it is essentially asymmetric, i.e. not of a coevolutionary type, rather, the animals follow the evolution of the host plant without significantly affecting it (Jermy 1987). Adaptations of bark-dwelling spiders can be seen in morphology, phenology, and physiology. One of the morphological adaptations is the typical body shape observable in many species (e.g. Araneidae: *Nuctenea umbratica* (Clerck, 1757); Philodromidae: *Philodromus margaritatus* (Clerck, 1757), *Philodromus fuscomarginatus* (De Geer, 1778); Thomisidae: *Coriarachne depressa* (C. L. Koch, 1837)). The body of these species is characteristically flattened, which well reflects an adaptation to modes of living between the bark layers or under the bark. This adaptation can be coupled with colour adaptations. *Philodromus fuscomarginatus*, for example, blends well with its reddish-brown coloration into the phloem layer of Scots pine (*Pinus sylvestris*), which is the almost exclusive habitat of this philodromid spider. *Philodromus margaritatus* with its dark colours blends well into the surface of trees with darker bark, and can thus hide from predators, mainly birds, which feed on it. The most important of the phenological adaptations is that many exclusive bark-dwelling species are eurychron, i.e. adults and juveniles can be found all year-round, or diplochron, i.e., the species has two reproductive periods annually. Reproduction throughout the entire year or throughout a substantial part of the year is made possible by the higher and more even temperature under the bark.

ii) In the case of a given tree species significant differences can be found within a more restricted region – even within a city. In urban sampling areas with strongly polluted air a number of species are missing (e.g. *Clubiona pallidula* (Clerck, 1757)) or are represented by a smaller population size (e.g. *Moebelia penicillata* (Westring, 1851)) which, in the garden suburb samples are dominant species on the same tree species (Horváth *et al.* 2001).

iii) The altitude has also an important role in the formation of a bark-dwelling spider assemblage of a given area. In mountain areas some species appear (e.g. *Segestria senoculata* (Linnaeus, 1758), *Clubiona corticalis* (Walckenaer, 1802), *Amaurobius fenestralis* (Ström, 1768), etc.) which do not occur in urban or lowland biotopes (Horváth, Szinetár 1998, 2002).

iv) Occurrence frequency may characteristically change within a genus with geographical latitude. The species *Segestria bavarica* C. L. Koch, 1843 is primarily Southern European, while *Segestria senoculata* is more widespread in Central and Northern Europe; the former species occurring northwards only in cities with warmer climate. In Southern Europe the third species of the genus, *Segestria florentina* (Rossi, 1790) may also appear under the bark (Hansen 1992).

v) Summer and winter assemblages show significant differences even in the bark of a single tree species. In winter the foliage-dwelling species migrate in a large number to the bark for wintering. On the other hand, in summer, only the real bark-dwelling and the accidental species can be found on the trunk, resulting characteristic differences (Horváth, Szinetár 2002, Horváth *et al.* 2001).

As a summary, it can be stated that the majority of real bark-dwelling species are not associated to special tree species nor to a given bark structure (*Philodromus margaritatus, Clubiona leucaspis, Segestria senoculata, Marpissa muscosa* (Clerck, 1757)). On the other hand, facultative bark-dwelling species show significant differences; the tree species with similar structure (within a given geographical latitude) can be characterised by similar spider assemblages (for example black pine↔scots pine) (Appendix 1). Despite this, with the change of geographical latitude a given tree species exhibits significant differences.

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Обзор върху паяците (Araneae), обитаващи кората на дърветата в Европа

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(Резюме)

Направен е преглед на информацията за паяците, обитаващи кората на дърветата в Европа. До момента са установени 298 вида под кората на различни видове дървета (*Pinus nigra*, *Picea abies*, *Fagus sylvatica* и др.). Високият брой на видовете се определя от случайно срещащи се, временно пребиваващи и постоянно живеещи под кората видове. По отношение на живеещите под кората паяци могат да се очертаят няколко зависимости: 1) при подкоровите популации доминират широко разпространените паяци, независимо от дървесния вид и местообитание; 2) в случаите на единични дървесни видове, значителни разлики във видовия състав на подкоровите съобщества могат да се наблюдават в по-малки райони, като например територията на един град; 3) надморската височина играе важна роля при формирането на съобществата на подкоровите паяци; 4) честотата на срещане се изменя в зависимост от географската ширина; 5) видовият състав на подкоровите паяци се изменя сезонно, дори и в единични дървесни видове. Значителни разлики са установени между летните и зимните сборове.

Appendix 1. List of spiders sampled on tree trunks, under and on bark of trees in Europe (nomenclature after PLATNICK 2005). **C** – Connection with bark: **E** – Exclusive bark-dwelling species, **F** – Facultative bark-dwelling species, **A** – Accidental species. Microhabitat preferences based on the quoted literature and own data (cf. BUCHAR, RUZICKA 2002, HEIMER, NENTWIG 1991, LOKSA 1969, 1971, ROBERTS 1995). The tree species investigated: *Acer campestre* – Field Maple; *Acer pseudoplatanus* – Planetree Maple; *Aesculus hyppocastaneum* – Horse chesnut; *Alnus glutinosa* – European Alder; *Betula pendula* – Silver birch; *Carpinus betulus* – European Hornbeam; *Fagus sylvatica* – European Beech; *Picea abies* – Norway Spruce; *Pinus nigra* – Black Pine; *Pinus sylvestris* – Scots Pine; *Platanus hybrida* – London Planetree; *Prunus avium* – Wild Cherry Tree; *Pyrus communis* – Pear Tree; *Pyrus malus* – Apple Tree; *Quercus robur* – English Oak; *Salix alba* – White Willow; *Ulmus glabra* – Camperdown Elm

Species	C	Season	Tree	References	Microhabitat preferences
1	2	3	4	5	6
Segestriidae					
Segestria bavarica C. L. KOCH, 1843	F1	all year	*Fagus sylvatica, Pinus nigra, Pinus sylvestris, Platanus hybrida, Quercus robur*	HANSEN 1992; SIMON 1995; SEBESTYÉN 1996; HORVÁTH, SZINETÁR 1998, 2002; HORVÁTH *et al.* 2001, 2005; KOVÁCS 2002	under tree bark, in fissures on rock walls
S. florentina (ROSSI, 1790)	F1	all year	*Platanus hybrida*	HANSEN 1992	under tree bark, holes in walls, in houses
S. senoculata (LINNAEUS, 1758)	F1	all year	*Fagus sylvatica, Picea abies, Pinus nigra, Pinus sylvestris Quercus robur*	WUNDERLICH 1982; SIMON 1995; WEISS 1995; KOPONEN 1996; HORVÁTH, SZINETÁR 1998, 2002; RINNE *et al.* 1998; KOVÁCS 2002; HORVÁTH *et al.* 2005	forests, rocks, under tree bark, in fissures on rock walls, under stones
Dysderidae					
Dasumia canestrini (L. KOCH, 1867)	A	III-IX.	*Platanus hybrida*	HANSEN 1992	among leaf litter, under tree bark
Harpactea hombergi (SCOPOLI, 1763)	F1	V-XI.	*Pinus nigra, Pinus sylvestris*	SIMON 1995; HORVÁTH, SZINETÁR 1998, 2002; HORVÁTH *et al.* 2005	forests, under tree bark, under stones
H. rubicunda (C. L. KOCH, 1838)	F1	II-X.	*Pinus nigra, Pinus sylvestris, Platanus hybrida, Pyrus malus*	WUNDERLICH 1982; SEBESTYÉN 1996; HORVÁTH, SZINETÁR 1998, 2002; PEKÁR 1999; HORVÁTH *et al.* 2001, 2004, 2005; KOVÁCS 2002	under stones, under tree bark, in houses
Oonopidae					
Oonops domesticus DALMAS, 1916	F1	all year	*Platanus hybrida*	HANSEN 1992	under bark, in houses
Tapineshis inermis (SIMON, 1882)	F1	all year	*Platanus hybrida*	HANSEN 1992	under bark, in houses

Appendix 1. Continued.

1	2	3	4	5	6
Mimetidae					
Ero aphana (WALCKENAER, 1802)	A	summer	*Platanus hybrida*	HANSEN 1992	on vegetation in forests and open habitats
E. furcata (VILLERS, 1789)	F1	summer	*Picea abies, Pinus sylvestris, Quercus robur*	SIMON 1995; WEISS 1995; RINNE *et al.* 1998; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on vegetation in various forests and open habitats
Uloboridae					
Hyptiotes paradoxus (C. L. KOCH, 1834)	A	VII-X.	*Pinus sylvestris*	SIMON 1995	on lower branches of coniferous trees
Theridiidae					
Achaearanea lunata (CLERCK, 1757)	F1	early summer	*Picea abies, Pinus sylvestris, Platanus hybrida*	HANSEN 1992; SIMON 1995; WEISS 1995; SEBESTYÉN 1996	on lower trunks and branches of trees
A. riparia (BLACKWALL, 1834)	F1	V-VII.	*Pinus nigra, Platanus hybrida, Pyrus malus*	SEBESTYÉN 1996; PEKÁR 1999; HORVÁTH, SZINETÁR 2002; HORVÁTH *et al.* 2005	on rock walls, on tree trunks in open habitats and in parks
A. simulans (THORELL, 1875) (syn. *Theridion simulans*)	F2	V-IX.	*Platanus hybrida, Quercus robur*	NICOLAI 1986; HANSEN 1992; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	bushes and trees
Anelosimus vittatus (C. L. KOCH, 1836) (syn. *Theridion vittatum*)	F1	V-VII.	*Pinus nigra, Pinus sylvestris, Platanus hybrida, Pyrus communis, Pyrus malus, Quercus robur*	KOSLINSKA 1967; NICOLAI 1986; SIMON 1995; SEBESTYÉN 1996; HORVÁTH, SZINETÁR 1998, 2002; PEKÁR 1999; HORVÁTH *et al.* 2001, 2004; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	edge, park, on bushes in orchards, on and under bark in winter period (X.-IV.)
Dipoena melanogaster (C. L. KOCH, 1837)	F2	V-VIII.	*Pinus nigra, Platanus hybrida, Pyrus malus, Quercus robur*	SEBESTYÉN 1996; HORVÁTH, SZINETÁR 1998; BOGYA *et al.* 1999; HORVÁTH *et al.* 2001; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on herbs, on bushes, on trees (mainly in coniferous forests)
D. torva (THORELL, 1875)	E	summer	*Pinus sylvestris, Quercus robur*	SIMON 1995; KUBCOVÁ, SCHLAGHAMERSKÝ 2002; KOPONEN 2004	on tree bark and branches
Crustulina guttata (WIDER, 1834)	A	summer	-	WUNDERLICH 1982	among low vegetation and detritus in dry places, rarely on bark

Appendix 1. Continued.

1	2	3	4	5	6
Enoplognatha latimana HIPPA, OKSALA, 1982	A	summer	*Pyrus malus*	BOGYA *et al.* 1999	on vegetation, in orchards
E. mordax (THORELL, 1875)	A	summer	*Platanus hybrida*	SEBESTYÉN 1996	in sandy areas
E. ovata (CLERCK, 1757)	F2	summer	*Picea abies, Pinus sylvestris, Pyrus malus, Quercus robur*	SIMON 1995; WEISS 1995; KOPONEN 1996; PEKÁR 1999; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on herb vegetation and bushes in forest habitats
Keijia tincta (WALCKENAER, 1802) (syn. *Theridion tinctum*)	F1	I–VI.	*Fagus sylvatica, Picea abies, Pinus nigra, Pinus sylvestris, Platanus hybrida, Pyrus communis, Pyrus malus, Quercus robur*	HANSEN 1992; SIMON 1995; KOPONEN 1996; SEBESTYÉN 1996; KOPONEN *et al.* 1997; HORVÁTH, SZINETÁR 1998, 2002; RINNE ET AL. 1998; BOGYA *et al.* 1999; PEKÁR 1999; HORVÁTH *et al.* 2001, 2004, 2005; KOVÁCS 2002; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on bushes and trees in various forests
Lasaeola tristis (HAHN, 1833) (syn. *Dipoena tristis*)	F2	V–VII.	*Pinus nigra, Quercus robur*	KOPONEN 1996; RINNE *et al.* 1998; HORVÁTH, SZINETÁR 2002	on low vegetation in open habitats
Neottiura bimaculata (LINNAEUS, 1767) (syn. *Theridion bimaculatum*)	A	V–VI.	*Pyrus malus*	BOGYA *et al.* 1999; PEKÁR 1999	on different plants in open and forest habitats
N. suaveolens (SIMON, 1879) (syn. *Theridion suaveolens*)	A	?	*Pyrus malus*	BOGYA *et al.* 1999	on vegetation in xerothermic habitats
Paidiscura pallens (BLACKWALL, 1834) (syn. *Theridion pallens*)	A	IV–V.	*Fagus sylvatica, Pinus sylvestris, Quercus robur*	NICOLAI 1986; SIMON 1995; KOPONEN 1996; KOPONEN *et al.* 1997; RINNE *et al.* 1998	on bushes and trees in light forests and their edges
Robertus lividus (BLACKWALL, 1836)	A	all year	*Picea abies, Pinus sylvestris, Quercus robur*	SIMON 1995; WEISS 1995; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	in various forests and open habitats, under stones and detritus
R. scoticus JACKSON, 1914	A	summer	*Picea abies*	WEISS 1995	in mountain spruce forests, in moss

Appendix 1. Continued.

1	2	3	4	5	6
Steatoda bipunctata (LINNAEUS, 1758)	F1	all year	*Picea abies, Pinus nigra, Pinus sylvestris, Platanus hybrida, Pyrus malus, Quercus robur*	WUNDERLICH 1982; SIMON 1995; WEISS 1995; KOPONEN 1996; SEBESTYÉN 1996; KOPONEN *et al.* 1997; HORVÁTH, SZINETÁR 1998, 2002; RINNE *et al.* 1998; BOGYA *et al.* 1999; HORVÁTH *et al.* 2001, 2004, 2005; KOVÁCS 2002; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	forests, buildings, under tree bark, in hollow trees, in houses
S. castanea (CLERCK, 1757) (syn. *Teutana castanea*)	F1	spring	*Pyrus communis, Pyrus malus*	PEKÁR 1999	under bark, in and around houses, occasionally a field in orchards
S. grossa (C. L. KOCH, 1838)	A	all year	*Platanus hybrida*	HANSEN 1992	in and around houses, occasionally a fields
S. triangulosa (WALCKENAER, 1802)	A	autumn	*Pinus nigra, Platanus hybrida*	HANSEN 1992; HORVÁTH, SZINETÁR 2002	in and around houses occasionally a fields
Theridion blackwalli O. P.-CAMBRIDGE, 1871	F2	V-VII.	*Pinus nigra, Platanus hybrida, Quercus robur*	SEBESTYÉN 1996; HORVÁTH, SZINETÁR 1998, 2002; HORVÁTH *et al.* 2001, 2004, 2005; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on tree trunks in floodplain forests, on edges, in parks
T. familiare O. P.-CAMBRIDGE, 1871	A	summer	*Platanus hybrida, Pyrus malus*	KOSLINSKA 1967; HANSEN 1992	in and near houses, under stones
T. impressum L. KOCH, 1881	A	V-VII.	*Pinus nigra, Pyrus malus*	HORVÁTH, SZINETÁR 1998; PEKÁR 1999; HORVÁTH *et al.* 2001	on vegetation in all open habitats, in winter period (I-IV) also on bark
T. melanurum HAHN, 1831 (syn. *Theridion denticulatum*)	F2	early summer	*Platanus hybrida, Pyrus malus*	KOSLINSKA 1967; HANSEN 1992; SEBESTYÉN 1996	in houses and in forests, under bark in urban habitats
T. mystaceum L. KOCH, 1870	E	V-VII.	*Betula pendula, Fagus sylvatica, Picea abies, Pinus nigra, Pinus sylvestris, Platanus hybrida, Quercus robur*	WUNDERLICH 1982; NICOLAI 1986; HANSEN 1992; SIMON 1995; WEISS 1995; KOPONEN 1996; SEBESTYÉN 1996; HORVÁTH, SZINETÁR 1998, 2002; RINNE *et al.*. 1998; HORVÁTH *et al.* 2001, 2004, 2005; KOVÁCS 2002; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	forests, on tree trunks (mainly in coniferous forests)

Appendix 1. Continued.

1	2	3	4	5	6
T. nigrovariegatum Simon, 1873	A	summer	Pyrus malus	Bogya et al. 1999	on vegetation and on rocks
T. pinastri L. Koch, 1872	F1	VI-VII.	Pinus nigra, Pinus sylvestris, Platanus hybrida, Pyrus communis, Pyrus malus, Quercus robur	Hansen 1992; Simon 1995; Bogya et al. 1999; Pekár 1999; Kubcová, Schlaghamerský 2002; Horváth et al. 2005	on solitary trees and in forests, (mainly on coniferous), in winter period on and under bark
T. varians Hahn, 1833	A	VI-VII.	Picea abies, Pinus sylvestris, Pyrus communis, Pyrus malus, Quercus robur	Koslinska 1967; Nicolai 1986; Simon 1995; Weiss 1995; Rinne et al. 1998; Pekár 1999; Kubcová, Schlaghamerský 2002	on bushes and trees in various habitats, in orchards
Linyphiidae					
Abacoproeces saltuum (L. Koch, 1872)	A	all year summer	Pinus sylvestris	Simon 1995	among leaf litter in different forests
Agyneta conigera (O. P.-Cambridge, 1863)	A	V-VII.	Quercus robur	Rinne et al. 1998	among moss und grass in wet habitats
Anguliphantes angulipalpis (Westring, 1851)	A	IX-V.	Pinus sylvestris	Simon 1995	among grass and leaf litter in dry and semi-humid forests
Araeoncus humilis (Blackwall, 1841)	A	all year	Picea abies, Pinus sylvestris, Pyrus malus, Quercus robur	Hansen 1995; Weiss 1995; Bogya et al. 1999; Kubcová, Schlaghamerský 2002	in various open habitats
Asthenargus helveticus Schenkel, 1936	A	?	Picea abies	Weiss 1995	among leaf litter and detritus in semi-humid forests
Bathyphantes gracilis (Blackwall, 1841)	A	all year	Quercus robur	Wunderlich 1982; Rinne et al. 1998; Kubcová, Schlaghamerský 2002	in wet meadows and various open and forest habitats
B. nigrinus (Westring, 1851)	A	all year	Quercus robur	Kubcová, Schlaghamerský 2002	among vegetation in various semi-humid and humid habitats
B. parvulus (Westring, 1851)	A	all year	Quercus robur	Kubcová, Schlaghamerský 2002	among vegetation in various open and forest habitats
Centromerus pabulator (O. P.-Cambridge, 1875)	A	X-IV.	Pinus sylvestris	Simon 1995	in spruce forests, and in various mountain habitats

Appendix 1. Continued.

1	2	3	4	5	6
C. silvicola (KULCZYŃSKI, 1887)	A	?	*Picea abies*	WEISS 1995	among moss in beech and in spruce forests
C. similis KULCZYŃSKI, 1894	A	?	*Pyrus malus*	BOGYA et al. 1999	among leaf litter in semi-humid forests
C. sylvaticus (BLACKWALL, 1841)	A	XI-IV.	*Picea abies, Pinus sylvestris, Quercus robur*	SIMON 1995; WEISS 1995; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	among moss and detritus in various open and forest habitats
Ceratinella brevis (WIDER, 1834)	A	V-VI.	*Pinus sylvestris*	SIMON 1995	in moss, leaf litter, detritus in forest habitats
C. major KULCZYŃSKI, 1894	A	?	*Pinus sylvestris*	SIMON 1995	among detritus in various forests
Diplocephalus cristatus (BLACKWALL, 1833)	A	all year	*Platanus hybrida*	HANSEN 1992	at ground level in various open habitats
D. helleri (L. KOCH, 1869)	A	summer	*Picea abies*	WEISS 1995	in very humid mountain habitats
D. latifrons (O. P.-CAMBRIDGE, 1863)	A	all year	*Picea abies*	WEISS 1995	among wet leaf litter and in detritus in forests
D. picinus (BLACKWALL, 1841)	A	all year	*Quercus robur*	KUBCOVÁ, SCHLAGHAMERSKÝ 2002	among wet leaf litter and in detritus in forests
Diplostyla concolor (WIDER, 1834)	A	all year	*Picea abies, Pinus sylvestris*	SIMON 1995; WEISS 1995	in leaf litter and in detritus in forests and in open habitats
Drapetisca socialis (SUNDEVALL, 1833)	E	autumn	*Acer pseudoplatanus, Betula pendula, Fagus sylvatica, Picea abies, Pinus sylvestris, Quercus robur, Salix alba, Ulmus glabra*	WUNDERLICH 1982; NICOLAI 1986; SIMON 1995; WEISS 1995; KOPONEN 1996; KOPONEN et al. 1997; RINNE et al. 1998; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on tree bark in both decidious and coniferous forests
Entelecara acuminata (WIDER, 1834)	A	summer	*Pinus sylvestris, Quercus robur*	SIMON 1995; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on bushes and trees in various habitats

Appendix 1. Continued.

1	2	3	4	5	6
E. berolinensis (WUNDERLICH, 1969)	E	summer autumn	*Pyrus communis*	WUNDERLICH 1982	on bark
E. congenera (O. P.-CAMBRIDGE, 1879)	A	early summer	*Picea abies, Pyrus malus*	WEISS 1995; BOGYA *et al.* 1999	on coniferous trees and bushes
E. erythropus (WESTRING, 1851)	A	summer	*Pyrus malus, Quercus robur*	RINNE *et al.* 1998; PEKÁR 1999; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	among moss and grass, on bushes and trees in various habitats, in cultural landscapes
Erigone atra BLACKWALL, 1833	A	all year	*Picea abies, Pinus nigra, Pinus sylvestris, Platanus hybrida, Pyrus malus, Quercus robur*	SIMON 1995; WEISS 1995; SEBESTYÉN 1996; BOGYA *et al.* 1999; HORVÁTH, SZINETÁR 2002; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	wide range of open habitats
E. dentipalpis (WIDER, 1834)	A	all year	*Picea abies, Platanus hybrida, Quercus robur*	HANSEN 1992; WEISS 1995; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	among grass in wide range of open habitats
Erigonella hiemalis (BLACKWALL, 1841)	A	?	*Picea abies*	WEISS 1995	among moss and detritus in various open and forest habitats
Gnathonarium dentatum (WIDER, 1834)	A	autumn - spring	*Quercus robur*	KUBCOVÁ, SCHLAGHAMERSKÝ 2002	among detritus and on vegetation in very humid habitats
Gonatium rubellum (BLACKWALL, 1841)	A	summer	*Picea abies*	WEISS 1995	in mountain spruce forests
Gongylidium rufipes (LINNAEUS, 1758)	A	autumn - spring	*Quercus robur*	KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on herbs and bushes in very humid forests
Helophora insignis (BLACKWALL, 1841)	A	late autumn and winter	*Quercus robur*	KOPONEN 1996; RINNE *et al.* 1998	juveniles on tree branches, adults on low vegetation in forests
Hylyphantes graminicola (SUNDEVALL, 1830)	A	early summer	*Quercus robur*	RINNE *et al.* 1998	on bushes in forests and on their edges

Appendix 1. Continued.

1	2	3	4	5	6
Hypomma cornutum (Blackwall, 1833)	F2	early summer	*Pyrus malus, Quercus robur*	Koslinska 1967; Koponen 1996; Koponen et al. 1997; Rinne et al. 1998; Kovács 2002; Kubcová, Schlaghamerský 2002; Koponen 2004	on various vegetation in wetlands, on bushes and trees, on bark
Kratochviliella bicapitata Miller, 1938	F1	?	*Picea abies, Ulmus glabra*	Wunderlich 1982; Nicolai 1986; Weiss 1995	among stones and detritus and on bark of trees in semi-humid habitats
Labulla thoracica (Wider, 1834)	A	all year	*Picea abies*	Weiss 1995	among roots at foot of tree trunks, on rock walls
Lepthyphantes leprosus (Ohlert, 1865)	A	all year	*Quercus robur*	Koponen 1996	among stones and in cellars
L. minutus (Blackwall, 1833)	E	all year	*Picea abies, Pinus sylvestris, Quercus robur*	Wunderlich 1982; Simon 1995; Weiss 1995; Koponen 1996; Koponen et al. 1997; Rinne et al. 1998; Kubcová, Schlaghamerský 2002	on and under tree bark, in hollow trees in forest habitats
Linyphia triangularis (Clerck, 1757)	A	VIII–XI.	*Pinus nigra, Pinus sylvestris, Platanus hybrida, Quercus robur*	Hansen 1992; Simon 1995; Koponen 1996; Rinne et al. 1998; Horvath, Szinetár 2002; Kubcová, Schlaghamerský 2002	on vegetation in forest edges and in forests
Macrargus boreus Holm, 1968	A	?	*Quercus robur*	Koponen 1996; Rinne et al. 1998	on tree branches
Meioneta innotabilis (O. P.-Cambridge, 1863) (syn. *Agyneta innotabilis*)	E	VIII.	*Acer pseudoplatanus, Fagus sylvatica, Pinus nigra, Pinus sylvestris, Platanus hybrida, Quercus robur, Salix alba, Ulmus glabra*	Wunderlich 1982; Nicolai 1986; Simon 1995; Koponen 1996; Sebestyén 1996; Koponen et al. 1997; Rinne et al. 1998; Kubcová, Schlaghamerský 2002	on tree trunks
Meioneta rurestris (C. L. Koch, 1836)	A	all year	*Picea abies, Pinus sylvestris, Platanus hybrida, Pyrus malus, Quercus robur*	Simon 1995; Weiss 1995; Sebestyén 1996; Rinne et al. 1998; Bogya et al. 1999; Kubcová, Schlaghamerský 2002	in all grassland types

Appendix 1. Continued.

1	2	3	4	5	6
Micrargus georgescuae MILLIDGE, 1975	A	V-X.	*Picea abies*	WEISS 1995	in ground layer of subalpine forests
Microlinyphia impigra (O. P.-CAMBRIDGE, 1871)	A	IV-VI.	*Platanus hybrida*	HANSEN 1992	on vegetation in wetland habitats
M. pusilla (SUNDEVALL, 1830)	A	spring summer	*Picea abies, Platanus hybrida*	HANSEN 1992; WEISS 1995	on vegetation in various open habitats
Microneta viaria (BLACKWALL, 1841)	A	all year	*Pinus sylvestris*	SIMON 1995	among leaf litter and detritus in forest habitats
Midia midas (SIMON, 1884) (syn. *Lepthyphantes midas*)	E	?	*Platanus hybrida, Quercus robur*	HANSEN 1992; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on and under bark and in hollow trees
Minyriolus pusillus (WIDER, 1834)	A	spring	*Picea abies*	WEISS 1995	in moss and lichens in coniferous forests
Mioxena blanda (SIMON, 1884)	A	autumn	*Pinus sylvestris*	SIMON 1995	in various habitats, under stones on rock steppes
Moebelia penicillata (WESTRING, 1851) (syn. *Entelecara penicillata*)	E	all year	*Acer pseudoplatanus, Betula pendula, Fagus sylvatica, Picea abies, Pinus nigra, Pinus sylvestris, Platanus hybrida, Pyrus malus, Quercus robur, Salix alba*	KOSLINSKA 1967; WUNDERLICH 1982; NICOLAI 1986; HANSEN 1992; SIMON 1995; WEISS 1995; KOPONEN 1996; SEBESTYÉN 1996; KOPONEN et al. 1997; HORVÁTH, SZINETÁR 1998, 2002; RINNE et al. 1998; HORVÁTH et al. 2001, 2005; KOVÁCS 2002; KUBCOVÁ, SCHLAGHAMERSKÝ 2002; KOPONEN 2004	on tree trunks, on tree bark
Mughiphantes pulcher (KULCZYŃSKI, 1881) (syn. *Lepthyphantes pulcher*)	A	III-X.	*Picea abies*	WEISS 1995	on rock walls and on tree trunks
Neriene clathrata (SUNDEVALL, 1830)	F2	all year	*Platanus hybrida, Quercus robur*	HANSEN 1992; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	among leaf litter and detritus in forest habitats, under bark of old trees
N. emphana (WALCKENAER, 1842)	A	VI-VIII.	*Pyrus communis*	PEKÁR 1999	on shrubs and dry tree branches in forests

Appendix 1. Continued.

1	2	3	4	5	6
N. montana (CLERCK, 1757)	F2	IV-VI.	Quercus robur	KOPONEN 1996; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on bushes, tree trunks in floodplain forests
N. peltata (WIDER, 1834)	A	IV-VIII.	Quercus robur	RINNE et al. 1998	on bushes in semi-humid forests
Obscuriphantes obscurus (BLACKWALL, 1841)	A	VI-IX.	Quercus robur	RINNE et al. 1998	on shrubs and herb vegetation in various open and forest habitats, on coniferous trees
Oedothorax apicatus (BLACKWALL, 1850)	A	summer autumn	Pyrus malus	BOGYA et al. 1999	at ground level in various open habitats
O. retusus (WESTRING, 1851)	A	V-X.	Quercus robur	KUBCOVÁ, SCHLAGHAMERSKÝ 2002	among grass in various medows
Palliduphantes pallidus (O. P.-CAMBRIDGE, 1871)	A	IV-VIII.	Pinus sylvestris	SIMON 1995	at ground level in various open and forest habitats
Pelecopsis elongata (WIDER, 1834)	A	winter	Picea abies, Platanus hybrida	HANSEN 1992; WEISS 1995	among moss and detritus in rocky habitats, in pine forests, sometimes on trunks
P. mengei (SIMON, 1884)	A	all year	Quercus robur	KUBCOVÁ, SCHLAGHAMERSKÝ 2002	among detritus in various semi-humid forests
P. radicicola (L. KOCH, 1872)	A	all year	Pinus sylvestris	SIMON 1995	in detritus in various forests and heatlands
Pityohyphantes phrygianus (C. L. KOCH, 1836)	A	early summer	Picea abies, Quercus robur	WEISS 1995; RINNE et al. 1998	on branches in the canopy of coniferous trees and on junipers
Porrhomma microphthalmum (O. P.-CAMBRIDGE, 1871)	A	?	Quercus robur	KUBCOVÁ, SCHLAGHAMERSKÝ 2002	among grass and leaf litter in various open habitats, sporadically also in forests
P. montanum JACKSON, 1913	A	?	Pinus sylvestris	SIMON 1995	among leaf litter in humid forests
P. oblitum (O. P.- CAMBRIDGE, 1871)	F1	?	Pinus sylvestris, Quercus robur	KOVÁCS 2002; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	in various open and forest habitats, under bark in semi-humid and humid forests

Appendix 1. Continued.

1	2	3	4	5	6
P. pallidum JACKSON, 1913	A	?	Pinus sylvestris	SIMON 1995	at ground level in spruce forests, under stones in scree slopes
P. pygmaeum (BLACKWALL, 1834)	A	?	Quercus robur	RINNE et al. 1998	at ground level, on bushes and herb vegetation in wetlands and floodplain forests
Prinerigone vagans (AUDOUIN, 1826)	A	autumn - spring	Platanus hybrida	HANSEN 1992	among grass in open habitats, in parks
Saloca diceros (O. P.-CAMBRIDGE, 1871)	A	autumn - spring	Picea abies	WEISS 1995	among leaf litter and detritus in forests
Savignia frontana BLACKWALL, 1833 (syn. Savignya frontana)	A	all year	Quercus robur	KOPONEN et al. 1997; RINNE et al. 1998	among grass and moss in peat bogs and in marshy forests
Silometopus reussi (THORELL, 1871)	A	all year	Picea abies, Quercus robur	WUNDERLICH 1982; WEISS 1995;	among detritus in various mainly semi-humid habitats
Syedra myrmicarum (KULCZYŃSKI, 1882)	A	?	Pinus sylvestris	SIMON 1995	in the nest of ants (Manica rubida, Formica fusca)
Tapinocyba affinis LESSERT, 1907	A	?	Picea abies	WEIS, 1995	among moss and detritus in forests
T. pallens (O. P.- CAMBRIDGE, 1872)	A	autumn - spring	Quercus robur	RINNE et al. 1998	among moss and detritus in forests
Tenuiphantes flavipes (BLACKWALL, 1854) (syn. Lepthyphantes flavipes)	A	all year	Pinus sylvestris, Quercus robur	SIMON 1995; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	among leaf litter and detritus in forests
T. mengei (KULCZYŃSKI, 1887) (syn. Lepthyphantes mengei)	A	all year	Pinus sylvestris	SIMON 1995	at ground level in open and forest habitats
T. tenebricola (WIDER, 1834) (syn. Lepthyphantes tenebricola)	A	III-X.	Picea abies, Quercus robur	WEISS 1995; RINNE et al. 1998	among leaf litter and detritus and under stones in forests
T. tenuis ((BLACKWALL, 1852) (syn. Lepthyphantes tenuis)	A	all year	Pinus sylvestris, Platanus hybrida, Quercus robur	HANSEN 1992; SIMON 1995; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	among grass in various open and semi-open habitats, often in disturbed habitats

Appendix 1. Continued.

1	2	3	4	5	6
Thyreostenius parasiticus (WESTRING, 1851)	F1	all year	*Picea abies, Pinus sylvestris, Pyrus malus, Quercus robur*	WUNDERLICH 1982; SIMON 1995; WEISS 1995; KOPONEN 1996; BOGYA *et al.* 1999; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	in various habitats and stratums, on scree slopes, on walls and often under bark in forest habitats
Tiso vagans (BLACKWALL, 1834)	A	spring – autumn	*Platanus hybrida*	HANSEN 1992	among grass in various grasslands, in orchards and parks
Trematocephalus cristatus (WIDER, 1834)	A	summer	*Pinus sylvestris*	SIMON 1995	on trees, bushes and herb vegetation in forests and open habitats
Trichoncoides piscator (SIMON, 1884)	A	?	*Pyrus malus*	BOGYA *et al.* 1999	in leaf litter in mixed forests, in agriculture habitats in orchards, in arable lands
Trichopterna cito (O. P.- CAMBRIDGE, 1872)	A	all year	*Platanus hybrida*	HANSEN 1992	among grass in various xerothermic open habitats
Troxochorus nasutus SCHENKEL, 1947	F1	spring – summer	*Picea abies*	WUNDERLICH 1982; WEISS 1995	among grass and moss, on tree trunks in mountain beech and spruce forests
Walckenaeria acuminata BLACKWALL, 1833	A	all year	*Pinus sylvestris*	SIMON 1995	among detritus in various open and semi-open habitats
W. antica (WIDER, 1834)	A	?	*Pinus sylvestris, Quercus robur*	SIMON 1995; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	at ground level in various open and forest habitats
W. cucullata (C. L. KOCH, 1836)	A	spring – autumn	*Picea abies, Pinus sylvestris*	SIMON 1995; WEISS 1995	among leaf litter and detritus in forests
W. dysderoides (WIDER, 1834)	A	summer	*Pinus sylvestris*	SIMON 1995	among moss and detritus in various forest and open habitats
W. obtusa BLACKWALL, 1836	A	spring – autumn	*Pinus sylvestris*	SIMON 1995	among moss and grass in various forests, often in spruce forests

Appendix 1. Continued.

1	2	3	4	5	6
Tetragnathidae					
Metellina merianae (Scopoli, 1763)	A	all year	*Picea abies*	Weiss 1995	in dark, humid spaces, in entrances of caves
Pachygnatha degeeri Sundevall, 1830	A	all year	*Pinus sylvestris, Pyrus malus, Quercus robur*	Koslinska 1967; Simon 1995; Kubcová, Schlaghamerský 2002	among detritus in various open habitats, often in suburban grasslands and agriculture areas
P. listeri Sundevall, 1830	A	autumn – spring	*Quercus robur*	Kubcová, Schlaghamerský 2002	among leaf litter and grass in wetlands and forests
Tetragnatha dearmata Thorell, 1873	A	VI.	*Quercus robur*	Rinne et al. 1998; Koponen 2004	on vegetation in semi-humid and humid open and forest habitats
T. montana Simon, 1874	A	V-IX.	*Quercus robur*	Kubcová, Schlaghamerský 2002	on herb vegetation in partly shaded wetlands, often in floodplain forests
T. obtusa C. L. Koch, 1837	A	VI-VIII.	*Pinus sylvestris*	Simon 1995	on bushes and solitary trees, not only in semi-humid and humid habitats
T. pinicola L. Koch, 1870	A	V-VI.	*Pinus sylvestris*	Simon 1995	on vegetation in open and forest habitats
Araneidae					
Aculepeira ceropegia (Walckenaer, 1802)	A	early summer	*Pyrus communis, Pyrus malus*	Pekár 1999	on herbs and bushes in various open habitats and on forest edges, in orchards
Araneus diadematus Clerck, 1757	A	VIII-IX.	*Picea abies, Pinus nigra, Pinus sylvestris, Quercus robur*	Simon 1995; Weiss 1995; Koponen 1996; Horváth, Szinetár 1998, 2002; Rinne et al. 1998; Kovács 2002; Kubcová, Schlaghamerský 2002	on herbs, bushes, trees in various open and forest habitats
A. sturmi (Hahn, 1831) (syn. *Atea sturmi*)	A	V-VII.	*Picea abies, Pinus sylvestris, Platanus hybrida, Quercus robur*	Simon 1995; Weiss 1995; Sebestyén 1996; Rinne et al. 1998; Kubcová, Schlaghamerský 2002	on shrubs and in canopies of trees on forest edges, often on young conifers

Appendix 1. Continued.

