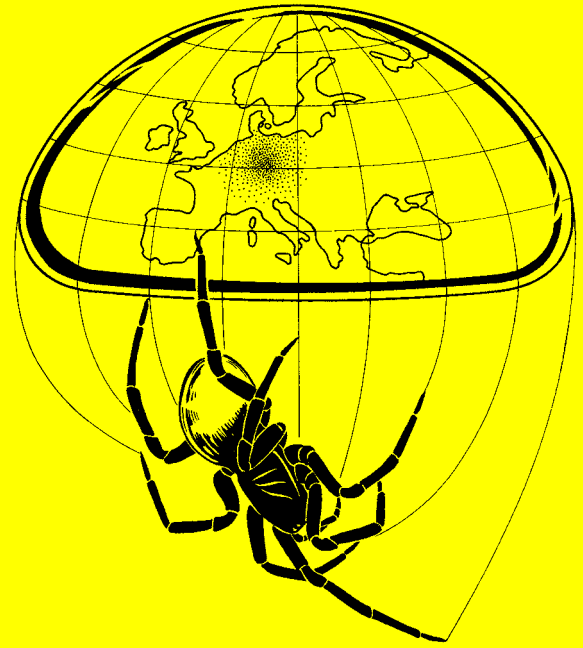
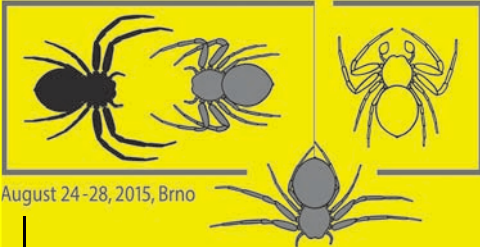


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29th European Congress of Arachnology



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Arachnology 2015

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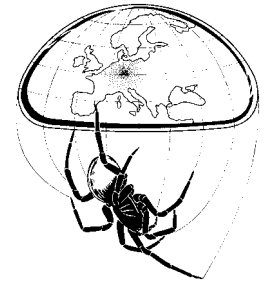
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Preface to the Proceedings of the 29th European Congress of Arachnology, Brno, 2015 August 24-28

At the 28th European Congress in Torino I was approached by the society president, Wolfgang Nentwig, with the question whether I could organise the next congress because the society had not received an invitation for 2015. I was surprised and astonished at the same time by his request and had to think for a couple of days about it. I have to admit that I was planning to organise a congress in a near future. But 2015 was very near – only 11 months to go. After checking out the possibilities I decided to make it.

Before this congress there have been two international arachnology meetings organised in the Czech Republic over an approximately 20-year period. In 1971 there was the 5th International Congress of Arachnology in Brno; and in 1994 there was the 15th European Colloquium of Arachnology in České Budějovice.

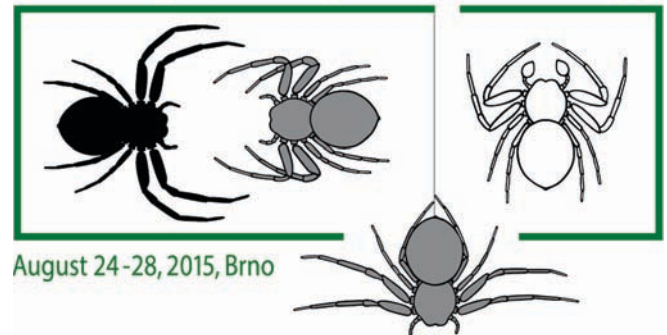
I assembled a team composed of three co-organisers (Vladimír Hula, Jana Niedobová, Yuri Marusik), two secretaries (Ivana Tarabová and Hana Bezděková from the TA-Service), the photographer (Radek Šich), English editor (L. Brian Patrick), editor of publications (Šárka Mašová) and a number of helpers (Guadalupe Corcobado, Lucie Havlová, Ondřej Košulič, Eva Líznarová, Radek Michalko, Ondřej Michálek, Lenka Sentenská, Zdeněk Škopek). A couple of other members of the Czech Arachnological Society gave a helpful hand (Petr Dolejš, Martin Forman, Pavel Just, Tomáš Krejčí, Ondřej Macháč).

The 29th European Congress of Arachnology was jointly organised by the Masaryk University, Czech Arachnological Society and Mendel University. It began on Saturday morning with an intensive two-day workshop on IUCN Red Listing – concepts and tools, led by Pedro Cardoso. There were about 10 participants from all over the world. The other workshop announced, Experimental design and modern data analysis, was cancelled due to insufficient interest. Most of the participants, however, turned up on Sunday afternoon. They were greeted by a young blond (cardboard) lady, who became a regular participant over the week.

During the Opening Ceremony the honorary committee member, Jan Buchar, gave a short commemorative speech on the congress from 1971; sadly 3 months later Jan passed away (see the obituary in this volume). Then Vlastimil Růžička reminded us the atmosphere of the České Budějovice colloquium. And finally, Peter Dvořák, the vice-rector of Masaryk University, spoke about the university.

Brno is the city of Johann Gregor Mendel, the father of a modern genetics. In 2015 we were commemorating 150 years since he gave a lecture about the results of breeding experiments at the meeting of the Natural History Society in Brno. And therefore the main emphasis of the congress was on Mendel's legacy: the first plenary lecture was on developmental genetics (by Wim Damen), there was a major session on arachnid cytogenetics, the Opening Party was at the Mendel museum and the logo of the congress was inspired by Mendel's discovery of the genotypic ratio (1:2:1) for heterozygotes in the F1 generation (the three different colours, while the different spider postures represented ecology, behaviour, physiology and taxonomy).

29th European Congress of Arachnology



The congress was attended by 169 participants and accompanying persons from 36 countries across the globe, with a dominance of local (Czech) arachnologists (23 %), followed by Germans and Slovenians. The programme had a traditional structure: scientific sessions were held over four days, followed by a social programme in the evening. One exception was the Arachnological Games (we played the Kubb in teams) followed by a barbecue at the Starobrno restaurant. In comparison with the previous congresses the ESA assembly was held on Thursday. The main task of the assembly was to approve new by-laws of the society.

The scientific programme included 13 sessions. Although there was a proposal for two symposia prior to the congress – one for 'Ecosystem services and adaptation' and 'Diversification of spider silks: how and why do new silk phenotypes evolve?' – none was eventually organised (due to low interest in the topics). The largest sessions were on Behavioural ecology, Ecology and Cytogenetics of arachnids. Altogether there were 61 oral communications and 75 posters. The sessions were arranged to avoid parallel sessions. Beside sessions, there were four plenary talks, at the beginning of each of four days of talks. Wim Damen from the Jena University in Germany, opened the congress with his talk on how genes control segmentation during ontogenetic development in a theridiid spider. Gabriele Uhl from the University of Greifswald in Germany spoke about various facets of mating behaviour in the cannibalistic spider, *Argiope bruennichi*. Jordi Moya-Laraño from the Experimental Station of Arid Zones in Spain presented a simulation program on eco-evolutionary dynamics in complex food webs. Finally, on the very last day Jonathan Pruitt from the University of Pittsburgh in the US, presented results on the personality of spiders.

On Wednesday there were the mid-congress excursions. Participants could choose to take one of three trips. Luckily, the weather was nice. One was a collecting trip in the Pavlovské vrchy Hills protected area and nearby areas which are located south of Brno. Participants could see some rare arthropods, including spiders on dry grasslands. At the end of the trip they visited Křivé jezero Nature Reserve, a water meadow between two rivers. The largest group of participants took the cornucopia trip that included bits of everything: spider collection, sight-seeing and wine tasting. They went to Mikulov town which is located at the foot of Pavlovské vrchy. In the



1 Konrad Wiśniewski, 2 Henning Haase, 3 Arthur Decae, 4 Iván Prazsak, 5 Davide Ruiu, 6 Luiz Filipe Bartoleti, 7 Paula Cushing, 8 Nik Lupšė, 9 Artem Sozontov, 10 Inese Cera, 11 Seppo Koponen, 12 Marjan Komnenov, 13 Heli Humme, 14 Ondřej Machač, 15 Robert Tropek, 16 Hana Svojanovská, 17 Matjaž Gregorič, 18 Shakira Quiñones-Lebrón, 19 Lenka Kubcová, 20 Miguel Richard, 21 Věra Opatová, 22 Fabian Hofmann, 23 Ren-Chung Cheng, 24 Matjaž Kuntner, 25 Gabriele Uhl, 26 Stanislav Korenko, 27 Wolfgang Nentwig, 28 Zdeněk Škopek, 29 Ravid Steimpress, 30 Rahsen Kaya, 31 Igor Armiach, 32 Eisen Yagmur, 33 Ondřej Michálek, 34 Ulla Thyssen, 35 Søren Toft, 36 Francesco Ballarín, 37 Lenka Sentenská, 38 Liana Lasut, 39 Igor Gajič, 40 Marco Isaià, 41 John Hågmo, 42 Lucia Kuhn-Nentwig, 43 Holger Frick, 44 Christoph Hörweg, 45 Daniel Gloor, 46 Lenka Petráková, 47 Lukasz Trębicki, 48 Augustine Niba, 49 Jiří Král, 50 L. Brian Patrick, 51 Wim Damen, 52 Christo Deltshev, 53 Christian Kropf, 54 Tamás Szűts, 55 Marika Fedorák, 56 Elisabeth Bauchenfl, 57 Peter Jäger, 58 Anne-Sarah Ganske, 59 Andzej Tanasevitch, 60 Shou-Wang Lin, 61 Rimma Seyfullina, 62 Tomas Nowicki, 63 Nina Polchaninova, 64 Christoph Muster, 65 Vardit Makover, 66 Gordana Grbić, 67 Maciej Barros, 68 Nollie Hallensleben, 69 Gábor Kovács, 70 Roland Horváth, 71 František Stáhlavský, 72 Peter Gajdoš, 73 Anna Šestáková, 74 Pavel Žila, 75 Katrin Kunz, 76 Anja Jungmann, 77 Guilherme Gainett, 78 Pedro Cardoso, 79 Jordi Moya-Laraso, 80 Theo Blick, 81 Marek Zábka, 82 Madeleine Miller, 83 Jan Dolanský, 84 Jāša Lokovšek, 85 Vlastimil Růžička, 86 Jan Raška, 87 Petr Doléž, 88 Milan Režáč, 89 Thiago Kloss, 90 Marlis Dumke, 91 Eva Liznarová, 92 Jan Ehart, 93 Vladimír Hula, 94 Jens Runge, 95 Sara Normark, 96 Matyáš Hiiman, 97 Janet Beccalon, 98 Pavel Just, 99 Jonathan Pruitt, 100 Lior Ventura, 101 Alba Cherubini, 102 Alessio Trotta, 103 Luka Katušić, 104 Martina Pavlek, 105 Elena Piano, 106 Stefano Mammola, 107 Phillip Steinhoff, 108 Jana Niedobová, 109 Jana Frisová-Christophoryová, 110 Katarína Krajčovičová, 111 Jesús Hernández Corral, 112 Jana Kotrbová, 113 Jana Pišková, 114 Orsolya Belenzai, 115 Csaba Szinetár, 116 Hirotsugu Ono, 117 Yael Lubin, 118 Karin Sindemark Kronestedt, 119 Torbjørn Kronestedt, 120 Eran Avital, 121 Robert Bosmans, 122 Marij Declere, 123 Rudy Jocuqué, 124 André Walter, 125 Blerina Vrenozzi, 126 Jagoba Malumbres-Olarte, 127 Azucena Claudia Reyes, 128 Sara Goodacre, 129 Rebecca Wilson, 130 Cor Vink, 131 Peter van Helsingingen, 132 Peter Kozel, 133 Paul Seiden, 134 Maura Seiden, 135 Lucie Havlová, 136 Manielle van Dam, 137 Marnix Bos, 138 Jutta Schneider, 139 Simona Krajič-Fišer, 140 Efrat Gavish-Begev, 141 Christian Komposch, 142 Stano Pekár (photo: R. Šich)



Jan Buchar, the honorary committee member

morning they walked up the hill, a protected area and could see some Pannonian spider species. Then they took a short walk through the historical centre of the town, visited a wine-producing company where they learned about the wine biological production process and tasted wine. The smallest group of attendees explored the Lednice-Valtice Cultural Landscape, a UNESCO World Heritage Site; a large landscape area famous for the masterful integration of various architectural structures, chateaux and French-style gardens. The participants walked up the stairs (to heaven) of a Minaret, took a boat trip and saw beavers' constructions, to reach a romantic castle ruin, the John's Castle. In the evening we returned to Brno for the big social event, the Russian party. There was lots of fine caviar and fish provided by Yuri Marusik, home-made whiskeys from all corners of Europe and music provided by a DJ.

A couple of participants went for the post-congress excursion to the Podyjí (Thaya) National Park situated along the deep Dyje River valley. We visited the underground city of Znojmo, tasted wine in the old monastery cellars of Znovín winery, took a boat trip to the early medieval Bítov Castle where we practiced archery and explored stuffed dogs.

During the Closing Ceremony awards were presented. There were 64 student presentations registered for the competition. I wish to congratulate again the students that received an award for their oral presentation or a poster. Altogether 12

students were awarded, six for oral presentations and six for posters. The awards were given in two categories. In Ecology and Behaviour the best oral presentations were: 1. Lenka Sentenská (Czech Republic), 2. Eva Líznarová (Czech Republic), 3. Andreas Fischer (Germany). The best posters were: 1. Thiago Kloss (Brasil), 2. Marlis Dumke (Germany), 3. Elena Piano (Italy). In Taxonomy and Genetics (which actually covered also other topics not mentioned in the title) the best oral presentations were: 1. Stefano Mammola (Italy), 2. Luka Katušić (Croatia), 3. Liana Lasut (Switzerland). The best posters were: 1. Guilherme Gainett (Brasil), 2. Nik Lupše (Slovenia), 3. Matyáš Hiřman (Czech Republic). The evaluating committees had to work hard throughout the whole week.

Beside the student awards, the Arachnological cup was given for non-scientific activities at the ceremony. The winner of the Arachnid Film competition, Lukáš Pich, was awarded for his film named "Wolf Spider: The mother". The best team of the Kubb, called THUG Greifswald (composed of Jens Runge, Katrin Kunz, Guilherme Gainett, Tomas Nowicki, Shou-Wang Lin) won a cup too.

I should not forget to mention the sponsors of this congress. Without the generous financial help of Becherovka, Dynex, Ento Sphinx, Keyence International, Masaryk University, Mendel Museum, Nikon, Olympus, Regina Coeli, Réva Rakvice and Zeiss, the congress fee would have been much higher. Particular thanks goes to the European Society of Arachnology, American Arachnological Society, Grupo Ibérico de Aracnología, British Arachnological Society, Arachnologische Gesellschaft, Czech Arachnological Society and Siri Scientific Press for providing prizes for the student competition. Thanks to the support by European Society of Arachnology, Pensoft, Grupo Ibérico de Aracnología and Czech Arachnological Society, we were able to provide 18 student grants and to support six colleagues from low-income countries.

This Proceedings includes five contributions, two will follow in vol. 52, nine manuscripts were submitted.

At last but not least I would like to thank all participants for attending the congress and making it an unforgettable event (at least for me).

Stano PEKÁR

A collection of sea spiders (Pycnogonida: Pantopoda) in the National Museum, Prague (Czech Republic)

Petr Dolejš



doi: 10.5431/aramit5103

Abstract. The arachnological collection of the National Museum, Prague contains material preserved in ethanol and a microscopic slide of recent sea spiders (Pycnogonida: Pantopoda). The collection is small, containing only twelve specimens. A revision of all of them revealed the presence of nine species from five families: *Anoplodactylus lentus* Wilson, 1878, *Boreonymphon abyssorum* (Norman, 1873), *Callipallene* sp., *Endeis spinosa* (Montagu, 1808), *Nymphon grossipes* (Fabricius, 1780), *Nymphon hirtipes* Bell, 1853, *Nymphon stroemi* Krøyer, 1844, *Nymphon tenellum* (Sars, 1888) and *Pycnogonum litorale* (Ström, 1762). The material preserved in ethanol was collected in the North Atlantic Ocean and adjacent seas, the pycnogonid mounted on the slide was collected in Mediterranean. Four of the sea spiders came from the Sars collection (Bergen, Norway) and four specimens came from the V. Frič collection (Prague, Czech Republic). From these two sources, six specimens were mounted for exhibition and educational purposes. Although the collection contains no types, it introduces an interesting group of marine animals.

Keywords: Callipallenidae, Endeidae, Frič, Nymphonidae, Phoxichilidae, Pycnogonidae, Sars, zoological collection

I would like to dedicate this paper to two scientists who passed away in 2015: Roger Norman Bamber, a specialist on Pycnogonida, and Jan Buchar, an arachnologist and my supervisor.

Sea spiders (Pycnogonida) are strange looking, exclusively marine invertebrates feeding on sessile or slow-moving (or sometimes dead) animals. However, catching quick-moving prey was also reported (Lotz 1968). They are often considered the sister group of Euchelicerata, i.e. a class of the subphylum Chelicerata but alternative hypothesis also exist – see Dunlop et al. (2014) for a review.

Their body, termed the trunk, is extremely reduced and serves just as attachment for the legs. The first segment, the cephalosoma, contains four primordial segments that are telescoped into the first trunk segment – the first for an ocular tubercle with four eyes (may be absent) and a proboscis, and the next three giving rise to the appendage pairs of the chelifores, palps and ovigers. The fourth pair of appendages in the cephalosoma is the first pair of walking legs and belongs to the trunk (Winter 1980). Behind the cephalosoma, there are three trunk segments, each bearing a pair of nine-articled walking legs comprised from coxa 1, coxa 2, coxa 3, femur, tibia 1, tibia 2, tarsus, propodus and the main claw. There has been long-lasting controversy concerning which appendages are homologous among arthropods. According to Jäger et al. (2006), Manuel et al. (2006) and Brenneis et al. (2008), the pycnogonid appendages are homologous to those of euchelicerates and mandibulates as follows: chelifores ~ chelicerae ~ antennae I (innervated from deutocerebrum), palps ~ pedipalps ~ antennae II (innervated from tritocerebrum), ovigers ~ legs I ~ mandibles, legs I ~ legs II ~ maxillae I, legs II ~ legs III ~ maxillae II. The last (fourth) trunk segment bears the abdomen which is reduced to a small protuberance.

The reduced body of sea spiders causes several organ systems, like the intestine and gonads, to protrude into the legs, such that the genital openings are often located on the ventral surface of coxa 2 (usually of legs III and IV). Eggs are stored in the femora of all legs of the female. The typical first lar-

val form (feeding on cnidarians), the protonymphon, usually hatches from the eggs that are carried by the male in many families. The larval body possesses a proboscis, chelifores and two pairs of ambulatory legs that turn into palps and ovigers during ontogeny. Information about biology of sea spider can be found in Arnaud & Bamber (1987).

Catalogues of sea spiders were published by museums in Germany (Dunlop et al. 2007, Weis et al. 2011, Lehmann et al. 2014). The National Museum in Prague has already published catalogues of various non-type zoological material (e.g. Jiroušková et al. 2011, Mlíkovský et al. 2013, Dolejš & Vaňoušová 2015) and this paper continues by providing information about the sea spider collection in Prague.

Material and methods

All eleven ethanol-preserved pycnogonid specimens are kept in 80 % ethanol. Eight of them had been identified, three (plus the specimen mounted on the slide) only to genus level. Therefore, all specimens were first revised based on the literature mentioned below each species. Of the formerly identified specimens, only two of them had been identified correctly. Thus, labels with appropriate species names were put on the jars. Second, specimens were cross-referenced with the accessory catalogues. However, data for only four specimens were found in the catalogues (N^os 1876/1902, 19/1960/3066 and 19/1960/3109); the remaining specimens thus have a “general” number for Pycnogonida: P6d-9/2003 (P6j-118/1988 for the specimen mounted on the slide). Conversely, one specimen was not found in the collection despite being mentioned in the accessory catalogue from the year 1902: *Colossendeis proboscidea* (Sabine, 1824) from Bjørnøya (“W von Bären Insel”). This specimen had come to the National Museum in Prague as an exchange from the Museum für Naturkunde Berlin on 21 October 1902 (accessory N^o 1875/1902), but was either lost or destroyed. The remaining specimens in Berlin are deposited under N^o ZMB 19 (Dunlop et al. 2007).

The third step was the determination of sex and measuring body lengths using an Olympus SZX12 stereomicroscope equipped with an ocular micrometer. Males were recognized by the presence of cement gland openings and hairy swellings located distally on the fifth article of the ovigers helping the

This contribution was presented at the 29th European Congress of Arachnology, Brno, 2015 August 24-28.

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(nymphonid) males in carrying the eggs. Females were recognized according to the swollen femora of the legs (and sometimes eggs visible inside them) without cement glands and missing ovigers (except members of the families Callipallenidae and Nymphonidae where ovigers are also present in females but the swellings are lacking) (Bamber 2010). The body length in sea spiders means the distance between the anterior margin of the cephalosoma (i.e. without the proboscis) and posterior margin of the last (fourth) segment including the lateral processes but not the abdomen (Just 1972, Bamber 2010).

Current nomenclature and the Life Science Identifier numbers (lsid) were adopted from PycnoBase (Bamber et al. 2015). The species are arranged systematically according to Bamber (2010). Data for each specimen are arranged as follows: Material – number of specimens (with a note in the case they are mounted), their sex (body length), name of the collector, date of collection and locality. Identification – name on the original label and literature used for revision/redetermination/identification. Biology and ecology – any available data. Notes – if any.

Systematic list

Class: Pycnogonida Latreille, 1810

Order: Pantopoda Gerstäcker, 1863

Suborder: Eupantopoda Fry, 1978

Superfamily: Nymphonoidea Pocock, 1904

Family: Nymphonidae Wilson, 1878

Genus: *Boreonymphon* Sars, 1888

Boreonymphon abyssorum (Norman, 1873)

urn:lsid:marinespecies.org:taxname:134676

Material. 1 ♀ (7.0 mm) collected by F. A. Dohrn on an unknown date in the Barents Sea, RUSSIA (Fig. 1).

Identification. Originally labelled as *Boreonymphon robustum* Bell, redetermined according to Just (1972) and Bamber (2010).

Biology and ecology. Depth 500–2000 m (Bamber 2010).

Notes. Came to the National Museum as an exchange from the Museum für Naturkunde Berlin on 21 October 1902 (accessory N^o 1876/1902). The remaining specimens in Berlin are deposited in two vials under N^o ZMB 64 and are labelled as *B. robustum* (Dunlop et al. 2007). It is probable that they were also erroneously identified and that they are in fact *B. abyssorum* like the specimen deposited in Prague.

Genus: *Nymphon* Fabricius, 1794

Nymphon grossipes (Fabricius, 1780)

urn:lsid:marinespecies.org:taxname:134688

Material. 1 mounted pair: ♂ (5.5 mm) and ♀ (4.8 mm) without any data; ex. coll. V. Frič (N^o 19/1960/3066) (Fig. 2).

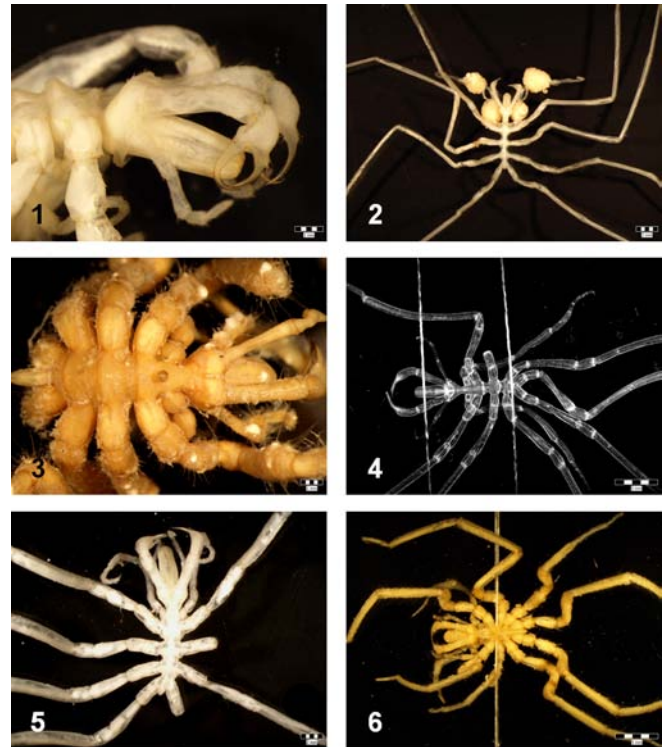
Identification. Originally labelled as *Nymphon* sp., identified according to Turpaeva (2009), Bamber (2010) and de Kluijver & Ingalsuo (2015).

Biology and ecology. Depth usually 6–400 m (Bamber 2010), on silty sand, rock and shells (Turpaeva 2009).

Nymphon hirtipes Bell, 1853

urn:lsid:marinespecies.org:taxname:134690

Material. 1 ♂ (8.0 mm) collected by an unknown collector on an unknown date in the Davis Strait; ex. coll. V. Frič (N^o 19/1960/3109) (Fig. 3).



Figs 1-6: Nymphonidae. **1.** *Boreonymphon abyssorum*, lateral view of the anterior part of the female body; **2.** *Nymphon grossipes*, an ovigerous male; **3.** *Nymphon hirtipes*, a male with malformed left chelifore; **4.** *Nymphon stroemi*, a mounted subadult specimen from Bergen; **5.** *N. stroemi*, a juvenile from the North Sea; **6.** *Nymphon tenellum*, a male from Bergen. Scale bars 1 mm (Figs 1, 3), 2 mm (Figs 2, 5), 5 mm (Figs 4, 6)

Identification. Originally labelled as *Chaetonymphon hirtipes*, revised according to Hedgpeth (1948), Child (1982) and Turpaeva (2009).

Biology and ecology. Depth 3–1506 m, on silty sediments (Turpaeva 2009).

Note. Left chelifore malformed and left oviger with extra projections.

Nymphon stroemi Krøyer, 1844

urn:lsid:marinespecies.org:taxname:134711

Material. 1 mounted subadult specimen (8.0 mm) collected by an unknown collector on an unknown date in Bergen, NORWAY; ex. coll. Sars (Fig. 4).

Identification. Originally labelled as *Nymphon grossipes* Fabr., redetermined according to Turpaeva (2009), Bamber (2010) and de Kluijver & Ingalsuo (2015).

Material. 1 juvenile specimen (8.3 mm) collected by an unknown collector on an unknown date in the North Sea (Fig. 5).

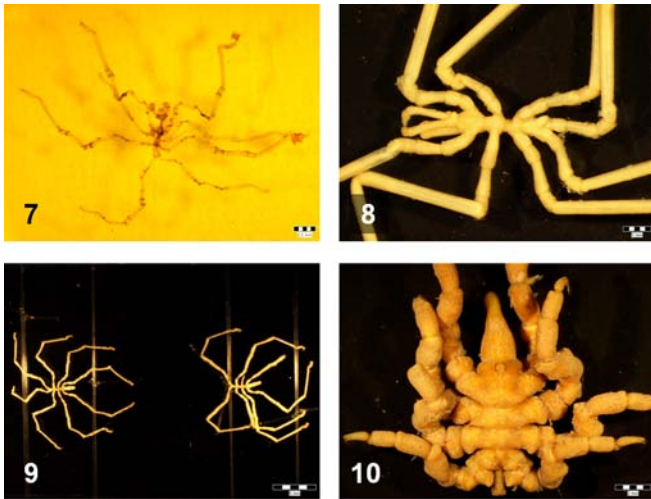
Identification. Originally labelled as *Nymphon* sp., identified according to Turpaeva (2009), Bamber (2010) and de Kluijver & Ingalsuo (2015).

Biology and ecology. Depth 12–1300 m (Bamber 2010), on silty sediments (Turpaeva 2009).

Nymphon tenellum (Sars, 1888)

urn:lsid:marinespecies.org:taxname:134712

Material. 1 mounted ♂ (5.2 mm) collected by an unknown collector on an unknown date in Bergen, NORWAY; ex. coll. Sars (Fig. 6).



Figs 7-10: Non-nymphonid sea spiders. **7.** *Callipallene* sp., a juvenile mounted on a microscopic slide, scale bar 0.5 mm; **8.** *Anoplodactylus lentus*, a female from Woods Hole, scale bar 1 mm; **9.** *Endeis spinosa*, two mounted females, scale bar 5 mm; **10.** *Pycnogonum littorale*, a female from Puffin Island, scale bar 2 mm

Identification. Originally labelled as *Nymphon hirtum* F., re-determined according to Child (1982), Bamber (2010) and de Kluijver & Ingalsuo (2015).

