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Guilotes, a new genus of Coelotinae spiders from Guangxi Zhuang Autonomous Region, China (Araneae, Agelenidae)

Bing Li[1,2], Zhe Zhao[3], Haifeng Chen[1], Zhiyan Wu[1], Chuntian Zhang[2], Shuqiang Li[3]

1 *College of Life Science, Langfang Normal University, Langfang 065000, Hebei Province, China* **2** *College of Life Science, Shenyang Normal University, Shenyang, Liaoning 110034, China* **3** *Institute of Zoology, Chinese Academy of Sciences, Beijing 100101, China*

Corresponding authors: *Zhiyan Wu* (lfwuzhiyan@126.com); *Chuntian Zhang* (chuntianzhang@aliyun.com); *Shuqiang Li* (lisq@ioz.ac.cn)

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Abstract

A new genus of the subfamily Coelotinae F.O. Pickard-Cambridge, 1893, *Guilotes* Z. Zhao & S. Li, **gen. n.** from China is described, as well as four new species: *G. ludiensis* Z. Zhao & S. Li, **sp. n.** (♂♀, type species), *G. qingshitanensis* Z. Zhao & S. Li, **sp. n.** (♂♀), *G. xingpingensis* Z. Zhao & S. Li, **sp. n.** (♂♀) and *G. yandongensis* Z. Zhao & S. Li, **sp. n.** (♀). The DNA barcodes of all species are documented for future use.

Keywords

Asia, barcodes, new species, taxonomy

Introduction

The spider subfamily Coelotinae (Araneae, Agelenidae) comprises 743 valid species belonging to 30 genera (World Spider Catalog 2018; Li and Quan 2017). Coelotinae are recorded only in the Nearctic, Palearctic, and Indo-Malaya regions with 89% of the species distributed in Asia, 7% in Europe, and 4% in North America. New coelotine genera and species had been recently discovered (Chen et al. 2015a, b, 2016a, b;

Zhang and Marusik 2016; Zhang et al. 2016a, b; Zhao and Li 2016; Komnenov 2017; Okumura 2017; Quasin et al. 2017; Zhang and Zhao 2017; Zhang et al. 2017; Zhu et al. 2017; Li et al. 2018a, b). Zhao and Li (2017) studied the evolutionary history and biogeography of Coelotinae using molecular data (8 genes, ~ 6.5 kb) on 18 genera and 286 coelotine species. The well resolved phylogeny of coelotine spiders promoted the new taxa erecting and taxonomic revisions (Chen et al. 2016b; Zhao and Li 2016; Li et al. 2018a, b). So far, there are 387 coelotine species (about 52% of the total) from 24 genera reported from China. However, in the karst regions of China, there are still many poorly known species with unusual characters which are not belonging to any known coelotine genera (World Spider Catalog 2018).

In this study, *Guilotes* Z. Zhao & S. Li, gen. n. is proposed to include four new species. The new genus was confirmed by the phylogenetic framework of coelotine spiders (Zhao and Li 2017). The molecular topologies supported *Guilotes* as a monophyletic group in Guangxi *Coelotes* groups. The new species of *Guilotes* are compared with those of the morphological similar genus *Notiocoelotes* Wang, Xu & Li, 2008. All specimens of *Guilotes* were collected from karst regions in southern China.

Materials and methods

Specimens were examined with a LEICA M205C stereomicroscope. Photographs were captured with an Olympus C7070 wide zoom digital camera (7.1 megapixels) mounted either on an Olympus SZX12 dissecting microscope or on an Olympus BX51 compound microscope. Photos from multiple focal ranges were combined using Helicon Focus (Version 3.10) photo stacking software. Female epigyne and male palp were dissected form the body to be proper examined. The epigyne was removed and treated in a warmed 10% potassium hydroxide (KOH) solution before study. Measurements were obtained with a LEICA M205C stereomicroscope and are given in millimeters. Eye diameters were measured as the maximum diameter from either dorsal or frontal views. Leg measurements are given as: total length (femur, patella + tibia, metatarsus, tarsus). Images of the male left palp are presented. Terminology of the structures follows Wang (2002), Chen et al. (2015b) and Zhang et al. (2016b).

References to figures in the cited papers are listed in lowercase (figure or figs); figures from this paper are noted with an initial capital (Figure or Figs). Abbreviations used in the text and figures:

A	epigynal atrium;
ALE	anterior lateral eye;
ALE–PLE	distance between ALE and PLE;
AME	anterior median eye;
AME–ALE	distance between AME and ALE;
AME–AME	distance between AME and AME;
AME – PME	distance between AME and PME;
C	conductor;
CD	copulatory duct;
CF	cymbial furrow;

CO	copulatory opening;
E	embolus;
EB	embolic base;
ET	epigynal tooth;
FD	fertilization duct;
LC	lamella of conductor;
LTA	lateral tibial apophysis;
MA	median apophysis;
OC	outgrowth of conductor;
PA	patellar apophysis;
PLE	posterior lateral eye;
PME	posterior median eye;
PME–PLE	distance between PME and PLE;
PME–PME	distance between PME and PME;
RTA	retrolateral tibial apophysis;
S	spermatheca;
SB	spermathecal base;
SH	spermathecal head;
ST	subtegulum;
T	tegulum;
TS	tegular sclerite.

DNA barcodes were also obtained for the species delimitation and matching. A partial fragment of the mitochondrial cytochrome oxidase subunit I (*CO1*) gene was amplified and sequenced for all species using the primers LCO1490-oono (5’-CWACAAAYCATARRGATATTGG-3’) and C1-N-2776 (5’-GGATAATCAGAATANCGNCGAGG-3’). For additional information on extraction, amplification and sequencing procedures, see Zhao and Li (2017). All sequences were analyzed using BLAST and are deposited in GenBank. The accession numbers are provided in Table 1.

Taxonomy

Family Agelenidae C.L. Koch, 1837
Subfamily Coelotinae F.O. Pickard-Cambridge, 1893

Genus *Guilotes* Z. Zhao & S. Li, gen. n.

http://zoobank.org/024F72C8-3B81-4F0A-96C6-B25424ADB896
Figs 1–8

Type species. *Guilotes ludiensis* Z. Zhao & S. Li, sp. n.

Etymology. The generic name is derived from the pinyin word “Gui”, referring to the Guangxi Zhuang Autonomous Region (Gui is a short name for Guangxi) where the genus is distributed, and “*-lotes*” as part of *Notiocoelotes*, which is similar to the new genus. The gender is masculine.

Diagnosis. The males of the genus *Guilotes* are similar to those of the genus *Notiocoelotes* by cymbial furrow long (Figs 1C, 3C, 5C) and embolus long and filiform (Figs 1B, 3B, 5B), but can be distinguished by the chelicerae with 5–6 promarginal and five retromarginal teeth; the presence of a patellar apophysis (Figure 1C) and conductor short not reaching the embolus base (Figure 1B). The females of the genus *Guilotes* are similar to those of the genus *Notiocoelotes* by atrium oval and posterior (Figs 2A, 4A, 6A, 7A), hoods absent, copulatory ducts large, but can be distinguished

Table 1. Voucher specimen information.

Guilotes species	Voucher code	GenBank accession number	Sequence length	Collection localities
G. ludiensis sp. n.	IZCAS-Ar34051(zz391)	KY778823	1194bp	Guilin City, Guangxi, China
G. qingshitanensis sp. n.	IZCAS-Ar34059(zz892)	KY778825	1194bp	Guilin City, Guangxi, China
G. xingpingensis sp. n.	IZCAS-Ar34067(zz890)	KY778824	1194bp	Guilin City, Guangxi, China
G. yandongensis sp. n.	IZCAS-Ar34075(zz392)	KY778813	1194bp	Baise City, Guangxi, China

All specimens (including molecular vouchers) are deposited in the Institute of Zoology, Chinese Academy of Sciences (**IZCAS**) Beijing, China.

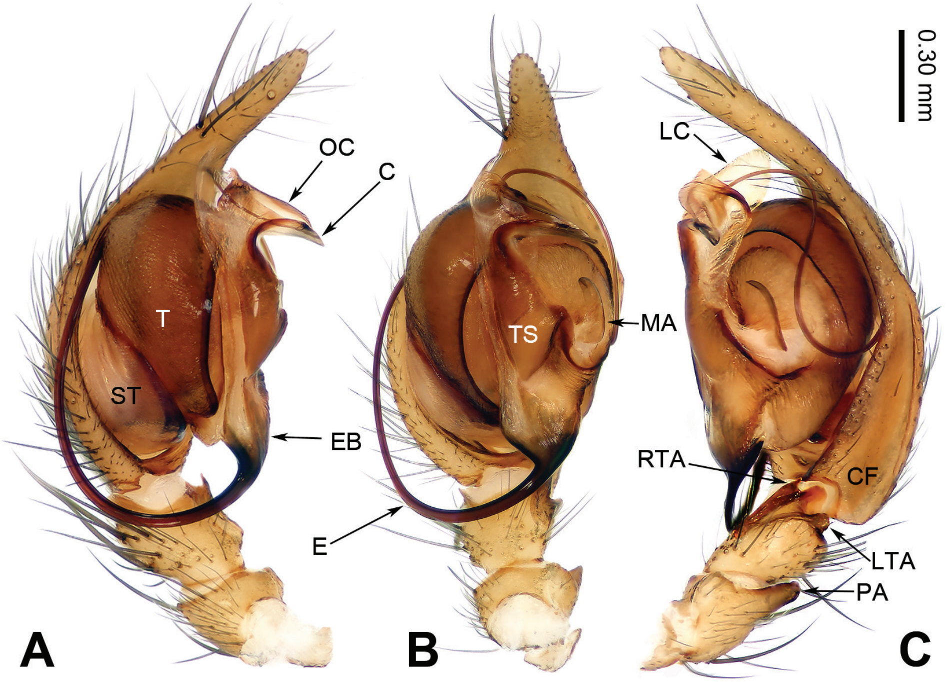

Figure 1. Left male palp of *Guilotes ludiensis* sp. n., holotype. **A** Prolateral view **B** Ventral view **C** Retrolateral view.

by the chelicerae with 4–6 promarginal and 5–6 retromarginal teeth, the absence of a tongue-shaped atrial scape (Figure 2A), and the presence of two epigynal teeth (Figure 2A, absent in *G. qingshitanensis* sp. n. (Figure 4A)).

Description. Medium sized spiders, with total length 4.17–8.66. Carapace yellowish brown; cephalic area, labium, endites and sternum brown; chelicerae dark brown (Figs 2C–E, 4C–E, 6C–E, 7C–E). Abdomen gray with dark gray chevron stripes (Figs 2C–D, 4C–D, 6C–D, 7C). Spinnerets yellowish brown (Figs 2C–E, 4C–E, 6C–E, 7C–E). Legs yellowish brown with dark rings (Figs 2C–E, 4C–E, 6C–E, 7C–E). Chelicerae usually with 4–6 promarginal and 5–6 retromarginal teeth. Anterior lateral spinnerets larger than posterior median spinnerets but smaller than

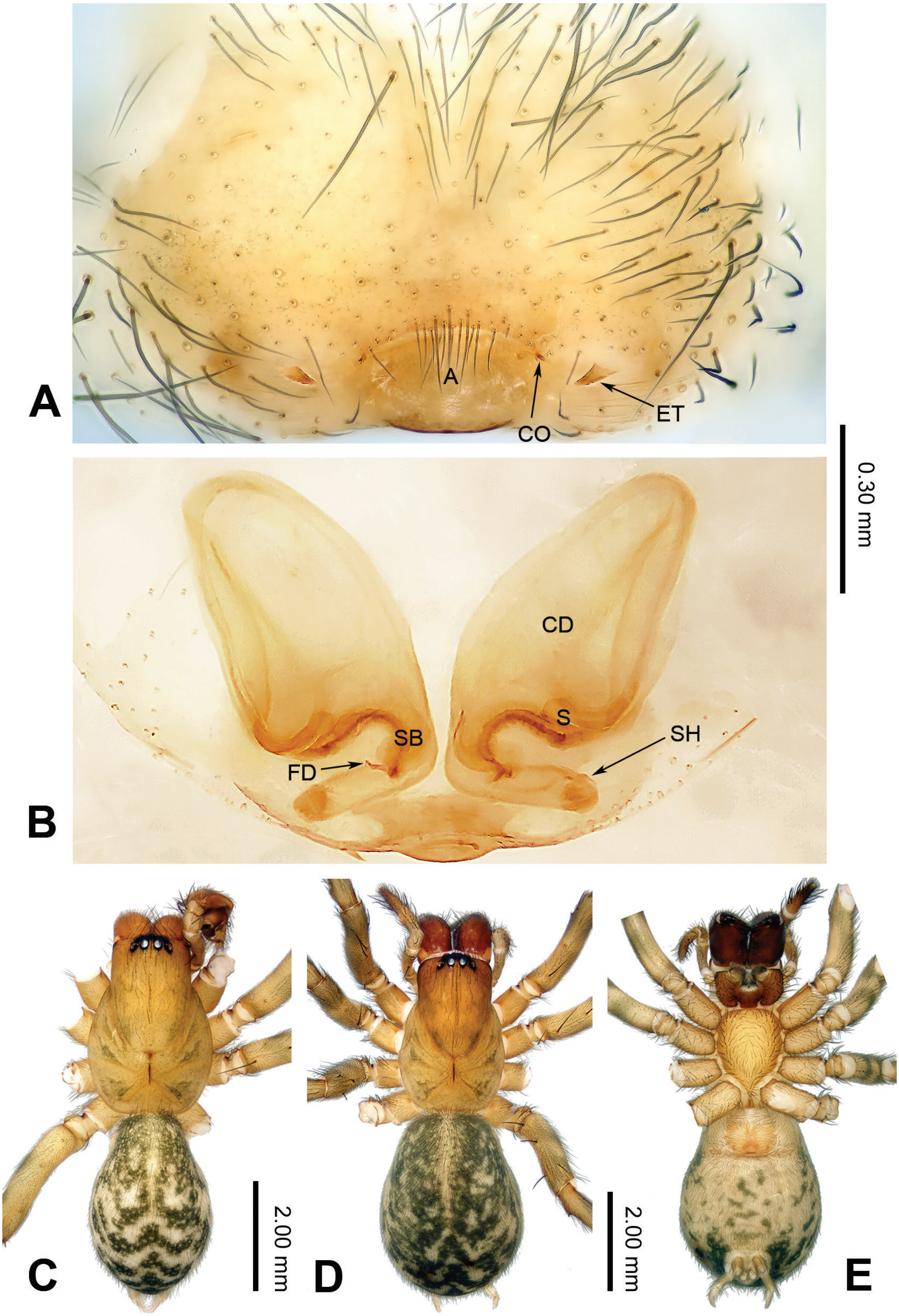

Figure 2. Epigyne and habitus of *Guilotes ludiensis* sp. n. **A** Epigyne, ventral **B** Vulva, dorsal **C** Male habitus, dorsal **D** Female habitus, dorsal **E** Female habitus, ventral. Scale bar equal for **D** and **E**.

posterior lateral spinnerets; colulus slide-shaped; distal article of the spinneret longer than coxa. Leg formula 4123. Palp: patellar apophysis finger-shaped, RTA large and LTA small (Figs 1C, 3C, 5C). Cymbial furrow equal to (Figs 1C, 5C) or longer (Figure 3C) than 1/2 length of cymbium. Embolus long and filiform, beginning at 4 to 5 o'clock position (Figs 1B, 3B, 5B). Conductor short and broad with an outgrowth (Figs 1A, 3A, 5A) and a dorsal lamella (LC = lamella of conductor; Figs 1C, 3C, 5C). Median apophysis broad (Figs 1C, 5C) or thin, sharp and elongated (Figure 3C). Epigyne: with two teeth (Figs 2A, 6A, 7A, absent in *G. qingshitanensis* sp. n. (Figure 4A)). Atrium oval and posterior (Figs 2A, 4A, 6A, 7A). Hoods absent. Copulatory openings centrally located (on corners of the atrium; Figs 2A, 4A, 6A, 7A). Copulatory duct expanded and sac-like (Figs 2B, 6B, 7B) or elongate and convoluted (Figure 4B). Spermathecae long, spermathecae heads long, stretched to the back (Figs 2B, 4B, 6B, 7B).

Natural history. All species of this genus were collected from moist caves with soluble rock.

Comments. The new genus was supported as monophyletic within the Guangxi *Coelotes* group (Zhao and Li 2017: 993, figure 3 - see ZZ391, ZZ392, ZZ890, and ZZ892). Males and females of each species were collected from the same caves and double-checked using DNA barcoding.

The divergence time analyses showed the split of *Guilotes* gen. n. and other close related clades early than 30 million years ago (Zhao and Li 2017: figure 3, S8). *Guilotes* and *Notiocoelotes* are very similar in morphology and present similar distribution areas (Wang et al. 2008, Liu et al. 2010, Zhang et al. 2016b); thus, it is meaningful to distinguish between them.

Distribution. Guangxi Zhuang Autonomous Region, China (Figure 8).

Guilotes ludiensis Z. Zhao & S. Li, sp. n.

http://zoobank.org/BA5B15BE-8B5C-4D02-9FF3-CD43C6073703
Figs 1–2, 8

Type material. Holotype ♂ (IZCAS-Ar34050): China: Guangxi Zhuang Autonomous Region: Guilin City: Ludi Cave, 25°18.551'N, 110°15.822'E, elevation: 200 m, 6.XII.2015, Z. Chen and X. Zhang leg. **Paratypes:** 1♀ (IZCAS-Ar34051, zz391, KY778823), same cave as holotype, 25°18.505'N, 110°15.793'E, elevation: 200 m, 9.XII.2012, Z. Chen and Z. Zhao leg.; 1♂3♀♀ (IZCAS-Ar34052–Ar34055), same data as holotype; 2♀♀ (IZCAS-Ar34056, Ar34057), same cave as the holotype, 25°18.237'N, 110°16.218'E, elevation: 150 ± 3 m, 5–6.I.2018, Z. Chen leg.

Etymology. The specific name is an adjective and refers to the type locality, Ludi Cave.

Diagnosis. Males of *Guilotes ludiensis* sp. n. can be distinguished from *G. xingpingensis* sp. n. with the long patellar apophysis, wide lateral tibial apophysis (Figs 1C, 5C) and narrow conductor (Figs 1A, 5A) with swollen OC and large LC (Figure 1C).

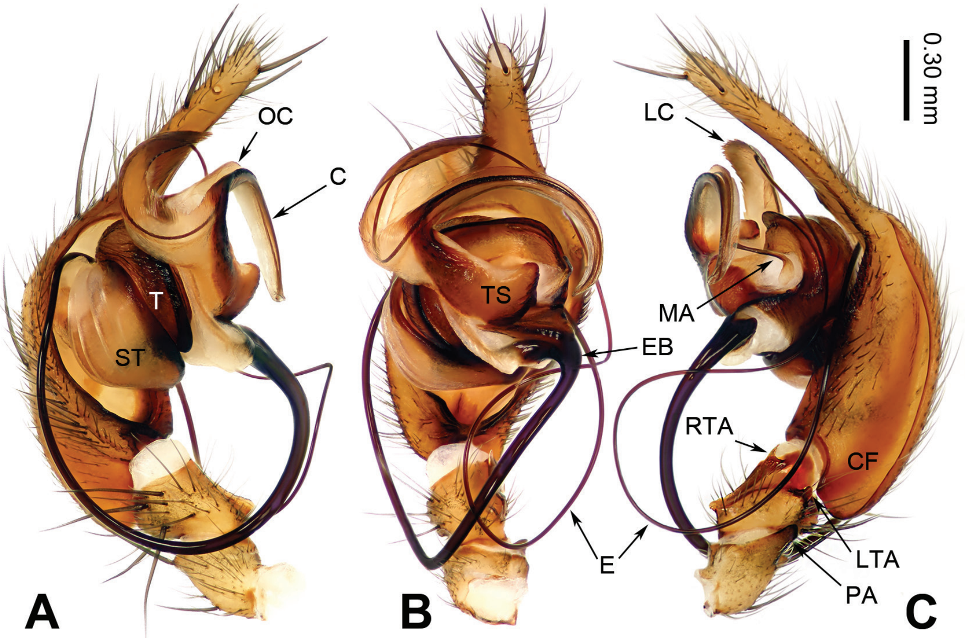

Figure 3. Left male palp of *Guilotes qingshitanensis* sp. n., holotype. **A** Prolateral view **B** Ventral view **C** Retrolateral view.

Differ from *G. qingshitanensis* sp. n. by the straight and short conductor with a LC and embolus beginning at 5 o'clock position (Figure 1B). Females can be distinguished from *G. xingpingensis* sp. n. by the epigynal teeth located in the middle of the atrial lateral margins (Figure 2A), copulatory ducts concave laterally and narrow fertilization ducts (Figure 2B). Differ from *G. qingshitanensis* sp. n. by the presence of epigynal teeth (Figure 2A) and sac-like of copulatory ducts (Figs 2B, 4B). Differ from *G. yandongensis* sp. n. by locations of epigynal teeth near the atrial lateral margins, atrium twice wider than long (Figure 2A), copulatory ducts ending horizontally and narrow fertilization ducts (Figure 2B).

Description. Male (holotype, IZCAS-Ar34050): Total length 5.94. Carapace 3.56 long, 2.77 wide. Abdomen 2.38 long, 1.78 wide. Eye diameters and interdistances: AME: 0.08, ALE: 0.16, PME: 0.15, PLE: 0.15; AME–AME: 0.04, AME–ALE: 0.03, AME–PME: 0.10, ALE–PLE: 0.02, PME–PME: 0.05, PME–PLE: 0.05. Leg measurements: I: 11.22 (3.96, 3.26, 2.60, 1.40); II: 10.51 (3.61, 3.36, 2.18, 1.36); III: 10.01 (3.39, 3.05, 2.38, 1.19); IV: 12.41 (4.17, 3.68, 3.17, 1.39). Chelicerae with five promarginal and five retromarginal teeth. Palp: patellar apophysis finger-shaped, its length shorter than width of patella (Figure 1C); RTA narrow, pointed tip (Figure 1C); LTA short, approximately 1/2 length of RTA (Figure 1C); cymbial furrow long, subequal to 2/3 length of cymbium (Figure 1C); embolus filiform, beginning at 5 o'clock position (Figure 1B); conductor short, horizontally directed (Figure 1A–B); OC located at the base of the conductor (Figure 1A) and LC located behind the outgrowth (Figure 1C); median apophysis small, spoon-like (Figure 1B–C).

Female (one of the paratypes, IZCAS-Ar34053): Total length 5.54. Carapace 2.57 long, 1.44 wide. Abdomen 2.97 long, 2.08 wide. Eye diameters and interdistances: AME: 0.05, ALE: 0.12, PME: 0.10, PLE: 0.11; AME–AME: 0.06, AME–ALE: 0.03, AME–PME: 0.08, ALE–PLE: 0.05, PME–PME: 0.08, PME–PLE: 0.07. Leg measurements: I: 7.08 (2.59, 2.21, 1.42, 0.86); II: 6.13 (2.06, 1.80, 1.46, 0.81); III: 5.52 (2.01, 1.61, 1.21, 0.69); IV: 7.66 (2.79, 2.41, 1.61, 0.85). Chelicerae with six promarginal and five or six retromarginal teeth. Epigyne: teeth short, less than 1/2 atrial length, located near the atrial lateral margins (Figure 2A); atrium small, occupying 1/7 epigynal plate (Figure 2A); copulatory ducts broad, occupying 3/4 epigynal plate (Figure 2B); spermathecae cylindrical, elongated and posterior, stay away from each other (Figure 2B); spermathecal heads long, stretched to the back (Figure 2B).

Variation. Total length: males 5.94–6.53 (n = 2); females 5.54–7.13 (n = 6).

Distribution. Males and females of this species were collected from Ludi Cave, Guilin City, Guangxi Zhuang Autonomous Region, China (Figure 8).

Guilotes qingshitanensis **Z. Zhao & S. Li, sp. n.**

http://zoobank.org/55071426-8B9F-4386-9A9E-9EA29B53AF78
Figs 3–4, 8

Type material. Holotype ♂ (IZCAS-Ar34058): China: Guangxi Zhuang Autonomous Region: Guilin City: Lingchuan County, Qingshitan Town, Yanbei Village, Yanbei Cave, 25°30.622'N, 110°14.969'E, elevation: 173 m, 7.XII.2015, X. Zhang and Z. Chen leg. **Paratypes:** 1♀ (IZCAS-Ar34059, zz892, KY778825), same cave as holotype, 25°31.137'N, 110°14.908'E, elevation: 173 m, 21.XII.2013, H. Zhao leg.; 1♂2♀♀ (IZCAS-Ar34060–Ar34062), same data as holotype; 2♂♂2♀♀ (IZCAS-Ar34063–Ar34066), same cave as holotype, 25°31.607'N, 110°14.967'E, elevation: 201 ± 4 m, 3.I.2018, Z. Chen leg.

Etymology. The specific name is an adjective and refers to the type locality, Qingshitan Town.

Diagnosis. Males of *Guilotes qingshitanensis* sp. n. differ from *G. ludiensis* sp. n. and *G. xingpingensis* sp. n. by long and bent conductor and OC (Figure 3A–B), LC with saw-shaped margin (Figure 3C), embolus beginning at 4 o'clock position (Figure 3B), small median apophysis with needle-shaped top and spoon-shaped end (Figure 3B–C). Females differ from *G. ludiensis* sp. n., *G. xingpingensis* sp. n. and *G. yandongensis* sp. n. by the absence of epigynal teeth (Figure 4A) and spiral copulatory ducts (Figure 4B).

Description. Male (holotype, IZCAS-Ar34058): Total length 6.92. Carapace 3.53 long, 2.51 wide. Abdomen 3.39 long, 2.01 wide. Eye diameters and interdistances: AME: 0.08, ALE: 0.15, PME: 0.14, PLE: 0.16; AME–AME: 0.06, AME–ALE: 0.05, AME–PME: 0.08, ALE–PLE: 0.04, PME–PME: 0.10, PME–PLE: 0.10.

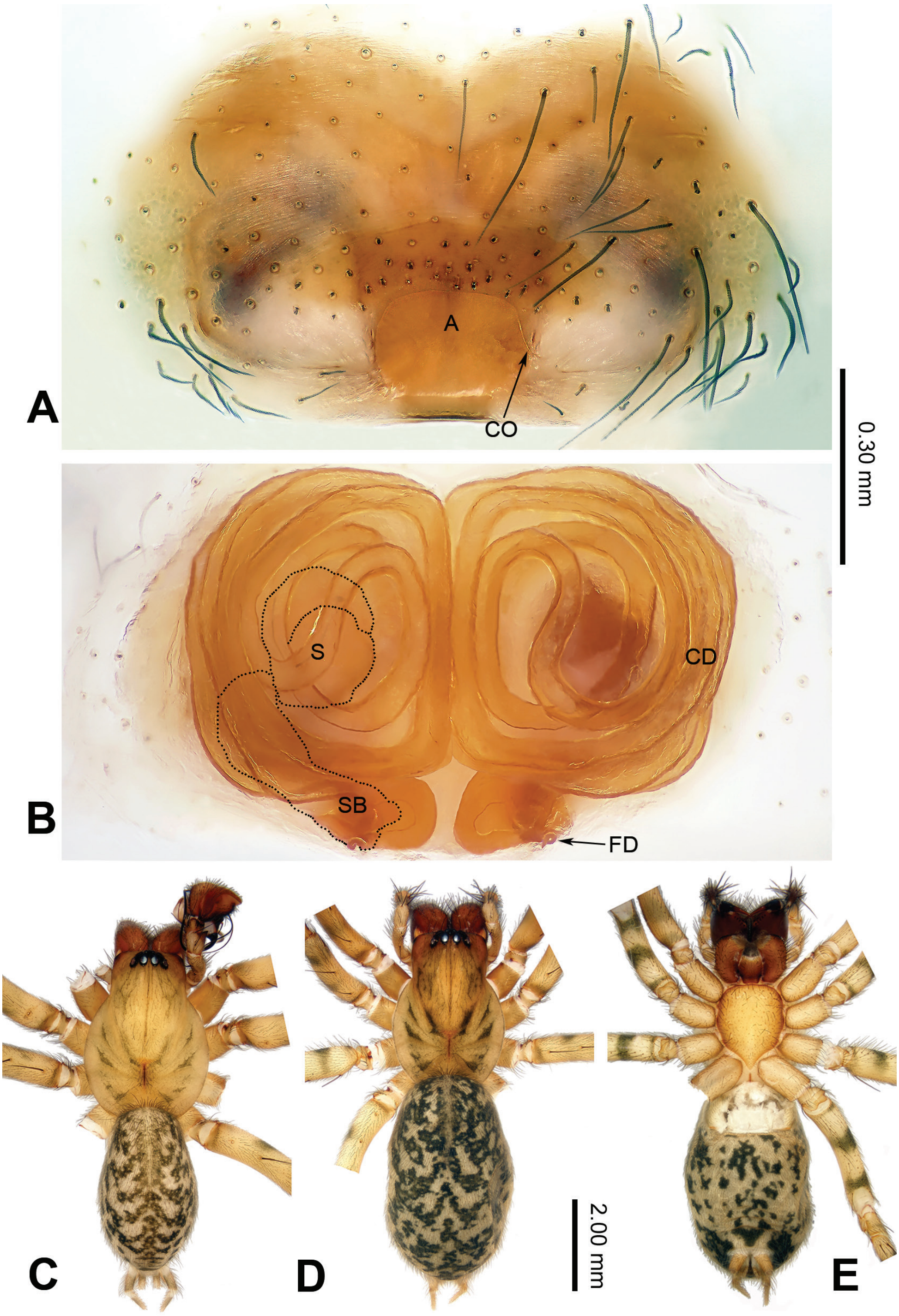

Figure 4. Epigyne and habitus of *Guilotes qingshitanensis* sp. n. **A** Epigyne, ventral **B** Vulva, dorsal **C** Male habitus, dorsal **D** Female habitus, dorsal **E** Female habitus, ventral. Scale bars equal for **C–E**.