1	2	3	4	5	6
A. triguttatus (FABRICIUS, 1775) (syn. Araneus triguttata)	A	V-VI.	Quercus robur	KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on trees in deciduous forests and on forest edges
Araniella alpica (L. KOCH, 1869)	A	VI-VIII.	Picea abies	WEISS 1995	on trees and bushes in forest and their edges
A. cucurbitina (CLERCK, 1757)	A	V-VIII.	Pinus sylvestris, Pyrus communis, Pyrus malus, Quercus robur	KOSLINSKA 1967; SIMON 1995; KOPONEN 1996; RINNE et al. 1998; PEKÁR 1999; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on bushes and trees in all forest and open habitats
A. displicata (HENTZ, 1847)	A	V-VII.	Pinus sylvestris	SIMON 1995	on bushes and trees on forest edges, often on young conifers
Cyclosa conica (PALLAS, 1772)	A	IV-VI.	Picea abies	WEISS 1995	on bushes and trees in forests, forest edges
C. oculata (WALCKENAER, 1802)	A	IV-VII.	Pyrus malus	KOSLINSKA 1967	on herb vegetation in wet meadows, sporadic in semi-humid and humid forests
Gibbaranea bituberculata (WALCKENAER, 1802)	A	IV-VI.	Pinus nigra	HORVÁTH, SZINETÁR 1998, 2002; HORVÁTH et al. 2004	on vegetation in steppes, xerothermic forest margins, in winter period rarely on bark
G. gibbosa (WALCKENAER, 1802)	A	V-VI.	Pinus sylvestris, Pyrus communis, Pyrus malus, Quercus robur	SIMON 1995; PEKÁR 1999; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on bushes and trees on xerothermic slopes and in orchards
G. omodea (THORELL, 1870)	A	IV-VI.	Picea abies	WEISS 1995	in the canopy of coniferous trees
Hypsosinga pygmaea (SUNDEVALL, 1831)	A	V-VI.	Pyrus malus	BOGYA et al. 1999	on vegetation in open habitats
Larinioides ixobolus (THORELL, 1873)	A	VII-X.	Pinus nigra, Platanus hybrida	SEBESTYÉN 1996, HORVÁTH et al. 2005	on buildings and on trees near water
L. patagiatus (CLERCK, 1757)	A	all year	Platanus hybrida	SEBESTYÉN 1996	on shrubs and trees on forest edges, near ponds

Appendix 1. Continued.

1	2	3	4	5	6
Mangora acalypha (Walckenaer, 1802)	A	V-VII.	*Pinus nigra*	Horváth, Szinetár 2002	on vegetation in all open habitats and in forest edges
Nuctenea silvicutrix (C. L. Koch, 1835)	E	IV-VIII.	*Picea abies*	Weiss 1995	on conifers on peat bogs
N. umbratica (Clerck, 1757)	F1	all year females VI-VIII. males	*Picea abies, Pinus nigra, Pinus sylvestris, Platanus hybrida, Quercus robur*	Wunderlich 1982; Hansen 1992; Simon 1995; Koponen 1996; Sebestyén 1996; Koponen et al. 1997; Horváth, Szinetár 1998, 2002; Rinne et al.. 1998; Horváth et al. 2001, 2004, 2005; Kovács 2002; Koponen 2004	forests, buildings, under tree bark, on wooden constructions
Parazygiella montana (C. L. Koch, 1839) (syn. *Zygiella montana*)	A	summer	*Picea abies*	Weiss 1995	on shrubs and lower branches of trees in subalpine forests
Stroemiellus stroemi (Thorell, 1872) (syn. *Zygiella stroemi*)	F1	V-VI.	*Platanus hybrida, Quercus robur*	Koponen 1996; Koponen et al. 1997; Sebestyén 1996; Rinne et al. 1998	on tree trunks and on rocky walls
Zilla dioida (Walckenaer, 1802)	A	IV-V.	*Pinus sylvestris*	Simon 1995	on bushes and lower braches in light forests
Zygiella atrica (C. L. Koch, 1845)	A	summer	*Pinus sylvestris, Quercus robur*	Simon 1995; Koponen 1996; Koponen et al. 1997; Rinne et al. 1998	on shrubs and solitary trees, on various natural and artificial vertical surfaces
Z. x-notata (Clerck, 1757)	F2	summer-autumn	*Platanus hybrida*	Hansen 1992	on wall of houses, on tree trunks and on rocky walls
Lycosidae					
Acantholycosa lignaria (Clerck, 1758)	F2	summer	*Picea abies*	Weiss 1995	on fallen tree trunks, in forests clearings in the mountains
Pardosa agrestis (Westring, 1861)	A	III-IX.	*Pinus sylvestris, Pyrus malus*	Simon 1995; Bogya et al. 1999	in open habitats, in early stages of succession
P. ferruginea (L. Koch, 1870)	A	VII-IX.	*Picea abies*	Weiss 1995	in mountain spruce forests and meadows
P. lugubris (Walckenaer, 1802)	A	III-IX.	*Picea abies*	Weiss 1995	on ground layer in various forests and their edges

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Appendix 1. Continued.

1	2	3	4	5	6
P. prativaga (L. KOCH, 1870)	A	IV-IX.	*Quercus robur*	RINNE *et al.* 1998; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	in underlogged meadows and on marshy pond margins
P. riparia (C. L. KOCH, 1833)	A	V-VII.	*Picea abies*	WEISS 1995	on wet meadows and forest clearings
Pirata hygrophilus THORELL, 1872	A	V-IX.	*Quercus robur*	KUBCOVÁ, SCHLAGHAMERSKÝ 2002	in humid habitats, often in floodplain and in marshy forests
Pisauridae					
Pisaura mirabilis (CLERCK, 1757)	A	VII-VIII.	*Pinus sylvestris, Pyrus malus*	SIMON 1995; BOGYA *et al.* 1999	in ground and on herb layer in various open and partly shaded habitats
Agelenidae					
Agelena gracilens C. L. KOCH, 1841	A	summer	*Platanus hybrida*	SEBESTYÉN 1996	on bushes in various habitats
A. labyrinthica (CLERCK, 1757)	A	VII-X.	*Pinus nigra, Pyrus malus, Quercus robur*	BOGYA *et al.* 1999; HORVÁTH, SZINETÁR 2002; KOVÁCS 2002	among herb vegetation on various forest edges
Histopona torpida (C. L. KOCH, 1834)	A	IV-XI.	*Picea abies*	WEISS 1995	among stones, roots, in hollow trees
Tegenaria agrestis (WALCKENAER, 1802)	A	summer-autumn	*Pinus sylvestris, Pyrus malus*	SIMON 1995; BOGYA *et al.* 1999	mainly in ground layer in various dry and open habitats
T. campestris C. L. KOCH, 1834	A	V-IX.	*Quercus robur*	KUBCOVÁ, SCHLAGHAMERSKÝ 2002	among branches of bushes in forests
T. ferruginea (PANZER, 1804)	F2	II-XI.	*Pinus nigra, Pinus sylvestris*	SIMON 1995; HORVÁTH, SZINETÁR 1998, 2002; HORVÁTH *et al.* 2001	in hollow trees, under tree bark, in buildings
T. nemorosa SIMON, 1916	A	?	*Platanus hybrida*	HANSEN 1992	in houses, in dry open habitats, on tree trunks
T. pagana C. L. KOCH, 1840	A	?	*Platanus hybrida*	HANSEN 1992	in houses, in dry open habitats
T. parietina (FOURCROY, 1785)	A	all year	*Pinus sylvestris, Platanus hybrida*	HANSEN 1992; SIMON 1995	on rock walls, in houses, in dry open habitats
T. silvestris L. KOCH, 1872	A	II-X.	*Quercus robur*	KUBCOVÁ, SCHLAGHAMERSKÝ 2002	under stones in scree slopes in semi-humid and humid forests

Appendix 1. Continued.

1	2	3	4	5	6
Textrix denticulata (OLIVIER, 1789)	F1	summer	*Pinus sylvestris*	SIMON 1995	under stones in scree slopes and under tree bark on forest edges
Cybaeidae					
Cybaeus angustiarum L. KOCH, 1868	A	VIII.	*Picea abies*	WEISS 1995	under stones, in wet decaying trunks and tree stumps in shaded forests
Hahnidae					
Cryphoeca silvicola (C. L. KOCH, 1834)	F1	autumn - spring	*Picea abies, Quercus robur*	WEISS 1995; RINNE *et al.* 1998	under tree bark, among detritus and under stones in mountain forests
Hahnia picta KULCZYŃSKI, 1897	E	III-VI.	*Acer campestre, Aesculus hyppocastaneum, Platanus hybrida, Pyrus communis*	WUNDERLICH 1982; SEBESTYÉN 1996	under tree bark
H. pusilla C. L. KOCH, 1841	A	III-XII.	*Quercus robur*	KOPONEN 1996; KOPONEN *et al.* 1997; RINNE *et al.* 1998; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	among moss, leaf litter and detritus in forest habitats
Tuberta maerens (O. P.-CAMBRIDGE, 1863)	F1	autumn	*Platanus hybrida*	HANSEN 1992	under tree bark and under stones
Dictynidae					
Argenna subnigra (O.P.-CAMBRIDGE, 1861)	A	summer -autumn	*Platanus hybrida*	WUNDERLICH 1982	among grass, leaf litter and under stones in open habitats
Cicurina cicur (FABRICIUS, 1793)	A	spring - autumn	*Pyrus malus*	KOSLINSKA 1967	in leaf litter and under stones in forests and in open habitats with high humidity
Dictyna arundinacea (LINNAEUS, 1758)	A	V-VI.	*Pinus sylvestris, Platanus hybrida*	HANSEN 1992; SIMON 1995	on vegetation in various open habitats

Appendix 1. Continued.

1	2	3	4	5	6
D. civica (LUCAS, 1850)	A	VI-XI.	Pinus nigra	HORVÁTH, SZINETÁR 2002	on various sun-exposed vertical surfaces, on walls of houses, on tree trunks in towns
D. major MENGE, 1869	A	early summer	Pinus sylvestris	SIMON 1995	on bushes in humid mountain habitats, in peat bogs
D. pusilla THORELL, 1856	A	spring - summer	Picea abies, Pinus sylvestris, Platanus hybrida, Pyrus malus	KOSLINSKA 1967; SIMON 1995; SEBESTYÉN 1996; KOVÁCS 2002	on tree branches in various forests and their edges
D. uncinata THORELL, 1856	A	V-VIII.	Pinus nigra, Platanus hybrida, Pyrus communis, Pyrus malus, Quercus robur	KOSLINSKA 1967; SEBESTYÉN 1996; PEKÁR 1999; HORVÁTH, SZINETÁR 2002; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on tree branches on forest edges, in orchards and in gardens
Lathys humilis (BLACKWALL, 1855)	F1	IV-VI.	Pinus nigra, Pinus sylvestris, Platanus hybrida, Quercus robur	WUNDERLICH 1982; HANSEN 1992; HORVÁTH, SZINETÁR 1998, 2002; HORVÁTH et al. 2001; KOVÁCS 2002; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on trees (mainly on coniferous) in forests, and in parks in winter period on and under bark
Mastigusa arietina (THORELL, 1871)	F2	all year	Quercus robur	WUNDERLICH 1982	in the nest of ants on xerothermic slopes and forest margins, under bark
Nigma flavescens (WALCKENAER, 1830)	A	V.	Pinus sylvestris	SIMON 1995	on foliage mainly in oak forests, on shrubs on forest edges
N. puella (SIMON, 1870)	A	IV-VIII.	Pinus sylvestris	SIMON 1995	on bushes
N. walckenaeri (ROEWER, 1951)	F2	VI-X.	Pinus nigra, Platanus hybrida	SEBESTYÉN 1996; HORVÁTH, SZINETÁR 1998, 2002; HORVÁTH et al. 2001	on foliage of trees and bushes, on walls of houses, in winter period on and under bark
Amaurobiidae					
Amaurobius erberi (KEYSERLING, 1863)	A	autumn - winter	Platanus hybrida	HANSEN 1992	under stones

Appendix 1. Continued.

1	2	3	4	5	6
A. fenestralis (STRÖM, 1768)	F1	IV-XI.	*Picea abies, Pinus nigra*	WUNDERLICH 1982; WEISS 1995; HORVÁTH, SZINETÁR 1998, 2002; HORVÁTH *et al.* 2005	under tree bark, in hollow trees, in fissures on rock walls
A. jugorum L. KOCH, 1868	A	VI-IV.	*Pinus nigra*	HORVÁTH, SZINETÁR 2002; HORVÁTH *et al.* 2005	under stones in forest steppes, rock steppes and their edges, on tree trunk
Callobius claustrarius (HAHN, 1833)	A	autumn - spring	*Picea abies*	WEISS 1995	under stones in spruce, beech and scree forests
Coelotes terrestris (WIDER, 1834)	A	autumn - spring	*Picea abies*	WEISS 1995	at gruond level in forests
Eurocoelotes inermis (L. KOCH, 1855) (syn. *Coelotes inermis*)	A	all year	*Picea abies*	WEISS 1995	at gruond level in forests
Titanoecidae					
Titanoeca schineri L. KOCH 1872	A	VI-XI.	*Pyrus malus*	BOGYA *et al.* 1999	under stones on rock steppes, on sand dunes
Miturgidae					
Cheiracanthium mildei L. KOCH, 1864	F1	V-VI.	*Pinus nigra, Platanus hybrida, Pyrus malus*	HANSEN 1992; SEBESTYÉN 1996; HORVÁTH, SZINETÁR 1998, 2002; BOGYA *et al.* 1999; HORVÁTH *et al.* 2001	on trees, on and in buildings and in various xerotherm open habitats, orchards, in winter under bark
C. oncognathum THORELL, 1871	A	V.	*Quercus robur*	KOPONEN *et al.* 1997; RINNE *et al.* 1998	on herb vegetation on rock steppes and other xerothermic habitats
Anyphaenidae					
Anyphaena accentuata (WALCKENAER, 1802)	F1	V-VIII.	*Alnus glutinosa, Carpinus betulus, Fagus sylvatica, Picea abies, Pinus nigra, Pinus sylvestris, Platanus hybrida, Prunus avium, Pyrus malus, Quercus robur*	KOSLINSKA 1967; WUNDERLICH 1982; SIMON 1995; KOPONEN 1996; SEBESTYÉN 1996; KOPONEN *et al.* 1997; RINNE *et al.* 1998; HORVÁTH, SZINETÁR 1998, 2002; HORVÁTH *et al.* 2001, 2004, 2005; KOVÁCS 2002; KUBCOVÁ, SCHLAGHAMERSKÝ 2002; KOPONEN 2004	on leaves and branches of trees in deciduous and mixed forests, winter on and under bark

Appendix 1. Continued.

1	2	3	4	5	6
A. sabina L. KOCH, 1866	A	?	*Platanus hybrida*	HANSEN 1992	on trees
Liocranidae					
Agroeca brunnea (BLACKWALL, 1833)	F2	all year	*Pinus sylvestris, Quercus robur*	SIMON 1995; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	in detritus in various forests, at gruond level, on shrubs and on tree trunks
Liocranum rupicola (WALCKENAER, 1830)	F2	III-XII.	*Pinus nigra*	WUNDERLICH 1982; HORVÁTH, SZINETÁR 1998	on sun-exposed scree slopes, in buildings, on vertical surfaces, under bark
L. rutilans (THORELL, 1875)	F2	VI-IX.	-	WUNDERLICH 1982	on sun-exposed scree slopes, under bark
Clubionidae					
Clubiona brevipes BLACKWALL, 1841	F1	IV-VII.	*Fagus sylvatica, Pinus nigra, Pinus sylvestris, Platanus hybrida, Quercus robur*	HANSEN 1992; SIMON 1995; SEBESTYÉN 1996; HORVÁTH, SZINETÁR 1998; HORVÁTH *et al.* 2001; KOVÁCS 2002; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on tree bark, on bushes in sun-exposed forests and edges
C. caerulescens L. KOCH, 1867	A	V-IX.	*Picea abies*	WEISS 1995	on bushes in semi-humid forests
C. comta C. KOCH, 1839	F2	IV-VII.	*Carpinus betulus, Picea abies, Pinus nigra, Pinus sylvestris, Quercus robur*	SIMON 1995; KOPONEN 1996; KOPONEN *et al.* 1997; RINNE *et al.* 1998; HORVÁTH, SZINETÁR 2002; KOVÁCS 2002; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on trees (mainly in deciduous forests), among moss, under stones, under bark in winter period on bark
C. corticalis (WALCKENAER, 1802)	E1	IV-IX.	*Pinus nigra, Pinus sylvestris*	SIMON 1995; HORVÁTH, SZINETÁR 1998, 2002; HORVÁTH *et al.* 2005	under tree bark, on peat bogs and in semi-humid and humid mountain forests

Appendix 1. Continued.

1	2	3	4	5	6
*C. genevensis** L. KOCH, 1866 In case of HANSEN (1992) and SIMON (1995) – according to self-revision all data are *C. leucaspis* SIMON, 1932.		IV-VI.	*Alnus glutinosa, Fagus sylvatica, Pinus nigra, Pinus sylvestris, Platanus hybrida, Pyrus malus, Prunus avium, Quercus robur*	HANSEN 1992; SIMON 1995; HORVÁTH, SZINETÁR 1998, 2002; BOGYA *et al.* 1999; HORVÁTH *et al.* 2001; KOVÁCS 2002	Notes: *C. genevenis* is a ground-dwelling species of dry sandy lands. See details in text.
C. leucaspis SIMON, 1932	E	III-VII.	*Pinus nigra, Pinus sylvestris, Quercus robur*	DI FRANCO 1993; MALTEN 1994; KOVÁCS 2002; HORVÁTH *et al.* 2005	forests, edges, under tree bark, on tree trunks (mainly on coniferous) in winter period on bark
C. marmorata L. KOCH, 1866	F1	?	*Pyrus malus*	BOGYA *et al.* 1999	on tree bark and on tree branches in deciduous forests and on solitary trees
C. lutescens WESTRING, 1851	A	V-VIII.	*Quercus robur*	RINNE *et al.* 1998; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on herb vegetation and on bushes in various open and forest habitats
C. pallidula (CLERCK, 1757)	F1	IV-IX.	*Alnus glutinosa, Carpinus betulus, Fagus sylvatica, Picea abies, Pinus nigra, Pinus sylvestris, Platanus hybrida, Prunus avium, Quercus robur*	KOPONEN 1996; SEBESTYÉN 1996; HORVÁTH, SZINETÁR 1998; RINNE *et al.* 1998, 2002; HORVÁTH *et al.* 2001, 2004, 2005; KUBCOVÁ, SCHLAGHAMERSKÝ 2002; KOVÁCS 2002; KOPONEN 2004	on tree trunks (mainly in deciduous forests) often in nests, in winter period under bark
C. reclusa O. P.-CAMBRIDGE, 1863	A	female all year, male IV-VIII.	*Picea abies*	WEISS 1995	at ground level and on herb vegetation in wetlands and forest edges
C. stagnatilis KULCZYŃSKI, 1897	A	V-X.	*Pinus sylvestris*	SIMON 1995	on herb vegetation in wetlands

Appendix 1. Continued.

1	2	3	4	5	6
C. subsultans THORELL, 1875	F1	IV-X.	*Picea abies, Pinus sylvestris, Quercus robur*	SIMON 1995; WEISS 1995; RINNE *et al.* 1998	under tree bark and among detritus in forest habitats
C. terrestris WESTRING, 1851	F2	all year	*Picea abies, Pinus nigra, Pinus sylvestris, Platanus hybrida*	HANSEN 1992; SIMON 1995; WEISS 1995; HORVÁTH, SZINETÁR 2002	among leaf litter and detritus, under tree bark in various forest habitats
C. trivialis C. L. KOCH, 1843	A	V-IX.	*Picea abies*	WEISS 1995	on bushes in wide range of open habitats
Corinnidae					
Cetonana laticeps (CANESTRINI, 1868)	E	V-VIII.	*Pyrus communis*	WUNDERLICH 1982	on and under bark
Phrurolithus festivus (C. L. KOCH, 1835)	F2	IV-X.	*Pinus nigra, Platanus hybrida, Pyrus malus, Quercus robur*	HANSEN 1992; PEKÁR 1999; HORVÁTH, SZINETÁR 2002; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	among grass and detritus in various open and forest habitats, sometimes on tree trunks
Zodariidae					
Zodarion hamatum WIEHLE, 1964	A	?	*Platanus hybrida*	HANSEN 1992	?
Gnaphosidae					
Drassodes lapidosus (WALCKENAER, 1802)	A	IV-X.	*Pyrus malus*	BOGYA *et al.* 1999	under stones, on various sun-exposed vertical surfaces in xerothermic habitats
Drassyllus pusillus (C. L. KOCH, 1833)	A	IV-XI.	*Pyrus malus*	BOGYA *et al.* 1999	at ground level in various open habitats
Gnaphosa montana (L. KOCH 1866)	F1	IV-X.	*Picea abies*	WEISS 1995	under bark of fallen trunks and tree stumps in mountain forests
Haplodrassus cognatus (WESTRING, 1861)	E	III-X.	*Quercus robur*	KOPONEN 1996; RINNE *et al.* 1998; KUBCOVÁ, SCHLAGHAMERSKÝ 2002; KOPONEN 2004	under tree bark on solitary trees and forest edges, in hollow trees
Micaria cyrnea BRIGNOLI, 1983	?	?	*Platanus hybrida*	HANSEN 1992	?

Appendix 1. Continued.

1	2	3	4	5	6
M. pulicaria (SUNDEVALL, 1831)	A	spring – early autumn	*Pyrus communis*	PEKÁR 1999	among grass, moss in various open habitats
M. subopaca WESTRING, 1861	E	IV-X.	*Fagus sylvatica, Pinus nigra, Platanus hybrida, Pyrus communis, Quercus robur*	WUNDERLICH 1982; NICOLAI 1986; HANSEN 1992; KOPONEN 1996; SEBESTYÉN 1996; KOPONEN *et al.* 1997; HORVÁTH, SZINETÁR 1998, 2002; RINNE *et al.* 1998; HORVÁTH *et al.* 2001, 2005; KUBCOVÁ, SCHLAGHAMERSKÝ 2002; KOPONEN 2004	on solitary trees, on and under bark in various open and forest habitats
Scotophaeus quadripunctatus (LINNAEUS, 1758)	F1	II-X.	*Quercus robur*	WUNDERLICH 1982; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	under tree bark, in hollow trees in beech, oak and floodplain forests, in houses
S. scutulatus (L. KOCH, 1866)	F1	all year	*Pinus nigra, Pinus sylvestris, Platanus hybrida, Quercus robur*	WUNDERLICH 1982; HANSEN 1992; SEBESTYÉN 1996; HORVÁTH, SZINETÁR 1998, 2002; HORVÁTH *et al.* 2001, 2004, 2005; KOVÁCS 2002; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	under tree bark in forests, parks, in buildings and in houses
S. validus (LUCAS, 1846)	?	?	*Platanus hybrida*	HANSEN 1992	?
Zelotes tenuis (L. KOCH, 1866)	?	?	*Platanus hybrida*	HANSEN 1992	?
Zoridae					
Zora spinimana (SUNDEVALL, 1833)	A	?	*Picea abies, Pinus sylvestris, Platanus hybrida, Quercus robur*	HANSEN 1992; SIMON 1995; WEISS 1995; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	in various open and forest habitats, sometimes on tree trunks
Philodromidae					
Philodromus albidus KULCZYŃSKI, 1911	F1	early summer	*Platanus hybrida, Quercus robur*	HANSEN 1992; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on shrubs and trees on forest steppes, in oak forests and in orchards
P. aureolus (CLERCK, 1757)	F1	IV-VII.	*Fagus sylvatica, Pinus nigra, Pinus sylvestris, Pyrus malus, Quercus robur*	WUNDERLICH 1982; SIMON 1995; HORVÁTH, SZINETÁR 1998, 2002; BOGYA *et al.* 1999; HORVÁTH *et al.* 2001, 2004, 2005; KOVÁCS 2002	on shrubs and trees in forest edges and in orchards

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Appendix 1. Continued.

1	2	3	4	5	6
P. cespitum (WALCKENAER, 1802)	F1	spring - summer	*Pinus sylvestris, Platanus hybrida, Pyrus communis, Pyrus malus*	HANSEN 1992; SIMON 1995; SEBESTYÉN 1996; BOGYA *et al.* 1999; PEKÁR 1999	on shrubs and trees in forest edges and in orchards
P. collinus C. L. KOCH, 1835	F1	early summer	*Picea abies, Pinus sylvestris, Platanus hybrida*	WUNDERLICH 1982; HANSEN 1992; SIMON 1995; WEISS 1995	on shrubs and trees in forests, mainly on coniferous trees
P. dispar WALCKENAER, 1826	F2	IV-VII.	*Pinus nigra, Pinus sylvestris, Quercus robur*	HORVÁTH, SZINETÁR 1998; HORVÁTH *et al.* 2001; KOVÁCS 2002	on vegetation in forests and forest edges
P. emarginatus (SCHRANK, 1803)	E	early summer	*Pinus sylvestris, Pyrus malus*	SIMON 1995; BOGYA *et al.* 1999	on tree trunks in coniferous forests
P. fuscomarginatus (DE GEER, 1778)	E	VI-VIII.	*Picea abies, Pinus sylvestris*	WUNDERLICH 1982; WEISS 1995; KOVÁCS 2002	on tree trunks in pine forests, on and under bark of *Pinus sylvestris*
P. longipalpis SIMON, 1870	F1	IV-VII.	*Pinus nigra, Pinus sylvestris, Platanus hybrida, Pyrus malus*	SEBESTYÉN 1996; HORVÁTH, SZINETÁR 1998; BOGYA *et al.* 1999; KOVÁCS 2002	on trees (mainly on coniferous), shrubs and herbs in forests, in forest edges, in parks
P. margaritatus (CLERCK, 1757)	E	V-VIII.	*Alnus glutinosa, Carpinus betulus, Fagus sylvatica, Picea abies, Pinus nigra, Pinus sylvestris, Platanus hybrida, Pyrus communis, Pyrus malus, Quercus robur*	WUNDERLICH 1982; SIMON 1995; SEBESTYÉN 1996; HORVÁTH, SZINETÁR 1998, 2002; PEKÁR 1999; HORVÁTH *et al.* 2001, 2004, 2005; KOVÁCS 2002	on tree trunks and branches in forests and on forest edges
P. praedatus O. P.-CAMBRIDGE, 1871	F1	IV-VII.	*Pinus nigra, Quercus robur*	HORVÁTH, SZINETÁR 1998, 2002; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on herb vegetation and on trees and shrubs (mainly on coniferous) in forests, on forest edges, in parks

Appendix 1. Continued.

1	2	3	4	5	6
P. rufus WALCKENAER, 1826	F1	V-VI.	*Carpinus betulus, Fagus sylvatica, Picea abies, Pinus nigra, Pinus sylvestris, Quercus robur*	SIMON 1995; HORVÁTH, SZINETÁR 1998, 2002; HORVÁTH *et al.* 2001; KOVÁCS 2002	on vegetation in various habitats, edges in orchards, in winter period mainly under bark
Tibellus oblongus (WALCKENAER, 1802)	A	early summer autumn	*Pyrus communis, Pyrus malus*	BOGYA *et al.* 1999; PEKÁR 1999	among grass in various open habitats, also in orchards
Thomisidae					
Coriarachne depressa (C. L. KOCH, 1837)	E	V-IX.	*Fagus sylvatica, Pinus sylvestris, Quercus robur*	WUNDERLICH 1982; SIMON 1995; KOVÁCS 2002	under tree bark in pine forests
Diaea dorsata (FABRICIUS, 1777)	F1	IV-VI.	*Picea abies, Pinus nigra, Pinus sylvestris, Pyrus communis, Quercus robur*	SIMON 1995; WEISS 1995; HORVÁTH, SZINETÁR 1998, 2002; PEKÁR 1999; KOVÁCS 2002; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on leaves of bushes and trees in forest habitats, in winter period on and under bark
D. livens SIMON, 1876 (syn. *Diaea pictilis*)	F1	IV-VI.	*Pinus nigra, Platanus hybrida, Pyrus malus, Quercus robur*	SEBESTYÉN 1996; BOGYA *et al.* 1999; HORVÁTH, SZINETÁR 2002; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on branches of solitary trees (mainly oak) and on forest edges, in winter period on and under bark
Misumena vatia (CLERCK, 1757)	A	V-VII.	*Pyrus malus*	BOGYA *et al.* 1999	on flowers in meadows, other open habitats
Misumenops tricuspidatus (FABRICIUS, 1775)	F2	V-VIII.	*Pinus nigra, Platanus hybrida, Pyrus communis, Pyrus malus, Quercus robur*	SEBESTYÉN 1996; BOGYA *et al.* 1999; PEKÁR 1999; HORVÁTH, SZINETÁR 2002; KOVÁCS 2002; HORVÁTH *et al.* 2004	on herbs and bushes, on lower branches of trees in semi-open and partly shaded habitats, often in orchards, in winter period on bark
Ozyptila praticola (C. L. KOCH, 1837)	F2	III-XII.	*Platanus hybrida, Quercus robur*	HANSEN 1992; KOPONEN 1996; SEBESTYÉN 1996; RINNE *et al.* 1998; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	in various forest habitats, at ground level and also on tree trunks

Appendix 1. Continued.

1	2	3	4	5	6
O. sanctuaria (O. P.-CAMBRIDGE, 1871)	A	?	*Platanus hybrida*	HANSEN 1992	among grass in dry habitats
Pistius truncatus (PALLAS, 1772)	F1	summer	*Fagus sylvatica, Picea abies, Pyrus malus, Quercus robur*	BOGYA *et al.* 1999; KOVÁCS 2002; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on bushes and lower branches of trees, also on tree trunks on forest steppes and forest edges
Synaema globosum (FABRICIUS, 1775)	A	V-VII. J: autumn, spring	*Fagus sylvatica, Picea abies, Pinus nigra, Pinus sylvestris, Platanus hybrida, Quercus robur*	HANSEN 1992; HORVÁTH, SZINETÁR 2002; KOVÁCS 2002; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on vegetation (mainly on flowers) in open habitats and on edges
Tmarus piger (WALCKENAER, 1802)	F2	early summer	?	WUNDERLICH 1982	on herb vegetation and on bushes on forest steppes, light forests and their edges
T. stellio SIMON, 1875	F1	?	*Pyrus malus, Quercus robur*	BOGYA *et al.* 1999; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on tree trunk in floodplain forests and in orchards
Thomisus onustus WALCKENAER, 1805	A	V-VIII.	*Pyrus communis*	PEKÁR 1999	on flowers in medows and other open habitats
Xysticus acerbus THORELL, 1872	A	IV-V.	*Pyrus malus*	BOGYA *et al.* 1999	among grass on xerothermic habitats
X. albomaculatus KULCZYŃSKI, 1891	E	spring – autumn	*Pyrus communis*	WUNDERLICH 1982	on and under bark
X. audax (SCHRANK, 1803)	F2	spring – early summer	*Picea abies, Pinus sylvestris, Quercus robur*	SIMON 1995; WEISS 1995; KOPONEN 1996; RINNE *et al.* 1998	on bushes and on herb vegetation in various open and forest habitats
X. cristatus (CLERCK, 1757)	A	IV-VI.	*Pinus sylvestris, Pyrus malus*	SIMON 1995; BOGYA *et al.* 1999	among grass in medows and other open habitats, also in fields and in orchards
X. kochi THORELL, 1872	A	summer	*Platanus hybrida*	SEBESTYÉN 1996	among grass and on vegetation in various open habitats, also in fields, orchards and gardens

Appendix 1. Continued.

1	2	3	4	5	6
X. lanio C. L. KOCH, 1835	F2	spring - early summer	Betula pendula, Fagus sylvatica, Pinus sylvestris, Pyrus malus, Quercus robur	NICOLAI 1986; SIMON 1995; KOPONEN 1996; KOPONEN et al. 1997; RINNE et al. 1998; BOGYA et al. 1999; KUBCOVÁ, SCHLAGHAMERSKÝ 2002; KOPONEN 2004	on shrubs and herb vegetation in forests and their edges, on tree trunks
X. ulmi (HAHN, 1831)	A	VI-VII.	Pinus sylvestris, Platanus hybrida	SIMON 1995; SEBESTYÉN 1996	on vegetation in wet meadows and on marshy pond margins
Salticidae					
Aelurillus v-insignitus (CLERCK, 1757)	A	spring - summer	Picea abies	WEISS 1995	on soil surface in xerothermic open habitats
Ballus chalybeius (WALCKENAER, 1802) (syn. Ballus depressus)	F1	summer	Carpinus betulus, Pinus sylvestris, Platanus hybrida, Pyrus malus, Quercus robur	HANSEN 1992; SIMON 1995; SEBESTYÉN 1996; BOGYA et al. 1999; KOVÁCS 2002; KUBCOVÁ, SCHLAGHAMERSKÝ 2002	on bushes and among leaf litter in forests, also in canopies and on bark (mainly oak)
Carrhotus xanthogramma (LATREILLE, 1819)	A	summer	Pyrus malus	BOGYA et al. 1999	on bushes and on trees in rock steppes and in orchards
Dendryphantes rudis (SUNDEVALL, 1833)	F1	V-VIII.	Pinus nigra, Pinus sylvestris, Quercus robur	SIMON 1995; HORVÁTH, SZINETÁR 2002; KOVACS 2002; HORVÁTH et al. 2005	on branches in coniferous forests and their margins, in winter period on and under bark
Euophrys frontalis (WALCKENAER, 1802)	A	spring early summer	Pinus sylvestris	SIMON 1995	among moss, leaf litter and and under stones in forest habitats
Evarcha falcata CLERCK, 1757)	A	V-VII.	Picea abies	WEISS 1995	at ground level and on herbs in various open and forest habitats
Heliophanus cupreus (WALCKENAER, 1802)	A	spring - summer	Platanus hybrida, Pyrus malus	HANSEN 1992; BOGYA et al. 1999	at ground level and on herbs in various open and forest habitats
H. dubius C. L. KOCH, 1835	A	V-VI.	Quercus robur	RINNE et al. 1998	on bushes on rock steppes, in pine forests and on xerothermic forest edges

Appendix 1. Continued.