Biology and ecology. Depth mainly 200-600 m (Bamber 2010). Glandular secretions used by paternal care were described by Dogiel (1911, sub *Chaetonymphon spinosum*).

Family: Callipallenidae Hilton, 1942

Genus: *Callipallene* Flynn, 1929

***Callipallene* sp.**

Material. 1 juvenile specimen (0.7 mm) mounted on a microscopic slide, collected by F. B. Liechtenstern, on 24 September 1879 in Rovinj, CROATIA (Fig. 7).

Identification. Originally labelled as *Pycnogonum*, re-determined according to Bamber (2010), Lehmann et al. (2014) and de Kluijver & Ingalsuo (2015).

Biology and ecology. The callipallenids show a direct development via a postlarva on the male (Bamber 2010).

Note. Five common *Callipallene* species occur in Mediterranean (Lehmann et al. 2014).

Superfamily: Phoxichilidioidea Sars, 1891

Family: Phoxichilididae Sars, 1891

Genus: *Anoplodactylus* Wilson, 1878

***Anoplodactylus lentus* Wilson, 1878**

urn:lsid:marinespecies.org:taxname:158478

Material. 1 ♀ (3.5 mm) collected by an unknown collector in July 1891 in Woods Hole, USA (Fig. 8).

Identification. Originally labelled as *Phoxichilidium maxillare*, re-determined according to Hedgpeth (1948) [generic placement also according to Turpaeva (2009) and Bamber (2010)].

Biology and ecology. Ontogeny was described by Morgan (1891, sub *Phoxichilidium maxillare*) and the coloured granules in the hemolymph by Dawson (1934).

Family: Endeidae Norman, 1908

Genus: *Endeis* Philippi, 1843

***Endeis spinosa* (Montgou, 1808)**

urn:lsid:marinespecies.org:taxname:134674

Material. 2 mounted (from dorsal and ventral view) ♀♀ (2.2 mm) collected by an unknown collector on an unknown date in Bergen, NORWAY; ex. coll. Sars (Fig. 9).

Identification. Originally labelled as *Pallene spinipes* F., re-determined according to Bamber (2010) and de Kluijver & Ingalsuo (2015).

Biology and ecology. Mainly from the littoral zone to depths of 40 m, feeding on hydroids, but also common on algae (Bamber 2010). Ontogeny was described by Dogiel (1913, sub *Phoxichilus spinosus*).

Superfamily: Pycnoidea Pocock, 1904

Family: Pycnogonidae Wilson, 1878

Genus: *Pycnogonum* Brünnich, 1764

***Pycnogonum littorale* (Ström, 1762)**

urn:lsid:marinespecies.org:taxname:239867

Material. 1 ♀ (6.3 mm) collected by J. Thompson on an unknown date at the Puffin Island Biological Station, UNITED KINGDOM (Fig. 10).

Identification. Originally labelled as *Pycnogonum littorale*, revised according to Turpaeva (2009), Bamber (2010) and de Kluijver & Ingalsuo (2015).

Biology and ecology. From the littoral to 1262 m, feeding on sea anemones (Bamber 2010), on rocky, stony sediments (Turpaeva 2009). *Pycnogonum littorale* became one of the model species for studying various aspects of sea spiders (e.g. Vilpoux & Waloszek 2003, Ungerer & Scholtz 2009, Machner & Scholtz 2010) given its fairly well known biology (e.g. Tomaschko et al. 1997, Wilhelm et al. 1997 and references therein).

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Cave survey yields a new spider family record for Israel

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Abstract. Leptonetidae and Phyxelididae were discovered as part of the first thorough cave survey of arthropods in Israel, and are reported here for the first time from caves in Israel. Both families were found in relatively temperate and humid caves at the western part of Israel and in intermediate elevation, at the cave entrance and the twilight zone. Leptonetidae were recorded for the first time in Israel.

Keywords: Araneae, *Cataleptoneta*, Leptonetidae, Levant, *Phyxelida*, Phyxelididae, trogliphiles

Cave dwelling species can be classified into three groups, according to their affinity to life in caves: trogllobites are obligatory cave species, and therefore usually have morphological adaptations such as reduction or complete loss of vision and pigmentation as well as elongation of the appendages; trogliphiles (which can be divided into eutrogliphile and subtrogliphile, see Sket 2008) are species that have a strong affinity to caves but can also live outside caves, and therefore lack these morphological adaptations. A third group of cave dwellers are the troglonexes, species that live in caves but are required to leave the cave periodically for various needs (Trajano 2005, Sket 2008). Spiders include nearly 1000 true trogllobite species, and many more species are trogliphiles and can be found at the entrances of caves (Reddell 2005, Romero 2009).

Leptonetidae Simon, 1890, is one example of a spider family with both trogllobite and trogliphile species (Ledford 2004, Jocqué & Dippenaar-Schoeman 2006, Ledford et al. 2011). Leptonetids are small six-eyed haplogyne spiders that construct sheetwebs. Thirteen of the 22 recognized leptonetid genera have a Palearctic distribution, and many of the species are associated with caves (Deltshev 1985, Ledford 2004, Jocqué & Dippenaar-Schoeman 2006, Ledford et al. 2011, Deltshev et al. 2014, World Spider Catalog 2015). Phyxelididae Lehtinen, 1967 is mainly an Afrotropical family of small-medium cribellate eight-eyed spiders. Species belonging to this family build tangled webs or sheetwebs and many of the 14 known genera are found in dark places (Griswold 1990, Jocqué & Dippenaar-Schoeman 2006). Of the 272 leptonetid species and the 64 phyxelidid species known worldwide only one of each of these families was previously recorded from the Levant sensu stricto (World Spider Catalog 2015). *Cataleptoneta edentula* Denis, 1955 was described from a cave in Lebanon (Denis 1955) and *Phyxelida anatolica* Griswold, 1990 was described from a cave in Southern Turkey (close to Syria) and was later recorded under stones in a pine forest in the Cyprus mountains (Griswold 1990, Thaler & Knoflach 1998, World Spider Catalog 2015).

The Levant is a historical and geographical term used for the lands at the eastern edge of the Mediterranean Sea (Por 1975), and as such, has many definitions of its specific limits. Here we use the Levant 'sensu stricto', namely the island

of Cyprus and the mainland area including Israel, Jordan, Lebanon, Palestine and Syria. The Levant mainland is, as a unit, unusually heterogeneous topographically, climatically and biologically. It includes four main topographic elements, each element continues from the north to the south: the coastal plain, the western mountain ridge, the rift valley and the eastern mountain ridge. The topographic and climatic heterogeneity can be explained by geological processes and the crossing of horizontal zonal climatic belts by these four topographic elements (Por 1975, Danin 1988). Israel has se-

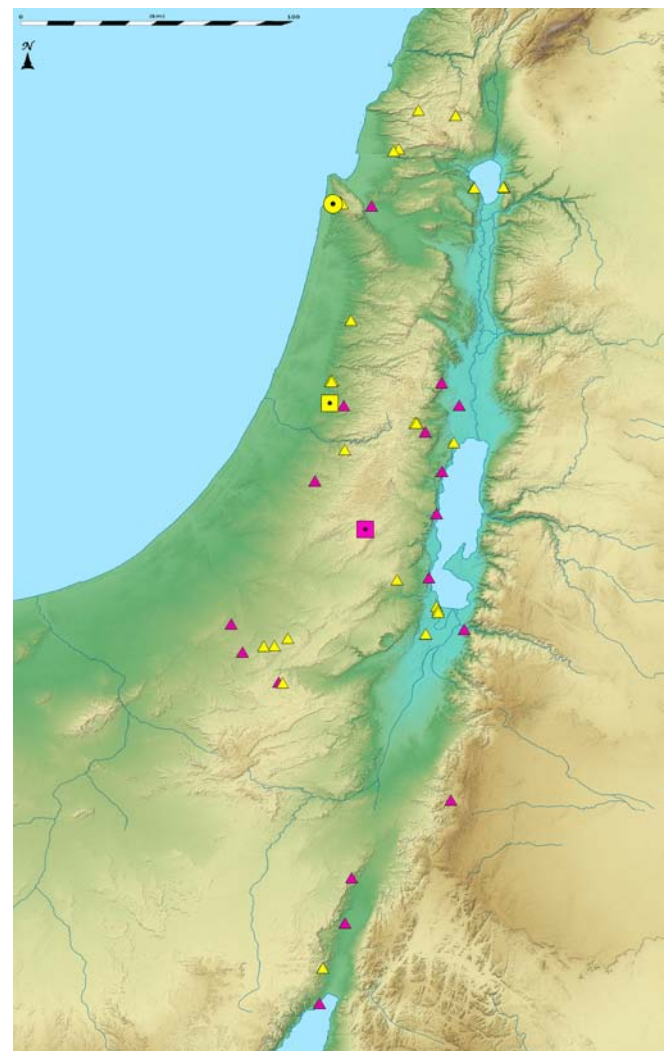


Fig. 1: Geographic-topographic representation of the surveyed sites. Locality of Leptonetidae marked with a circle, localities of Phyxelididae marked with squares, all other sampling localities marked with triangles. Caves with specific environmental records (33) marked in yellow/light grey, other sites (22) marked in purple/dark grey (adapted from Aharon 2015, based on Eric Gaba – <http://commons.wikimedia.org/wiki/User:Sting>)

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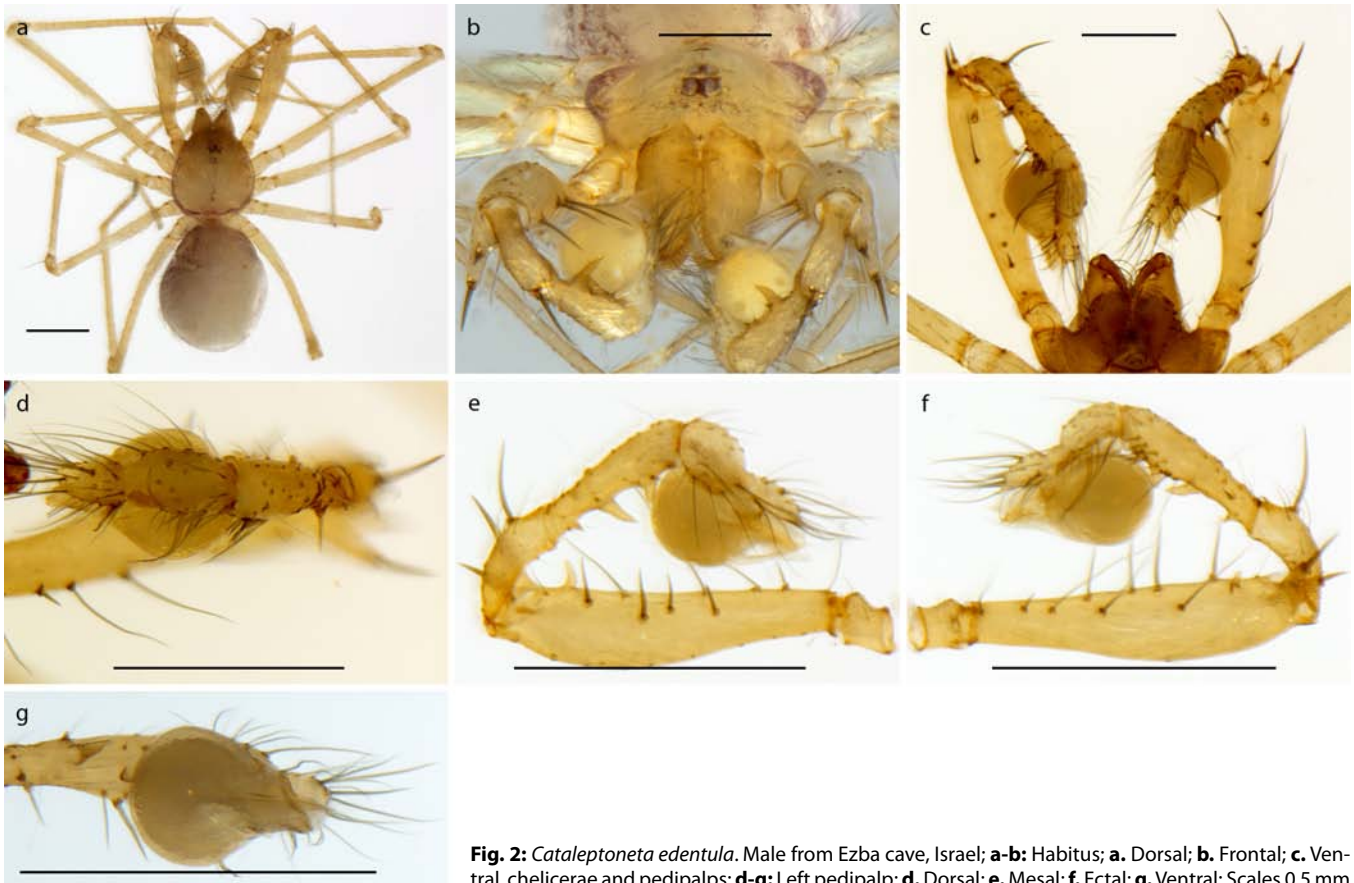


Fig. 2: *Cataleptoneta edentula*. Male from Ezba cave, Israel; **a-b:** Habitus; **a.** Dorsal; **b.** Frontal; **c.** Ventral, chelicerae and pedipalps; **d-g:** Left pedipalp; **d.** Dorsal; **e.** Mesal; **f.** Ectal; **g.** Ventral; Scales 0.5 mm

veral climatic, phytogeographical and zoogeographical zones, as a result of its location on a biogeographical crossroads (Por 1975, Yom-Tov & Tchernov 1988). The three zoogeographical regions that are used for terrestrial animals in Israel are: Palearctic, Palaeoeremic, and Ethiopian, in addition to the Oriental zoogeographical element that has no specific geographical affinity (Por 1975). The Palearctic zoogeographical region includes northern Galilee and is the most widespread zoogeographical element in the Levant. The Palaeoeremic zoogeographical region includes the Negev desert as well as the Jordan valley and the Arava valley. South of the Jezreel Valley, in the north of Israel, and north of the Negev desert are transition zones that includes both Palearctic and Palaeoeremic elements, while the Ethiopian zoogeographical region includes mainly the Jordan valley, the Arava valley, and the coastal plain (Por 1975). Our cave survey aimed at recording the arachnid cave fauna from all of the zoogeographical zones of Israel.

Study sites, material and methods

Between September 2013 and June 2014 we sampled in more than 40 caves in the three zoogeographical regions of Israel: Ethiopian (Jordan Rift valley and Dead Sea valley), Palaeoeremic (Negev desert including the Arava valley) and Palearctic (central and northern Israel including the western mountain ridge (upper Galilee and Judean mountains). The survey was conducted in three different seasons: late summer to autumn, spring, and late spring to early summer. In 33 of the caves we collected arachnids by means of pitfall-traps (with NaCl solution, left in caves for 74-77 days) and hand collecting (with flashlights and UV light); in the rest of the caves only hand

collecting was used. Spider collection in nature reserves was conducted under a permit by the Nature and Parks Authorities (No. 2014/40313 for Efrat Gavish-Regev). For the 33 caves (above), spiders were collected at the cave entrance, the intermediate part of the cave (twilight zone) and the dark zone, when it was applicable (some caves were short and did not contain twilight and dark zones). In addition we recorded the physical and climatic attributes of each cave such as length, opening size, elevation, geology, precipitation, temperature, humidity and luminance. Temperature measurements were taken using PicoLite 16-K, a single-trip USB Temperature Logger (FOURTEC), measuring the temperature once an hour during 74-77 days. Illumination was recorded at the time of sampling using an ExTech 401025 Lux light meter. Localities are marked on Fig. 1, and transliterated names of the localities follow the "Israel Touring Map" (1:250,000) and "List of Settlements," published by the Israel Survey, Ministry of Labour. Geographic coordinates are given in WGS84. Elevation, precipitation, and geological data were provided by the GIS (Geographic Information System) center, The Hebrew University of Jerusalem. All specimens collected were transferred into 75 % ethanol. Specimens were examined and illustrated using a Nikon SMZ 25 stereomicroscope, and identified to species when possible using taxonomic literature (Nentwig et al. 2015, World Spider Catalog 2015). Female genitalia were cleared using a 10 % KOH solution. Photographs were taken using NIS-Elements D (Nikon 2015 version 420). Multi-layer pictures were combined using Zerene Stacker (Version 1.04), and edited using GIMP ver. 2.6.10 and Inkscape ver. 0.48. Left structures (pedipalps) are illustrated unless otherwise stated.

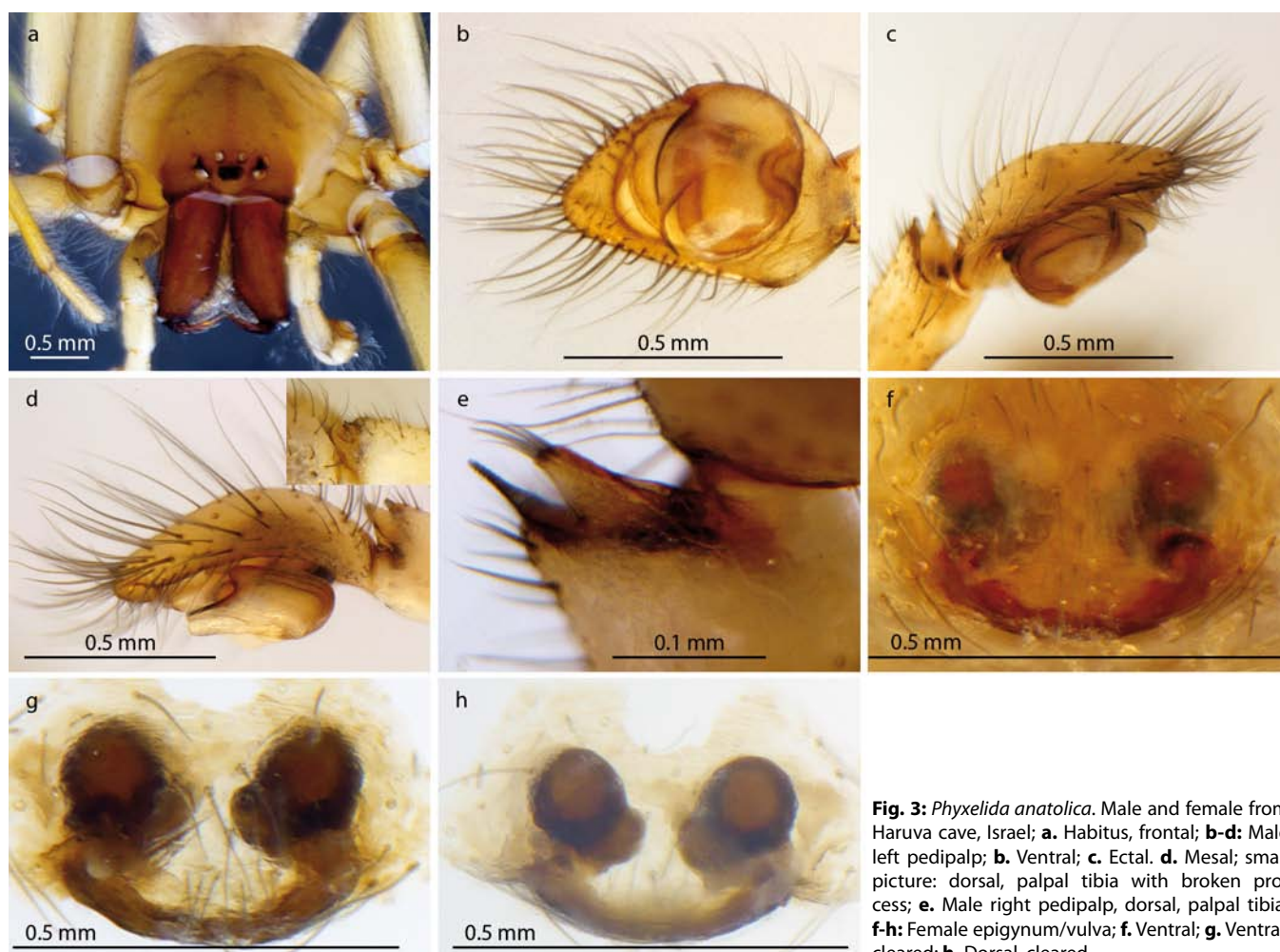


Fig. 3: *Phyxelida anatolica*. Male and female from Haruva cave, Israel; **a.** Habitus, frontal; **b-d:** Male left pedipalp; **b.** Ventral; **c.** Ectal. **d.** Mesal; small picture: dorsal, palpal tibia with broken process; **e.** Male right pedipalp, dorsal, palpal tibia; **f-h:** Female epigynum/vulva; **f.** Ventral; **g.** Ventral, cleared; **h.** Dorsal, cleared

Results

As part of this cave survey we collected one male belonging to the troglophile family Leptonetidae, and more than ten individuals, including an adult male and several females, belonging to the Afrotropical family Phyxelididae (see Fig. 1 for all caves surveyed, and for localities of new records). The overall ranges of elevation, temperature and precipitation (March-June) for all 33 caves, where measurements were taken, included large part of the range found in Israel: -380 to 773 m a.s.l., 7-32 °C and 50-850 mm (March-June), respectively. Yet Leptonetidae and Phyxelididae were found in Israel only in rather temperate caves, with precipitation above 500 mm (details are given below).

Leptonetidae. We found only one male belonging to this troglophile family in the entrance of Ezba cave (32.7118°N, 34.9747°E) on March 13th, 2014. This is a large and rather temperate cave, with a temperature of 14.5 -20 °C (entrance minimum-maximum; March-June 2014). The cave is situated in the Karmel mountain in the north-west of Israel, 120 meter a.s.l., and with yearly average of 650 mm precipitation. The leptonetid spider found in Ezba cave (Fig. 2) belongs to the genus *Cataleptoneta* Denis, 1955, and to the type species of the genus *Cataleptoneta edentula* Denis, 1955, described from a cave in Lebanon and reported thus far only from Lebanon. The spider family Leptonetidae is recorded for the first time in Israel.

Phyxelididae. We found twelve individuals, including three adults (one male and two females) belonging to this Afrotropical family. The specimens were recorded from Haruva cave (31.9133°N, 34.9607°E), as well as from Suseya cave in the West Bank (31.4061°N, 35.1033°E), on March 9th, March 31st, and on August 1st 2014, respectively. Haruva is a large and rather temperate cave, with a temperature of 14.5 - 19.5 °C (entrance minimum-maximum; March-June 2014) and 16 - 19.5 °C (twilight zone minimum-maximum; March-June 2014). Haruva cave is situated in the Judean lowlands in the centre of Israel, 180 meter a.s.l., and with yearly average of 500 mm precipitation. The cave of Suseya is situated in the southern Hebron mountains, part of the Judean mountains, between the Judean and Negev deserts, at 773 meter a.s.l., and with yearly average of 250 mm precipitation; we did not measure temperatures and illumination in this cave. Although the cave of Suseya is situated in an arid region, the vegetation found in this area, namely semi-steppe batha, includes Mediterranean plants which dominate bathas in more mesic, northern parts of Israel (Danin 2015). This suggests better climatic conditions that can enable the existence of spiders with Palearctic affinities. The phyxelid spiders found in these caves (Fig. 3) belong to the genus *Phyxelida* Simon, 1894, and to the species *Phyxelida anatolica* Griswold, 1990, described from a cave in southern Turkey, close to Syria, and later reported from Cyprus mountain pine forests (Thaler & Knoflach 1998).

Discussion

Despite more than 35 years of active taxonomical research in arachnology (Lubin & Gavish-Regev 2009, Zonstein & Marusik 2013), it is still common to find new records of known spider species for Israel, and species new to science here. It is less common to find new records of spider families (but see Levy 2003: Anyphaenidae and Hahniidae, Marusik & Zonstein 2011: Synsphyridae, and Zonstein et al. 2015: Mysmenidae and Phyxelididae, see below).

Both new family records are known from the Levant sensu stricto: Leptonetidae was reported from Lebanon, and Phyxelididae from Cyprus and southern Turkey not far from northern Israel, where our new records were found. After submitting this short-communication for publication, Phyxelididae was reported from Mount Meron in the upper Galilee and from the Karmel mountain ridge Israel in a paper by Zonstein et al. (2015). Due to the morphological resemblance of the new records from Israel to the known species from the Levant and the localities where they were found in Israel, the recorded species were assigned to the species known from Lebanon and Cyprus and Turkey.

Cataleptoneta edentula, though not presenting any morphological adaptation to life in caves, was recorded thus far only from two caves: the type locality cave in Lebanon and Ezba cave in Israel.

Phyxelida anatolica is the northernmost representative of *Phyxelida*, and was suggested to be restricted to caves (Griswold 1990), however Thaler & Knoflach (1998) suggested it is a hygrophilic or "refugial-cavatic" species, as it was found under stones in pine forest in the Cyprus mountains. Zonstein et al. (2015) recently reported one male and one female, but did not give details of the habitat where the specimens were collected, and stated that the two specimen records are the easternmost and southernmost localities of this species. Here we report two localities that are further south than the previous localities: Haruva cave (31.9133°N, 34.9607°E) and Suseya cave (31.4061°N, 35.1033°E).

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Catching of spiders in shallow subterranean habitats in the Czech Republic

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Abstract. Spiders occurring in soils and fissured rocks were investigated using pipe traps. Four microphthalmic species, namely *Hahnia microphthalma*, *Porrhomma egeria*, *P. microps* and *P. cambridgei* were collected. *Hahnia microphthalma* is reported from the Czech Republic for the first time. The importance of collecting material by complex pipe traps (consisting of a perforated pipe and a set of removable cups) to record the depth distribution of spiders in subterranean habitats is stressed. The importance of the soil and fissure network formed by sandy marlite bedrock and of alluvial soils for the life of subterranean spiders is documented.

Keywords: alluvial soil, microphthalmic, pipe traps, sandy marlite, troglomorphy

For humans, caves are more accessible than other subterranean habitats. Much of what we know about subterranean biology comes from the study of caves, partly because of the adventure and excitement of visiting and exploring caves, which are certainly more exciting than visiting, for example, talus slopes (Culver & Pipan 2009). Terrestrial shallow subterranean habitats are formed in soil, rock mantle formed in bare and forest scree, slope and alluvial sediments and in fissured rock and cave entrances (Culver & Pipan 2014). A depth of about 10 m represents the natural border between shallow and deep subterranean habitats (Novak et al. 2012, Růžička et al. 2013). Our knowledge concerning invertebrates that live only several metres under the surface is very limited.

Many subterranean invertebrates display similar morphologies that have evolved convergently under similar selective pressures imposed by the subterranean environment. Subterranean spiders show typical morphological changes known as troglomorphisms: depigmentation, microphthalmic and lengthening of the legs (Culver & Pipan 2009).

Arachnological research into shallow subterranean habitats has a long tradition in the Czech Republic. Independently of Jubertie & Delay (1981), Růžička (1982) started to investigate invertebrates living in talus slopes using board traps. Numerous surprising findings have been reported since, including five taxa new to science, and twelve species of arthropods new to the Czech Republic (Růžička & Klimeš 2005). *Wubanoides uralensis* (Pakhorukov, 1981) (respectively *Wubanoides uralensis lithodytes* Schikora, 2004), was recorded for the first time in Europe and several troglomorphic populations/taxa have been described (Růžička 1988a, 1998, 2011). His research has documented that freezing talus slopes represent a classic example of a palaeoregion that significantly contributes to the protection and maintenance of regional landscape biodiversity (Růžička et al. 2012).

The main component of traps used by López & Oromí (2010) for catching invertebrates in shallow subterranean habitats on the Canary Islands is a 75 cm long plastic pipe with an inner diameter of 11 cm. Many small holes (5-7 mm in diameter) are drilled along its surface, and a bottle containing preservation fluid (and bait) is lowered inside on a

nylon cord. The pipes are installed vertically into holes in a suitable terrain. This kind of trap is a modification of a similar pipe used by Gers (1992). Barranco et al. (2013), Ortuño et al. (2013) and Jiménez-Valverde et al. (2015) used such traps to investigate invertebrates in stony slopes and river deposits in continental Spain; Nitzu et al. (2014) used a similar trap in Romania.