Leg measurements: I: 12.64 (4.96, 3.65, 2.25, 1.78); II: 11.08 (4.22, 3.21, 2.24, 1.41); III: 9.69 (3.85, 2.56, 2.44, 0.84); IV: 14.02 (5.02, 3.97, 3.43, 1.60). Chelicerae with six promarginal and five retromarginal teeth. Palp: patellar apophysis finger-shaped, its length subequal to width of patella (Figure 3C); RTA narrow, keel-shaped apex (Figure 3C); LTA short, approximately 1/5 length of RTA (Figure 3C); cymbial furrow long, subequal to 1/2 length of cymbium (Figure 3C); embolus filiform, beginning at 4 o'clock position (Figure 3B–C); conductor long and bent (Figure 3A); outgrowth of the conductor beginning at the base of conductor, with similar shape as conductor (Figure 3A); lamella of the conductor broad, with saw-shaped margin (Figure 3C); median apophysis small, its end spoon-shaped while its top needle-shaped (Figure 3C).

Female (one of the paratypes, IZCAS-Ar34061): Total length 7.82. Carapace 3.53 long, 2.35 wide. Abdomen 4.29 long, 3.01 wide. Eye diameters and interdistances: AME: 0.09, ALE: 0.16, PME: 0.16, PLE: 0.15; AME–AME: 0.08, AME–ALE: 0.05, AME–PME: 0.08, ALE–PLE: 0.04, PME–PME: 0.10, PME–PLE: 0.09. Leg measurements: I: 9.74 (2.69, 3.27, 2.24, 1.54); II: 8.71 (2.82, 2.69, 1.92, 1.28); III: 8.14 (2.69, 2.37, 1.99, 1.09); IV: 10.97 (3.08, 3.53, 3.01, 1.35). Chelicerae with five or six promarginal and five retromarginal teeth. Epigyne: teeth absent (Figure 4A); atrium small, occupying 1/7 epigynal plate (Figure 4A); copulatory ducts long and spiral (Figure 4B); spermathecae long and longitudinally lengthening (Figure 4B); spermathecal heads and stalk covered by the copulatory ducts in dorsal view (Figure 4B); spermathecal bases horizontally extended (Figure 4B).

Variation. Total length: males 6.92–7.69 (n = 4); females 5.54–7.13 (n = 5).

Distribution. Males and females of this species were collected from Yanbei Cave, Guilin City, Guangxi Zhuang Autonomous Region, China (Figure 8).

Guilotes xingpingensis Z. Zhao & S. Li, sp. n.

http://zoobank.org/181B0155-FC02-4D9C-B169-25CD54DDB6A4
Figs 5–6, 8

Type material. Holotype ♂ (IZCAS-Ar34067, zz890, KY778824): China: Guangxi Zhuang Autonomous Region: Guilin City: Yangshuo County, Xingping Town, Luotian Village, Luotian Cave, 24°56.731'N, 110°31.459'E, elevation: 217 m, 17.XII.2013, H. Zhao leg. **Paratypes:** 3♂♂4♀♀ (IZCAS-Ar34068–Ar34074), same cave as holotype, elevation: 241 m, 8.XII.2015, X. Zhang and Z. Chen leg.

Etymology. The specific name is an adjective and refers to the type locality, Xingping Town.

Diagnosis. Males of *Guilotes xingpingensis* sp. n. differ from *G. ludiensis* sp. n. by the patellar apophysis short, lateral tibial apophysis narrow, conductor wide with flat outgrowth and small lamella (Figure 5C). Females differ from *G. ludiensis* sp. n. by the sail-shaped copulatory ducts and fertilization ducts wide and long (Figure 6B).

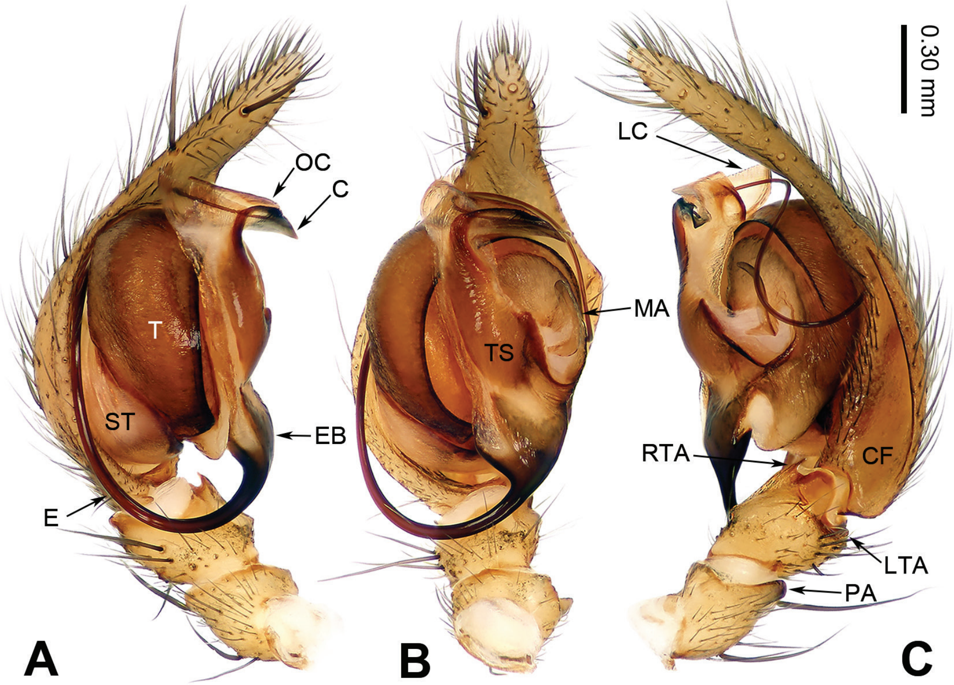

Figure 5. Left male palp of *Guilotes xingpingensis* sp. n., holotype. **A** Prolateral view **B** Ventral view **C** Retrolateral view.

Description. Male (holotype, IZCAS-Ar34067): Total length 5.03. Carapace 2.65 long, 1.75 wide. Abdomen 2.38 long, 1.56 wide. Eye diameters and interdistances: AME: 0.06, ALE: 0.13, PME: 0.12, PLE: 0.13; AME–AME: 0.07, AME–ALE: 0.06, AME–PME: 0.08, ALE–PLE: 0.02, PME–PME: 0.10, PME–PLE: 0.11. Leg measurements: I: 9.68 (3.28, 2.97, 2.09, 1.34); II: 7.84 (2.56, 2.31, 1.88, 1.09); III: 7.32 (2.56, 1.94, 1.88, 0.94); IV: 10.20 (3.44, 2.97, 2.66, 1.13). Chelicerae with six promarginal and five retromarginal teeth. Palp: patellar apophysis short, its length approximately half length of patella, finger-shaped (Figure 5C); RTA narrow, pointed tip (Figure 5C); LTA short, approximately 1/4 length of RTA (Figure 5C); cymbial furrow long, subequal to 1/2 length of cymbium (Figure 5C); embolus filiform, beginning at 5 o'clock position (Figure 5A, B); conductor short, horizontally directed (Figure 5A); base of conductor with one outgrowth (Figure 5A); lamella of the conductor located behind the outgrowth (Figure 5C); median apophysis small, spoon-shaped (Figure 5B–C).

Female (one of the paratype, IZCAS-Ar34071): Total length 6.99. Carapace 3.21 long, 2.24 wide. Abdomen 3.78 long, 2.44 wide. Eye diameters and interdistances: AME: 0.06, ALE: 0.12, PME: 0.11, PLE: 0.12; AME–AME: 0.07, AME–ALE: 0.04, AME–PME: 0.08, ALE–PLE: 0.04, PME–PME: 0.09, PME–PLE: 0.09. Leg measurements: I: 9.55 (3.72, 2.56, 2.12, 1.15); II: 8.49 (3.72, 2.28, 1.53, 0.96); III: 7.89

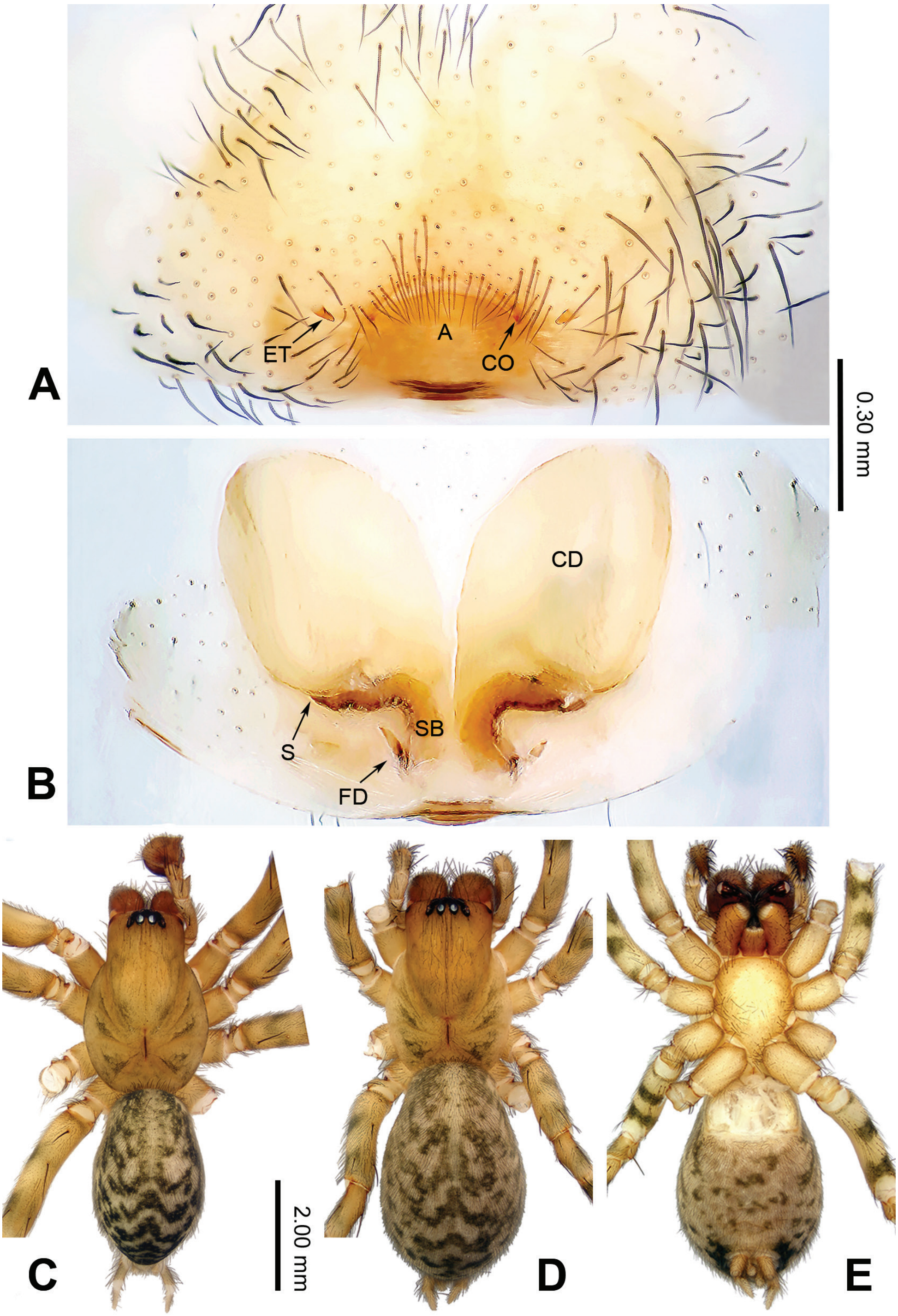

Figure 6. Epigyne and habitus of *Guilotes xingpingensis* sp. n. **A** Epigyne, ventral **B** Vulva, dorsal **C** Male habitus, dorsal **D** Female habitus, dorsal **E** Female habitus, ventral. Scale bars equal for **C–E**.

(3.09, 2.12, 1.73, 0.95); IV: 10.71 (4.11, 3.14, 2.05, 1.41). Chelicerae with five promarginal and five retromarginal teeth. Epigyne: teeth short, about 1/4 atrial length, located near the atrial lateral margins (Figure 6A); atrium small, occupying 1/8 epigynal plate (Figure 6A); copulatory ducts broad, occupying 3/4 epigynal plate (Figure 6B); spermathecae bean-shaped with complex lumen and posterior, stay away from each other, and below the copulatory ducts (Figure 6B); spermathecal heads long, stretched to the back (Figure 6B).

Variation. Total length: males 4.17–6.41 (n = 4); females 4.40–6.99 (n = 4).

Distribution. Males and females of this species were collected from Luotian Cave, Guilin City, Guangxi Zhuang Autonomous Region, China (Figure 8).

Guilotes yandongensis Z. Zhao & S. Li, sp. n.

http://zoobank.org/315FCE4E-69D1-4138-994C-8953E4A8F0E8
Figs 7–8

Type material. Holotype ♀ (IZCAS-Ar34075, zz392, KY778813): China: Guangxi Zhuang Autonomous Region: Baise City: Debao County, Yandong Town, Xingwang Village, Podi Cave, 23°14.268'N, 110°14.597'E, elevation: 632 m, 9.XII.2012, Z. Zhao and Z. Chen leg. **Paratypes:** 2♀♀ (IZCAS-Ar34076, Ar34077), same cave as holotype, 11.XII.2015, X. Zhang and Z. Chen leg.

Etymology. The specific name is an adjective and refers to the type locality, Podi Cave.

Diagnosis. Females of *Guilotes yandongensis* sp. n. can be differ from *G. qingshitanensis* sp. n. by having the epigynal teeth (Figure 7A) and wide fertilization duct (Figure 7B); they differ from *G. ludiensis* sp. n. and *G. xingpingensis* sp. n. by the copulatory ducts with folded lateral margin (Figure 7B).

Description. Female (holotype, IZCAS-Ar34075): Total length 5.77. Carapace 2.51 long, 1.61 wide. Abdomen 3.26 long, 2.05 wide. Eye diameters and interdistances: AME: 0.08, ALE: 0.12, PME: 0.12, PLE: 0.12; AME–AME: 0.04, AME–ALE: 0.04, AME–PME: 0.08, ALE–PLE: 0.05, PME–PME: 0.09, PME–PLE: 0.07. Leg measurements: I: 7.49 (2.81, 2.34, 1.25, 1.09); II: 7.11 (2.67, 2.03, 1.38, 1.03); III: 6.32 (2.19, 1.88, 1.47, 0.78); IV: 8.65 (2.81, 2.59, 2.19, 1.06). Chelicerae with four promarginal and five retromarginal teeth. Epigyne: teeth short, subequal to 1/3 atrial length, located far from the atrial lateral margins (Figure 7A); atrium small, occupying less than 1/8 epigynal plate (Figure 7A); copulatory ducts broad, occupying 3/4 epigynal plate, with folded lateral margin (Figure 7B); spermathecae long (Figure 7B); spermathecal heads long, stretched to the back (Figure 7B); spermathecal stalks long, lengthening along the margin of copulatory ducts (Figure 7B).

Variation. Total length: females 5.77–8.85 (n=3).

Distribution. All specimens of this species were collected from Podi Cave, Baise City, Guangxi Zhuang Autonomous Region, China (Figure 8).

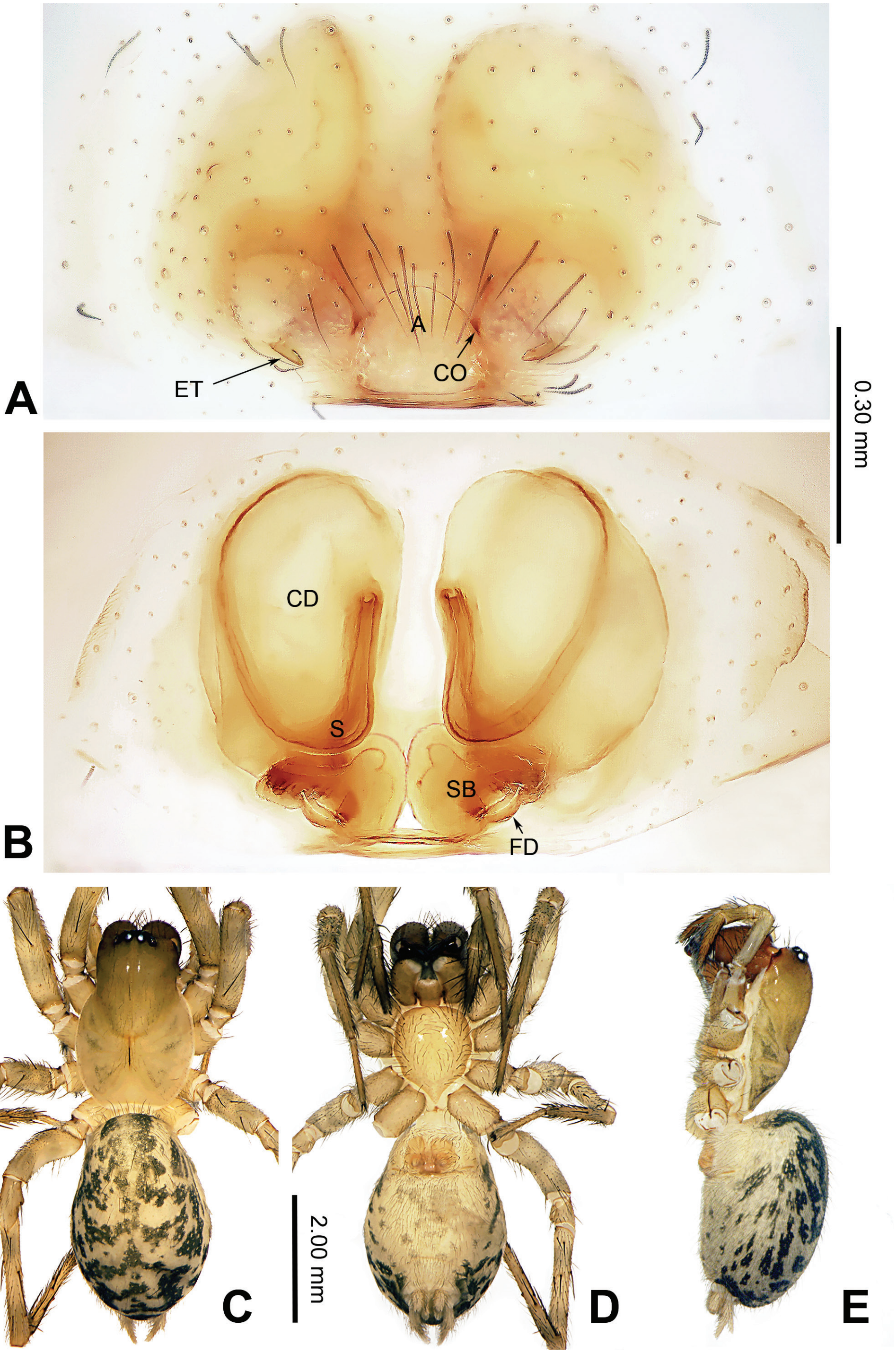

Figure 7. Epigyne and habitus of *Guilotes yandongensis* sp. n. **A** Epigyne, ventral **B** Vulva, dorsal **C** Female habitus, dorsal **D** Female habitus, ventral **E** Female habitus, lateral. Scale bars equal for **C–E**.

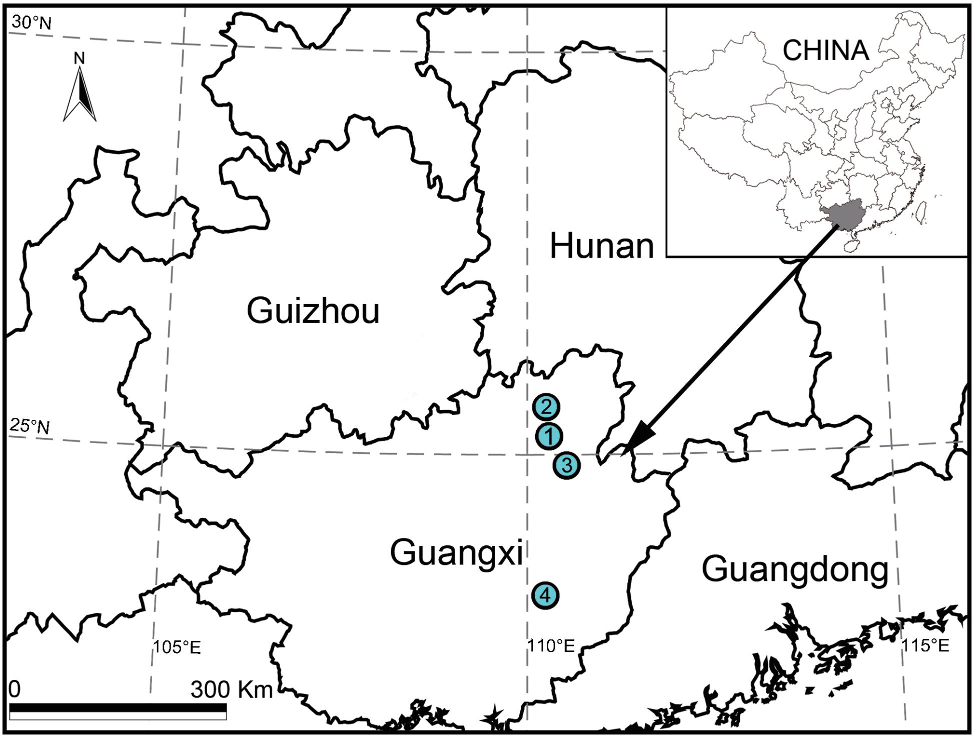

Figure 8. Localities of *Guilotes* species in China. **1** *G. ludiensis* sp. n. **2** *G. qingshitanensis* sp. n. **3** *G. xingpingensis* sp. n. **4** *G. yandongensis* sp. n.

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RESEARCH ARTICLE

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A survey of the *Porrhoclubiona* Lohmander, 1944 from Central Asia (Araneae, Clubiondae)

Yuri M. Marusik[1,2,3], Mikhail M. Omelko[4,5]

1 *Institute for Biological Problems of the North RAS, Portovaya Str. 18, Magadan, Russia* **2** *Department of Zoology & Entomology, University of the Free State, Bloemfontein 9300, South Africa* **3** *Zoological Museum, Biodiversity Unit, FI-20014 University of Turku, Finland* **4** *Far Eastern Federal University, Sukhanova 8, Vladivostok 690950, Russia* **5** *Federal Scientific Center of the East Asia Terrestrial Biodiversity FEB RAS, Vladivostok, 690022 Russia*

Corresponding author: *Yuri M. Marusik* (yurmar@mail.ru)

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Abstract

Clubiona Latreille, 1804, with more than 500 named species, is one of the largest genera of Araneae. The genus has 15 synonyms, most of which are not listed in the World Spider Catalog (2018) and unknown to many arachnologists. The most comprehensive survey of *Clubiona* sensu lato by Wunderlich (2011) also lacked a few synonyms. In this paper all genus group names described in *Clubiona* are listed with their type species. Most of these names correspond to the species groups recognised in *Clubiona* sensu lato. We agree that *Porrhoclubiona* Lohmander, 1944 (= *Clubiona genevensis*-group) deserves a status of a separate genus and provide the diagnosis of this taxon. Three species of *Porrhoclubiona* that occur in Central Asia are surveyed, and two of them are described as new to science: *P. laudata* (O. Pickard-Cambridge, 1885), **comb. n**. (♂♀, Xinjiang, Tibet, China), *P. bosmansi* **sp. n.** (♂♀, Tajikistan), and *P. moradmandi* **sp. n.** (♂♀, Fars, Iran). It seems that all records of *P. genevensis* L. Koch, 1866 from China refer to *P. laudata*. The records of *Clubiona vegeta* Simon, 1918 from Tajikistan and Iran refer to *P. bosmansi* sp. n. and *P. moradmandi* sp. n., respectively. The following new combinations have been established: *Porrhoclubiona decora* (Blackwall, 1859), **comb. n.**, *P. diniensis* (Simon, 1878), **comb. n.**, *P. leucaspis* (Simon, 1932), **comb. n.**, *P. minor* (Wunderlich, 1987), **comb. n.**, *P. pseudominor* (Wunderlich, 1987), **comb. n.**, *P. pteronetoides* (Deeleman-Reinhold, 2001), **comb. n.**, *P. vegeta* (Simon, 1918), **comb. n.**, *P. viridula* (Ono, 1989), **comb. n.**, and *P. wunderlichi* (Mikhailov 1992), **comb. n.** (all ex. *Clubiona*). SEM study of the structure considered earlier as scopula in *Clubiona* and *Porrhoclubiona* reveals that it is represented by several lateral rows of movable macrosetae (spines) with a locking mechanism.

Keywords

Aranei, *Clubiona*, India, Iran, new combination, new species, new status, redescription, Tajikistan, Xinjiang

Introduction

Clubiona Latreille, 1804 with more than 500 species (WSC 2018) is one of the largest genera of the order Araneae. There have been several attempts to split this genus either to genera and subgenera (Lohmander 1944; Wunderlich 2011) or to species groups (Mikhailov 1990, 1992, 1995, 2003; Deeleman-Reinhold 2001). One of the most distinct groups of the genus is the *Clubiona genevensis*-group (Bosmans et al. 2017) or subgenus *Porrhoclubiona* Lohmander, 1944 belonging to *Microclubiona* Lohmander, 1944. Both subgenus and genus are currently considered in the genus *Clubiona*, although both sexes have autapomorphies lacking in other clubionids. While studying spiders described by O. Pickard-Cambridge from the Himalayas, we recognised one species of *Clubiona* belonging to the *C. genevensis*-group. While tubes with types from the Himalayas are lacking any name or geographical labels it was easy to identify these specimens as *C. laudata* due to the figures in Pickard-Cambridge (1885). Because this species is very similar to *C. genevensis*, we decided to compare it to available specimens. Comparison of this species with specimens identified as *C. genevensis* from Tajikistan and southern Iran revealed differences between them as well as with syntypes of *C. laudata*. The goals of this paper are 1) to provide the first redescription of *C. laudata*, 2) the description of two new species, 3) revalidation, re-diagnosis, and re-delimitation of *Porrhoclubiona*.