1	2	3	4	5	6
H. flavipes Hahn, 1832	A	spring - summer	*Pyrus malus*	Bogya *et al.* 1999	on vegetation on various xerothermic open habitats
H. kochi Simon, 1868	A	?	*Platanus hybrida*	Hansen 1992	on vegetation on various xerothermic open habitats
H. tribulosus Simon, 1868	A	V-VI.	*Platanus hybrida*	Hansen 1992	on vegetation on various xerothermic open habitats, on meadows and on forest edges
Icius hamatus (C. L. Koch, 1846)	A		*Platanus hybrida*	Hansen 1992	?
Macaroeris nidicolens (Walckenaer, 1802)	F1	summer	*Fagus sylvatica, Picea abies, Pinus nigra, Pinus sylvestris, Platanus hybrida, Pyrus malus, Quercus robur*	Hansen 1992; Sebestyén 1996; Horváth, Szinetár 1998, 2002; Bogya *et al.* 1999; Horváth *et al.* 2001, 2005; Kovács 2002	on branches of trees (mainly coniferous) in xerothermic habitats, in winter period on and under bark
Marpissa muscosa (Clerck, 1757)	E	IV-X.	*Carpinus betulus, Fagus sylvatica, Pinus nigra, Pinus sylvestris, Platanus hybrida, Pyrus communis, Pyrus malus, Quercus robur*	Wunderlich 1982; Sebestyén 1996; Horváth, Szinetár 1998, 2002; Bogya *et al.* 1999; Kovács 2002; Horváth *et al.* 2004, 2005	under tree bark, on the trunks in various open and partly shaded habitats
Pseudeuophrys erratica (Walckenaer, 1826) (syn. *Euophrys erratica*)	F1	summer	*Pinus nigra, Quercus robur*	Koponen 1996; Horváth, Szinetár 1998; Rinne *et al.* 1998; Kovács 2002; Horváth *et al.* 2005	on bushes, on trees, under bark and on surface of rocks in various open and forest habitats
P. vafra (Blackwall, 1867 (syn. *Euophrys vafra*)	A		*Platanus hybrida*	Hansen 1992	?
Pseudicius encarpatus (Walckenaer, 1802)	E	V-VIII.	*Pinus nigra, Pinus sylvestris, Platanus hybrida, Pyrus malus, Quercus robur*	Hansen 1992; Sebestyén 1996; Horváth, Szinetár 1998, 2002; Bogya *et al.* 1999; Horváth *et al.* 2001; Kovács 2002; Kubcova, Schlaghamerský 2002	under bark of solitary trees and in forests and in orchards, parks, on tree bark
P. epiblemoides Chyzer, Kulczyński, 1891	E	?	*Quercus robur*	Dobroruka, 2001	on trunks of oak

Appendix 1. Continued.

1	2	3	4	5	6
Salticus cingulatus (PANZER, 1797)	F1	summer	Picea abies, Quercus robur	WEISS 1995; KOPONEN 1996; KOPONEN et al. 1997; RINNE et al. 1998; KOPONEN 2004	on tree bark of solitary trees, rarely on walls of houses
S. mutabilis LUCAS, 1846	?	?	Platanus hybrida	HANSEN 1992	?
S. scenicus (CLERCK, 1757)	F2	spring -autumn	Pyrus malus	WUNDERLICH 1982; PEKÁR 1999	on rock walls, on the surface of scree slopes and on walls of houses, on tree trunks
S. unciger (SIMON, 1868)			Platanus hybrida	HANSEN 1992	?
S. zebraneus (C. L. KOCH, 1837)	E	V-VI.	Pinus nigra, Pinus sylvestris, Platanus hybrida, Pyrus malus, Quercus robur	WUNDERLICH 1982; HANSEN 1992; SIMON 1995; SEBESTYÉN 1996; BOGYA et al. 1999; HORVÁTH, SZINETÁR 2002; KUBCOVÁ, SCHLAGHAMERSKÝ 2002; HORVÁTH et al. 2005	on the trunks and lower branches of trees in various open and forest habitats
Sibianor aurocinctus (OHLERT, 1865) (syn. Bianor aurocinctus)	A	spring - autumn	Pinus sylvestris	SIMON 1995	among short vegetation and stones on rock steppes on xerothermic habitats
Sitticus distinguendus (SIMON, 1868)	A	summer	Pyrus malus	BOGYA et al. 1999	among grass on sand dunes, on spoil heaps
S. pubescens (FABRICIUS, 1775)	A	all year	Pyrus malus	BOGYA et al. 1999	on various sun-exposed vertical surfaces, on rock walls, walls of houses, on tree trunks
S. saxicola (C. L. KOCH, 1846)	A	?	Picea abies	WEISS 1995	in various habitats, on edges, on rock walls
Synageles hilarulus (C. L. KOCH, 1846)	F2	?	Pyrus communis	WUNDERLICH 1982	among grass on rock steppes, on bark
S. venator (LUCAS, 1836)	F2	spring - autumn	–	WUNDERLICH 1982	on vegetation in various open habitats, rarely on bark
Talavera petrensis (C. L. KOCH, 1837) (syn. Euophrys petrensis)	A	?	Pinus sylvestris	SIMON 1995	at ground level, in various open and dry habitats, under stones

Advance in the study of biodiversity of Caucasian spiders (Araneae)

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Abstract: The history of investigation of the Caucasian areaneofauna can be divided into four periods: 1866-1938, 1939-1978, 1979-1998 and 1999 to the present. According to published data, over 1000 species belonging to 46 families are known from the Caucasus. The species richest families are as follows: Linyphiidae (~180), Salticidae (122), Gnaphosidae (>100), Lycosidae (>100), Theridiidae (80), Dysderidae (70) and Thomisidae (70). In the different families endemism values vary from 0 to 100%. The average level of endemism in the Caucasus is about 22%, the highest level of endemism among species-rich families was found in the Dysderidae, being around 60%.

Key words: spiders, Caucasus, fauna, zoogeography, endemism

Introduction

The Caucasus is a territory lying between the Black and the Caspian seas. There are no strict geographical borders that separate the mountain from the areas lying to the north and south. Conventionally, the northern border of the Caucasus coincides with the northern foothills of the Caucasus Major, and the southern border is formed by the southern borders of Georgia, Armenia and Azerbaijan (Fig. 1).

The study of Caucasian arachnids was initiated by L. Kᴏᴄʜ (1866) who described the gnaphosid *Melanophora caucasia* (= *Zelotes c.*) from this region. The history of the study of Caucasian spiders can be conveniently divided into 4 periods: 1) beginning (1866-1938); 2) pre-Dᴜɴɪɴ (1939-1978); 3) Dᴜɴɪɴ (1979-1998); and 4) modern (1999 to the present). In the first period the greatest contribution to the knowledge of Caucasian spiders was made by the Russian and foreign authors: A.I. Kroneberg, L. Koch, W. Kulczyński, E. Simon, T. Thorell, E. Werzbitski and A.M. Zavadski (Fig. 2). During this period many new species were described or recorded from the area. According to Cʜᴀʀɪᴛᴏɴᴏᴠ's (1932) catalogue, 178 species of spiders were known from the Caucasus in 1926. A decade later, the number of Caucasian species reached 206 (Cʜᴀʀɪᴛᴏɴᴏᴠ 1936). It is worth mentioning that all these arachnologists lived far from the Caucasus.

We date the beginning of the second period from the series of papers published by Cʜᴀʀɪ-ᴛᴏɴᴏᴠ which dealt with the cave fauna of the region (Cʜᴀʀɪᴛᴏɴᴏᴠ 1939, 1941a, b) (Fig. 3). At the same time, a Georgian arachnologist, Tamara S. Mkheidze began her career. During the second period important contributions to the study of Caucasian arachnids were made by T.S. Mkheidze (Tbilisi), S.A. Spassky (Novocherkassk), D.E. Charitonov, A.S. Utotchkin (Perm), V.E. Pichka (Kiev) and several other authors (Fig. 3). During this period the rise of knowledge of the taxonomy and faunistics of Caucasian spiders was somewhat slow.

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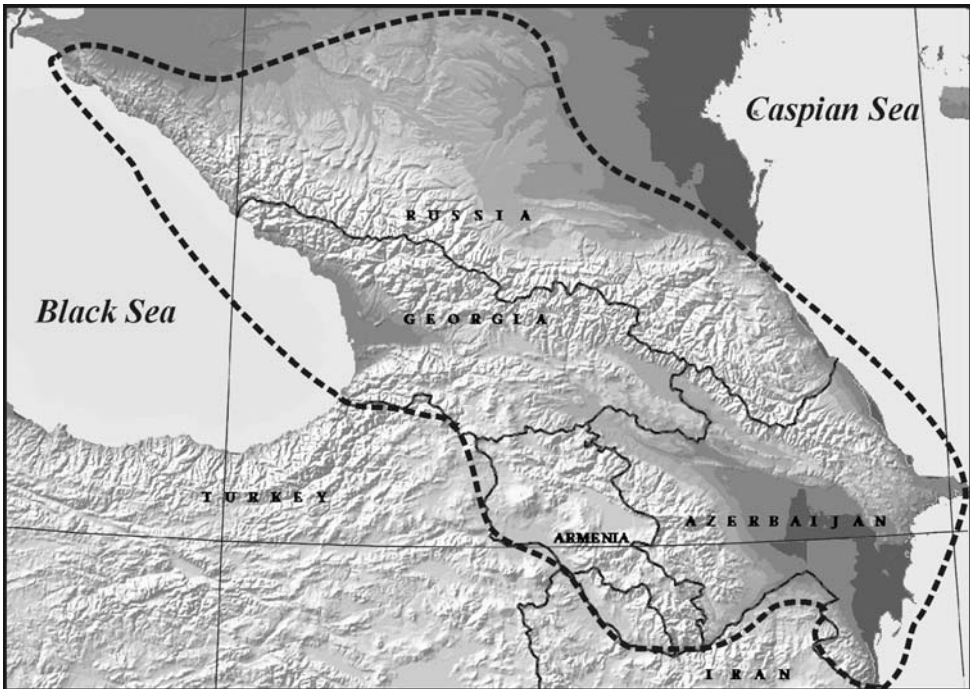
Fig. 1. Conventional borders of Caucasus.

The third period began when Peter M. Dunin started working at the Institute of Zoology of Azerbaijan, Baku (Fig. 3). The time of Dunin's employment coincides with the activation of arachnological studies in the entire Soviet Union. During this period many young arachnologists such as A.A. Zyuzin, V.I. Ovtsharenko, A.V. Ponomarev, K.Yu. Eskov, A.V. Tanasevitch, K.G. Mikhailov, Yu.M. Marusik and D.V. Logunov started to study spiders, including those from the Caucasian region. This period was characterized by a great growth in the number of described and reported species. We name this period after Dunin because he made the most important contribution, publishing over 30 papers on Caucasian spiders and describing over 60 species from the area.
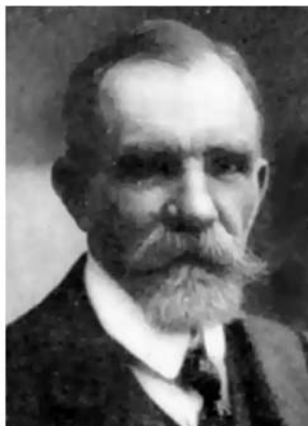
Ludwig KOCH   Eugène SIMON   Wladislaw KULCZYŃSKI

Fig. 2. Portraits of the first generation of arachnologists, who had taken part in the study of the Caucasian fauna.

Sergei SPASSKY   Dmitri CHARITONOV   Peter DUNIN

Fig. 3. Portraits of the second and third generations of arachnologists, who had taken part in the study of the Caucasian fauna.

Besides Dunin, an important contribution was made by A.V. Tanasevitch in his revisional studies of Caucasian linyphiids (TANASEVITCH 1987, 1990). He described about 40 species and reported over 100 species from the Caucasus. Besides this, Tanasevitch revised the Central Asian fauna, and many species from Central Asia were later found in the Caucasus. After the collapse of the Soviet Union, the study of Caucasian arachnids nearly ceased because of military conflicts, lack of financing and other reasons. During this period most studies were based on museum materials collected earlier. Most of the works from this period were published by Ovtsharenko and co-authors (OVTSHARENKO *et al.* 1992, 1994, 1995).

In the fourth, or modern period, arachnological studies intensified in Azerbaijan. During this period papers were published by E.F. Guseinov (=Huseynov), D.V. Logunov, Yu.M. Marusik, K.G. Mikhailov, S. Koponen, P.T. Lehtinen, G.N. Azarkina, M.M. Kovblyuk and several other authors. Although the number of species described was not high, this period was marked by the large number of new supraspecific taxa (4 families, about 25 genera) reported from the Caucasus for the first time (MARUSIK, GUSEINOV 2003, MARUSIK *et al.* 2005). During all periods of investigation of Caucasian spiders there were taxonomical, faunistic and mixed papers. Faunistic papers published during the 2nd and 3rd periods have many deficiencies: 1) many species, genera and even families were incorrectly identified; 2) many descriptions and redescriptions were inadequate, and it is impossible to identify spiders based on these papers. Inaccuracy of identifications during this period was related to the lack of appropriate literature in Azerbaijanian and Georgian libraries, the lack of revisional studies and the lack of access to comparative material stored in Moscow, St. Petersburg and abroad.

Difficulties in the study of Caucasian spiders

There are several difficulties in the study of Caucasian spiders. They are related to the following factors: 1) lack of access to the types described by Mkheidze in 1940-1990 (more than 30 species); 2) lack of the types of species described by L. Koch (9 species) and V. Kulczyński; 3) the materials on which faunistic papers by Mkheidze, Kulczyński, Werzbitski were based are not accessible or were lost during World War II. Some materials collected by Guseinov were also lost. Until recently, the study of Caucasian spiders was hampered by the lack of revisions and redescriptions of old materials from adjacent areas like Turkey, Asia Minor and Near East, Bulgaria, Greece and the Crimea. Many new species were described from these areas at the end of 19th century and the

beginning of 20th. Most of these species had long been known only from the original publications. Significant progress in the study of Caucasian spiders was achieved because of revisions of various families from Israel made by G. LEVY (1985, 1986, 1987, 1991, 1992, 1995, 1996, etc.). Levy revised and redescribed many spider species previously described from the eastern Mediterranean and northern Africa. Besides Levy, large contributions were made by K. Thaler and B. Knoflach (KNOFLACH 1996, 1999, KNOFLACH, THALER 2000, THALER, KNOFLACH 1998, THALER *et al*. 2000, etc.) on the Theridiidae and several other groups from southern Europe. Near the end of 20th century, the spiders of the family Salticidae were almost completely revised in Central Asia and partially in the Caucasus by Logunov and his co-authors (LOGUNOV 1996, 1999 a, b, LOGUNOV, MARUSIK 1999, 2003, LOGUNOV *et al*. 1999, RAKOV, LOGUNOV 1996, etc.)

Recent state of knowledge

According to MIKHAILOV's (1997) catalogue, 886 species of spiders were known from the Caucasus in 1997. In the following years over 100 additional species were reported from Georgia (MKHEIDZE 1997) and Azerbaijan. Of the Transcaucasian regions, the most thoroughly studied country is Azerbaijan with over 600 species (MARUSIK, GUSEINOV 2003). In Georgia, 456 species of spiders are known to date, and only 127 species from Armenia (MIKHAILOV 2002). We do not have exact data about the number of species from the Russian Caucasus.

Studies conducted by us in Azerbaijan after 2001 revealed that the fauna of the Caucasus was inadequately known. During a short-term expedition to the Absheron Peninsula and Lenkoran we found 16 genera and 4 families (Desidae, Mysmenidae, Palpimanidae and Prodidomidae) new to the Caucasus as a whole, including 5 genera new to the fauna of the former Soviet Union (MARUSIK, GUSEINOV 2003). Subsequent expeditions to Nakhchivan and other parts of Azerbaijan revealed several additional genera new to Azerbaijan, the whole of the Caucasus and even the former USSR, e.g. *Siwa* GRASSHOFF, 1970 (MARUSIK *et al*. 2004). The number of new species reported for Azerbaijan, the Caucasus, and all of the former Soviet Union is several dozen. It is worth mentioning that the species new to the Caucasus were found not only among poorly studied families such as the Lycosidae and Gnaphosidae, but also in the well studied Araneidae. For example, *Cyclosa sierrae* SIMON, 1870, *Singa neta* (O. P.-CAMBRIDGE, 1872) and *Siwa atomaria* (O. P.-CAMBRIDGE, 1876) found in Nakhchivan (MARUSIK *et al*. 2005b) were new to the former Soviet Union. Two days of collecting in Sukhum, Abkhazia, and several hours of collecting in Adler (near Sochi) revealed a family new to the Caucasus (Zoropsidae) (MARUSIK, KOVBLYUK 2004), and two families new to the European part of Russia (Mysmenidae, Oonopidae) (MARUSIK 2005).

Because of collecting efforts during the last 5 years, the spider fauna of Azerbaijan, with 44 families, became the most family-rich of all the regions of the former Soviet Union. The total number of families known from the Caucasus is now 46. Two of them, Cybaeidae and Zoropsidae, have not yet been found in Azerbaijan. There is no doubt that the diversity of families in the Caucasus, and particularly in Azerbaijan, will be increased. The presence of representatives of the Anapidae, Cithaeronidae, Hersiliidae, Phyxelididae, Sicariidae and Synaphridae is likely. *Comaroma simony* BERTKAU, 1889, belonging to the first mentioned family, is common in Europe in thick leaf litter. Cithaeronids, hersiliids and sicariids are known from adjacent Turkmenistan and Iran. Phyxelidids are known from Turkey and synaphrids have been reported from Turkmenistan, the Crimea and several Mediterranean countries (MARUSIK *et al*. 2005b). It is worth mentioning that most of the undescribed and newly reported taxa were found not in mountains, or other poorly accessible areas, but in coastal lowlands: the Absheron Peninsula, Lenkoran and Sukhum. These areas have a semi-arid or subtropical climate.

The thoroughness with which the various Caucasian spider families have been studied differs greatly. Among species-rich families the best studied ones are the Clubionidae, Dysderidae, Linyphiidae and Salticidae. Several special publications are devoted to these families. The least

studied families are the Agelenidae, Dictynidae, Gnaphosidae, Lycosidae, Philodromidae, Theridiidae and Thomisidae. The study of the Azerbaijanian Agelenidae reveals that, among 19 species found in the republic, 14 are new to the science and one is new to the Caucasus (GUSEINOV *et al*. 2005). A very high number of new taxa were found in the Gnaphosidae. Many species found in Azerbaijan belong to genera unknown to us. Among other families from Azerbaijan, such as the Lycosidae, Dictynidae, Thomisidae and Theridiidae, the proportion of new taxa is lower than in the Agelenidae. For instance, the percentage of new species among the theridiids is about 20%. Although the Linyphiidae is the most species-rich family and one of the best studied in the region, we recognized, among new material from Azerbaijan, several species new to the science or to Azerbaijan. New species were found also among other well studied families such as the Dysderidae.

The species diversity of all families represented in the Caucasus is summarized in Table 1. According to the literature and unpublished personal data the fauna of the region includes at least 970 species. For some of the families we provide estimated data, which is slightly higher than the number of reported species.

Table 1. Number of species in each family found in the Caucasus, number and percentage of endemic species. * evaluation data; ** % from reported/ known species.

	Family	Number of species	Number of endemics	%**
1.	Agelenidae	35	18	51
2.	Amaurobiidae	5	1	20
3.	Anyphaenidae	2	0	0
4.	Araneidae	48	0	0
5.	Argyronetidae	1	0	0
6.	Atypidae	1	0	0
7.	Clubionidae	29	4	14
8.	Cheiracanthidae	8	0	0
9.	Cybaeidae	2	1	50
10.	Desidae	1	1	100
11.	Dictynidae	18	1	6
12.	Dysderidae*	70	>59	91
13.	Eresidae	3	1	33
14.	Filistatidae	3	1	33
15.	Gnaphosidae*	100	>10	>12
16.	Hahniidae	6	1	17
17.	Heteropodidae	2	0	0
18.	Leptonetidae	2	2	100
19.	Linyphiidae*	180	>45	>27
20.	Liocranidae	6	3	75
21.	Corinnidae	6	3	50
22.	Lycosidae*	100	16	>20
23.	Mimetidae	3	1	50
24.	Mysmenidae	2	0	0
25.	Nemesiidae	4	4	100
26.	Nesticidae	9	7	78
27.	Oecobiidae	6	0	0

Table 1. Continued.

	Family	Number of species	Number of endemics	%**
28.	Oonopidae	5	3	60
29.	Oxyopidae	4	0	0
30.	Palpimanidae	1	1	100
31.	Philodromidae*	30	1	>4
32.	Pholcidae	6	2	33
33.	Pisauridae	3	0	0
34.	Prodidomidae	2	1	50
35.	Salticidae	122	17	14
36.	Scytodidae	1	0	0
37.	Segestriidae	3	0	0
38.	Tetragnathidae	18	0	0
39.	Theridiidae	80	6	8
40.	Theridiosomatidae	1	0	0
41.	Thomisidae*	70	>10	>15
42.	Titanoecidae	7	1	14
43.	Uloboridae	6	0	0
44.	Zodariidae	7	5	71
45.	Zoridae	4	0	0
46.	Zoropsidae	1	0	0
		1022	>226	>22

The most diverse spider families in Caucasus are as follows: Linyphiidae (~180), Salticidae (122), Gnaphosidae (>100), Lycosidae (>100), Theridiidae (80), Dysderidae (70) and Thomisidae (70). The spider fauna of the Caucasus comprises about 1/3 of the species diversity of the former Soviet Union and about 2.5% of the world species diversity. In terms of family diversity, the fauna of Caucasus encompasses 42% of the families of the world. The value of endemism in different families ranges from 0 to 100%. The highest level of endemism was found not only in the families with few species like the Nemesiidae, Leptonetidae or Desidae, but also in the species-rich families like the Dysderidae. In total, the level of endemism in the Caucasian fauna is not less than 22%, and probably this value will increase when several families like the Gnaphosidae, Philodromidae and Linyphiidae are properly revised. We think that the largest growth in species, new to the science and new to the region, will be in such families as the Gnaphosidae, Lycosidae, and Linyphiidae. There is no doubt that in Armenia and Georgia numerous new species of Agelenidae and Dysderidae will be found as well.

The most promising areas for finding species new to the fauna of the Caucasus are the arid regions of Azerbaijan, Georgia and Armenia, the subtropical coasts of the south-east, the whole western Caucasus and the high mountains. High altitudes are promising only in terms of new species with limited ranges, but subtropical and arid territories should produce many new or newly reported supraspecific taxa. At present we are working in collaboration with colleagues from different countries on revisions of the Corinnidae, Liocranidae, Lycosidae, Oonopidae, Philodromidae and Theridiidae. In their general species diversity, spiders of the Caucasus are similar to those of oribatid mites. According to TARBA (2002) the number of oribatids in the Caucasus reaches 770 species. This number comprises 10% of the world species diversity (2.5% in spiders). Possibly, the high value of species diversity of mites in the Caucasus reflects a poor level of study of Oribatida in the rest of the world. The value of endemics among spiders (22%) and oribatids (17%) is very similar.

Caucasus – Far East disjunctions

One of the most interesting and unique characteristics of the Caucasian spider fauna is the presence of about a dozen species with Caucasus-Far East disjunctions. When we began to study spiders of this area in 1980 we were faced with five species (*Octonoba yesoensis*, *Phintella castriesiana*, *Myrmarachne formicaria*, *Rhomphea sagana* and *Tmarus horvathi*) that were known in Azerbaijan and/or Georgia and in the Far East (MARUSIK 1987, LOGUNOV, MARUSIK 1991). Now, the number of such species has increased to 9 (MARUSIK *et al*. 2004) due to the recent discovery of Caucasian species in the Far East (*Rhomphea hyrcana, Larinia bonneti*) and of Far Eastern species in Caucasus (*Yaginumena maculosa, Howaia mogera*).

Why do we call this situation unique? It is because such long disjunctions are unknown in other groups of animals. We were able to find one species of feather beetle, one species of saw-fly and one terrestrial mollusc with the same disjunction pattern. All these groups are taxonomically difficult in comparison to those of the spider species with disjunctions. We asked several experts in species-diverse groups such as Curculiniodae, Carabidae, Rhopalocera, Arctiidae, Noctuidae, Heteroptera, but none of them knew of disjunctive ranges at the species level. Although they are more common in spiders, supraspecific disjunctions are also known in insects. The high percentage of spider species with disjunctive ranges indicates that evolution, or at least morphological evolution, occurs more slowly in them than in other arthropods.

Ethological studies

Despite the almost 140 years of faunistic and taxonomic studies of the Caucasian araneofauna, investigation of the biology of spiders in this region began only recently. It started with a paper by GUSEINOV (1997), who gave preliminary information on the natural prey of some species of wandering spiders occurring in the Absheron Peninsula, Azerbaijan. Later, the diets of 20 species from six families (Salticidae, Thomisidae, Philodromidae, Oxyopidae, Gnaphosidae, Filistatidae) were studied in detail, and this formed an important part of the Ph.D. thesis of the third author (GUSEINOV 1999). Some of these results are already published in a series of separate papers (GUSEINOV 2004a, b, 2005), and some are in press. Moreover, in cooperation with Robert Jackson (Canterbury, New Zealand) and his students, some ethological aspects, such as predatory behaviour and prey preference, of a few Azerbaijanian jumping spiders have been investigated (CERVEIRA *et al*. 2003, GUSEINOV *et al*. 2004). In addition to these studies on the natural prey and predatory behaviour of spiders in Azerbaijan, investigation of their microhabitat preferences is also in progress.

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Възход в изследванията на паяците на Кавказ (Araneae)

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(Резюме)

Направен е преглед на проучванията на кавказката аранеофауна, които според авторите могат да бъдат разделени на четири периода: Начален – от 1866 до 1938 г., преди Дунин – от 1939 до 1978 г., по времето на Дунин – от 1979 до 1998 г., и Съвременен – от 1999 г. досега. Понастоящем от територията на Кавказ са известни над 1000 вида паяци, принадлежащи към 46 семейства. Най-богати на видове са: Linyphiidae (около 180), Salticidae (122), Gnaphosidae (над 100), Lycosidae (над 100), Theridiidae (80), Dysderidae (70) и Thomisidae (70). Ендемизмът сред семействата варира в широки граници – от 0% до 100%, като средно е около 22%. Сред семействата с по-голям брой видове най-висок ендемизъм се наблюдава при Dysderidae – около 60%.

History of study and a brief survey of the araneofauna of the Left-Bank Ukraine (Araneae)

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Abstract: A brief history of the development of the Ukrainian arachnology from the 70s of the 18th century till recently is given, with a detailed analysis of spider study of the Left-Bank Ukraine. According to original and literature data, 716 spider species from 34 families have been registered in the area in question, 41 species need confirmation. The Linyphiidae is the richest in species family followed by Salticidae and Gnaphosidae. The zoogeographical analysis demonstrated that the main part of the fauna is represented by widespread species. The boundary of distribution of several Asiatic and Mediterranean species passes through the investigated area.

Key words: spiders, faunistics, zoogeography, Left-Bank Ukraine

Introduction

The development of arachnology and the accumulation of faunistic and ecological data have encouraged us to launch systematization of obtained results. The information on Ukrainian spiders is scattered in different papers, mainly written in Russian and unavailable for western specialists. Mikhailov's catalogue of spiders of the territories of the former USSR (MIKHAILOV 1997) points out the records of species for Ukraine as a whole, distinguishing the Crimea and the Carpathians. Kharitonov's catalogue is more precise, but it was published as far back as 1932. Nowadays, summary of recent knowledge is needed. This paper is a preliminary overview of the history of spider study and the data collected in the process of elaboration of a catalogue of spiders of the Left-Bank Ukraine.

Study Area and Materials

Ukraine, a former republic of the Soviet Union, is situated in East Europe between 44°26´ - 52°36´ N and 22°9´ - 40°15´E, and covers the area of 603 700 km². It borders with Russia in the North and East, and with Poland, Slovakia, Hungary, Moldova, and Romania in the West. The main part of the country is located within the East European, or Russian Plane, with the Carpathians in the West and the Crimea peninsula in the South. The main territory (55% in the forest zone and 90% in the steppe zone) has been ploughed up. Virgin steppes have remained only in nature reserves and unarable lands. Pine, mixed and deciduous (mainly oak) forests grow in flood lands and the flat interfluves of the forest and forest-steppe zones. There is a vast net of meadows, often overgrazed or mowed, bogs and wetlands preserved. Costal habitats and saline marshes are typical for the southern part; chalk, granite and limestone outcrops are spread in the East.

Three main botanical zones are represented in Ukraine: forest, forest-steppe and steppe.

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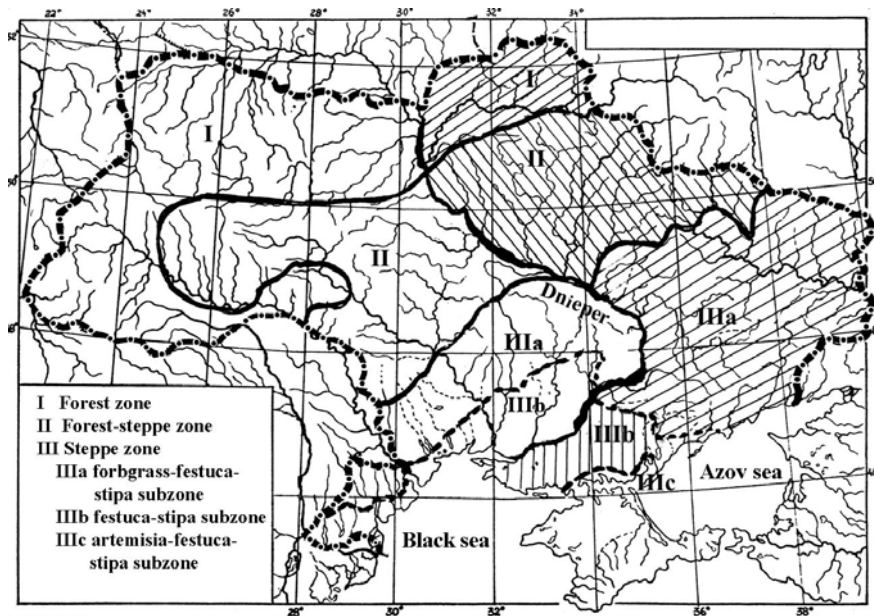
Fig. 1. Map of Ukraine.

The latter, according to the geo-botanical ranging (GEO-BOTANICAL RANGING OF THE UKRANIAN SSR 1977) is divided, in its turn, into three subzones: forbgrass-festuca-stipa steppe, festuca-stipa, and artemisia-festuca-stipa, or semi-desert steppe (Fig. 1). Traditionally, from historical and physiographic point of view, the main river of Ukraine - the Dnieper, divides it into two parts - the so-called Right-Bank Ukraine and the Left-Bank Ukraine, which differ in the specificity of their flora and fauna. So, the Left-Bank part is the area stretching from the left river bank in the West to the frontier in the North and East and to the Azov and Black seashore in the South. The landscape is mainly flat not higher than 360 m above the sea level, with the southwestern hills of the Central Russian Upland in the Northeast and the Donetsk chain of hills in the Southeast.

Spiders were collected in 123 localities in 8 administrative regions. Apart of our private collections we have re-examined also all the collections preserved in the following institutions: Zoological Museum of Moscow State University, Zoological Institute of the Russian Academy of Science, St-Petersburg (Russia), Museum of Nature of the Kharkov State University (Ukraine). Unfortunately, many collections have been lost, not only the old ones, but also some of the modern ones (Table 1), and the presence of many species cannot be proved.

Results and Discussion

The history of spider study in Ukraine

Arachnology in Ukraine developed as part of the science of the Russian Empire and later of the USSR. The history was briefly described and presented by Kirill Mikhailov at the 21st European Colloquium of Arachnology and its proceedings (MIKHAILOV 2004). The first data about spiders of modern Ukraine were scattered in the works of famous Russian and foreign naturalists. Thus, FALK (1786) and GMELIN (1788) found *Lycosa singoriensis* (LAXMANN, 1770) in the Crimea Peninsula, and that was the first spider species mentioned for Ukraine.

The first period of the accumulation of faunistic knowledge goes back to the 30s of the 18th century: 10 species were recorded for the Zhitomir and the North Kiev Region, 10 species

for the South of Khmelnitsk Region (EICHVALD 1830, here and further we give the contemporary administrative division); 2 species for the Zhaporozhye Region (SCHLATTER 1836); 5 for the Kharkov and 3 for Odessa regions (KRYNICKI 1837); 17 species were found in the vicinities of Kamyanets-Podolsk, Khmelnitsk Region (BELKE 1853, 1859); 5 species in the Dniepropetrovsk Region (NORDMANN 1863); and one in Melitopol, the Zaporozhye Region (SHATILOV 1866). The first true arachnological review belongs to REINGARD (1874, 1877), who registered 32 species in the Kharkov Region. The well known work by THORELL, 'Verzeichniss Südrussischer Spinnen', was issued in 1875, and enriched significantly the knowledge on spiders of the Russian Empire. It contains 245 records for the contemporary Kharkov, Dniepropetrovsk, Kherson, Odessa regions and the Crimea. Afterwards, at the end of 19th/beginning of 20th century, besides short notes (SCHMIDT 1895, LEBEDINSKY 1914, STRAND 1910, SPASSKY 1914 and others), detailed lists of species for several localities and governments were published by different authors. LUKYANOV (1897) published on the spiders of Chernigov, Kiev and Poltava regions, a total of 79 species; FREIBERG (1897) investigated the vicinity of Dniepropetrovsk, 29 species; GRESE (1909) – Provalye, the Lugansk Region, 55 species; SPASSKY (1927) – Crimea and the Kherson Region, 136 species; PERELESHINA (1931) – the Odessa, Nikolaev, Kherson regions, a total of 47 species. The culmination of the first period of the spider research in the former Russian Empire and the USSR was the 'Katalog der Russischen Spinnen' by KHARITONOV (1932) and its addition (1936). By the early 30s of the 20th century 377 species were registered in Ukraine (excl. western provinces, which were not part of the USSR at that time).

After this period a more than 30-year gap in spider research followed, which can be explained by the historical and political situation in the USSR (the Second World War, repressions), and the third modern period began in the 70s with the PhD thesis by LEGOTAY (1973), mentioning 341 spider species from the Ukrainian Carpathians. Later on, the research of Ukrainian fauna was carried out quite unevenly. There are still many black spots in the central and western parts. According to the catalogue of spiders of the territories of the former Soviet Union (MIKHAILOV 1997), in August 1996, 808 species were registered in Ukraine, including 421 species in the Carpathians and 311 species in Crimea. The research of the Crimean fauna was renovated in 2000 by Kovblyuk, who published the preliminary catalogue of spiders of the Crimea Peninsula, mentioning 473 species (KOVBLYUK 2003b).

The fauna of the Left-Bank Ukraine turned out to be best investigated, which gives sufficient data for the analysis. On the basis of 22 literature sources, KHARITONOV (1932) reported 181 spiders (178 according to the modern classification). In this article we mention only the first and main papers (Table 1). Purposive study of the Polesye (forest zone) began in the 90s of the last century with the Evtushenko's investigations (EVTUSHENKO 1991 a, b, 1993). Before his works, there were only several species known due to Lukyanov's paper (LUKYANOV 1897). Now 385 species are recorded in this area. Many researchers have worked and are still working in the forest-steppe zone: REINGARD (1874, 1877) and THORELL (1875); in the modern period – ASTAKHOVA (1974, 1978), KIRILENKO, LEGOTAY (1981), POLCHANINOVA (2003), and especially GNELITSA (1993, 1997, 2000 b, c, 2001), who investigated the main habitats of the Sumy Region with particular interest to the systematics and ecology of the Linyphiidae. Four hundred forty-seven species are currently known from this region. The research of the steppe zone was carried out by THORELL (1875), FREIBERG (1897), PERELESHINA (1927), SPASSKY (1914, 1927), GRESE (1909) in the 18th – early 20th century (Table 1), and were continued by GURYANOVA (1992, 1993), POLCHANINOVA (1990 b, 1992, 1996) and PROKOPENKO (2001, 2002). As a result, 569 species are presently known from the Ukrainian steppes.