Schlick-Steiner & Steiner (2000) constructed a trap consisting of a perforated pipe and a set of removable plastic cups situated on a central-thread metal axis. Through this arrangement, the cups collect animals entering the tube through holes at particular depths. Using these complex pipe traps (with a length of 95 cm), Laška et al. (2011) studied the distribution of spiders in soil profiles and Rendoš et al. (2012) studied the distribution of invertebrates in limestone scree slopes. The design of perforation varies from a horizontal line of holes, to a network of holes up to horizontal cuttings accompanied by holes (Fig. 1a-c). The aim of this present study was to test the performance of pipe traps in soils and crevice systems.

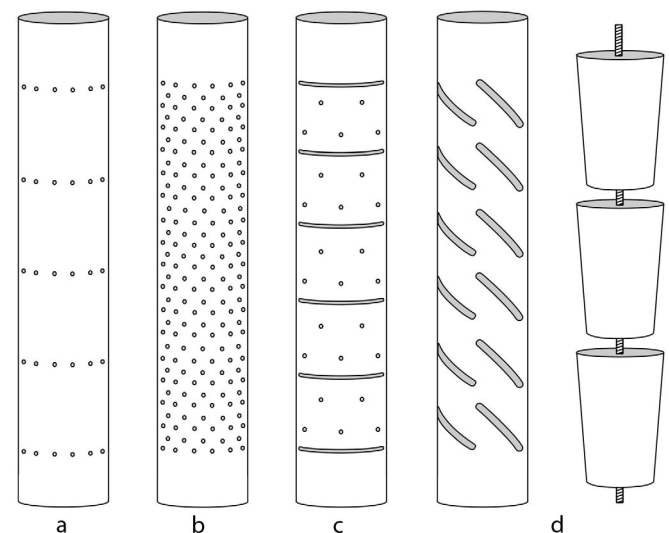


Fig. 1: Design of perforation; **a.** Schlick-Steiner & Steiner (2000); **b.** López & Oromí (2010); **c.** Laška et al. (2011); **d.** our design and a set of cups

Material and methods

Sampling. Six pipe traps (one per site) were deployed from 2013 to 2015, and were emptied twice a year. The plastic pipes have an inner diameter of 7 cm, and are perforated with a system of oblique cuts 5 mm wide (Fig. 1d). This design has been registered at the Czech Industrial Property Office under No. 36420. Plastic cups were mounted onto a metal-thread rod at

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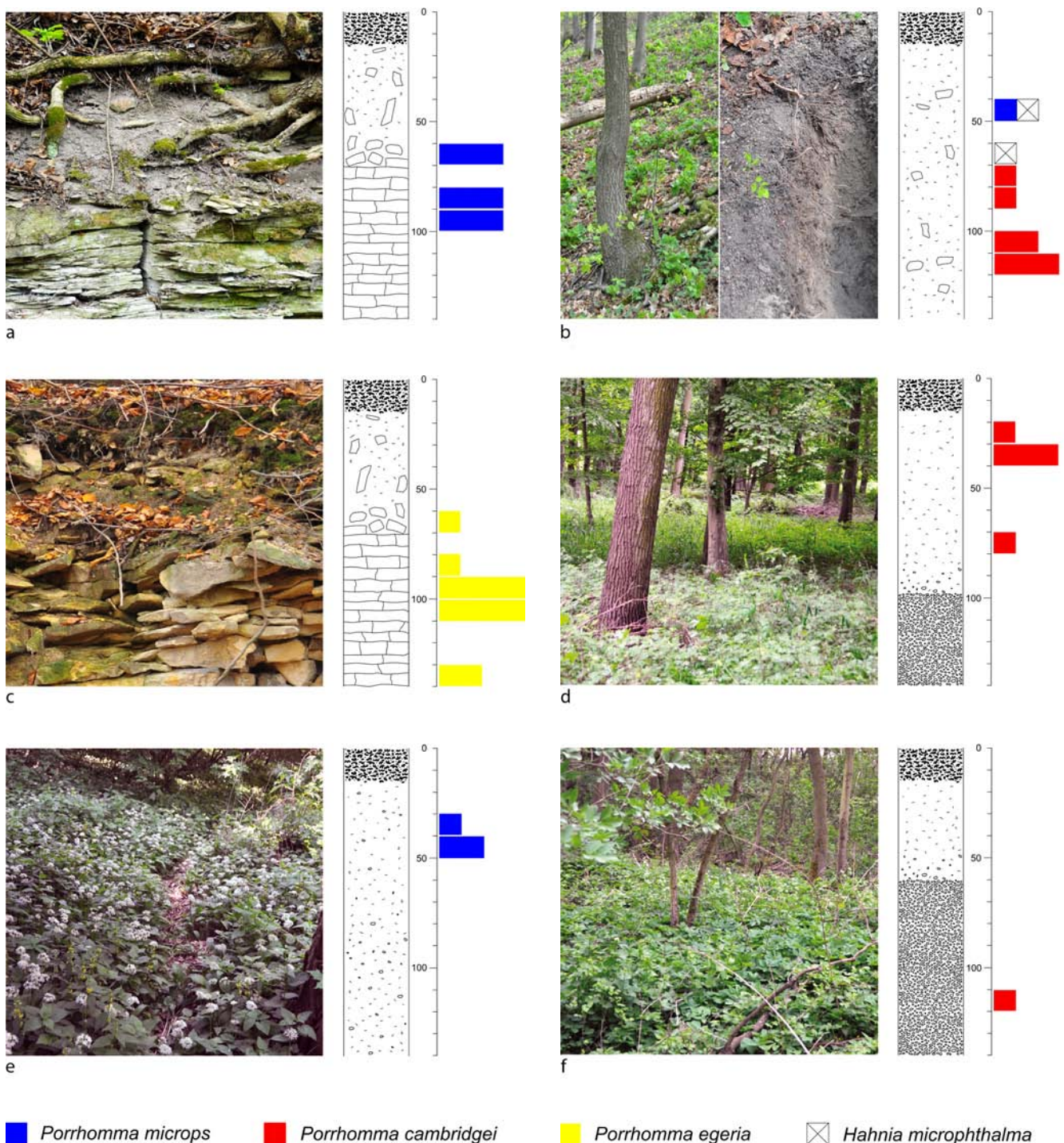


Fig. 2: Study sites with terrain profile and the depth-dependent occurrence of microphthalmic species; **a.** site SM-1, upper margin of a sandy marlite slope; **b.** site SM-2, lower margin of a sandy marlite slope; **c.** site SM-3, sandy marlite table hill; **d.** site AS-1, lowland forest; **e.** site AS-2, lowland forest; **f.** site AS-3, lowland forest

10 cm distances and contained a mixture of 7 % formalin and 5 % glycerol, plus a few drops of detergent (Růžička 1988b). In the final version, we used plastic or brass components to avoid damage to material caused by rust. We installed these traps in excavated trenches in sandy marlite terrains, or in boreholes (15 cm in diameter) in lowland forests, the deepest reaching 160 cm below the surface. The free space around the trap was filled by excavated material or – in the case of boreholes – by a mixture of excavated material and artificial rubble (Keramzit) or starch-based packing peanuts.

Study sites. Traps were installed in sandy (arenaceous) marlite (SM) terrains, and in alluvial soils in lowland forests (AS) (Figs 2a–f).

SM-1. Jenišovice-Mravín (49.9446°N, 16.0522°E, 335 m a.s.l.). On the upper margin of a sandy marlite slope at the border between a deciduous forest and a lucerne field: 0–60 cm stony soil, 60–100 cm fissured rock (Fig. 2a). The pipe with ten cups at a depth of 10–100 cm operated from 25 October 2013 to 29 September 2015. The spider assemblage of adjacent open habitats was studied by Dolanský (2002).

SM-2. The same locality as SM-1, 50 m apart (49.9445°N, 16.0516°E, 315 m a.s.l.), at the lower margin of a sandy marlite slope covered by deciduous forest (Fig. 2b). The whole profile studied consisted of a clay soil. The pipe with nine cups at a depth of 40–120 cm operated from 25 October 2013 to 29 September 2015.

SM-3. Kounov (50.2320°N, 13.6899°E, 515 m a.s.l.). Mixed forest on a sandy marlite table hill, 15 m from a quarry wall: 0–70 cm stony soil, 70–140 cm fissured rock (Fig. 2c). The pipe with 14 cups at a depth of 10–140 cm operated from 1 November 2013 to 25 September 2015.

AS-1. Lednice (48.7867°N, 16.8448°E, 170 m a.s.l.). Lowland forest with rich herb and shrub vegetation (Fig. 2d): 0–90 cm clay soil. Fluctuating water table. The pipe with nine cups at a depth of 10–90 cm operated from 29 June 2014 to 17 May 2015.

AS-2. Znojmo (48.8466°N, 16.1033°E, 220 m a.s.l.). Lowland forest with rich herb and shrub vegetation (Fig. 2e): 0–70 cm sandy soil. The pipe with seven cups at a depth of 10–70 cm operated from 20 August 2014 to 11 May 2015.

AS-3. Pardubice (50.0458°N, 15.7727°E, 220 m a.s.l.). Lowland forest with rich herb and shrub vegetation (Fig. 2f): 0–60 cm alluvial soil, 60–160 cm sand. The pipe with 16 cups at a depth of 10–160 cm operated from 15 May 2014 to 23 September 2015.

Results and discussion

Spiders

In total, we captured 335 spider specimens belonging to 32 species (Appendix): 155 spiders belonging to 20 species at site SM-1 (Tab. 1), 44 belonging to 10 species at site SM-2 (Tab. 2), 118 belonging to 12 species at site SM-3 (Tab. 3), 7 belonging to 3 species at site AS-1 (Tab. 4), 11 belonging to 3 species at site AS-2 (Tab. 5) and 7 belonging to 3 species at site AS-3 (Tab. 6). Spiders were recorded down to a depth of 120 cm. *Cicurina cicur* was the most abundant species. Species that were clearly tied to surface habitats (e.g., *Agroeca cuprea*) were usually recorded only a few tens of centimetres deep. Some individual records can be considered as accidental, e.g. the record of *Linyphia hortensis* at a depth of 110 cm, due to the fact that it is a typical shrub layer inhabitant (Buchar & Růžička 2002). *Cicurina cicur*, *Mioxena blanda*, *Palliduphantes pallidus*, *P. alutacius* and *Syedra myrmicarum* were depigmented with fully developed eyes. Four species were depigmented with reduced eyes and were clearly adapted to life in subterranean habitats. These species represent objects of our special interest.

Habnia microphthalma

Material: Jenišovice-Mravín (SM-2), 25 October 2013–18 April 2014 1♀; 28 April–29 September 2015, 1♀. This species is reported for the first time from the CZECH REPUBLIC.

Posterior median eyes reduced (Fig. 3a). Szita et al. (1998) and Hänggi & Stäubli (2012) found various stages of eye reduction in their material, and also differences in the form of the translucent copulatory ducts. The picture of the copulatory ducts of the epigyne of our specimens is in agreement with that of the type specimen (Fig. 3b; cf. Snazell & Duffey 1980; Fig. 3).

Snazell & Duffey (1980) described the species according to two records from Great Britain. Hänggi & Stäubli (2012) summarized other records: three in Germany, one in Switzerland, and one in Hungary (Fig. 4). British specimens were collected in chalk grassland and in a field with a clay soil over-

Tab. 1: The species assemblage at SM-1. The number of males, females and juveniles (♂♂/♀♀/juv. [if determinable]) and the depth range (in cm) are shown. The species considered microphthalmic are shown in bold.

Species	♂♂/♀♀/juv.	Depth range
<i>Leptyphantes leprosus</i>	0/1	10
<i>Panamomops menzei</i>	1/0	10
<i>Tenuiphantes flavipes</i>	6/1	10–20
<i>Histoipona torpida</i>	0/4	10–40
<i>Phrurolithus festivus</i>	1/1	10–40
<i>Amaurobius jugorum</i>	1/2/3	10–70
<i>Cicurina cicur</i>	31/22/6	10–70
<i>Harpactea rubicunda</i>	12/27	10–80
<i>Agroeca cuprea</i>	1/0	20
<i>Diplostyla concolor</i>	4/4	20–30
<i>Micrargus herbigradus</i>	2/2	20–30
<i>Coelotes terrestris</i>	1/1	20–40
<i>Liocranum rupicola</i>	1/0	30
<i>Ozyptila praticola</i>	0/1	30
<i>Harpactea lepida</i>	1/0	40
<i>Walckenaeria nudipalpis</i>	0/1	40
<i>Mioxena blanda</i>	3/1	40–60
<i>Syedra myrmicarum</i>	0/2	50–80
<i>Porrhomma microps</i>	5/4	70–100
<i>Mastigusa arietina</i>	0/1	90

Tab. 2: The species assemblage at site SM-2

Species	♂♂/♀♀/juv.	Depth range
<i>Clubiona terrestris</i>	1/0	40
<i>Coelotes terrestris</i>	1/0	40
<i>Histoipona torpida</i>	0/1	40
<i>Micrargus herbigradus</i>	6/3	40–70
<i>Cicurina cicur</i>	6/3/11	40–110
<i>Porrhomma microps</i>	0/1	50
<i>Habnia microphthalma</i>	0/2	50–70
<i>Amaurobius jugorum</i>	0/1	80
<i>Porrhomma cambridgei</i>	4/3	80–120
<i>Linyphia hortensis</i>	0/1	110

Tab. 3: The species assemblage at site SM-3

Species	♂♂/♀♀/juv.	Depth range
<i>Coelotes terrestris</i>	1/0	10
<i>Diplostyla concolor</i>	1/5	10
<i>Inermocoelotes inermis</i>	1/0	10
<i>Nusoncus nasutus</i>	0/1	10
<i>Harpactea lepida</i>	1/2/3	10–40
<i>Microneta viaria</i>	0/2	10–50
<i>Palliduphantes pallidus</i>	3/3	10–100
<i>Cicurina cicur</i>	40/24/16	10–140
<i>Harpactea hombergi</i>	0/0/1	20
<i>Centromerus sellarius</i>	0/1	30
<i>Porrhomma egeria</i>	1/8/3	70–140

Tab. 4: The species assemblage at site AS-1

Species	♂♂/♀♀/juv.	Depth range
<i>Robertus lividus</i>	0/1	10
<i>Palliduphantes alutacius</i>	0/1	10
<i>Porrhomma cambridgei</i>	3/1/1	30–80

Tab. 5: The species assemblage at site AS-2

Species	♂♂/♀♀/juv.	Depth range
<i>Cicurina cicur</i>	4/1/1	10
<i>Palliduphantes alutacius</i>	0/2	20
<i>Porrhomma microps</i>	1/1/1	40–50

Tab. 6: The species assemblage at site AS-3

Species	♂♂/♀♀	Depth range
<i>Palliduphantes alutacius</i>	2/2	20
<i>Syedra myrmicarum</i>	1/1	20
<i>Porrhomma cambridgei</i>	0/1	120

lying chalk. Records in Germany were situated on sandstone and limestone bedrock (Sühlig et al. 1998). The Hungarian locality was situated in an old field on loess (Szita et al. 1998).

All previous specimens were collected on the surface by pitfall traps, photoelectors or by sweeping. Snazell & Duffey (1980) conclude that some of the characteristics of the spider suggest a subterranean habitat. We document for the first time that *H. microphthalma* inhabits the soil at a depth of about 50–70 cm.

Porrhomma cambridgei

Material: Jenišovice-Mravín (SM-2), 18 April–13 August 2014, 1♂ 1♀; 21 November 2014–28 April 2015, 2♂; 28 April–29 September 2015, 1♂ 2♀. Lednice (AS-1), 29 June–5 November 2014, 1♂ 1j.; 5 November 2014–17 May 2015, 2♂ 1♀. Pardubice (AS-3), 28 April–23 September 2015, 1♀.

Pickard-Cambridge (1871) noted that the species “*Linyphia? oblonga*” is characterized by “eyes very small”. Based on the vulva structure, Millidge & Lockett (1952) synonymized this microphthalmic form with *Porrhomma oblitum* (O. P.-Cambridge, 1871). Finally, Merrett (1994) removed it from synonymy with *P. oblitum* and revalidated it as a separate species *P. cambridgei* Merrett, 1994. It is clearly characterized by femora I and II without dorsal spines, a cephalothorax width < 0.58 mm, and reduced eyes. It has been recorded from Great Britain, Germany, Switzerland, northern Italy and the Czech Republic (Thaler et al. 2003).

We and Růžička et al. (2011, sub. *P. aff. myops*) captured this species in sandy marlite terrain and in alluvial soils at a depth of 35–120 cm. Thaler et al. (2003) collected this species on tree bark in the Bohemian Karst and we also obtained several specimens from conglomerate terrain and from karst caves.

Porrhomma egeria

Material: Kounov (SM-3), 5 April–14 July 2014, 1j.; 21 April–25 September 2015, 1♂ 8♀ 2j.

Porrhomma egeria inhabits caves and scree slopes, it also occurs in mountain spruce forests and subalpine zone (Buchar & Růžička 2002). It is fairly widespread in north-western, central and northern Europe (Nentwig et al. 2015). Its abundant occurrence in creviced rock is recorded for the first time.

Porrhomma microps

Material: Jenišovice-Mravín (SM-1), 21 November 2014–28 April 2015, 2♀; 28 April–29 September 2015, 5♂ 2♀. Jenišovice-Mravín (SM-2), 13 August–21 November 2014, 1♀. Znojmo (AS-2), 20 August 2014–11 May 2015, 1♂ 1♀ 1j.

Porrhomma microps is widespread in continental Europe (Nentwig et al. 2015). It inhabits leaf litter in floodplain forests and was also recorded in caves, not deeper than 10 m. It was also recorded in the soil on a sandy marlite at a depth of 55–135 cm by Laška et al. (2011), and in lowland forest at a depth of 5–45 cm by Růžička et al. (2011). The specimen reported by Růžička et al. (2013, Fig. 6) from a depth of 80 m was misidentified and is actually *P. profundum* M. Dahl, 1939.

Habitats

Sandy marlite. In a clay soil at site SM-2, we captured three microphthalmic species together: *Porrhomma microps*, *Hahnia microphthalma* and *P. cambridgei* (Tab. 2). We captured *P. egeria* in a layer of fissured rock at site SM-3 (Tab. 3).

Porrhomma microcavense Wunderlich, 1990 was reported from a sandstone landscape for the first time in the Czech Republic (Buchar & Růžička 2002). However, in detail, it was recorded above a sandy marlite layer. Furthermore slightly microphthalmic specimens of *Oreonetides quadridentatus* (Wunderlich, 1972) were captured by Laška et al. (2011; sub *Maro* sp.) at a depth of 45 and 65 cm in clay soil on sandy marlite bedrock, together with *Porrhomma microps*.

Alluvial soils. We collected *P. cambridgei* and *P. microps* in alluvial soil/sand in three different localities in lowland forests near a river. In the same habitat, Růžička et al. (2011) collected these two species together. Together with *H. microphthalma*, these two species can be considered soil spiders.

Concluding remarks

The importance of shallow subterranean habitats for the evolution of subterranean life is well known (Růžička 1999, Giachino & Vailati 2010, Růžička et al. 2013, Culver & Pipan



Fig. 3: *Hahnia microphthalma*; a. eye arrangement; b. epigyne. Scale line 0.1 mm

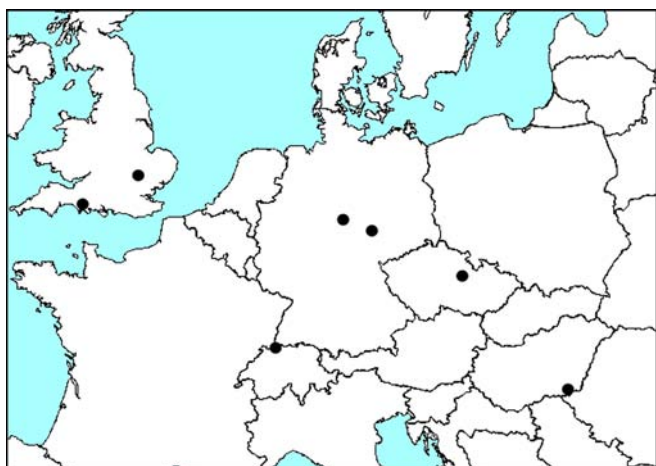


Fig. 4: *Hahnia microphthalma*: map of the known records

2014) and has been repeatedly documented in recent years. Using pipe traps, Deltshv et al. (2011) collected spiders in soils down to the depth of 80 cm in the Bulgarian mountains. *Zanherella relicta* (Kratochvíl, 1935), described from a cave in Montenegro, was recorded, which represents the first record of the family Anapidae in Bulgaria. Gilgado et al. (2015) collected the troglomorphic millipede *Typhlopsychrosoma baeticaense* (Mauriès, 2013), known from caves, in mountain screes and concluded that some subterranean species might have surprisingly wide distribution areas, and that study of shallow subterranean habitats will surely improve our poor knowledge on subterranean biodiversity.

There is a wide spectrum of sedimentary rocks containing variable amounts of clay and silt designated as marl or marlite. Their properties depend on mineralogical composition and diagenesis. In the Alicante region (Spain), the marl offers no suitable interstices for a subterranean fauna, and marl layers constitute physical barriers to the movement of subterranean animals (Ortuño et al. 2013, Gilgado et al. 2015). On the other hand, in the Czech Republic, the indurated sandy marlite forms a fissure network. This fissure network, together with soils originating from this bedrock, constitutes a subterranean habitat that seems to be very suitable for the subterranean fauna, according to our findings.

In subterranean biology, there is a common idea that alluvial plains are barriers to subterranean faunas, and that they do not have suitable spaces (Uéno 1987). However, this depends on the size of the sand and gravel grains. Christian (1998) recorded a subterranean palpigrade *Eukoenenia austriaca* (Hansen, 1926) (usually found in caves) in the bottom substrate of the tombs of St. Stephen's Cathedral in Vienna. These catacombs were dug down to the Pleistocene gravel of the Danube river. Gilgado & Ortuño (2015) recorded a subterranean zygentomid *Coletinia maggii* (Grassi, 1887) (usually found in surface habitats, ant nests and caves) in a subsoil gravel layer in an alluvial plain in northern Spain. We collected subterranean spiders in three different alluvial plains. These findings suggest the possibility that alluvial deposits might represent 'connectors' between other subterranean habitats, at least for some subterranean animals. Moreover, in the locality AS-1, we collected not only the subterranean spider *Porrhoma cambridgei* at a depth of 30–80 cm, but also a pale subterranean *Niphargus* sp. at a depth of 0–90 cm. Crustaceans thus

migrated into soil horizons from shallow aquatic interstitial habitats at the time of flooding.

The modified space around the pipe can represent an artificial corridor through which invertebrates can migrate in a vertical direction. Nevertheless, the vertical distributions of spiders are clearly species-specific as also documented by Laška et al. (2011). In both cases of the common occurrence of *P. microps* and *P. cambridgei* (our site SM-2 and Růžička et al. 2011), the smaller species *P. cambridgei* occupies deeper soil horizons.

On the other hand, the soil structure is destroyed during installation of the traps, and fine crevices are closed. The reconstruction of the network of voids can take several years, as we infer by the catching of the first adults of *P. egeria* after two years of investigation.

Finally, we would like to recommend the use of complex pipe traps, which enables precise documentation of the depth distribution of species. We would like to emphasize that to document the occurrence of troglomorphic invertebrates, data on the subterranean habitat (not only data on surface habitat, e.g. plant associations) are important.

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Appendix

Taxonomic survey of species collected. **Dysderidae:** *Harpactea hombergi* (Scopoli, 1763), *Harpactea lepida* (C. L. Koch, 1838), *Harpactea rubicunda* (C. L. Koch, 1838); **Theridiidae:** *Robertus lividus* (Blackwall, 1836); **Linyphiidae:** *Centromerus sellarius* (Simon, 1884), *Diplostyla concolor* (Wider, 1834), *Leptyphantes leprosus* (Ohlert, 1865), *Linyphia hortensis* Sundevall, 1830, *Micrargus herbigradus* (Blackwall, 1854), *Microneta viaria* (Blackwall, 1841), *Mioxena blanda* (Simon, 1884), *Nusoncus nasutus* (Schenkel, 1925), *Palliduphantes alutaci* (Simon, 1884), *Palliduphantes pallidus* (O. P.-Cambridge, 1871), *Panamomops mengei* Simon, 1926, *Porrhomma cambridgei* Merrett, 1994, *Porrhomma egeria* Simon, 1884, *Porrhomma microps* (Roewer, 1931), *Syedra myrmicarum* (Kulczyński, 1882), *Tenuiphantes flavipes* (Blackwall, 1854); *Walckenaeria nudipalpis* (Westring, 1851); **Agelenidae:** *Coeolotes terrestris* (Wider, 1834), *Histopona torpida* (C. L. Koch, 1834), *Inermocoelotes inermis* (L. Koch, 1855); **Hahniidae:** *Habnia microphthalmalma* Snazell & Duffey, 1980; **Dictynidae:** *Cicurina cicur* (Fabricius, 1793); *Mastigusa arietina* (Thorell, 1871); **Amaurobiidae:** *Amaurobius jugorum* L. Koch, 1868; **Liocranidae:** *Agroeca cuprea* Menge, 1873, *Liocranum rupicola* (Walckenaer, 1830); **Phrurolithidae:** *Phrurolithus festivus* (C. L. Koch, 1835); **Thomisidae:** *Ozyptila praticola* (C. L. Koch, 1837).

Spiders and harvestmen on tree trunks obtained by three sampling methods

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Abstract. We studied spiders and harvestmen on tree trunks using three sampling methods. In 2013, spider and harvestman research was conducted on the trunks of selected species of deciduous trees (linden, oak, maple) in the town of Přerov and a surrounding floodplain forest near the Bečva River in the Czech Republic. Three methods were used to collect arachnids (pitfall traps with a conservation fluid, sticky traps and cardboard pocket traps). Overall, 1862 spiders and 864 harvestmen were trapped, represented by 56 spider species belonging to 15 families and seven harvestman species belonging to one family. The most effective method for collecting spider specimens was a modified pitfall trap method, and in autumn (September to October) a cardboard band method. The results suggest a high number of spiders overwintering on the tree bark. The highest species diversity of spiders was found in pitfall traps, evaluated as the most effective method for collecting harvestmen too.

Keywords: Araneae, arboreal, bark traps, Czech Republic, modified pitfall traps, Opiliones

Trees provide important microhabitats for arachnids including specific microclimatic and structural conditions in the bark cracks and hollows (Wunderlich 1982, Nikolai 1986). Some species lives on tree trunks throughout the year, whereas other spiders use trees only for a certain period, mainly during overwintering (Horváth et al. 2001, 2004). Facultative bark-dwelling spiders which usually live in the canopies are found on trees only in late autumn to early spring, i.e. in season when deciduous trees are without leaves (Horváth & Szinetár 2002).

Bark-dwelling spiders are relatively rarely studied. Information on bark-dwelling spiders are scattered in studies focused on the diversity of fauna of particular forest habitats (e.g. Weiss 1995, Horváth & Szinetár 2002, Blick 2011) or parks and towns (e.g. Hansen 1992, Horváth & Szinetár 1998). Applied research may study bark-dwelling spiders as pest-control agents in orchards (e.g., Bogyá et al. 1999, Pekár 1999). Some studies are focused specifically on spider biology, e.g. overwintering (Pekár 1999, Spitzer et al. 2010) or habitat stratification (e. g. Simon 1994). Several species find shelter on tree trunks during harsh conditions, e.g. floods (Zulka 1989, Marx et al. 2012). In Europe, several hundreds of spider species were reported on the bark of different tree species (Szinetár & Horváth 2006, Blick 2011).

Different methods can be used to collect arachnids living on tree trunks. The most popular ones are arboreal eclectors placed on trunks (e.g. Albrecht 1995, Kubcová & Schläghammer 2002, Blick 2011) or branches in canopies (e.g. Koponen 2004, Moeed & Meads 1983, Simon 1995). Another method is the bark trap which can be made from wrapped cardboard (e.g. Bogyá et al. 1999, Horváth & Szinetár 1998, 2002, Horváth et al. 2001, 2004, 2005) or polyethylene bubble film (Isaia et al. 2006). Pitfall traps (i.e. Barber traps) were adopted to sample trunk inhabiting invertebrates too (e.g. Pinzon & Spence 2008). Canopy-inhabiting invertebrates can be sampled by fogging (e.g. Otto & Floren 2007), window traps, various types of eclectors or direct beating of branches (Bolzern & Hänggi 2005, Blick & Gossner 2006, Aguilar 2010), but these methods are expensive, time-consuming or difficult.