Materials and methods

Specimens were photographed with a Canon EOS 7D camera attached to an Olympus SZX16 stereomicroscope and with a SEM JEOL JSM-5200 scanning microscope at the Zoological Museum, University of Turku, Finland, and digital images were montaged using "Zerene Stacker" image stacking software. Epigynes were cleared in a 10% KOH/water solution until soft tissues were dissolved. Photographs were taken in dishes with cotton on the bottom to hold the specimens in an appropriate position. All measurements are given in millimetres. Abbreviations used are as follows:

Fe	femur,	**d**	dorsal,
Pt	patella,	**p**	prolateral,
Mt	metatarsus,	**r**	retrolateral,
Ti	tibia,	**v**	ventral.
Ta	tarsus,		

The material examined is deposited in the following institutes:

OUMNH	The Oxford University Museum of Natural History
ZMMU	Zoological Museum of the Moscow State University, Russia

ZMUT	Zoological Museum, University of Turku
MMUE	The Manchester Museum, the University of Manchester
ZMUI	Zoological Museum, University of Isfahan

Comparative material: *Porrhoclubiona leucaspis* (Simon, 1932): 2♂ (ZMUT), FRANCE, *Paris*, Jardin des Plantes, on *Platanus* trunk, 13.04.1968 (Pentti Häkkilä); 1♀ (ZMUT), FRANCE, *Corsica*, St Georgis-Cauro, in litter of deciduous forest, 25.05.1972 (P. Lehtinen). *Clubiona pallidula* (Clerck, 1757): 1♂ (ZMUT), FINLAND, Nauvo, Kasaholm, 10.06.1959 (P.T. Lehtinen).

Taxonomy

Clubiona Latreille, 1804

Clubiona Latreille, 1804: 134 (type *Araneus pallidulus* Clerck, 1757).
Hirtia Thorell, 1881: 222 (type *H. hatamensis* Thorell, 1891).
Atalia Thorell, 1887: 54 (type *A. concinna* Thorell, 1887).
Tolophus Thorell, 1891: 26 (type *T. submaculatus* Thorell, 1891).
Paraclubiona Lohmander, 1944: 19 (type *Aranea corticalis* (Walckenaer, 1802).
Microclubiona Lohmander, 1944: 20 (type *C. trivialis* C.L. Koch, 1834).
Porrhoclubiona Lohmander, 1944: 20 (subgenus of *Microclubiona*, type *C. clandestina* Menge, 1873 (= *C. genevensis* L. Koch, 1866).
Hyloclubiona Lohmander, 1944: 20 (subgenus of *Microclubiona*, type *C. comta* C.L. Koch, 1839).
Heteroclubiona Lohmander, 1944: 20 (subgenus of *Clubiona,* type *C. terrestris* Westring, 1851).
Epiclubiona Lohmander, 1944: 20 (subgenus of *Clubiona*, type *C. neglecta* O. Pickard-Cambridge, 1862, not *C. similis* L. Koch, 1866 as indicated by Wunderlich 2011).
Euryclubiona Lohmander, 1944: 21 (subgenus of *Clubiona*, type *C. subsultans* Thorell, 1875).
Gauroclubiona Lohmander, 1944: 21 (subgenus of *Clubiona*, type *C. coerulescens* L. Koch, 1867).
Bucliona Benoit, 1977: 68 (type *Clubiona dubia* O. Pickard-Cambridge, 1869).
Japoniona Mikhailov, 1990: 143 (*C. japonica* L. Koch, 1878).
Bicluona Mikhailov, 1994: 52 (subgenus of *Clubiona*, *Liocranum jucundum* Karsch, 1879).
Marmorclubiona Wunderlich, 2011: 136 (type *C. marmorata* L. Koch, 1866).
Breviclubiona Wunderlich, 2011: 139 (type *C. brevipes* Blackwall, 1841).
Anaclubiona Ono, 2010: 4 (type *C. zilla* Dönitz & Strand, 1906).

Note. Above we have listed all names that are currently considered synonyms of *Clubiona*. Most are missing from the WCS (2018), but almost all are listed in Wunderlich (2011) and in Mikhailov (2012). One name is lacking in all three aforementioned publications, *Hirtia*. Because many genus group names correspond to the species groups and very distinct from *Clubiona* s. str., and *Clubiona* is one of the largest genera of spiders, most of the genus group names can be considered separate genera (if they are not junior synonyms). Notably, Wunderlich (2011) suggested to resurrect all genus group names in *Clubiona*, describing several genera and three family group names, two for recent species, Microclubionini Wunderlich, 2011 and Altaini Wunderlich, 2011, and one for the fossil genus *Eodoter* Petrunkevitch, 1858 (Eodotinae Wunderlich, 2011). Mikhailov (2012) synonymised all genera listed above with *Clubiona*.

The *Clubiona genevensis*-group fits Lohmander's *Porrhoclubiona* Lohmander, 1944 with the type species *C. genevensis*. Wunderlich (2011) considers *Porrhoclubiona* as separate genus in Microclubionini. Here we follow Wunderlich's subdivision of *Clubiona* sensu lato.

Comments. While trying to rediagnose *Porrhoclubiona* we noticed a peculiar modification of leg I and II in females: they have a kind of scopula (Figs 2d, 3a). A similar modification was documented for *Clubiona comta* C.L. Koch, 1839 (= *Hyloclubiona c.*) by Marusik and Kunt (2010). We thought that it was a diagnostic character for two related genera, but checking *Clubiona pallidula*, the generotype (Fig. 2e) and some other species revealed that this character is present in many species of *Clubiona* s. l. Locket & Millidge (1951: 125) mentioned scopulae on legs I and II present in all British *Clubiona*, that it was well developed only in females and can be reduced to a single row in a smaller species. Deeleman-Reinhold (2001) also reported the presence of scopulae in the *Clubiona pteronetoides*-group without specifying in which sexes.

Light microscopy (Fig. 2d, e) indicated that the modified setae cannot be considered as scopula. They are absent ventrally on the tarsus-tibia but located ventrolaterally and additionally are adpressed and not erect. SEM microscopy reveals that that "setae" in "scopula" are movable spines and have locking mechanisms (*Lm*), at least on the metatarsi and tibiae (Fig. 3e). A locking spine mechanism is known in several unrelated groups of spiders like Oonopidae, Corinnidae, Phrurolithidae, etc. (cf. Marusik et al. 2013: figs 7–10). In that groups, the locking mechanism is present in both sexes and such as ventral paired spines only. These spines are long, and when erect act as a catching basket for prey capture. The function of such spines arranged in 3–4 rows on each side of the segment is unclear.

Porrhoclubiona Lohmander, 1944

Porrhoclubiona Lohmander, 1944: 20 (subgenus of *Microclubiona*, type *C. clandestina* Menge, 1873 (= *C. genevensis* L. Koch, 1866).
Porrhoclubiona: Prószyński and Staręga 1971: 234; Sterghiu 1985: 54 (considered as subgenus).
Porrhoclubiona: Wunderlich 2011: 140 (considered as a genus).
Clubiona genevensis-group: Bosmans et al. 2017: 2.
Clubiona pteronetoides-group: Deeleman-Reinhold 2001: 96.

Note. Above we listed only two of the most recent publications dealing with this species group.

Diagnosis. *Porrhoclubiona* differs from all other clubionids by having modified setae on the cymbium (Figs 4a, c, d, f, g, i, 5a–c and Bosmans et al. 2017: figs 52–79), a retrolateral basal extension of the cymbium (called here a tutaculum, *Tu*, Figs 4a, c, d, f, g, i, 5g and Bosmans et al. 2017: figs 55, 59, 63, 67), a tegular groove (*Tg*) serving as a kind of conductor for the embolus (Figs 4b, c and Bosmans et al. 2017: figs 55, 59, 63, 67), the presence (Fig. 4h) of a prolateral tibial apophysis (*Pt*) which is lacking in other genera and strongly reduced, and posteriorly located subtegulum (*St*) (vs. large prolateral subtegulum in other genera). *Porrhoclubiona* differs from *Clubiona* s. str. by the smaller size, strongly protruding male chelicera (cf. Fig. 2b and Fig. 2f), shape of endites with a deep constriction (vs. unmodified endites, Fig. 2i, j), undivided short tibial apophysis of the male palp (vs. divided); brush of long modified setae on cymbium (vs. unmodified setae), filamentous embolus (vs. short, stick-like). Females of *Porrhoclubiona* differ from these of *Clubiona* by the shape of receptacles: round sclerotised (or primary, *Sr*) and round hyaline (or secondary, *Hr*) receptacles (vs. both pairs of receptacles elongate). Females of *Porrhoclubiona* have no such distinct differences from other genera as males.

Comments. Aside from those mentioned in the diagnosis, characters that separate *Porrhoclubiona* from all other genera previously considered in *Clubiona*, such as the presence of a patch/brush of modified setae on the cymbium, a cymbial extension that can be considered a tutaculum (*Tu*) and a tegular groove (*Tg*) serving as a conductor, a simple retrolateral tibial apophysis, and the presence of a prolateral apophysis, a few more characters should be mentioned. The two genera differ by spination of leg I: *Porrhoclubiona* is lacking metatarsal spines which are present in *Clubiona* and have fewer ventral tibial spines (cf. Fig. 2d and Fig. 2e). *Porrhoclubiona* has better developed “scopula”, which stretch along the entirety of tibia I, while in *Clubiona* it occupies only the distal ½ of the tibia (cf. Fig. 2d and Fig. 2e).

Although the retrolateral tibial apophysis of the male palp looks simple, from SEM figures it is rather broad (Fig. 5e) and the tip has a kind of filamentous extension (*Fl*). This tip can be long, like in *P. vegeta* (Bosmans et al. 2017: fig. 65) or *P. moradmandi* sp. n. (Fig. 5e), or rather short like in *P. bosmansi* sp. n. or *P. genevensis* (Figs 4c, 5f). Although the base of the embolus looks like one sclerite, in fact it is composed of two sclerites (Figs 4b, e, h, 9c, d, 10b’), heavily sclerotised part of the tegulum (*Ts*) and the base of the embolus (*Eb*).

Some species can be separated based on the proportions of the cymbial setae. *Porrhoclubiona lecucaspis* has distinctly longer basal part of the setae (*Sb*) than *P. moradmandi* sp. n. and *P. bosmansi* sp. n. (cf. Fig. 5c and Fig. 5a, b, respectively).

The haematodocha in *Porrhoclubiona* is rather large, but the subtegulum is strongly reduced and located posterior to the embolus base (Figs 4h, 6a, d, 7a, d); however, it is not large and or located prolaterally as in all other *Clubiona* s. l. It appears that species in this genus can be separated by the shape of the sperm duct course and relative width of the sperm duct (cf. Fig. 9c and Fig. 9d).

While studying morphology of the *Porrhoclubiona* with SEM, we found several notable characters:

- The femur has few bald areas (*Ba*), not covered with a transversal furrow as other parts of the cuticle (Fig. 3d). Such bald areas are known in several unrelated families.

- – The tarsal organ (*To*) in *Porrhoclubiona* is (if we recognized it correctly) slit like (Fig. 3c).
- – The trichobothrial base has five transversal ridges (Fig. 3g).
- – *Porrhoclubiona moradmandi* sp. n. has modified short setae (*Ms*) on the cymbium (Fig. 5d) (may also be peculiarly broken setae).

Composition. Bosmans et al. (2017) listed eight species belonging to the *Clubiona genevensis*-group. We establish a new combination for all of them except the generotype *Porrhoclubiona decora* (Blackwall, 1859), comb. n. (Madeira, Azores), *P. diniensis* (Simon, 1878), comb. n. (western Mediterranean), *P. genevensis* (L. Koch, 1866) (West Palaearctic?), *P. leucaspis* (Simon, 1932), comb. n. (western North Africa, Western Europe), *P. minor* (Wunderlich, 1987), comb. n. (the Canaries), *P. pseudominor* (Wunderlich, 1987), comb. n. (the Canaries), *P. vegeta* (Simon, 1918), comb. n. (Mediterranean or West Palaearctic) and *P. wunderlichi* (Mikhailov, 1992), comb. n. (Mongolia). Two species assigned to this group by Wunderlich (2011) were overlooked by Bosmans et al. (2017): *P. pteronetoides* (Deeleman-Reinhold, 2001), comb. n. and *P. viridula* (Ono, 1989), comb. n. both from SE Asia. Deeleman-Reinhold (2001) considered these two species in a separate group, the *Clubiona pteronetoides*-group. Males of *P. pteronetoides* and *P. viridula* have dorsal abdominal scuta unknown in other species of the group, and possibly lack modified setae on the cymbium.

Aside from the species mentioned above, we consider three more species in this genus, *P. laudata* (O. Pickard-Cambridge, 1885), comb. n., ex. *Clubiona* and two new species, *P. bosmansi* sp. n. and *P. moradmandi* sp. n.

Porrhoclubiona laudata (O. Pickard-Cambridge 1885), comb. n.

Figs 1b, 6a–c, 10c

Clubiona laudata O. Pickard-Cambridge, 1885: 23, pl. 2, f. 16 (♂♀).
Clubiona genevensis: Zhou et al. 1983: 157, f. 8a–d (♂♀); Hu and Wu 1989: 305, f. 244.1–4 (♂♀); Zhang and Hu 1989: 58, f. 6, 21 (♂♀); Song et al. 1999: 416, f. 245R-S, 248L–M (♂♀); Hu 2001: 287, f. 166.1–4 (♂♀) (all misidentifications).

Material examined. Lectotype ♂ (designated here) and paralectotype ♂ (OUMNH) with a label "B[ottle] 381, v[ial] 1", label reads "Road from Yarkand to Bursi, May 28th to June 17th, 1874".

Note. All species described by O. Pickard-Cambridge (1885) based on materials from the Second Yarkand Mission are lacking labels with species names or geographical localities. The WSC (2018) indicates that the species was described based on the male only, although Pickard-Cambridge (1885: 24) also described a female. The species distribution is indicated as China (Yarkand), although Pickard-Cambridge (1885) mentioned the species was described based on specimens collected on the road from Yarkand (lying in SW Xinjiang, China) to Bursi (lying in the Leh District of the Jammu and Kashmir, India).

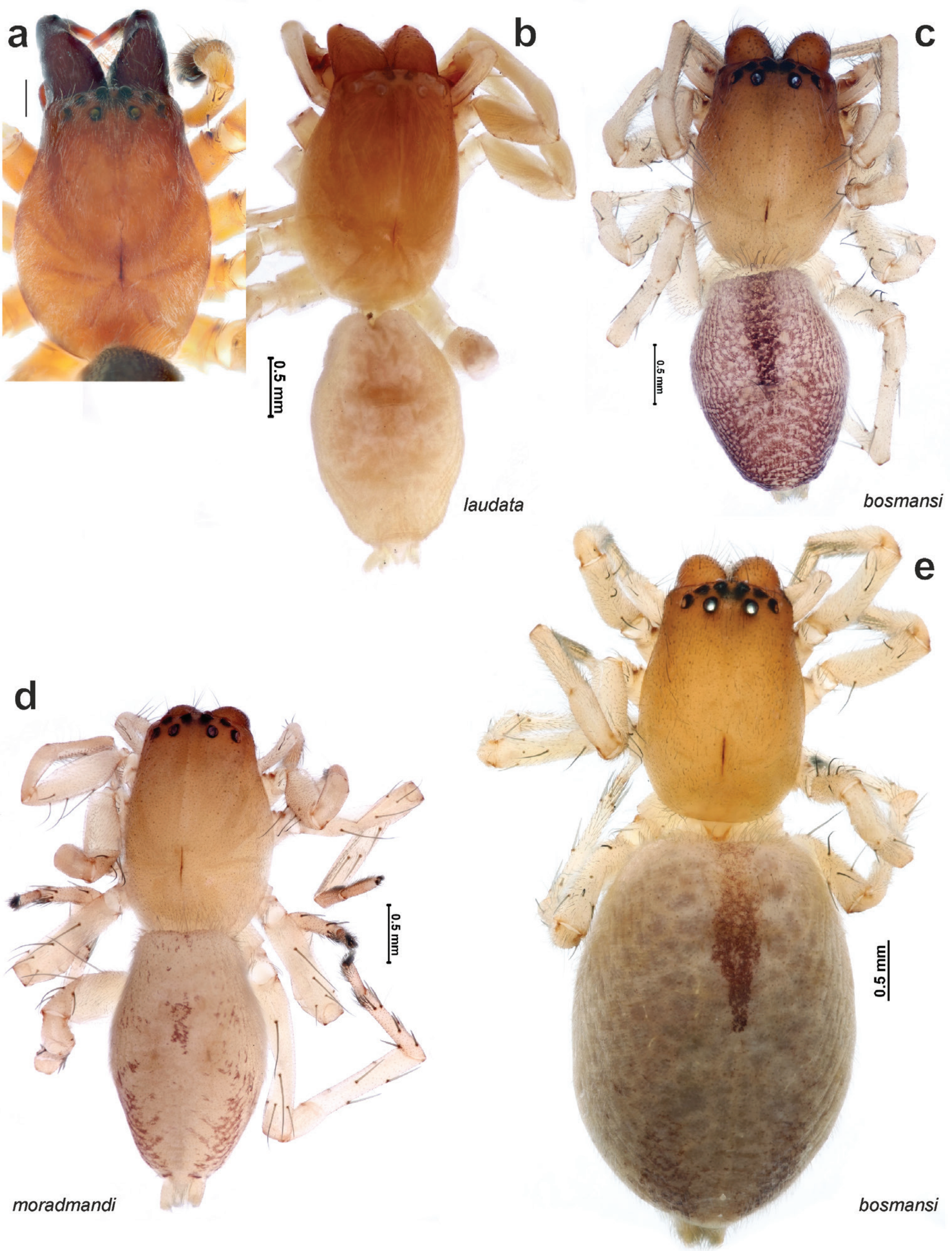

Figure 1. General appearance of *Clubiona pallidula* (**a**), *Porrhoclubiona laudata* (**b**), *P. bosmansi* sp. n. (**c, e**) and *P. moradmandi* sp. n. (**d**). **a** prosoma, dorsal **b–d** male habitus, dorsal **e** female habitus, dorsal.

Diagnosis. *Porrhoclubiona laudata* differs from *P. leucaspis* by the conical tibial apophysis (vs. broad and rounded at the tip, Figs 4i, 6e) and thinner basal part of the embolus. Tibetan species differ from other species occurring in Central Asia by the large palp (cf. Figs 10b–d).

Description. Male (lectotype). Carapace 2.11 long, 1.41 wide. Abdomen 1.98 long, 1.29 wide. Total length 4.10. Carapace brown, darker in head area, fovea dark-brown, thin.

Labium, maxillae, chelicerae, and sternum yellowish. Chelicerae with 2 promarginal teeth.

Leg lengths

	Fe	Pa	Ti	Mt	Ta	Total
I	1.13	0.70	1.14	0.74	0.46	4.17
II	1.36	0.79	1.44	0.94	0.51	5.04
III	1.06	0.54	0.93	0.89	0.44	3.86
IV	1.46	0.73	1.24	1.43	0.36	5.22

Leg spination

	Fe	Pa	Ti	Mt
I	3d 1p	–	1-1v	–
II	3d 1p	–	1-1v	0-1v
III	3d 1p 1r	–	1p 1r 1-0v	2d 2p 1r 2-2v
IV	3d 1p 1r	1r	2p 2r 1-0v	4p 3r 2-2v

Abdomen without distinct pattern.

Palp as in Figs 6a–c, 10c. Tibial apophysis gradually tapering, subconical; anterior margin of cymbium broad; base of embolus (*Be*) equal to ½ of tegular length, basal part of embolus (*Eb*) as long as approx. 2/3 of the base.

Female. Lacking among type series. Pickard-Cambridge (1885) described it as: “The female is rather larger, but resembles the male in colours and markings, except that the abdomen is less marked and streaked with rusty red; the form of the genital aperture, which is quite small, is characteristic”. Description of *C. genevensis* from Western China seems to refer to this species. Epigyne as long as wide.

Distribution. Exact type locality is unknown and in either in southwestern Xinjiang (China) or in adjacent Northeastern Jammu and Kashmir (India). It seems that all records of *C. genevensis* from China (Xinjiang and Tibet) refer to this species.

Porrhoclubiona bosmansi **sp. n.**

http://zoobank.org/99107F93-8949-4D57-AD13-061A26879084

Figs 1c, e, 2a–d, j, 3, 4a–c, 5a, g, 7d–f, 8d–f, 9a, 10d

Clubiona vegeta: Andreeva 1976: 77.

Types. Holotype ♂ and paratype ♂ (ZMMU) TAJIKISTAN, **Khalton** area, Dangara Distr, Sanglogh (= Sanglok), Mt. Range, above Shar-Shar Pass, 38°17.937'N, 69°13.598'E, 1700–2060 m, 29 Apr 2015 (Y.M. Marusik), 1♀ (ZMMU) TAJIKISTAN, **Khalton** area, environs of Khovaling, Obimazar River, 38°20.940'N, 69°58.194'E, 1413 m, gravely river shore with some bushes, 27 Apr 2015 (Y.M. Marusik).

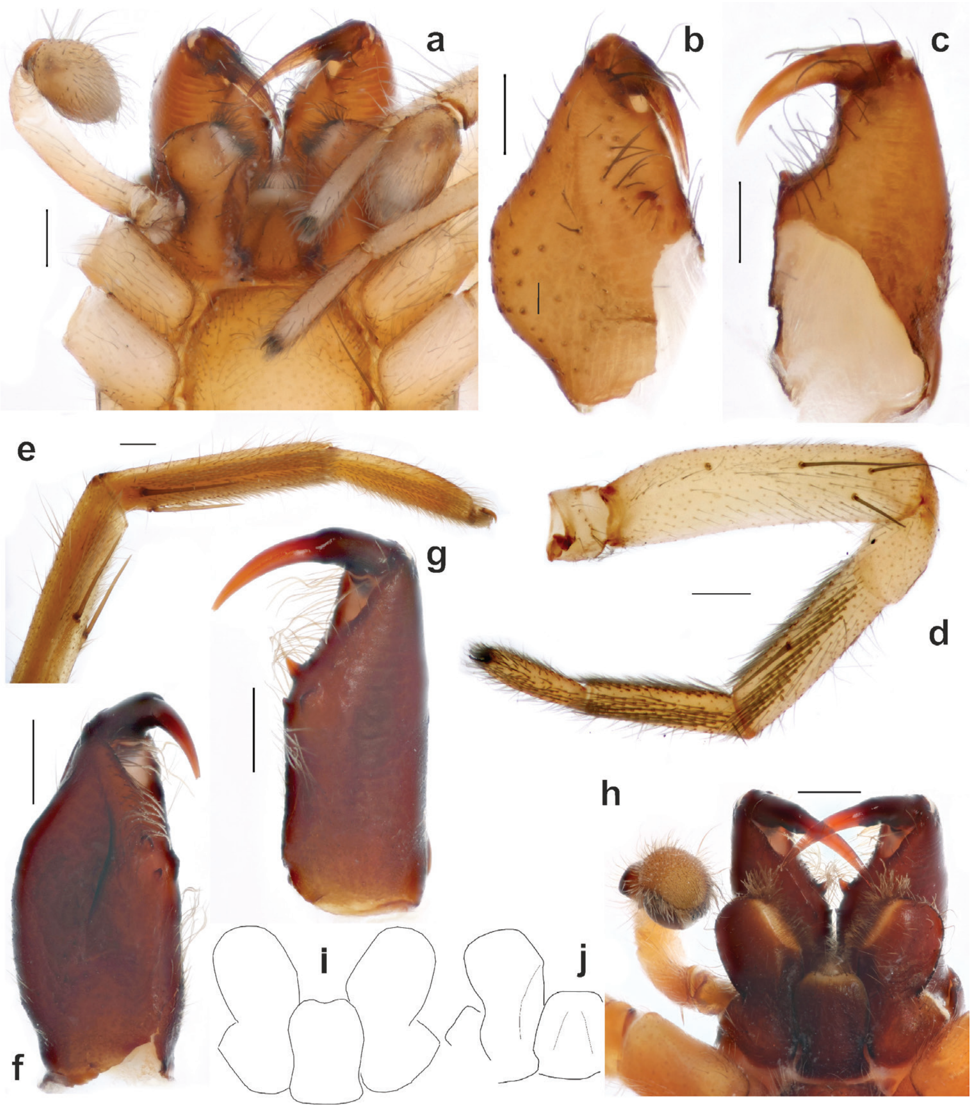

Figure 2. Somatic characters of *Porrhoclubiona bosmansi* sp. n. (**a–d, j**) and *Clubiona pallidula* (**e, f–i**). **a, h** anterior part of male prosoma, ventral, showing mouth parts **b, f** left male chelicera, mesal **c, g** left male chelicera, posterior **e** female tibia–tarsus I, prolateral **d** female leg I, prolateral **i–j** maxilla and labium, ventral.

Etymology. The specific name is a patronym in honour of our friend and colleague Robert Bosmans (Gent, Belgium) who made significant contributions to the study of the *Clubiona genevensis*-group.

Diagnosis. *Porrhoclubiona bosmansi* sp. n. differs from *P. laudata* by having a smaller carapace (1.7–1.77 vs. 2.11), smaller palp (cf. Fig. 10c and Fig. 10d) and thinner tibial apophysis. The new species differs from *P. moradmandi* sp. n. by the smaller palps and shorter modified cymbial hairs (cf. Fig. 5a and Fig. 5b), fewer pro- and retro-

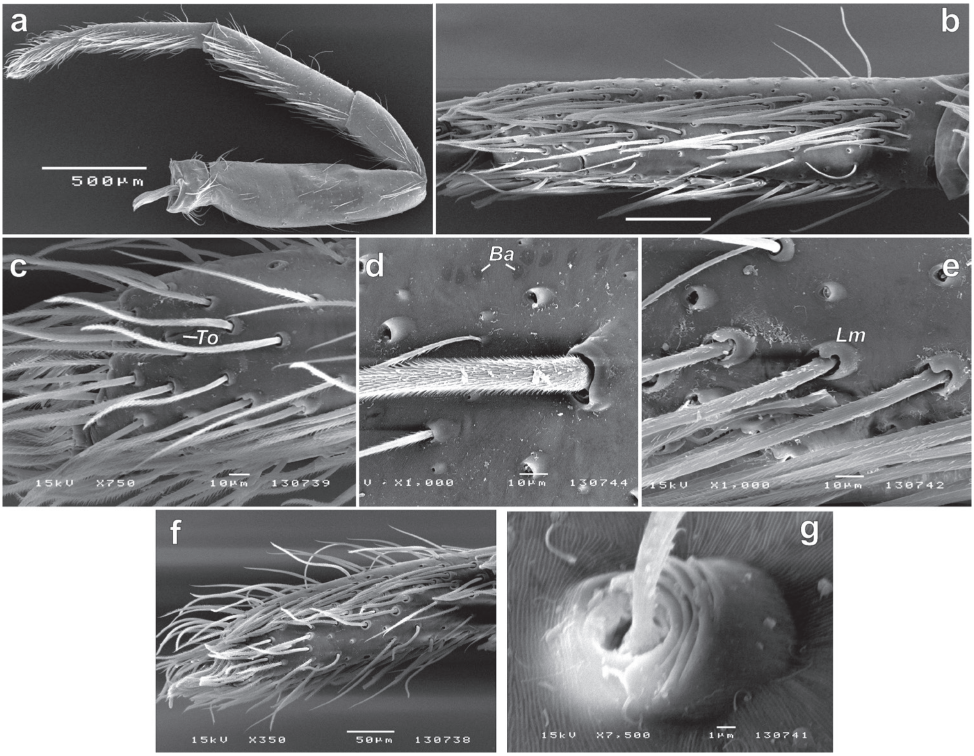

Figure 3. SEM micrographs of the female leg I of *Porrhoclubiona bosmansi* sp. n. **a** whole leg, prolateral **b** metatarsus, subventral **c** distal part of tarsus, lateral, showing tarsal organ **d** femur, showing bold areas and spine **e** tibia, showing spines with locking mechanism **f** tarsus, subventral, showing spines lacking locking mechanism **g** trichobothrium. Abbreviations: *Ba*–bald areas, *Lm*–locking mechanism, *To*–tarsal organ.

lateral spines on metatarsus III (2-2 vs. 3-3), and inclined anterior edge of the embolic base (vs. almost horizontal, cf. Fig. 10b' and Fig. 10d'). Female of *P. bosmansi* sp. n. differs from those of *P. moradmandi* sp. n. by the shape of the epigynal fovea, which is more transverse and lacking posterior notch (cf. Fig. 8a–c, d–f). Females of the two species differ by the shape of the copulatory ducts and relative position of hyaline and sclerotised receptacles: sclerotised receptacles located anterior to the hyaline receptacles in *P. bosmansi* sp. n. and posteriorly in *P. moradmandi* sp. n. (cf. Fig. 9a and 9b).