The main lines of recent investigations are ecological-faunistic research, and systematics of some families, particularly Gnaphosidae and Linyphiidae (due to the works by GNELITSA since

Table 1. Three periods of the spider research in the Left-Bank Ukraine. Abbreviations: ZIN RAN – Zoological Institute of the Russian Academy of Sciences, St. Petersburg; Zoomuz MSU – Zoological Museum of Lomonosov Moscow State University, Moscow; KhNU– Kharkov National University, Kharkov; STTI – Sumy Teachers' Training Institute, Sumy; DonNU – Donetsk National University, Donetsk; TNU – Taurian National University, Simferopol; Inst. of Zoology – Institute of Zoology, Kiev; Naturhistoriska Rijkmus – Museum of Nature History, Stockholm; p.c. – private collection.

| | 1836–1930s | | | 1940s-1960s | 1970s till recently | | | |
Author	Year of publication	Number of species recorded	Species deposition		Collector	Years of research	Number of species found	Species deposition
Schmidt	1836	2	ZIN RAN	–	Astakhova	1974-1978	134	Mus. of Nature, KhNU
Krynicki	1837	5	ZIN RAN		Zyuzin	since 1976	10	p.c., Alma-Ata
Reingardt	1874, 1877	32	lost		Talanov, Nazarenko	1989	220	lost
Thorell	1875	88	Naturhistoriska Rijkmus		Kirilenko, Legotay	1981,1984	158	lost
Freiberg	1897	29	lost		Polchaninova	since 1984	646	p.c., KhNU
Lukyanov	1897	27	lost		Gnelitsa	since 1990	164	p.c., STTI
Greze	1909	55	Zoomus. MSU		Guryanova	since 1991	130	p.c., Inst. of Zoology
Spassky	1914, 1927	43	ZIN RAN		Evtushenko	since 1991	373	p.c., Inst. of Zoology
Pereleshina	1927	21	Zoomus. MSU		Prokopenko	since 1997	446	p.c., DonNU
Kharitonov	1932, 1936	181			Kovblyuk	since 1997	40	Dpt. of Zoology, TNU
178 species according to the modern classification					716 species recorded, 41 need confirmation			

1990 and those of KOVBLYUK – 2003 a, 2004). A number of papers deal with the fauna inventory of nature reserves and other protected territories (GURYANOVA, KHOMENKO 1991, POLCHANINOVA 1988, 1990 a, 1997, 2001, PROKOPENKO 1998 a, GNELITSA 2000a), transformed lands - coal mine spoiled banks (PROKOPENKO 1998 b, 2001), city parks (PROKOPENKO 2000, 2003, PROKOPENKO, MARTYNOV 2003); and buildings (EVTUSHENKO 2000). These works investigate mainly the ecological aspects of forming and dynamics of the spider communities, and the impact of the anthropogenic pressure on their structure. Several works were devoted to phenology (ZYUZIN, TYSHCHENKO 1978) and trophoecology – spiders in the nestlings' food (POLCHANINOVA, PRISADA 1995) or vice versa, spiders as predators and their preys in agroecosystems (POLCHANINOVA 1990 c, 1993).

The survey of the spider fauna

According to personal and literature data, by September 2005, 716 spider species from 34 families have been recorded in the Left-Bank Ukraine. Twenty two species were described from the area, 16 of them are valid. The records of 41 species cannot be confirmed because of the lack of material. We have put them in an additional list, and will further deal with only 675 species.

As a result of our research, 385 species have been registered in the forest zone, 447 in the forest-steppe, 565 in the steppe, among them 518 in the forbgrass-festuca-stipa subzone (further Steppe I), and 407 in the festuca-stipa one (further Steppe II). The third, semi-desert subzone has not been investigated so far (Table 2). As we can see, the fauna of the first steppe subzone is the richest. It is stipulated by both objective reasons – vast territory and habitat diversity (from flood land and ravine forests in the North to dry steppes, coastal biotopes and saline marshes in the South), and subjective one – being better investigated. As in many regional faunas in Palearctic, family Linyphiidae is best represented; Gnaphosidae and Salticidae are 3 times less numerous in species (Table 2). Their comparative richness among the species of the second rank is determined by the fauna of the southern areas. The next rich in species families are Lycosidae, Theridiidae, Araneidae, and Thomisidae. Eight main families make up 81% of the fauna. Their ratio changes towards the South. Naturally, in the forest and forest-steppe zone, the share of Linyphiidae increases, while that of Salticidae, Gnaphosidae, Philodromidae, and Thomisidae decreases. It is especially noticeable in the second steppe subzone, where the difference between Linyphiidae and Gnaphosidae amounts to less than 5% (Fig. 2). The number of Lycosidae decreases in the forest zone, while that of Araneidae and Theridiidae differs without a visible zonal trend (Fig. 2).

We have analyzed the zoogeographic composition of the araneofauna of the Left-Bank Ukraine and, according to the current distribution of species, 21 main chorotypes were distinguished and further grouped into 7 complexes. I – Cosmopolitan and Multiregional, II – Holarctic, III – Transpalearctic and Transeurasiatic, IV – West-Central Palearctic (9 groups, more or less widely distributed from Europe to the East, but do not reach the Pacific Ocean); V – European, VI – Mediterranean - Asiatic, VII – disjunctive (Euro-American, Amphipalearctic, etc). The classification was adopted from GORODKOV (1984). As expected, the majority of species have wide areas. Holarctic ones amount to 15 % (Fig. 3), Transeurasiatic - 14%, Transpalearctic are of less importance (5%). These species with circum- and transareas, together with the complex of Cosmopolitan and Multiregional ones, comprise 36% of the fauna. The West-Central Palearctic complex is the most numerous - 46.5%; of these the group of Euro-Siberian species is the biggest (14% of the fauna as a whole). The widely distributed West-Central Palearctic species (from Europe and North Africa to West or Middle Siberia and Central Asia) and Westpalearctic (not further than West Siberia, Kazakhstan and Caucasus) are poorly represented (about 5%). A complex with different kinds of European ranges makes up 13%. As a whole these species are widespread in Europe, and only 2.7% of the fauna is restricted to East Europe, or Middle and East, or South and East Europe. Eleven species are distributed from the Mediterranean region to Central or Middle

Table 2. Species composition of the spider families in different zones and subzones of the Left-Bank Ukraine. Abbreviations: Steppe I − Forbgrass-festuca-stipa subzone, Steppe II − Festuca-stipa subzone, NS − Number of species.

Families	Total		Forest zone		Forest-steppe		Steppe I		Steppe II	
	NS	%	NS	%	NS	%	NS	%	NS	%
Atypidae	2	0.3	0	0.0	2	0.4	1	0.2	1	0.2
Scytodidae	1	0.1	1	0.3	1	0.2	1	0.2	1	0.2
Pholcidae	3	0.4	2	0.5	3	0.7	3	0.6	3	0.7
Segestriidae	1	0.1	0	0.0	1	0.2	1	0.2	0	0.0
Dysderidae	5	0.7	1	0.3	1	0.2	5	1.0	3	0.7
Oonopidae	1	0.1	1	0.3	0	0.0	0	0.0	0	0.0
Mimetidae	3	0.4	2	0.5	1	0.2	3	0.6	2	0.5
Oecobiidae	1	0.1	1	0.3	0	0.0	0	0.0	0	0.0
Eresidae	1	0.1	0	0.0	1	0.2	1	0.2	1	0.2
Uloboridae	1	0.1	0	0.0	1	0.2	1	0.2	1	0.2
Nesticidae	1	0.1	0	0.0	1	0.2	0	0.0	0	0.0
Theridiidae	52	7.7	31	8.1	35	7.8	43	8.3	36	8.8
Linyphiidae	204	30.2	130	33.8	151	33.8	125	24.1	69	17.0
Tetragnathidae	13	1.9	10	2.6	13	2.9	13	2.5	10	2.5
Araneidae	40	5.9	30	7.8	34	7.6	34	6.6	29	7.1
Lycosidae	55	8.1	30	7.8	41	9.2	41	7.9	41	10.1
Pisauridae	3	0.4	3	0.8	3	0.7	3	0.6	2	0.5
Agelenidae	7	1.0	5	1.3	5	1.1	6	1.2	4	1.0
Argyronetidae	1	0.1	1	0.3	1	0.2	1	0.2	1	0.2
Hahniidae	4	0.6	3	0.8	3	0.7	2	0.4	1	0.2
Dictynidae	22	3.3	9	2.3	10	2.2	15	2.9	12	2.9
Titanoecidae	6	0.9	2	0.5	3	0.7	3	0.6	5	1.2
Oxyopidae	3	0.4	1	0.3	2	0.4	2	0.4	2	0.5
Anyphaenidae	1	0.1	1	0.3	1	0.2	1	0.2	1	0.2
Liocranidae	9	1.3	4	1.0	7	1.6	8	1.5	7	1.7
Clubionidae	17	2.5	12	3.1	13	2.9	14	2.7	11	2.7
Miturgidae	9	1.3	4	1.0	6	1.3	8	1.5	7	1.7
Zodariidae	2	0.3	0	0.0	0	0.0	2	0.4	1	0.2
Gnaphosidae	72	10.6	26	6.8	34	7.6	60	11.6	52	12.8
Zoridae	6	0.9	4	1.0	5	1.1	5	1.0	4	1.0
Sparassidae	1	0.1	1	0.3	1	0.2	1	0.2	1	0.2
Philodromidae	24	3.6	15	3.9	12	2.7	23	4.4	19	4.7
Thomisidae	36	5.3	20	5.2	26	5.8	32	6.2	32	7.9
Salticidae	68	10.1	35	9.1	29	6.5	60	11.6	48	11.8
	675	100	385	100	447	100	518	100	407	100
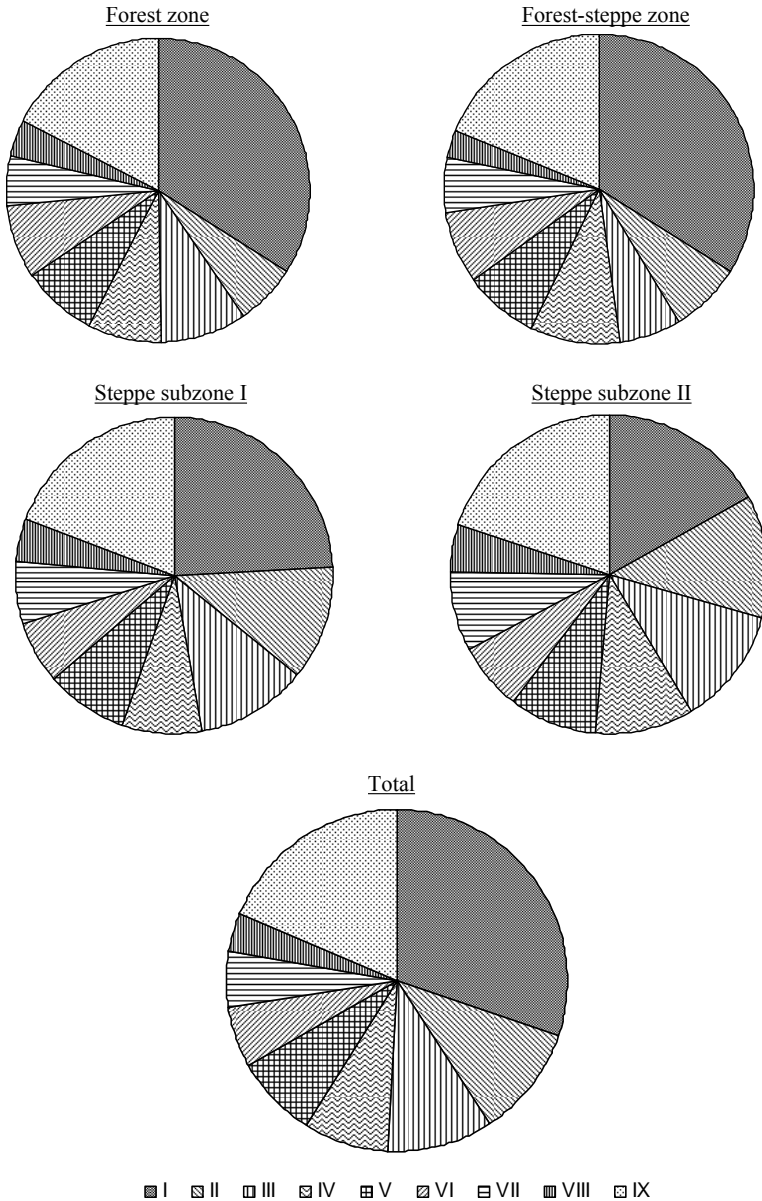
Fig. 2. Contribution to species diversity by the main spider families in different zones/subzones of the Left-Bank Ukraine. I − Linyphiidae, II − Gnaphosidae, III − Salticidae, IV − Lycosidae, V − Theridiidae, VI − Araneidae, VII − Thomisidae, VIII − Philidromidae, IX − Others. Abbreviation and species ratio as in Table 2.

Asia; twelve species have different kinds of disjunctive areas. One species, *Agelenopsis potteri* (Blackwall, 1846), was introduced from North America.

A number of species have their borders of distribution in the investigated area. To our mind, there are no endemics, because there is no physiographical restricted areas. Four species, being found only in the area are known mainly from the type localities. Except one, they were recorded in the southern steppes, and may occur in similar habitats eastwards, in Russia. We consider them to be Pontic species (*Harpactea azovensis* Kharitonov, 1956, *Larinia elegans* Spassky, 1939,
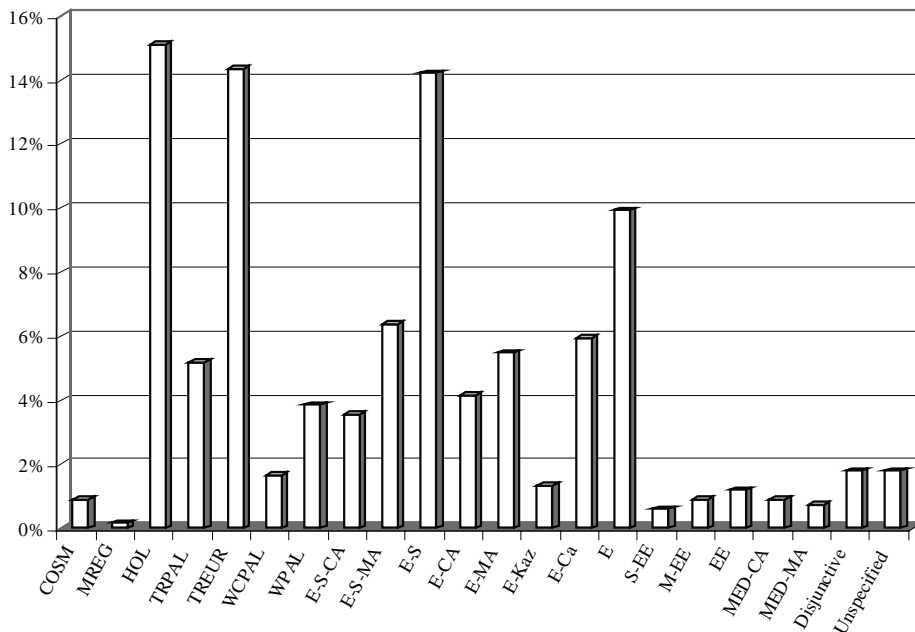
Fig. 3. Zoogeografical composition of the spider fauna of the Left-Bank Ukraine. Chorotypes: COSM – Cosmopolitan, MREG – Multiregional, HOL – Holarctic, TRPAL – Transpalearctic, TREUR – Transeurasiatic, WCPAL – west-central-Palearctic, WPAL – westpalearctic, E-S-CA – Euro-Sibero-central Asiatic, E-S-MA – Euro-Sibero-middle Asiatic, E-S – Euro-Siberian, E-CA – Euro-central Asiatic, E-MA – Euro-middle Asiatic, E-Kaz – Euro-Kazakhstanian, E-Ca – Euro-Caucasian, E – European (wide), S-EE – South-East European, M-EE – middle-east European, EE – east European, MED-CA – Mediterranean-central Asiatic, MED-MA – Mediterranean-middle Asiatic, Disjunctive, Unspecified.

Drassodes charkovie (THORELL, 1875), *Philodromus dilutus* THORELL, 1875). In Left Bank Ukraine we have not found species with southern boundaries of distribution, while there is a bulk of species whose northern limit of distribution reaches the area. They came from the Mediterranean realm (*Minicia candida* DENIS, 1946, *Sintula retroversus* (O.P.-CAMBRIGE, 1875), *Pardosa vittata* (KEYSERLING, 1863), *Trachyzelotes barbatus* (L. KOCH, 1866), *T. malkini* (PLATNICK, MURPHY, 1984), *Philodromus glaucinus* SIMON, 1870, *Singa lucina* (SAVIGNY, AUDOUIN, 1826), or have another origin (*Agelena orientalis* C. L. KOCH, 1837, *Tegenaria lapicidinarum* SPASSKY, 1934, *Dictyna armata* THORELL, 1875, *Trachyzelotes lyonneti* (SAVIGNY, AUDOUIN, 1826). Ten species are spread in Central, Middle Asia or Kazakhstan, in arid areas, and reach East European steppes but do not get over the Dnieper. However, taking into consideration the scarce knowledge of the araneofauna of the Right-Bank steppes, we may expect them to appear westwards (*Pelecopsis laptevi* (TANASEVITCH, FET, 1986), *Sauron fussicornis* ESKOV, 1995, *Mustelicosa dimidiata* (THORELL, 1875), *Pirata cereipes* (L. KOCH, 1826), *Devade tenella* (TYSTSHENKO, 1965), *Gnaphosa cumensis* PONOMARJOV, 1981, *Leptodrassus memorialis* SPASSKY, 1940, *Talanites strandi* SPASSKY, 1940, *Xysticus mongolicus* SCHENKEL, 1863, *Mogrus larisae* LOGUNOV, 1995). Both *Minicia caspiana* TANASEVITCH, 1990 and *Synageles scutiger* PROSZYNSKI, 1979 have North and West borders, *Gnaphosa moesta* THORELL, 1875 has North and East ones; and, finally, two European species do not spread eastwards (*Zodarion rubidum* SIMON, 1914, *Sintula spiniger* BALOGH, 1935).

In conclusion we want to emphasize that the study of spiders in the area continues. The comparatively short list of species may be explained not only by insufficient data, but also by the flat landscape, mainly transformed in agroecosystems.

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Преглед на изследванията върху паяците (Araneae) на Левия бряг (Украйна) с нови данни

Н. Полчанинова, Е. Прокопенко

(Резюме)

В статията е представен кратък преглед на проучванията върху паяците на Украйна от 70-те години на 18 век до наши дни, като е обърнато особено внимание на тези, отнасящи се до аранеофауната на Левия бряг. Обобщените литературни и авторови данни показват, че до момента на изследваната територия са установени 716 вида паяци от 34 семейства, а 41 вида се нуждаят от потвърждение. Семейство Linyphiidae е представено с най-много видове, следват го Salticidae и Gnaphosidae с приблизително три пъти по-малко таксони от видовата група. Зоогеографският анализ показва, че основната част от фауната е съставена от видове с широки ареали. Освен тях, са регистрирани и голям брой медитерански и азиатски видове, чиито граници на разпространение минават през изследваната територия.

On the biogeography of Romanian spiders (Araneae)

Andreea Tatole[1]

Abstract: The biogeographical structure of the Romanian spider fauna is analyzed differentially: first at macro-regional level, in order to outline the global distribution of the species, and secondly at the level of Palearctic subregions, to show the affinities of the species with different types of climate and habitats. The results show that Palearctic and Holarctic elements dominate among Romanian spiders as 81.16% of the species are widespread and occur throughout Europe.

Key words: spiders, zoogeographical analysis, macro-regions, Palearctic subregions, Romania

Introduction

One of the most obvious features of the living world is its lack of uniformity in distribution – plants and animals showing both spatial and temporal distribution patterns (BĂNĂRESCU, BOȘCAIU 1973; COX, MOOR 1985). As the anthropic pressure is growing, controlling its effects on the different species of plants and animals is becoming more and more important, and biogeography plays a significant role in conservation (BĂNĂRESCU, TATOLE 1996).

Material and Methods

The zoogeographical analysis of the Romanian spider fauna was carried out using the checklist published by WEISS, URÁK (2000), which was renewed following the data from the catalog of PLATNICK (2004). The intra-Palearctic analysis was made using the map of the biogeographic subregions given by the European Environmental Agency (online at http://dataservice.eea.eu.int/atlas/viewdata/viewpub.asp?id=221)

Results and Discussion

The biogeographical analysis of the spider fauna has been made in two steps: first at macro-regional level in order to depict the global distribution of the species, and secondly at the level of Palearctic subregions to emphasize their climatic affinities.

Macro-regional level

The general accepted system in biogeography is the one defined by WALLACE (1876) for mammals (Fig. 1), but the limits of the zoogeographic regions are still a subject of debate, since a single geographic element may or may not represent a barrier for a certain group of organisms. Nevertheless, most of the zoologists are using this system as a matter of standardization.

COX (2001) suggested the reconsideration of the zoogeographic regions for various reasons: (1). The Wallace's system is based on the dispersion patterns of terrestrial mammals, whose dis-

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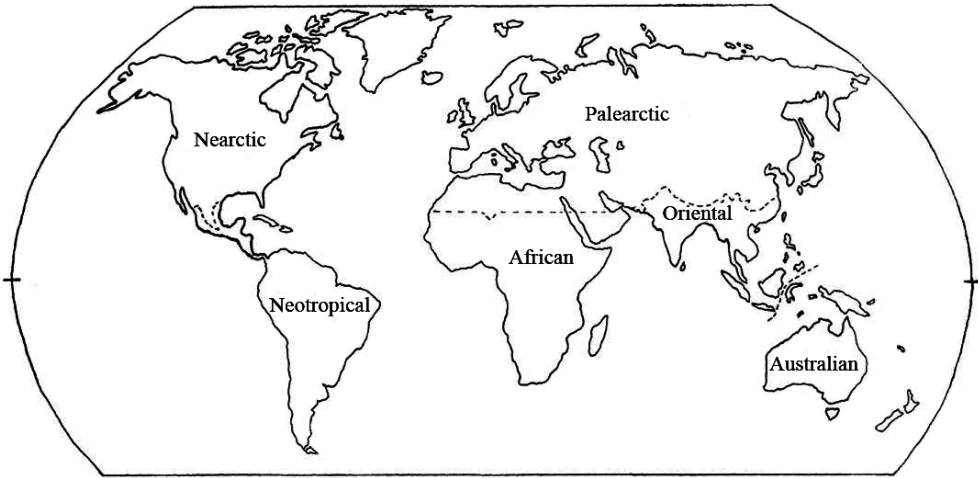
Fig. 1. Map of the zoogeographic regions as defined by Wallace (after Cox, 2001).

tribution is limited to the continental area, and which do not have the means to cross the oceans. The majority of all the other groups of terrestrial animals have distribution patterns closer to those of the flowering plants, being able to disperse either actively, or passively (e.g. on or inside the body of the birds). Thus, "it seems to be inappropriate to call Wallace's Regions "Zoogeographic regions", with the implication that these are the patterns of distribution of animals in general. It would, therefore, be better to refer to them more specifically as "Mammal zoogeographic regions", with the implication that other groups of animals may have different patterns (as they do)" (Cox 2001); (2). As the mammals are limited to the continental plates, and the regions correspond to them, it would be more accurate to name the regions after the names of the continents; (3). The Wallace's Line does not reflect the reality and it has not had a positive effect on the zoogeographical researches. Many scientists tried to find "the better" place to draw it – a futile action, since there is no such place, and the studies did not lead to the further development of biogeography, being a mere comparative study of the competitive and dispersion abilities of the different groups of animals colonizing the area. The best solution is represented by the exclusion of these islands from both regions, limiting the Oriental and the Australian to the continental plates, and the area in between to be named Wallacea; (4). From the historical point of view, the area occupied now
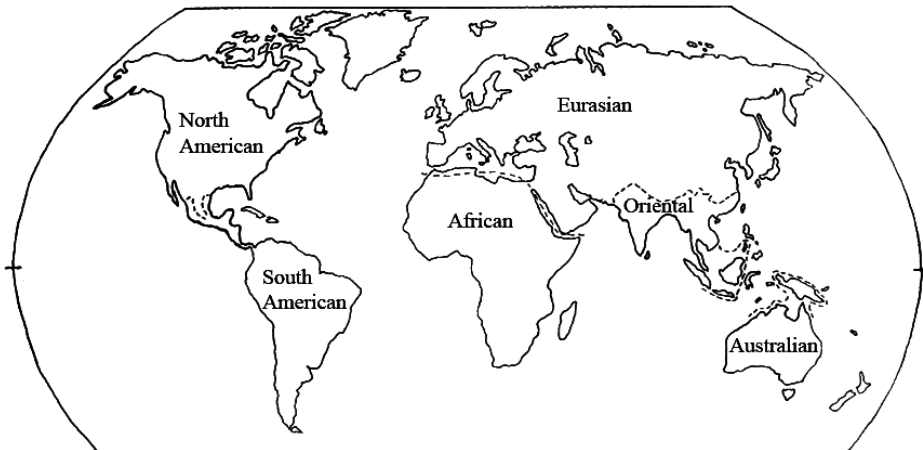
Fig. 2. Map of zoogeographic regions after Cox (2001).

by the Sahara Desert has represented a crossover region between the European and African flora. Once the climatic regime had changed during Pliocene, the South of Europe became at first warm-temperate, afterwards changing into the nowadays Mediterranean, and the desert has grown northwards including the area just to the south of it. Thus, the Sahara is an area where the former tropical flora of North Africa has disappeared, and logically is considered a part of the African Region. Fig. 2 shows the model of Cox (2001).

Because Cox's ideas have not been widely accepted yet, we have analyzed the zoogeographical structure of the Romanian spider fauna in accordance to both models. The results obtained following the Wallace's model are presented in Fig. 3. As seen from the figure, the Palearctic elements (85.74%) are dominant, followed by the Holarctic ones (11.34%), while the affinities between the Palearctic Region and all the other ones are much weaker than those with the Nearctic Region. Following Cox's model, the results are only slightly different (Fig. 4) – the North African species being included in the African Region and not in the Palearctic one.
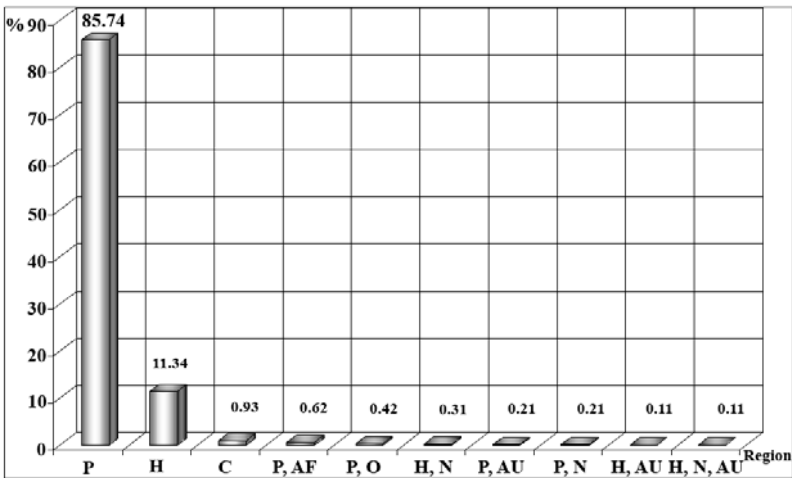
Fig. 3. Comparative share of the zoogeographical elements in the Romanian spider fauna.
AF=African; AU=Australian; C=Cosmopolitan; H=Holarctic; N=Neotropical; O=Oriental; P=Palearctic.
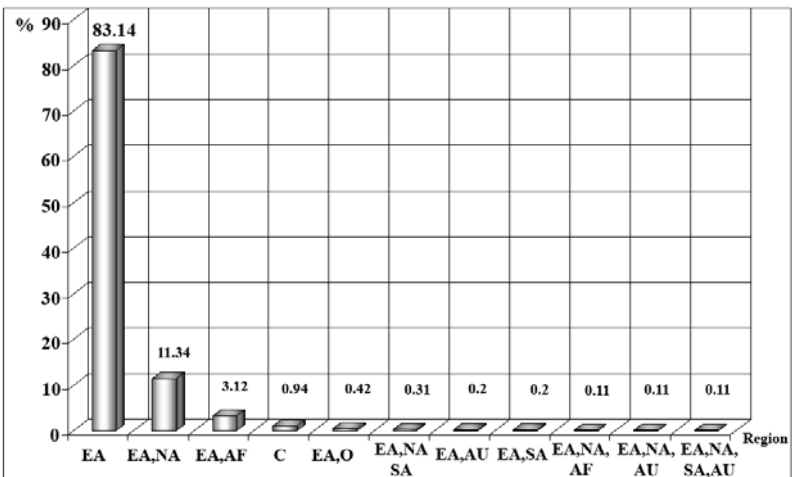
Fig. 4. Comparative share of the zoogeographical elements in the Romanian spider fauna (after Cox's biogeographic division). EA=Eurasian; NA=North American; SA=South American; AF=African; AU=Australian; O=Oriental; C=Cosmopolitan.
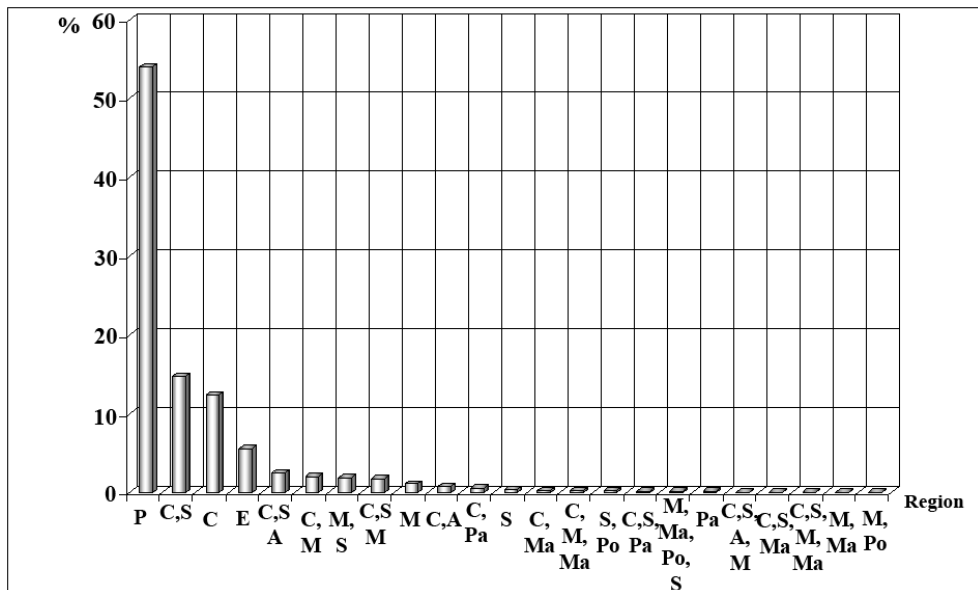
Fig. 5. Comparative share of the intra-Palearctic zoogeographical elements in the Romanian spider fauna. P=Palearctic; C=Continental; S=Steppic; E=Endemic; A=Alpine; M=Mediterranean; Ma=Macaronezian; Pa=Pannonian; Po=Pontic.

Palearctic sub-regions level

To analyze the structure at this stage, we considered the biogeographic subregions given by the European Environmental Agency. The Palearctic Kingdom is divided into 11 subregions, the following 5 falling within the borders of Romania: Continental, Alpine, Pannonian, Steppic, and Pontic. Analyzing the obtained data, one can observe that the vast majority of species have extended areals, a fact proven by the sheer dominance of Palearctic elements – 54%, followed by the Continental and Steppe ones – 14.78%, and the Continental ones – 12.38% (Fig. 5). Thus, out of 961 species hitherto registered in Romania, 780 (81.16%) are widely distributed throughout Europe. The occurrence of a certain species in quite different areas (e.g. *Meta bourneti* is known from four different regions – Continental, Steppe, Alpine, Mediterranean) suggests that in fact its areal is still insufficiently known and the species has larger ecological plasticity, which allows a much wider distribution.

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Биогеографски анализ на аранеофауната на Румъния (Araneae)

А. Татоле

(Резюме)

Биогеографската структура на аранеофауната на Румъния е анализирана на макро-ниво по класическото разделяне на царствата, предложено от Уолъс през 1876 г., и на ниво „подрегиони" в Палеарктичното царство. Анализът показва, че палеарктичните и холарктичните елементи доминират в румънската фауна, като 81.16% от видовете имат широко разпространение в Европа.

The spider fauna of the Gülek Pass (Turkey) and its environs (Araneae)

Aydın Topçu[1], Hakan Demir[1], Osman Seyyar[1], Tuncay Türkeş[2]

Abstract: The present study puts on record 140 species belonging to 70 genera and 28 families established in the region of Gülek Pass, Turkey. Five species, *Enoplognatha mordax* (THORELL, 1875), *Araneus sturmi* (HAHN, 1831), *Hypsosinga albovittata* (WESTRING, 1851), *Lycosa singoriensis* (LAXMANN, 1770) and *Pardosa hortensis* (THORELL, 1872), are new country records. The zoogeographical categories and habitats for all the spiders established in the region are presented.

Key words: spiders, faunistics, new records, Toros Mountains

Introduction

The Turkish spiders are rather poorly studied. The most important papers dealing with the araneofauna of the country are those of KULCZYŃSKI (1903), NOSEK (1905), ROEWER (1960), KAROL (1967), and a series of publications of BRIGNOLI (1968, 1972, 1978a,b, 1979a,b). All existing information was summarised recently by BAYRAM (2002) and TOPÇU *et al.* (2005). In terms of spiders, still quite a number of regions remain to be faunistically prospected. The Gülek Pass in Toros Mountains is one of these white spots. The aim of the current study is to put on record the results of the investigations carried out between 2001 and 2003 in Gülek Pass and its environs, and to provide an analysis of the species diversity.

Study area and Material

The Gülek Pass forms the main passage through the Toros Mountains, which are situated in southeastern Turkey. It has transitional characteristics between the low plains of the Mediterranean region and the high central plateau of Anatolia. Dominating the Mediterranean coast are the western and main ranges of the Toros Mountains, which tower over the narrow plains along the Mediterranean Sea. Rivers and streams that flow into the sea have cut steep-sided, narrow valleys through the main Toros range, providing natural passes through the mountains. The pass connects the alluvial Adana Plain, one of the most highly developed agricultural areas in Turkey, with the interior regions.

The vegetation types of the four main areas sampled are listed below:

- Steppe area, with plant community composed of: *Berberis crataegina*, *Crataegus monogyna*, *Eleagnus angustifolia*, *Onobrychis cornuta*, *Convolvulus compactus*, *Genista albida*, *Poa annua*, *Muscari longipes*, *Astragalus*, and *Acantholimon.*

- Forest area, with plant community composed of: *Quercus infectoria*, *Q. coccifera*,

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Q. cerris, *Sytrax officinalis*, *Phillyrea latifolia*, *Pistacia terebinthus*, *Rhamnus hirtellus*, *Juniperus excelsa*, *J. oxycedrus*, *Pinus brutia*, and *Cedrus libani*.

- Rocky area, with plant community composed of: *Cotoneaster nummularia*, *Teucrium chamaedrys*, *Centaurea drabafolia*, *Thymus spyleus*, *Salvia cryptantha*, *Arenaria angustifolia*, *Dianthus tabrisianus*, *Hypericum perfoliatum*, *Veronica multifida*, *Salvia lavandulifolia*, and *Potentilla speciosa*.

- Marshy area, with plant community composed of: *Salix alba*, *Euphorbia macroclada*, *Phragmites australis*, *Juncus inflexus*, *Mentha aquatica*, *Primula auriculata*, *Alchemilla ellenbergiana*, and *Polygonum amphibium*.

The material was collected from April 2001 to June 2003 by pit-fall trapping and hand collecting. The collecting sites are indicated on map (Fig. 1). The entire collection is currently preserved in the Arachnology Museum of Niğde University (NUAM).