This study is focused on the comparison of the species spectrum of spiders and harvestmen obtained by three simple low-cost trap designs – modified pitfall traps, cardboard bands and sticky traps.

Material and methods

The study was carried out in Přerov Town (49°26'58"N, 17°27'23"E) and a surrounding floodplain forest fragment (49°28'8"N, 17°29'7"E) in the Czech Republic. Both localities are situated at 220 m a.s.l. Spiders and harvestmen were sampled on the trunks of three different species of deciduous trees (Littleleaf linden – *Tilia cordata*, Norway maple – *Acer platanoides*, English oak – *Quercus robur*) using three different methods. Simple pitfall traps were made from the 1.5-litre plastic bottles (Fig. 1) filled with 0.25 litre of a saturated solution of salt (NaCl). Sticky traps were made from ordinary transparent sticky tape 20 cm wide and 40 cm long covered with a layer of glue 95-10-0220 used against tree pests (tape Stromset made by Propher, Fig. 2). Cardboard bands were made from corrugated cardboard 20 cm wide and 40 cm long (Fig. 3). Altogether, 90 traps were installed on 90 trees (each tree with one trap, 15 traps for each method in the forest as well as in the town, i.e. 45 trees in the forest and 45 trees in the town). The tree species were equally sampled by different traps in the forest and in the town (15 lindens, 15 maples and 15 oaks in both forest and town). Traps were placed on the tree trunks at a height of 4 m. Traps were exposed from May 5th to October 27th 2013 and sampled monthly. Spiders and harvestmen were identified to species level using common identification keys (Miller 1971, Šilhavý 1971, Nentwig et al. 2015). Nomenclature follows the World Spider Catalog (2015) and Martens (2013).

Results

Overall, 1862 spiders and 864 harvestmen were trapped, representing 56 spider species from 15 families and seven harvestman species from one family (Tab. 1). One third of all spiders were immature specimens (*Clubiona* 57 %, *Theridion* 23 %, *Philodromus* 20 %). Juveniles of Linyphiidae, which could not be determined to genus level, were not counted. Although the number of recorded individuals was higher in the forest than in town, the number of species was similar between the localities (39 vs. 39 species of spiders and seven vs. five harvestman species respectively). The highest number of species and specimens of spiders and harvestmen were found on oak. A total of 1133 spiders belonging to 48 species and

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Fig. 1: Pitfall trap made from a plastic bottle

Fig. 2: Sticky trap

Fig. 3: Cardboard band trap

805 harvestmen belonging to seven species were captured in modified pitfall traps. In total 16 spider species were recorded by pitfall trapping exclusively (30 % of all species sampled by this method). The most abundant taxa obtained using this method were *Anyphaena accentuata*, *Clubiona pallidula* (*Clubiona* sp.), *Drapetisca socialis* and the harvestman *Rilaena triangularis*. A total of 560 spiders belonging to 31 species but only 27 (mainly immature) harvestmen were sampled by cardboard bands (Tab. 1). Four spider species were obtained by this method exclusively (13 % of all species recorded by this method). The most abundant taxa obtained using this method were *Clubiona pallidula* and *Nuctenea umbratica*. A total of 169 spiders belonging to 24 species and 32 harvestmen belonging to three species were stuck on sticky traps. Three spider species were sampled by sticky traps exclusively (11 % of all species captured by this method). The most abundant taxa obtained with this method were *Philodromus* sp. and *Drapetisca socialis*. The number of spider and harvestman

specimens trapped in pitfall traps was the highest in May at both localities (Fig. 4), whereas the number of species was the highest in July (Fig. 5). The effectivity of cardboard bands (both in the number of individuals and species) was highest in October (Figs 4, 5). Only 11 species of spiders were trapped by all methods, other species were recorded by one method exclusively, or by a combination of two methods (Tab. 1).

Discussion

The 56 spider species collected during this study mostly represent common arboreal species. The number of spider species is low in comparison with some other methods like eclectors (e.g. Albert 1976, Platen 1985, Simon 1995, Koponen 1996, Blick 2009, 2012). Evidently, trunk eclectors are much more effective in sampling the whole spider species spectrum compared to our methods. Using trunk eclectors in different forests in Germany Blick (2011) found a total of 334 spider species between 1990 and 2003. In a different project (Blick

Tab. 1: List of all collected spiders and harvestmen species and the number of specimens collected at two localities and by three different methods. L – linden, O – oak, M – maple; PT – pitfall traps, CB – cardboard bands, ST – sticky traps. Bold numbers indicate trapping exclusively with one method.

Species/Family	Locality		Tree			Method		
	Forest	Town	L	O	M	PT	CB	ST
Araneae								
Segestriidae								
<i>Segestria senoculata</i> (Linnaeus, 1758)	1	3	.	3	1	3	1	.
Mimetidae								
<i>Ero furcata</i> (Villers, 1789)	1	.	.	1	.	1	.	.
Theridiidae								
<i>Anelosimus vittatus</i> (C. L. Koch, 1836)	2	12	9	.	5	13	1	.
<i>Dipoena melanogaster</i> (C. L. Koch, 1837)	4	4	.	8	.	4	3	1
<i>Enoplognatha ovata</i> (Clerck, 1757)	12	2	3	9	2	10	.	4
<i>Parasteatoda lunata</i> (Clerck, 1757)	8	7	6	3	6	12	3	.
<i>Parasteatoda simulans</i> (Thorell, 1875)	.	1	1	.	.	.	.	1
<i>Platnickina tincta</i> (Walckenaer, 1802)	24	23	10	31	6	10	24	13
<i>Steatoda bipunctata</i> (Linnaeus, 1758)	.	2	.	2	.	.	2	.
<i>Theridion mystaceum</i> L. Koch, 1870	22	14	9	21	6	.	29	7
<i>Theridion varians</i> Hahn, 1833	4	10	6	7	1	9	1	4
<i>Theridion</i> sp. (juv.)	61	42	40	46	17	50	17	36
Linyphiidae								
<i>Agyneta innotabilis</i> (O. P.-Cambridge, 1863)	.	11	.	7	4	9	.	2
<i>Agyneta rurestris</i> (C. L. Koch, 1836)	7	2	5	4	.	7	1	1
<i>Bathypantes</i> sp. (juv.)	1	.	.	1	.	1	.	.
<i>Drapetisca socialis</i> (Sundevall, 1833)	95	24	69	21	29	99	4	16
<i>Entelecara acuminata</i> (Wider, 1834)	13	12	7	2	16	22	.	3
<i>Erigone atra</i> Blackwall, 1833	.	1	1	.	.	.	.	1
<i>Hypomma cornutum</i> (Blackwall, 1833)	12	.	.	12	.	7	5	.
<i>Leptyphantes minutus</i> (Blackwall, 1833)	80	15	17	39	39	53	42	.
<i>Moebelia penicillata</i> (Westring, 1851)	24	20	20	12	12	10	34	.
<i>Neriere montana</i> (Clerck, 1757)	13	.	.	13	.	2	11	.

Species/Family	Locality		Tree			Method		
	Forest	Town	L	O	M	PT	CB	ST
<i>Tenuiphantes flavipes</i> (Blackwall, 1854)	2	2	.	2	2	3	.	1
<i>Trematocephalus cristatus</i> (Wider, 1834)	8	6	4	2	8	11	1	2
Tetragnathidae								
<i>Pachygnatha listeri</i> Sundevall, 1830	1	.	.	1	.	1	.	.
<i>Tetragnatha pinicola</i> L. Koch, 1870	4	2	1	5	.	2	.	4
Araneidae								
<i>Araneus</i> sp. (juv.)	.	8	.	.	8	6	.	2
<i>Gibbaranea gibbosa</i> (Walckenaer, 1802)	.	3	3	.	.	3	.	.
<i>Larinioides sclopetarius</i> (Clerck, 1757)	.	4	4	.	.	4	.	.
<i>Nuctenea umbratica</i> (Clerck, 1757)	24	45	8	30	31	20	49	
<i>Zygiella atrica</i> (C. L. Koch, 1845)	.	1	.	.	1	1	.	.
Agelenidae								
<i>Agelena labyrinthica</i> (Clerck, 1757)	.	1	.	.	1	.	1	.
<i>Eratigena atrica</i> (C. L. Koch, 1843)	.	1	1	.	.	1	.	.
<i>Tegenaria silvestris</i> (L. Koch, 1872)	5	.	.	3	2	4	.	1
Dictynidae								
<i>Brigittea civica</i> (Lucas, 1850)	.	2	2	.	.	1	.	1
<i>Dictyna uncinata</i> Thorell, 1856	1	.	1	.	.	.	.	1
<i>Emblyna annulipes</i> (Blackwall, 1846)	.	2	.	.	2	.	2	.
<i>Lathys humilis</i> (Blackwall, 1855)	4	.	.	3	1	3	1	.
<i>Nigma flavescens</i> (Walckenaer, 1830)	2	.	.	2	.	1	.	1
<i>Nigma walckenaeri</i> (Roewer, 1951)	.	10	.	.	10	2	8	.
Eutichuridae								
<i>Cheiracanthium mildei</i> L. Koch, 1864	.	10	1	.	9	5	5	.
Anyphaenidae								
<i>Anyphaena accentuata</i> (Walckenaer, 1802)	241	114	78	214	73	316	33	6
Clubionidae								
<i>Clubiona brevipes</i> Blackwall, 1841	8	.	.	8	.	8	.	.
<i>Clubiona comta</i> C. L. Koch, 1839	3	.	1	2	.	2	1	.
<i>Clubiona lutescens</i> Westring, 1851	.	3	2	.	1	2	1	.
<i>Clubiona pallidula</i> (Clerck, 1757)	175	124	62	184	53	105	191	3
<i>Clubiona</i> sp. (juv.)	202	54	68	114	74	175	51	30
Gnaphosidae								
<i>Micaria subopaca</i> Westring, 1861	3	.	.	3	.	2	1	.
Philodromidae								
<i>Philodromus albidus</i> Kulczyński, 1911	1	13	10	.	4	10	1	3
<i>Philodromus</i> sp. (juv.)	23	47	17	31	22	53	.	17
Thomisidae								
<i>Ozyptila praticola</i> (C. L. Koch, 1837)	36	4	.	40	.	11	29	.
<i>Pistius truncatus</i> (Pallas, 1772)	5	.	1	4	.	.	5	.
<i>Synema globosum</i> (Fabricius, 1775)	1	.	.	1	.	1	.	.
<i>Xysticus lanio</i> C. L. Koch, 1835	18	.	2	12	4	18	.	.
Salticidae								
<i>Ballus chalybeius</i> (Walckenaer, 1802)	8	5	3	10	.	13	.	.
<i>Evarcha falcata</i> (Clerck, 1757)	1	.	.	1	.	1	.	.
<i>Salticus scenicus</i> (Clerck, 1757)	.	8	5	.	3	8	.	.
<i>Salticus zebraneus</i> (C. L. Koch, 1837)	9	19	7	17	4	18	4	6
Opiliones								
Phalangiidae								
<i>Lacinius dentiger</i> (C. L. Koch, 1847)	3	1	.	2	2	4	.	.
<i>Lacinius ephippiatus</i> (C. L. Koch, 1935)	17	6	.	11	12	23	.	.
<i>Mitopus morio</i> (Fabricius, 1799)	1	.	.	.	1	1	.	.
<i>Opilio canestrinii</i> (Thorell, 1876)	7	20	5	12	10	26	1	.
<i>Opilio saxatilis</i> C. L. Koch, 1839	3	.	3	.	.	1	.	2
Phalangiidae spp. (juv.)	26	.	.	26	.	.	26	.
<i>Phalangium opilio</i> Linnaeus, 1761	12	1	4	7	2	9	.	3
<i>Rilaena triangularis</i> (Herbst, 1799)	566	202	203	471	94	741	.	27

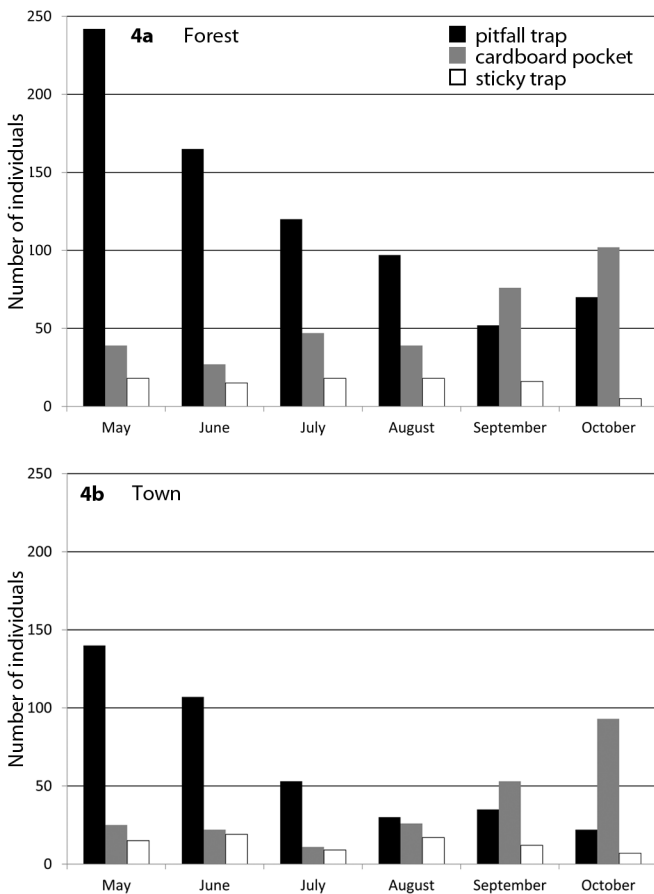


Fig. 4: Number of spider specimens obtained by three sampling methods during one year (total number); above (4a) – forest, below (4b) – town

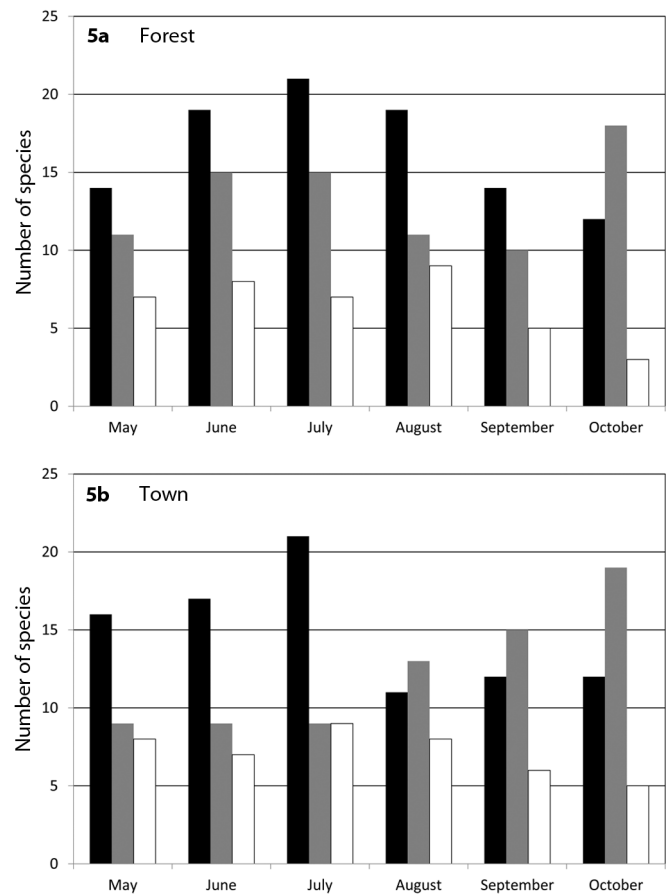


Fig. 5: Number of spider species obtained from three sampling methods during one year (total number); above (5a) – forest, below (5b) – town

2010), 105–151 spider species was sampled using just 8 eclectors in different forest reserves in Hesse (Germany). Similarly, Platen (1985) sampled 69 species using just one eclector.

Nevertheless, in comparison with other studies using modified pitfall traps, its efficiency was similar: Weiss (1995) found 57 species and Machač (2014) found 33 spider species and 3 harvestman species from 18 traps contrary to 48 species recorded by pitfall traps in this study. We trapped relatively more harvestman species than has been published (Sührig & Rothländer 2006), but without some typical bark-dwelling species, e.g. from the genus *Leiobunum*. The number of species can also be influenced by the type of locality, both localities are relatively disturbed and without protected nature status.

Most of the collected spider species in the forest are widespread, silvicolous spiders with a known arboreal occurrence (Szinétár & Horváth 2006). In the town, synanthropic species of spiders were collected too, e.g. *Brigittea civica*, *Cheiracanthium mildei* and *Nigma walckenaeri* (Buchar & Růžička 2002). The most dominant species found in the town and the forest are the common spider species *Anyphaena accentuata*, *Clubiona pallidula* and the harvestman *Rilaena triangularis*, known from previous studies (e.g. Horváth et al. 2001, Horváth & Szinetár 2002). The greatest number of spider specimens collected using cardboard bands were obtained during September and October (almost 60% of them). The exclusive species recorded in cardboard bands were *Agelena labyrinthica*, *Emblina annulipes*, *Pistius truncatus* and *Steatoda bipunctata*. Tree trunks provide important shelters for the overwintering of spiders (Pekár 1999, Horváth & Szinetár 2002, Szinetár

& Horváth 2006). Corrugated cardboard bands simulate tree bark asperities and spiders used them preferably (Isaia et al. 2006). During summer months, these cardboard bands are inhabited mostly by females with egg sacs, e.g. *Clubiona pallidula*, *Nuctenea umbratica* or *Ozyptila praticola*, which provide calm and warm shelters. Similarly, the spider *Oreonetides quadridentatus* is known to migrate onto tree trunks from soil during spring (Kopecký & Tuf 2013). Cardboard bands seem to be effective for sampling species living under bark or overwintering on trunks. On the contrary, this method is not suitable for harvestmen as only one aggregation of unidentified juveniles was found.

The pitfall traps made from PET bottles obtained the most spider specimens and the largest number of spider species (48) as well as harvestmen species (seven). Also, the highest portion of exclusive species was recorded by this method, including a majority of specimens belonging to Araneidae and Salticidae as well as harvestmen. The highest number of spider and harvestman specimens was obtained by this method during May, including the harvestman *Rilaena triangularis* which is most active in this month (Klimeš 1990). Pinzon & Spence (2008) found only 33 species on trunks using trunk pitfall traps in the forests of Canada. Trunk pitfall traps are, however, very effective for sampling of spiders and harvestmen living on tree trunks (Weiss 1995).

The sticky trap method was not effective for arachnids at all. Twenty-four spider (mostly juveniles and small species) and three harvestman species were obtained using this method only. Moreover, harvestmen were usually damaged when

releasing them from the glue. This method is not usually used for sampling arachnids, but is suitable for monitoring ballooning spiders (e.g. Greenstone et al. 1985). Sticky traps are more suitable for flying insects, e.g. Coleoptera, Diptera or Hymenoptera (Horváth et al. 2005, Bar-Ness et al. 2012).

Based on our results, we can recommend pitfall trapping for sampling spiders and harvestmen from tree trunks. In autumn and during winter, this method can be combined (or replaced) with cardboard bands (bark traps) as an effective method to collect arachnids searching for overwintering shelters.

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Scientific heritage of Alexandru Roșca: publications, spider collection, described species

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Abstract: The scientific heritage of the Romanian arachnologist Alexandru Roșca (publications, spider collection, and described species) was surveyed. For almost 40 years Alexandru Roșca studied the spiders from territories that are now parts of Romania, Ukraine, Bulgaria, and Moldova. Despite political repression, Roșca made a significant contribution to the study of the spiders of Romania and bordering countries, reflected in his 19 papers including the Ph.D. thesis. A complete list of Roșca's papers is presented. The 'Alexandru Roșca' spider collection is deposited in the Grigore Antipa National Museum of Natural History (Bucharest, Romania). According to the register it includes 596 species (1526 specimens) of spiders. Part of the collection was revised by different scientists and later by the present authors. During the period 1931–1939, Roșca described 13 spider species. To date, five species names have been synonymised. We propose that six species should be treated as **nomina dubia** because of their poor descriptions and lack of availability of types and/or other specimens. For two of Roșca's species, *Pardosa roscai* (Roewer, 1951) and *Tetragnatha reimoseri* (Roșca, 1939), data and figures are presented and information on them is updated.

Keywords: *Pardosa roscai*, Romania, spider collection, *Tetragnatha reimoseri*

The analysis of historical data (including literature data and collections) is important for obtaining complete information on spider diversity and composition, for defining habitat preferences of species, for estimating faunal change due to human impacts on habitats and climate change and thus for nature conservation management (Helsdingen 2000, Aakra 2009, Fedoriak et al. 2012, Komposch 2015). The Romanian spider fauna is relatively well studied. The first list of Romanian spiders was published by Fuhn & Oltean (1970). Dumitrescu (1979) published the 'Bibliographia Arachnologica Romanica', which included a list of more than 300 papers on both Romanian and foreign arachnids written by Romanian authors as well as the contributions of foreign specialists on Romanian arachnological material. The detailed analysis of the history of arachnological studies in Romania was published soon after (Dumitrescu 1981). The most recent checklist of the fauna was published by Weiss & Petrișor (1999) and it was updated and published online by Weiss & Urák (2000) who presented 972 species. Since then a number of additional species were recorded for Romania (Moscaliuc 2013).

An important contribution to spider fauna studies in Romania and adjacent countries was made during the period 1930–1968 by the Romanian arachnologist Alexandru Roșca. However, complete information about his publications, described species, material deposited in the 'Alexandru Roșca' collection in the Grigore Antipa National Museum of Natural History (Bucharest, Romania) as well as an analysis of his records for the territories that are now parts of Romania, Ukraine, Bulgaria and Moldova is still lacking.

Alexandru Roșca's life (2.10.1895–7.8.1969) was significantly influenced by historical events during the 20th century. He survived two world wars, overcame cancellation of his

scientific degree and dismissal from the University (October 16, 1947) and was later rehabilitated (January 29, 1964). Despite these hardships, he made a significant contribution to the study of the spiders of Romania and bordering countries.

The aim of the present study is to provide a complete list of Roșca's arachnological publications and to provide information about the current status of his collection and the described spider species.

Material and methods

We obtained information about the scientific heritage of Alexandru Roșca from the publications and documents stored in the libraries of Chernivtsi National University (Chernivtsi, Ukraine), the Vernadsky National Library (Kyiv, Ukraine), the National Library of Belarus (Minsk, Belarus), the Mihai Eminescu Central University Library (Iași, Romania), the Scientific Library of the Grigore Antipa National Museum of Natural History (Bucharest, Romania) as well as in Roșca-Toderaș family archive.

We digitalised the register of the 'Alexandru Roșca' collection deposited in the Grigore Antipa National Museum of Natural History. The complete and unchanged data from the original register dating back to 1972 are available (Fedoriak 2015: pp. 144-161). It provides the following data: name of the taxa (596 species in 21 families), number of specimens per species, locality (mostly names of settlements), and the date of collecting. Until recently the material had no inventory numbers. The revision of different parts of the collection was done by different arachnologists who rearranged specimens in glass tubes and placed them in plastic jars with 70% alcohol (Petrișor 1999, Fedoriak & Moscaliuc 2013). The rest of the collection is in the same condition as it was received and requires reorganization and verification.

We collected information on the results of previous revisions of the 'Alexandru Roșca' collection. These results are available in different forms:

- published data (Braun 1982, Urak & Weiss 1997, Petrișor 1999, Fedoriak & Moscaliuc 2013);
- notes in the register of the 'Alexandru Roșca' collection;
- additional labels which were added to Salticidae specimens by I. E. Fuhn.

Photographs were taken by Liviu A. Moscaliuc using a Leica 205C stereomicroscope with a mounted Canon EOS 60D camera and were processed with 'Windows 10 Photos'

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and various photo stacking software packages. The pictured specimens are part of the arachnological collections of Department of Zoology, Institute of Biology, Siedlce University of Natural Sciences and Humanities (Poland), Grigore Antipa National Museum of Natural History (MNINGA, Romania) and C. Deltchev's private collection (Bulgaria).

Results

According to the register of the 'Alexandru Roşca' collection deposited in the Grigore Antipa National Museum of Natural History (Bucharest, Romania), the first spider material was collected in May 1928; the last material was collected in May 1966. For almost 40 years he studied spiders in the territories that are now parts of Romania, Ukraine, Bulgaria and Moldova.

Roşca also studied spiders from different regions of Romania. In general, he provided data on spiders per study region as follows: Bucovina in six publications including his thesis (Roşca 1930, 1935, 1936a, 1936b, 1937b, 1938a), Moldova in five publications (Roşca 1937a, 1938c, 1946a, 1946b, 1968), Transylvania in three publications (Roşca 1932, 1958, 1959), Dobrogea in two publications (Roşca 1938b, 1939), Bessarabia in one paper (Roşca 1940).

Two of Roşca's publications are not faunistic. One of them concerns the interpretation of the notion of "biotope" and provides information about biotope preferences of some spider species (Roşca 1943). The second one deals with the silk collar that can be found around some of the burrows dug by *Hogna vultuosa* [= *Geolycosa vultuosa* (C.L. Koch, 1838)]. This silk collar, as Roşca noted, is used to protect the spiderlings in their first stages of life (until pigmented) against debris and powerful sunlight (Roşca 1947).

Roşca and his family managed to save the collection of spiders. According to the certificate #1582 dating back to 26.7.1972, the Grigore Antipa National Museum of Natural History acquired the collection of 1526 specimens representing 596 Araneae species sold by Olivia Toderaş (Alexandru Roşca's daughter). The collection came in handmade cardboard boxes containing glass vials with rubber covers and was accompanied by the register. Until now only a part of the collection has been reorganized and verified (Tab. 1).

Currently 506 specimens from the collection have been verified (some of them twice by different arachnologists), 296 are under the process of verification and 724 require reorganization and verification (Tab. 1).

During the period 1931–1939, Roşca described 13 spider species from the territories that now are parts of Romania, Ukraine and Bulgaria. So far no type material was found in 'Alexandru Roşca' collection.

To date, five species names have been synonymised: *Aranea multipunctata* Roşca, 1935 [= *Larinioides ixobolus* (Thorell, 1873)]; *Theridium botezati* Roşca, 1935 [= *Phylloneta impressa* (L. Koch, 1881)]; *Coelotes intermedius* Roşca, 1935 [= *Inermocoelotes falciger* (Kulczyński, 1897)]; *Arctosa turbida* Roşca, 1935 [= *Arctosa stigmata* (Thorell, 1875)]; *Acantholycosa trajani* Roşca, 1939 [= *Pardosa nebulosa* (Thorell, 1872)].

Six of Roşca's species are here considered doubtful:

Ceratinella marculi Roşca, 1932: the description of this species was based only on one specimen. The description of size and colour/tegument sculpture as well as the habitat in which it was collected is rather indicative for several other species within

this genus. The epigyne is represented very schematically and looks similar to *C. brevipes*, *C. wideri* and *C. scabrosa*.

Diplocephalus subrufus Roşca, 1935 [= *Diplocephalus alpinus subrufus* Roşca, 1935] was described based on a male and a female. It was given subspecific status as *Diplocephalus connectens subrufus* (Drensky 1939). Drensky noted that he had not examined the specimens. Roşca stated that the difference between his species and *D. connectens* was the lack of a sulcus between the anterior median and posterior median eyes, thus his species has a single peaked conical head region compared to a double pointed head region of *D. connectens*. But the description and the figures do not allow us to distinguish it from other possibly related species.

Walckenaera fusca Roşca, 1935 is a species described by Roşca based on one female only. In the description the author

Tab. 1: Information on the revised material from 'Alexandru Roşca' spider collection (Family names and data as in original)

Family	Species	Specimens	Notes
Araneidae	50	183	Requires reorganization and verification
Gnaphosidae	39	71	Requires reorganization and verification
Xysticidae	82	296	Under the process of verification
Theridionidae	40	104	Verified by Fedoriak & Moscaliuc (2013)
Hahniidae	2	3	Requires reorganization and verification
Lycosidae	61	165	Verified by Petrişor (1999). This part of the collection contains 12 specimens of Pisauridae which were also verified by Fedoriak & Moscaliuc (2013)
Argyronetidae	1	2	Verified by Petrişor (1999)
Sicariidae	1	4	Requires reorganization and verification
Zoridae	2	11	Requires reorganization and verification
Dysderidae	8	10	Verified by Petrişor (1999)
Linyphiidae	43	105	Requires reorganization and verification
Micryphantidae	96	149	Requires reorganization and verification
Clubionidae	56	124	Requires reorganization and verification
Salticidae	49	138	Verified by Fuhn & Gherasim (1995) and recently by Moscaliuc & Fedoriak (2015)
Dictynidae	27	73	Requires reorganization and verification
Pholcidae	2	15	Verified by Fedoriak & Moscaliuc (2013)
Mimetidae	2	2	Verified by Fedoriak & Moscaliuc (2013)
Eresidae	1	1	Require reorganization and verification
Oxyopidae	2	12	Verified by Fedoriak & Moscaliuc (2013)
Agelenidae	23	34	Verified by Petrişor (1999)
Tetragnathidae	9	24	Verified by Petrişor (1999)
Totals	596	1526	

differentiated it from *W. obtusa* Blackwall, 1836 by variations in epigyne morphology. However, the latter species has an epigyne morphology (with a trapezoidal plate in the middle) that is quite different from Roşca's description of an inverted arch-like epigyne opening.