Description. Male (holotype-paratype). Total length 3.55–3.63. Carapace 1.71–1.77 long, 1.11–1.29 wide. Abdomen 1.86–1.88 long, 1.23–1.30 wide. Carapace light-brown, cephalic area darker. Labium, maxillae, chelicerae brown. Sternum yellowish. Chelicerae with one prolateral tooth, retrolateral teeth absent.

Leg lengths (paratype).

	Fe	Pa	Ti	Mt	Ta	Total
I	1.07	0.60	1.03	0.71	0.41	3.83
II	1.17	0.59	1.01	0.83	0.36	3.96
III	1.00	0.50	0.79	0.86	0.36	3.50
IV	2.88	0.64	1.07	3.50	0.43	8.52

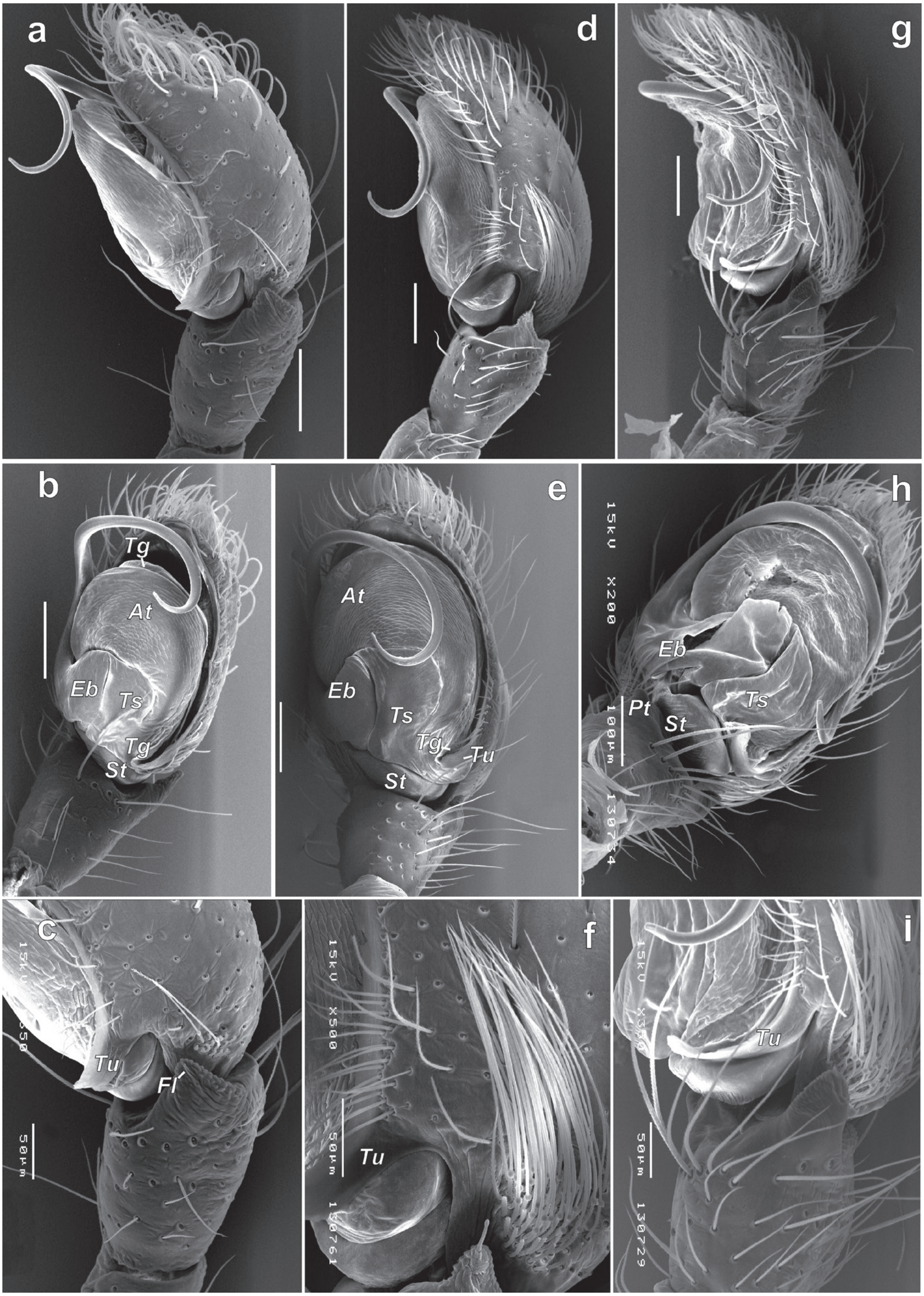

Figure 4. SEM micrographs of the male palp of *Porrhoclubiona bosmansi* sp. n. (**a–c**), *P. moradmandi* sp. n. (**d–f**) and *P. leucaspis* (**g–i**). **a, d, g** retrolateral **b, e** retro-ventral h ventral **c, i** tibia and proximal part of bulb and cymbium; retrolateral **f** cymbium and part of tegulum, retrolateral. Abbreviations: *At*–anterior part of tegulum, *Eb*–base of embolus, *Fl*–filamentous extension, *Pt*–prolateral tibial apophysis, *St*–subtegulum, *Tg*–tegular groove, *Ts*–sclerotised part of tegulum, *Tu*–tutaculum.

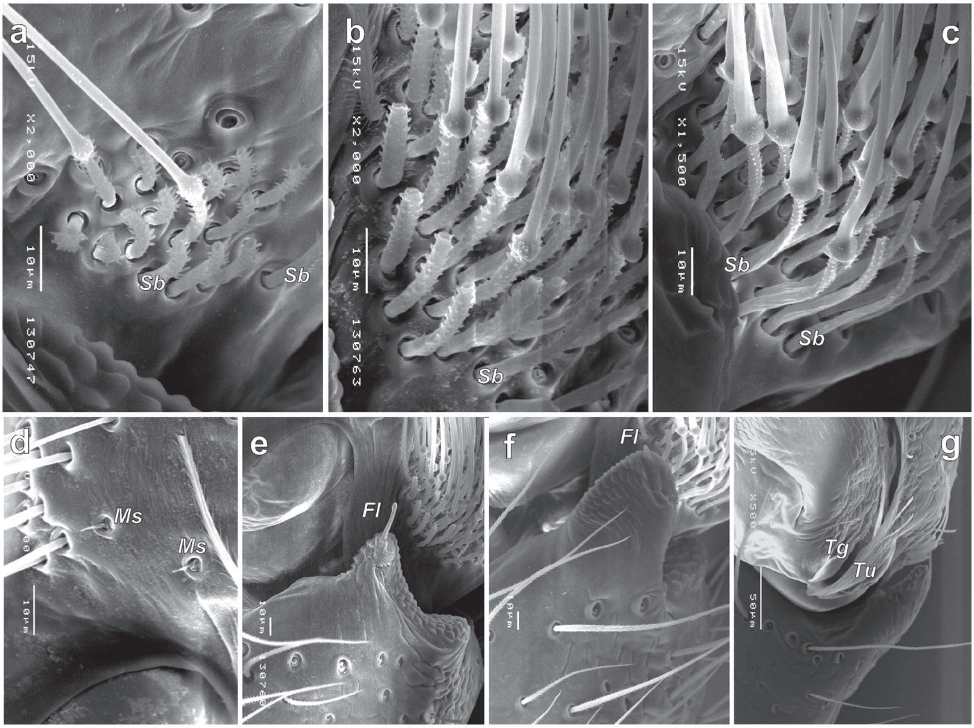

Figure 5. SEM micrographs of the male palp of *Porrhoclubiona bosmansi* sp. n. (**a, g**), *P. moradmandi* sp. n. (**b, d, e**) and *P. leucaspis* (**c, f**). **a–c** modified cymbial setae **d** proximal part of cymbium with modified short setae **e–f** tibial apophysis **g** basoretrolateral part of cymbium showing tutaculum and tegular groove. Abbreviations: *Fl*–filamentous extension, *Ms*–modified short setae, *Sb*–basal part of setae, *Tg*–tegular groove, *Tu*–tutaculum.

Leg spination

	Fe	Pa	Ti	Mt
I	3d 1p	–	1-0v	1-1v
II	3d 1p	–	1-2r	1-1v
III	3d 1p 1r	–	1p 1r 1-0v	2p 2r 1-2v
IV	3d 1p 1r	1r	2p 2r 1-0v	4p 4r 2-1v

Abdomen yellow-reddish at dorsal part with dark-reddish cordial mark. Lateral sides of abdomen reddish, ventral side yellowish.

Palp as in Figs 4a–c, 5a, g, 7d–f, 10d. Tibial apophysis triangular, wider than long; anterior edge of cymbium almost flat (horizontal, not rounded); setae in cymbial brush not dense, approx. 1/3 of cymbial length; anterior part of tegulum (*At*) longer than base of embolus (*Be*); posterior edge (*Pb*) of the basal part of embolus inclined as well as anterior part of embolic base.

Female. Carapace 2.1 long, 1.43 wide. Abdomen 3.38 long, 2.4 wide. Total length 5.5. Coloration as in males, but somewhat lighter. Chelicerae with 4 prolateral and 3 retrolateral teeth.

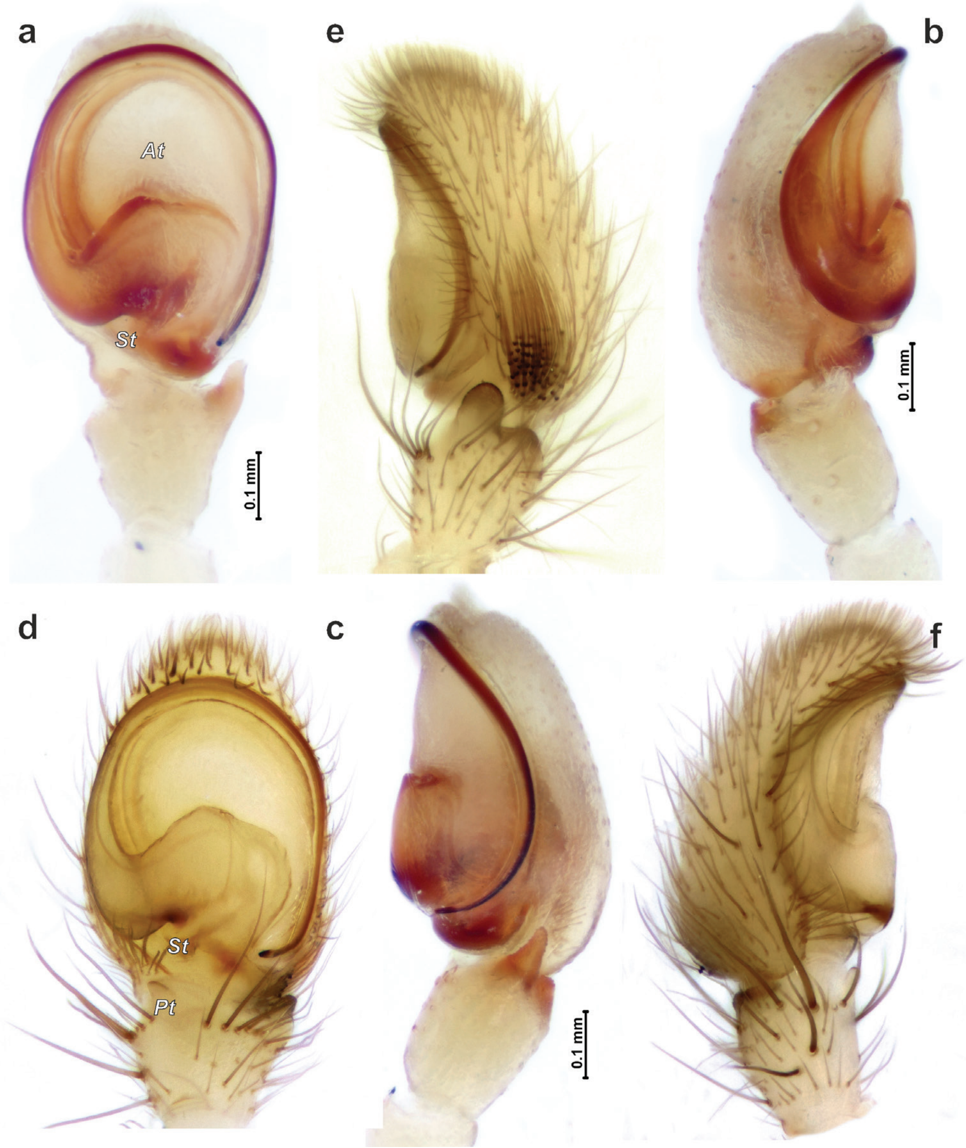

Figure 6. Male palp of *Porrhoclubiona laudata* (**a–c**) and *P. leucaspis* (**d–f**). **a, d** ventral **b, f** prolateral **c, e** retrolateral. Abbreviations: *At*–anterior part of tegulum, *Pt*–prolateral tibial apophysis, *St*–subtegulum.

Leg lengths

	Fe	Pa	Ti	Mt	Ta	Total
I	1.07	0.57	0.89	0.71	0.43	3.67
II	1.21	0.71	1.00	0.71	0.40	4.04
III	1.14	0.57	0.64	0.81	0.41	3.58
IV	1.57	0.69	1.14	1.36	0.50	5.26

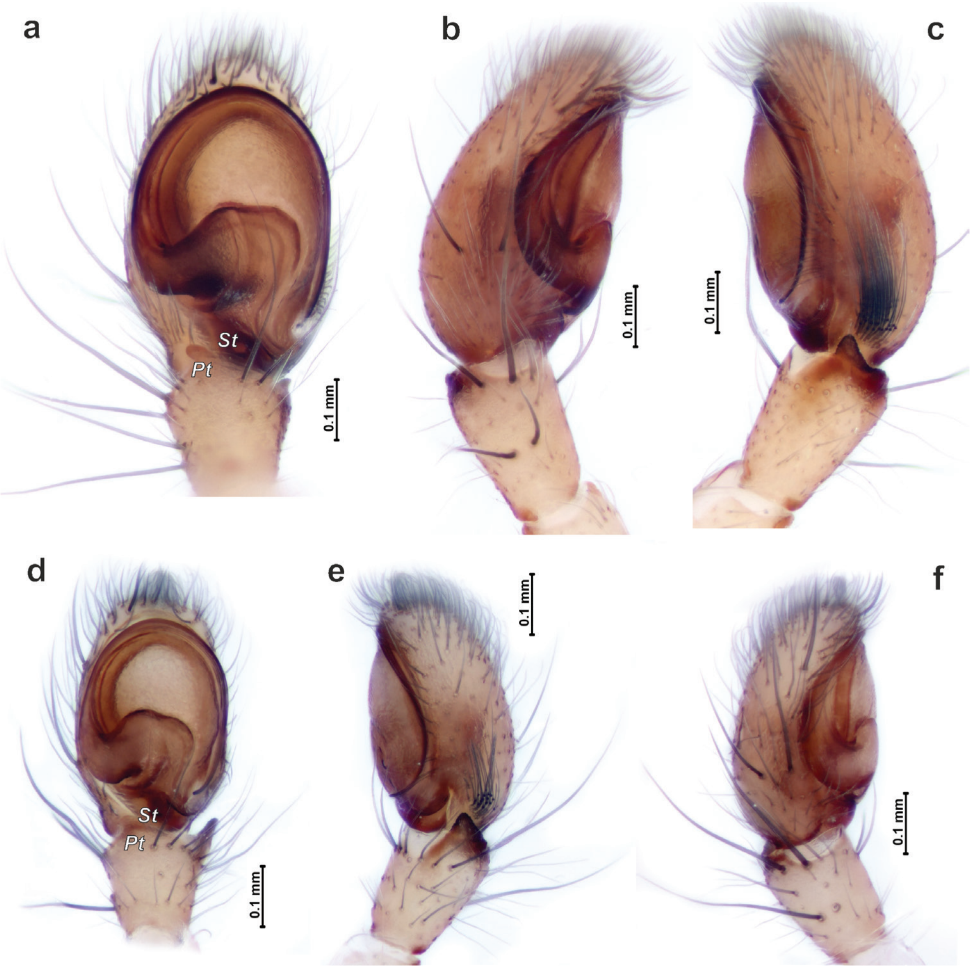

Figure 7. Male palp of *Porrhoclubiona moradmandi* sp. n. (**a–c**) and *P. bosmansi* sp. n. (**d–f**). Abbreviations: *Pt*–prolateral tibial apophysis, *St*–subtegulum.

Leg spination

	Fe	Pa	Ti	Mt
I	3d 1p	–	1-0v*	–*
II	3d 1p	–	1-2v*	0-1v*
III	3d 1p 1r	–	1p 1r 1-0v	3p 3r 0-1v
IV	3d 1p 1r	1r	3p 3r 1-1v	4p 4r 1-1v

Epigyne as in Figs 8d, e, 9a. Fovea oval, more than twice as wide as long, posterior notch absent; translucent sclerotised receptacles (*Sr*) spaced by approx. one radius in intact epigyne; hyaline receptacles (*Hr*) located posterior to sclerotised receptacle; hyaline receptacles 1.3 times larger than sclerotised receptacles; loop of copulatory duct (*Dl*) directed posteriorly and spaced from each other by approximately one diameter.

Distribution. Hatlon Province of Tajikistan.

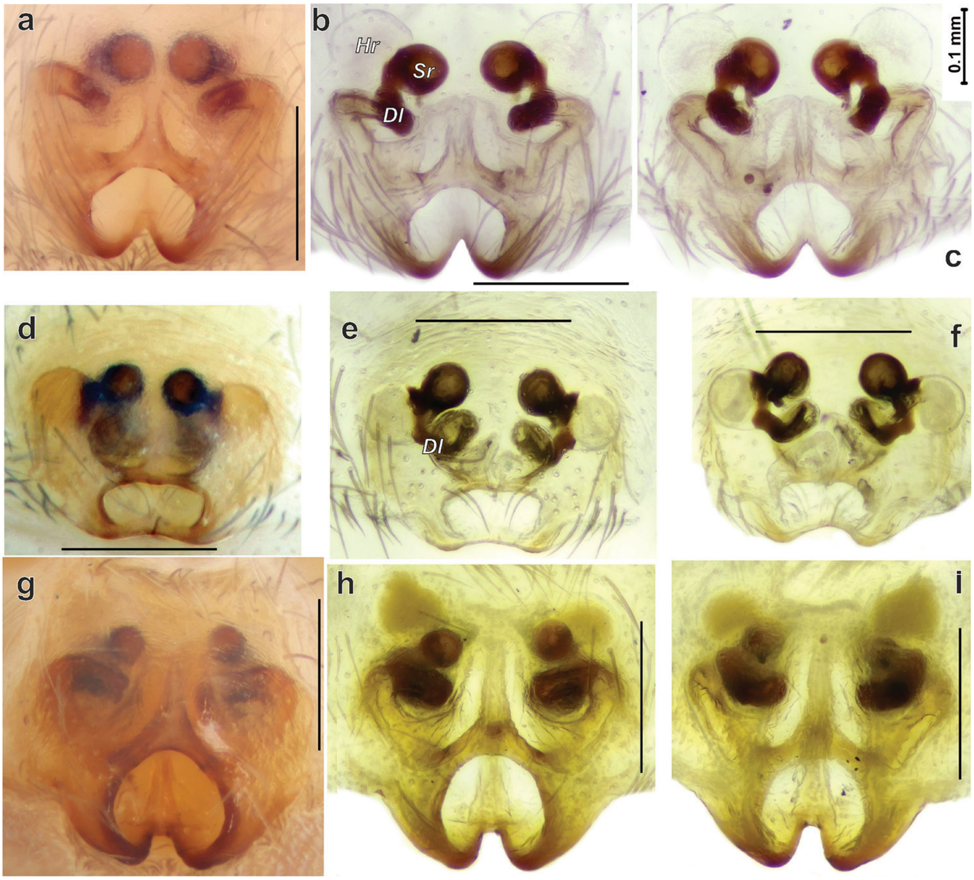

Figure 8. Epigyne of *Porrhoclubiona moradmandi* sp. n. (**a–c**), *P. bosmansi* sp. n. (**d–f**) and *P. leucaspis* (**g–i**). **a, d, g** intact, ventral **a, d, g** intact, ventral **b, e, h** macerated, ventral **c, f, i** macerated, dorsal. Abbreviations: *Dl*–loop of copulatory duct, *Hr*–hyaline (secondary) receptacle, *Sr*–sclerotized (primary) receptacle.

Porrhoclubiona moradmandi sp. n.

http://zoobank.org/B5FF090D-1086-412B-842D-68179EACF675
Figs 1d, 4d–f, 5b, d, e, 7a–c, 8a–c, 9b, d, 10b

Types. Holotype ♂ and paratype ♀ (MMUM), paratypes 2♂ (ZMUI), 14 ♂ 4juv (ZMMU), IRAN, **Fars** Prov., Shiraz City, nearby Qur'an Gate, 29°38'08"N, 52°33'42"E, leaf and pine needle litter in small park, 19 Dec 2013 (Y.M. Marusik).

Etymology. The specific name is a patronym in honour of the well-known Iranian arachnologist, Professor Majid Moradmand (Isfahan).

Diagnosis. The new species differs from *P. bosmansi* sp. n. by the less intense colouration of the male (cf. Figs 1c & 1d). Males of this species can be distinguished by the larger palp (cf. Figs 7a–c & 7d–f and 10b & 10d), horizontal orientation of embolic base anterior edge and posterior edge of the basal part of the embolus (vs. inclined (cf. Figs 10b' and 10d')) and relatively longer tibia – length/width ratio approx. 2 (vs. short-

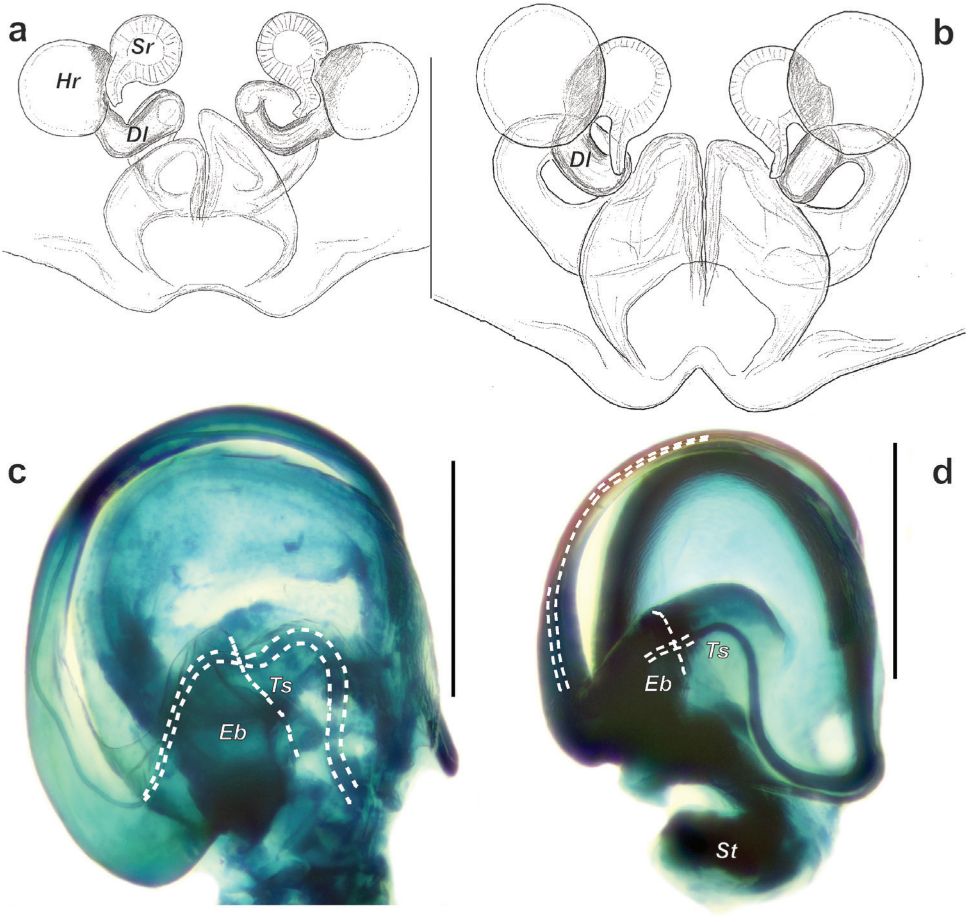

Figure 9. Endogyne and bulb of *Porrhoclubiona bosmansi* sp. n. (**a**), *P. moradmandi* sp. n. (**b, d**) and *P. leucaspis* (**c**). **a–b** endogyne, dorsal **c–d** macerated tegulum, ventral, showing course of sperm duct. Abbreviations: *Eb*–base of embolus, *Dl*–loop of copulatory duct, *Ts*–sclerotised part of tegulum, *St*–subtegulum.

er, ratio ca. 1.5). Females of *P. moradmandi* sp. n. can be distinguished from *P. bosmansi* sp. n. by the shape of the epigyne: epigynal fovea pentagonal (vs. oval) with distinct posterior notch (*vs.* lacking), anterior position of hyaline receptacles (vs. sclerotised receptacle located anteriorly), anteriorly directed loop of copulatory duct (vs. posteriorly). *Porrhoclubiona moradmandi* sp. n. is very similar to *P. leucaspis* by the abdominal pattern, palp shape, and particularly by having a filamentous extension (*Fl*) of the tibial apophysis, although the female differs by the shape of the copulatory ducts and receptacle proportions (cf. Fig. 8a–c and Fig. 9b and Bosmans et al. 2017: figs 45–51).

Description. Male. Total length 3.38–4.67. Carapace 1.70–2.17 long, 1.17-1.64 wide. Abdomen 1.57–2.50 long, 1.0–1.57 wide. Carapace yellow to light brown without pattern, Labium, maxillae and chelicerae light brown. Sternum yellow. Chelicerae with one promarginal, retromarginal teeth absent.

Leg lengths (paratype with carapace 2.17 long)

	Fe	Pa	Ti	Mt	Ta	Total
I	1.27	0.79	1.29	0.86	0.50	4.70
II	1.57	0.86	1.64	1.07	0.53	5.67
III	1.21	0.64	0.93	0.97	0.43	4.18
IV	2.88	0.77	1.29	3.50	0.50	8.94

Leg spination

	Fe	Pa	Ti	Mt
I	3d 1p	–	1-0v	–
II	3d 1p	–	1-2v	1-1v
III	3d 1p 1r	–	1p 1r 1-0v	3p 3r 1-1v
IV	3d 1p1r	1r	2p 2r 1-0v	4p 4r 1-1v

Abdomen yellow with greyish V-shaped stripes (indistinct due to poor condition of the specimen) dorsally.

Palp as in Figs 4d–f, 5b, d, e, 7a–c, 9d, 10b. Tibial apophysis subtriangular, wider than long; tip with filamentous extension (*Fl*); anterior edge of cymbium rounded, with one distinct macroseta; modified setae of cymbial brush dense and long almost ½ of cymbial length; basal part of embolus ca. ½ of embolus base height, anterior edge of embolic base and posterior edge of basal part of embolus horizontal; base of embolus shorter than anterior part of tegulum.

Female. Total length 4.08. Carapace 1.93 long, 1.29 wide. Abdomen 2.07 long, 1.33 wide.

Coloration as in males. Chelicerae with 3 or 4 promarginal and 4 retromarginal teeth.