Results and Discussion

A total of 140 species belonging to 70 genera and the following 28 families were found (Table 1; respective number of species indicated in brackets): Sicariidae (1), Scytodidae (1), Pholcidae (4), Dysderidae (4), Palpimanidae (1), Mimetidae (2), Eresidae (1), Oecobiidae (1), Uloboridae (1), Theridiidae (8), Linyphiidae (5), Tetragnathidae (2), Araneidae (13), Lycosidae (13), Pisauridae (1), Oxyopidae (4), Agelenidae (2), Dictynidae (2), Amaurobiidae (2), Titanoecidae (2), Miturgidae (2), Liocranidae (1), Zodariidae (2), Gnaphosidae (24), Sparassidae (1), Philodromidae (6), Thomisidae (23) and Salticidae (11). One hundred and thirty-five species are new for the region, while the species: *Enoplognatha mordax* (THORELL, 1875), *Araneus sturmi* (HAHN, 1831), *Hypsos-*
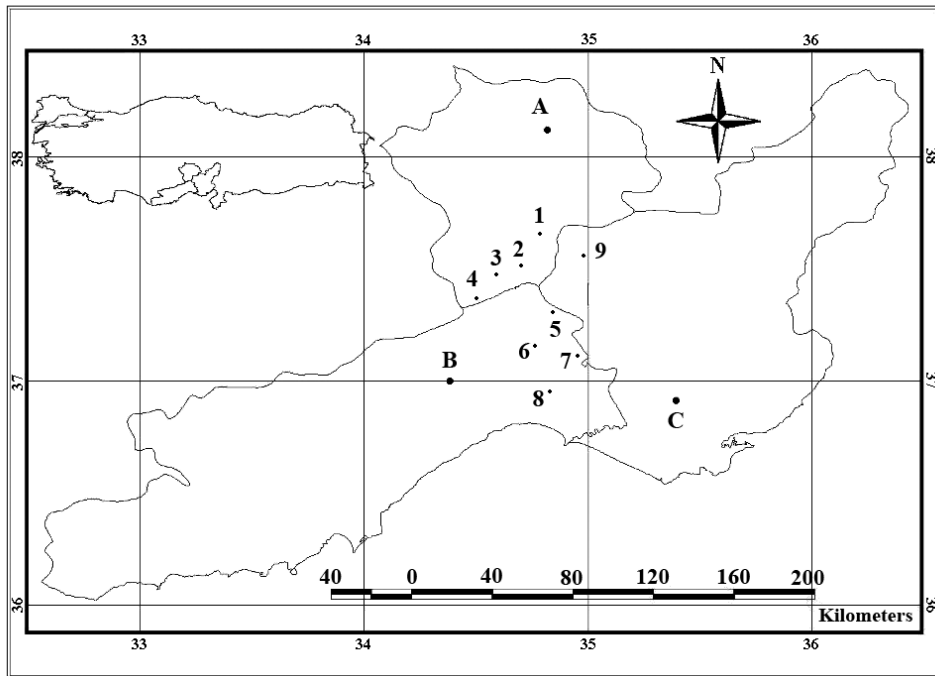
Fig. 1. Map of Gülek Pass and its environs. Localities: A - Niğde Province, 1 - village of Gümüş, 2 - village of Maden, 3 - village of Alihoca, 4 - Meydan Plateau; B - Mersin Province, 5 - village of Belemedik, 6 - town of Gülek, 7 - village of Sarışık, 8 – village of Çamlıyayla; C - Adana Province, 9 - Pozantı District.

inga albovittata (Westring, 1851), *Lycosa singoriensis* (Laxmann, 1770) and *Pardosa hortensis* (Thorell, 1872), are new for the Turkish araneofauna. Best represented are the families: Gnaphosidae - 17.14% of all records, Thomisidae - 16.42%, Lycosidae - 9.28%, Salticidae - 7.85%, Theridiidae - 5.71%, Philodromidae - 4.28%, and Lyniphiidae - 3.57%. The genus *Xysticus* is by far the species richest of all, having 13 species found to occur in the investigated region.

Concerning habitats, most of the species were found in marshy (101) and forest (50) areas, while a comparatively low number of species was registered in rocky (28) and steppic (26) habitats (Table 1).

Table 1. List of the spiders established in the Gülek Pass and their habitat distribution. Habitats: S - Steppic area, F - Forest area, R - Rocky area, M - Marshy area. **Localities:** Niğde Province: 1 - Gümüş, 2 - Maden, 3 - Alihoca, 4 - Meydan Plateau; Mersin Province: 5 - Belemedik, 6 - Gülek, 7 - Sarışık, 8 - Çamlıyayla; Adana Province: 9 - Pozantı District.

Species	Distribution	Habitats	Locality
Sicariidae			
Loxosceles rufescens (Dufour, 1820)	Cosmopolitan	S	2
Scytodidae			
Scytodes thoracica (Latreille, 1802)	Holarctic, Pacific Is.	S	2, 6
Pholcidae			
Holocnemus pluchei (Scopoli, 1763)	Mediterranean	R	7
Pholcus opilionoides (Schrank, 1781)	Holarctic	R	2, 3, 5, 7
Pholcus phalangioides (Fuesslin, 1775)	Cosmopolitan	R	2, 5, 7
Hoplopholcus asiaminoris Brignoli, 1978	Turkey	R	5, 7
Dysderidae			
Dysdera crocata C. L. Koch, 1838	Cosmopolitan	S, M	5, 6
Dysdera erythrina (Walckenaer, 1802)	Europe, Georgia, Turkey	M, F	2, 3, 6, 9
Dysdera ninnii Canestrini, 1868	Southern Europe, Ukraine, Turkey	M	2, 4
Dysdera taurica Charitonov, 1956	Southern Europe, Ukraine, Turkey	M	2, 5
Palpimanidae			
Palpimanus gibbulus Dufour, 1820	Mediterranean, Central Asia	M	3, 9
Mimetidae			
Ero aphana (Walckenaer, 1802)	Palearctic	M, F	5
Mimetus laevigatus (Keyserling, 1863)	Mediterranean to Central Asia	M, F	6
Eresidae			
Eresus cinnaberinus (Olivier, 1789)	Palearctic	S, R	2, 5
Oecobiidae			
Uroctea durandi (Latreille, 1809)	Mediterranean	F, M	2, 3, 5, 6, 9
Uloboridae			
Uloborus walckenaerius Latreille, 1806	Palearctic	F, M	3, 5

Table 1. Continued.

Species	Distribution	Habitats	Locality
Theridiidae			
Achaearanea tepidariorum (C.L. KOCH, 1841)	Cosmopolitan	S, R	9
Crustulina scabripes SIMON, 1881	Mediterranean	S, R	6
Steatoda albomaculata (DE GEER, 1778)	Cosmopolitan	S, R, M	5
Steatoda bipunctata (LINNAEUS, 1758)	Holarctic	S, R	6
Steatoda castanea (CLERCK, 1757)	Palearctic	S, M	5, 7
Steatoda grossa (C. L. KOCH, 1838)	Cosmopolitan	S, M	7
Steatoda paykulliana (WALCKENAER, 1805)	Europe, Mediterranean to Central Asia	S, R	2, 3, 6, 9
Enoplognatha mordax (THORELL, 1875)	Palearctic	S, M	5, 7
Linyphiidae			
Erigone atra BLACKWALL, 1833	Holarctic	M, F	4
Erigone dentipalpis (WIDER, 1834)	Holarctic	M, F	5
Frontinellina frutetorum (C.L. KOCH, 1834)	Palearctic	M, F	5, 6, 8, 9
Lepthyphantes leprosus (OHLERT, 1865)	Holarctic, Chile	M, F	5
Tenuiphantes zimmermanni (BERTKAU, 1890)	Europe, Russia, Turkey	M, F	4
Tetragnathidae			
Tetragnatha extensa (LINNAEUS, 1758)	Holarctic, Madeira	M, F	5, 9
Tetragnatha montana SIMON, 1874	Palearctic	M, F	4
Araneidae			
Aculepeira ceropegia (WALCKENAER, 1802)	Palearctic	M, F	3
Agelenatea redii (SCOPOLI, 1763)	Palearctic	F	5, 9
Araneus diadematus CLERCK, 1757	Holarctic	M, F	1, 2, 4, 7, 9
Araneus marmoreus CLERCK, 1757	Holarctic	M	2
Arainella cucurbitina (CLERCK, 1757)	Palearctic	M	7, 8
Argiope bruennichi (SCOPOLI, 1772)	Palearctic	M, F	6
Argiope lobata (PALLAS, 1772)	Old World	M, F	6, 7
Cyclosa conica (PALLAS, 1772)	Holarctic	M, F	6
Hypsosinga pygmaea (SUNDEVALL, 1831)	Holarctic	M	5
Mangora acalypha (WALCKENAER, 1802)	Palearctic	M, F	3, 5, 6, 9
Neoscona adianta (WALCKENAER, 1802)	Palearctic	M	3, 5, 6, 7, 9
Araneus sturmi (HAHN, 1831)	Palearctic	M	2, 6, 7
Hypsosinga albovittata (WESTRING, 1851)	Europe, North Africa, Russia	M	3
Lycosidae			
Arctosa cinerea (FABRICIUS, 1777)	Palearctic, Congo	M	2, 3, 8
Arctosa perita (LATREILLE, 1799)	Holarctic	M	2, 5, 7
Arctosa personata (L. KOCH, 1872)	Western Mediterranean	M	2, 5, 7

Table 1. Continued.

Species	Distribution	Habitats	Locality
Arctosa fulvolineata (LUCAS, 1846	West Palearctic	M	7
Geolycosa vultuosa (C.L. KOCH, 1838)	Southeastern Europe to Central Asia	M	6
Pardosa agrestis (WESTRING, 1861)	Palearctic	M, F	8
Pardosa agricola (THORELL, 1856)	Europe to Kazakhstan	M	4
Pardosa amentata (CLERCK, 1757)	Europe, Russia, Turkey	M	2, 3, 5, 6
Pardosa proxima (C.L. KOCH, 1847)	Palearctic, Canary Is.,Azores	F	2, 5
Pardosa pullata (CLERCK, 1757)	Europe, Russia, Turkey, Central Asia	M, F	2, 3, 5, 7
Trochosa terricola THORELL, 1856	Holarctic	M, F	9
Lycosa singoriensis (LAXMANN, 1770)	Palearctic	M, F	2, 3
Pardosa hortensis (THORELL, 1872)	Palearctic	M, F	2, 3, 5, 6
Pisauridae			
Pisaura mirabilis (CLERCK, 1758)	Palearctic	M	2, 6, 9
Oxyopidae			
Oxyopes lineatus LATREILLE, 1806	Palearctic	M	3, 6
Oxyopes nigripalpis KULCZYNSKI, 1891	Mediterranean	M	3
Oxyopes heterophthallus (LATREILLE, 1804)	Palearctic	M	2, 9
Oxyopes ramosus (MARTINI, GOEZE, 1778)	Palearctic	M	2
Agelenidae			
Agelena labyrinthica (CLERCK, 1757)	Palearctic	S, M	2, 5
Tegeneria parietina (FOURCROY, 1785)	Europe, North Africa to Central Asia	S, M	6
Dictynidae			
Dictyna latens (FABRICIUS, 1775)	Europe to Central Asia	M	9
Dictyna arundinacea (LINNEAUS, 1758)	Holarctic	M, F	6, 9
Amaurobiidae			
Amaurobius ferox (WALCKENAER, 1860)	Holarctic	M, F	2
Amaurobius fenestralis (STRÖM, 1768)	Europe to Central Asia	M, F	2
Titanoecidae			
Nurscia albomaculata (LUCAS, 1846)	Europe to Central Asia	R	7
Titanoeca schineri L. KOCH, 1872	Palearctic	S, R	6
Miturgidae			
Cheiracanthium erraticum (WALCKENAER, 1802)	Palearctic	M	3
Cheiracanthium punctorium (VILLERS, 1789)	Europe to Central Asia	M	5
Liocranidae			
Agroeca inopina O. P.-CAMBRIDGE, 1886	Europe, Algeria, Turkey	S	2
Zodaridae			
Zodarion germanicum C.L. KOCH, 1837	Europe, Turkey	M	2

Table 1. Continued.

Species	Distribution	Habitats	Locality
Zodarion rubidum SIMON, 1914	Europe, Turkey, USA (introduced)	M	3
Gnaphosidae			
Callilepis nocturna (LINNAEUS, 1758)	Palearctic	M	6
Drassodes cupreus (BLACKWALL, 1834)	Palearctic	M	2, 6, 7
Drassodes lapidosus (WALCKENAER, 1802)	Palearctic	R, M, F	2, 3, 8
Drassodes pubescens (THORELL, 1856)	Palearctic	S, R	4, 7, 8
Drassodes villosus (THORELL, 1856)	Palearctic	M	3, 5, 6
Drassyllus praeficus (L. KOCH, 1866)	Europe to Central Asia	R	4, 5
Drassylus pusillus (C.L. KOCH, 1833)	Palearctic	M, F	8
Gnaphosa lucifuga (WALCKENAER, 1802)	Palearctic	S, R	6
Gnaphosa lugubris (C.L. KOCH, 1839)	Europe to Central Asia	S, R	6
Gnaphosa montana (L. KOCH, 1866)	Palearctic	F	4
Gnaphosa opaca HERMAN, 1879	Europe to Central Asia	R	4
Haplodrassus dalmatensis (L. KOCH, 1866)	Palearctic	S, R	8
Haplodrassus signifer (C.L. KOCH, 1839)	Holarctic	S, R	5, 6, 7
Haplodrassus umbratilis (L. KOCH, 1866)	Europe to Kazakhstan	S, R	2, 6, 8, 9
Micaria formicaria (SUNDEVALL, 1831)	Palearctic	F	7
Micaria rossica THORELL, 1875	Holarctic	F	2
Nomisi aussereri (L. KOCH, 1872)	Palearctic	F	6
Nomisia exornata (C.L. KOCH, 1839)	Europe to Central Asia	M, F	6, 7, 8, 9
Nomisia ripariensis (O.P.-CAMRIDGE, 1872)	Greece, Azerbaijan, Turkey	F	7
Zelotes caucasicus (L. KOCH, 1866)	Europe to Central Asia	R	6, 7
Zelotes electus (C.L. KOCH, 1839)	Europe to Central Asia	S, R	2
Zelotes latreillei (SIMON, 1878)	Europe, Azerbaijan, Turkey	M, F	9
Zelotes longipes (L. KOCH, 1866)	Palearctic	R, F	2
Zelotes puritanus CHAMBERLIN, 1922	Holarctic	R, F	6
Sparassidae			
Micrommata virescens (CLERCK, 1757)	Palearctic	M	3
Philodromidae			
Paratibellus oblongiusculus (LUCAS, 1846)	Europe to Central Asia	M, F	6
Philodromus aureolus (CLERCK, 1757)	Palearctic	M, F	6, 7, 8
Philodromus praedatus O.P.-CAMBRIDGE, 1871	Europe, Russia, Turkey	M	7
Thanatus formicinus (CLERCK, 1757)	Holarctic	M, F	4, 5, 6
Thanatus vulgaris SIMON, 1870	Holarctic	M, F	2, 3, 6
Tibellus oblongus (WALCKENAER, 1802)	Holarctic	M, F	5, 8
Thomisidae			
Heriaeus graminicola (DOLESCHALL, 1852)	Europe to Central Asia	M	1, 2, 3, 5, 6, 7

Table 1. Continued.

Species	Distribution	Habitats	Locality
Heriaeus melloteei Simon, 1886	Palearctic	M	4, 6, 8, 9
Misumena vatia (Clerck, 1757)	Holarctic	M	3, 4, 6
Ozyptila claveata (Walckenaer, 1837)	Palearctic	M, F	4
Ozyptila praticola (C.L. Koch, 1837)	Holarctic	M, F	5
Ozyptila simplex (O.P.-Cambridge, 1862)	Palearctic	M, F	6
Pisitus truncatus (Pallas, 1772)	Palearctic	M	2, 3, 6, 7
Runcinia grammica (C.L. Koch, 1837)	Palearctic, St. Helena, South Africa	M	5, 7, 8, 9
Synema globosum (Fabricius, 1775)	Palearctic	M	1, 2, 3, 5, 6, 7
Thomisus onustus Walckenaer, 1805	Palearctic	M	1, 2, 3, 5, 6, 7, 8, 9
Xysticus bifasciatus C.L. Koch 1837	Palearctic	S, M	5
Xysticus cristatus (Clerck, 1757)	Palearctic	M, F	2, 3, 5, 6
Xysticus ferrugineus Menge, 1876	Palearctic	M, F	3
Xysticus kempeleni Thorell, 1872	Europe to Central Asia	R, M	5
Xysticus kochi Thorell, 1872	Europe, Mediterranean to Central Asia	M	1, 3, 5, 6
Xysticus lanio C.L. Koch	Palearctic	M, F	2, 3, 5, 6
Xysticus lineatus (Westring, 1851)	Palearctic	M, F	5
Xysticus ninnii Thorell, 1872	Palearctic	S, F	5, 6
Xysticus robustus (Hahn, 1832)	Europe to Central Asia	M	4, 6
Xysticus sabulosus (Hahn, 1832)	Palearctic	M, F	4, 5
Xysticus striatipies L. Koch, 1870	Palearctic	M	6, 7
Xysticus ulmi (Hahn, 1831)	Palearctic	M	5, 6
Xysticus viduus Kulczynski, 1898	Palearctic	M, F	4
Salticidae			
Evarcha arcuata (Clerck, 1757)	Palearctic	M	5
Evarcha falcata (Clerck, 1757)	Palearctic	M	5
Habrocestum latifasciatum (Simon, 1868)	Eastern Mediterranean	M	6, 9
Heliophanus aeneus (Hahn, 1832)	Palearctic	M	3
Heliophanus auratus C.L. Koch, 1835	Palearctic	M	6, 7
Heliophanus flavipes Hahn, 1832	Palearctic	M	9
Heliophanus lineiventris Simon, 1868	Palearctic	S, M	1, 2
Heliophanus mordax (O.P.-Cambridge, 1872)	Greece to Central Asia	M	2, 3, 9
Philaeus chrysops (Poda, 1761)	Palearctic	R, M	1, 2, 3, 5, 8, 9
Phlegra fasciata (Hahn, 1826)	Palearctic	M	6
Plexippoides gestroi Dalmas, 1920	Eastern Mediterranean	M	4

The zoogeographic classification of the spiders has been made on the basis of literature data reflecting their current distribution (PLATNICK 2006) (Fig. 2). Thus, our analysis shows that species with Palearctic distribution, represented on the studied territory by 67 species, are most numerous. Among them common species are: *Heliophanus flavipes*, *Runcinia grammica*, *Haplodrassus umbratilis*, *Oxyopes lineatus* and *Mangora acalypha*. The European-Central Asian chorotype is represented by 27 species, of them *Xysticus kempeleni*, *Nomisia exornata* and *Pardosa agricola* being most typical for the concerned region. The following data represent the species number of each zoogeographic category (in brackets are the most numerous species): Holarctic - 23 (*Tibellus oblongus*, *Haplodrassus signifer* and *Trochosa terricola*); Mediterranean - 10 (*Palpimanus gibbulus* and *Crustulina scabripes*); Cosmopolitan - 6; European-Asia Minor - 4, Middle East-European - 2, Old World - 1 and Turkish endemics - 1.
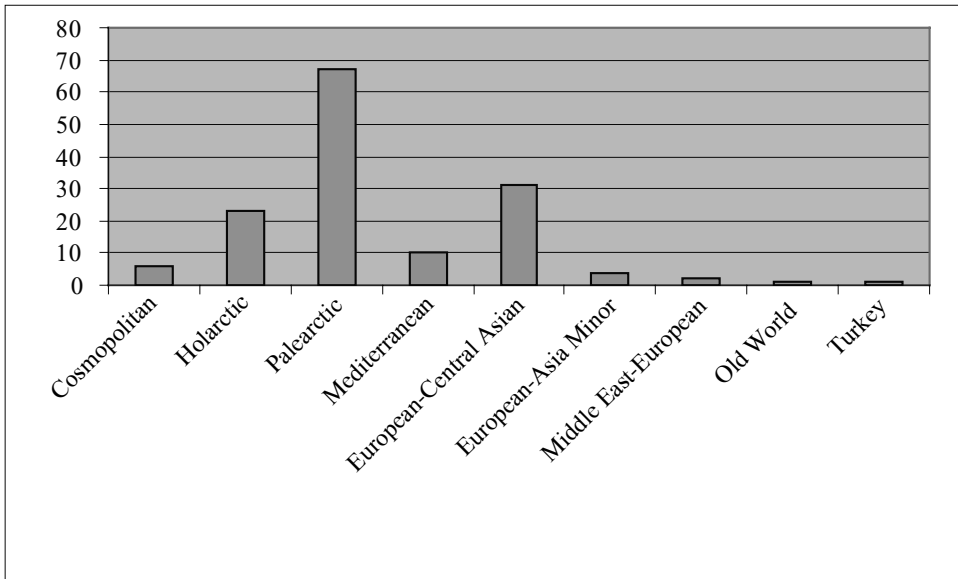
Fig. 2. Relative share of the defined chorotypes of spiders found in the Gülek Pass.

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Аранеофауната на прохода Гюлек (Турция) и неговите околности (Araneae)

А. Топчу, Х. Демир, О. Сейяр, Т. Тюркеш

(Резюме)

В статията се съобщават 140 вида паяци от 70 рода и 28 семейства, установени в района на прохода Гюлек, намиращ се в планината Торос (Югоизточна Турция). Пет вида – *Enoplognatha mordax* (Thorell, 1875), *Araneus sturmi* (Hahn, 1831), *Hypsosinga albovittata* (Westring, 1851), *Lycosa singoriensis* (Laxmann, 1770) и *Pardosa hortensis* (Thorell, 1872), са нови за фауната на Турция. Представени са данни за зоогеографската принадлежност и конкретните местообитанията на всеки един от установените видове.

New spider species records for the Isle of Mull, UK (Araneae)

Susan P. Bennett[1], David Penney[2]

Abstract: Thirty-eight spider species were collected in pitfall traps from the Isle of Mull, UK. The following 24 species are new records for Mull: *Clubiona compta* (Clubionidae); *Drassodes cupreus* (Gnaphosidae); *Pardosa nigriceps, Pirata hygrophilus* (Lycosidae); *Xysticus erraticus* (Thomisidae); *Agyneta ramosa, Ceratinella brevipes, C. brevis, Dicymbium nigrum, D. tibiale, Evansia merens, Gongylidiellum vivum, Hypselistes jacksoni, Micrargus herbigradus, Monocephalus fuscipes, Palliduphantes ericaeus, Peponocranium ludicrum, Pocadicnemis pumila, Tenuiphantes alacris, T. cristatus, Walckenaeria cuspidata, W. nudipalpis, W. unicornis* (Linyphiidae); *Zora spinimana* (Zoridae). Thirteen genera and two families (Gnaphosidae and Zoridae) are new records. More than 60% of the species collected were new records making a new total of 72, an increase of 50%. Such a large number of new records from a small sample size demonstrates the island's araneofauna is poorly known and warrants further investigation.

Key words: Clubionidae, Gnaphosidae, Linyphiidae, Lycosidae, Thomisidae, Zoridae

Introduction

CODDINGTON, LEVI (1991) considered the spider fauna of Western Europe (especially England) the most completely known when compared to other regions of the world. The British spider fauna consists of in excess of 620 species in 33 families (HARVEY *et al.* 2002). Although spider distributions in Great Britain are relatively well known, some remote regions remain understudied. This is particularly true of some off-shore islands, such as the Isle of Mull off the west coast of Scotland (Fig. 1). At the south-western tip of the island is an area of conservation interest called the Tireragan estate, which comprises hazel and birch woodland. The area has been deer-fenced for the last ten years to encourage natural regeneration and the consequences of this management practice for the existing arthropod communities is not known. Moreover, there is relatively little known about the baseline communities of spiders prior to the implementation of this conservation method. Therefore, it is important to inventory the species present in order to anticipate and assess future changes in the araneofauna, which may come about as a result of changes in management strategy.

Methods

Sampling consisted of 64 pitfall traps set in hazel and birch woodlands of the Tireragan estate for a period of four days during May 2004. Each trap consisted of a plastic cup 6.5 cm diameter × 9.5 cm deep containing 50 ml of 70% ethanol. Spiders were identified under ethanol using a Wild M8 zoom stereo-microscope and ROBERTS (1993); taxonomy follows PLATNICK (2006).

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Results and discussion

A total of 413 identified individuals, belonging to 38 species (Table 1) were captured. Linyphiidae constituted 71% of the total species, and more than 50% of the total individuals caught. In their provisional atlas of spider distribution throughout the British Isles, HARVEY *et al*. (2002) listed 48 species recorded for the island. Of the 38 species identified in this survey, 24 had not been recorded previously. This equates to 63% of the species collected and generates a new total of 72 species for the island.

Furthermore, 13 genera and two families (Gnaphosidae, Zoridae) were recorded for the first time. Based on the distribution maps in HARVEY *et al*. (2002), none of the new species records are remarkable finds, because they are all widely distributed throughout the UK. However, an increase of 50% in the known spider fauna for the island based on such a limited sampling effort demonstrates a paucity of arachnologi-

Fig. 1. UK mainland; arrow points to the Isle of Mull.

cal faunistic knowledge for this region. Additional sampling using a range of techniques will surely yield many more species and until this is undertaken this region of the UK must be considered poorly studied from an arachnological viewpoint.

Table 1. Complete list of spider species known from the Isle of Mull. * = new species record, ** = previously known species collected again in this study.

Segestriidae	*Erigonella hiemalis* (BLACKWALL, 1834)
Segestria senoculata (LINNAEUS, 1758)	**Evansia merens* O. P. - CAMBRIDGE, 1900
Theridiidae	***Gonatium rubens* (BLACKWALL, 1833)
Enoplognatha ovata (CLERCK, 1757)	**Gongylidiellum vivum* O. P. - CAMBRIDGE, 1875)
**Robertus lividus (BLACKWALL, 1836)	*Hilaira frigida* (THORELL, 1872)
Linyphiidae	*Hypomma cornutum* (BLACKWALL, 1833)
*Agyneta ramosa JACKSON, 1912	**Hypselistes jacksoni* (O. P. - CAMBRIDGE, 1902)
Centromerus prudens (O. P. - CAMBRIDGE, 1873)	**Micrargus herbigradus* (BLACKWALL, 1854)
*Ceratinella brevipes (WESTRING, 1851)	*Microlinyphia pusilla* (SUNDEVALL, 1830)
*Ceratinella brevis (WIDER, 1834)	**Monocephalus fuscipes* (BLACKWALL, 1836)
*Dicymbium nigrum (BLACKWALL, 1834)	*Oedothroax agrestis* (BLACKWALL, 1853)
*Dicymbium tibiale (BLACKWALL, 1836)	*Oedothorax gibbosus* (BLACKWALL, 1841)
Diplostyla concolor (WIDER, 1834)	*Oreonetides vaginatus* (BLACKWALL, 1872)
Erigone arctica (WHITE, 1852)	*Meioneta nigripes* (SIMON, 1884)

Table 1. Continued.

*Palliduphantes ericaeus (BLACKWALL, 1853)	**Lycosidae**
**Palliduphantes pallidus (O. P. - CAMBRIDGE, 1871)	*Alopecosa pulverulenta* (CLERCK, 1757)
*Peponocranium ludicrum (O. P. - CAMBRIDGE, 1861)	*Arctosa perita* (LATREILLE, 1799)
*Pocadicnemis pumila (BLACKWALL, 1841)	*Pardosa amentata* (CLERCK, 1757)
**Saaristoa abnormis (BLACKWALL, 1841)	*Pardosa monticola* (CLERCK, 1757)
Tapinopa longidens (WIDER, 1834)	**Pardosa nigriceps* (THORELL, 1856)
*Tenuiphantes alacris (BLACKWALL, 1853)	***Pardosa pullata* (CLERCK, 1757)
*Tenuiphantes cristatus (MENGE, 1866)	**Pirata hygrophilus* THORELL, 1872
**Tenuiphantes mengei (KULCZYŃSKI, 1887)	***Trochosa terricola* THORELL, 1856
**Tenuiphantes tenebricola (WIDER, 1834)	**Pisauridae**
**Tenuiphantes zimmermanni (BERTKAU, 1890)	*Pisaura mirabilis* (CLERCK, 1757)
*Walckenaeria cuspidata BLACKWALL, 1833	**Agelenidae**
Walckenaeria antica (WIDER, 1834)	*Textrix denticulata* (OLIVER, 1789)
**Walckenaeria acuminata BLACKWALL, 1833	**Hahnidae**
*Walckenaeria nudipalpis (WESTRING, 1851)	*Antistea elegans* (BLACKWALL, 1841)
*Walckenaeria unicornis O. P. - CAMBRIDGE, 1861	***Cryphoeca silvicola* (C. L. KOCH, 1834)
Tetragnathidae	**Amaurobiidae**
**Pachygnatha degeeri SUNDEVALL, 1830	*Amaurobius similis* (BLACKWALL, 1861)
**Pachygnatha clercki SUNDEVALL, 1823	**Zoridae**
Metellina mengei (BLACKWALL, 1869)	**Zora spinimana* (SUNDEVALL, 1833)
Metellina merianae (SCOPOLI, 1763)	**Philodromidae**
Metallina segmentata (CLERCK, 1757)	*Tibellus oblongus* (WALCKENAER, 1802)
Tetragnatha extensa (LINNAEUS, 1758)	**Thomisidae**
Zygiella x-notata (CLERCK, 1757)	***Ozyptila trux* (BLACKWALL, 1846)
Araneidae	*Xysticus cristatus* (CLERCK, 1757)
Araneus diadematus (CLERCK, 1757)	**Xysticus erraticus* (BLACKWALL, 1834)
Larinioides cornutus (CLERCK, 1757)	

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Нови данни за паяците (Araneae) от остров Мъл (Великобритания)

С. Бенет, Д. Пени

(Резюме)

Статията представя резултатите от проучване на аранеофауната на шотландския остров Мъл. Уловени са 38 вида паяци, от които семействата Gnaphosidae и Zoridae, тринадесет рода и следните 24 вида (повече от 60% от всички установени при изследването): *Clubiona compta* (Clubionidae); *Drassodes cupreus* (Gnaphosidae); *Pardosa nigriceps, Pirata hygrophilus* (Lycosidae); *Xysticus erraticus* (Thomisidae); *Agyneta ramosa, Ceratinella brevipes, C. brevis, Dicymbium nigrum, D. tibiale, Evansia merens, Gongylidiellum vivum, Hypselistes jacksoni, Micrargus herbigradus, Monocephalus fuscipes, Palliduphantes ericaeus, Peponocranium ludicrum, Pocadicnemis pumila, Tenuiphantes alacris, T. cristatus, Walckenaeria cuspidata, W. nudipalpis, W. unicornis* (Linyphiidae); *Zora spinimana* (Zoridae), са нови за острова. С настоящото изследване броят на обитаващите острова паяци достига 72 вида, което представлява увеличение от 50%. Тези данни показват, че аранеофауната на Мъл е все още слабо проучена и са необходими допълнителни изследвания в бъдеще.

New data on jumping spiders in the Republic of Macedonia with a complete checklist (Araneae: Salticidae)

Marjan Komnenov[1]

Abstract: The arachnological investigations carried out in the Republic of Macedonia in the last 10 years significantly increased the knowledge on the jumping spiders (Salticidae). New data on the distribution of 58 species are presented in the paper, among them 17 species and 3 genera are new for the country. The paper provides also a comprehensive checklist of all hitherto registered Salticidae in Macedonia comprising 81 species. Four species are deleted from the list, as the reason for this action is explained.

Key words: jumping spiders, new records, checklist, Republic of Macedonia

Introduction

The first data concerning jumping spiders of the Republic of Macedonia can be found in the works of STOJIĆEVIĆ (1907, 1929) and DOFLEIN (1921). This information was summarized later by DRENSKY (1936), who reported 45 species. Further data can be found in the papers of NIKOLIĆ, POLENEC (1981), ČURČIČ *et al.* (2000), DELTSHEV *et al.* (2000), BLAGOEV (2002), KOMNENOV (2002, 2003), LAZAROV (2004) and FISHER, AZARKINA (2005). The present study puts on record the new material collected in the country in the last 10 years and also provides a critical review of all available literature data.

Study area and materials

The material was collected by the author in the period 1995-2005 during research expeditions organised by the Biology Students Research Society. The following regions were visited: Shar Planina Mt., Bistra Mt., Jakupica Mt., Pelister Mt., Nidzhe Mt., Kozhuf Mt., Ograzhden Mt., as well as some other parts of the country. The spiders were collected in different biotopes by hand (under stones, bark and leaf litter), by pitfall traps and sweeping (meadow). The materials are preserved in the collection of the author. The taxonomic classification and distribution of the species follow PLATNICK (2006).

Results

The family Salticidae is represented in Macedonia by 81 species of 32 genera: *Aelurillus* - 6, *Afraflacilla* - 1, *Asianellus* - 1, *Ballus* - 1, *Bianor* - 1, *Carrhotus* - 1, *Chalcoscirtus* - 2, *Cyrba* - 1, *Dendryphantes* - 2, *Euophrys* - 3, *Evarcha* - 4, *Heliophanus* - 10, *Icius* - 1, *Leptorchestes* - 1, *Macaroeris* - 1, *Marpissa* - 2, *Mendoza* - 1, *Menemerus* - 1, *Mogrus* - 1, *Myrmarachne* - 1, *Neaetha* - 1, *Neon* - 2, *Pellenes* - 6, *Philaeus* - 1, *Phlegra* - 4, *Pseudeuophrys* - 2, *Pseudicius* - 2, *Saitis* - 2, *Salticus* - 5, *Sitticus* - 8, *Synageles* - 3, and *Talavera* - 3. Seventeen species, *Aelurillus* sp. 1, *Aelurillus* sp. 2, *A. m-nigrum*, *A. laniger*, *Chalcoscirtus nigritus*, *Euophrys herbigrada*, *E.*

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rufibarbis, *Heliophanus dubius*, *Icius subinermis*, *Menemerus semilimbatus*, *Mogrus neglectus*, *Pellenes brevis*, *Phlegra cinereofasciata*, *Saitis tauricus*, *Salticus propinquus*, *Sitticus distinguendus*, and *Talavera aequipes*, are new to the Macedonian fauna (marked in the check list with *) and two species (*Aelurillus laniger* and *Icius subinermis*) are new also to the Balkan Peninsula (marked in the check list with **).

The species *Euophrys gambosa* (SIMON, 1868), *Macaroeris flavicomis* (SIMON, 1884) and *Pseudicius espereyi* FAGE, 1921 are mentioned by NIKOLIĆ, POLENEC (1981) as species probably occurring in Macedonia, but their presence has still not been confirmed and therefore they are not included in the checklist. NIKOLIĆ, POLENEC (1981) and BLAGOEV (2002) cited *Talavera aequipes ludio* (SIMON, 1871), but the presence of this species in Macedonia is very doubtful and highly improbable. Its taxonomic status is uncertain as well and needing revision (Logunov pers. comm., Proszynski pers. comm.). On the territory of Macedonia only *Talavera aequipes* has been recorded for sure.

Compared with the number of jumping spiders recorded from the neighbouring countries, e.g. Greece - 139 species (BOSMANS, CHATZAKI 2005), Bulgaria - 82 species (DELTSHEV, BLAGOEV 2001) and Serbia - 49 species (DELTSHEV *et al.* 2003) the number of recorded species shows that jumping spiders in Macedonia are relatively well studied. Further investigations will undoubtedly increase their number in the country.

Checklist of the Salticidae registered in the Republic of Macedonia

**Aelurillus* sp. 1
New data: Skopje, Radishani, 1♂, 03.09.1995.
Distribution: Republic of Macedonia.
Note: It's very likely a new species (Azarkina, pers.comm.).

**Aelurillus* sp. 2
New data: Slandol, rocky site, 300 m alt., 2♂♂, 28.09.2002.
Distribution: Republic of Macedonia.
Note: It's very likely a new species (Azarkina, pers.comm.).

Aelurillus concolor KULCZYŃSKI, 1901
Literature data: FISHER, AZARKINA 2005.
Distribution: Central Asia, Iran, Republic of Macedonia.

***Aelurillus laniger* LOGUNOV, MARUSIK, 2000
New data: Skopje, Radishani, 1♂, 04.05.1996.
Distribution: Kazakhstan, Republic of Macedonia.

**Aelurillus m-nigrum* KULCZYŃSKI, 1891
New data: Katlanovo, 1♀, 23.05.1996.
Distribution: Palearctic.
Note: The record in Macedonia is among the westernmost ones (AZARKINA 2002).

Aelurillus v-insignitus (CLERCK, 1757)
Literature data: KOMNENOV, 2002, 2003, FISHER, AZARKINA 2005.
New data: Ograzhden Mt., along the Prevedenska Reka River, 800-1167 m alt., 1♂, 14.07.2000; Pelister Mt., track to Nizhepole, 1200-1500 m alt., 1♀, 13.07.2001; Skopje, Vodno Mt., 900 m alt., 1♂, 05.05.2002; Skopje, Vodno Mt., 900 m alt., 1♂, 29.10.2002; Plachkovica Mt., Lisec, 1764 m alt., 1♂, 08-20.05.2002; Skopje, Vodno Mt., 900 m alt., 2♂♂, 26.04.2003; Demir Kapija, from Stojkova Chuka to Samarot, 550 m alt., 1♂ 2♀♀, 21.05.2005.
Distribution: Palearctic.

Afraflacilla epiblemoides (Chyzer, 1891)

Literature data: Stojićević 1929, Drensky 1936, Nikolić, Polenec 1981, Blagoev 2002.

Distribution: Central and Eastern Europe.

Note: The presence of this species in Macedonia is yet to be confirmed.

Asianellus festivus (C. L. Koch, 1834)

Literature data: Stojićević 1929, Drensky 1936, Nikolić, Polenec 1981, Blagoev 2002.

New data: Katlanovo, 1♂, 02.06.2002.

Distribution: Palearctic.