Centromerus crinitus Roşca, 1935 is another species that Roşca described on based on one female only and compared it with *C. similis* [= *Centromerus sellarius* (Simon, 1884)]. However, the provided figure is rather a conundrum and of no help for any comparison.

For *Tarentula strandi* Roşca, 1936 and *Tarentula roeweri* Roşca, 1937 both sexes were described and illustrated. They were recognized and placed within the genus *Alopecosa* by Fuhn & Niculescu-Burlacu (1971). However, the authors mentioned that they searched for them but found no specimens at the type locality.

We propose that these six species should be designated **nomina dubia** because of their poor descriptions and the unavailability of types or other specimens.

Two of Roşca's species are valid and information on them is updated: *Eucta reimoseri* Roşca, 1939 [= *Tetragnatha reimoseri* (Roşca, 1939)] and *Lycosa maculata* Roşca, 1939 [= *Pardosa roscai* (Roewer, 1951)].

Pardosa roscai (Roewer, 1951) (Fig. 1)

Illustrated material. BULGARIA: 1♂1♀, Shabla town (43.53794°N, 28.53523°E), Tuzlata place, 28.6.1993, leg. & det. C. Deltshv.

Other examined specimens. ITALY: fragments (the material is macerated probably due to a poor preservative) (MNINGA inv.nr. ARA 252/1), Toscana, Pisa (43.72284°N, 10.40169°E), 7.6.1958, det. C. Sterghiu. ROMANIA: 2♂♂ (MNINGA inv.nr. ARA 330/1), Grindul Caraorman (45.07746°N, 29.37816°E), 5.5.1967, det. C. Sterghiu; 7♀♀ (MNINGA inv. nr. ARA 330/12), same location, 6.5.1967, det. C. Sterghiu; 4♀♀ (MNINGA inv.nr. ARA 330/13), same location, sand dune, 6.5.1967, det. C. Sterghiu; 14♀♀ (MNINGA inv.nr. ARA 330/15), same location, 5.5.1967, det. C. Sterghiu; 26♀♀ (MNINGA inv.nr. ARA 330/16), same location, 5.5.1967, det. C. Sterghiu; 7♀♀ (MNINGA inv.nr. ARA 330/2), same location, 5.5.1967, det. C. Sterghiu; 1♀ (MNINGA inv. nr. ARA 330/3), same location, 1.5.1957, det. C. Sterghiu; 5♀♀ (MNINGA inv.nr. ARA 330/5), same location, *Juncus* meadow, 5.5.1967, leg. I. Fuhn, det. C. Sterghiu; 2♀♀ 1 subadult ♂ (MNINGA inv.nr. ARA 330/10), same location, 30.4.1957, leg. I. Fuhn, det. C. Sterghiu; 1♀ (MNINGA inv. nr. ARA 330/4), Ciupercenii Noi (43.90768°N, 22.94809°E), 7.05.1973, leg. I. Fuhn, det. C. Sterghiu; 1♀ (MNINGA inv. nr. ARA 330/14), same location, 9.5.1963, leg. I. Fuhn, det. C. Sterghiu; 1♀ (MNINGA inv.nr. ARA 330/11), Ciupercenii Vechi (43.94231°N, 22.89760°E), 7.5.1963, det. C. Sterghiu; 2♀♀ (MNINGA inv.nr. ARA 330/6), Murighiol-Sărături (45.03371°N, 29.15407°E), 10.6.1967, det. C. Sterghiu; 6♀♀ 2 subadult ♂♂ (MNINGA inv.nr. ARA 330/7), Gârla Împuţită (45.09243°N, 29.65179°E), Black Sea shore, 14.10.1970, det. C. Sterghiu; 6♀♀ 1 subadult ♂ (MNINGA inv.nr. ARA 330/9), same location, 14.10.1970, leg. I. Fuhn, det. C. Sterghiu; 4♀♀ 2 subadult ♂♂ (MNINGA inv.nr. ARA 330/8), Sulină cemetery (45.15029°N, 29.67073°E), 16.10.1970, leg. I. Fuhn, det. C. Sterghiu; 1♀ (MNINGA inv.nr. ARA 526/52), Caracal (44.11574°N, 24.34246°E), 7.5.1958, leg. A. Cohen,

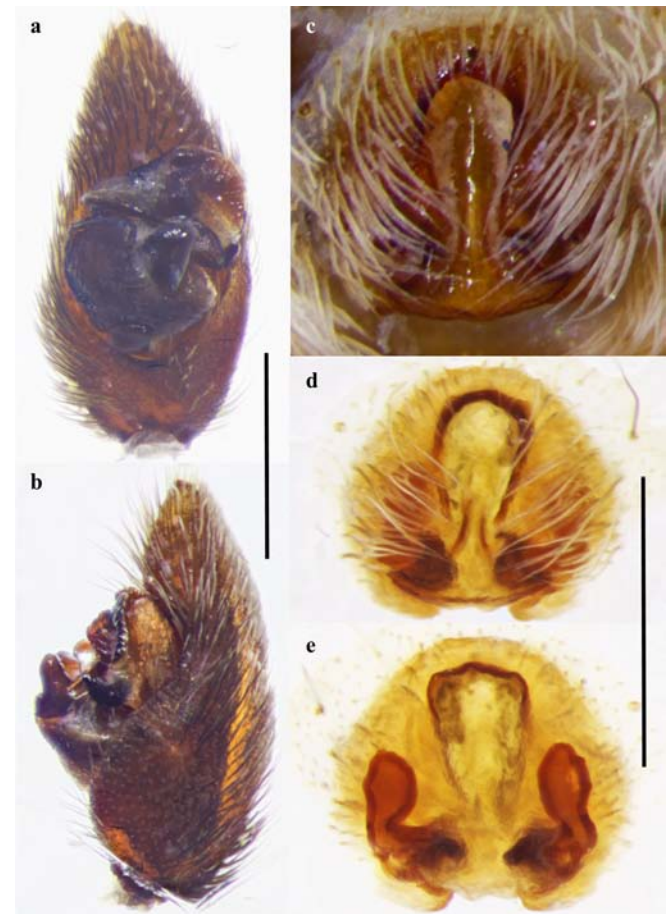


Fig. 1: *Pardosa roscai* (Roewer, 1951). Male and female from Shabla town, Bulgaria: Right pedipalp: **a.** Ventral; **b.** Lateral; **c.** Epigyne (not cleared); **d.** Epigyne (cleared); **e.** Vulva. Scale bars 0.5 mm

det. I. Fuhn; 1♀ (MNINGA inv.nr. ARA 526/33), location and date unknown, leg. P. Banarescu.

Diagnosis. Distinguished from its congeners by the morphology of the genitalia. **Male.** Prosoma dorsum dark brown, darker region inside the eye field. Light median band, irregular in shape. Discontinued lateral bands with faint radial pattern. Palpus dark brown covered with dark hairs. Apical part of the back of the palp covered with a dense field of lighter and shorter setae. Conductor bifurcated, terminal apophysis with an acute, sclerotized end. Long horizontal and tapered embolus (Fig. 1a). **Female.** Similar colouration pattern of prosoma as for the male, different only in the shade of brown which is lighter and slightly reddish. Epigyne with an upturned T shaped septum and double outward facing sclerotized copulatory pockets at the base. Covered with white setae (Fig. 1c-e). **Distribution.** Turkey, Bulgaria, Romania (World Spider Catalog 2016, Helsdingen 2015).

Tetragnatha reimoseri (Roşca, 1939) (Figs 2-3)

Illustrated material. POLAND: 1♂ 1♀, Siedlce Ponds (52.19298°N, 22.29157°E), Siedlce, rushes, sweeping with a net, 27.6.2005, leg. & det. I. Hajdamowicz; ROMANIA: 1♂ 1♀ (MNINGA inv.nr. 40002, tube 37), Caraorman (45.08673°N, 29.39596°E), 11.8.1967, leg. X. Palade, det. M. Vasiliu.

Other examined specimens. POLAND: 1♀, Siedlce Ponds (52.19298°N, 22.29157°E), Siedlce, rushes, sweeping with a net, 8.6.2006, leg. & det. M. Oleszczuk; 1♂, same locality,

27.5.2000, leg. & det. P. Jastrzębski; 1♀, same locality, 8.6.2006, leg. & det. P. Jastrzębski. ROMANIA: 1♀ (MNINGA inv. nr. 40002, tube 32), Periprava (45.39962°N, 29.54424°E), 15.9.1966, leg. & det. M. Vasiliu; 2♀♀ 1 subadult ♂ (MNINGA inv. nr. 40002, tube 38), same location, 24.7.1958, leg. A. Cohen, det. M. Vasiliu; 1♀ (MNINGA inv. nr. 40002, tube 39), same location, 27.6.1967, leg. & det. M. Vasiliu; 3 subadult ♀♀ (MNINGA inv. nr. 40002, tube 40), same location, 12.10.1966, leg. X. Palade, det. M. Vasiliu; 1 subadult ♂ (MNINGA inv. nr. 40002, tube 33), Corciovata lake (45.23538°N, 29.28529°E), 29.3.1967, leg. Ș. Torcea, det. M. Vasiliu; 2♀♀ 1 subadult ♂ (MNINGA inv. nr. 40002, tube 34), Caraorman (45.08673°N, 29.39596°E), 8.4.1967, leg. X. Palade, det. M. Vasiliu; 1♂ 7♀♀ (MNINGA inv. nr. 40002, tube 37), same location, 11.8.1967, leg. X. Palade, det. M. Vasiliu; 1 subadult ♂ (MNINGA inv. nr. 40002, tube 35), Crișan (45.18005°N, 29.35145°E), 24.9.1967, leg. I. Paina, det. M. Vasiliu; 7♀♀ 1 subadult ♂ (MNINGA inv. nr. 40002, tube 36), Roșca canal (45.36027°N, 29.39929°E), 9.9.1967, leg. I. Paina, det. M. Vasiliu; 1 subadult ♂ (MNINGA inv. nr. ARA 579, tube 4), Danube Delta, 30.6.1956, det. C. Sterghiu.

Diagnosis. Distinguished from its congeners by the morphology of the genitalia and the unmistakable shape of the abdomen, with the spinnerets placed at about two thirds of its length, marking the beginning of a “tail” (compare with data by Wunderlich (2011: p. 213 & 217) for *Tetragnatha isidis* (Simon, 1880)). General yellow grey colouration, marble abdomen. Powerful prognathous chelicerae (Figs 2-3) with long bifurcated dorsal tooth on the male chelicera (Fig. 3b-d). **Distribution.** Austria, Belgium, Germany, Hungary, Italy, Netherlands, Poland and Romania (World Spider Catalog 2016, Helsdingen 2015). Ukraine and Belarus are excluded because misidentifications were reported by Polchaninova & Prokopenko (2013) and Ivanov (2013b).

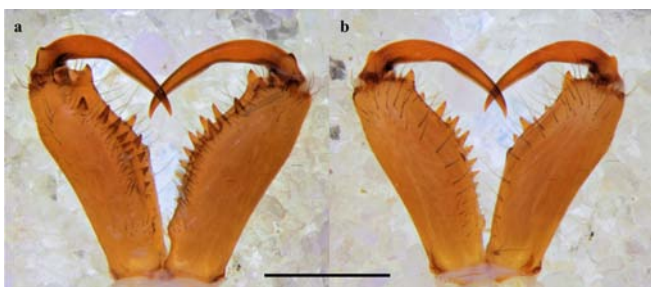


Fig. 2: *Tetragnatha reimoseri* (Roșca, 1939). Female from Siedlce Ponds, Poland. Chelicerae; **a.** Ventral; **b.** Dorsal. Scale bar – 1 mm

Discussion

The biographical information and some data about Roșca's collection and publications are available in a few literature sources written in Romanian (Bonnet 1945, Dumitrescu 1979, Bejinariu & Istrate 1998, Ardelean et al. 2000, Vasiliu 2001, Satco 2004, Bejinariu 2005). However, the information is often incomplete or erroneous. In particular, Bejinariu (2005) mentioned that the collection of spiders was obtained by the Grigore Antipa National Museum of Natural History in 1970, whereas this occurred in 1972. Some literary sources mention Roșca to be the author of 13 or 15 published works, but in fact 19 of his papers were published. We present all Roșca's papers chronologically in the references with the author's family name as in

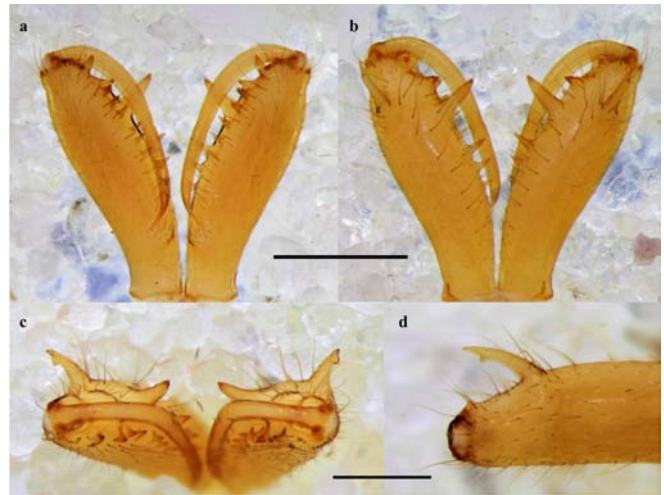


Fig. 3: *Tetragnatha reimoseri* (Roșca, 1939). Male from Caraorman, Romania. Chelicerae; **a.** Ventral; **b.** Dorsal; **c.** Frontal; **d.** Bifurcated dorsal tooth. Scale bar – 1 mm/0.5 mm

the original works. Roșca did not complete his ‘Romania Spider Catalog’.

It is worth mentioning that there are no type specimens of Roșca's species in the collection but only specimens of two species that were synonymised. There is no Roșca's material in the collection of the Brukenthal National Museum in Sibiu (Romania) (Weiss 1998). Olivia Toderas (Alexandru Roșca's daughter) convinced us that spiders collected by her father can be found nowadays only in the Grigore Antipa National Museum of Natural History. Neither Roșca nor other members of his family gave specimens to any other person or institution. So we presume that the rest of Roșca's material was lost or destroyed when the family moved.

At the end of 20th century specimens from the ‘Alexandru Roșca' spider collection were verified by different arachnologists (Braun 1982, Fuhn & Gherasim 1995, Urak & Weiss 1997, Petrișor 1999, Fedoriak & Moscaliuc 2013).

Braun (1982) analysed species described by Bösenberg, mainly from Germany. He stated that ‘of 40 species ... only two are valid (*Theridium bertkai* = *Theridium boesenbergi*, *Hypomma fulvum* = *Enidia fulva*), 17 are synonyms, 15 seem to be synonymous and 6 are doubtful’ (Braun 1982). A number of the 38 nominal species were reported from the Balkan Peninsula. For his revision Braun also analysed specimens assigned to Bösenberg's species from the ‘Alexandru Roșca' spider collection. He mentioned, that out of 14 verified samples 4 were ‘mixta composita’, 12 species were wrongly identified and 2 species were identified correctly (Braun 1982). In the same paper Braun cited some critical comments by Drensky (1939) on species described by Roșca. According to Drensky, Roșca had insufficient access to literature on spiders of Romania and neighbouring countries, especially the Balkans and therefore made some mistakes. Urak & Weiss (1997) recorded the Linyphiidae species *Silometopus reussi* (Thorell, 1871) registered as *Tapinocyba pygmaea* (Blackwall, 1834) in the ‘Alexandru Roșca' spider collection. One could come to the wrong conclusion that the collection has a low scientific value with regard to the above mentioned criticism.

Nevertheless, later Petrișor (1999) verified 200 specimens which belonged to Lycosidae, Argyronetidae, Dysderidae, Agelenidae and Tetragnathidae according to the ‘Alexandru

Roşca' collection. Her analysis revealed 11 cases of misidentification and some cases of wrongly used nomenclature (Petrişor 1999). For instance, *Zygiella* species were mentioned by Petrişor (1999) to be found within Tetragnathidae and *Pisaura* species within Lycosidae. We recently verified the Pisauridae and found 1 ♂, 3 ♀♀ of *Pisaura novicia* (L. Koch, 1878) not previously recorded for Romania. They were recorded as *Pisaura listeri* (Scopoli, 1763) by Roşca and as *Pisaura mirabilis* (Clerck, 1757) by Petrişor (Fedoriak & Moscaliuc 2013).

In the introduction of the Salticidae Fauna of Romania (Fuhn & Gherasim 1995) the authors mention that the spider collections of Grigore Antipa Museum were studied for Salticidae. The cited locations for species derived either from literature (including Roşca's publications) or as original and/or verified data (where the studied collections are mentioned including Roşca's collection). No critical analysis of the data from the collections was made. By re-checking the 'Alexandru Roşca' collection we found out that Fuhn added his own labels to some of the vials with the new or corrected species names. By studying his labels in comparison with the original ones we can draw the following conclusions: Dr. Fuhn relabelled some of the wrongly identified specimens and also those vials that contained more specimens and more species than stated in the original register of the 'Alexandru Roşca' collection. He managed to correct a majority of the initial labelling errors but at the same time he made erroneous identifications of species and even genera (Moscaliuc & Fedoriak 2015).

Information on the two remaining valid species described by Roşca is updated (see also results):

***Lycosa maculata* Roşca, 1939** [valid name *Pardosa roscai* (Roewer, 1951)]: the current name implies that the species was not described by Roşca, but in fact it was properly described by Roşca (1939) and only renamed by Roewer. Roşca provided a detailed description and, in our view, not very clear figures of the female and male copulatory organs. The taxonomic name was preoccupied by Hahn (1822) for *Lycosa maculata* (now *Arctosa maculata*). Because of the homonymy Roewer (1951) replaced the name with *Lycosa roscai*. Later it was reduced to the rank of subspecies as *Pardosa cribrata roscai* (Fuhn & Niculescu-Burlacu 1971) and was again elevated to a species by Bayram et al. (2009). The original material was collected by Roşca at several localities (Lipniţa, Medgidia and Gârliţa) on the territory of Romania, county of Constanta (Dobrogea region), as well as in the county of Durostor, which is now located on the territory of Bulgaria. Roşca mentioned the species as inhabiting wet meadows; mature specimens can be found in May (Roşca 1939). *P. roscai* is common in Bulgaria (Blagoev et al. 2016) and has recently been recorded abundantly in fields of genetically modified potatoes, treated with insecticide twice a season (Nedvěd et al. 2006). The species is recorded from localities along the Black Sea coast and its distribution is mostly limited to the Mediterranean basin (Elverici 2012).

***Eucta reimoseri* Roşca, 1939** [valid name *Tetragnatha reimoseri* (Roşca, 1939)] was named after the Austrian arachnologist Reimoser. Males and females were found by Roşca (1939) near the salt lakes Şabla and Duranculac, which are now in Bulgaria (previously belonging to the county of Constanta, Romania). Roşca's original description of *T. reimoseri* is very detailed, but the epigyne is depicted in a simplified manner and it is described as being similar to that of *Tetragnatha*

montana Simon, 1874; the chelicerae of the male are depicted from both sides. Several well illustrated descriptions are available for *T. reimoseri*. Crome (1954) and Wiehle (1963) (both sub *Eucta kaestneri*) supplied many detailed illustrations for both sexes. Vasiliu (1968) depicted only a female and pointed to the possibility of a synonymy between *Eucta isidis*, *E. reimoseri* and *E. kaestneri*. An insufficient amount of material was available to the author to verify this hypothesis. *T. reimoseri* is a rare species due to several reasons: limited range, specific habitat requirements and small size of local populations. This led to inclusion of this species as endangered in the Red Lists of Germany, Belgium and Poland (Platen et al. 1996, Maelfait et al. 1998, Starega et al. 2002). The known records are summarised by Hajdamowicz & Jastrzębski (2007). Later *T. reimoseri* was also recorded from Eastern Ukraine (Polchaninova 2009) and corrected to *T. isidis* by Polchaninova & Prokopenko (2013). *T. reimoseri* was similarly recorded for Belarus (Ivanov 2013a) and soon afterwards, due to misidentification, excluded from the 'The checklist of Belarusian spiders (Arachnida, Araneae)' by the same author (Ivanov 2013b). The records both from Ukraine and Belarus are listed by Mikhailov (2013), which is cited in the most commonly used sources on spider distribution in Europe (World Spider Catalog 2016, Helsdingen 2015). IJland & Helsdingen (2011) recorded the species from Italy and provided the information on *T. reimoseri* (indicating its junior synonyms) distribution. On the basis of scrupulous taxonomic remarks these authors drew the provisional conclusion that the European records of *Tetragnatha isidis* (Simon, 1880) and *T. reimoseri* (Roşca, 1939) concern one and the same species, for which the specific name *T. reimoseri* should be used (IJland & Helsdingen 2011: p. 23). Picard et al. (2014) published further analysis of the systematic position of *T. isidis* versus *T. reimoseri*.

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*Nachruf/Obituary***In memoriam Prof. RNDr. Jan Buchar, DrSc. (1932–2015)**

During the opening ceremony of the 29th European congress of Arachnology held in Brno last year, Professor Jan Buchar received an enormous, long-lasting applause for his speech. It was his farewell address.

Jan Buchar passed away on 17th November 2015. He was a kind of “celebrity” of Czech as well as world arachnology. He was an important zoologist, the leading personality who notably influenced progress of arachnology from the 1960's to the present days. Czech arachnologists called him “our Spider Father“, and this nickname summarizes it all. Jan Buchar was the founding father of large Czech arachnological school. He shared more than just his knowledge with several generations of Czech arachnologists; he shared his generous personality and much of his spare time.

Jan Buchar (Fig. 1) was born on 18th February 1932 in Bystrá nad Jizerou – a small village surrounded by beautiful nature in the foothills of the Krkonoše Mts. All his family admired nature – so it was not surprising that nature became Jan Buchar's job, mission and destiny. The career of a university professor was perhaps predestined for him.

After finishing secondary school in Jilemnice, Jan Buchar began studies at the Faculty of Science of the Charles University in Prague (1951–1955) and thus started his life-long relationship with the Faculty. He was studying and teaching there, doing research and leading the Department of Zoology (1986–1990) and later the section of Invertebrates (1990–1995). In 1994, he was appointed Professor of Zoology. He was regularly commuting to the University and working there until his last days.

He always expressed the opinion that research at universities should be multidisciplinary and universal. Beside modern biochemical and molecular approaches, it is necessary to involve also comparative morphology as well as regional faunistics and ecology. In an interview he mentioned that there is no gap in understanding phylogeny, but rather in the control over deteriorating conditions of the environment crucial for the survival of the human race on the Earth.

Although the topic of Jan Buchar's M.Sc. thesis was the ciliates, he turned his attention to arachnology as early as 1958. His supervisor was Prof. František Miller (1902–1983) from the University of Agriculture in Brno. Jan Buchar gained his first arachnological experiences exploring spider communities on meadows, using formalin pitfall traps. Since the wolf spiders were the dominant family there, they became his life-long object of research and his great love. Jan Buchar published much work dealing with taxonomy, faunistics, zoogeography and ecology of these spiders. However, he did not focus only on lycosids and the territory of Europe, he also worked with material from Nepal, Bhutan, Mongolia, the Caucasus and Hindu Kush. Jan Buchar thus became an international expert in taxonomy and zoogeographic studies of Palaearctic wolf spiders. He also cooperated with numerous foreign institutions and published scientific papers in cooperation with number of significant scientists. Crucial was his meeting with Konrad Thaler (1940–2005) at the International Congress in Paris (1968). It led to a close friendship, reci-

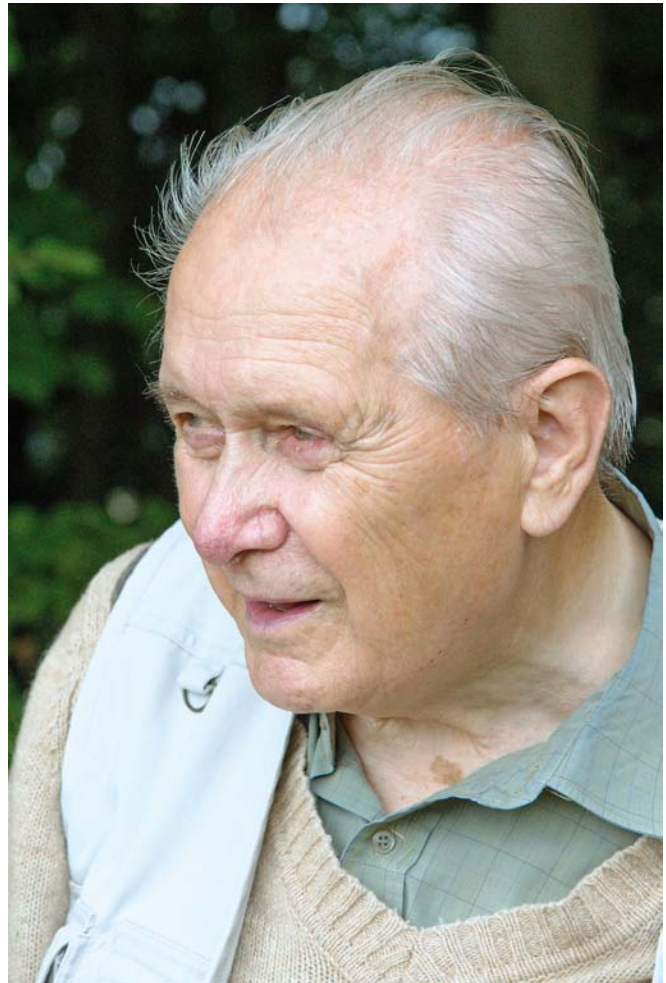


Fig. 1: Prof. Jan Buchar, 2014 (photo M. Kubec)

procal visits and mutual collaboration leading to 16 scientific papers and a description of five new species (Fig. 2).

In the field of Czech arachnology, Jan Buchar's work was a milestone in exploring the Czech as well as the Slovak spider fauna. His publications were focused not only on the complex study of Czech spiders but also on exploitation of faunistic data defining the ecological requirements of individual spider species. This data enable us to monitor environmental changes in Central Europe.

Jan Buchar discovered that spiders are an important group for bioindication of the degree of anthropological influences on the environment. His classification of spider species with respect to the degree of originality of habitats also became a model for other arthropod groups, namely insects. The classification was the basis of modern Czech arachnology. Other projects followed: grid square mapping contributed to the objective classification of species abundance and to creating distribution maps for each species. These new approaches and results from the study of Central European spiders spanning almost 50 years were summarized in the crucial work of Czech arachnology, the Catalogue of Spiders of the Czech Republic. The Catalogue presents a variety of possibilities for

the evaluation of natural conditions and is thus used by arachnologists and ecologists from the whole of Europe. This book contains description and characteristics of 830 spider species and is undoubtedly the best national catalogue of spiders in the world.

About 130 original papers are evidence of Jan Buchar's scientific erudition. He was very prolific also in the area of popularization, as documented by more than 40 popular papers, several books and instructive natural history films. He is also the author of several university textbooks.

Jan Buchar was a member of editorial boards of many scientific or environmental journals, e.g. *Arachnologische Mitteilungen*, *Věstník Československé společnosti zoologické* (later *Acta Societatis Zoologicae Bohemicae*), *Opera Corcontica* and *Živa*.