Leg lengths

	Fe	Pa	Ti	Mt	Ta	Total
I	0.94	0.57	0.77	0.59	0.39	3.26
II	1.03	0.60	0.93	0.64	0.43	3.63
III	0.94	0.50	0.60	0.73	0.36	3.13
IV	2.88	0.67	1.03	3.50	0.43	8.51

Leg spination

	Fe	Pa	Ti	Mt
I	3d 1p	–	1-0v	–
II	3d 1p	–	2-2v	0-1v
III	3d 1p 1r	–	1p 1r 1-0v	3p 2r 0-1v
IV	3d 1p 1r	1r	3p 3r 1-1v	3p 3r 1-1v

Epigyne as in Figs 8a–c, 9b. Fovea pentagonal with deep posterior notch; translucent receptacles spaced by less than radius in intact epigyne; copulatory duct well distinct in ventral view; hyaline receptacles located anteriorly from the sclerotised re-

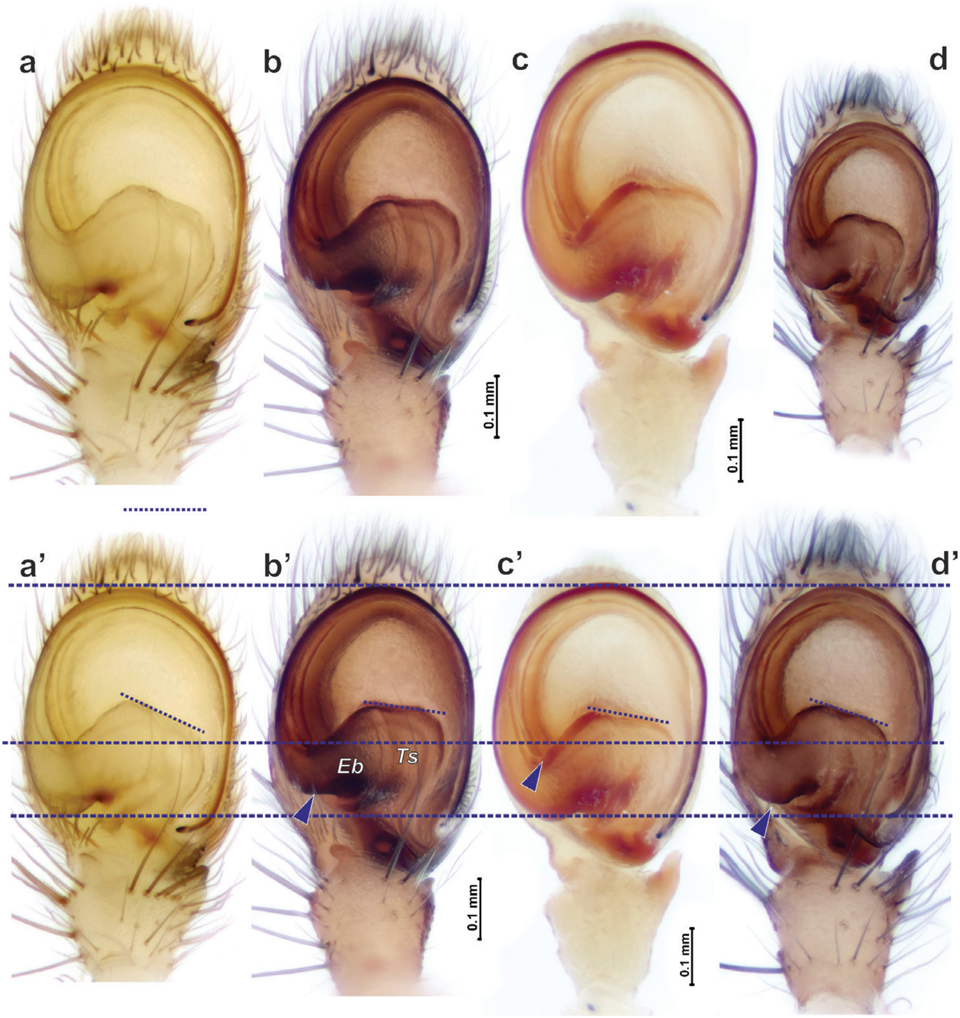

Figure 10. Comparison of male palp of *Porrhoclubiona leucaspis* (**a**), *P. moradmandi* sp. n. (**b**), *P. laudata* (**c**) and *P. bosmansi* sp. n. (**d**). **a–d** palps in the same scale **a'–d'** palps shown in the same size, demonstrating different proportions. Arrows point major differenced, broken inclined line reflects differences in the angle of embolic base anterior margin, ca 25°, 8°, 10.5° and 19°. Abbreviations: *Eb*–base of embolus, *Ts*–sclerotised part of tegulum.

ceptacles; loop of copulatory duct directed anteriorly; mesal part of copulatory ducts spaced by more than 3 times their diameters.

Distribution. It is known from the type locality only.

Acknowledgements

We thank Zoë Simmons (Oxford, UK) and Dmitry Logunov (Manchester, UK) for their help in obtaining syntypes of *P. laudata*. Kirill Mikhailov (Moscow, Russia) provided us with specimens of *Porrhoclubiona* from Central Asia. We also thank Seppo Koponen (Turku, Finland) for providing museum facilities, and specimens of *Porrhoclubiona* from Europe. The English of the earlier draft was kindly checked by Sarah Crews (San Francisco, USA).

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RESEARCH ARTICLE

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A new species of *Loxosceles* Heineken & Lowe (Araneae, Sicariidae), with updated distribution records and biogeographical comments for the species from Mexico, including a new record of *Loxosceles rufescens* (Dufour)

Alejandro Valdez-Mondragón[1,2], Mayra R. Cortez-Roldán[3],
Alma R. Juárez-Sánchez[3], Karen P. Solís-Catalán[3]

1 CONACYT Research Fellow. Laboratory of Arachnology (LATLAX), Laboratorio Regional de Biodiversidad y Cultivo de Tejidos Vegetales (LBCTV), Instituto de Biología, Universidad Nacional Autónoma de México (UNAM), sede Tlaxcala, Ex-Fábrica San Manuel, San Miguel Contla, 90640 Santa Cruz Tlaxcala, Tlaxcala, Mexico **2** *Colección Nacional de Arácnidos (CNAN), Departamento de Zoología, Instituto de Biología, Universidad Nacional Autónoma de México (UNAM), Ciudad Universitaria, Apartado Postal 04510, Coyoacán, Mexico City, Mexico* **3** *Laboratory of Arachnology (LATLAX), Laboratorio Regional de Biodiversidad y Cultivo de Tejidos Vegetales (LBCTV), Instituto de Biología, Universidad Nacional Autónoma de México (UNAM), sede Tlaxcala, Ex-Fábrica San Manuel, San Miguel Contla, 90640 Santa Cruz Tlaxcala, Tlaxcala, Mexico*

Corresponding author: *Alejandro Valdez-Mondragón* (lat_mactans@yahoo.com.mx)

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Abstract

A new species of the spider genus *Loxosceles* Heineken & Lowe, 1832, *Loxosceles malintzi* **sp. n.**, is described from the states of Puebla, Morelos and Guerrero, in the central region of Mexico. The description is based on adult males and females with morphological and ultra-morphological images. Updated distribution maps are provided for the 39 species recorded from the Mexican territory (including the new species). The states with the greatest diversity are Baja California Sur, Baja California and Sonora, with five species each. A total of 441 records for the 39 species, based on arachnological collections, data bases and literature, were used to update the distribution maps. *Loxosceles boneti* Gertsch, 1958 is the species with the highest number of records in Mexico, with a total of 58 records from different localities. The states with the most records so far are Guerrero, with 55 records, Morelos, with 35 records, and Baja California Sur, with 30 records. *Loxosceles rufescens* (Dufour, 1820), an introduced species, is recorded for the second time in Mexico, from the state of Chihuahua, being the first well-documented record for the country. Mexico has the greatest diversity of species of *Loxosceles* worldwide, with 39 (two introduced species) of the 134 described species. Additionally, biogeographical comments for the species from Mexico are provided.

Keywords

Biogeography, *Loxosceles malintzi* sp. n., North America, taxonomy

Introduction

Spiders of the genus *Loxosceles* Heineken & Lowe, 1832 are better known in North America as “violin spiders”, “recluse spiders”, or “brown recluse spiders”; commonly known by the medical community and general public to cause dermonecrotic lesions caused by their poisonous bites and the venom component, Sphingomyelinase D, an enzyme that destroys endothelial cells lining the blood vessels (Vetter and Barger 2002; Vetter and Bush 2002; Vetter et al. 2003, 2009; Wendell 2003; Da Silva et al. 2004; Vetter 2005, 2008, 2015; Sandidge and Hopwood 2005; Ramos-Rodríguez and Méndez 2008; Manríquez and Silva 2009; Swanson and Vetter 2009). The genus *Loxosceles* belongs to the spider family Sicariidae Keyserling, 1880, which comprises three genera: *Hexophthalma* Karsch, 1879, with six species from Africa, *Sicarius* Walckenaer, 1847, with 21 species distributed in Central and South America, and *Loxosceles*, with 134 described species worldwide (Magalhães et al. 2017; World Spider Catalog 2018). Recently, Souza and Ferreira (2018) described the first troglomorphic species of *Loxosceles* from caves of Brazil. According to Binford et al. (2008), species of *Loxosceles* are classified into eight species groups: *reclusa, laeta, amazonica, gaucho, spadicea, rufescens, vonwredei* and *spinulosa*. However, the species group *amazonica* was merged with the species group *rufescens* by Duncan et al. (2010) based on molecular data. The *reclusa* group has the highest diversity, with 50 species, all from North America, primarily Mexico (Gertsch and Ennik 1983). Mexico has the highest diversity of recluse spiders worldwide, with 39 recorded species, of which 37 are native (including the new species herein described) and two are introduced species: *Loxosceles reclusa* Gertsch & Mulaik, 1940 and *Loxosceles rufescens* (Dufour, 1820) (Gertsch 1958, 1973; Gertsch and Ennik 1983; World Spider Catalog 2018). The first species described from Mexico was *Loxosceles yucatana* Chamberlin & Ivie, 1938 from the Yucatan Peninsula. The most complete systematic revision for North American species of *Loxosceles* was published by Gertsch and Ennik (1983), describing 20 new species from Mexico. Thus, this was the last and most complete taxonomic revision for the species that occur in the country. The most recent taxonomic contribution for the species of *Loxosceles* from Mexico was the description of the male of *Loxosceles mulege* by Jiménez and Llinas (2005) from Baja California Sur.

Some North American synanthropic species of *Loxosceles*, such as *L. reclusa* in the United States, have been closely studied for their biological, medical and physiological aspects, analyzing their abundances, distribution and natural history (Vetter and

Barger 2002; Vetter and Bush 2002; Vetter et al. 2003, 2009; Wendell 2003; Vetter 2005, 2008; Sandidge and Hopwood 2005; Swanson and Vetter 2009). However, these aspects are poorly known for species from Mexico. It is not yet known whether the introduced synanthropic species collected in houses and buildings may also be collected in natural areas around the houses. In 2017, four collectors collected around 40 *Loxosceles misteca* in two hours from a house in the state of Tlaxcala, Mexico. However, the species has never been collected in natural areas in the state (Valdez-Mondragón et al. 2018). This has been previously reported by Fischer and Vasconcellos-Neto (2005) with *L. laeta* and *L. intermedia* from South America, where these spiders are almost absent from natural areas immediately surrounding the infested buildings where they were collected. Additional research is required for the species from Mexico that have been reported from urban areas.

The primary aim of this paper is to describe a new species of *Loxosceles* from the central region of Mexico, distributed in the states of Puebla, Morelos and Guerrero. Additionally, we update the distribution records for the Mexican territory providing new records, including that of *L. rufescens*, an introduced species from the Mediterranean Basin and the Middle East (Nentwig et al. 2017; Tahami et al. 2017). Finally, we discuss the biogeography of the species of *Loxosceles* from Mexico based on biotic provinces.

Material and methods

The specimens were hand collected and deposited in ethanol (80%) in the Colección Nacional de Arácnidos (CNAN), Institute of Biology, Universidad Nacional Autónoma de México (IBUNAM), Mexico City, and the Laboratorio de Aracnología (LATLAX), Laboratorio Regional de Biodiversidad y Cultivo de Tejidos Vegetales (LBCTV), IBUNAM, Tlaxcala City. The descriptions and observations of the specimens were made using a Zeiss Discovery V8 stereoscope. A Zeiss Axiocam 506 color camera attached to a Zeiss AXIO Zoom V16 stereoscope was used to photograph the specimens. The male palps and female genitalia were dissected in ethanol (80%). The female genitalia were cleaned in potassium hydroxide (KOH-10%) for 5 to 10 minutes. The habitus, female genitalia and palps were submerged in 96% alcohol gel (ethanol) and covered with a thin layer of liquid ethanol (80%) to minimize diffraction during photography (Valdez-Mondragón and Francke 2015). For the electron micrographs, the morphological structures were dissected and cleaned with an ultrasonic cleaner at 20–40 kHz, critical-point dried, and examined at low vacuum in a Hitachi S-2460N scanning electron microscope (SEM). The descriptions were done following Gertsch and Ennik (1983) and Tahami et al. (2017). Morphological nomenclature follows Ramírez (2014), Planas and Rivera (2015) and Magalhães et al. (2017a, b). All measurements are in millimeters (mm). Measurements on electron micrographs are in micrometers (µm). To update the distribution maps, we used literature, databases and networks, mainly of CNAN, LATLAX and the Global Biodiversity Information Facility (GBIF) (http://www.gbif.org). The records of GBIF belong to specimens that where identified by A. Valdez-Mondragón (first author) in 2007 and by W. J. Gertsch (various dates). The specimens were deposited in the CNAN, in Mexico the second representative and diverse biological collection of *Loxosceles* after LATLAX, which was revised. Nine fieldtrips were made to different states in Mexico to collect additional material of different species: Puebla (March and June, 2017), Tlaxcala (April 2017, 2018; May 2018), Hidalgo (May, 2017), Oaxaca (June, 2017), Guerrero (September, 2017), and Oaxaca (March, 2018). The distribution maps were made using QGIS v. 2.18. For georeferencing and corroboration of localities, two programs were used: GeoLocate online version (http://www.museum.tulane.edu/geolocate/) and Google Earth v.7.1.5.1557. The geographic coordinates were transformed from NAD83 to WGS84 on the online site of INEGI: Transformation of coordinates TRANINV (http://www.inegi.org.mx). Geographical coordinates are given in degrees. Photographs, electron micrographs and maps were edited using Adobe Photoshop CS6.

Abbreviations:

AME	anterior median eyes;
PLE	posterior lateral eyes;
PME	posterior median eyes.

Taxonomy

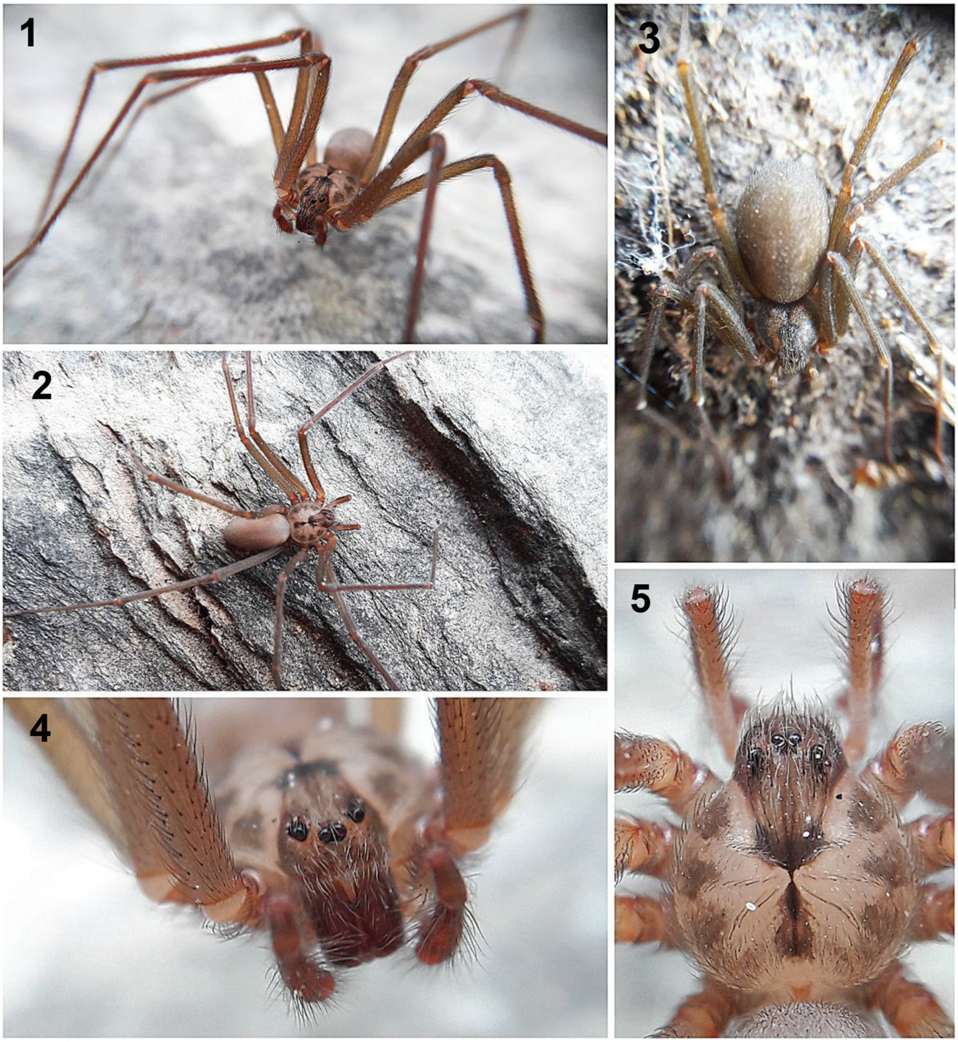
Family Sicariidae Keyserling, 1880
Genus *Loxosceles* Heineken & Lowe, 1832

Loxosceles malintzi sp. n.

http://zoobank.org/27AB2D03-1166-4734-9107-47241F5156C2
Figs 1–10, 18–67

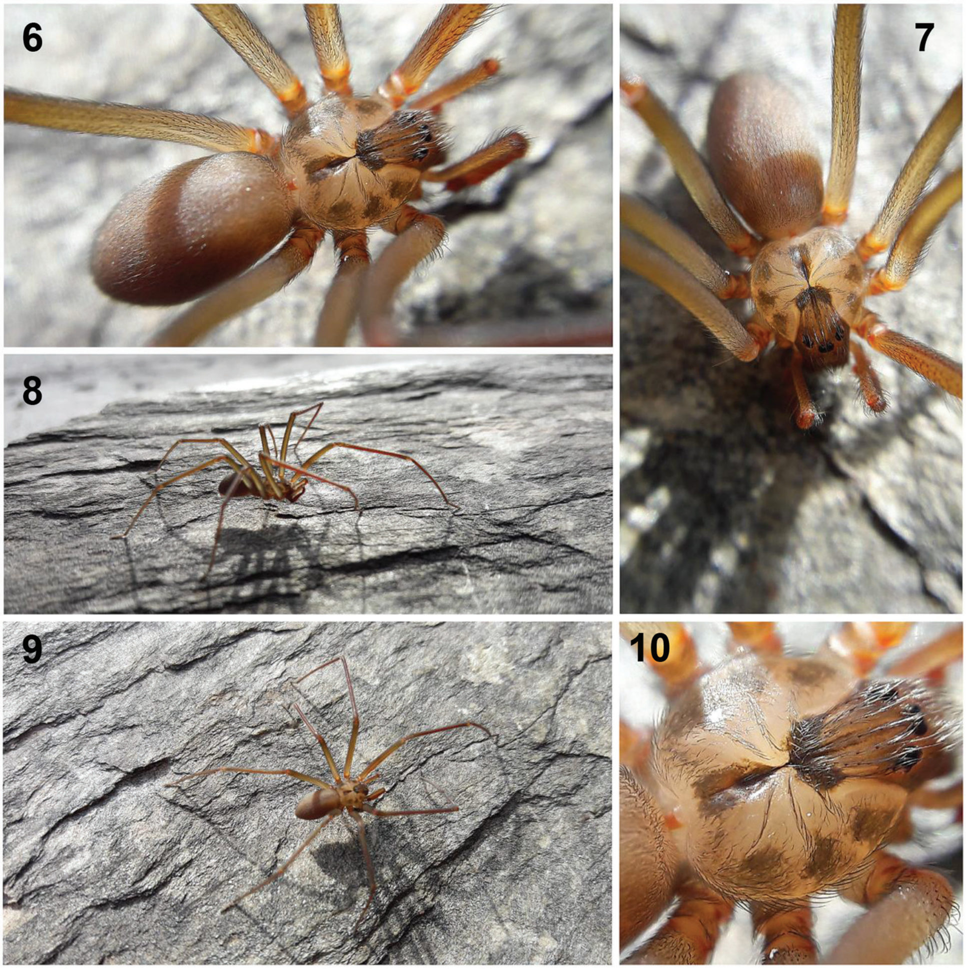
Type material. MEXICO: *Puebla:* male holotype (CNAN-T01262) from 1.5 km NE of Panteón de San Pablo Anicano (18.1355, –90.1010, 1223 m), Municipality San Pablo Anicano, 5.VII.2017, A. Valdez, A. Juárez, M. Cortez, J. Valerdi Cols. (night collecting). Paratypes: 2 males (CNAN-T01263), 2 females (CNAN-T01264, CNAN-T01265), same data as holotype.

Other material examined. MEXICO: *Puebla:* 1 male, 1 female (LATLAX-Ara 0149), 5 males, 6 females, 19 immatures (LATLAX-Ara0148), same data as holotype. 2 males, 1 female, 13 immatures (LATLAX-Ara0125) [10-III-2017, A. Valdez, E. Briones, A, Juárez, M. Cortez, J. Valerdi Cols.], same locality as holotype. 4 females, 2 immatures (LATLAX-Ara 0122) from 3 km S of San Juan Rabozo (18.54062, –98.44353; 1298 m), Municipality Izúcar de Matamoros, 10-III-2017, A. Valdez, E. Briones, M. Cortez, J. Valerdi, M. Sánchez Cols. 24 immatures (LATLAX-Ara0144) [05-VII-2017, A. Valdez, M. Cortez, A. Juárez, J. Valerdi Cols.], same locality. 8 immatures (LATLAX-Ara 0123),



Figures 1–5. Live specimens of *Loxosceles malintzi* sp. n. from the type locality: 1.5 km NE of Panteón de San Pablo Anicano, Municipality San Pablo Anicano, Puebla, Mexico **1, 2, 4, 5** Male holotype (CNAN-T01262) **3** Female paratype (CNAN-T01264). Photos by Alejandro Valdez-Mondragón (2018).

from road to Tepenene (18.49335, –98.39623; 1300 m) Municipality Izúcar de Matamoros, 10-III-2017, A. Valdez, E. Briones, M. Cortez, J. Valerdi, M. Sánchez Cols. 1 female, 7 immatures (LATLAX-Ara0146) [05-VII-2017, A. Valdez, M. Cortez, A. Juárez, J. Valerdi Cols.], same locality. 1 male, 3 female, 31 immatures (LATLAX-Ara0145), 1 male (LATLAX-Ara0194) from 2 km S of Agua Escondida (18.54999, –98.45229; 1275 m), Municipality Izucár de Matamoros 05-VII-2017, A. Valdez, M. Cortez, A. Juárez, J. Valerdi Cols.1 male, 1 female, 13 immatures (LATLAX-Ara0124) from Santa Cruz Tejalpa (18.35028, –98.37773; 986 m), Municipality Tehuitzingo, 10-III-2017, A. Valdez, E. Briones, M. Cortez, J. Valerdi, M. Sánchez Cols. 7 immatures (LATLAX-



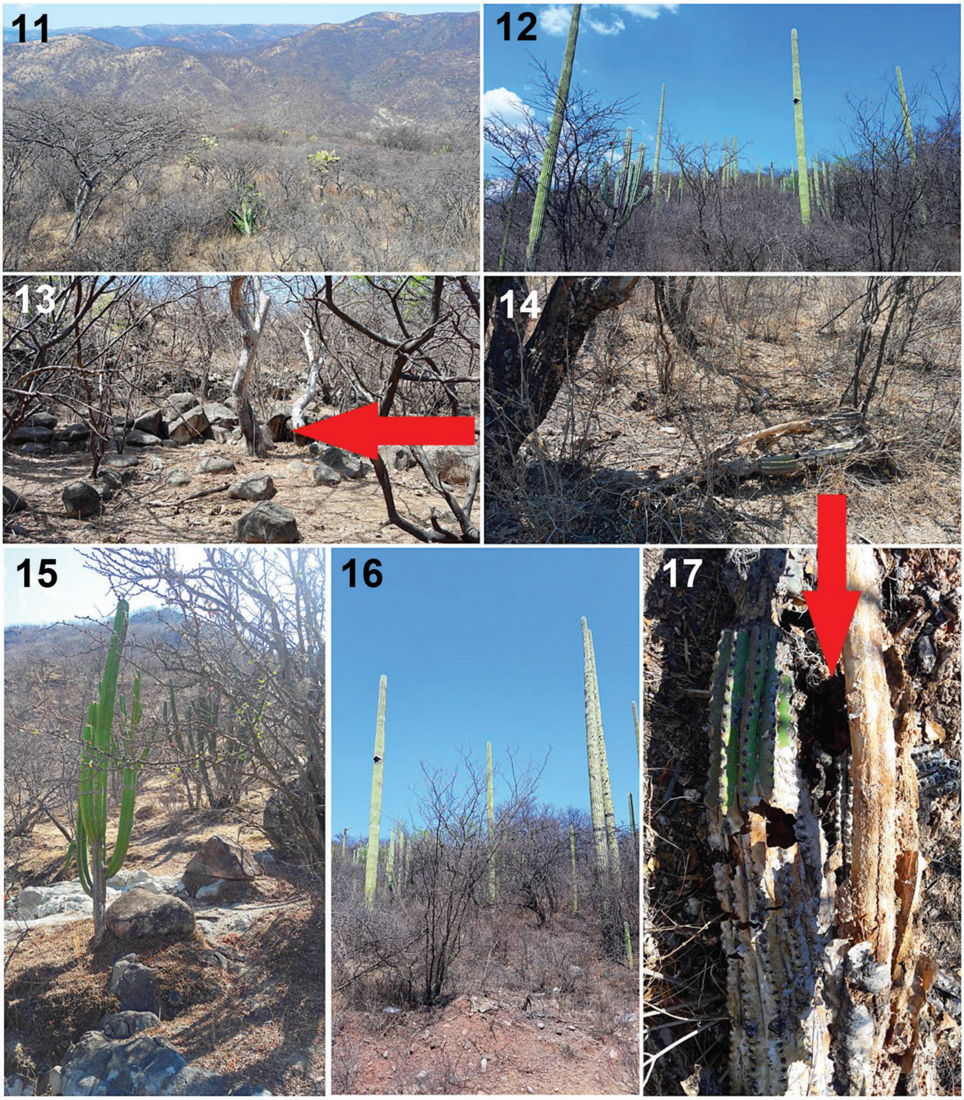
Figures 6–10. Live male of *Loxosceles malintzi* sp. n. from 1.5 km SE of Guadalupe Alchipin, Mpio, Ahuehuetitla, Puebla, Mexico. Photos by Alejandro Valdez-Mondragón (2018).

Ara0126) from 9 km NE of Garzones Santa Gertrudis (18.31016, −98.02065; 1686 m), Municipality Acatlán de Osorio, 11-III-2017, A. Valdez, E. Briones, M. Cortez, J. Valerdi, M. Sánchez Cols. 1 male, 6 immatures (LATLAX-Ara0127), 1 female (LATLAX-Ara0185) from 4 km NE of Totoltepec Guerrero (18.26285, −97.84125; 1427 m), Municipality Totoltepec, 11-III-2017, A. Valdez, E. Briones, M. Cortez, J. Valerdi, M. Sánchez Cols. 10 immatures (LATLAX-Ara0147) from 1.5 km SE of Guadalupe Alchipin (18.25741, −98.21145; 1256 m), Municipality Ahuehuetitla, 05-VII-2017, A. Valdez, E. Briones, M. Cortez, J. Valerdi, M. Sánchez Cols. 2 male, 4 female, 28 immatures (LATLAX-Ara0150) from 2 km al S de Petlatzingo (18.05715, −97.9122; 1439 m) Municipality Petlatzingo, 06-VII-2017, A. Valdez, E. Briones, M. Cortez, J. Valerdi, M. Sánchez Cols. *Guerrero:* 1 male, 8 females, 14 immatures (LATLAX-Ara0163) from road to Mexcaltepec viejo (18.42838, −99.54851; 1142 m), Municipality Taxco de Alarcón, 20-IX-2017, A. Valdez, I. Navarro, P. Solís, J. Valerdi Cols. 1 male (CNAN-Ar009171) 2 km W of Ahuelican "Cerro de la Coronilla" (18.01628, −99.52875; 855 m), Municipality Tepecoacuilco de Trujano, 09-I-2009, O. Francke, A. Valdez, C. Quijano, T. López Cols. *Morelos:* 1 male (CNAN-Ar009174), 1 male (CNAN-Ar009176) from Ticumán (18.76111, −99.11917; 960 m), Municipality Tlaltizapán, 24-IX-2011, G. Montiel Col. 1 male (CNAN-Ar009000) from Biological Station El Limón Cuachichinola (18.52641, −98.93343; 1293 m), Municipality Tepalcingo, 21-IX-2012, G. Montiel, D. Barrales, J. Arreguin Cols. 1 male, 2 immatures (CNAN-Ar009001) from Biological Station El Limón Cuachichinola (18.55132, −98.94288; 1434 m), Municipality Tepalcingo, 22-IX-2012, G. Montiel, D. Barrales, J. Arreguin Cols.