Ballus chalybeius (Walckenaer, 1802)

Literature data: Stojićević 1929, Drensky 1936, Nikolić, Polenec 1981, Blagoev 2002.

New data: Demir Kapija, from village Dren to Prsti, *Quercus coccifera* shrubs, 250-350 m alt., 1♂, 21.05.2005.

Distribution: Europe, North Africa to Central Asia.

Carrhotus xanthogramma (Latreille, 1819)

Literature data: Stojićević 1929, Drensky 1929, 1936, Nikolić, Polenec 1981, Blagoev 2002.

New data: Dojran, Zafirka, *Quercus coccifera* shrubs, 1♂, 24.04.2005.

Distribution: Palearctic.

Chalcoscirtus infimus (Simon, 1868)

Literature data: Deltshev *et al.* 2000, Blagoev 2002.

New data: Bitola, inside military barracks Stiv Naumov, 1♀, 20-30.06.2000; Kajmakchalan Mt., exact locality unknown, 1♀, 07-22.07.2002; village Teovo, near the Babuna Reka River, 1♀, 17.05.2003.

Distribution: Southern, Central Europe to Central Asia.

Chalcoscirtus nigritus (Thorell, 1875)

New data: Bitola, inside military barracks Stiv Naumov, 1♂, 20-30.06.2000.

Distribution: Palearctic.

Cyrba algerina (Lucas, 1846)

Literature data: Stojićević 1929, Drensky 1936, Nikolić, Polenec 1981, Blagoev 2002.

New data: Slandol, 300 m alt., 4♂♂ 14♀♀juv., 28.09.2002; Demir Kapija, from village Dren to Prsti, *Quercus coccifera* shrubs, 250-350 m alt., 1♂, 21.05.2005; Slandol, above village Ulanci, 1♀, 05.07.2005.

Distribution: From Canary Islands to Central Asia.

Dendryphantes hastatus (Clerck, 1757)

Literature data: Nikolić, Polenec 1981, Blagoev 2002.

Distribution: Palearctic.

Note: The presence of this species in Macedonia is yet to be confirmed.

Dendryphantes rudis (Sundevall, 1833)

Literature data: Stojićević 1929, Drensky 1936, Blagoev 2002.

New data: Pelister Mt., ski track near Kopanki hut, on tree branches, 2♂♂ 1♀, 20.07.2001; Pelister Mt., near Kopanki hut, meadow, 1♀, 07.07.2001.

Distribution: Palearctic.

Euophrys frontalis (Walckenaer, 1802)

Literature data: Stojićević 1929, Drensky 1936, Blagoev 2002, Komnenov 2002, 2003, Lazarov 2004.

New data: Ograzhden Mt., near Ograzhden Peak, 1170 m alt., 1♀, 13.07.2000; Bitola,

below Tumbe Kafe, 1♂ 1♀, 04.06.2000; Bitola, inside military barracks Stiv Naumov, 5♂♂, 29-31.05.2000; Skopje, village Kadino, in garden, 1♂, 25.05.2001; Skopje, Vodno Mt., 1♀, 02.06.2001; Kozhuf Mt., exact locality unknown, beech forest, 1000-1200 m alt., 1♀, 09-27.07.2004.

Distribution: Palearctic.

Euophrys herbigrada (Simon, 1871)

New data: Slandol, above village Ulanci, 1♀, 16.03.2002; Skopje, Vodno Mt., 600-900 m alt., 2♀♀, 26.04.2003; village Marvinci, Isarot, hill pasture in *Quercus coccifera* shrubs, 120 m alt., 1♀, 24.04.2005; Dojran, spring area of the Toplec River, 170 m alt., 1♀, 24.04.2005; village Mlado Nagorichane, 2♀♀, 29.04.2005.

Distribution: Europe.

Notes: The material was provisionally identified as *E. herbigrada.* Males are required to confirm the presence of the species in Macedonia.

Euophrys rufibarbis (Simon, 1868)

New data: Bitola, below Tumbe Kafe, 2♀♀, 04.06.2000; Karadzica Mt., Orlov Kamen, near the Patishka Reka River, 1♀, 19.03.2005.

Distribution: Palearctic.

Notes: Having at disposal only females, the true species identity remains uncertain. Males are required to confirm the present identification.

Evarcha arcuata (Clerck, 1757)

Literature data: Drensky 1929, 1936, Nikolić, Polenec 1981, Blagoev 2002, Lazarov 2004.

New data: Shar Planina Mt., Ljuboten hut, near road, 1300-1400 m alt., 2♀♀, 08.07.1999; Bitola, below Tumbe Kafe, 1♀, 04.06.2000; Ograzhden Mt., children's resort Suvi Laki, near the Suvolachka Reka River, 1000-1100 m alt., 1♀, 11.07.2000; Ograzhden Mt., along the Prevedenska Reka River 800-1167 m alt., 1♂, 14.07.2000; Pelister Mt., below Hotel Molika, 1200-1400 m alt., 1♀ 12.07.2001; Gevgelija, Negorski Banji spa, wetland, 1♂ 3♀♀, 09.04.2005.

Distribution: Palearctic.

Evarcha falcata (Clerck, 1757)

Literature data: Drensky, 1929, 1936, Nikolić, Polenec 1981, Blagoev 2002, Komnenov 2002, 2003, Lazarov 2004.

New data: Katlanovo, 2♂♂ 1♀, 23.05.1996; Jakupica Mt., Gorno Kjule, beech forest, 1500-1800 m alt., 1♂, 13.07.1999; Kitka Mt., from village Dolno Kolichani to Kitka hut, 600-1350 m alt., 1♀, 30.05.1999; Kitka Mt., from village Dolno Kolichani to Kitka hut, 600-1350 m alt., 2♀♀ 11.05.2002; village Gabrovnik, Oraov Dol, 1♂, 19.06.2002; Kajmakchalan Mt., exact locality unknown, 2♀♀, 07-22.07.2002; Kajmakchalan Mt., from Redir hut to the military barracks, 1600-1800 m alt., 1♂, 07.2002; village Miravci, 1♂, 22.05.2005.

Distribution: Palearctic.

Evarcha jucunda (Lucas, 1846)

Literature data: Fisher, Azarkina 2005.

New data: Katlanovo, 2♂♂, 23.05.1996; Krivolak, inside military training polygon Krivolak, near the Vardar River, 1♂, 05.06.2000; Kozhuf Mt., near the Dlaboka Reka River, 1♀, 09-27.07.2004; village Karabunishta, near St. Ilija Monastery, 450 m alt., 1♂, 30.08.2003.

Distribution: Mediterranean, introduced in Belgium.

Evarcha laetabunda (C. L. Koch, 1846)

Literature data: Drensky 1929, 1936, Nikolić, Polenec 1981, Blagoev 2002, Komnenov 2003.

New data: Bitola, inside military barracks Stiv Naumov, 1♂, 01.06.2000; Plachkovica Mt., Lisec, 1764 m alt., 1♂, 08-20.05.2002.

Distribution: Palearctic.

Heliophanus aeneus (Hahn, 1832)

Literature data: Drensky 1929, 1936, Stojićević 1929, Baum 1930, Nikolić, Polenec 1981, Blagoev 2002.

Distribution: Palearctic.

Note: The presence of this species in Macedonia is yet to be confirmed.

Heliophanus auratus C. L. Koch, 1835

Literature data: Stojićević 1929, Drensky 1936, Nikolić, Polenec 1981, Deltshev *et al.* 2000, Blagoev 2002, Komnenov 2002.

New data: Kitka Mt., from village Dolno Kolichani to Kitka hut, 600-1350 m alt., 1♀, 30.05.1999; Jakupica Mt., near the Chepleska River to village Nezhilovo, 750-900 m alt., 7♀♀, 18.07.1999; Krivolak, inside military training polygon Krivolak, near the Vardar River, 1♀, 06.06.2000; Krivolak, inside military training polygon Krivolak, near the Vardar River, 1♀, 07.06.2000; Ograzhden Mt., near the Bezgashtevska Reka River, 700-1000 m alt., 3♀♀, 14.07.2000; Pelister Mt., above Neolica hut, meadow, 1500-1700 m alt., 1♀, 19.08.2000; Pelister Mt., village Lavci, near the Lavska Reka River, 800-900 m alt., 1♂, 26.08.2000; Pelister Mt., village Nizhepole, 1000 m alt., 1♀, 13.07.2001; Pelister Mt., near the Rotinska Reka River, 3♀♀ 09.08.2001; village Teovo, near the Babuna Reka River, 2♂♂ 1♀, 17.05.2003; Deshat Mt., from military barracks Bitushe to Velivrv Peak, 1149-1500 m alt., 2♀♀, 20.07.2003.

Distribution: Palearctic.

Heliophanus cupreus (Walckenaer, 1802)

Literature data: Stojićević 1907, 1929, Drensky 1929, 1936, Nikolić, Polenec 1981, Blagoev 2002, Komnenov 2002, 2003.

New data: Shar Planina Mt., Ljuboten hut, near road, 1300-1400 m alt., 1♀, 08.07.1997; Kitka Mt., from village Dolno Kolichani to Kitka hut, 600-1350 m alt., 1♂, 30.05.1999; Jakupica Mt., above Cheples hut, meadow with fern, 1450-1500 m alt., 2♀♀, 11.07.1999; Bitola, inside military barracks Stiv Naumov, 1♂, 29-31.05.2000; Pelister Mt., Hotel Molika, 1200-1400 m alt., 1♂, 12.07.2001; Kitka Mt., from village Dolno Kolichani to Kitka hut, 600-1350 m alt., 1♂ 1♀, 11.05.2002; Plachkovica Mt., Lisec, 1764 m alt., 3♂♂, 17.05.2002; village Gabrovnik, Oraov Dol, 1♂, 19.06.2002; Veles, Dolgi Rid, 2♂♂, 19.06.2002; Kajmakchalan Mt., Chemerika, meadow in Scots pine forest, 1♂, 16.07.2002; Kajmakchalan Mt., village Budimirci, near the Trnovchica Reka River 750 m alt., 1♂, 21.07.2002; Bushava Mt., Krushevo, near reservoir, 1400 m alt., 1♂, 02.05.2005; Demir Kapija, from Stojkova Chuka to Samarot, meadow in oak forest, 550 m alt., 1♂ 1♀, 21.05.2005; village Miravci, 2♂♂, 22.05.2005.

Distribution: Palearctic.

*Heliophanus dubius C. L. Koch, 1835

New data: Kajmakchalan Mt., above Redir hut, Scots pine forest, 1♀, 19.07.2002.

Distribution: Palearctic.

Heliophanus flavipes (Hahn, 1832)

Literature data: Stojićević 1907, 1929, Drensky 1929, 1936, Blagoev 2002, Komnenov 2003.

New data: Bitola, inside military barracks Stiv Naumov, 1♀, 20-30.06.2000; Jablanica Mt., Krivi Virovi, high-mountain pasture, 1700-1800 m alt., 1♀, 08.06.2003.

Distribution: Palearctic.

Heliophanus kochii Simon, 1868

Literature data: Stojićević 1929, Drensky 1936, Nikolić, Polenec 1981, Blagoev 2002.

New data: Bitola, inside military barracks Stiv Naumov, 1♂, 29-31.05.2000; Bitola, inside military barracks Stiv Naumov, 1♂, 20-30.06.2000; Skopje, Stenkovec, quarry, 500 m alt., 1♂, 20.10.2002; village Teovo, near the Babuna Reka River, 2♂♂ 1♀, 17.05.2003.

Distribution: Palearctic.

Heliophanus lineiventris Simon, 1868

Literature data: Komnenov 2002, 2003.

New data: Jakupica Mt., Gorno Kjule, high mountain pasture, 2000 m alt., 3♀♀, 11.07.1999; Skopje, Kuchevishka Bara, 1♂, 28.07.1999; Krivolak, inside military training polygon Krivolak, near the Vardar River, 1♀, 07.06.2000; Kitka Mt., from village Dolno Kolichani to Kitka hut, 600-1350 m alt., 1♀, 11.05.2002; Kajmakchalan Mt., Belo Grotlo, pine forest, 1750 m alt., 1♀, 17.07.2002; Kajmakchalan Mt., high-mountain pasture, 2000-2200 m alt., 1♂, 07.2002; village Teovo, near the Babuna Reka River, 1♂, 17.05.2003; Korab Mt., high mountain pasture, 2200 m alt., 2♂♂, 07.09.2003.

Distribution: Palearctic.

Heliophanus melinus L. Koch, 1867

Literature data: Stojićević 1929, Drensky 1936, Nikolić, Polenec 1981, Blagoev 2002, Komnenov 2003.

New data: Skopje, Radishani, 1♀, 04.05.1996; Katlanovo, 1♀, 23.05.1996; Skopje, Kisela Voda, 4♂♂ 1♀, 18.05.1999; Jakupica Mt., beech forest, 1500-1800 m alt. 1♂, 11.07.1999; Jakupica Mt., snow patches, high-mountain pasture, 2100 m alt., 1♀, 13.07.1999; Bitola, Titov Rid, 744 m alt., 2♂♂, 06-10.05.2000; Bitola, inside military barracks Stiv Naumov, 2♂♂, 29-31.05.2000; Bitola, below Tumbe Kafe, 1♀, 04.06.2000; Bitola, inside military barracks Stiv Naumov, 1♀, 20-30.06.2000; Veles, near the Babuna Reka River, 2♀♀, 27.05.2001; Katlanovo, 1♂, 02.06.2002; village Teovo, near the Babuna Reka River, 1♂, 17.05.2003; Kozhuf Mt., exact locality unknown, 1♂, 09-27.07.2004; Dojran, spring of the Toplec River, 170 m alt., 2♂♂, 24.04.2005; village Mlado Nagorichane, 9♂♂, 29.04.2005; Demir Kapija, from village Dren to Prsti, *Quercus coccifera* shrubs, 250-350 m alt., 11♂♂ 6♀♀, 21.05.2005; Demir Kapija, from Stojkova Chuka to Samarot, meadows in oak forest, 550 m alt., 2♂♂, 21.05.2005.

Distribution: Palearctic.

Heliophanus simplex Simon, 1868

Literature data: Stojićević 1929, Drensky 1936, Nikolić, Polenec 1981, Blagoev 2002.
Distribution: Palearctic.
Note: The presence of this species in Macedonia is yet to be confirmed

Heliophanus tribulosus Simon, 1868

Literature data: Stojićević 1929, Drensky 1936, Nikolić, Polenec 1981, Blagoev 2002.
New data: Village Marvinci, Isarot, hill pasture in *Quercus coccifera* shrubland, 120 m alt., 1♂, 24.04.2005.
Distribution: Europe to Kazakhstan.

**Icius subinermis* (Simon, 1937)

New data: Skopje, Ostrovo, found dead in apartment, 1♂, 02.02.2002.
Distribution: Western Mediterranean, Germany, Republic of Macedonia.

Leptorchestes berolinensis (C. L. Koch, 1846)

Literature data: Stojićević 1929, Drensky 1936, Blagoev 2002.
New data: Skopje, Vodno Mt., 1♀, 12.08.1995; Bitola, inside military barracks Stiv Naumov, 1♀, 20-30.06.2000.
Distribution: Europe to Turkmenistan.

Macaroeris nidicolens (Walckenaer, 1802)

Literature data: Doflein 1921, Stojićević 1929, Drensky 1929, 1936, Baum 1930, Blagoev 2002.

New data: Katlanovo, 1♂, 23.05.1996; Bitola, inside military barracks Stiv Naumov, 1♂, 14-26.05.2000; Bitola, inside military barracks Stiv Naumov, 1♂, 29-31.05.2000; Krivolak,

inside military training polygon Krivolak, near the Vardar River, 1♂, 05.06.2000; Bitola, inside military barracks Stiv Naumov, 6♀♀, 20-30.06.2000; Pelister Mt., Caparska Preseka, meadow, 1500 m alt., 1♀, 09.07.2001; Pelister Mt., near Kopanki hut, meadow, 1♀, 07.07.2001; village Gabrovnik, Oraov Dol, 1♂, 19.06.2002; Skopje, Vodno Mt.. 1♂, 07.07.2002; Skopje, inside building of the Institute of Agriculture, 5♂♂ 40♀♀, 08.06.2005; Slandol, above village Ulanci, 1♂, 05.07.2005.

Distribution: Europe to Central Asia.

Marpissa muscosa (Clerck, 1757)
Literature data: Drensky 1929, 1936, Stojićević 1929, Nikolić, Polenec 1981, Blagoev 2002, Lazarov 2004.

New data: Pelister Mt., village Lavci, near the Lavska Reka River, 800-900 m alt., 1♂ 1♀, 26.08.2000; Skopje, Vodno Mt., 1♂, 01.06.2002.

Distribution: Palearctic.

Marpissa nivoyi (Lucas, 1846)
Literature data: Doflein 1921, Blagoev 2002.

New data: Katlanovo, wetland, 1♀, 30.05.2002; Katlanovo, wetland, 5♀♀, 05.07.2005.

Distribution: Palearctic.

Mendoza canestrinii (Ninni, 1868)
Literature data: Doflein 1921, Drensky 1929, 1936, Stojićević 1929, Nikolić, Polenec 1981, Blagoev 2002.

Distribution: Palearctic.

Note: The presence of this species in Macedonia is yet to be confirmed.

**Menemerus semilimbatus* (Hahn, 1829)
New data: Skopje, Vlae, 1♂1♀, 07.08.1995; Katlanovo, 1♀, 02.05.1996; Vodno Mt., Pripor, 1♂, 11.08.2001; Gevgelija, Bogdanci, 1♂ 1♀ juv., 01.06.2005.

Distribution: Canary Islands to Azerbaijan; Argentina.

**Mogrus neglectus* (Simon, 1868)
New data: Krivolak, inside military training polygon Krivolak, near the Vardar River, 1♀, 07.06.2000; Slandol, above village Ulanci, 1♂, 16.03.2002; Slandol, above village Ulanci, 2♀♀, 23.06.2002; Slandol, above village Ulanci, 5♀♀, 05.07.2005.

Distribution: Greece, Republic of Macedonia, Turkey, Israel, and Azerbaijan.

Note: The new localities in Macedonia form the northernmost border of species' distribution.

Myrmarachne formicaria (De Geer, 1778)
Literature data: Stojićević 1929, Drensky 1936, Blagoev 2002.

New data: Krivolak, inside military training polygon Krivolak, near the Vardar River, 1♂, 05.06.2000; Skopje, village Kadino, in garden, 1♂, 01.10.2000; Gevgelija, Nergorski Banji spa, wetland, 1♂, 09.04.2005.

Distribution: Palearctic.

Neaetha absheronica Logunov, Guseinov, 2001
Literature data: Fisher, Azarkina 2005.

New data: Probishtip, 1♂, 10.06.1996.

Distribution: Azerbaijan and Republic of Macedonia.

Notes: According to Logunov, Guseinov (2002) the areal of *N. absheronica* reaches the Balkan Peninsula in the west. Therefore, all records of *N. membrosa* in the region should in fact be referred to this species.

Neon levis (SIMON, 1871)

Literature data: Ćurčić *et al.* 2000, BLAGOEV 2002.

Distribution: Palearctic.

Neon reticulatus (BLACKWALL, 1853)

Literature data: LAZAROV 2004.

New data: Ograzhden Mt., children's resort Suvi Laki, 1000 m alt., 1♀, 15.07.2000; Skopje, Stenkovec, quarry, 500 m alt., 1♀, 20.10.2002.

Distribution: Holarctic.

*Pellenes brevis SIMON, 1868

New data: Village Mlado Nagorichane, 2♂♂, 29.04.2005.

Distribution: Spain, France, Germany, Greece (incl. Rhodos Island), and Republic of Macedonia.

Pellenes diagonalis (SIMON, 1868)

Literature data: FISHER, AZARKINA 2005.

New data: Slandol, above village Ulanci, 1♂, 16.03.2002.

Distribution: Greece (incl. Corfu Island), Republic of Macedonia, Turkey, and Israel.

Pellenes geniculatus (SIMON, 1868)

Literature data: FISHER, AZARKINA 2005.

Distribution: Southern Palearctic, Tanzania, introduced in Belgium.

Pellenes nigrociliatus (SIMON, 1875)

Literature data: STOJIĆEVIĆ 1907, 1929, DRENSKY 1929, 1936, NIKOLIĆ, POLENEC 1981, BLA-GOEV 2002, KOMNENOV 2003.

New data: Katlanovo, 1♀, 23.05.1996; Skopje, Zajchev Rid, meadow, 1♀, 26.05.1999; Slandol, above village Ulanci, 1♂, 16.03.2002; Skopje, exact locality unknown, 1♀, 06.2002; village Teovo, near the Babuna Reka River, 1♂, 17.05.2003.

Distribution: Palearctic.

Pellenes seriatus (THORELL, 1875)

Literature data: KOMNENOV 2002, LAZAROV 2004.

New data: Shar Planina Mt., near Jelak hut, meadow, 1♀, 07-23.07.1995; Katlanovo, 2♂♂, 02.05.1996; Bitola, Titov Rid, 744 m alt., 2♂♂, 06-10.05.2000; Skopje, village Petrovec, canal, 1♂ 1♀, 30.05.2002; Kajmakchalan Mt., Chemerika, meadow in Scots pine forest, 1♀, 16.07.2002; Kajmakchalan Mt., above Redir hut, Scots pine forest, 1♀, 19.07.2002; Kajmakchalan Mt., from Redir hut to military barracks, 1600-1800 m alt., 1♂, 07.2002; village Teovo, near the Babuna Reka River 1♂, 17.05.2003; Kozhuf Mt., Chichi Kjaja, beech forest, 1400-1650 m alt., 1♀, 09-27.07.2004; village Miravci, 1♂, 22.05.2005.

Distribution: Greece, Bulgaria, Republic of Macedonia, Russia, Central Asia.

Pellenes tripunctatus (WALCKENAER, 1802)

Literature data: DELTSHEV *et al.* 2000, BLAGOEV 2002.

Distribution: Palearctic.

Philaeus chrysops (PODA, 1761)

Literature data: STOJIĆEVIĆ 1907, 1929, DRENSKY 1929, 1935, 1936, NIKOLIĆ, POLENEC 1981; DELTSHEV *et al.* 2000, BLAGOEV 2002, KOMNENOV 2002, 2003, LAZAROV 2004.

New data: Katlanovo, 2♂♂ 4♀♀, 23.05.1996; Skopje, Radishani, 1♂, 30.04.2000; Bitola, Titov Rid, 744 m alt., 2♂♂ 1♀, 06-10.05.2000; Bitola, inside military barracks Stiv Naumov, 1♂, 20-30.06.2000; Veles, near the Babuna Reka River, 1♂ 1♀, 27.05.2001; Skopje, Vodno Mt.,

900 m alt., 1♂ 2♀♀, 02.06.2001; Pelister Mt., Jorgov Kamen-Nizhepole, 1200-1500 m alt., 1♂, 13.07.2001; Pelister Mt., Orlovi Bari-Muza, high mountain pasture, 1♂ 1♀, 18.07.2001; Kitka Mt., from village Dolno Kolichani to Kitka hut, 600-1350 m alt., 1♀, 11.05.2002; Katlanovo, 2♂♂ 1♀, 02.06.2002; Kajmakchalan Mt., near Redir hut, 2♂♂, 08-22.07.2002; village Teovo, near the Babuna Reka River, 2♀♀, 17.05.2003; Bistra Mt., Medenica, 2♂♂ 2♀♀, 06.06.2003; Jablanica Mt., Krivi Virovi, high mountain pasture, 1♀, 08.06.2003; Bistra, Tonivoda, 1♀, 13.07.2003; Deshat Mt., near Lake Lokuv, 1550 m alt., 1♀, 20.07.2003; Kozhuf Mt., Alcak, meadow, 1500-1700 m alt., 1♂, 09-27.07.2004; village Mlado Nagorichane, 1♀ 1♂ juv., 29.04.2005; Demir Kapija, from Stojkova Chuka to Samarot, meadows in oak forest, 550 m alt., 1♂ 1♀, 21.05.2005.

Distribution: Palearctic.

Phlegra bresnieri (Lucas, 1846)

Literature data: Stojićević 1929, Drensky 1936, Nikolić, Polenec 1981, Blagoev 2002.

Distribution: Southern Europe to Azerbaijan; Tanzania.

Note: The presence of this species in Macedonia is yet to be confirmed.

**Phlegra cinereofasciata* Simon, 1868

New data: Veles, near the Babuna Reka River, 1♂, 27.05.2001; Katlanovo, village Kozhle - village Blace, 1♀, 24.02.2002; Slandol, above village Ulanci, 1♀, 16.03.2002; Skopje, Vodno Mt., 600-900 m alt., 1♂, 26.04.2003; Slandol, above village Ulanci, 1♀, 05.07.2005.

Distribution: France to Central Asia.

Phlegra fasciata (Hahn, 1826)

Literature data: Stojićević 1907, 1929, Drensky 1929, 1936, Nikolić, Polenec 1981, Blagoev 2002, Komnenov 2003.

New data: Katlanovo, 1♂, 1♀, 02.05.1996; Skopje, Radishani, 1♀, 04.05.1996; Skopje, Zajcev Rid, meadow, 1♂, 26.05.1999; Jakupica Mt., snow patches, high-mountain pasture, 2100 m alt., 1♀, 13.07.1999; Bitola, Titov Rid, 744 m alt., 1♀, 06-10.05.2000; Prilep, Markovi Kuli, meadow, 1♂, 16-18.05.2000; Bitola, inside military barracks Stiv Naumov, 1♀, 20-30.06.2000; Pelister Mt., near Lake Malo Ezero, high mountain pasture, 2100 m alt., 1♀, 16.07.2001; village Gabrovnik, Oraov Dol, 1♂, 19.06.2002; village Teovo, near the Babuna Reka River, 1♂ 1♀,17.05.2003; Gevgelija, Negorski Banji spa, wetland, 1♂, 09.04.2005; Demir Kapija, from Stojkova Chuka to Samarot, 550 m alt., 1♂, 21.05.2005; village Miravci, 1♂ 1♀, 22.05.2005; Dojran, Zafirka, *Quercus coccifera* shurbs, 1♀, 24.04.2005; Dojran, spring of the Toplec River, 170 m alt., 1♂ 1♀, 24.04.2005; village Mlado Nagorichane, 1♀, 29.04.2005; village Karabunishta, near St. Ilija Monastery, 450 m alt., 1♀, 30.08.2003.

Distribution: Palearctic.

Phlegra lineata (C. L. Koch, 1846)

Literature data: Nikolić, Polenec 1981, Blagoev 2002.

Distribution: Southern Europe, Syria.

Note: The presence of this species in Macedonia is yet to be confirmed.

Pseudeuophrys erratica (Walckenaer, 1826)

Literature data: Stojićević 1929, Drensky 1936, Blagoev 2002, Komnenov 2003, Lazarov 2004.

New data: Jakupica Mt., beech forest, 1500-1800 m alt. 1♂, 11.07.1999; Kitka Mt., from village Dolno Kolichani to Kitka hut, 600-1350 m alt., 1♂, 11.05.2002; Kajmakchalan Mt., from Redir hut to military barracks, 1600-1800 m alt., 2♂♂, 07.2002.

Distribution: Palearctic (introduced in USA).

Pseudeuophrys obsoleta (Simon, 1868)

Literature data: Komnenov 2003; Fisher, Azarkina 2005.

New data: Kitka Mt., from village Dolno Kolichani to Kitka hut, 600-1350 m alt., 1♀, 30.05.1999; Jakupica Mt., beech forest, 1500-1800 m alt. 1♂, 11.07.1999; Bitola, inside military barracks Stiv Naumov, 1♂, 29-31.05.2000; Bitola, below Tumbe Kafe, 1♂, 04.06.2000; Bitola, inside military barracks Stiv Naumov, 1♀, 20-30.06.2000; Skopje, village Kadino, garden, 1♂, 25.05.2001; Veles, near the Babuna Reka River, 2♀♀, 27.05.2001; Skopje, Vodno Mt., 900 m alt., 1♂ 1♀, 02.06.2001; Pelister Mt., Orlovi Bari-Muza, high mountain pasture, 220-2350 m alt., 2♀♀, 18.07.2001; Prespa, Ezerani, 1♂, 20.04.2002; Kitka Mt., from village Dolno Kolichani to Kitka hut, 600-1350 m alt., 2♂♂, 11.05.2002; Skopje, Vodno Mt., 900 m alt., 1♀, 26.04.2003; village Teovo, near the Babuna Reka River, 1♀, 17.05.2003; Gevgelija, Negorski Banji spa, wetland, 1♂, 09.04.2005; village Marvinci, Isarot, hill pasture in *Quercus coccifera* shrubs, 120 m alt., 1♂, 24.04.2005; Demir Kapija, from village Dren to Prsti, *Quercus coccifera* shrubs, 250-350 m alt., 1♀, 21.05.2005.

Distribution: Palearctic.

Pseudicius encarpatus (Walckenaer, 1802)

Literature data: Stojićević 1929, Drensky 1936, Nikolić, Polenec 1981, Blagoev 2002.
Distribution: Europe to Kazakhstan.
Note: The presence of this species in Macedonia is yet to be confirmed.

Pseudicius picaceus (Simon, 1868)

Literature data: Fisher, Azarkina 2005.
New data: Katlanovo, 1♂, 23.05.1996; Veles, near the Babuna Reka River, 1♂, 27.05.2001; Skopje, inside building of the Institute of Agriculture, 08.06.2005.
Distribution: Mediterranean.

Saitis barbipes (Simon, 1868)

Literature data: Stojićević 1929, Drensky 1936, Nikolić, Polenec 1981, Blagoev 2002.
Distribution: Mediterranean, Central Europe (introduced?).
Notes: This species has been reported in the country only once, from Skopje (cf. Stojićević 1929) and this record was not confirmed by modern authors. It is very likely due to a misidentification of *S. tauricus*, which is a common species in Macedonia (see below).

**Saitis tauricus* Kulczyński, 1905

New data: Skopje, Ostrovo, 1♀, 11.11.2002; Gevgelija, garden, 2♂♂, 1♀, 06.2003; Skopje, inside building of the Institute of Agriculture, 1♀, 01.07.2005.
Distribution: Bulgaria, Greece, Republic of Macedonia, Turkey, Ukraine.

Salticus cingulatus (Panzer, 1797)

Literature data: Stojićević 1907, 1929, Drensky 1929, 1936, Nikolić, Polenec 1981, Blagoev 2002.
Distribution: Palearctic.
Note: The presence of this species in Macedonia is yet to be confirmed.

Salticus mutabilis Lucas, 1846

Literature data: Nikolić, Polenec 1981, Blagoev 2002.
Distribution: Europe, the Azores, Georgia, Argentina.
Note: The presence of this species in Macedonia is yet to be confirmed.

**Salticus propinquus* Lucas, 1846

New data: Dojran, Zafirka, *Quercus coccifera* shrubs, 1♂, 24.04.2005.
Distribution: Mediterranean.
Note: On the Balkan Peninsula this Mediterranean species is known only from Greece and Macedonia.

Salticus scenicus (Clerck, 1757)

Literature data: Drensky 1929, 1936, Stojićević 1929, Nikolić, Polenec 1981, Blagoev 2002, Komnenov 2002.

New data: Shar Planina Mt., near Jelak hut, meadow, 1♀, 07-23.07.1995.

Distribution: Holarctic.

Salticus zebraneus (C. L. Koch, 1837)

Literature data: Stojićević 1929, Drensky 1936, Nikolić, Polenec 1981, Blagoev 2002, Komnenov 2002, Lazarov 2004.

New data: Krivolak, inside military training polygon Krivolak, near the Vardar River, 1♀, 07.06.2000; Skopje, village Kadino, garden, 1♂, 25.05.2001; Ohrid, docks, 1♂, 15.06.2002; Skopje, inside building of the Institute of Agriculture, 4♀♀, 08.06.2005.

Distribution: Palearctic.

Sibianor aurocinctus (Ohlert, 1865)

Literature data: Stojićević 1929, Drensky 1936, Nikolić, Polenec 1981, Blagoev 2002.

Distribution: Palearctic.

Note: The presence of this species in Macedonia is yet to be confirmed.

Sitticus atricapillus (Simon, 1882)

Literature data: Stojićević 1929, Drensky 1936, Nikolić, Polenec 1981, Blagoev 2002, Komnenov 2002, 2003, Kronenstedt, Logunov 2003.

New data: Pelister Mt., Kunina Stena, 1900 m alt., 2♂♂, 10.07.2000; Pelister Mt., from Virovi to Pelister Peak, 2200-2601 m alt., 2♂♂ 2♀♀, 10.07.2001; Pelister Mt., Pelister Peak, 2601 m alt., 1♀, 10.07.2001; Pelister Mt., Shiroka, high mountain pasture, 1♂, 16.07.2001; Pelister Mt., from Lake Golemo Ezero to Lake Malo Ezero, high mountain pasture, 1♂, 17.07.2001; Pelister Mt., Orlovi Bari-Muza, 1♂, 18.07.2001; Bistra Mt., Medenica, 1♂, 06.06.2003; Bistra, Tonivoda, 2♂♂ 1♀, 13.07.2003; Deshat Mt., Velivrv Peak, 2350 m alt., 1♂ 2♀♀, 20.07.2003; Kozhuf Mt., Dlabok Dol, 1♀, 09-27.07.2004.

Distribution: Europe.

Note: Re-examination of all specimens from Macedonia previously identified as *S. zimmermanni* showed that they belong to *S. atricapillus* (cf. Kronestedt, Logunov 2003).

Sitticus caricis (Westring, 1861)

Literature data: Stojićević 1929, Drensky 1936, Nikolić, Polenec 1981, Blagoev 2002.

Distribution: Palearctic.

Note: The presence of this species in Macedonia is yet to be confirmed.

**Sitticus distinguendus* (Simon, 1868)

New data: Skopje, near the Lepenec River, sandy soil, 1♂, 03.09.2002.

Distribution: Palearctic.

Sitticus dzieduszyckii (L. Koch, 1870)

Literature data: Stojićević 1907, 1929, Drensky 1929, 1936, Nikolić, Polenec 1981, Blagoev 2002.

Distribution: Europe.

Note: The presence of this species in Macedonia is yet to be confirmed.

Sitticus floricola (C. L. Koch, 1837)

Literature data: Stojićević 1907, Drensky 1929, 1936, Nikolić, Polenec 1981, Blagoev 2002.

New data: Deshat Mt., near Lake Lokuv, 1550 m alt., 1♂, 20.07.2003.

Distribution: Palearctic.

Sitticus penicillatus (Simon, 1875)

Literature data: Stojićević 1929, Drensky 1936, Nikolić, Polenec 1981, Blagoev 2002.
New data: Katlanovo, 1♀, 02.05.1996; Bitola, inside military barracks Stiv Naumov, 1♀, 14-26.05.2000; village Crnichani, Odzheva Cheshma, 160 m alt., 2♂♂, 24.04.2005.
Distribution: Palearctic.

Sitticus pubescens (Fabricius, 1775)

Literature data: Stojićević 1907, 1929, Drensky 1929, 1936, Nikolić, Polenec 1981, Blagoev 2002.
New data: Bitola, inside military barracks Stiv Naumov, 1♂, 29-31.05.2000; Plachkovica Mt., Lisec, 1764 m alt., 2♂♂, 08-20.05.2002; Deshat Mt., from military barracks Bitushe to Velivrv Peak, 1149-1500 m alt., 1♀, 20.07.2003 Bushava Mt., Krushevo, near reservoir, 1400 m alt., 1♂, 01.08.2004.
Distribution: Europe, USA.

Sitticus saltator (O. P.-Cambridge, 1868)

Literature data: Stojićević 1929, Drensky 1936, Nikolić, Polenec 1981, Blagoev 2002.
Distribution: Palearctic.
Note: The presence of this species in Macedonia is yet to be confirmed.

Synageles dalmaticus (Keyserling, 1863)

Literature data: Drensky 1935, 1936, Nikolić, Polenec 1981, Blagoev 2002.
New data: Village Miravci, 1♂, 22.05.2005.
Distribution: Mediterranean.

Synageles hilarulus (C. L. Koch, 1846)

Literature data: Stojićević 1929, Drensky 1936, Blagoev 2002.
Distribution: Palearctic.
Note: The presence of this species in Macedonia is yet to be confirmed.

Synageles venator (Lucas, 1836)

Literature data: Drensky 1924, 1929, 1936, Nikolić, Polenec 1981, Blagoev 2002.
Distribution: Palearctic, Canada.
Note: The presence of this species in Macedonia is yet to be confirmed.