Jan Buchar presented results of his research at national as well as international congresses. He was an honorary member of the European Society of Arachnology, a long-time member of the International Society of Arachnology and *Arachnologische Gesellschaft*. As a co-author, he took part in preparing an important Checklist of the Spiders of Central Europe. In the Czech Republic, Jan Buchar collaborated with many scientific and environmental organisations. Above all he established, and for decades led, the Arachnological Section of the Czechoslovak Entomological society. He also initiated popular collecting field trips and organised more than 70 un-

forgettable seminars on arachnology. Everyone who visited his office was astonished by his huge library and large spider collection. His spider collection and series of historical books are now a showpiece of the National Museum in Prague. Jan Buchar was respected not only for his outstanding identification skills and broad knowledge but mainly for his humane qualities and friendly attitude.

Most of us met Jan Buchar during our studies; we were his students and he was our very kind, amiable, helpful teacher and lecturer. He supervised about 50 arachnological diploma and PhD theses dealing with faunistics, ecology and nature protection, zoogeography, taxonomy, morphology, histology, cytogenetics and ethology. Thousands of students were influenced by his inspiring lectures on the Zoology of Invertebrates, Zoogeography, Arachnology and many others. They took place both in large auditoriums as well as in his office for just a few students. The most exciting experience was to accompany Jan Buchar in the field – he knew Czech nature and the landscape perfectly (Fig. 3). But he also organized several student expeditions to the Caucasus and Central Asia. We still remember these common journeys. We were climbing on the rock steppe, observing spiders... This was the real arachnological school!

Jan Buchar had been guiding us for many years, he inspired and encouraged us. We were given a chance to be involved in his unique school. He brought us to our life-long interest and employment: learning about the life of arachnids on our planet. We'll always miss you, Professor Buchar.

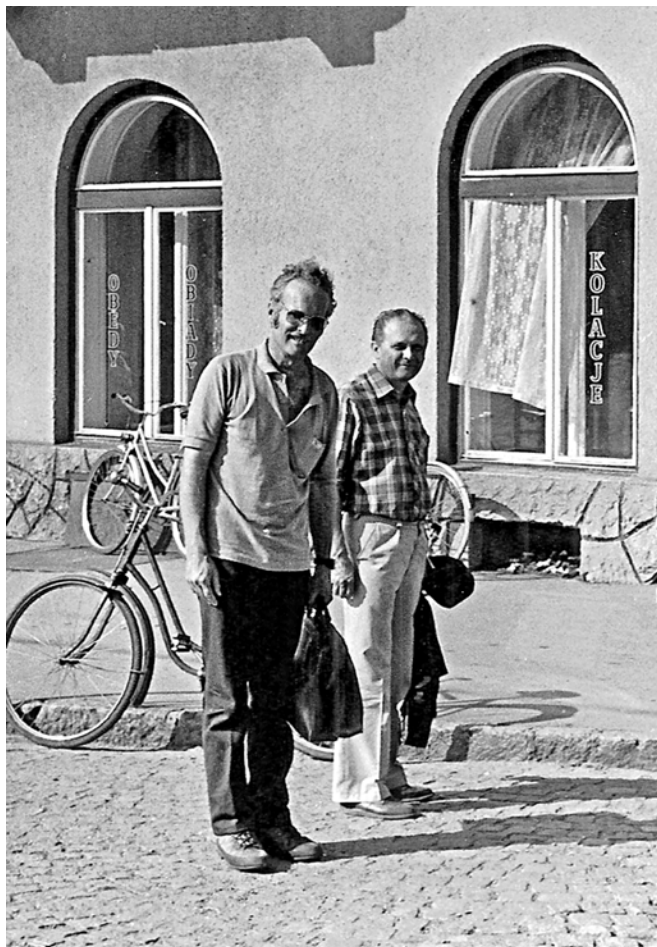


Fig. 2: Prof. Jan Buchar with Prof. Konrad Thaler at the first Czechoslovak-Polish Arachnological Symposium in Ostrava, 1986 (personal archive of J. Buchar)

Spiders described by Jan Buchar:

Abbreviations:

- * = valid species, deposition of the type material is given in parenthesis
- BZL = Biologiezentrum, Linz, Austria
- IZLI = Institute of Zoology & Limnology, Innsbruck, Austria
- IZS = Institute of Zoology, Sofija, Bulgaria
- MHNG = Museum d'Histoire Naturelle, Genève, Switzerland
- NMB = Naturhistorisches Museum, Basel, Switzerland
- NMBE = Naturhistorisches Museum, Bern, Switzerland
- NMP = National Museum, Prague, Czech Republic [inventory number in brackets]
- NMW = Naturhistorisches Museum, Wien, Austria
- SMF = Senckenbergischen Museum, Frankfurt am Main, Germany
- SNMB = Slovak National Museum, Bratislava, Slovakia
- ZISP = Zoological Institute, Sankt Peterburg, Russia
- ZMMU = Zoological Museum of the Moscow State University, Moskva, Russia

Agyneta milleri (Thaler, Buchar & Kürka, 1997)* (MHNG, NMP [P6E 2943], NMW, SNMB)

Alopecosa kalavrita Buchar, 2001* (NMBE, NMP [P6A 6061], NMW)

Alopecosa psammophila Buchar, 2001* (NMP [P6E 2863])

Arctosa janetscheki Buchar, 1976* (IZLI)

Arctosa kozarovi Buchar, 1968 (syn. of *Arctosa tbilisiensis* Mcheidze, 1946; IZS)

Arctosa renidescens Buchar & Thaler, 1995* (MHNG, NMB, NMP [P6A 4934], NMW)



Fig. 3: Prof. Jan Buchar with students on the last field excursion, May 31, 2015 (photo P. Dolejš)

Aulonia kratochvíli Dunin, Buchar & Absolon, 1986* (NMP [P6A 4933], ZISP)
Dorjulopirata dorjulanus Buchar, 1997* (NMB)
Drassodes tirtschensis Miller & Buchar, 1972* (NMP [P6E 2937])
Evippa nigerrima (Miller & Buchar, 1972)* (NMP [P6E 2919–2923])
Gnaphosa danieli Miller & Buchar, 1972* (NMP [P6E 2880–2881])
Haplodrasus bohemicus Miller & Buchar, 1977* (NMP [P6A 5851, P6E 2973])
Hippasa bifasciata Buchar, 1997* (NMB)
Mughiphantes hindukuschensis (Miller & Buchar, 1972)* (NMP [P6E 2892])
Pardosa aquila Buchar & Thaler, 1998* (BZL, MHNG, NMW, ZMMU)
Pardosa bulgarica Buchar, 1968 (syn. of *Pardosa roscai* (Roewer, 1951); NMP [P6A 4937])
Pardosa dagestana Buchar & Thaler, 1998* (NMW)
Pardosa drenskii Buchar, 1968* (NMP [P6A 4936])
Pardosa ibex Buchar & Thaler, 1998* (NMW, ZMMU)
Pardosa martensi Buchar, 1978* (SMF)
Pardosa orealis Buchar, 1984* (SMF)
Pardosa pseudotorrentum Miller & Buchar, 1972* (NMP [P6E 2929–2932])
Pardosa tasevi Buchar, 1968* (IZS)
Pardosa thaleri Buchar, 1976 (syn. of *Pardosa bifasciata* (C. L. Koch, 1834); IZLI)
Pardosa tikaderi Buchar, 1984 (syn. of *Pardosa mongolica* Kulczyński, 1901; SMF)
Piratula hurkai (Buchar, 1966)* (NMP [P6A 4935])
Trochosa dentichelis Buchar, 1997* (NMB)
Trochosa graveleyi Buchar, 1976* (IZLI)
Zelotes kodaensis Miller & Buchar, 1977 (syn. of *Zelotes puritanus* Chamberlin, 1922; NMP [P6A 5352, P6E 2897–2898])
Zoica oculata Buchar, 1997* (NMB)

Species named in honour of Jan Buchar:

Bathypantes eumenis buchari Růžička, 1988
Harpactea buchari Dunin, 1991
Kirschenblatia buchari Boháč, 1977 (syn. of *Philonthus spinipes* Sharp, 1874) [Coleoptera, Staphylinidae]
Lychas buchari Kovařík, 1997 [Scorpiones, Buthidae]
Pardosa buchari Ovtcharenko, 1979
Philodromus buchari Kubcová, 2004
Sintula buchari Miller, 1968 (syn. of *Sintula spiniger* (Balogh, 1935))

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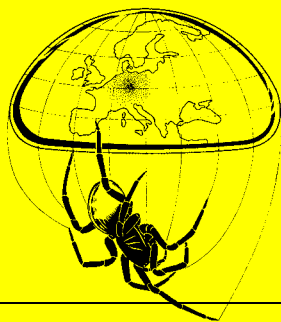
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Epigaecic invertebrate community structure in two subtropical nature reserves, Eastern Cape, South Africa: Implications for conservation management

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Abstract. Epigaecic invertebrates were sampled at non-invaded ('Indigenous Forest' and 'Indigenous Grassland') and alien-invaded ('Eucalyptus' and 'Mixed alien') sub-sites in the Nduli and Luchaba Nature Reserves using pitfall traps. A total of 2054 specimens belonging to three phyla (Arthropoda, Mollusca and Annelida) was caught and sorted into seven orders, 18 families, one tribe, 45 genera (22 identified to species level) and 20 morphospecies. Higher species richness occurred in 'Indigenous Forest' and 'Mixed Alien' sub-sites while higher specimen counts were made in invaded ('Mixed Alien' and 'Eucalyptus') sub-sites during summer months, peaking in January. Canonical Correspondence Analysis results show that some measured site variables, e.g. litter depth, grazing intensity, percentage of alien vegetation cover, and soil chemical properties accounted for invertebrate taxa composition and distribution trends at sub-sites. Although habitat-patch level characteristics (including abiotic factors) were important for determining species distributions, increased levels of infestation by invasive alien vegetation across sub-sites did not necessarily impact on epigaecic invertebrates in a predictable manner. For guiding management decisions, future studies on the effects of invasive alien plants on epigaecic invertebrates should distinguish between ecological effects and adverse impacts on species of conservation concern.

Keywords: alien and indigenous vegetation, environmental variables, epigaecic invertebrates, nature reserves, ordination

Biological invasions are a main component of global change with strong ecological and socio-economic consequences (Simberloff et al. 2013, Schirmel et al. 2016). Such changes can affect resident animal communities by modifying habitats (Schirmel et al. 2011), food resources (Wolkovich et al. 2009) or biotic interactions (Schweiger et al. 2010). Effects on local fauna can be negative in terms of abundances and diversity (Hanula & Horn 2011, Holmquist et al. 2011), and functional diversity (Schirmel & Buchholz 2013). Reported effects of invasive species are often biased towards negative consequences (Kumschick & Richardson 2013), but positive effects of invasive plants on animals are also known (Schlaepfer et al. 2011).

Monitoring biodiversity in protected areas (PAs) forms an integral component of assessing their performance and providing the necessary information for effective management. In South Africa, PAs play a significant role as refugia, providing high quality habitat patches for invertebrate biodiversity conservation even though challenges resulting from their size and numbers do arise (Samways 2005, Foxcroft et al. 2011, Samways et al. 2012). Even within these reserves, alien invasive plants impact invertebrate species composition and distribution patterns differently (Richardson & van Wilgen 2004, Halaj et al. 2008, Foxcroft et al. 2010). Invertebrates constitute a significant proportion of terrestrial and freshwater biodiversity (Hamer & Slotow 2002), serve a series of critical ecosystem functions (McGeoch et al. 2011) and, as a consequence, must necessarily be considered in protected area monitoring systems (Vane-Wright 1993).

Little is known about habitat-level impacts of invasive and indigenous vegetation on the richness, abundance and diversity of epigaecic invertebrate taxa within PAs of the Eastern Cape Province of South Africa. Such studies are likely

to yield additional insight into how and under which conditions invasive plants alter ecosystem function and biodiversity patterns in such habitats (Samways et al. 2012, Samways & Bohm 2012).

The Nduli and Luchaba Nature Reserves (protected areas), situated in the Eastern Cape Province of South Africa fall within the Albany Centre of Endemism, which has high levels of endemic plant and animal extinctions due to several stressors including invasive alien plants (Smith & Wilson 2002, Preston 2003, Oxborough et al. 2010, Egoh et al. 2011). These reserves are growing in significance as elements of the matrix within which raising public awareness for conserving indigenous biodiversity can be undertaken.

The goal of this preliminary study was to assess habitat characteristics at a priori selected invaded and non-invaded vegetation patches and compare their effects on epigaecic invertebrate assemblages.

Study area, material and methods

The study was carried out in the Nduli and Luchaba Nature Reserves (Fig. 1). These are situated at 31°30'S, 28°42'E and 31°35'S, 28°45'E, respectively, in the King Sabata Dalindyebo (KSD) Municipality. The two reserves are located about 3.5 km apart and fall within the Mthatha moist grassland biome. Nduli Nature Reserve (170 ha) was originally established in 1951 and re-proclaimed in 1972 in terms of the Cape Nature Conservation Ordinance of 1965. Luchaba Nature Reserve (460 ha) is an un-proclaimed protected area on state land, managed as a nature reserve by the Operations Directorate of the Eastern Cape Parks & Tourism Agency (ECPTA). Climate at both reserves is characterized by average winter and summer temperatures of 13 °C and 26 °C respectively, with average annual precipitation of 634 mm (DWAf 2005). Natural forest in the reserve area is made up of indigenous trees, e.g. *Acacia karroo*, *A. sieberiana*, *A. xanthophloea*, *Erythrina caffra* and *Zanthoxylum capense* (Palgrave 2002). Common grass species in the reserves are *Eragrostis curvula*, *E. plana*, *E. racemosa*, *Paspalum dilatatum*, *Themeda triandra* and *Pennisetum* spp., while invasive alien plant species present in Luchaba Nature Reserve comprise *Eucalyptus grandis*, *Acacia mearnsii*, *Lantana camara*, *Solanum mauritianum* and *Cestrum laevigatum* (Olckers & Hulley 1991). The geology of the re-

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serves comprises predominantly shales and sandstones of the Beaufort series of the Karoo system. These land forms are interlaced with dolerite dykes (Acocks 1988).

Sampling site stratification

Site one in the Nduli Nature Reserve (dominated by indigenous vegetation), measuring 130 m², was mapped out and divided into two sub-sites comprising 'Indigenous Forest patch' and 'Indigenous Grassland patch' each measuring 60 m². The second site is in the Luchaba Nature Reserve (comprising predominantly invasive alien plants), measured 250 m² and was also divided into two sub-sites, each measuring 60 m²

for the study. These sub-sites were a 'Eucalyptus patch' and 'Mixed Alien patch' (Tab. 1). Each of the four sub-sites was further stratified into four square grids (sampling units = SU) measuring 10 m² and separated from each other by 8-9 m.

Invertebrate species sampling using pitfall traps

Although the interpretation of pitfall trap data is contentious because the size of catch is not only affected by density, but also the activity of the species being sampled (Saska et al. 2013), this method has been widely used for sampling epigeic invertebrates because it is less costly, efficient and easy to use (Southwood & Henderson 2000, Parr & Chown 2001, Un-

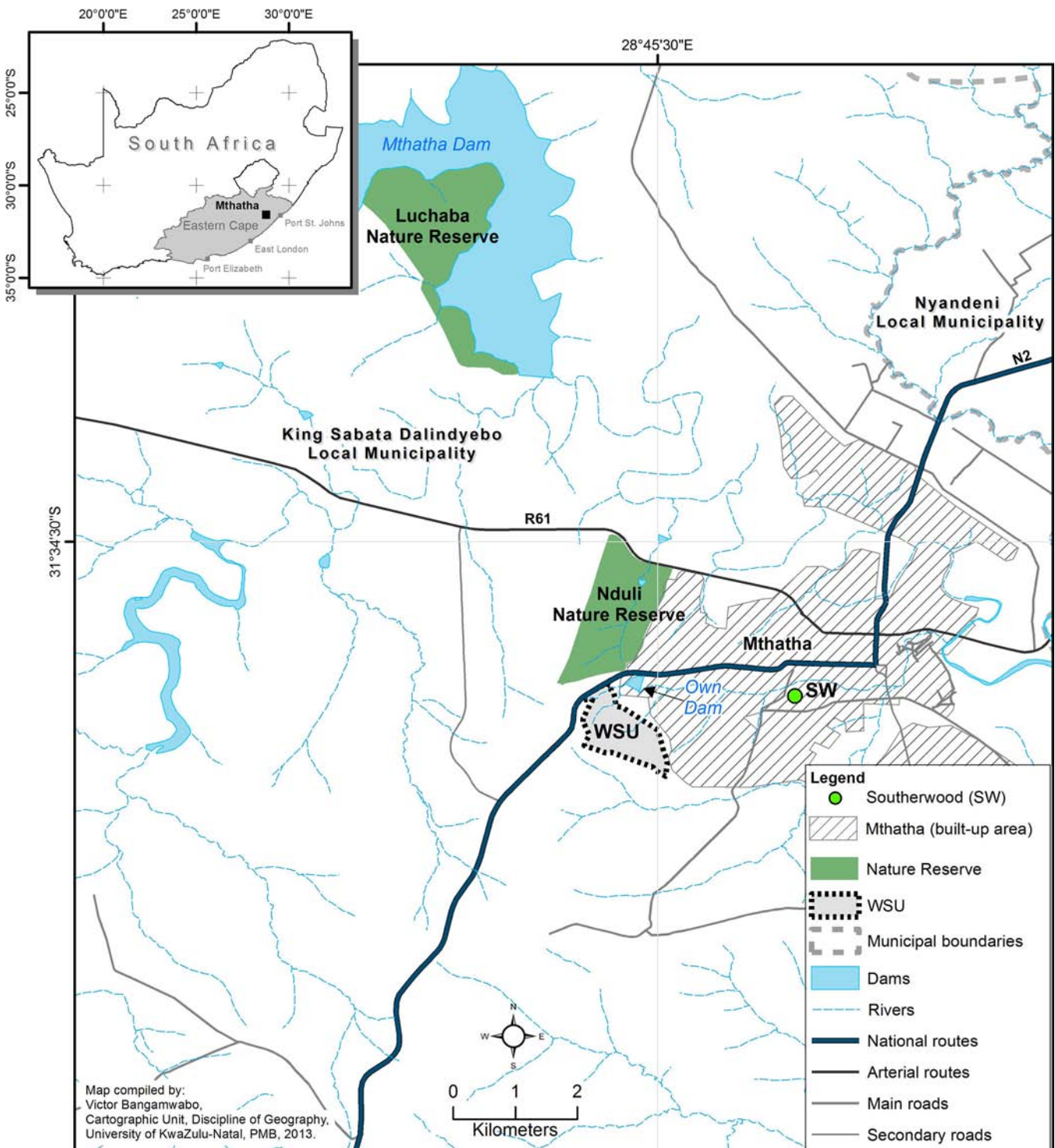


Fig. 1: Map of the study area, King Saba Dalindyebo (KSD) Municipality, Eastern Cape Province, South Africa

Tab. 1: Site description and sampling unit labels at Nduli and Luchaba Nature Reserves

Site Name	Sub-sites	Sampling unit labels	Dominant vegetation /disturbance regime
Site 1: Nduli Nature Reserve	Indigenous Forest patch (IF)	IFA, IFB, IFC, IFD	Native acacias, <i>Podocarpus</i> sp., <i>Erythrina</i> sp. Minimally grazed
	Indigenous Grassland patch (IG)	IGA, IGB, IGC, IGD	Native grasses e.g. <i>Eragrostis curvula</i> , <i>Paspalum dilatatum</i> , <i>Pennisetum</i> sp. Rich and sedges Moderately grazed
Site 2: Luchaba Nature Reserve	Eucalyptus patch (EU)	EUA, EUB, EUC, EUD	Gum trees (<i>Eucalyptus grandis</i>) Highly grazed
	Mixed Alien patch (MA)	MAA, MAB, MAC, MAD	<i>Lantana camara</i> , <i>Acacia mearnsii</i> , <i>Solanum mauritanium</i> Indigenous herbs Highly grazed

derwood & Fisher 2006). In this study, four pitfall traps, each made up of a 250 ml blue plastic cup with a rim diameter of 7.5 cm and 9.5 cm deep were sunk into the ground in square grids within each sampling unit such that the open end of the cup was flush with the ground surface. Traps were filled with soapy water as a trapping medium, and left open in the ground for 24 hours to capture soil-surface dwelling (epigaeic) invertebrate specimens (Forbanka & Niba 2013). Trapped specimens were sorted from flying arthropods, preserved in 70 % alcohol, and transported to the laboratory for preliminary identification. Identification was done using a Zeiss stereo dissecting microscope (Model STEMI DV4) and field guides (Picker et al. 2004). Spider identities were confirmed using reference works by Dippenaar-Schoeman & Jocqué (1997). Ants were identified at the Biosystematics Division of the Agricultural Research Council (ARC) in Pretoria. Unidentified morpho-species were coded and preserved in 70 % alcohol for future identification by taxon specialists. Specimen data was collected in 64 traps per month across all sites during 12 sampling months from May 2010 to April 2011.

Measurement of environmental variables

A number of environmental variables were hypothesized to be important in determining faunal composition and distribution across sampling units at the sites (Avuletey & Niba 2014) and were measured as follows:

- i) Soil pH, phosphorus, potassium and zinc contents were determined by collecting (through digging) 200 g of top soil samples to the depth of 10 cm in each SU. The samples were analysed at the Mthatha Dam Soil Analytical Services Laboratory using standardized protocols for measuring soil chemical properties (Soon & Warren 1993)
- ii) Litter depth (cm) was measured using a calibrated wooden ruler placed perpendicularly on the soil surface to determine the depth and thickness of the litter
- iii) Grazing intensity was assessed by classifying available dung and degree of trampling as 0 (none), 1 (low), 2 (medium) and 3 (high)
- iv) Extent of alien plant cover was estimated by determining the percentage of total area of SU surface covered by these plants
- v) Percentage (%) shade (insolation) was estimated as amount of sunlight that penetrated the SU during the sampling interval between 11:30 am and 13:30 pm on clear sunny days

Data on soil characteristics were collected once during each of the four seasons of the year while the rest of the measured variables were collected monthly.

Data analysis

Data sets were collated for each sampling unit (SU) for each month and arranged in data matrices as proposed by Clarke & Gorley (2006). The statistical software program DIVERSE in PRIMER V 6 (Clarke & Warwick 2001) was used to determine Shannon diversity index (H') and Pielou's evenness index (J) for species data. Ordination methods attempt to give a broad overview of invertebrate community structure and patterns across site sampling units (Clark & Gorley 2006, Ter Braak & Looman 1995). The computer software package CANOCO (Ter Braak & Šmilauer 2002), which combines into one algorithm Correspondence Analysis (CA) on species data and weighted multiple regressions on environmental variable data, was used. This technique related species composition to known variations in the environment. Canonical Correspondence Analysis (CCA) in CANOCO produced an ordination diagram in which points represented species and sites, and vectors (arrows) represented measured site (environmental) variable gradients. Such a diagram shows patterns of variation in species composition that can be explained best by the measured site variables (Ter Braak & Looman 1995).

Results

A total of 2054 specimens belonging to three phyla (Arthropoda, Mollusca and Annelida) was caught and sorted into seven orders, 18 families, one tribe, 45 genera (22 identified to species level) and 20 morphospecies. The Araneae constituted the richest order with eleven families and 21 genera (10 identified species) followed by the Coleoptera with four families, one tribe (Hopliini), and 13 genera (seven identified to species). Most specimens collected belonged to the order Hymenoptera at 60% (58% Formicidae) while the Stylomatophora was represented by one family and one species. A total of 20 morphospecies collected from traps were sorted into two morphospecies of the Annelida, three of woodlice (Crustacea), two of millipedes and centipedes (Myriapoda) and 13 morphospecies of ticks, mites and scorpions (other Arachnida). Indices of species diversity and evenness trends at across sub-sites are shown in Tab. 2. Only specimens identified to tribe, genus and species levels were included in the multivariate analyses.

Tab. 2: Taxonomic profile and abundance of epigeic invertebrate taxa sampled at sub-sites in the Nduli and Luchaba Nature Reserves

^aOrder or higher taxonomic level (Phylum/Class), ^bCode names used in analyses

ORDER ^a /Family/Tribe/ Genus/Species	Code ^b	EU	MA	IF	IG	total
ARANEAE						
Araneidae						
<i>Cyclosa</i> sp.	Cycsp	.	.	3	.	3
Clubionidae						
<i>Clubiona</i> sp.	Clusp	.	.	2	.	2
Dysderidae						
<i>Dysdera crocata</i> C.L. Koch, 1838	Dys	3	3	1	2	9
Eutichuridae						
<i>Cheiracanthium furculatum</i> Karsch, 1879	Che	1	.	2	6	9
Eresidae						
<i>Dresserus</i> sp.	Dresp	.	.	1	2	3
Gnaphosidae						
<i>Xerophaeus crustosus</i> Purcell, 1907	Xer	.	.	2	.	2
<i>Zelotes uquathus</i> FitzPatrick, 2007	Zel	3	1	2	.	6
Lycosidae						
<i>Hogna</i> sp.	Hogsp	.	.	2	1	3
<i>Pardosa crassipalpis</i> Purcell, 1903	Par	211	184	10	35	440
<i>Pardosa</i> sp.	Parsp	12	9	2	4	27
Pisauridae						
<i>Afropisaura</i> sp.	Afrsp	2	.	.	.	2
<i>Nilus (Thalassius)</i> sp.	Thasp	.	5	19	1	25
Salticidae						
<i>Evarcha</i> sp.	Evasp	2	15	1	5	23
<i>Habrocestum dotatum</i> Peckham & Peckham, 1903	Hab	1	4	2	.	7
<i>Hyllus argyrotroxus</i> Simon, 1902	Hyl	.	5	2	3	10
<i>Langona warchalowskii</i> Wesołowska, 2007	Lan	2	.	1	11	14
<i>Thyene</i> sp.	Thysp	.	.	.	2	2
<i>Thyenula aurantiaca</i> (Simon, 1902)	Thy	2	.	.	3	5
<i>Thyenula juvenca</i> Simon, 1902	Thyj	.	.	.	3	3
Theridiidae						
<i>Theridion</i> sp.	Thesp	.	1	.	.	1
Thomisidae						
<i>Xysticus</i> sp.	Xyssp	10	2	2	5	19
COLEOPTERA						
Chrysomelidae						
<i>Plagioderma</i> sp.	Plasp	.	1	.	.	1
<i>Sagra</i> sp.	Sagsp	.	.	.	1	1
<i>Sonchbia sternalis</i> (Fairmaire, 1888)	Son	.	3	1	.	4
Hydrophilidae						
<i>Hydrophilus</i> sp.	Hydsp	.	1	.	3	4

ORDER ^a /Family/Tribe/ Genus/Species	Code ^b	EU	MA	IF	IG	total
Scarabaeidae						
<i>Anachalcos convexus</i> Boheman, 1857	Ana	.	.	2	.	2
<i>Anisonyx editus</i> Péringuey, 1902	Ani	.	4	.	.	4
<i>Aphodius</i> sp.	Aphsp	.	.	2	.	2
<i>Diplognatha gagates</i> Forster, 1771	Dip	1	2	.	.	3
<i>Gymnopleurus</i> sp.	Gymsp	.	.	4	.	4
Hopliini [tribe]	Hoptr	23	.	10	.	33
<i>Kheper nigoaeneus</i> (Boheman, 1857)	Khe	.	1	3	.	4
<i>Sisyphus</i> sp.	Sissp	.	2	.	4	6
Tenebrionidae						
<i>Pachyphaleria capensis</i> Laporte de Castelnau, 1840	Pac	5	1	2	.	8
<i>Psammodes bertolonii</i> Guérin-Méneville, 1844	Psa	.	.	.	5	5
HYMENOPTERA						
Formicidae						
<i>Camponotus</i> sp.	Camsp	71	258	179	112	806
<i>Carebara vidua</i> F. Smith, 1858	Car	1	.	3	.	4
<i>Messorcapensis</i> (Mayr, 1862)	Mes	.	1	.	.	1
<i>Pheidole</i> sp.	Phesp	117	74	32	16	223
<i>Polyrhachis gagates</i> F. Smith, 1858	Pol	.	3	.	.	3
<i>Streblognathus aethiopicus</i> (F. Smith, 1858)	Stre	.	3	.	2	5
<i>Tetraponera</i> sp.	Tetsp	.	.	2	.	2
<i>Technomyrmex</i> sp.	Tecsp	60	49	67	46	252
BLATTODEA						
Blaberidae						
<i>Bantua</i> sp.	Bansp	.	3	1	.	4
Blattidae						
<i>Deropeltis erythrocephala</i> (Fabricius, 1781)	Der	.	2	2	13	17
STYLOMMATOPHORA						
Valloniidae						
<i>Vallonia</i> sp.	Valsp	2	4	.	.	6
DIPLOPODA						
2 morphospecies						10
ISOPODA						
3 morphospecies						2
ANNELIDA						
2 morphospecies						2
ARACHNIDA (Acari, Scorpiones)						
13 morphospecies						41
Total no. of taxa [only tribe or lower]/sub-site		18	26	29	23	
Total no. of individuals/ sub-site (N)		529	635	447	270	
Margalef's index (d')		3.4	3.6	3.9	4.3	
Shannon diversity index (H')		1.8	1.6	1.3	2.0	
Pielou's evenness Index (J)		0.55	0.52	0.42	0.63	

Spatio-temporal distribution of species across sites

Three invertebrate species (*Pardosa crassipalpis*, *Camponotus* sp. and *Technomyrmex* sp.) occurred throughout the year at all sub-sites, and fourteen taxa (genus and species) were recorded only from indigenous (forest and grassland) vegetation sub-sites while eight were sampled exclusively from invaded (Eucalyptus and Mixed alien) sub-sites. 24 taxa including one tribe (Hopliini) occurred in both invaded and non-invaded sampling units. The Mixed Alien patch had the highest specimen count while the grassland patch had the lowest (Tab. 2). Species richness peaked in summer (January and February) while highest specimen counts occurred in January at the Mixed Alien and Eucalyptus sub-sites. Specimen counts for *Camponotus* sp. accounted for overall high abundance trends in August at the Indigenous Forest sub-site.