Etymology. The species epithet is a noun in apposition and refers to the volcano "La Malinche, *Malintzi* or Matlalcueye" (meaning "blue skirt" in Nahuatl language), a seismically active volcano (4,420 m) of the Transmexican Volcanic Belt, located in the states of Tlaxcala and Puebla. This last state is where the type locality is located.

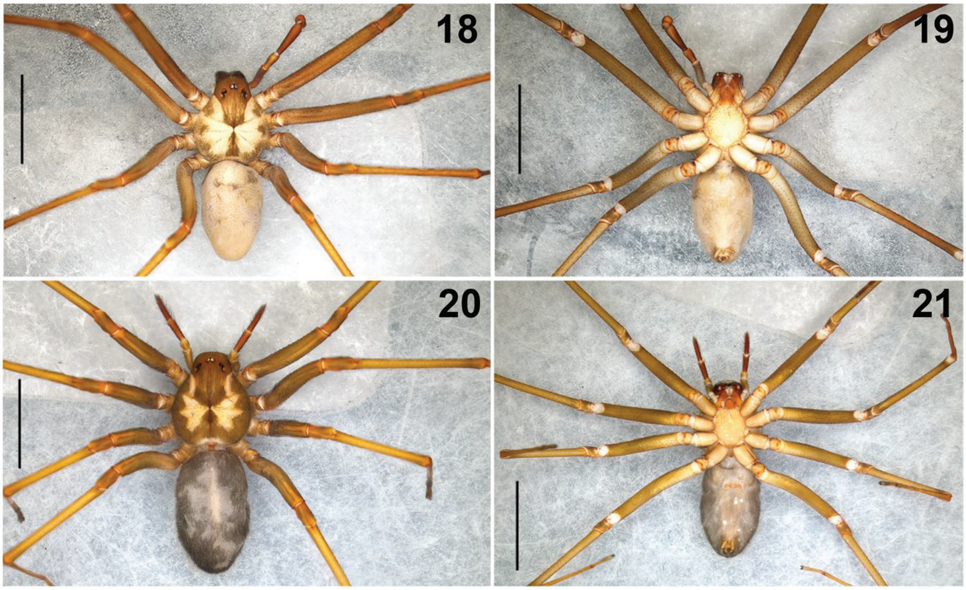
Diagnosis. *Loxosceles malintzi* sp. n. resembles *L. huasteca* Gertsch & Ennik, 1983 and *L. coyote* Gertsch & Ennik, 1983 in having a long, slender male palpal tibia and by the embolus (Gertsch and Ennik 1983: figs 173−176, 200−203). However, *L. malintzi* has a more slender palpal tibia (Figs 22−24, 38, 55−62), 4.4× longer than wide (in *L. huasteca* the tibiae is 2.7× longer than wide (Gertsch and Ennik 1983: fig. 200), and *L. coyote* is 2.9× longer than wide (Gertsch and Ennik 1983: fig. 173)). The palpal tibia of *L. malintzi* is nearly straight (Figs 22−24, 55−62) (in *L. huasteca* and *L. coyote* it is more curved ventrally (Gertsch and Ennik 1983: figs 200, 173 respectively)). In dorsal view, the palpal tibia in *L. malintzi* is nearly straight (Fig. 23) (in *L. huasteca* and *L. coyote* it is more curved each side (Gertsch and Ennik 1983: figs 201, 174 respectively)). In retrolateral view, the embolus of *L. malintzi* is straight as in *L. huasteca* (Gertsch and Ennik 1983: fig. 200), but slightly shorter (Figs 24, 25); also, *L. huasteca* has a small spur near tip of embolus (Gertsch and Ennik 1983: fig. 202), which is absent in *L. malintzi* (Figs 25−27, 40, 41). The embolus in *L. coyote* (Gertsch & Ennik, 1983: figs 173, 176) is markedly longer and wider than in *L. malintzi*, which is smaller and more slender (Figs 22, 24−26, 38−41, 55−62). Females resemble *L.colima* Gertsch, 1958 (Gertsch and Ennik 1983: figs 291−292) and *L. devia* Gertsch & Mulaik, 1940 (Gertsch and Ennik 1983: figs 42−46) in having long and curved seminal receptacles; however, *L. malintzi* has seminal receptacles finger-shaped, shorter than those of *L. colima* and less curved than those of *L. devia* (Figs 30, 63–67); also, the base of the receptacles in the new species point obliquely and they are closer to each other (Figs 30, 63–67), whereas in *L. colima* and *L. devia*, the base of the receptacles are widely separated (Gertsch and Ennik 1983: figs 42–46, 291–292).

Description. Male (holotype) (CNAN-T01262): *Measurements:* Total length 9.30. Carapace 4.40 long, 3.90 wide. Clypeus length 0.62. Diameter of AME 0.22, PME 0.24, PLE 0.22; AME-PME 0.26 Labium: length 0.96, width 0.80. Sternum: length 2.30, width 2.10. Leg lengths: I (total 28.20): femur 7.50 / patella 1.60 / tibia 8.90 / metatarsus 8.40 / tarsus 1.80; II (31.45): 8.40 / 1.60 / 9.80 / 9.75 / 1.90; III (24.10): 7.00 / 1.60 / 6.60 / 7.50 / 1.40; IV (26.90): 7.50 / 1.60 / 7.30 / 8.80 / 1.70. Leg formula: 2-1-4-3.



Figures 11–17. Habitat and microhabitat of *Loxosceles malintzi* sp. n. **11–14, 17** Tropical deciduous forest from of the type locality: 1.5 km NE of Panteón de San Pablo Anicano, Municipality San Pablo Anicano, Puebla, Mexico (arrows indicate the micro habitat where the specimens can be found, under big rocks and inside of a rotten and dry cactus in the ground of the genus *Pachycereus*) **15, 16** Tropical deciduous forest from 1.5 km SE of Guadalupe Alpichin, Municipality Ahuehuetitla, Puebla, Mexico. Photos by Alejandro Valdez-Mondragón (2017).

Prosoma: Carapace pale orange, longer than wide, pyriform, with small, numerous setae, with well-defined dark brown "violin" pattern dorsally (Figs 5–7, 10, 18, 29), which is reddish brown in the ocular region and markedly dark brown in posterior part (Figs 18, 29). Carapace with three irregular brown spots on each side. Fovea with



Figures 18–21. *Loxosceles malintzi* sp. n. **18, 19** Habitus of male holotype, dorsal and ventral views, respectively **20, 21** Habitus of female paratype, dorsal and ventral views, respectively. Scale bar: 1 mm.

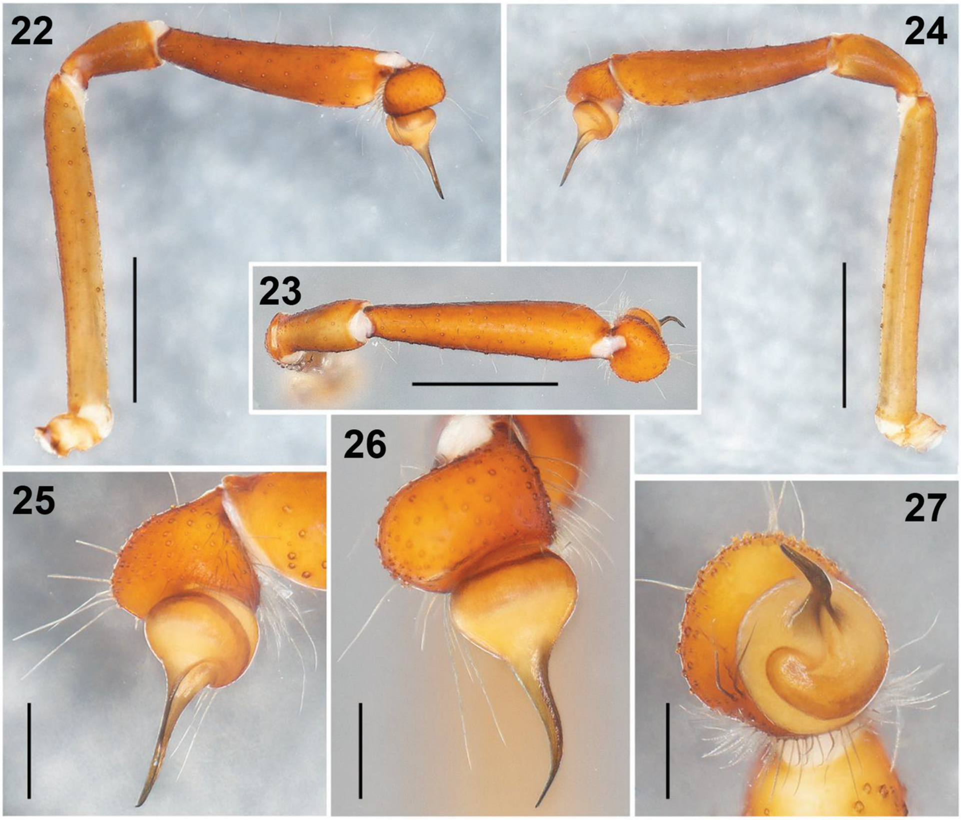
a dark brown triangular pattern projected towards posterior part (Figs 18, 29). Six eyes in three groups, clypeus brown (Figs 4, 5, 29). Sternum pale orange, longer than wide (Figs 19, 46). Labium reddish, longer than wide, fused to the sternum, rounded in the middle (Fig. 19). Endites pale orange basally, reddish orange distally and white apically. Endites longer than wide, rounded basally, with sparse long setae, becoming shorter distally (Fig. 19).

Legs: Coxae pale yellow, gray towards pro- and retrolateral parts (Fig. 19). Legs with scales (seta) (Fig. 32). Trochanters orange. Femora pale orange, paler on femora III and IV (Figs 18, 19, 36). Patellae reddish basally, pale gray distally. Patellae with two ventral lyriform organs (Figs 35, 37). Claws with seven teeth (Figs 33, 34).

Chelicerae: Fused basally, chelated chelicerae laminae, reddish orange, stridulatory lines laterally (Figs 44, 45, 49). Fangs reddish orange, with long and thin setae around them (Figs 44, 45, 47, 48). VO on posterior part of the fang (Figs 47, 48).

Opisthosoma: Pale orange, darker posteriorly (Figs 18, 19), oval, longer than wide and high (Figs 18, 19). Region of gonopore pale orange, with small setae. Colulus long, pale orange, conical (Fig. 50). Spinnerets pale orange, anterior lateral spinnerets cylindrical and the longest, posterior median spinnerets smallest, with long setae; posterior median spinerets cylindrical and with many long setae (Figs 50, 51). Tracheae opening near posterior margin of opisthosoma (Fig. 53).

Palps: Trochanters pale orange, femora brown, long and thin, patellae brown, tibiae reddish orange and almost cylindrical, wider distally than ventrally (Figs 22–24, 38). Tarsus oval, reddish orange, bulb spherical, with long and straight embolus

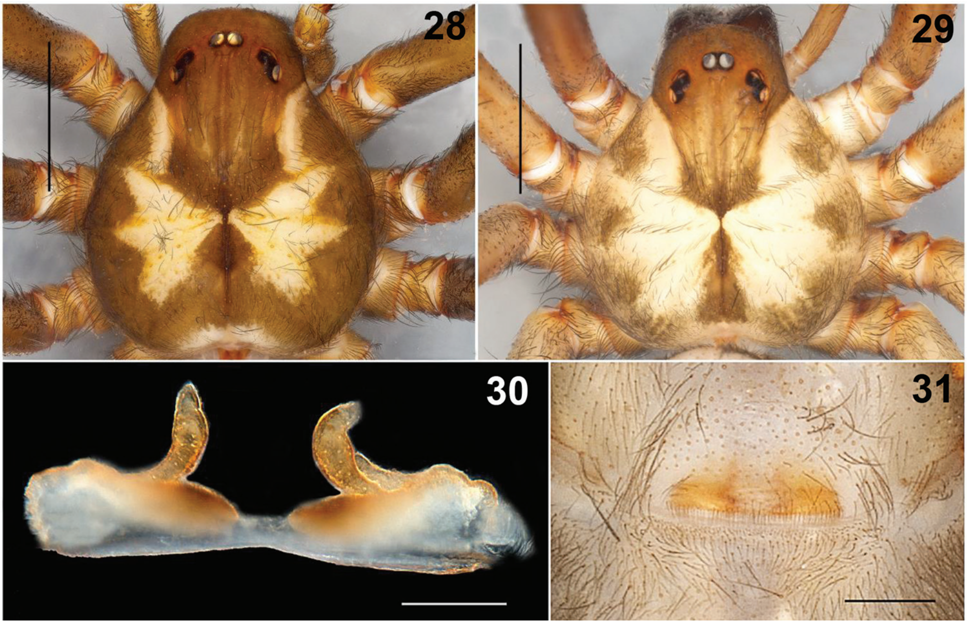


Figures 22–27. *Loxosceles malintzi* sp. n. Male Holotype: **22–24** Left palp, prolateral, dorsal and retrolateral views respectively **25–27** Detail of the bulb and embolus, retrolateral, dorsal and apical views, respectively. Scale bars: 1 mm (**22–24**), 0.5 mm (**25–27**).

(Figs 22–27, 38–41). Spermatic outlet at the tip of embolus (Figs 42, 43). Embolus with oval cuticular marks (unknown function) (arrows, Figs 42, 43).

Female (Paratype) (CNAN-T01264): *Measurements:* Total length 9.60. Carapace 4.30 long, 3.60 wide. Clypeus length 0.56. Diameter of AME 0.20, PME 0.23, PLE 0.21; AME-PME 0.25 Labium: length 0.87, width 0.67. Sternum: length 2.12, width 1.90. Leg lengths: I (total 19.65): femur 5.35 / patella 1.40 / tibia 5.90 / metatarsus 5.50 / tarsus 1.50; II (19.00): 5.70 / 1.50 / 6.20 / 4.40 / 1.20; III (18.10): 5.20 / 1.40 / 4.70 / 5.40 / 1.40; IV (20.90): 5.90 / 1.40 / 5.60 / 6.50 / 1.50. Leg formula: 4-1-2-3.

Differs from male as follows: *Prosoma:* Carapace pale orange, with well-defined dark brown "violin" pattern (Figs 20, 28). Carapace without three irregular brown spots on each side but with a wide and well-defined dark brown marginal region, forming a pale "bat-wing"-shaped region in the middle (Fig. 28). Sternum darker orange (Fig. 21). Labium more reddish orange, less rounded in the middle. Endites more reddish orange, less rounded basally.



Figures 28–31. *Loxosceles malintzi* sp. n. **28, 29** Caparace of female paratype and male holotype, respectively. Female Paratype: **30** Seminal receptacles **31** Genital area, ventral view. Scale bars: 1 mm (**28, 29, 31**), 0.2 mm (**30**).

Legs: Coxae yellow, paler gray towards pro- and retrolateral parts (Fig. 21). Trochanters darker orange. Femora pale brown (Figs 20, 21). Patellae reddish brown basally, darker gray distally. Tibiae brown, metatarsi and tarsi dark orange (Figs 20, 21).

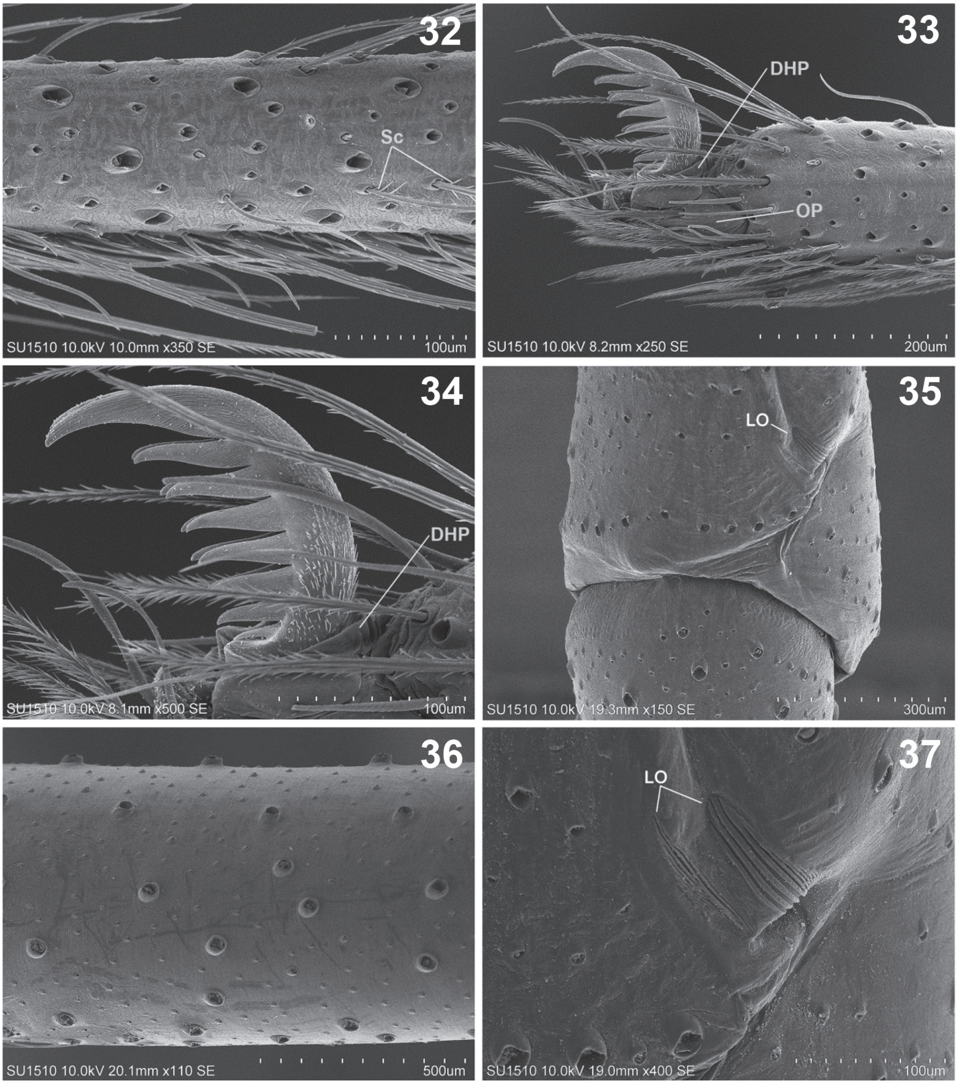
Chelicerae: Darker reddish brown, with stridulatory lines laterally.

Opisthosoma: Opisthosoma dark gray (Figs 20, 21). Spinnerets darker orange. [Note: Vetter (2015) mentioned that the opisthosoma color depends what the spider eats, so the coloration is variable].

Palps: Trochanters pale orange, femora pale brown, patellae brown, tibiae and tarsi reddish with several long and wide spread setae around. Tibiae cylindrical, tarsi conical (Fig. 20).

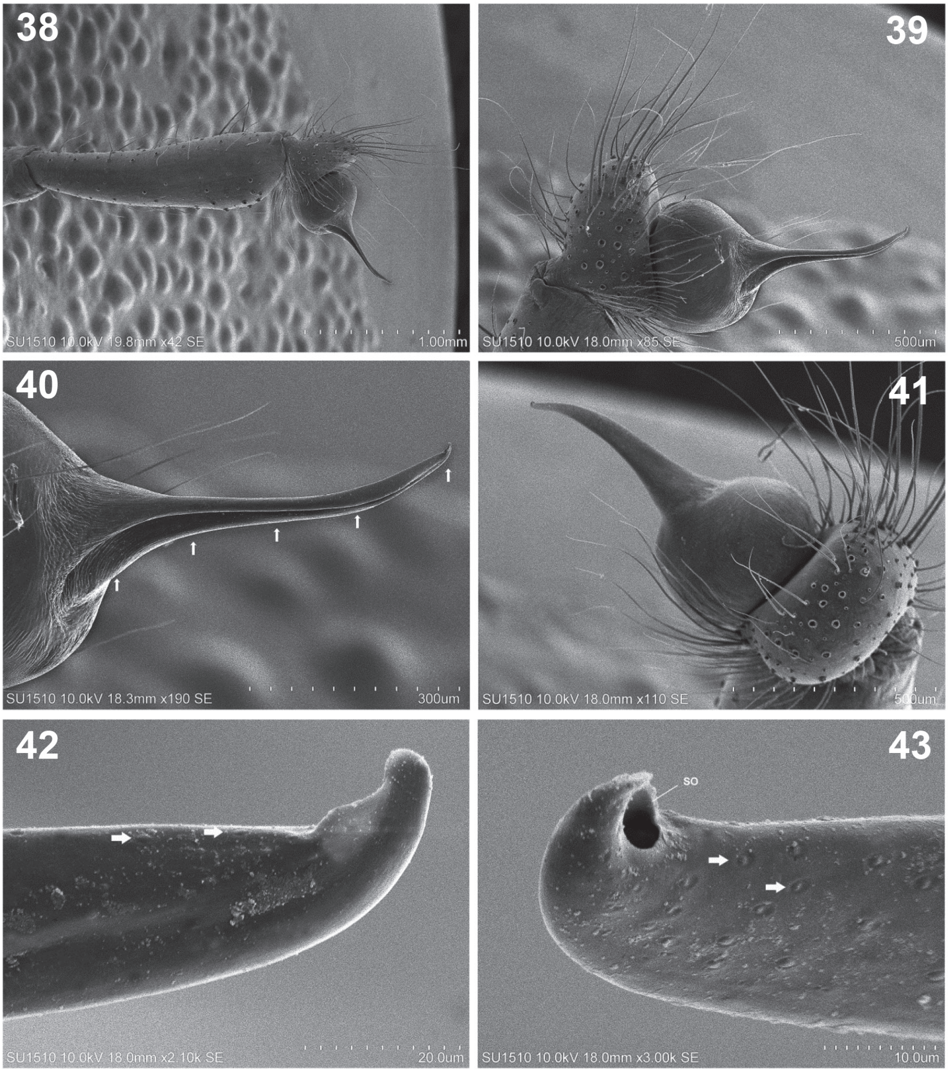
Genital area: Seminal receptacles visible by transparency in ventral view (Fig. 31). Seminal receptacles asymmetric, finger-shaped (Fig. 30). Right lobe long and curved, with one small accessory lobe receptacle next to it. Left lobe long, less curved than right one, without accessory receptacles. Base of seminal receptacles wide and strongly sclerotized, directed toward each other in oblique position (Fig. 30). See variation section for more details.

Variation. MALES. *Puebla:* Males from San Pablo Anicano are light brown, with brown spots on carapace well marked, legs darker than the body. *Morelos:* Males from Biological Station "El Limón" are light brown, with dark irregular brown spots on carapace, legs same color as carapace. Male from Tlaltizapan is light brown, with light



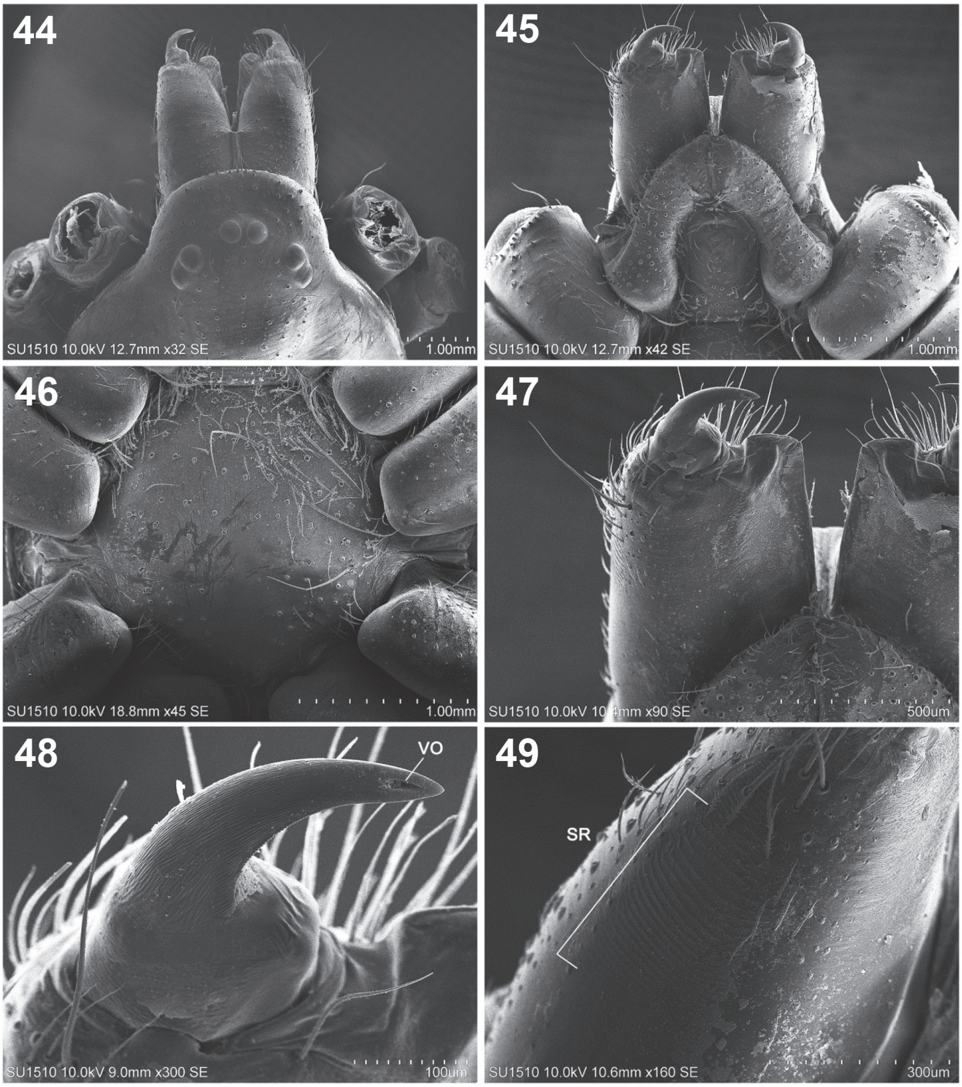
Figures 32–37. *Loxosceles malintzi* sp. n. Male **32** Right metatarsus I, retrolateral view, showing different type of setae insertions **33** Right tarsus I, prolateral view, showing the claws **34** Detail of claws and setae **35** Right leg I, ventral view of patella and tibia, showing the lyriform organ (LO) **36** Right femur I, retrolateral view **37** Detail of LO of patella I. Abbreviations: DHP, dorsal hood of podotarsite; LO, lyriform organ; OP, open podotarsite; Sc, scale (seta).

brown spots on carapace, legs darker than the body. *Guerrero:* Male from road to Mexcaltepec Viejo, is light brown, with dark brown spots strongly marked on carapace, pale brown legs. Male from Tepecoacuilco de Trujano, is light brown, with dark brown spots on carapace slightly marked, legs light brown. *Puebla:* Agua Escondida, Municipality of Izúcar de Matamoros (N= 2): Tibia I 7.3, 7.5; carapace length (CL) 3.6, 4.4, carapace width (CW) 3.0, 3.2. 1.5 km NE of Panteón de San Pablo Anicano (*N* = 3): Tibia I