**Talavera aequipes* (O. P.-Cambridge, 1871)

New data: Village Crnichani, Odzheva Cheshma, 160 m alt., 1♂, 24.04.2005.
Distribution: Palearctic.

Talavera monticola (Kulczyński, 1884)

Literature data: Ćurčić *et al*. 2000, Blagoev 2002.
Distribution: Central and Southern Europe.

Talavera petrensis (C. L. Koch, 1837)

Literature data: Stojićević 1929, Drensky 1936, Nikolić, Polenec 1981, Blagoev 2002.
Distribution: Europe to Central Asia.
Note: The presence of this species in Macedonia is yet to be confirmed.

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Нови данни за скачащите паяци на Република Македония с пълен списък на установените досега видове (Araneae: Salticidae)

М. Комненов

(Резюме)

В статията се съобщават нови данни за разпространението на 58 вида паяци от семейство Salticidae. От тях, 17 вида и 3 рода са нови за страната, а два вида – *Aelurillus laniger* и *Icius subinermis* – се съобщават за пъри път от Балканския полуостров. Представен е пълен списък на досега установените в Македония видове. Четири таксона от видовата група – *Euophrys gambosa*, *Macaroeris flavicomis*, *Pseudicius espereyi* и *Talavera aequipes ludio*, са изключени от списъка поради липса на конкретни данни за тяхното присъствие в страната. Представени са и оригинални данни за местообитанията на отделните видове.

Spiders in Mangalavanam, an ecosensitive mangrove forest in Cochin, Kerala, India (Araneae)

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Abstract: A preliminary study was conducted to document the spider fauna in Mangalavanam, an ecosensitive and threatened mangrove forest located in the heart of Cochin City in Kerala state, India. Mangalavanam is popularly known as the Green Lung of Cochin City. The faunistic survey yielded 51 species of spiders belonging to 40 genera and 16 families. This represents 27% of the total families reported from India. Araneidae was the most dominant family recording 12 species belonging to 8 genera. On species level, *Pisaura gitae* TIKADER, 1970 was the dominant species. Guild structure analysis revealed seven feeding guilds, namely orb weavers, stalkers, ground hunters, foliage runners, sheet web builders, scattered line weavers and ambushers. Orb weavers and stalkers were the dominant feeding guilds representing 33% and 29% respectively of the total collection. The genus *Tapponia* is reported for the first time from India.

Key words: Mangalavanam, diversity, urban forest, spiders, *Tapponia*

Introduction

Urban areas in India are faced with excessive population along with the pressure of unplanned economic development, industrialization, and vehicular emissions. In this paper, we present the results of a faunistic survey conducted to document the spider diversity in Mangalavanam, an ecologically threatened urban forest located in the heart of Cochin City in Kerala state, India.

Materials and Methods

Cochin (Kochi) city, acclaimed as the commercial capital of Kerala, Queen of the Arabian Sea, Gateway of South India, etc., is located on the west coast of India at a latitude of 9° 58' N and longitude of 76° 14' E. Lying at sea level, this port city receives an annual rainfall of 343 cm with 139 rainy days. Temperature ranges from 20°C to 35°C. Mangalavanam, popularly known as the Green Lung of Cochin City, is a mangrove forest located in the north-west area of the city. This green belt, with an area of 2.4 ha, also supports many varieties of rare and endemic mangrove vegetation. *Acanthus ilicifolius* LINNAEUS, *Avicennia officinalis* LINNAEUS, *Bruguiera gymnorrhiza* (LINNAEUS) LAMARCK, *Kandelia candel* (LINNAEUS) DRUCE, *Rhizophora apiculata* BLUME and *Excoecaria agallocha* LINNAEUS are a few among them (RAMACHANDRAN, MOHANAN 1989). Mangalavanam was in the limelight recently owing to a series of protests by environmentalists to protect this area from being turned into a parking zone for vehicles coming to the High Court of Kerala State.

Spiders were collected from Mangalavanam in February 2005. Collections were made by a visual searching method following a line transect. Each plant along the transect was carefully

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searched for spiders. Smaller spiders were collected by leading them into tubes containing alcohol with the help of a brush dipped in alcohol. Sedentary spiders found on the leaf blades, tree trunks and those on the webs were caught in the jar by holding it open beneath them and by tapping the spiders into it with the lid. Running and vagabond species such as lycosids were caught by throwing a kerchief over them and carefully holding them with the hand in the folds, then transferring them to the jars. The collected spiders were preserved in 70% alcohol. Adult males and females were identified up to species level with the help of available literature (TIKADER 1970, 1977, 1980, 1982, 1987, BARRION, LITSINGER 1995, MURPHY, MURPHY 2000). Immature spiders were identified up to generic level. The scientific names of spiders and their classification follow PLATNICK (2005). Voucher specimens were deposited in the reference collection housed with the Arachnology Division, Department of Zoology, Sacred Heart College, Cochin, Kerala, India.

Table 1. Total number of families, genera, species composition and functional guilds of spiders sampled from Mangalavanam urban forest, India.

No.	Family	No. of genera	No. of species	Guild
1.	Araneidae	8	12	Orb web weavers
2.	Clubionidae	1	1	Foliage hunters
3.	Corinnidae	1	1	Ground runners
4.	Hersiliidae	1	1	Foliage hunters
5.	Linyphiidae	1	1	Sheet web builders
6.	Lycosidae	2	2	Ground runners
7.	Miturgidae	1	1	Foliage hunters
8.	Oxyopidae	2	4	Stalkers
9.	Pisauridae	1	1	Foliage hunters
10.	Salticidae	10	11	Stalkers
11.	Scytodidae	1	2	Foliage hunters
12.	Sparassidae	1	1	Foliage hunters
13.	Tetragnathidae	3	4	Orb web weavers
14.	Theridiidae	3	4	Scattered line weavers
15.	Thomisidae	3	4	Ambushers
16.	Uloboridae	1	1	Orb web weavers
	Total	**40**	**51**	

Orb web weavers (33%)

Foliage hunters (12%)

Scattered line weavers (8%)

Ambushers (8%)

Stalkers (29%)

Ground runners (8%)

Sheet web builders (2%)

Fig. 1. Guild structure of spiders collected from Mangalavanam urban forest, India.

Results and Discussion

Spiders representing 16 families, 40 genera and 51 species were recorded from Mangalavanam during the study (Tables 1, 2). This represents 27% of the total families reported from India (SILIWAL *et al*. 2005). Araneidae was the dominant family constituting 12 species from 8 genera. The Salticidae was represented by 11 species from 10 genera. On species level, *Pisaura gitae* TIKADER, 1970 was the dominant species. Guild structure analysis revealed seven feeding guilds (UETZ *et al*. 1999). These are orb web weavers, stalkers, ground runners, foliage hunters, sheet web builders, scattered line weavers and ambushers (Table 1). Orb web weavers constituted the dominant feeding guild representing 33% of the total collection (Fig. 1). They are followed by stalkers and foliage hunters constituting 29% and 12% respectively of the total catch.

Table 2. Checklist of spiders collected from Mangalavanam urban forest, India. * - species endemic to India.

Family	Genus/ Species
Scytodiidae	*Scytodes thoracica* (LATREILLE, 1802)
	Scytodes sp.
Hersiliidae	*Hersilia savignyi* LUCAS, 1836
Uloboridae	*Uloborus* sp.
Theridiidae	*Achaearanea mundula* (L. KOCH, 1872)
	A. tepidariorum (C.L. KOCH, 1841)
	Theridion sp.
	Theridula angula TIKADER, 1970*
Linyphiidae	*Erigone* sp.
Tetragnathidae	*Leucauge celebesiana* (WALCKENAER, 1842)
	L. pondae TIKADER, 1970*
	Opadometa sp.
	Tetragnatha mandibulata WALCKENAER, 1842
Araneidae	*Araneus mitificus* (SIMON, 1886)
	A. nympha (SIMON, 1889)
	Argiope aemula (WALCKENAER, 1842)
	A. pulchella THORELL, 1881
	Cyclosa confraga (THORELL, 1892)
	Cyclosa quinqueguttata (THORELL, 1881)
	Cyrtarachne sp.
	Cyrtophora citricola (FORSKÅL, 1775)
	Eriovixia laglaizei (SIMON, 1877)
	Gasteracantha geminata (FABRICIUS, 1798)
	Neoscona mukerjei TIKADER, 1980*
	N. vigilans (BLACKWALL, 1865)
Lycosidae	*Lycosa* sp.
	Pardosa sumatrana (THORELL, 1890)
Pisauridae	*Pisaura gitae* TIKADER, 1970*
Oxyopidae	*Oxyopes birmanicus* THORELL, 1887
	O. quadridentatus THORELL, 1895
	O. sunandae TIKADER, 1970*
	Tapponia sp.
Miturgidae	*Cheiracanthium* sp.
Clubionidae	*Clubiona* sp.
Corinniidae	*Castianeira* sp.
Sparassidae	*Heteropoda* sp.
Thomisidae	*Amyciaea forticeps* (O. P.-CAMBRIDGE, 1873)
	Thomisus lobosus TIKADER, 1965*
	T. pugilis STOLICZKA, 1869*
	Xysticus sp.
Salticidae	*Asemonea tenuipes* (O. P.- CAMBRIDGE, 1869)
	Bavia sp.
	Carhottus sp.
	Cyrba sp.
	Hyllus sp.
	Menemerus bivittatus (DUFOUR, 1831)
	Myrmarachne orientales TIKADER, 1973
	M. plataleoides (O. P.-CAMBRIDGE, 1869)
	Phintella vittata (C.L. KOCH, 1846)
	Plexippus petersi (KARSCH, 1878)
	Telamonia dimidiata (SIMON, 1899)

The genus *Tapponia* has been discovered for the first time from India. Also, 7 species collected from Mangalavanam are endemic to the Indian region (Table 2).

This study brought out the fact that Mangalavanam, the urban forest in Kochi city which is on the verge of destruction due to rapid urbanization, is an abode of spiders in addition to the multitude of migratory birds nesting in this mangrove forest. This rich diversity of spiders is also indicative of the overall biodiversity of this urban forest since spiders are considered to be useful indicators of the species richness and health of terrestrial ecosystems (NOSS 1990) and amply emphasizes the need for preserving this forest patch intact from a biodiversity conservation perspective.

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Паяци (Araneae) в Мангалаванам – уязвима мангрова гора в Кохин (Керала, Индия)

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(Резюме)

Проведено е пионерно проучване на аранеофауната на уязвимата мангрова гора "Мангалаванам", намираща се в центъра на град Кохин, щата Керала в Индия. Установени са 51 вида паяци, принадлежащи към 40 рода и 16 семейства, което представлява 27 % от всички семейства, срещащи се в Индия. Най-богато на видове е семейство Araneidae (12 вида от 8 рода). Преобладаващият в изследвания район вид е *Pisaura gitae* Tikader, 1970. Родът *Tapponia* се регистрира за първи път в Индия. На поведенческа основа са разграничени няколко екологични типа паяци-тъкачи на кълбовидни мрежи, наземни ловци, ловци в подстилката, тъкачи на пеленовидни мрежи, ловци от засада и др. Видовете, изграждащи кълбовидни мрежи и тези, които дебнат жертвите си от засада, доминират в изследвания район със съответно 33% и 29% представеност в цялата колекция.

Preliminary studies on the spider fauna in Mannavan shola forest, Kerala, India (Araneae)

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Abstract: A pioneering study was conducted to reveal the spider diversity in Mannavan shola Forest in Kerala state, India. Mannavan shola, the largest Shola patch in Asia, exists in "Western Ghats", one of the biodiversity hot spots of the world. A total of 72 species of spiders belonging to 57 genera of 20 families were collected from this area during this five-day study. This represents 5% of the total families recorded in India. Guild structure analysis of the collected spiders revealed 6 feeding guilds viz., orb-web builders, foliage hunters, ground hunters, sheet web builders, scattered line weavers and ambushers. The families Araneidae, Tetragnathidae, Salticidae and Thomisidae exhibited maximum species diversity. The dominant family was Araneidae with 17 species. The most striking feature of the spider fauna of Mannavan shola is the number of new records. About 15 species discovered in Mannavan shola are endemic to Western Ghats of Kerala. The high species diversity of spiders in Mannavan shola can be attributed to the high diversity of plants and insects. Because of the complex interaction of various climatic factors such as high rainfall and humidity, with topographical features, Mannavan shola holds many smaller but diverse environmental niches which make this shola forest an important centre of speciation in Western Ghats. This is the first report of the spider fauna from any shola forest in India.

Key words: Mannavan shola, India, spiders, diversity, guild structure

Introduction

Though spiders form one of the most ubiquitous and diverse groups of organisms existing in Kerala, their study has always remained largely neglected. They have, however, largely been ignored because of the human tendency to favour some organisms over others of equal importance because they lack a universal appeal (HUMPHRIES *et al*. 1995). Due to high species endemism, Western Ghats are listed in the 34 'Biodiversity hotspots' of the world (MITTERMEIER *et al.* 2005). Inaccessibility of these forest areas had considerably facilitated its protection. Due to the scarcity of workers much of the arthropodan diversity in Western Ghats remains unexplored. As a result, the disappearance of many species remains undocumented. With the extinction of such species any prospect for their future utilization ceases. Considering the importance of spiders in the natural suppression of many insect pests and as bioindicators, urgent efforts are needed to understand their diversity. The present knowledge on the spiders of Western Ghats remains confined to the works of POCOCK (1895, 1899, 1900), HIRST (1909), GRAVELY (1915, 1935), SHERRIFF (1919, 1927a,b,c), SINHA (1951), SUBRAMANIAN (1955) and CHARPENTIER (1996). Recently JOSE, SEBASTIAN (2001), SMITH (2004), SUGUMARAN *et al*. (2005), and JOSE *et al*. (2006) tried to document the diversity of spider fauna in and around Western Ghats. However, there are many works on the vertebrate and

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invertebrate diversity in the Mannavan shola forest (NAIR 1991), but there is no work on spider diversity. The aims of this study were to investigate the diversity of spiders in this shola ecosystem and to reveal the species richness, endemism, affinity and similarity with other geographic faunas. Though the study of spiders from Mannavan shola forest is still far from complete, the present study forms a basis for further investigations on this group.

Materials and Methods

Mannavan Shola forms the largest Shola patch in Asia with an approximate size of 14 km². It is located in Idukki district falling within the Marayur Forest range of Munnar Division. Mannavan shola forest is situated at 10˚05' N latitude and 77˚05' E longitude and forms a part of Western Ghats. Elevation ranges from 600 m to 1350 m, with average elevation being 1100 m. Annual rainfall is 1720 mm, there is more rain in June - August. The vegetation comprises mostly of southern subtropical hill forests, gradually transforming to the southern montane wet temperate forests. This type of forest is composed of tree species much stunted in habit with spreading canopy, twiggy branchlets and foliage of different colours ranging from dark green to purplish, depending upon the flushing periods of various component species. Wild fauna of this shola forest is also quite diverse and characteristic and the endemic Nilgiri Tahr is one among them, totally restricted to the shola-grassland ecosystem and the associated rocky cliffs. Temperature ranges from a maximum of 17°-25° C with an average of 19º C. This shola was pronounced a reserved forest with a government order in 1901 (NAIR 1991).

The study was of limited duration extending for five days from December 8, 2003 to December 12, 2003. Bushes, tree trunks, ferns, forest floor, foliage and grass lands were all searched for spiders and collected by hand picking method as suggested by TIKADER (1987). Global Positioning System hand unit (GPS) was used to determine the exact geographical locations. The identification of spiders was done following TIKADER (1970, 1977, 1980, 1982), KOH (1996), MURPHY, MURPHY (2000) and DIPPENAAR (2002).

Results

A total of 72 species of spiders belonging to 57 genera of 20 families were collected during the study (Table 1). Voucher specimens were preserved in 70% ethanol and deposited in a reference collection lodged with the Division of Arachnology, Department of Zoology, Sacred Heart College, Thevara, Cochin, Kerala, India.

Functional groups: The collected spiders can be divided into six functional groups (guilds) based on their foraging behaviour in the field (UETZ *et al.* 1999). The dominant guild was of the orb web builders (Fig. 1) and it comprised of 30 species of spiders. Spiders of the families Araneidae, Tetragnathidae and Uloboridae fall under this category. Spiders of the category ground runners formed the next dominant guild in this ecosystem comprising of 13 species of spiders. Foliage runners (12 species), ambushers (8 species), scattered line weavers (6 species) and sheet web builders (3 species) are the other functional groups.

Family diversity: Out of the 59 families recorded in the Indian region, 20 families are discovered in Mannavan shola. This represents 36% of the total families recorded in India. Araneidae was the dominant family in this biome, which is composed of 17 species of 10 genera. Tetragnathidae was the next dominant family with 10 species of 6 genera. Salticidae (7 species), Lycosidae (6 species) and Thomisidae (6 species) was the order of dominance of the other major families in this ecosystem. The families consisting of hunting and wandering spiders represent 55% of the spiders found.
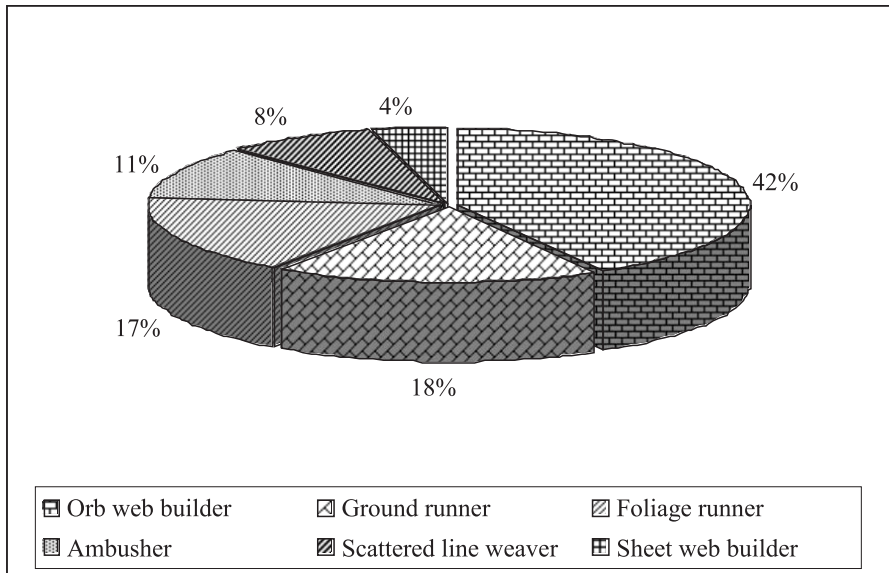
Fig. 1. Composition (%) of guild structure of spiders collected from Mannavan shola during the study.

Generic diversity: Out of the 252 genera recorded from the Indian region (Siliwal *et al*. 2005), 57 genera are discovered in Mannavan shola. Maximum generic diversity was found in Araneidae (10), Salticidae (7), Tetragnathidae (6) and Thomisidae (6). The number of genera recorded here is higher than that of other major Indian spider studies viz., Andaman and Nicobar islands – 33 genera, Sikkim – 41 genera and Calcutta – 47 genera (Tikader 1970, 1977, Tikader, Biswas 1981). Genera such as *Arachnura* (Araneidae); *Castianeira, Oedignatha* (Corinnidae); *Linyphia* (Linyphiidae); *Tibellus* (Philodromidae); *Hyllus, Phintella, Telamonia* (Salticidae); *Achaearanea, Argyrodes, Coleosoma, Theridula* (Theridiidae); *Camaricus, Misumenops, Ozyptila, Pistius, Xysticus* (Thomisidae) and *Miagrammopes* (Uloboridae) are first records for Kerala state of India.

Species richness: A total of 72 species are discovered from a limited area of 14 km². This number is very high compared with other regions like Andaman and Nicobar islands – 65 species, Sikkim – 55 species and Calcutta – 99 species (Tikader 1970, 1977 and Tikader, Biswas 1981). The above three studies were conducted over a period of one to two years while the present study was limited to five days.

New records: The most striking feature of the spider fauna of Mannavan shola is the number of new records. Two species, *Oedignatha carli* (Corinnidae) and *Hyllus diardi* (Salticidae), and 2 genera, *Neriene* (Linyphiidae) and *Coleosoma* (Theridiidae), were recorded for the first time from India. A total of 30 species were recorded for the first time from Kerala (Table 1).

Endemism: A total of 252 endemic species of spiders are reported from India so far (Siliwal *et al*. 2005). Among the collection, 15 species discovered in Mannavan shola are endemic, known so far exclusively from the Western Ghats of Kerala (Jose *et al*. 2006). Similarly, 44 species are endemic to India. Of the 72 species of spiders found in Mannavan shola, 24 species are found to be endemic to Indo-Srilankan region.

Affinities: The present studies conducted in Mannavan shola revealed that the spider fauna of this ecosystem bears affinities with Oriental and Palearctic regions. The presence of species like *Cyclosa bifida, Eriovixia excelsa, Gasteracantha dalyi* (Araneidae); *Leucauge decorata* and *Nephila pilipes* (Tetragnathidae) bears oriental affinities. A small fraction of species, namely

Table 1. List of the spiders collected from Mannavan shola. [1] - First report from India, [*] - First report from Kerala.

No.	Family/Species	Guild
	Araneidae	Orb web builder
1.	*Arachnura* * *angura* TIKADER, 1970	
2.	*Araneus bilunifer* POCOCK, 1900	
3.	*A. himalayaensis* * TIKADER, 1975	
4.	*A. nympha* * (SIMON, 1889)	
5.	*Argiope pulchella* THORELL, 1881	
6.	*Chorizopes bengalensis* TIKADER, 1975	
7.	*Cyclosa bifida* * (DOLESCHALL, 1859)	
8.	*C. hexatuberculata* * TIKADER, 1982	
9.	*C. insulana* (COSTA, 1834)	
10.	*Cyrtarachne* sp.	
11.	*Cyrtophora bidenta* * TIKADER, 1970	
12.	*Eriovixia excelsa* (SIMON, 1889)	
13.	*Gasteracantha dalyi* POCOCK, 1900	
14.	*G. kuhli* C. L. KOCH, 1837	
15.	*G. remifera* BUTLER, 1873	
16.	*Neoscona mukerjei* TIKADER, 1980	
17.	*N. vigilans* * (BLACKWALL, 1865)	
	Clubionidae	Foliage runner
18.	*Clubiona drassodes* CAMBRIDGE, 1874	Ground runner
	Corinnidae	
19.	*Castianeira* * *zetes* SIMON, 1897	
20.	*Oedignatha* * *carli* [1] REIMOSER, 1934	
	Ctenidae	Ground runner
21.	*Ctenus indicus* GRAVELY, 1931	
	Gnaphosidae	Ground runner
22.	*Poecilochroa* sp.	
	Hersilidae	Foliage runner
23.	*Hersilia* sp.	
	Linyphiidae	Sheet web builder
24.	*Linyphia* * *urbasae* TIKADER, 1970	
25.	*Neriene* [1] sp.	
	Lycosidae	Ground runner
26.	*Hippasa agelenoides* (SIMON, 1884)	
27.	*H. greenalliae* (BLACKWALL, 1867)	
28.	*H. lycosina* * POCOCK, 1900	
29.	*H. olivacea* * (THORELL, 1887)	
30.	*Lycosa carmichaeli* GRAVELY, 1924	
31.	*Pardosa atropalpis* GRAVELY, 1924	
	Miturgidae	Foliage runner
32.	*Cheiracanthium* sp.	
	Oxyopidae	Foliage runner
33.	*Oxyopes birmanicus* THORELL, 1887	
34.	*O. shweta* * TIKADER, 1970	
	Philodromidae	Ambusher
35.	*Philodromus* sp.	

Table 1. Continued.

No.	Family/Species	Guild
36.	*Tibellus** sp.	
	Pholcidae	Scattered line weaver
37.	*Artema atlanta* WALCKENAER, 1837	
	Psechridae	Sheet web builder
38.	*Psechrus torvus* (CAMBRIDGE, 1869)	
	Salticidae	Foliage runner
39.	*Bavia* sp.	
40.	*Hasarius* sp.	
41.	*Hyllus** *diardi*[1] (WALCKENAER, 1837)	
42.	*Myrmarachne plataleoides* (CAMBRIDGE, 1869)	
43.	*Phintella** *vittata* (C.L. KOCH, 1846)	
44.	*Telamonia** *dimidiata* (SIMON, 1899)	
45.	*Thiania* sp.	
	Scytodidae	Ground runner
46.	*Scytodes fusca* WALCKENAER, 1837	
	Sparassidae	Ground runner
47.	*Heteropoda phasma* SIMON, 1897	
48.	*Olios* sp.	
	Tetragnathidae	Orb web builder
49.	*Herennia ornatissima* (DOLESCHALL, 1859)	
50.	*Leucauge decorata* (BLACKWALL, 1864)	
51.	*L. dorsotuberculata** TIKADER, 1982	
52.	*L. tessellata* (THORELL, 1887)	
53.	*Nephila kuhlii** DOLESCHALL, 1859	
54.	*Nephila pilipes* (FABRICIUS, 1793)	
55.	*Opadometa fastigata* (SIMON, 1877)	
56.	*Tetragnatha sutherlandi* GRAVELY, 1921	
57.	*Tylorida culta** (CAMBRIDGE, 1869)	
58.	*T. ventralis* (THORELL, 1877)	
	Theridiidae	Scattered line weaver
59.	*Achaearanea** *mundula* (L. KOCH, 1872)	
60.	*Argyrodes** *gazedes* TIKADER, 1970	
61.	*Coleosoma*[1] sp.	
62.	*Theridula** *angula* TIKADER, 1970	
63.	*Steatoda* sp.	
	Thomisidae	Ambusher
64.	*Camaricus** *khandalaensis* TIKADER, 1980	
65.	*Misumena decorata** TIKADER, 1980	
66.	*Misumenops** *andamanensis* TIKADER, 1980	
67.	*Ozyptila** sp.	
68.	*Pistius** sp.	
69.	*Xysticus** *himalayaensis* TIKADER, BISWAS, 1974	
	Uloboridae	Orb web builder
70.	*Miagrammopes** sp.	
71.	*Uloborus krishnae* TIKADER, 1970	
72.	*Zosis geniculata* (OLIVIER, 1789)	

Araneus nympha (Araneidae) and *Nephila kuhlii* (Tetragnathidae) show Palearctic affinities. Affinities with the island fauna of Sri Lanka are also pronounced. *Argiope pulchella*, *Cyclosa insulana*, *Gasteracantha remifera* (Araneidae) *Tylorida culta*, *Tylorida ventralis* (Tetragnathidae) are some of the species having Srilankan affinities discovered from Mannavan shola. A total of 16 species recorded in Mannavan shola are widely distributed in South Asia; 6 of these are found only in the Indo-Srilankan region.

Faunal similarity: Faunal similarity of spiders found in Mannavan shola with other regions of India is also striking. *Artema atlanta* (Pholcidae); *Myrmarachne plataleoides* (Salticidae) and *Nephila pilipes* (Tetragnathidae) are species commonly found in the spider fauna of Andaman and Nicobar islands (Tikader 1977). Species like *Cyrtophora bidenta*, *Cyclosa insulana* (Araneidae); *Oxyopes shweta* (Oxyopidae); *Leucauge decorata*, *Leucauge tessellata*, *Nephila pilipes* (Tetragnathidae); *Argyrodes gazedes* and *Theridula angula* (Theridiidae) are commonly found in the spider fauna of Sikkim (Tikader 1970). *Argiope pulchella* (Araneidae); *Nephila kuhlii*, *Tylorida ventralis*, *Leucauge decorata* (Tetragnathidae); *Phintella vittata* and *Telamonia dimidiata* (Salticidae) are also found in Calcutta (Tikader 1981).

Discussion

Of about 1442 species reported from India (Siliwal *et al.* 2005), 72 species have been recorded from Mannavan shola. The high species diversity of spiders in Mannavan shola can be attributed to the high diversity of plants (850 spp.) and insects (7500 spp., 65 spp. of butterflies) (Swarupanandan *et al.* 2000). It can be assumed that a high floral diversity sustains a high faunal diversity by providing diverse microhabitat especially for invertebrates. Unlike other ecologically important zones, there is no previous work to compare the spider diversity. This indicates the need for further sampling in this area. Because of the complex interaction of various climatic factors like high rainfall and humidity, with topographical features Mannavan shola holds many smaller but diverse environmental niches. The presence of diverse habitats like forests, bushes and grasslands in this ecosystem is further evidence to this. This makes Mannavan shola an important centre of speciation in Western Ghats.

There are many environmental factors that affect species diversity (Rosenzweig 1995). However, when spiders were divided according to their functional group there was a significant effect of habitat on the diversity of these groups. The web building and foliage running spiders rely on vegetation for some part of their lives, either for finding food, building retreats or for web building. The structure of the vegetation is therefore expected to influence the diversity of spiders found in the habitat. Studies have demonstrated that a correlation exists between the structural complexity of habitats and species diversity (Hawksworth, Kalin-Arroyo 1995). Diversity generally increases when a greater variety of habitat types are present (Ried, Miller 1989). Uetz (1991) suggests that structurally more complex shrubs can support a more diverse spider community. Downie *et al.* (1999) and New (1999) have demonstrated that spiders are extremely sensitive to small changes in the habitat structure, including habitat complexity, litter depth and microclimate characteristics. Spiders generally have humidity and temperature preferences that limit them to areas within the range of their "physiological tolerances" which make them ideal candidates for land conservation studies (Riechert, Gillespie 1986). Therefore, documenting spider diversity patterns in this ecosystem can provide important information to justify the conservation of this ecosystem.

The most striking result is the surprisingly high diversity in this biome compared with other biomes that have been surveyed in India. The number of species found here is a lot higher than in other studies conducted in Western Ghats (Sugumaran *et al.* 2005). However, that study was

conducted for a period of more than one year and sampling for the present study was done in a limited number of days only. Culin, Yeargan (1983) noted that the species richness of spiders is significantly higher in systems that have not been heavily manipulated. Species richness is only one way of assessing habitat quality. The uniqueness of species compositions, as indicated by levels of endemism and habitat specialization, is more important in establishing regional conservation priorities (Platnick 1991). This shola habitat has a diverse spider community and further research should be encouraged in this biome. However, to maintain and manage this high diversity biome, factors other than habitat type need to be identified. Factors at the microhabitat scale, which may be important in influencing the diversity, need to be investigated. This conclusion is also supported by existence of 45 endemic and numerous widely distributed species in Western Ghats (Sugumaran *et al*. 2005). In a zoogeographic respect the widely distributed spiders are more dominant. However the characteristic faunal element is the endemic species. Their number is high and their faunistic composition reflects the local character of the fauna. Many of the species found in Mannavan shola are not reported from any other region in India. This phenomenon can be explained by the relative isolation of Western Ghats provided by mountains in the east and Arabian Sea in the west (Nagendra, Gadgil 1998). Thus the existing data suggest that Western Ghats represents one of the main centres of speciation in Asia. Holloway (2003) observed that conversion of forest to plantation and other man-induced disturbances lead to reduction in the diversity of invertebrates, both in species richness and in the taxonomic and biogeographic quality. Being an area of varied habitat, top priority must be given to the conservation of its rich diversity. This study is the first survey of shola forest spiders in Western Ghats. It also emphasizes the need for conservation of this ecosystem by characterizing species diversity and highlighting rare and endemic species in the sholas. This study serves as a baseline for future study of spiders in shola ecosystems. Such studies can build upon this one by using additional collecting methods and/or collecting in different seasons. Future studies can build upon this checklist and continue to catalogue the poorly documented spider fauna and perhaps discover new species along the way.

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Предварителни проучвания върху аранеофауната (Araneae) на Манаван Шола (Керала, Индия)

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(Резюме)

Проведено е пионерно изследване върху паяците, обитаващи гората Манаван Шола в индийския щат Керала. По отношение на биоразнообразието, Манаван Шола се нарежда сред световно значимите места на планетата. В рамките на пет дена са събрани общо 72 вида паяци от 57 рода и 20 семейства. Това представлява 5% от общия брой на всички семейства в Индия. Най-добре са представени семействата Araneidae, Tetragnathidae, Salticidae и Thomisidae, като в проучения район доминира Araneidae със 17 вида. Около 15 вида се приемат за ендемити на Кералски Западен Гатс. Високото видово разнообразие при паяците се свързва с високото видово разнообразие на растенията и насекомите. Анализирана е структурата на различните екологични типове паяци, като са установени шест групи – строители на кълбовидни мрежи, ловци в подстилката, наземни ловци, строители на пеленовидни мрежи, строители на неправилни мрежи и ловци от засада.

New data on the occurrence of *Gnaphosa rufula* (L. KOCH, 1866) and *Gnaphosa mongolica* SIMON, 1895 in Hungary (Araneae: Gnaphosidae)

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Abstract: Several years of study on the spider assemblages of mosaics of grassland habitats in Hungary revealed that two little known gnaphosid species are both dominant spiders of their particular habitats. *Gnaphosa rufula* (L. KOCH, 1866) proved to be one of the most dominant spiders in salt marshes and saline meadows, while *Gnaphosa mongolica* SIMON, 1895 was collected in large numbers on sandy grasslands. Hungary is their westernmost location. Both species can be collected mainly from April to August.

Key words: spiders, *Gnaphosa*, habitat preferences, phenology, faunistics

Introduction

Most of the grassland habitats of Hungary are mosaics of agricultural and different types of natural habitats. These habitats possess their specialised flora and fauna. In the last few years remarkable attention was devoted to many kinds of natural grassland habitats, e.g. loess steppes, alkaline grasslands, wet marshes and sandy grasslands from a faunistical and ecological point of view.

Our several years of studies on the spider assemblages of these mosaics of grassland habitats in Hungary revealed that two, previously little known gnaphosid species are in fact the dominant spiders of their particular habitats. *Gnaphosa rufula* (L. KOCH, 1866) was found for the first time in Hungary in 1998 (DUDÁS 2001, SZITA *et al.* 2000), while *Gnaphosa mongolica* SIMON, 1895 was known earlier from Hungarian and Romanian localities as *Gnaphosa spinosa* KULCZYŃSKI, 1897 (BALOGH, LOKSA 1946, 1948, CHYZER, KULCZYŃSKI 1897, LOKSA 1987, KEREKES 1988, WEISS, MARCU 1988). This name proved to be the junior synonym of *G. mongolica* (OVTSHARENKO *et al.* 1992). *G. mongolica* was also known from Kazakhstan, Kyrgyzstan, southern part of Russia, Ukraine and Mongolia, while *G. rufula* was found in Kazakhstan and the southern part of Russia; Hungary seems to be their known westernmost location (OVTSHARENKO *et al.* 1992, PLATNICK 2005).

Material and Methods

Collecting places and study years

The sampling sites were located in areas belonging to four national parks: alkaline and sandy grasslands of Bükk N.P., Hortobágy N.P., Kiskunság N.P. and Körös-Maros N.P. The surveys

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were carried out between 1998 and 2004. We collected spiders with pitfall traps with the standard methodology of our previous experiments (SAMU, SÁROSPATAKI 1995, TÓTH *et al*. 1996). In the case of *G. mongolica* we took into consideration Hungarian literature data as well. Currently these locations belong to the Duna-Ipoly N.P. For the exact location of the study sites and the years of sampling see Table 1 and Fig. 1. The nomenclature of plant communities of habitats follows FEKETE (1997) and DEVILLERS (2000). The system used by TOFT (1976) was adopted for presentation of phenological data.
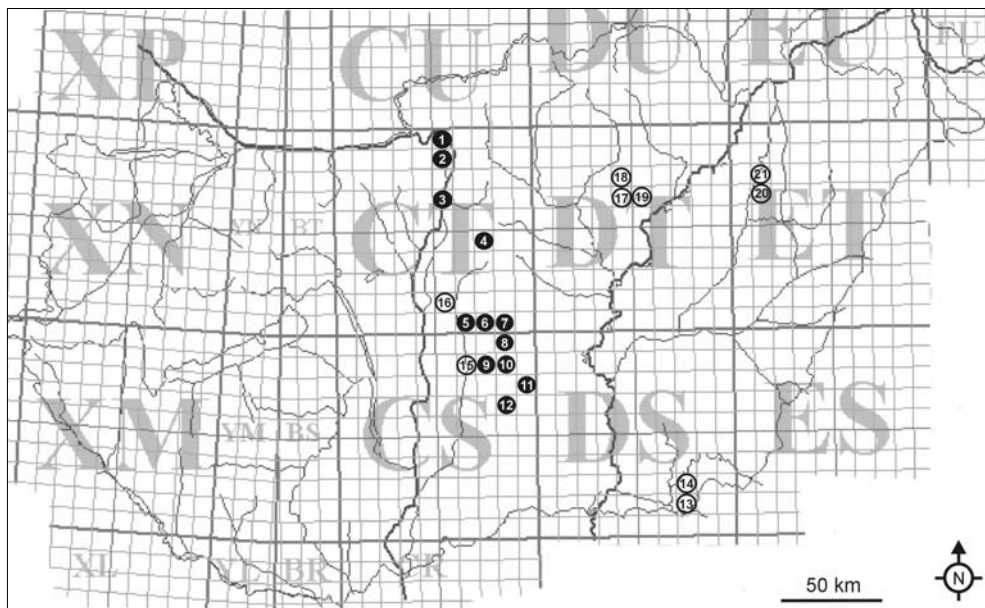
Fig. 1. Study sites of *Gnaphosa mongolica* (●) and *G. rufula* (o). Numbers correspond to those of Table 1.