Response of epigeaic invertebrates to measured site variables

Results of all measured environmental variables are shown in Tab. 3. The species – sampling units – environmental variable (CCA ordination) tri-plot (Fig. 2) indicated that most spe-

cies were clumped at the centre of the ordination, and related to certain measured environmental variable gradients. CCA ordination axes one and two (Tab. 4a) suggested that neither axis accounted for much variation in species data. Variance accounted for by measured environmental variables for both axes was 45.1 %. Monte-Carlo permutation tests were not significant for axis one (F=1.54, P>0.05). However, intra-set correlations extracted gradients of soil chemical properties (e.g. pH and Potassium (K) content), percentage shade (insulation) and grazing intensity that positively correlated with axis one of the ordination tri-plot, and may have determined the occurrence of most taxa at the Indigenous Grassland sampling units, e.g. *Cheiracanthium furculatum* and *Psammodes bertolonii* at SU IGB and *Dresserus* sp. at SU IGA.

Gradients of percentage alien vegetation cover and litter deposition negatively correlated with axis one of the ordination output (Tab. 4b). These variables were mostly important in determining species composition and distribution at the Eucalyptus, Mixed Alien and Indigenous Forest sub-sites. Litter depth explained the distribution of habitat-restricted specific species e.g. *Carebara vidua* at sampling unit EUA.

Tab. 3: Mean and range (in brackets) of measured environmental variables at sampling units (A-D) during the sampling period in the Nduli and Luchaba Nature Reserves. EUA-EUD (Eucalyptus), MAA-MAD (Mixed Alien), IFA-IFD (Indigenous Forest), IGA-IGD (Indigenous Grassland) sub-sites

Variables (Units)	EUA	EUB	EUC	EUD	MAA	MAB	MAC	MAD	IFA	IFB	IFC	IFD	IGA	IGB	IGC	IGD
Leaf litter depth (cm)	3.6 (1.5-5)	3.5 (1-7)	4.7 (2-8)	3.9 (2-5)	0.3 (0-2)	0.5 (0-3)	0.5 (0-2)	0.5 (0-2)	1.7 (0-3)	3.8 (2.5-6.5)	2.5 (1-4)	2.5 (1-3)	0	0	0	0
Alien veg. (%)	54 (30-80)	54 (30-100)	79 (50-100)	70 (20-100)	70 (40-90)	68 (60-90)	71 (50-90)	72 (50-80)	0.8 (0-5)	0.4 (0-5)	0	0	0	0	0	0
Shade (%)	50 (30-70)	31 (20-40)	72 (30-80)	68 (30-90)	62 (30-90)	63 (40-90)	67 (40-90)	67 (40-90)	85 (70-100)	81 (70-90)	67 (50-80)	71 (50-100)	87 (70-100)	90 (80-100)	84 (70-100)	91 (70-100)
Potassium (ppm)	187 (90-220)	169 (80-190)	194 (75-210)	162 (100-180)	231 (200-250)	167 (120-186)	179 (144-220)	164 (98-193)	233 (210-256)	194 (200-263)	232 (183-231)	217 (184-224)	3348 (250-368)	392 (320-410)	381 (340-422)	273 (210-310)
Phosphorus (ppm)	20 (14-23)	27 (11-45)	15 (11-21)	17 (14-21)	34 (24-48)	23 (12-26)	24 (14-30)	22 (15-25)	12 (9-18)	22 (10-24)	21 (13-27)	19 (15-30)	18 (8-31)	22 (11-31)	17 (12-26)	30 (11-35)
Zinc (ppm)	0.3 (0.2-0.5)	0.4 (0.1-0.6)	0.05 (0.1-0.8)	0.4 (0.1-0.8)	0.4 (0.2-0.8)	0.2 (0.1-0.3)	0.3 (0.1-0.6)	0.2 (0.1-0.3)	0.2 (0.1-0.4)	1.1 (0.2-1.7)	0.8 (0.4-1.6)	0.9 (0.1-0.6)	0.4 (0.2-0.5)	0.3 (0.2-0.8)	0.4 (0.2-0.8)	0.4 (0.2-0.6)
Grazing intensity	2 (1-3)	2 (1-3)	3 (0-3)	2 (2-3)	2 (1-3)	2 (1-3)	2 (1-3)	2 (1-3)	1 (0-2)	1 (0-2)	0 (0-0)	0 (0-0)	2 (0-3)	2 (1-3)	1 (0-2)	1 (0-2)
pH	4.9 (4-5.5)	4.2 (4-6)	3.9 (4-6.6)	4 (3.8-4.5)	3.5 (3.8-5)	3.1 (3-4.2)	3.2 (3-4)	3.9 (4-5.1)	4.8 (4.5-6)	5.6 (4.3-7)	6.5 (5.2-7.5)	5.9 (5-6.2)	4.3 (4-5)	4.7 (4-7.8)	4.5 (4-5.5)	4.5 (4-5.8)

Tab. 4a: Summary of the first two CCA axes weightings. Variances explained by the two axes are given. Monte-Carlo permutation tests for Axis 1: (F=1.154, P>0.05) and for all four axes (Global: F=1.68, P<0.05). *Significant

Axes	1	2	All four axes
Eigen values	0.27	0.20	.
Species-environmental variable correlations	0.97	0.94	.
Cumulative percentage variance of species data	14.7	26	.
Cumulative % variance species/envir. var. relations	25.5	45.1	.
Total inertia	.	.	1.85
F-ratio	1.54	.	1.68
p-value	0.33	.	0.04*

Tab. 4b: Intra-set correlations between each of the measured environmental variables and the first two canonical axes using pooled invertebrate species data recorded at sub-sites in the Nduli and Luchaba Nature Reserves

Variable	Intra-set Correlation		Inter-set Correlation	
	CCA1	CCA2	CCA1	CCA2
Litter deposition	-0.40	-0.37	-0.29	-0.39
Grazing Intensity	0.54	0.34	0.41	0.55
pH	0.03	-0.32	0.74	0.03
Potassium K	0.52	0.55	0.51	0.52
Phosphorus P	0.24	-0.26	-0.06	0.24
Zinc Z	-0.26	-0.44	0.43	-0.27
Alien vegetation	-0.34	0.02	-0.67	-0.34
Shade	0.55	0.32	0.38	0.56

Discussion

It is still poorly understood whether general patterns in impacts of invasive plants exist and whether these patterns are related to certain ecosystems or animal traits (Kumschick et al. 2015). Moreover, progress in understanding invasion impacts is challenged in several ways (Schirmel et al. 2016). Impacts are often not or differently defined (Jeschke et al. 2014), controversies about invasion impacts often rely on case studies, but meaningful generalisations based on single cases do not exist (Ricciardi et al. 2013). In this study, the impact of invasive plants on epigeaic invertebrates varied across sub-sites with neutral and decreasing effects on species diversity and abundance. The majority (24 taxa) occurred at both invaded and non-invaded vegetation sub-sites, while 14 taxa occurred exclusively at indigenous (forest and grassland) vegetation sub-sites, possibly due to the fact that these sites had minimal

and moderate grazing intensity respectively, and are more stable ecosystems. Generally, native plants are associated with a higher diversity and abundance of herbivore insects (Schirmel et al. 2016). This is often explained by co-evolutionary adaptations of native insects to leaf structural traits or to chemical compounds of native plants (Harvey & Fortuna 2012). Eight invertebrate species occurred only at the highly grazed invaded (Eucalyptus and Mixed Alien) sub-sites.

High invertebrate species richness and abundance occurred during the rainy summer months of January-February probably as a result of optimal habitat conditions which favoured maturation for various invertebrate taxa. This period is also characterized by high ambient temperatures which may have resulted in higher levels of invertebrate activity and their catch rates in traps. Even though the diversity and abundance patterns of invertebrate taxa (e.g. beetles, ants)

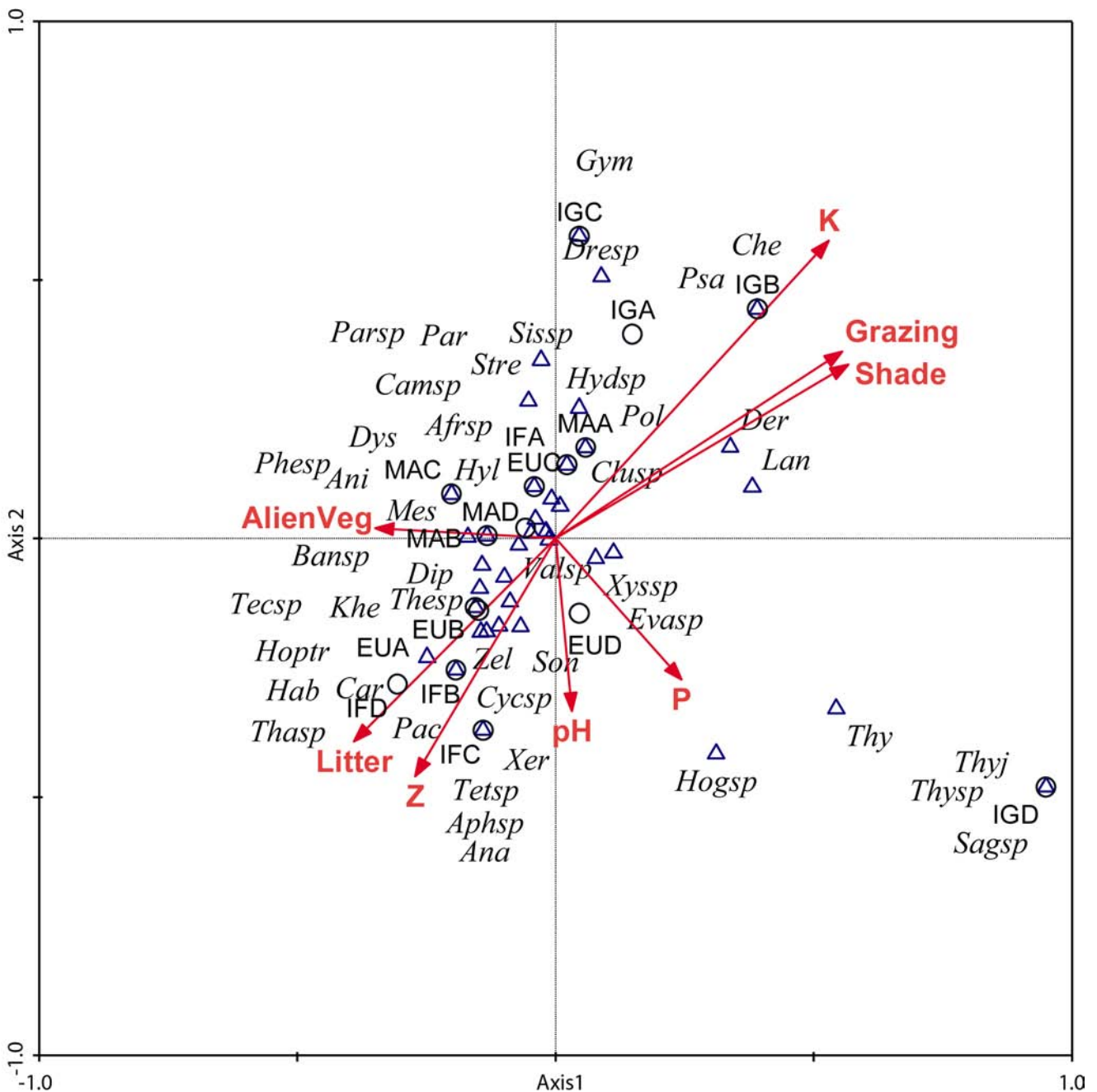


Fig. 2: Canonical Correspondence analysis (CCA) ordination of invertebrate species (Δ), site sampling units (\circ), and measured environmental variables (\blacktriangleright) using pooled data collected at Nduli and Luchaba Nature Reserves. Site description and sampling unit labels see Tab. 1, species code names see Tab. 2.

have been shown to be influenced significantly by seasonality (rainfall) and temperature (Davis 2002, Hahn & Wheeler 2002), other intrinsic factors could also have influenced the rate at which specimens were caught e.g. thermoregulation, body size, motivation or plasticity in diel rhythms (Atienza & Farinos 1996, Wallin & Ekblom 1994). Extrinsic factors could potentially impact on catch rates e.g. vegetation structure, soil surface litter (Hatten et al. 2007) as well as limitations associated with sampling design or short-term disturbances at sites (Mitchell 1963).

Litter deposition was found to be an important variable gradient influencing the composition and distribution of invertebrates across the Eucalyptus, Mixed Alien and Indigenous Forest sub-sites. High specimen counts at the Eucalyptus dominated sub-site could probably be due to abundant leaf litter deposition used by some taxa e.g. *Pachyphaleria capensis* as growth substrate for egg-laying and shelter from predators and desiccation (Albelho & Graça 1996, Magura et al. 2004, Hills et al. 2008, Tererai et al. 2013).

Grazing intensity can influence the distribution of invertebrate species either positively or negatively depending on grazing pressure (Souminan & Olofsson 2000). Grazing at very high intensities by game can reduce plant diversity leading to a reduction in faunal diversity due to exposure to predators (Allombert et al. 2005, Cheli & Corley 2010).

The composition and distribution patterns of widespread and habitat-restricted taxa e.g. *Langona warchalowskii* and *Cyclosa* sp. respectively were probably influenced by this gradient at the Indigenous Grassland sub-sites.

Soil chemical properties (e.g. pH, zinc and potassium) were also important in determining the occurrence of habitat-restricted invertebrate taxa e.g. *Cyclosa* sp. At Indigenous Forest sub-sites. Agwunobi & Ugwumba (2013) have noted that different faunal species associate with specific soil pH ranges due to their degree of vulnerability and resistance to acidity or alkalinity of the soil. Furthermore, highly acidic soils have fewer nutrients available, thereby providing less suitable environments for epigeic invertebrates (Magura et al. 2004).

Temperature has a significant effect on the activity of epigeic arthropods (Honek 1997, Saska et al. 2013) and therefore on their diversity and abundance (Davis 2002). In this study, CCA ordination axis one extracted percentage shade (insulation). This variable gradient may have influenced species composition and distribution patterns of *Clubiona* sp. (Araneae), *Hydrophilus* sp. and *Psammodes bertolonii* (Coleoptera) at the Indigenous Grassland sub-sites (Fig. 2).

Conclusion and management implications

Both direction and magnitude of plant-mediated invasion effects on animals cannot be generalised as universal response patterns but need specification in relation to ecosystem, taxa and functional groups as significant effects (either positive or negative), may thus remain undetected (Schirmel et al. 2016). This preliminary study shows that even though habitat-patch level characteristics (including abiotic factors) were important in determining invertebrate composition and distribution patterns, increased levels of infestation by invasive alien vegetation across sub-sites in the study did not necessarily impact species in a predictable manner.

There is urgent need to monitor and identify species at sub-sites over a much longer period to obtain a complete in-

ventory for comparison with existing regional baseline data for protected areas in South Africa. Although invertebrates remain critically important across a range of protected areas management objectives in the country, they should be explicitly and clearly linked to these objectives (McGeoch et al. 2011). Furthermore, for guiding management decisions, future studies on the effects of invasive alien plants on epigeic invertebrates should distinguish between ecological effects and adverse impacts on species of conservation concern.

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Activity-density data reveal community structure of Lycosidae at a Mediterranean shrubland

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Abstract. The structure of an ecological community is shaped by diverse factors and processes, including competition for resources between species with similar ecological niches. Species coexistence in the face of competition is achieved by various mechanisms, such as niche partitioning, e.g. division of resources in space and time. We studied the effect of environmental variables on activity-density of the four lycosid species found in a Mediterranean shrubland in Israel, in the spring of 2012. We tested if spatial and temporal niche partitioning enables coexistence among the four ecologically similar lycosid spiders, using multivariate analyses (RDA, Species Response Curves and Trait Analysis (RLQ)) of vegetation structure, habitat characteristics and land use, as well as time in the season. Activity-density was significantly affected by time in the season and the interaction of time and geophyte density. These findings provide first insights into the life cycles of lycosid species in Mediterranean shrublands in Israel, with spider species of the same size-group reaching their activity peaks at different times.

Keywords: *Alopecosa*, coexistence, *Hogna*, Israel, *Lycosa*, niche partitioning, *Pardosa*, seasonality, species assemblage, wolf spiders

Community structure is determined by a combination of factors such as regional species pool, biotic and abiotic environmental variables, and ecological and evolutionary processes (Zobel 1997). Within a community, species that use the same type of resources in a similar way, i.e. – having similar ecological niches, are considered as members of the same guild (Root 1967, Simberloff & Dayan 1991, Wilson 1999). One example of an ecological process, that may occur among species with similar ecological niches (i.e. within guilds), is competition, that can result in either species competitive coexistence or exclusion of species (Wilson 1999, Amarasekare 2003).

In order to coexist, two species' niches have to differ in their position on at least one of the four life-history related axes: resources, predation, space and time (Amarasekare 2003). Identical niches would often result in the exclusion of the species that is less able to maintain positive per capita growth under lowest resource level or highest predation (Amarasekare 2003). Resource partitioning between competitors co-occurring in a given habitat may take place through microhabitat partitioning and prey specialization and define the species' realized niche, i.e. the part of the ecological niche occupied by an organism given pressures from other species (Hutchinson 1957). This way, the abundance of microhabitats and prey types may influence the number of species of a given guild coexisting in a habitat. Temporal partitioning (actual activity time: night/day or seasonality) is another important manner of resource partitioning, which may allow coexistence of species in a given habitat or microhabitat (Kronfeld-Schor & Dayan 2003).

The species-rich spider family Lycosidae comprises over 2000 described species (World Spider Catalog 2016) that are relatively uniform in body structure. Most lycosid species belong to a single ecological guild of cursorial predators (Hatley & MacMahon 1980). Several lycosid species are usually found in a given habitat and cases of resource partitioning

between them at the temporal or spatial scales have previously been documented. For example, two lycosid species, *Hogna carolinensis* (Walckenaer, 1805) and *Rabidosa rabida* (Walckenaer, 1837), native to temperate forests in North America, are generalist predators and avoid competition by habitat partitioning; *Rabidosa rabida* is active on the ground, while *Hogna carolinensis* is mostly active under the surface (Kuenzler 1958). Many spiders have an annual or perennial life cycle, in which adults are only present during part of the year (Enders 1976). There also may be a period of dormancy, in which the species is not active at all, allowing for other species of the same guild to utilize the unused resources, with no direct competition (Framenau & Elgar 2005). This type of species turnover has been demonstrated in the prairies of Colorado, where adults of one species of *Gnaphosa* (Gnaphosidae) were shown to be active during May-June, while adults of a sympatric species are active during July-August (Weeks & Holtzer 2000). It is possible that both species were active during May-June, but in that case, they had different maturation times, leading to possible size-related trophic partitioning.

Developmental-stage-related partitioning may occur if an individual's requirements, including prey preferences, change during its lifetime. These changes may affect the habitat preference, time of activity and additional life-history traits. An example of developmental stage related partitioning can be seen in the lycosid species *Schizocosa mccooki* (Montgomery, 1904), as juveniles were found to prefer habitats of mixed shrubs and grasses, while the adults preferred shrubless grassy patches (Weeks & Holtzer 2000), thus partitioning microhabitats between them.

The habitat preferences of Lycosidae in Israel were studied only as part of spider faunal surveys (Mansour & Whitecomb 1986, Pluess et al. 2008) and as of yet we have very little information about the biology, ecology and taxonomy of Israel's lycosids. In particular, studies of the lycosid fauna of one of Israel's most abundant habitats, the Batha shrubland, were never carried out. The Batha shrubland is a characteristic habitat of the Mediterranean part of Israel, suggested to support a high biodiversity, due to its patchy structure, allowing for a high variation in microhabitats (Naveh & Whittaker 1980, Tews et al. 2004, van der Aart 1972).

A recent study (Bernstein 2014, Gavish-Regev unpubl. data) examined the impact of alternative urban development scenarios on species richness and abundance of plants, beetles and spiders in an ecological corridor, which comprises sub-

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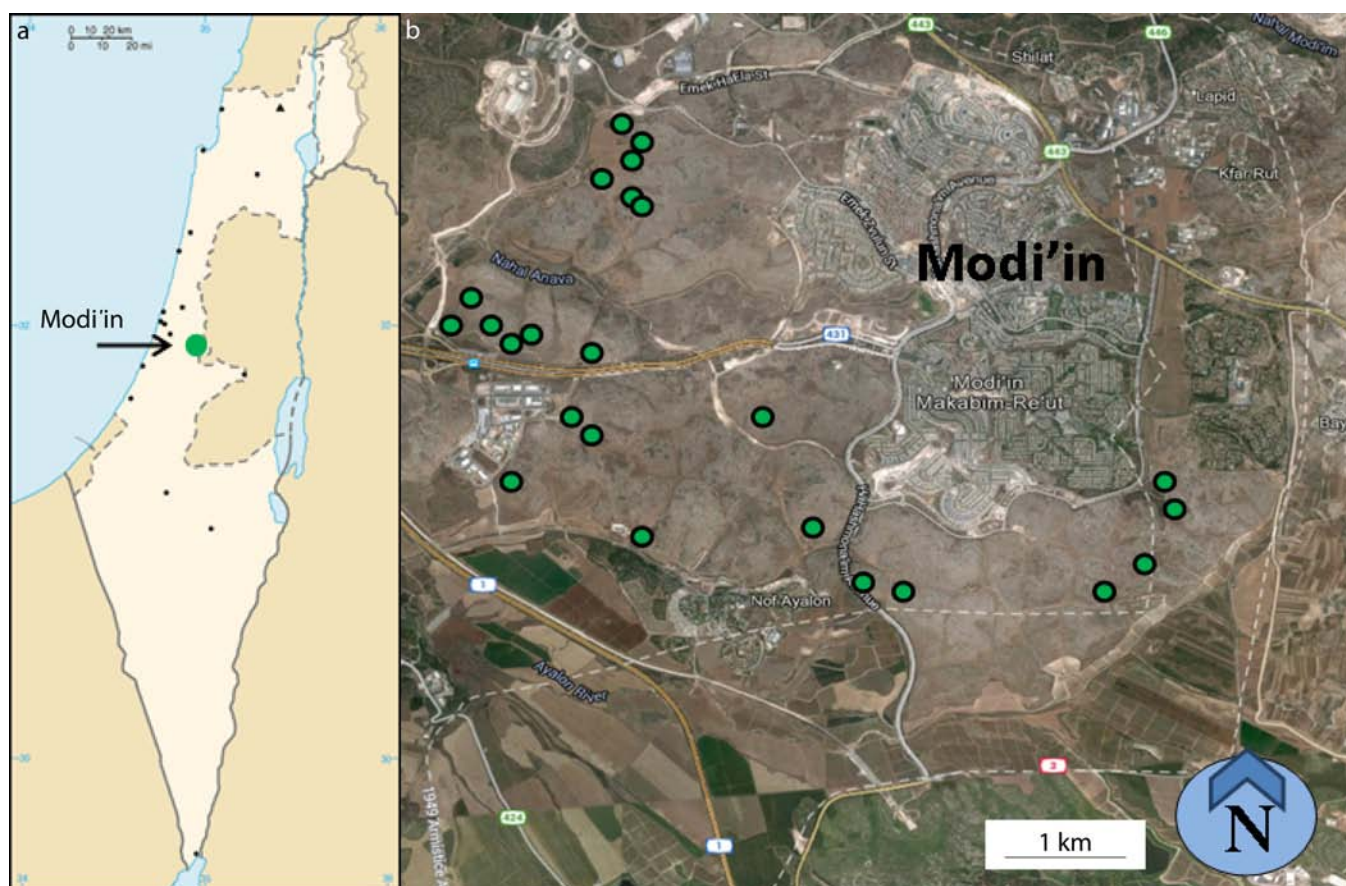


Fig. 1: The study area: **a.** Map of Israel, study area indicated with black arrow (based on Nagy Pirooska, 2009); **b.** Map of study area, sampling locations (24 samples) marked with green dots (based on Imagery © 2015 DigitalGlobe, Map data © 2015, Mapa GIsrael)

stantial areas of Batha shrublands. The study found lower activity-densities of lycosids (as a group) in patches with higher shrub densities, and higher activity-densities of lycosids in patches with a higher cover of small stones and in patches at a distance from agriculture (Gavish-Regev unpubl. data).

Using the dataset from Bernstein's study, we studied the effect of environmental variables, such as density of plant life-forms (bushes, dwarf shrubs and grasses), habitat characteristics and land use, as well as time in the season, on the activity-density of lycosid species, sex and developmental stages in spring of 2012. Our hypothesis was that lycosids are represented in the Batha shrubland of the Judean foothills by several species that can coexist due to microhabitat partitioning (spatial resource partitioning), and that coexistence of the different species of lycosids is facilitated by differences in microhabitat preferences that vary between sex and developmental stages. This is the first attempt to look at community structure of Lycosidae (i.e., species distribution in space and time) at the Mediterranean Batha shrubland.

Study area, material and methods

Study area. The study area includes four sites and is located around the city of Modi'in, in the Northern Judean foothills (Figs. 1, 2), at an elevation of 200-300 meters. Each site is an alternative urban development plan for Modi'in (Bernstein 2014). The study area is characterized by a Mediterranean climate (Csa) with average annual rainfall of 550 mm. The rock in the study area is mostly Cretaceous chalk with chert, and the soil is brown rendzina (Sneh 1998). The plant communities are characteristic of disturbed Mediterranean habitats,

and are influenced by grazing and fires. The most common plant community in the study area is the Batha shrubland dominated by dwarf shrubs, in particular Prickly Burnet (*Sarcopoterium spinosum* (L.) Spach). Yet, there are two additional plant communities: the Batha grassland (annual grasses) and bush patches (Garrigue) dominated by *Rhamnus lycioides* L. and *Pistacia lentiscus* L. (Alon 1993). The climax community, Maquis of *Rhamnus lycioides* L., *Ceratonia siliqua* L. and *Pistacia lentiscus* L. (Alon 1993), is very rare in the study area and therefore was not sampled in this study. The habitats in this study were sorted by General Habitat Category (GHC) (Bernstein 2014), the standard evaluation method in the BIOHAB system, which classifies natural habitats into categories based on the dominant plant life-forms (in this study, bushes, dwarf shrubs and grasses), regardless of local factors.



Fig. 2: Mediterranean Batha shrubland and grassland in the study area, May 2012

Spider sampling, measurements and environmental variables. Spiders were collected using pitfall traps with preservative liquid (20 % ethanol, 20 % acetic acid, 60 % glycerol), and moved to 75 % ethanol after sorting and identifying each specimen to the best taxonomic resolution possible (species or genus level) and sex according to its developmental stage (adult, sub-adult, juvenile). Each pitfall trap was made of two plastic cups (one inside the other; diameter 11.3 cm, height 13 cm) buried in the ground such that the rim was level with the ground surface.