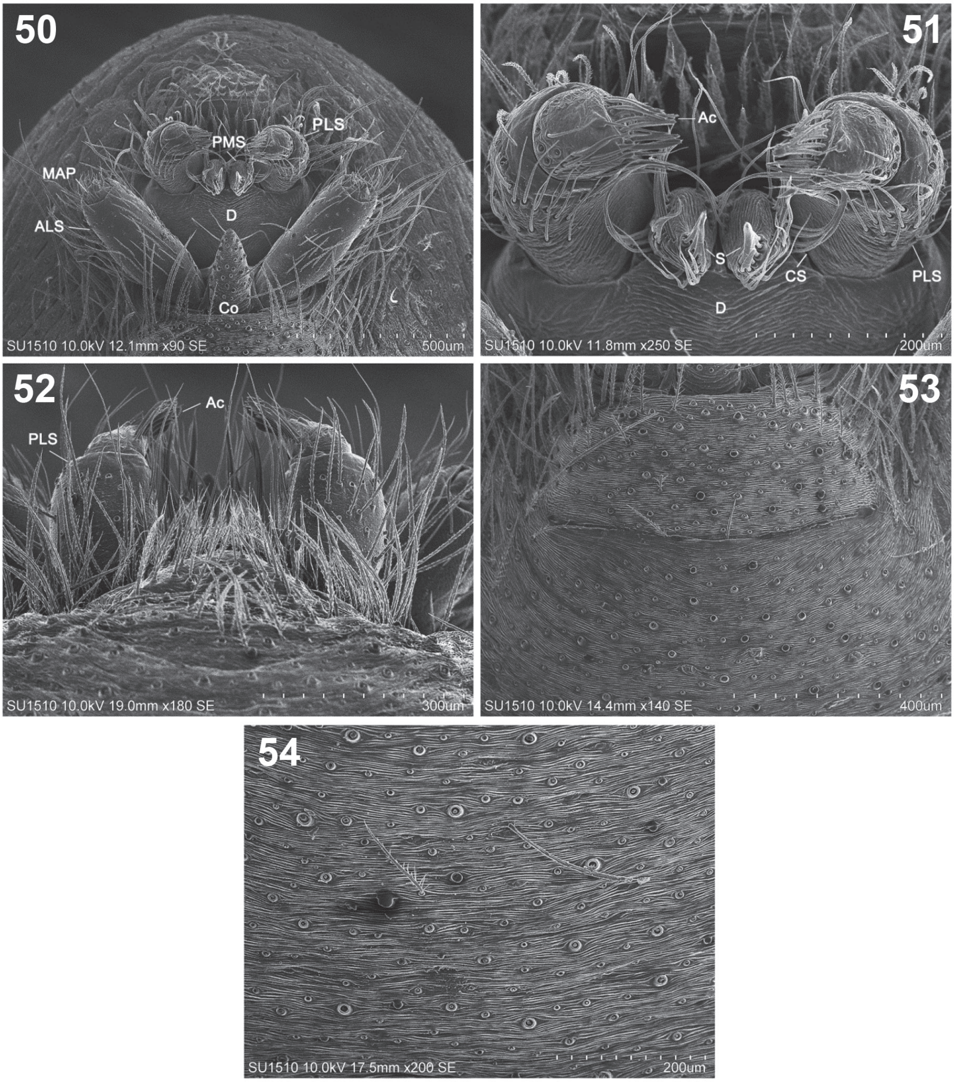
Figures 38–43. *Loxosceles malintzi* sp. n. Male **38** Left palp, prolateral view **39** Detail of tarsus, bulb and embolus **40** Detail of the embolus (arrows indicate the canal along the embolus) **41** Detail of tarsus, bulb and embolus, dorsal view **42, 43** Embolus tip, prolateral and retrolateral views respectively, showing the spermatic outlet (arrows indicate cuticular marks, unknown function). Abbreviations: SO, spermatic outlet

5.9–8.9 (*x* = 8.0), CL 4.1–4.5 (*x* = 4.0), CW 3.6–4.0 (*x* = 4.0). San Pablo Anicano (*N* = 2): Tibia I 7.5–9.0 (*x* = 8.0), CL 4.0–4.4 (*x* = 4.0), CW 3.36–3.7 (*x* = 4.0). *Morelos:* Biological Station "El Limon" (*N* = 2) Tibia I 7.5, 11.0, CL 4.0, 4.2, CW 3.2, 3.9. *Guerrero:* road to Mexcaltepec viejo (*N* = 1): Tibia I 9.0, CL 3.8, CW 3.3; Tepecoacuilco de Trujano (*N* = 1): Tibia I 7.0, CL 3.6, CW 3.2. FEMALES. *Puebla:* females from San Pablo Anicano are light brown on carapace and legs, with a dark brown marginal region on carapace strongly marked. Females from San Juan Rabozo are dark brown, with



Figures 44–49. *Loxosceles malintzi* sp. n. Male **44** Anterior part of carapace and chelicerae, dorsal view **45** Chelicerae, endites and labium, ventral view **46** Detail of sternum **47** Detail of right chelicera, posterior view **48** Detail of right fang of chelicerae, showing the venom outlet **49** Detail of stridulatory ridges of right chelicerae. Abbreviations: SR, stridulatory ridges; VO, venom outlet.

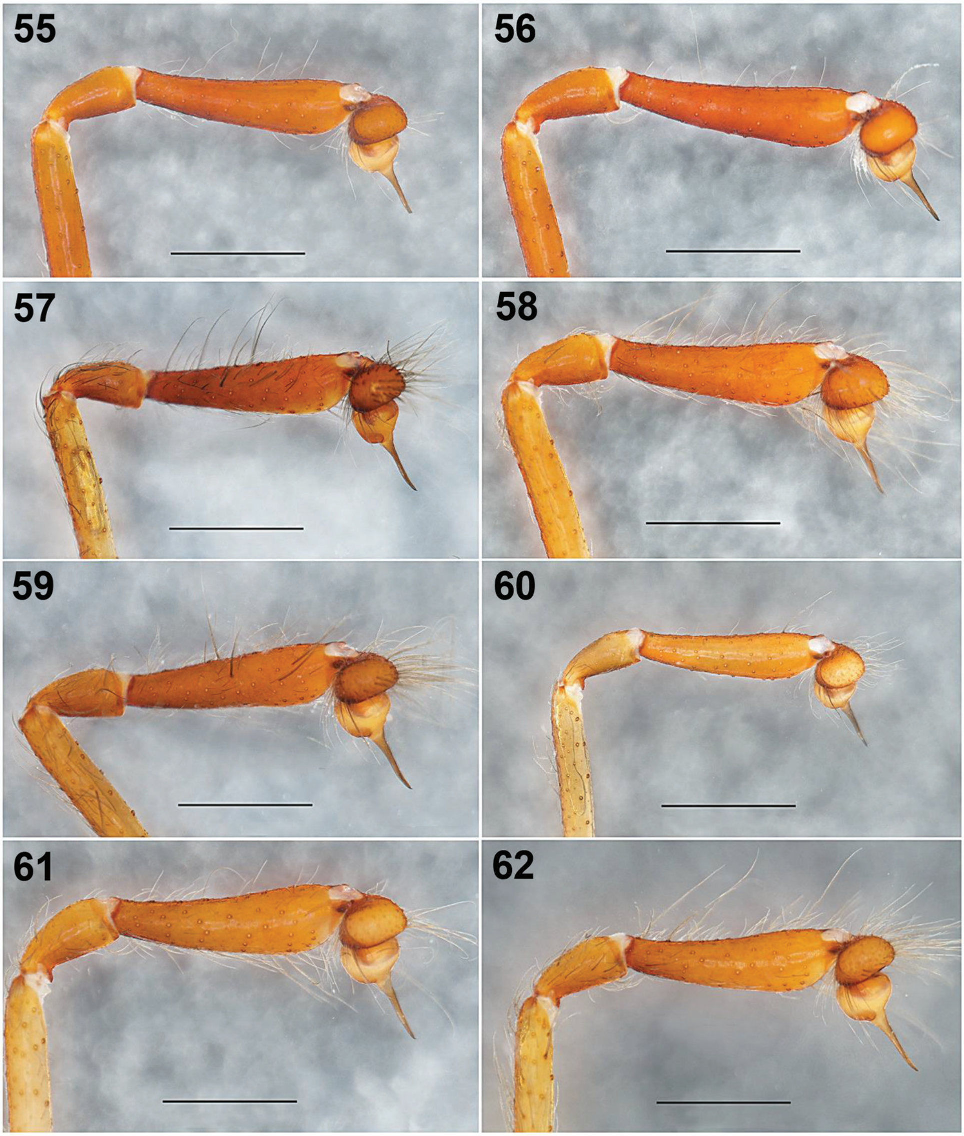
dark brown marginal region on carapace strongly marked, legs light brown. *Guerrero:* females from road to Mexcaltepec Viejo are brown dark on carapace, with dark brown marginal region on carapace strongly marked, legs the same color as the body. *Puebla:* 1.5 km NE of Panteón de San Pablo Anicano (N = 1): Tibia I 6.0, CL 4.2, CW 3.7. San Pablo Anicano (N = 3): Tibia I 4.2–5.5 (x = 4.6), CL 3.7–4.1 (x = 3.9), CW 2.8–3.6 (x = 3.2). San Juan Rabozo, Municipality of Izúcar de Matamoros (N = 4): Tibia I 4.9–6.1



Figures 50–54. *Loxosceles malintzi* sp. n. Male **50** Spinnerets **51** Detail of PMS and PLS **52** PLS, anterior view **53** Detail of the tracheae **54** Detail of the cuticle of the opisthosoma. Abbreviations: Ac, aciniform gland spigot; ALS, anterior lateral spinnerets; CS, curved spigot; Co, colulus; D, diastema; MAP, major ampullate glands; PLS, posterior lateral spinnerets; PMS, posterior median spinnerets; S, spigot.

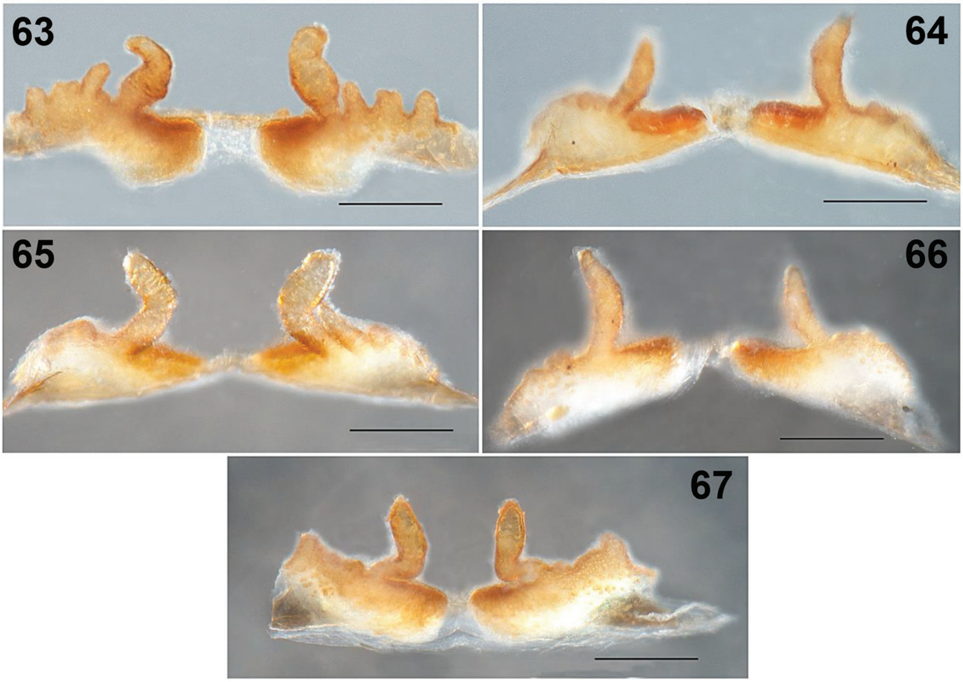
(x = 5.5), CL 3.5–4.3 (x = 3.9), CW 3.0–3.7 (x = 3.4). *Guerrero:* road to Mexcaltepec viejo (N = 4): Tibia I 5.7–6.2 (x = 6), CL 3.4–4.4 (x = 3.8), CW 3.4–3.7 (x = 3.6).

There is little variation in the shape of the male palps, even those from different populations (Figs 55–62). The seminal receptacles of females are asymmetrical and are broadly variable in shape, even in the specimens from the same locality (Figs 63–66). Some specimens have long and wide curved receptacles, finger-shaped (Figs 63, 65),



Figures 55–62. *Loxosceles malintzi* sp. n. Variation of the male palps, left palps, prolateral views **55, 56** 1.5 km al NE del Panteón de San Pablo Anicano, Municipality San Pablo Anicano, Puebla (type locality) **57** 2km al S de Agua Escondida, Municipality Izúcar de Matamoros, Puebla **58, 59** Biological Station El Limón Cuachichinola, Municipality Tepalcingo, Morelos **60** Road to Mexcaltepec viejo, Municipality Taxco de Alarcón, Guerrero **61** Ticumán, Municipality Tlaltizapán, Morelos **62** 2 km al Oeste de Ahuelican "Cerro de la Coronilla", Municipality Tepecuacuilco de Trujano, Guerrero. Scale bar: 0.5 mm.

with small accessory lobes receptacles on each side, more visible in some specimens than others (Figs 63, 65). Others have long and thin seminal receptacles (Figs 64, 66). The base of the seminal receptacles is variable; in some specimens wider, rounded



Figures 63–67. *Loxosceles malintzi* sp. n. Variation of the seminal receptacles of the females, dorsal views. Puebla **63, 64** Insurgentes Street, cerrada Insurgentes, Section San Juan, San Pablo Anicano, Municipality San Pablo Anicano **65, 66** 1.5 km al NE del Panteón de San Pablo Anicano, Municipality San Pablo Anicano. Guerrero **67** Road to Mexcaltepec viejo, Municipality Taxco de Alarcón. Scale bar: 0.2 mm.

and strongly sclerotized, directed towards each other in oblique position, but in other specimens, the base is slightly sclerotized and thinner (Figs 63–67).

Remarks. Gertsch (1958) and Gertsch and Ennik (1983) reported *Loxosceles zapoteca* Gertsch, 1958 (female specimen) and *Loxosceles boneti* Gertsch, 1958 (immature specimen) from the state of Puebla, with *Loxosceles malintzi* sp. n. being the third species from the state (Figs 75, 78). However, in the case of *L. zapoteca*, males from Puebla are unknown, so we cannot corroborate the accurate identity of the species. In the collected material of *L. malintzi* sp. n. from localities near Acatlán de Osorio where *L. zapoteca* was reported (Fig. 75), only males of the new species were collected but no males of *L. zapoteca*. Also, although there is high variation in the seminal receptacles in *L. malintzi* (Figs 63–67), the seminal receptacles are completely different from those of *L. zapoteca* (Gertsch and Ennik 1983: figs 48–52). Also, the male palp and female genitalia are different in both species (Gertsch and Ennik 1983: figs 32–35, 48–51). The record of *L. boneti* from Puebla is also doubtful: the specimen is an immature, and the type locality of *L. boneti* is Acapulco, Guerrero, 250 km from Puebla (Fig. 75).

Natural history. The specimens of *Loxosceles malintzi* sp. n. were collected in a tropical deciduous forest (Figs 11–16). The micro habitat where the specimens were collected was under and among large rocks, and inside of rotten and dry cactus of the genus *Opuntia* and *Pachycereus* (arrows, Figs 13, 14, 17). At the type locality, the specimens were collected close together on a live large cactus (*Pachycereus*). They were collected at night when males are more active. These specimens were collected at 1.5–2.0 m high in the live cactus where their webs where located. In addition, the new species has anthropogenic habits: the specimens from San Pablo Anicano, Puebla were collected inside a house, under a concrete laundry sink and among concrete blocks in a yard. Even an adult male was collected at night walking on the kitchen floor of the house.

Distribution. MEXICO: Puebla, Morelos, Guerrero (Figs 75, 78).

Loxosceles rufescens (Dufour, 1820)

Figs 68−72

Scytodes rufescens Dufour 1820c: 203, pl. 76, fig. 5 (male).
Loxosceles citigrada Heineken and Lowe in Lowe (transferred) 1832: 322, pl. 48, figs 1–14 (male, female).
See World Spider Catalog (2018) for complete records.

Material examined. MEXICO: *Chihuahua*: 1 male, 1 female (LATLAX-Ara0183) from Instituto de Biomédicas de la Universidad Autónoma de Ciudad Juárez (31. 74645, -106.4444; 1130 m), Municipality Ciudad Juárez, no date, P. Flores col.

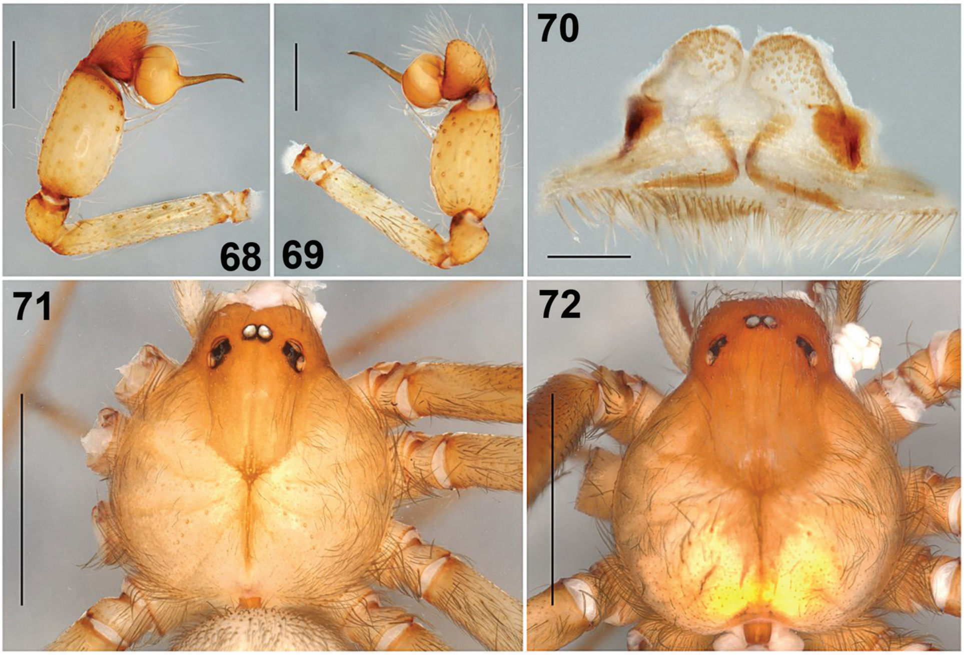
Diagnosis. *L. rufescens* resembles *Loxosceles foutadjalloni* Millot, 1941; in having male palpal tibia wide and a long embolus (Lotz 2012: fig. 9C), however in *L. rufescens* the male palp tibia is wider and the embolus is sigmoid-shaped (Figs 68−69), whereas in *L. foutadjalloni* the embolus is long and curved (Lotz 2012: fig. 9C). Females resemble *L. foutadjalloni* by the shape of the seminal receptacles (Lotz 2012: fig. 10B), however in *L. rufescens* they are short and round distally (Fig. 70), whereas in *L. foutadjalloni* the seminal receptacles are longer and distally bifurcated and rounded (Lotz 2012: fig. 10B).

Description. See Chomphuphuang et al. (2016).

Distribution. *Loxosceles rufescens* (Figs 68−72) has a natural distribution in the Mediterranean Basin and the Middle East (Nentwig et al. 2017; Tahami et al. 2017), but also is considered a cosmopolitan species (Nentwig et al. 2017; World Spider Catalog 2018).

Remarks. In Mexico, *L. rufescens* is only known from two records, from the states of Tamaulipas and Chihuahua (Fig. 73). Chickering (1937) reported *L. rufescens* from San Carlos Mountains, Tamaulipas; however, he never described or illustrated any specimen, which makes his record questionable (Fig. 74).

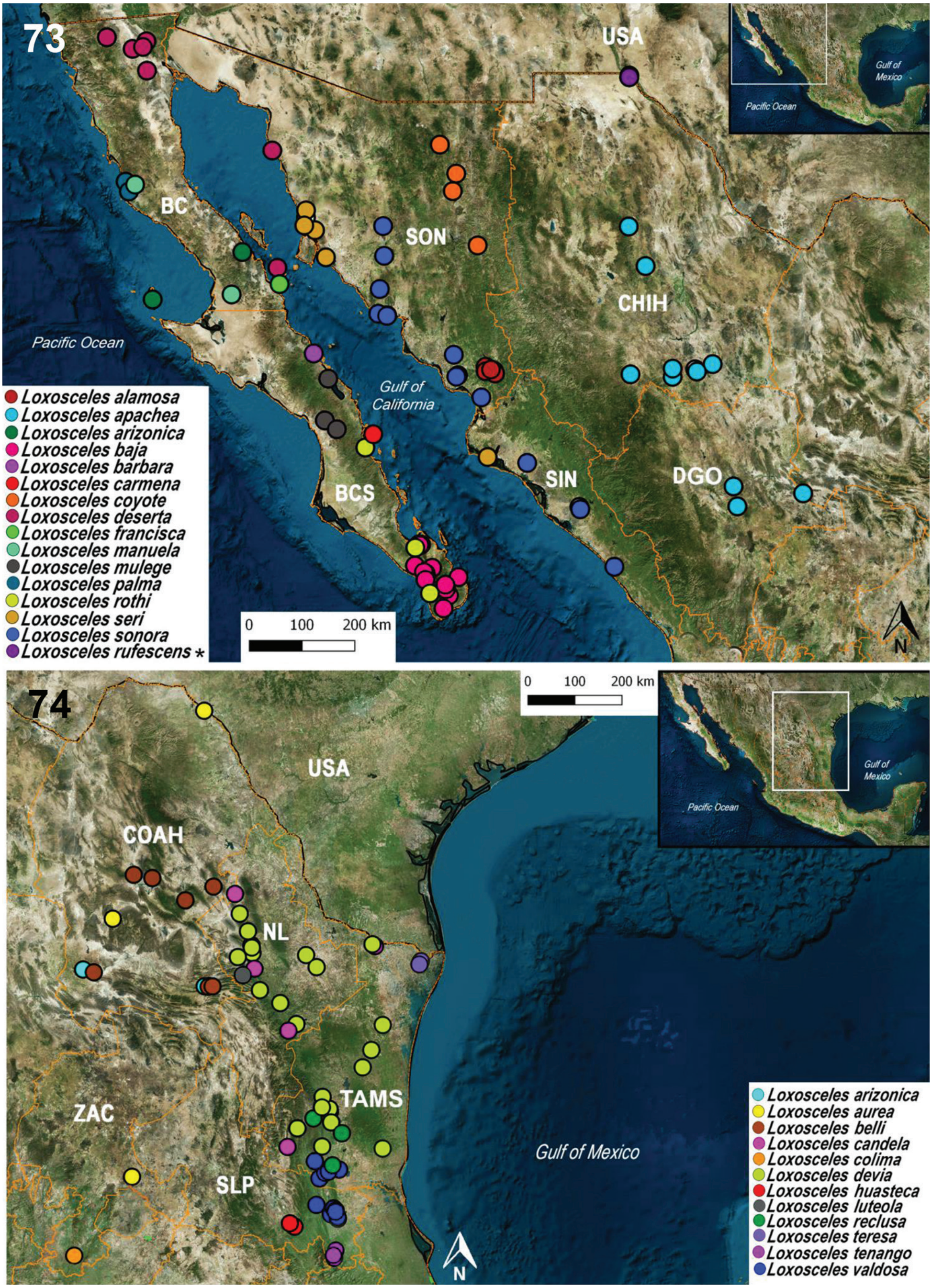
Updated distribution records for the 39 species of Loxosceles from Mexico. A total of 461 records of the 39 species of *Loxosceles* distributed in Mexico were reviewed. Twenty records were discarded for not having complete localities or having doubtful georeferences. Thus, a total of 441 records were used to make the distribution maps (Figs 73–76). The states with the most records are Guerrero with 55, Mo-



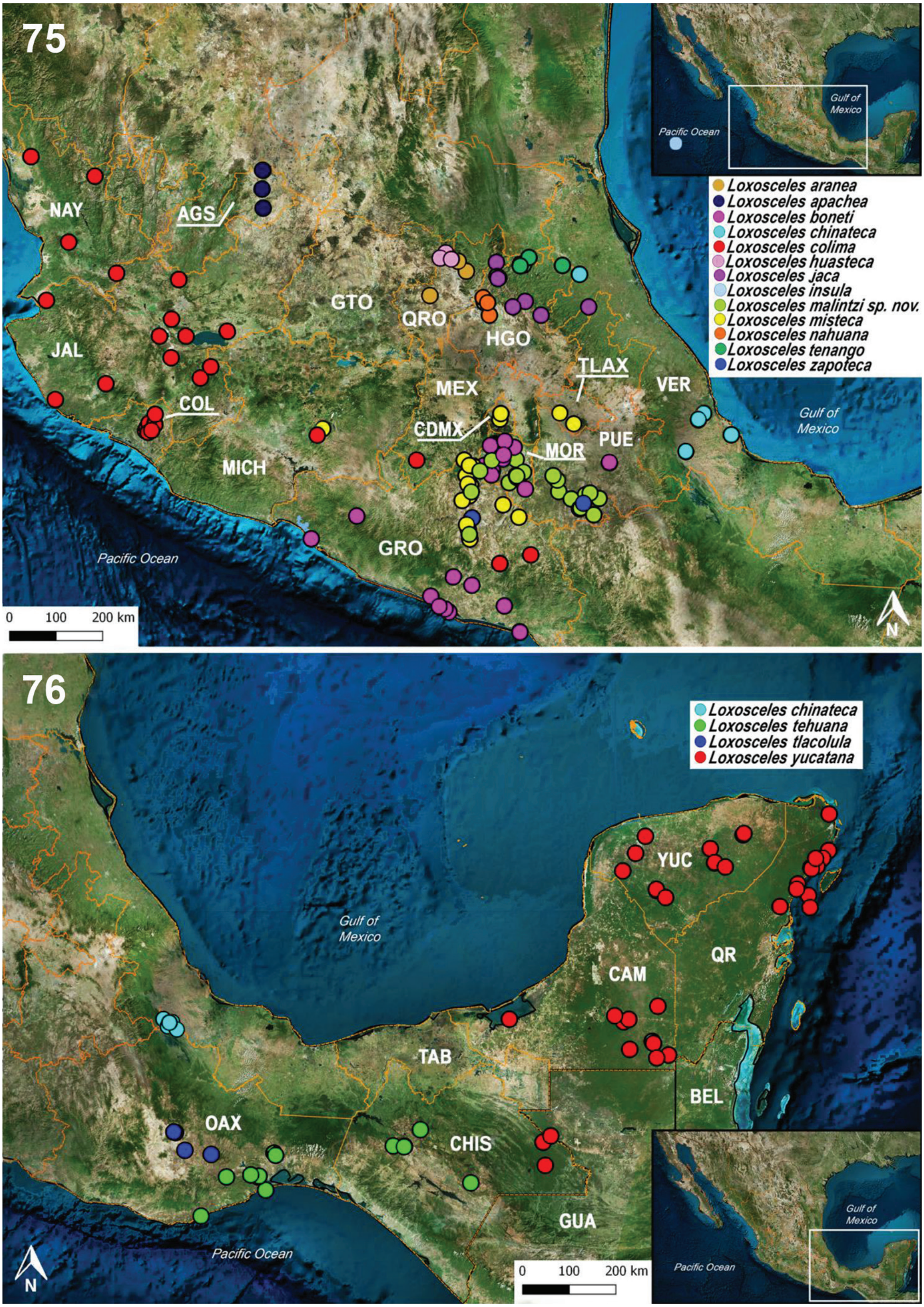
Figures 68–72. *Loxosceles rufescens* Dufour, 1820, from Ciudad Juárez, Chihuahua, Mexico **68, 69** Male, left palp, prolateral and retrolateral views respectively **70** Female, seminal receptacles, dorsal view **71, 72** Caparace dorsal view, male and female views respectively. Scale bars: 0.5 mm (**68, 69**), 0.2 mm (**70**), 1 mm (**71, 72**).

relos with 35, and Baja California Sur with 30 (Fig. 75). The state of Tabasco only has a single record (Appendix 1, Fig. 75). The most diverse states are Baja California Sur, Baja California, Sonora (with five species each), Guerrero, Tamaulipas (with four species each), and Oaxaca, Puebla, Hidalgo, Coahuila, San Luis Potosí, Nuevo León (with three species each) (Figs 73, 74). The least diverse states are Durango, Zacatecas, Michoacán, Querétaro, Chihuahua and Sinaloa (with two species each); Jalisco, Guanajuato, Quintana Roo, Colima, Chiapas, Yucatan, Campeche, Tabasco, Veracruz, Mexico City, Nayarit, Aguascalientes, Tlaxcala and state of Mexico (with a single species each) (Figs 73–76).