Results and Discussion

Diagnosis

Genitalia of both species are rather characteristic, easy to distinguish from other Hungarian *Gnaphosa* species (*G. alpica* SIMON, 1878; *G. bicolor* (HAHN, 1833); *G. lucifuga* (WALCKENAER, 1802); *G. lugubris* (C.L. KOCH, 1839); *G. microps* HOLM, 1939; *G. modestior* KULCZYŃSKI, 1897; *G. opaca* HERMAN, 1879) (SAMU, SZINETÁR 1999).

The males of *Gnaphosa mongolica* can be recognized by the long embolus originating from the prolateral part of the tegulum and by slightly curved median apophysis with hook-like apical part (Figs 2 a,b), while females have large diamond-shaped epigynal hood and the spermathecal ducts are anteriorly extended (Figs 2 c,d). Male body size: 7-9 mm, female body size: 8-11 mm. The males of *Gnaphosa rufula* can be recognised by the long narrow embolus with rounded basal prolateral protuberance and the slim and curved median apophysis (Figs 2 e,f). Females have deep epigynal atrium with long parallel lateral margins, wide epigynal midpiece and long wide median ducts of spermathecae (Figs 2 g,h). Male body size: 6-8 mm, female body size: 7-9 mm.

Habitat preferences

Both species prefer xerothermic habitats.

Gnaphosa mongolica: Specimens were collected in large numbers (85 females, 331 males) in sandy grasslands and on clearings of Juniper downs on sand (Fig. 1 and Table 1: 1-12). This species proved to be one of the most abundant spiders. Values ranged between 1st rank with 37.8% or 16% of all collected specimens of a given area to 7th rank with 4.9%. Their occurrence in adjacent agricultural fields was not investigated. Sandy grasslands (*Festucetum vaginatae*) are perennial, more or less open grasslands dominated by *Festuca vaginata* or feather grasses (*Stipa capillata*, *Stipa borysthenica*). Juniper downs on sand (*Festucetum vaginatae juniperetosum*) constitute a primary successive stage in the colonisation of sand dunes, with groove-like appearance of mosaics of open sandy grassland and juniper (*Juniperus communis*) shrubs.

Gnaphosa rufula: We collected 205 female and 450 male specimens of *G. rufula*. This species proved to be one of the most dominant spiders of saline steppes and saltmarsh meadows (Fig. 1 and Table 1: 13-21). Abundance values ranged between 2nd with 13%-11% of all collected specimens to 8th with 3%. This species may occur also in the adjacent non-saline meadows or cereal fields, but in negligible amount (1 or 2 specimens per year). The grassy saline steppe (*Achilleo-Festucetalia pseudovinae*) and the *Artemisia* saline steppe (*Artemisio-Festucetalia pseudovinae*) are dominant salt-steppe communities of dry soils. The latter developed on more low-laying surfaces, mostly constituting intermediate belts between grassy saline steppes and rills–alkali

Table 1. Sampling sites, study years and habitats of *G. mongolica* and *G. rufula* in Hungary.

| Nr. on Fig 1.	Sampling site	National park	Study years or lit. data	Plant community
1	Pócsmegyer	DINP	(BALOGH, LOKSA 1946)	*Festucetum vaginatae*
2	Szigetmonostor	DINP	(BALOGH, LOKSA 1948)	*Festucetum vaginatae*
3	Sashegy /Budapest/	DINP	(CHYZER, KULCZYŃSKI 1897)	?
4	Csévharaszt	DINP	(LOKSA 1987)	*Festucetum vaginatae juniperetosum*
5	Kunadacs	KNP	2001-2002	*Festucetum vaginatae*
6	Kunbaracs	KNP	2001-2002	*Festucetum vaginatae*
7	Kerekegyház	KNP	(LOKSA 1987)	*Festucetum vaginatae stipetosum*
8	Fülöpháza	KNP	2001-2002	*Festucetum vaginatae*
9	Soltszentimre	KNP	2001-2002	*Festucetum vaginatae*
10	Orgovány	KNP	2002-2004	*Festucetum vaginatae juniperetosum*
11	Bugac	KNP	(KEREKES 1988), 2001-2002	*Festucetum vaginatae juniperetosum*
12	Bócsa	KNP	2001-2002	*Festucetum vaginatae juniperetosum*
13	Csanádpalota	KMNP	1998-2000	*Artemisio-Festucetum pseudovinae*
14	Királyhegyes	KMNP	1998-2000	*Puccinellietum limosae + Artemisio-Festucetum pseudovinae*
15	Fülöpszállás	KNP	2001-2002	*Camphorosmetum annuae+ Artemisio-Festucetum pseudovinae*
16	Kunszentmiklós	KNP	2001-2002	*Artemisio-Festucetum pseudovinae*
17	Pély	BNP	1998-1999	*Agrostio-Alopecuretum pratensis + Artemisio-Festucetum pseudovinae*
17	Jászivány	BNP	1998-1999	*Camphorosmetum annuae+ Artemisio-Festucetum pseudovinae*
18	Heves	BNP	1998-1999	*Achilleo- Festucetum pseudovinae*
19	Tarnaszentmiklós	BNP	1998-1999	*Artemisio-Festucetum pseudovinae + Agrostio-Beckmannietum eruciformis*
20	Hajdúszoboszló	HNP	2004	*Achilleo- Festucetum pseudovinae + Agrostio-Alopecuretum pratensis*
21	Hortobágy	HNP	2004	*Artemisio-Festucetum pseudovinae+ Camphorosmetum annuae*
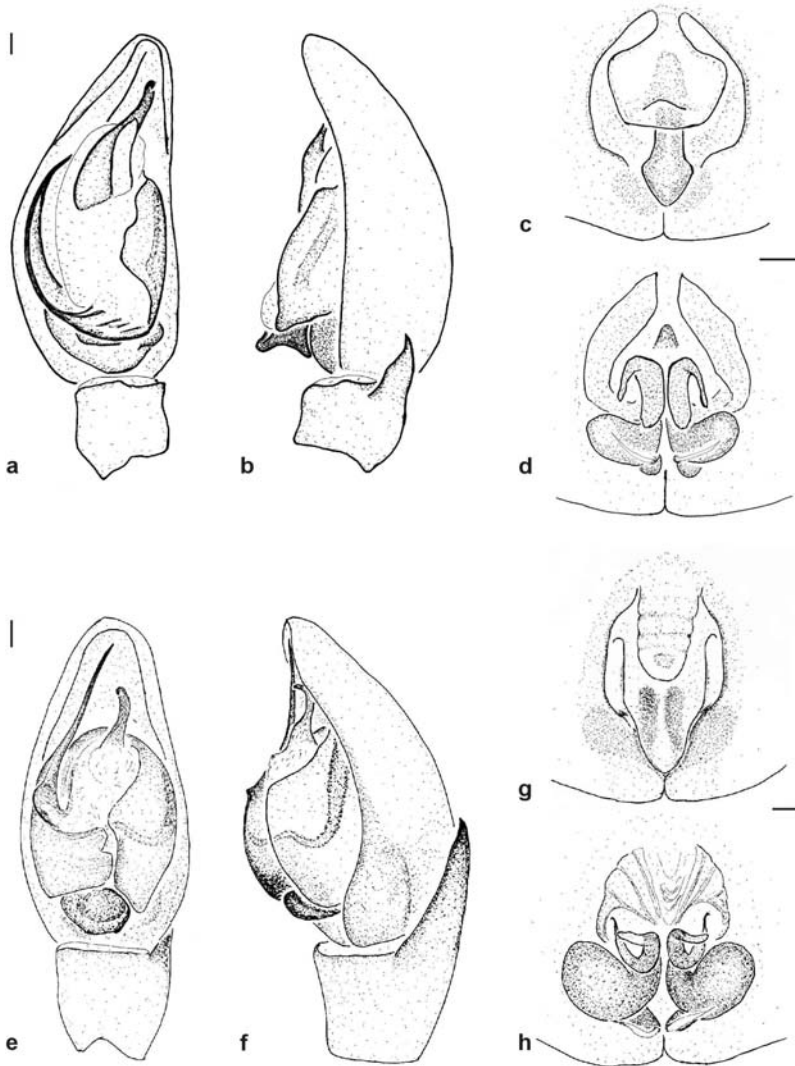
Fig. 2. *G. mongolica*: **a** - male palp, ventral view; **b** - retrolateral view; **c** - epigyne; **d** - spermatheca. *G. rufula*: **e** - male palp, ventral view; **f** - retrolateral view; **g** - epigyne; **h** - spermatheca. Scale lines: 0.1 mm

hollow communities. These rills are eroded shallow depressions with bare or sparsely vegetated saline soils, dry (*Camphorosmetum annuae*) or moist (*Puccinellietum limosae*) in spring and prone to white salt efflorescences.

Salt-marsh meadow communities (*Festuceto-Puccinellietalia*) are also associated with saline steppes. They mainly consist of medium tall often tussock-forming grasses developed on summer-dry carbonate-poor clay soils (*Agrostio-Beckmannietum eruciformis*) and on silt accumulations, in particular of drift lines of larger marshes and along rills (*Agrostio-Alopecuretum pratensis*).

Phenology

Both species are stenochronous – adult specimens can be collected mainly from April to August (Fig. 3). Individuals of *G. mongolica* overwinter in Hungary in juvenile or subadult stages and the first adult spiders appear at the beginning of April, while most of matures in May. Specimens
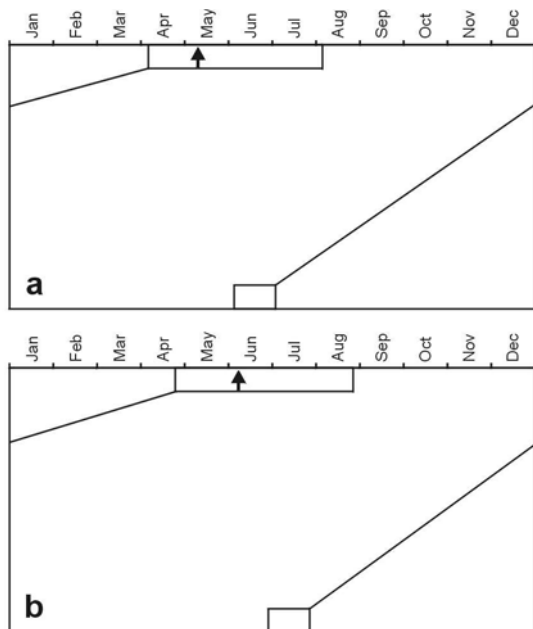
Fig. 3. Phenology of *G. mongolica* (a) and *G. rufula* (b). The figure covers one year. Small rectangle in the upper part of the figure = period of adulthood, the arrow in it = time of copulation. Small rectangle at the bottom = egg-laying period. Solid line = rate of development.

of *G. rufula* overwinter mainly as juveniles, the first adult spiders appear at the end of April and most of the individuals mature in June.

Hungarian spider fauna can be considered a well studied one (SAMU, SZINETÁR 1999). Exploration of special habitats like the extremely dry sandy grasslands and saline steppes, however, lead to surprising results: the discovery of two poorly known gnaphosid species with a relatively large body size which proved to be the dominant species of their respective habitat. The reasons for previous underestimation of the amount of these two species in the Hungarian arachnofauna might be the narrow niche of the species and the sparse data on these specific habitats. Taking into consideration their occurrence in such particular habitats (DEVILLERS 2000), the presence of *G. mongolica* and *G. rufula* can also be expected in the countries of the Balkan Peninsula.

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Нови данни за паяците *Gnaphosa rufula* (L. KOCH, 1866) и *Gnaphosa mongolica* SIMON, 1895 в Унгария (Araneae: Gnaphosidae)

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(Резюме)

Дългогодишните изследвания на паяците, обитаващи тревни хабитати в Унгария, показват, че два слабо познати вида – *Gnaphosa rufula* и *G. mongolica*, са доминанти в някои специфични местообитания. *G. rufula* е сред най-често срещаните видове паяци около солени блата и ливади, докато *G. mongolica* живее в песъчливи пасища. И двата вида могат да бъдат намерени в периода от април до август. Представени са оригинални илюстрации на мъжки и женски копулаторни органи, основаващи се на новия материал. Новите находки оформят западната граница на ареалите на двата вида.

A contribution to the knowledge of the Turkish spider fauna (Araneae)

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Abstract: Six spider species, *Araneus quadratus* Cʟᴇʀᴄᴋ, 1757, *Parazygiella montana* (C.L. Kᴏᴄʜ, 1834), *Alopecosa etrusca* Lᴜɢᴇᴛᴛɪ, Tᴏɴɢɪᴏʀɢɪ, 1969, *Arctosa stigmosa* (Tʜᴏʀᴇʟʟ, 1875), *Heliophanus cupreus* (Wᴀʟᴄᴋᴇɴᴀᴇʀ, 1802) and *Talavera aequipes* (O. P.-Cᴀᴍʙʀɪᴅɢᴇ, 1871), are reported for the first time from Turkey. Their morphology is briefly described and illustrated.

Key words: new records, *Araneus quadratus*, *Parazygiella montana*, *Alopecosa etrusca*, *Arctosa stigmosa*, *Heliophanus cupreus*, *Talavera aequipes*, Turkey

Introduction

The spiders of Turkey are insufficiently studied as hitherto only 613 species have been registered on the territory of the country (Tᴏᴘçᴜ *et al*. 2005). Taking into account the unique geographic position of the country as a bridge between Europe and Asia Minor, a much higher species diversity is expected, especially when the investigations are laid on a systematic ground. In comparison, the spider faunas of Bulgaria, Germany, Greece and Russia number 985 (Dᴇʟᴛsʜᴇᴠ, Bʟᴀɢᴏᴇᴠ 2001), 925 (Kᴏᴘᴏɴᴇɴ 1993), 856 (Bᴏsᴍᴀɴs, Cʜᴀᴛᴢᴀᴋɪ 2005) and 1974 species (Mɪᴋʜᴀɪʟᴏᴠ 2002), respectively. The present study reports six species new for the Turkish araneofauna. Information about the species morphology, exact locality and general distributions is provided for each species.

Material and Methods

The material were collected by pitfall trapping, or manually under stones and on plants, and were preserved in 70% ethanol. The identification and drawings were made by using SZX9 Olympus stereomicroscope with a camera lucida. The keys of Hᴇɪᴍᴇʀ, Nᴇɴᴛᴡɪɢ (1991), Rᴏʙᴇʀᴛs (1995), and Lᴏᴄᴋᴇᴛ, Mɪʟʟɪᴅɢᴇ (1951, 1953) were used for the species' identification. All measurements reported in the text are in millimetres. The material is deposited in the Arachnology Museum of Niğde University (NUAM).

Results

Araneus quadratus Cʟᴇʀᴄᴋ, 1757

Material examined: 1♀, Adana province, Belemedik, 15.VII.2002, found in the grass.

Female: Body length: 12.8; carapace length: 4.52, width: 5.96; length of legs: I - 22.9, II - 19.5, III - 14.2, IV - 20.8; leg I: coxa - 1.82, trochanter - 0.98, femur - 6.04, patella - 2.44,

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tibia- 4.88, metatarsus - 4.72, tarsus - 2.2. Carapace with extremely variable colours: pale yellow - greenish, orange and reddish-brown; edge darker. Chelicerae - brown. Opisthosoma: usually greenish-yellow varying to full red-brown, but always with 4 large, white spots. Sternum - elliptic, black, with bright central spot. Legs - light brown. Epigyne (see Fig. 1).

General distribution: Palearctic (PLATNICK 2006)

Parazygiella montana (C.L. KOCH, 1834)

Material examined: 7♀, Niğde province, 06.VII.2001. Found on tree trunks and rocks.

Female: Body length: 4.96-7.12; carapace length: 1.44-2.04, width: 1.68-2.56; length of legs: I - 6.36-9.58, II - 9.56-12.64, III - 4.08-6.44, IV - 5.14-8.24; leg I: coxa - 0.52-0.86, trochanter - 0.32-0.58, femur - 1.94-2.5, patella - 0.86-1.12, tibia - 1.38-1.96, metatarsus - 1.12-1.74, tarsus - 0.74-1.04. Carapace - brown with some white hairs. Opisthosoma - brown-yellowish, with four black spots. Sternum - oval, faintly sharp at the apex. Legs - yellow but articulary regions are very dark. Epigyne (see Fig. 2).

General distribution: Palearctic (PLATNICK 2006)

Alopecosa etrusca LUGETTI, TONGIORGI, 1969

Material examined: 2♀♀, Ankara province, 21.V.2004; 1♀, Osmaniye province, Kadirli district, Maksutoğlu plateau, 22.V.2002. Found on the ground.

Female: Body length: 17.42-18.5; carapace length: 7.92-8.52, width: 5.88-6.16; length of legs: I - 20.54-23.16, II - 19.66-22.78, III - 18.96-21.88, IV - 24.84-27.58; leg I: coxa - 2.14-2.32, trochanter - 1.34-1.66, femur - 5.08-5.84, patella - 1.92-2.32, tibia - 3.78-4.02, metatarsus - 3.94-4.26, tarsus - 2.34-2.74. Carapace - dark brown, ocular area black, lateral longitudinal bands yellowish, median band light, reticular black stripes in the centre. Opisthosoma - dark brown, with clear heart-like mark. Sternum - oval, black. Legs - yellow-brown, all coxae blackish, femora yellow, with black spots. Epigyne (see Fig. 3).

General distribution: Italy to Central Asia (PLATNICK 2006).

Arctosa stigmosa (THORELL, 1875)

Material examined: 1♂, Niğde province, 06.V.2001. Found on the ground.

Male: Body length: 7.32; carapace length: 3.82, width: 2.74; length of legs: I - 11.54, II - 9.44, III - 10.18, IV - 14.22; leg I: coxa - 1.24, trochanter - 0.66, femur - 2.64, patella - 0.95, tibia - 2.18, metatarsus - 2.34, tarsus - 1.52. Carapace - dark brown, ocular area very dark, median band not very clear, lateral bands clear, with two black lines between ocular area and fovea. Opisthosoma - blackish, with yellow-greenish longitudinal band covering half of the opistosoma. Sternum - oval. Legs - yellowish, covered with fine hairs. Male palp (see Fig. 4).

General distribution: Palearctic (PLATNICK 2006)

Heliophanus cupreus (WALCKENAER, 1802)

Material examined: 1♂, Ankara province, Kızılcahamam district, 21.V.2003. Found on low vegetation.

Male: Body length: 3.82; carapace length: 1.98, width: 1.42; length of legs: I - 3.97, II - 3.78, III - 4.25, IV - 6.22; leg I: coxa - 0.42, trochanter - 0.32, femur - 1.02, patella - 0.44, tibia - 0.82, metatarsus - 0.58, tarsus - 0.52. Carapace - dark brown-reddish, ocular area - dark brown or black, covered with some black and white hairs. Opisthosoma - grey, with metallic sheen and white hairs, with two white spots near the anterior spinnerets. Sternum - oval, black and shiny, covered with sparse white hairs. Legs - yellow-brown, with femora very dark; black lines present
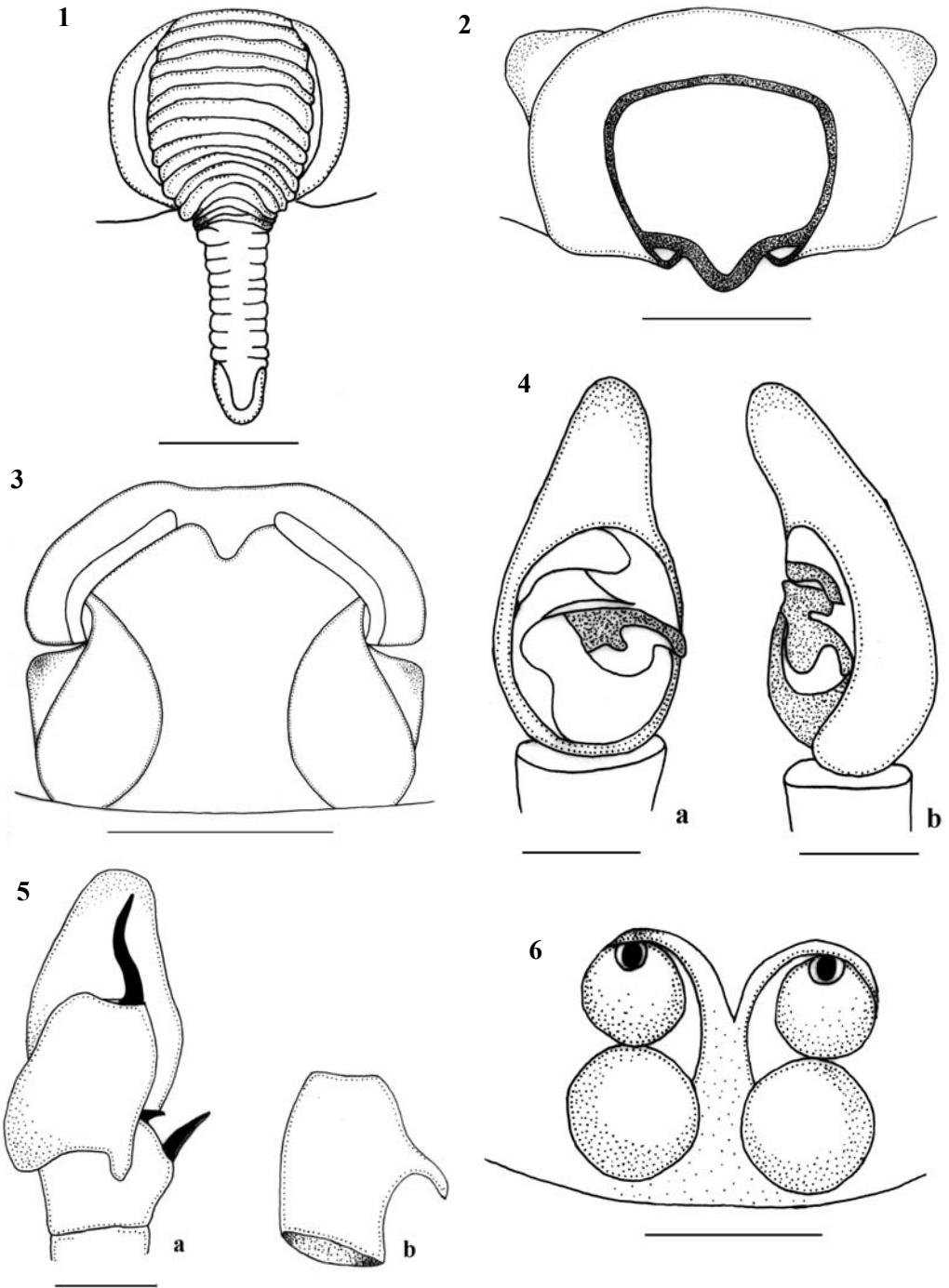
Figs. 1-6. 1 − *Araneus quadratus* Clerck, 1757: epigyne, ventral view. 2 − *Parazygiella montana* (C. L. Koch, 1834): epigyne, ventral view. 3 − *Alopecosa etrusca* Lugetti, Tongiorgi, 1969: epigyne, ventral view. 4 − *Arctosa stigmosa* (Thorell, 1875): male palp: a − ventral view, b − retrolateral view. 5 − *Heliophanus cupreus* (Walckenaer, 1802): male palp: a − ventral view, b − femoral apophyse. 6 − *Talavera aequipes* (O. P.-Cambridge, 1871): epigyne, ventral view. Scale lines: 0.5 mm.

along both sides of femur and tibia of all pairs of legs. Male palp (see Fig. 5) yellow to yellowish-brown, embolus long, tibial apophysis with a thin process.

General distribution: Palearctic (Bosmans, Chatzaki 2005)

Talavera aequipes (O. P.-Cambridge, 1871)

Material examined: 1♀, Ankara province, Çubuk district, 16.V.2003. Found under a willow tree.

Female: Body length: 5.42; carapace length: 2.02, width: 1.62; length of legs: I - 4.45, II - 4.08, III - 4.86, IV - 5.64; leg I: coxa - 0.52, trochanter - 0.42, femur - 1.28, patella - 0.6, tibia - 0.82, metatarsus - 0.55, tarsus - 0.44. Carapace - dark brown-blackish with some yellowish hairs, ocular area - black covered with numerous yellowish hairs. Opisthosoma - longer than carapace; black, with brownish spots, covered with whitish hairs. Sternum - oval, blackish with a small yellowish area in the centre. Legs - brown-yellowish. Leg I - darker than others. Epigyne (see Fig. 6).

General distribution: Palearctic (Bosmans, Chatzaki 2005)

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Принос към аранеофауната на Турция (Araneae)

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(Резюме)

За първи път от територията на Турция се съобщават шест вида паяци: *Araneus quadratus* Clerck, 1757, *Parazygiella montana* (C. L. Koch, 1834), *Alopecosa etrusca* Lugetti, Tongiorgi, 1969, *Arctosa stigmosa* (Thorell, 1875), *Heliophanus cupreus* (Walckenaer, 1802) и *Talavera aequipes* (O. P.-Cambridge, 1871). Представени са данни за морфологията на всеки един от видовете, както и илюстрации на таксономично важни белези.

Detection of *Borrelia burgdorferi* sensu lato, *Anaplasma phagocytophilum* and Spotted Fever Group Rickettsiae in ticks from the region of Sofia, Bulgaria (Acari: Parasitiformes: Ixodidae)

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Abstract: The aim of this study is to determine the prevalence of a number of bacterial pathogens in ticks from Sofia region. The data on prevalence for *Borrelia*, *Anaplasma* and *Rickettsia* in ticks can be used to assess the risk for human health of tick-borne diseases. Up to now, only a few surveys on the presence of *Borrelia* and *Anaplasma* in ticks from Bulgaria exist. Detection of *Rickettsia* spp. in ticks corresponds to the risk of tick-borne rickettsioses, because of existence of pathogenic and apathogenic rickettsiae. The high prevalence of tick-borne pathogens found revealed many cases of co-infections. Our data showed that about half of the males and one third of the tick females were simultaneously infected with two or three pathogens. Furthermore, the risk for humans to be infected becomes very high after a long stay of the tick in the skin.

Key words: *Ixodes*, *Rickettsia* spp., tick-borne diseases, co-infections

Introduction

Nowadays, tick-borne diseases are of great interest to the medical science. Lyme borreliosis is the most common tick-borne disease in the Northern Hemisphere. The etiological agent, *Borrelia burgdorferi* sensu lato, is transmitted by *Ixodes ricinus* Lᴀᴛʀᴇɪʟʟᴇ, 1795 ticks in Europe. The complex *B. burgdorferi* sensu lato, has been divided into a number of genospecies: *B. burgdorferi* sensu stricto, *B. afzelii* Cᴀɴɪᴄᴀ *et al.*, 1994 and *B. garini* Bᴀʀᴀɴᴛᴏɴ *et al.*, 1992 (Bᴀʀᴀɴᴛᴏɴ 1992, Cᴀɴɪᴄᴀ 1993, Jᴏʜɴsᴏɴ 1984). Some other species with still-questionable pathogenicity have been found in European *I. ricinus* ticks (Wᴀɴɢ 1997, Lᴇғʟᴇᴄʜᴇ 1997). The anaplasmosis had been a well known disease of domestic animals until 1980, but later it became associated with human infection as well. There are many reports of granulocytic anaplasmae-infected *I. ricinus* ticks – the main vector of the disease and some polymerase chain reaction (PCR) -proved cases of HGA have been reported in patients (Kᴀʀʟssᴏɴ 2001, Tʏʟᴇᴡsᴋᴀ-Wɪᴇʀᴢʙᴀɴᴏᴡsᴋᴀ 2001).

The etiological agents of rickettsioses belong to the genus *Rickettsia* divided into two groups: the typhus group and the spotted fever group. Mediterranean spotted fever is transmitted mainly by *Rhipicephalus sanguineus* Latᴦᴇɪllᴇ, 1806 ticks, and presents itself with tache noire, high fever, rash, headache, myalgia and arthralgia. Prevalence data for *Rickettsia* in ticks can be used to assess the risk of tick-borne disease for public health, because of existence of pathogenic and

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apathogenic rickettsiae. Up to now, only a few surveys on *Borrelia, Anaplasma* and *Rickettsia* prevalence in ticks from Bulgaria exist. The aim of this study is to determine the prevalence of the number of bacterial pathogens in ticks from the Sofia region.

Materials and Methods

The ticks were collected by flagging vegetation in the wooded area of the Sofia region in May 2005. The ticks were determined by sex and stage: 96 females, 70 males, 80 nymphs. The DNA was extracted using phenol-chloroform as described previously (Christova 2001). The ticks were mechanically homogenized in lysing buffer consisting of 10 mM Tris, 1 mM EDTA, 100 µg/ml proteinase K and 0.5% Soium dodecyl sulfate. After 1h of incubation at 60ºC and 10 min of boiling, 5 mM NaCl and 5 mM CTAB were added, and the samples were incubated at 65ºC for 20 min. DNA was precipitated with isopropanol, washed with 70% ethanol, air dried, and dissolved in 10 mM Tris, pH8. All DNA extracts were stored at -20ºC until usage. Two microliter aliquots of the tick extracts were amplified in 25 µl PCRs using *B. burgdorferi* sensu lato specific primers: LD primers (Marconi 1992), *Anaplasma* specific primers LA1/LA6 (Walls 2000) and *Rickettsia* specific primers Rick 16S For and B-Rick 16S Rev (Christova 2003b). Each PCR run included samples containing DNA of the various species as positive controls. Each PCR run also included negative controls containing PCR mix with water added instead of DNA extract. For typing of the complex *B. burgdorferi* sensu lato primers for genospecies were used: *B. burgdorfer* senso stricto BB1/BB2; *B. garinii* – BG1, BG2; *B. afzelii* – BA1/BA2. All ticks were studied for presence of *Borrelia* using dark field microscopy (D.F.M.). A detailed description of the method and its estimation was published previously (Tasseva 1999)

Results and Discussion

A total of 246 *I. ricinus* ticks were examined. The largest number of ticks harbouring borreliae was found among the females – 29% (28/96), followed by the males – 19% (13/70) (Table 1). It was lowest among the nymphs – 10% (8/80). This correlated with the data from other areas in Bulgaria (Atova 1993, Georgieva 1995) and confirmed the presence of transstadial transmission of borreliae in ticks. The largest number of *B. burgdorferi* sensu lato RCR-positive ticks was found among the males – 40% (28/70). The prevalence of the *B. burgdorferi* sensu lato complex was 35% (34/96) in females and the least – 14% (11/80) in nymphs. *B. afzelii* was the predominant species in the adults with prevalence of 19% (31/166). In the second place was *B. burgdorferi* sensu stricto species which was detected in 11% (18/166) of the adult ticks and in 3% (2/80) of the nymphs. Approximately 2% of the adult ticks and 1% of the nymphs carried simultaneously more than one *B. burgdorferi* species. Nineteen percent (32/166) of the adult ticks and 4% (3/80) of the nymphs harboured *Anaplasma phagocytophilum*.

Thirty one percent (52/166) of the adult ticks and 16% (13/80) of the nymphs were found to carry *Rickettsia* species. Our data showed good correlation between positive results from two methods: D.F.M. and PCR. The adults were more infected than nymphs. The differences were due to the different sensitivity and specificity of the two methods.

Three kinds of co-infections were found in *I. ricinus*: *Borrelia + Rickettsia, Anaplasma + Rickettsia*, and *Borrelia + Anaplasma*. *Borrelia* and *Anaplasma* co-infections in ticks have been reported by a number of authors (Schouls 1999, Jenkins 2001, Baumgarten 1999). Co-infections with these pathogens in patients have been confirmed by studies in the USA, Europe (Tissot-Dupont 1994, Nadelman 1997). Nineteen percent (18/96) of triple infections with agents were found in the females, 27% (19/70) - in the males, and 1% (1/80) - in the nymphs. Up to now only a few surveys on *Borrelia* and *Anaplasma* prevalence in ticks from Bulgaria have been carried

Table 1. Distribution of *Borrelia, Anaplasma* and *Rickettsia* species in *Ixodes ricinus* ticks.

Positive results:	No (%)	of	ticks					
	Female (n=96)		Males (n=70)		Adults (n=166)		Nymphs (n=80)	
D.F.M. *Borrelia*	28	(29)	13	(19)	41	(25)	8	(10)
PCR *Borrelia burgdorferi* sensu lato	34	(35)	28	(40)	62	(37)	11	(14)
PCR *Borrelia burgdorferi* sensu stricto	8		10		18		2	
PCR *Borrelia afzelii*	18		13		31		4	
PCR *Borrelia garinii*	5				5		5	
PCR *Borrelia* unspeciated	3		5		8			
PCR, ticks, infected with two *Borrelia* species	3				3		1	
PCR *Anaplasma phagocytophilum*	25	(26)	7	(10)	32	(19)	3	(4)
PCR *Rickettsia* species	23	(24)	29	(41)	52	(31)	13	(16)
PCR *Borrelia* + *Rickettsia*	8	(8)	7	(10)	15	(9)	2	(3)
PCR *Anaplasma* + *Rickettsia*	4	(4)	10	(14)	14	(8)	2	(3)
PCR *Borrelia* + *Anaplasma*	3	(3)	1	(1)	4	(2)		
PCR *Borrelia* + *Rickettsia* + *Anaplasma*	18	(19)	19	(27)	37	(22)	1	(1)

out (Chr ist ova 2001, 2003b). The high prevalence of tick-borne pathogens found revealed many cases of co-infections. Our data showed that about half of the males and one third of the females were infected simultaneously with two or three pathogens. Furthermore, the risk of human infection is very high due to the long stay of ticks in the skin.

However, co-infections with three microorganisms – *Borrelia, Anaplasma* and *Rickettsia* were found more frequently than co-infections with two microorganisms (Chr ist ova 2003a). There was a remarkable difference between prevalence rates established for the different sexes of the adult ticks. It is unclear what is causing these changes and whether they have any biological significance. Changes in prevalence are probably determined by many factors: animal reservoirs, temperature, humidity, etc. *B. afzelii* was the most common *Borrelia* species in all ticks that correlates with the most common clinical manifestation of late Lyme borreliosis in Bulgaria - neuroborreliosis (St oil ov 1995). Some of the *Ixodes* ticks were co-infected with different genera and/or species of the same genus. These ticks may be infected with multiple tick-borne pathogens which predetermines a possibility of simultaneous transmission during a single tick bite. The results of this

study show that many tick-borne diseases are probably endemic in Bulgaria. Further investigations based on molecular-biological methods will be useful to reveal the regional characteristics of these microorganisms.

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Установяване на *Borrelia burgdorferi* sensu lato, *Anaplasma phagocytophilum* и рикетсии от групата на петнистите трески в кърлежи (Acari: Parasitiformes: Ixodidae) от района на град София (България)

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(Резюме)

Целта на проучването е да установи разпространението на някои бактериални патогени в кърлежи от района на град София. Данните за наличието на *Borrelia*, *Anaplasma* и *Rickettsia* в тях са от голямо значение при оценката на риска от заразяване на човека със съответната инфекция, предавана чрез кърлежите. До момента проучвания за заразеността на кърлежите с *Borrelia* и *Anaplasma* в страната са доста оскъдни. Установяването на видове от род *Rickettsia* съответства на риска от причинените от кърлежи рикетсиози. Големият брой патогени показва наличието на взаимно заразяване. Резултатите показват още, че половината от мъжките и една трета от женските кърлежи са заразени с два или три инфекциозни агента едновременно. Особено висок е рискът за заразяване на човека при дълъг престой на кърлежа върху кожата.