The study area included four sites (the alternative urban development plans), that were sampled using the pitfall traps in three periods: 21-29.iii.2012, 11-20.iv.2012 and 9-17.v.2012. In each site three habitats were sampled (with two repeats per habitat) according to the dominant plant life-form: bushes, dwarf shrubs and grasses, a total of six samples (traps location) per site (Fig.1, samples are marked as green dots). Each sample included 13 pitfall traps, in fixed locations for all three sampling dates, a total of 936 pitfall traps for the entire sampling period (due to trampling by livestock, only 902 traps were retrieved).

Environmental variables, including habitat characteristics (% exposed ground, small stones for one square meter, large stones for one square meter), land use (% monthly grazing, % yearly grazing) and plant life-form (density of annual grasses, density of geophytes, density of dwarf shrubs, density of bushes) were measured once in all locations, prior to the collection period and used to test microhabitat preference (coexistence due to resource partitioning).

In order to test coexistence of size-groups we assigned each spider to one of three size categories: carapace length under 3 mm (juveniles only), 3-4.7 mm (adults and sub-adults of small species and juveniles of large species), over 4.7 mm (juveniles, sub-adults and adults of large species) (see Tab. 1 for the results of size groups). Carapace length was measured in Stereomicroscope Nikon SMZ using NIS-Elements D (Nikon 2015, version 420).

As few or no adult specimens of *H. cf. graeca* and *L. piochardi* were collected, all measures of adults of *H. cf. graeca* and most adults of *L. piochardi* were taken from material collected in other localities in Israel.

Statistical analysis. We used ordination methods (multivariate analysis - gradient analysis) with the program Canoco (Ter Braak & Šmilauer 2002) to test the effect of the environmental variables on lycosid activity-density, using activity-density as a measure of habitat use. We first performed DCA (detrended correspondence analysis) to determine the length of the gradient. As the first axis gradient was shorter than three

we used linear methods for the rest of the analysis (Leps & Šmilauer 2003). Redundancy analysis (RDA) with unrestricted Monte-Carlo permutations (4999 permutations) was performed testing ten variables (time in the season, and the nine environmental variables listed above). Partial RDA with unrestricted Monte-Carlo permutations (4999 permutations) was performed testing density of geophytes and time as separate main effects while the other variables served as co-variables. We used CanoDraw (Ter Braak & Šmilauer 2002), to create Species Response Curves, in order to examine the response of each species, sex and developmental stage to the significant variables found in the partial RDA. Response curves were fitted using, for the y-axis, the scores of the first axis obtained in the partial RDA plotted against each significant variable or interaction. The response variable is thus a measure of the activity-density of the species, sex and developmental stage that were affected significantly by the variable or interaction (Leps & Šmilauer 2003, Gavish-Regev et al. 2008). The curves were fitted using GAM (Generalised Additive Model: smooth term complexity with 3 d.f.). A Poisson distribution was assumed for the response variable, and Log was used as the link function. Curve selection was based on the Akaike information criterion (AIC) (Leps & Šmilauer 2003). For all ordinations, all spiders collected from the 13 traps of each sample were grouped due to a low number of captures and high variances between individual traps, i.e. a total of six samples per site and 24 samples in the study area each month (overall 72 samples). All analyses were performed at two levels: species level (undivided) and species divided by sex and developmental stage (males, females and, free-roving juveniles\ sub-adults).

In order to investigate the relationship between species traits and environmental variables, we used RLQ analysis (Doledec et al. 1996, Mouillot et al. 2013) with eight environmental variables (habitat characteristics and plant life-forms (as listed above)) (R table) and three species trait attributes (average size, burrow use and month of activity peak) (Q table), and the relative abundance of each sex and developmental stage of the four species (Total of nine species categories in table L). For the RLQ analysis, the R- and Q-tables first underwent principle component analysis (both tables using the Hill and Smith method (Hill & Smith 1976) for mixing quantitative variables and factors) and the L-table underwent correspondence analysis. RLQ analysis was conducted using the ade4 package in R (Chessel et al. 2004).

Results

From the 72 samples, only 67 samples were used for the analyses. Five samples were omitted due to zero catches of lycosid spiders: two from April and three from May.

Tab. 1: Average carapace length of Lycosidae collected around Modi'in in the spring of 2012, by species, sex and developmental stage. Adults of *L. piochardi* and *H. cf. graeca* were collected separately, adjacent to the study area

Sex/developmental stage	<i>Alopecosa albofasciata</i> (Brullé, 1832)	<i>Pardosa subordidatula</i> (Strand, 1915)	<i>Hogna cf. graeca</i>	<i>Lycosa piochardi</i> Simon, 1876
Males	4.1 mm (n=20) SD=0.238	3.3 mm (n=1)	7 mm (n=3) SD=0.231	9.5 mm (n=7) SD=1.833
Females	4.5 mm (n=23) SD=0.336	4.1 mm (n=22) SD=0.232	7 mm (n=6) SD=0.849	8.5 mm (n=8) SD=1.533
Juveniles	1.1 mm (n=2) SD=0.151	1.9 mm (n=25) SD=0.280	3.3 mm (n=27) SD=0.916	5.4 mm (n=25) SD=1.560
			March: 1.9 mm (n=2) SD=0.397	
			April: 2.6 mm (n=11) SD=0.369	April: 4.9 mm (n=8) SD=1.272
			May: 4.1 mm (n=14) SD=0.550	May: 5.6 mm (n=17) SD=1.662



Fig. 3: The lycosid species found in the current study (live females): **a.** *Alopecosa albofasciata* (Brullé, 1832); **b.** *Pardosa subsordidatula* (Strand, 1915); **c.** *Hogna cf. graeca*; **d.** *Lycosa piochardi* Simon, 1876

From all spiders collected (March, April, May), we identified a total of 385 lycosids, of which 302 were adults and 83 were either sub-adult or free-roving juveniles. Hatchlings were not counted. The lycosids were identified to four species (here listed in decreasing order of relative abundance): *Alopecosa albofasciata* (Brullé, 1832) (201 males, 58 females, 4 subadults; Fig. 3a), *Pardosa subsordidatula* (Strand, 1915) (2 males, 40 females, 27 subadults; Fig. 3b), *Hogna cf. graeca* (Roewer, 1951) (28 subadults; Fig. 3c) and *Lycosa piochardi* Simon, 1876 (1 female, 24 subadults; Fig. 3d).

Gradient analyses

Environmental variables and time. Habitat characteristics (exposed ground, small stones and large stones), land use (grazing) and plant life-forms (bushes, dwarf shrubs and grasses) did not affect the activity-density of the four lycosid species in this study, yet time in the season and, to some extent, density of geophytes had a significant effect on the activity-density of the four lycosid species.

The four species (undivided). Ordination analyses indicate that two significant variables: time in the season and geophyte density, explained 41.8 % of the variance of species activity-density (Tab. 2, Figs. 4a, 4b). In Partial RDA only time in the season and the interaction between time and geophyte density were found to affect species activity-density significantly (Tab. 3), while time was the only variable in the study to affect all four species significantly (Tab. 4, Fig. 5a), the interaction

Tab. 2: The effect of variables on the activity- density of Lycosidae species in the Batha shrubland: Ordination results. Monte-Carlo permutation tests (4999 runs) of redundancy analysis (RDA). Out of ten variables, three were included in the model, two were significant (time, Geophytes density), the third (Yearly grazing) was marginally significant.

Environmental variables	% explained variance	F-ratio	P-value
Time	38	40,3	0,0002
Geophyte density	4	3,8	0,04
Yearly grazing	3	3,4	0,055

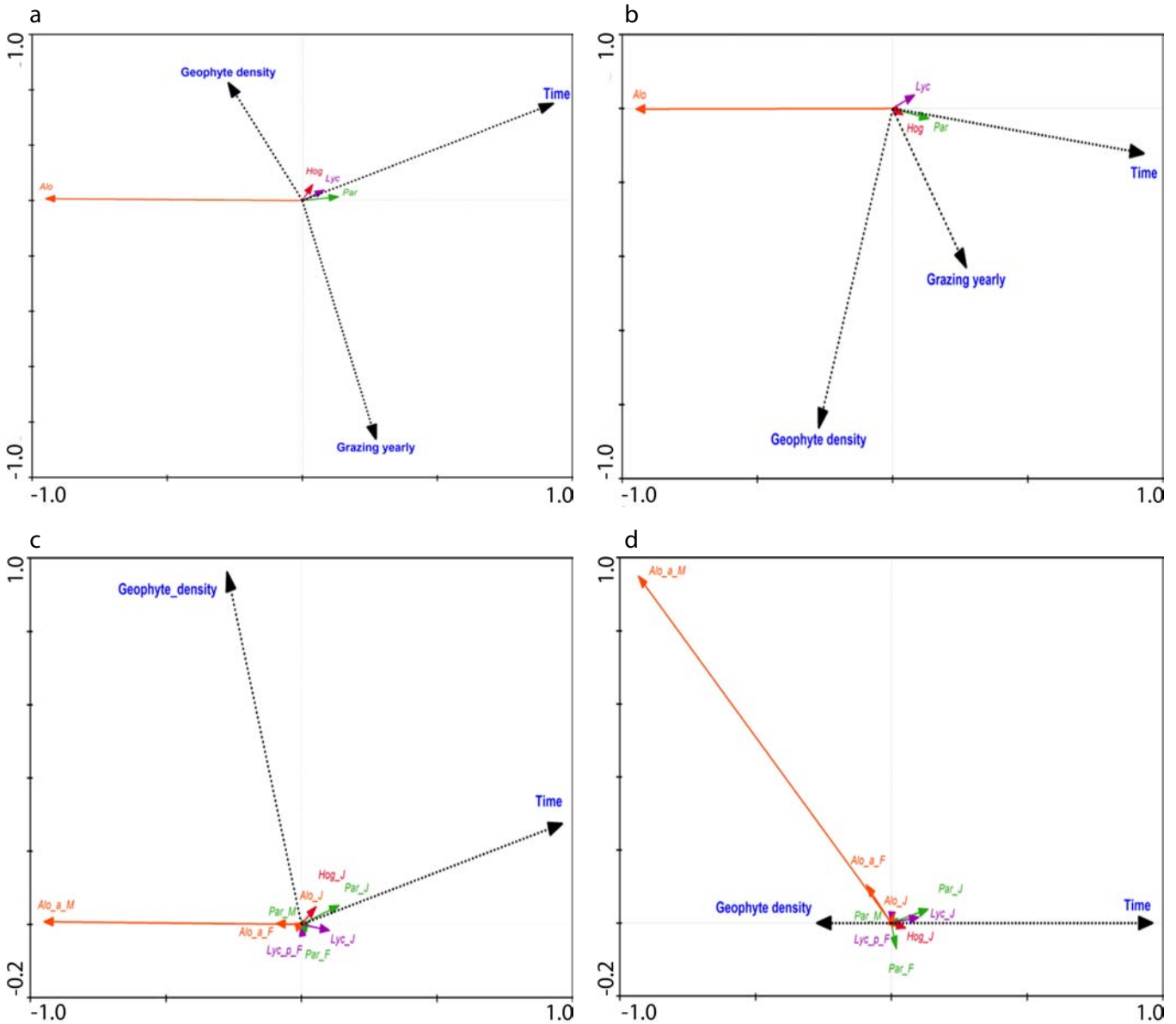


Fig. 4: Lycosid species, sex and developmental stage composition and activity-density based on three sampling dates, in the Mediterranean Batha shrubland, in the spring months of 2012. Ordination diagrams from a redundancy analysis (RDA) of 67 samples from Modi'in area; **a.** biplot (species – environment) of the first and second axes; **b.** biplot (species – environment) of the first and third axes; **c.** biplot (species, sex and developmental stage – environment) of the first and second axes; **d.** biplot (species, sex and developmental stage – environment) of the first and third axes. The quantitative variables are geophyte density, percent of yearly grazing and time; the arrow color of each family (and abbreviated species name) as follows: *Alopecosa albobfasciata*: orange (Alo), *Pardosa subsordidatula*: green (Par), *Lycosa piochardi*: violet (Lyc), and *Hogna cf. graeca*: red (Hog); Sex and developmental stage are indicated as M: male, F: female, J: juvenile

between time and geophyte density was found to affect only *A. albobfasciata* significantly and to affect *H. cf. graeca* and *L. piochardi* with marginal significance (Tab. 4, Fig. 5b).

Tab. 3: Partial RDA: The effect of variables on the activity-density of Lycosidae in the Batha shrubland: Ordination results. Monte-Carlo permutation tests (4999 runs). Out of ten variables, two (time and geophyte density) were included in the while the other variables served as co-variables.

Environmental variables	The four species undivided		The four species, divided by sex and developmental stage	
	F-ratio	P-value	F-ratio	P-value
Time	42	0,002	39	0,0002
Interaction between time and geophyte density	2	0,004	2,74	0,05

The four species, divided by sex and developmental stage.

Ordination analyses indicate that two significant variables: time in the season and geophyte density, explained 42 % of the variance of species, sex and age groups activity-density (Tab. 5, Figs. 4c, 4d). In Partial RDA only time and the interaction between time and geophyte density, were found to affect species activity-density significantly (Tab. 3), while time was the only variable to affect all species, sex and developmental stages significantly (Tabs. 6a-c, Fig. 5c), the interaction between time and geophyte density was found to affect all groups of *A. albobfasciata* significantly (Tab. 6a) and to affect juveniles of *H. cf. graeca* with marginal significance (Tab. 6c, Fig. 5d).

Trait analysis

For the four species, divided by sex and developmental stage,

Tab. 4: Partial RDA: The effect of time and the interaction between time and geophyte density on the four species of Lycosidae. Only variables with significant influence are presented.

Environmental variables	<i>H. cf. graeca</i>		<i>L. piochardi</i>		<i>P. subsordidatula</i>		<i>A. albofasciata</i>	
	F-ratio	P-value	F-ratio	P-value	F-ratio	P-value	F-ratio	P-value
Time	5,17	0,003	10,98	0,0001	11,88	0,001	30,95	< 1.0e-6
Interaction between time and geophyte density	3,18	0,031	2,75	0,05	Not significant	Not significant	9,71	0,00003

no significant effects were found in the RLQ analysis for the eight environmental variables and the three traits.

Discussion

We found that time in the season affected significantly the activity-density of all four species, sexes and developmental stages, while the interaction between time and geophyte density affected all species but *P. subsordidatula*. At this early stage of lycosid research in Israel, data is insufficient for any clear-cut conclusion, but we suggest a possible temporal partitioning that may contribute towards separation between similar-sized species in this Batha shrubland. The response in activity to the interaction between time and geophyte density might reflect different microhabitat preferences of males, females and juveniles and changes in their levels of activity over the sampling period.

Gradient analyses

Temporal partitioning. In the absence of habitat spatial segregation, coexistence of competitors can rely on separation in time (Carothers & Jaksić 1984, Kronfeld-Schor & Dayan 2003). Possible evidence for separation in time of the Batha lycosid guild may be differences in the activity-density of the different species along the sampling season. A possible mechanism may be separation by prey sizes, as reflected by the predator sizes. It has been demonstrated in lycosids (*Pardosa*, *Alopecosa*) and other non-web-hunting spiders that the preferred prey size is around 50–80 % of the spider's length (Nentwig & Wissel 1986). Maturation of the species in the guild at different times (see Tab. 1) may create different size-groups of spiders and thus reduce interspecific competition (Fig. 6). For example, in April, the juveniles of *H. cf. graeca* were in the lower size group (under 3 mm carapace length). In May they reach the middle size group (3.0–4.7 mm carapace length), when the adults of the smaller species (*P. subsordidatula*, *A. albofasciata*) are at low activity-density. The juveniles of *P. subsordidatula* that were collected in the traps during May all belong to the small size group (under 3 mm), when the juveniles of *H. cf. graeca*, collected in the same time, all belong to the larger size group (over 4.7 mm). Temporal

Tab. 5: The effect of variables on the activity-density of Lycosidae species divided by species, sex and developmental stage in the Batha shrubland. Ordination results Monte-Carlo permutation tests (4999 runs) of redundancy analysis (RDA). Out of ten variables, three were included in the model (time and geophyte density were significant, Yearly grazing, is shown for comparison with Tab. 2).

Environmental variables	% explained variance	F-ratio	P-value
Time	38	40,6	0,0002
Geophyte density	4	3,7	0,032
Yearly grazing	2	2,4	0,085

trophic separation has been shown previously between the North American species *Lycosa antelucana* and *Pardosa milvina* and between developmental stages within *Lycosa antelucana* (Hayes & Lockley 1990). For these groups different daily activity times were observed. This mechanism is left unexplored by us. However, *Pardosa subsordidatula*, *H. cf. graeca* and *L. piochardi* were observed by us to be nocturnally active, while *A. albofasciata* was mostly observed to be active in daytime.

Partitioning may also be driven by intraguild predation. Lycosids have been shown to feed on conspecifics and lycosids of other species (Rypstra & Samu 2005). If we assume that the preferred prey size is 50–80 % of the predator's body length, the observed seasonal partitioning may be due to predator avoidance by the smaller species. The activity of juvenile *P. subsordidatula* rises at the time of spring with the lowest activity density of adult *A. albofasciata* and *P. subsordidatula*. The activity of adult *A. albofasciata* and *P. subsordidatula* drops in May, when the large juveniles of *L. piochardi* become active.

Geophyte density. Geophyte density was the only habitat characteristic found to significantly affect activity-density of the lycosid species in this study (see below), but this effect was also related to time in the season. This single significant result is unexpected, as Lycosidae in other studies were found to have habitat and microhabitat preferences related to environmental variables such as vegetation structure (Cady 1983, Eason & Whitcomb 1965, Greenstone 1984, Workman 1977). In a former study (Gavish-Regev unpubl.) ordination analysis of the same dataset, analysed at the family level, revealed three

Tab. 6: Partial RDA: The effect of time and the interaction between time and geophyte density (time x density) on the four species of Lycosidae, divided by sex and developmental stage (n. s. not significant).

Environmental variables	<i>A. albofasciata</i> J		<i>A. albofasciata</i> F		<i>A. albofasciata</i> M	
	F-ratio	P-value	F-ratio	P-value	F-ratio	P-value
Time	2,8	0,049	5,09	0,0092	49,4	< 1.0e-6
Time x density	7,74	0,00018	4,07	0,0107	7,8	0,00016

Environmental variables	<i>P. subsordidatula</i> J		<i>P. subsordidatula</i> F		<i>P. subsordidatula</i> M	
	F-ratio	P-value	F-ratio	P-value	F-ratio	P-value
Time	38,67	< 1.0e-6	4,89	0,0042	0,56	0,05
Time x density	n. s.	n. s.	n. s.	n. s.	n. s.	n. s.

Environmental variables	<i>H. cf. graeca</i> J		<i>L. piochardi</i> J		<i>L. piochardi</i> F	
	F-ratio	P-value	F-ratio	P-value	F-ratio	P-value
Time	5,17	0,00319	10,27	0,00017	1,82	0,053
Time x density	3,18	0,031	n. s.	n. s.	3,04	0,0025

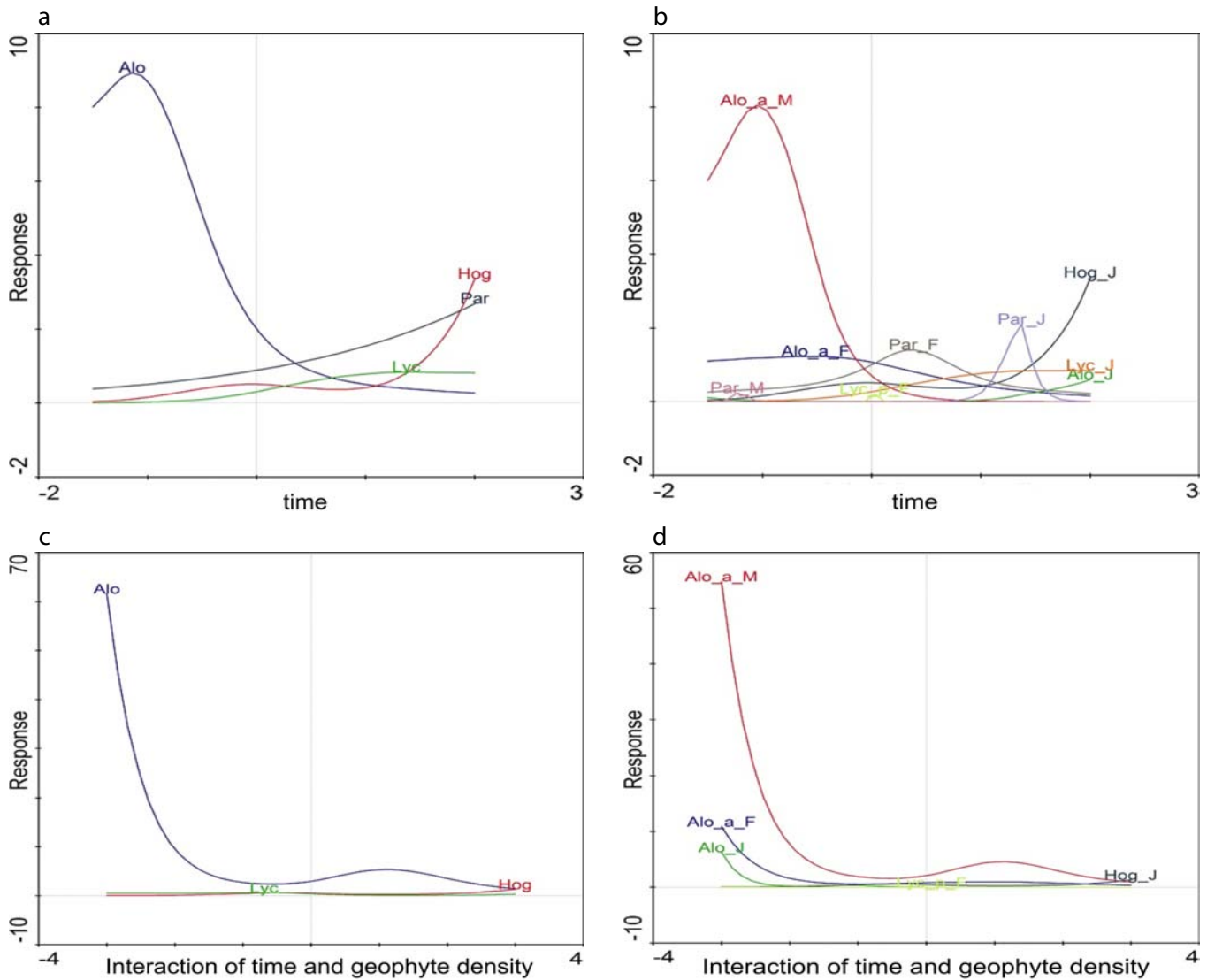


Fig. 5: Species Response Curves of four lycosid species, sex and developmental stage to the first axis of Partial RDA. Only curves of species showing significant response were included and fitted to generalized additive models (GAM). Species abbreviations as follows: *Alopecosa albofasciata*: (Alo/Alo_a); *Pardosa subsordidatula*: (Par); *Lycosa piochardi*: (Lyc/Lyc_p); *Hogna cf. graeca*: Hog; Sex and developmental stage are indicated as M: male, F: female, J: juvenile. **a.** response curve of species for time; **b.** response curve of species for the interaction of time and geophyte density; **c.** response curve of species, sex and developmental stage for time; **d.** response curve of species, sex and developmental stage for the interaction of time and geophyte density

significant environmental variables affecting activity-density of Lycosidae as a family: Shrub density (negative effect), cover by Small Stones (positive effect) and Distance from Agriculture (positive effect). It is possible that given larger sample sizes, similar effects may yet be found in lycosid species, sexes and developmental stages.

The activity-density of *A. albofasciata* was found to be significantly affected by the interaction between time in the season and geophyte density (Figs. 5b, 5d). The change is negative and implies a magnitude of response diminishing along the season (i.e., spiders respond less to geophyte density as the season progresses). It is possible that the observed trend is due to the seasonal change in vegetation structure (drying up) or a change in the nature of activity of the species along the season.

Geophyte density corresponds with relatively short, grazed vegetation, and with certain rock types (Noy-Meir & Oron 2001). Such conditions may be preferable for lycosid

males' reproductive behaviours, maximizing their visibility during display and courtship (similar to the use of display spaces by *Schizocosa ocreata* (Hentz, 1844), Cady 1983).

Trait analysis. This type of analysis potentially connects discrete traits found in different species to the effect of environmental variables on the species, yet, it failed to find any significant effect in the current study. We suggest that lack of significant results in this analysis stems from the scarcity of data. Moreover, the number of traits examined was low, due to insufficient knowledge of the life histories of the Lycosidae in Israel. Using larger datasets and more traits may improve the analysis.

Lycosidae species assemblage. In this study, a similar number of individuals were collected from two ground-dwelling spider families: Lycosidae (385) and Gnaphosidae (346), however only four species of lycosids were found, while 32 species of

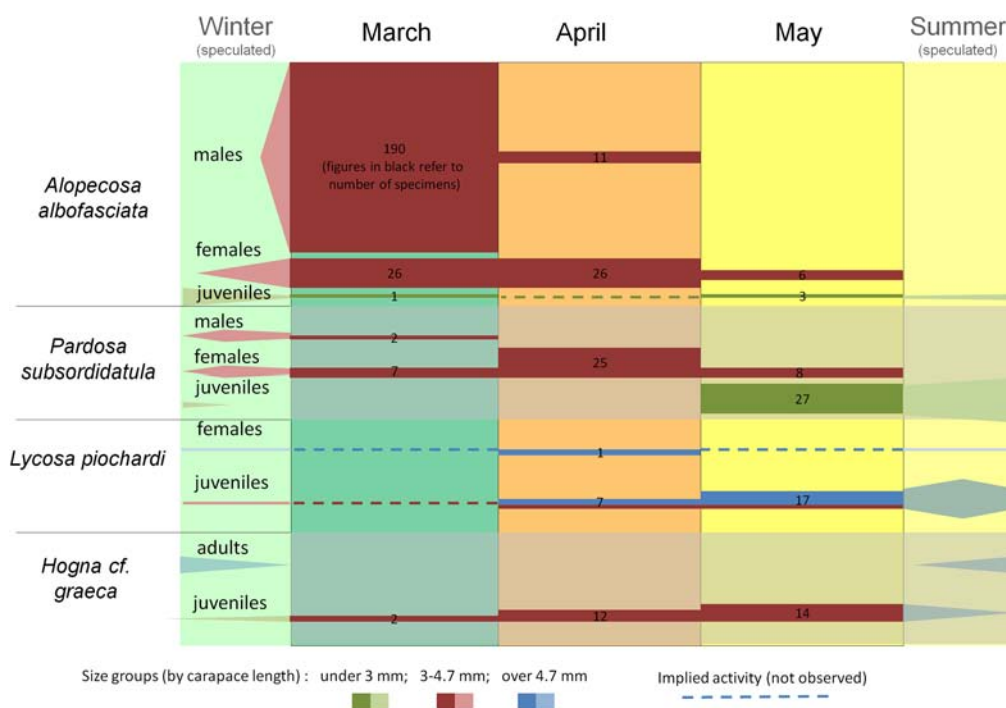


Fig. 6: Observed and implied lycosid activity in the study area (with implied trends in the summer and winter). Figures in black (and line width) denote number of specimens in study.

gnaphosids were found (Gavish-Regev unpubl. data). A possible explanation to the observed low lycosid species richness could be low activity-density of additional species or a poor regional species pool, which would result in lower number of species filtering (Zobel 1997), i.e., less lycosid species that are suitable for living in the Batha: 126 species of gnaphosids are recorded from Israel, compared to 30 species of lycosids (Levy 2009, Zonstein & Marusik 2013). If we assume that for each family's regional pool there is a certain percentage of species that are suitable to colonize the Batha shrubland (filtering), we expect to find more species from the family with a species-rich regional pool in comparison with the family with species-poor regional pool, but a similar magnitude. Indeed, the magnitude of the regional species pool that was found in this study is similar for the two families (25 % of gnaphosid species and 13 % of lycosid species).

It's important to note that all the spiders in this study were collected with pitfall traps and only a few direct observations were made in the field during the spring of 2012 and onwards. Pitfall trapping is a method biased towards more mobile individuals (Lang 2000). Adult males are expected to be more mobile, relative to females and juveniles and are less likely to remain in one habitat (as demonstrated in the North American *Schizocosa ocreata* (Cady 1983)). Indeed, more than half the lycosid specimens were adult males of *A. albofasciata*. Supplementing the collection techniques, enlarging the sample size and lengthening the sampling period to include more than one season will give us a more comprehensive understanding of the biology and ecology of Lycosidae in the Mediterranean Batha shrubland.

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