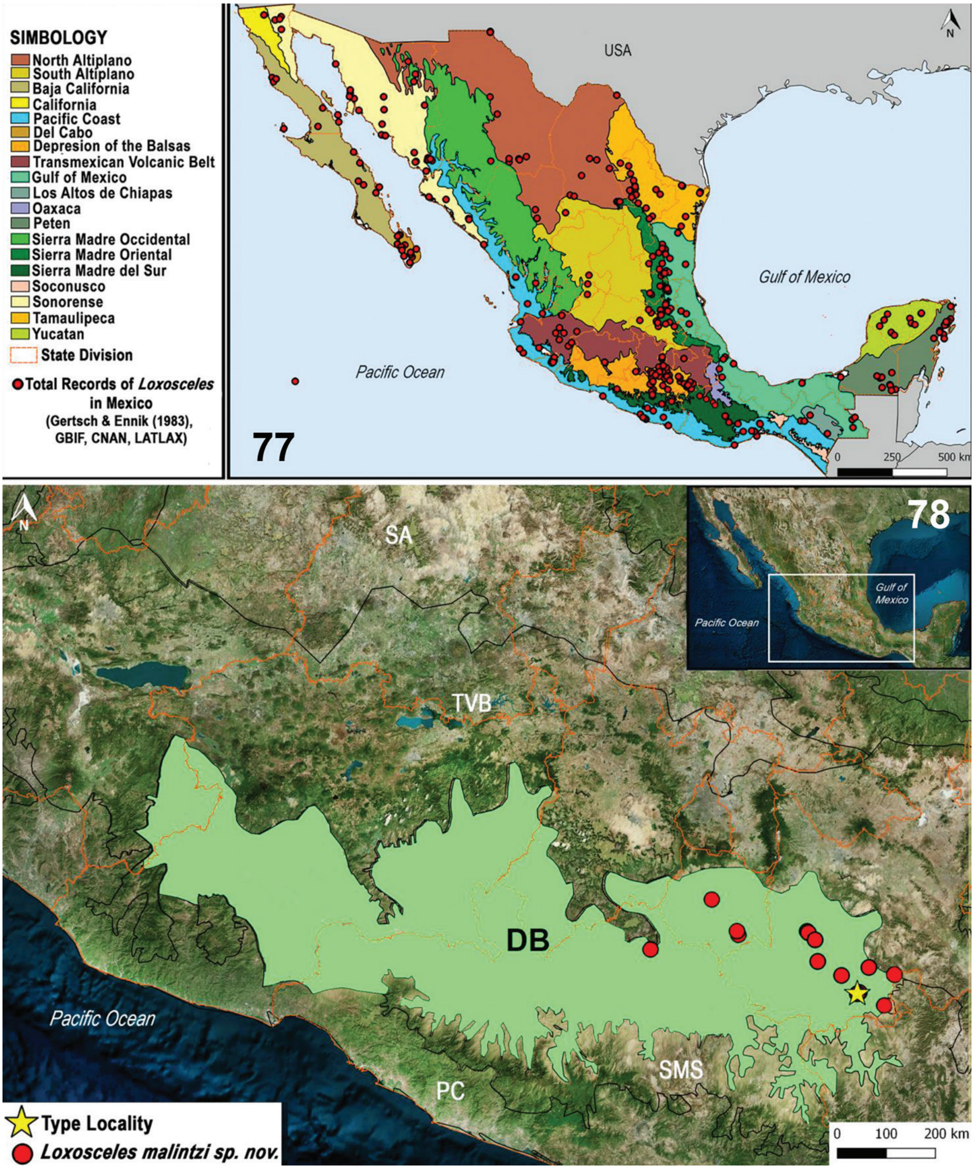
Regarding the number of total records per species of *Loxosceles*, the species with the most records are *L. boneti* with 59 and *L. colima* with 57 (Fig. 75). The species with the least number of records are *L. barbara, L. carmena, L. francisca, L. insula, L. luteola* and *L. rufescens* with a single record each (Fig. 74). A new record of *L. misteca* was found for Tlaxcala (Figs 75). A third record of *L. reclusa* was found for Tamaulipas (Fig. 74). The record of *L. rufescens* from Ciudad Juárez, Chihuahua represents the second record for the country of this introduced species and the first well-documented and illustrated record from Mexico (Figs 68–72, 73, Appendix 1).



Figures 73–74. Updated records of the species of *Loxosceles* for the states of north of Mexico. Asterisk in *L. rufescens* represents a new record for Mexico. Abbreviations for the Mexican states: BC, Baja California; BCS, Baja California Sur; CHIH, Chihuahua; COAH, Coahuila; DGO, Durango; NL, Nuevo León; SIN, Sinaloa; SLP, San Luís Potosí; SON, Sonora; TAMS, Tamaulipas; ZAC, Zacatecas.



Figures 75–76. Updated records of the species of *Loxosceles* for the states of central region and south of Mexico. Abbreviations for the Mexican states: AGS, Aguascalientes; CAM, Campeche; CDMX, Mexico City; CHIS, Chiapas; COL, Colima; MEX, Estado de México; GTO, Guanajuato; GRO, Guerrero; HGO, Hidalgo; JAL, Jalisco; MICH, Michoacán; MOR, Morelos; NAY, Nayarit; OAX, Oaxaca; PUE, Puebla; QR, Quintana Roo; QRO, Querétaro; TAB; Tabasco; TLAX, Tlaxcala; VER, Veracruz; YUC, Yucatán.



Figures 77–78. 77 Biogeographical provinces of Mexico showing the distribution records of the genus *Loxosceles* **78** Known records of *Loxosceles malintzi* sp. n. from the Depression of the Balsas province (green area), including the type locality.

Discussion

All 32 states of the Mexican Republic, including Mexico City, have records of some native or introduced species of *Loxosceles* (Figs 73–77). Regarding the distribution of species of *Loxosceles* in Mexico, although the highest diversity of species is in the north-west, more field work is necessary to collect additional material, mainly from the Baja California Peninsula where the species have been described based on one specimen of one sex (male or female) or few specimens (Fig. 73) (Gertsch and Ennik 1983).

Regarding the introduced species in Mexico, the record of *L. rufescens* from Ciudad Juárez, Chihuahua (Fig. 73), a widely distributed species throughout the Mediterranean Basin and the Middle East (Nentwig et al. 2017; Tahami et al. 2017), is the first well documented and illustrated record of this species from Mexico (Figs 68–72). The third record of *L. reclusa* from Mexico was found for the state of Tamaulipas. The first two records were recorded by Gertsch and Ennik (1983) (Fig. 74). *Loxosceles reclusa* is an introduced species. The natural distribution is from the south-central United States, from southern Illinois south to Texas and from eastern Tennessee west to Kansas (Saupe et al. 2011: fig. 2A, B). The records of *L. arizonica* from Coahuila state are doubtful (Fig. 74) because the natural distribution of the species is from Arizona, USA. For the central region of Mexico, some of the records are introduced species in temperate climates and mainly in urban zones. Such is the case of *L. misteca* in Mexico City and Tlaxcala (reported for the first time) (Fig. 75). The type locality of *L. misteca* is from Taxco de Alarcón, in Guerrero state; it is a common species in tourist caves of the state such as Grutas de Cacahuamilpa, Grutas del Mogote, Pozo Melendez, and Cave of Carlos Pacheco. These caves are located in a tropical deciduous forest, a habitat preferred by many species of *Loxosceles* from Mexico, mainly from the Pacific region (Figs 11–17). Regarding the species of *Loxosceles* from Mexico City, Durán-Barrón and Ayala-Islas (2007) and Durán-Barrón et al. (2009) reported two species: *L. misteca* and one undetermined species (*Loxosceles* sp.), probably a immature specimen of *L. misteca.* Also, Gertsch (1958) recorded *L. nahuana* for Mexico City based on an adult female; however, Gertsch and Ennik (1983) only cited specimens of *L. nahuana* from Hidalgo state where this species is distributed (Fig. 75), which makes the record this species in Mexico City questionable.

According to the biogeographical scheme for Mexico by Morrone (2004, 2005), all biogeographical provinces have recorded species of *Loxosceles* (Fig. 77). The highest diversity of species of *Loxosceles* from Mexico is towards the north, and the diversity tends to decrease towards the south of the country (Figs 73–76). The records of *Loxosceles* from Mexico are located mainly in biogeographical provinces of lowlands and in dry and tropical forests, including tropical deciduous forests, and also deserts, such as Baja California, Del Cabo, Sonorense, North Altiplano, Pacific Coast, Sierra Madre del Sur and Depression of the Balsas provinces (where *L. malintzi* sp. n. is distributed, Fig. 78) (Fig. 77). Although most of the species of *Loxosceles* from Mexico are distributed in tropical deciduous forest (Figs 11−17), species such as *L. chinateca* and *L. yucatana* are distributed in tropical rain forests. *Loxosceles chinateca* is from the states of Oaxaca and Veracruz (Gulf of Mexico and Oaxaca provinces), whereas *L. yucatana* is from the states of Chiapas, Tabasco and Yucatan Peninsula (Gulf of Mexico, Peten and Yucatan provinces) (Fig. 76). The records of *Loxosceles* in biogeographical provinces with mountains at high elevations (> 2000 m.a.s.l.), temperate climates, and with pine, oak or oak-pine forest are scarce. Such is the case of the Sierra Madre Occidental, highlands of North Altiplano, South Altiplano, Transmexican Volcanic Belt and Los Altos de Chiapas provinces, where some records of *Loxosceles* might be those of introduced species (Fig. 77). This idea is supported by ecological niche modeling for the species of *Loxosceles* from Mexico (in press). In the case of the Sierra Madre Oriental province, composed of high mountains and temperate and mountain mesophyll forests, the records of *Loxosceles* are mainly from the east of the province where the elevations are lower and the climate is more tropical (Fig. 77). Many of these records are from karstic caves, one of the preferred microhabitats of some species from Mexico (e.g. *L. misteca, L. boneti, L. chinateca, L. tehuana, L. tenango* and *L. yucatana*).

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Appendix I

List of the Mexican species of *Loxosceles* and records per state. *New records for Mexico. ** New records for State.

Species	Author(s), year	Records	States
L. alamosa	Gertsch & Ennik, 1983	4	Son
L. apachea	Gertsch & Ennik, 1983	20	Ags, Chih, Dgo
L. aranea	Gertsch, 1973	4	Qro
L. arizonica	Gertsch & Mulaik, 1940	18	BC, Coah
L. aurea	Gertsch, 1973	5	Coah, Zac
L. baja	Gertsch & Ennik, 1983	13	BCS
L. barbara	Gertsch & Ennik, 1983	1	BCS
L. belli	Gertsch, 1973	7	Coah
L. boneti	Gertsch, 1958	59	Gro, Mor, Pue
L. candela	Gertsch & Ennik, 1983	3	NL, Tams
L. carmena	Gertsch & Ennik, 1983	1	BCS
L. chinateca	Gertsch & Ennik, 1983	12	Oax, Ver
*L. colima***	Gertsch, 1958	57	Col, Gro, Jal, Mex, Mich**, Nay, Zac
L. coyote	Gertsch & Ennik, 1983	3	Son
L. deserta	Gertsch, 1973	10	BC, Son
L. devia	Gertsch & Mulaik, 1940	31	NL, Tams
L. francisca	Gertsch & Ennik, 1983	1	BC
L. huasteca	Gertsch & Ennik, 1983	5	Gto, Qro, SLP
L. insula	Gertsch & Ennik, 1983	1	Col
L. jaca	Gertsch & Ennik, 1983	8	Hgo
L. luteola	Gertsch, 1973	1	NL
L. malintzi sp. n.		25	Gro, Mor, Pue
L. manuela	Gertsch & Ennik, 1983	2	BC
*L. misteca***	Gertsch, 1958	18	CDMX, Gro, Mich**, Mor, Tlax**
L. mulege	Gertsch & Ennik, 1983	3	BCS
L. nahuana	Gertsch, 1958	7	Hgo
L. palma	Gertsch & Ennik, 1983	2	BC
L. reclusa	Gertsch & Mulaik, 1940	3	Tams
L. rothi	Gertsch & Ennik, 1983	3	BCS
*L. rufescens**	Dufour, 1820	1	Chih*
L. seri	Gertsch & Ennik, 1983	6	Sin, Son
L. sonora	Gertsch & Ennik, 1983	13	Sin, Son
L. tehuana	Gertsch, 1958	17	Chis, Oax
L. tenango	Gertsch, 1973	9	Hgo, SLP
L. teresa	Gertsch & Ennik, 1983	3	Tams
L. tlacolula	Gertsch & Ennik, 1983	4	Oax
L. valdosa	Gertsch, 1973	11	SLP, Tams
L. yucatana	Chamberlin & Ivie, 1938	41	Chis, Tab, Cam, Yuc, QR
L. zapoteca	Gertsch, 1958	9	Pue, Gro
TOTAL		**441**	

Ags: Aguascalientes, BC: Baja California, BCS: Baja California Sur, Cam: Campeche, CDMX: Mexico City, Coah: Coahuila, Col: Colima, Chis: Chiapas, Chih: Chihuahua, Dgo: Durango, Gto: Guanajuato, Gro: Guerrero, Hgo: Hidalgo, Jal: Jalisco, Mexico: State of Mexico, Mich: Michoacan, Mor: Morelos, Nay: Nayarit, NL: Nuevo Leon, Oax: Oaxaca, Pue: Puebla, Qro: Queretaro, QR: Quintana Roo, SLP: San Luis Potosi, Sin: Sinaloa, Son: Sonora, Tab: Tabasco, Tams: Tamaulipas, Tlax: Tlaxcala, Ver: Veracruz, Yuc: Yucatan, Zac: Zacatecas.

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Revision of the calcareous fen arachnofauna: habitat affinities of the fen-inhabiting spiders

Maija Štokmane[1], Inese Cera[2]

1 *University of Latvia, Faculty of Biology, Department of Zoology and Animal Ecology, Jelgavas street 1, LV–1004, Riga, Latvia* **2** *University of Latvia, Institute of Biology, Laboratory of Bioindication, Miera street 3, LV–2169, Salaspils, Latvia*

Corresponding author: *Maija Štokmane* (hidra4@inbox.lv)

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Abstract

Calcareous fens are one of the most species-rich habitats of the temperate zone of the Northern Hemisphere. In spite of this species richness, however, calcareous fens are still rather poorly investigated. Consequently, the data of the fen-associated spider fauna are also largely lacking. The aim of the research was to study the spider fauna of the calcareous fens of Latvia and to draw conclusions about what kind of spider species and ecological groups typically inhabit calcareous fen habitats. Spiders were sampled in the summer months of 2010, 2011, and 2012 at nine different calcareous fens of the coastal lowland of Latvia. The spider collection was performed by pitfall traps and a sweep net. The examined material comprised 6631 adult spider individuals representing 21 families and 149 species. The main spider ecological groups that dominated in the studied calcareous fens were hygrophilous and photophilous species which largely reflect the main properties of our studied habitats, all of which were wet, open mire habitats. Nevertheless, the fen arachnofauna consisted also of spider groups which are less typical for moist, sun-exposed, and alkaline environments, like xerophilous, sciophilous, and sphagnophilous species, respectively. Finally, several spider species collected in this study have not been previously reported for the spider fauna of Latvia, and many more might still be undiscovered in these unique and poorly investigated habitats. Therefore, it is suggested that calcareous fens deserve special attention and they should definitely be investigated further.

Keywords

Araneae, ecological groups, Latvia, mire habitats, spider fauna

Introduction

Mire habitats (fens and bogs) are among the most important wetland ecosystems of Europe. They are characterised by specialized flora and fauna and the presence of specially protected species (Bambe et al. 2008; Auniņš et al. 2013). In contrast to bogs, fen habitats are rather poorly investigated, the same being applied to their arachnofauna. There are only very few studies in Europe regarding the spider fauna of fens – we could find only a single study from Latvia (Cera et al. 2010), as well as one study from Estonia (Vilbaste 1980) and one from Poland (Kajak et al. 2000). Bogs are much more popular habitats for arachnological studies – there are several studies from Latvia (Šternbergs 1991; Spuņģis 2008), as well as from Estonia (Vilbaste 1980), Lithuania (Rėlys and Dapkus 2002b; Rėlys et al. 2002; Biteniekyté and Rélys 2006, 2008), Poland (Kupryjanowicz et al. 1998), Finland (Koponen 2002a,b, 2003, 2004), Norway (Pommeresche 2002), Denmark (Bruun and Toft 2004), Germany (Buchholz 2016), Russia (Oliger 2004), Romania (Urák and Samu 2008; Samu and Urák 2014) and other countries (Štambuk and Erben 2002; Scott et al. 2006).

Although both fens and bogs are mire habitats, there are several fundamental differences between them: (1) fens are mires that receive water and nutrients from groundwater and/or surface water, as well as from rainfall, while bogs depend solely on precipitation (McBride et al. 2011); (2) fens are mineral-rich type of mires which are usually characterized by basic or circumneutral conditions, while bogs are nutrient poor mires which have strongly acidic (pH < 5.0) soil conditions (Kellner 2003; Spitzer and Danks 2006; Horsák et al. 2011); (3) fens are dominated by brown mosses and sedges (e.g., *Carex*, *Cladium*, *Schoenus*), while bogs – by peat mosses (*Sphagnum* spp.) (Rydin and Jeglum 2006; Gałka et al. 2016); and (4) fens are rich in a floristic sense, while bogs have a low species diversity (Kellner 2003; McBride et al. 2011). Because of these differences between fens and bogs, and because of the fact that fens are much less studied than bogs, it is clear that more studies are needed in fen habitats.

Calcareous fens are one of those fen types which are especially worth studying because they belong to the most species-rich ecosystems of the temperate zone of the Northern Hemisphere (Joosten and Clarke 2002). In addition, there are some plant and animal species that occur almost exclusively in this habitat type. For example, *Scorpidium cossonii*, *Schoenus ferrugineus*, *Carex davalliana*, *Ophrys insectifera*, *Saussurea esthonica* and *Juncus subnodulosus* are plant species that can be found only within calcareous fens (Auniņš et al. 2013). Also, calcareous fens is a very important habitat for specially protected snail species, such as *Vertigo genesii* and *V. geyeri* (Cameron et al. 2003; Auniņš et al. 2013). Overall, calcareous fens are very rare in most of the countries in the European Union (Stanová et al. 2008), and they are considered priority habitats in Annex I of the EU Habitat Directive (EC 1992). Thus, because of the rarity of the calcareous fens and because of the presence of unique species within these habitats, it would be important and worthwhile to assess the quality of the calcareous fens, as well as to investigate their flora and fauna.

Spiders have been shown to be very good bioindicators (e.g., Marc et al. 1999; Pearce and Venier 2006), and thereby they are proposed as a group of organisms that are potentially useful tools for assessing the conservation value of rare and threatened habitats. Unfortunately, arachnids from calcareous fens are very poorly studied. In Latvia, spiders within calcareous fens have been investigated in some of our previous studies (Štokmane et al. 2013; Štokmane and Spuņģis 2014, 2016). These previous investigations had examined the influence of vegetation structure on spider diversity, while little attention was paid on the faunistic aspects of the fen spider communities. Thereby, the main purpose of the present study was to investigate the spider fauna of calcareous fens in greater detail and to analyse what kind of spider species and ecological groups are more typical for this habitat type.

Materials and methods

The present study is a compilation and an overview of our three previous studies made in the summers of the following years: 2010, 2011, and 2012. These studies were carried out in nine different calcareous fens of the coastal lowland of Latvia: (1) Kaņieris; (2) Apšuciems; (3) Engure-1; (4) Engure-2; (5) Slītere; (6) Platene; (7) Vītiņi; (8) Ječi; and (9) Ķirba (Figure 1). All the studied fens belong to the EU *Natura 2000* network.

A short overview of the used sampling methods is given in Table 1. As it can be seen, the spider capture methods as well as the time of sampling differed in each of the three study years. This was done in order to access more spider species and enlarge the species list, since it is well known that, firstly, each collecting method targets different spider species (e.g., Churchill and Arthur 1999) and, secondly, spiders exhibit seasonal variation in their occurrence (e.g., Marc et al. 1999). The sampling period of the present study, however, was limited to the summer months only (June/July/August). We decided that summer will be the optimal time for collecting spiders since it is the warmest season in Latvia (LEGMC 2014) when vegetation biomass is at its prime and food resources are plentiful, and thus we assumed that spider diversity as well as the number of species and individuals will be much greater at this period of time. Higher abundance and diversity of spiders during summer is also consistent with the findings of other researchers (e.g., Hatley and Macmahon 1980; Reddy and Venkataiah 1986).

A binocular microscope at 45× magnification was used to identify the spiders to species level. The unidentified adult species were recorded as morphospecies. Since juveniles could be identified only to family level, they were excluded from the study. The full species list of calcareous fen spiders as well as the number of collected individuals in each fen can be found in Appendix 1. The nomenclature of spider species followed the World Spider Catalog (2018).

In order to understand what kind of spider species inhabit calcareous fens, we carried out a literature survey and prepared a short description on the habitat preferences for each of our collected spider species. The habitat affinities of the spider species were derived from many different literature sources, but mainly from Locket and Millidge (1951, 1953), Roberts (1996), Harvey et al. (2002a,b), Almquist (2005, 2006), Matveinen-Huju et al. (2006), Oxbrough et al. (2006), Nentwig et al. (2012)

Figure 1. Map showing the calcareous fens studied (marked with circles). All fens are located in the coastal lowland of Latvia.

and Arachnologische Gesellschaft (2018). Based on the literature analysis, all the collected spider species were sorted into a number of ecological groups. These groups were distinguished mainly by taking into account the spider requirements for moisture and light, since these two abiotic factors are among the most important determinants characterizing the habitats of spiders (Entling et al. 2007). When taking into account the moisture preferences, the species were classified as either being hygrophilous (water-loving) or xerophilous (drought-loving), but when taking into account the light preferences, the species were classified as either being photophilous (sun-loving) or sciophilous (shade-loving). Species with a wide ecological amplitude (= found in many different habitat types) were classified as being habitat generalists.

In addition, we have summarized the information whether our detected spider species have been found within other European mires. We have chosen to include in our summary those mire studies in which the full spider species list has been published. Thus, we included the following studies: Cera et al. (2010) (calcareous fens of Latvia), Šternbergs (1991) (Baži bog of Latvia), Kajak et al. (2000) (fens of Poland), Kupryjanowicz et al. (1998) (bogs of Poland), Vilbaste (1980) (fens and bogs of Estonia), Koponen (2002a,b) (bogs of Northern Europe, including Sweden, Finland and northern Norway), Rėlys and Dapkus (2002b) (bogs of Lithuania), and Rėlys et al. (2002) (bogs of Lithuania and Finland). This information is presented as presence data in Appendix 2.

All our collected spider specimens are stored in 70% ethanol, labelled, and deposited in the Department of Zoology and Animal Ecology, Faculty of Biology, University of Latvia, Riga.

Table 1. A short overview of the used methods in each of the three study years. There were two different calcareous fens chosen at the wetlands of the lake Engure in 2010 (designated as Engure-1 and Engure-2).

Data	2010	2011	2012
Number of studied fens	5	8	1
The studied fens		Kaņieris	Apšuciems
		Apšuciems	
	Kaņieris	Engure	
	Apšuciems	Slītere	
	Engure-1	Platene	
	Platene	Vītiņi	
		Ječi	
		Ķirba	
Spider sampling methods	Pitfall trapping	Sweep netting	Pitfall trapping & sweep netting
Sampling dates	5 June – 3 July (in Platene: 6 June – 4 July)	16 – 17 July	Traps: 27 July – 22 August; Sweeping: 26 – 27 July
Detailed information on the methods	Štokmane et al. (2013)	Štokmane and Spuņģis (2014)	Štokmane and Spuņģis (2016)

Results

Overall, in the three study years a total number of 8,967 spider individuals (6631 adults and 2336 juveniles) were collected, representing 134 species and 15 morphospecies in 21 families. Most of the species (87 spp.) were collected only in a single year, while only five species were detected in all three study years (*Dolomedes fimbriatus*, *Evarcha arcuata*, *Tibellus maritimus*, *Xysticus ulmi* and *Kaestneria pullata*). Altogether eight spider species found during this investigation were registered as new species for the araneofauna of Latvia – *Cheiracanthium punctorium* (Eutichuridae), *Gnaphosa lapponum* (Gnaphosidae), *G. nigerrima* (Gnaphosidae), *Bathyphantes parvulus* (Linyphiidae), *Centromerus semiater* (Linyphiidae), *Microlinyphia impigra* (Linyphiidae), *Pirata tenuitarsis* (Lycosidae), and *Leptorchestes berolinensis* (Salticidae). The dominant spider species in each year and in each fen are given in Table 2. One of the most abundant and most frequently recorded species was *Dolomedes fimbriatus,* which occurred in the vast majority of the studied calcareous fens. Overall, however, there were rather large differences in spider species composition between fens, between study years, as well as between pitfall samples and the sweep-net samples.

By using relevant information from the literature (see the method section), we have prepared a short description of each of the collected spider species (Table 3). Also, all the collected spider species were sorted into ecological groups according to their habitat requirements. This classification was based mainly on spider requirements for moisture (hygrophilous/xerophilous species) and light (photophilous/sciophilous species). For some of the spider species we distinguished also sub-groups. In some cases, however, it was difficult to classify a spider species into a particular ecological group(-s), because the habitat preferences of some spiders are rather poorly defined (Eyre and Woodward 1996), and the information in the literature is sometimes contradictory (personal observation).

Table 2. The most abundant (>9.5%) spider species in each of the studied fens in each study year. Two of the fens (Vītiņi and Slītere) are not given here because too few spiders were collected within these fens.

	Apšuciems		**Engure-1**	**Engure-2**	**Ječi**	**Kaņieris**	**Ķirba**	**Platene**
Pitfall trapping	**2010**	**2012**	**2010**	**2010**		**2010**		**2010**
Antistea elegans	30.2	10.1		16.2				
Bathyphantes parvulus	9.5							
Centromerus sp.						11.6		
Hygrolycosa rubrofasciata		9.5						
Pardosa prativaga								36.4
Pardosa pullata				13.2				
Pirata tenuitarsis								13
Piratula uliginosa				15		34.7		
Piratula hygrophilus		9.9						
Piratula knorri								12.5
Piratula latitans			56.2					
Trochosa terricola		11.8						
Zora spinimana		9.6						
Sweep netting	**2011**	**2012**	**Engure 2011**		**2011**	**2011**	**2011**	**2011**
Dolomedes fimbriatus	19	59.5	33.3		19.5	39.1	41.2	37.5
Evarcha arcuata	26.2	13.1				10.1		
Tibellus maritimus	21.4		57.1		58.5	17.4	32.4	37.5

The spider ecological group composition in the studied calcareous fens and the number of spider species and individuals within each group is given in Figure 2. The most species-rich and the most abundant ecological group was hygrophilous species – more than a half of all spider species and individuals collected in the present study could be classified as hygrophilous (if including also hygrophilous-photophilous and hygrophilous-sciophilouspecies). Photophilous species (including photophilous-hygrophilous and photophilous-xerophilous) was another large group in the studied fens – overall, 46 of our collected spider species (34% of all spiders) and 3088 individuals (48%) could be classified as photophilous species. The rest of the ecological groups, xerophilous, sciophilous, and habitat generalists, were represented by a rather low number of species and individuals.

Discussion

In the present study we investigated the spider fauna of the calcareous fens of the coastal lowland of Latvia. The full species list of the calcareous fen spiders is given in Appendix 1. The main purpose of the present study was to clarify the habitat preferences of the spider species collected during our investigations in the calcareous fens. The habitat preferences of each spider species are described in Table 3.

The arachnofauna of the studied calcareous fens consisted of a wide spectrum of different spider ecological groups. The vast majority of the spider species and individuals found in the fens were hygrophilous or photophilous or hygrophilous-photophilous.

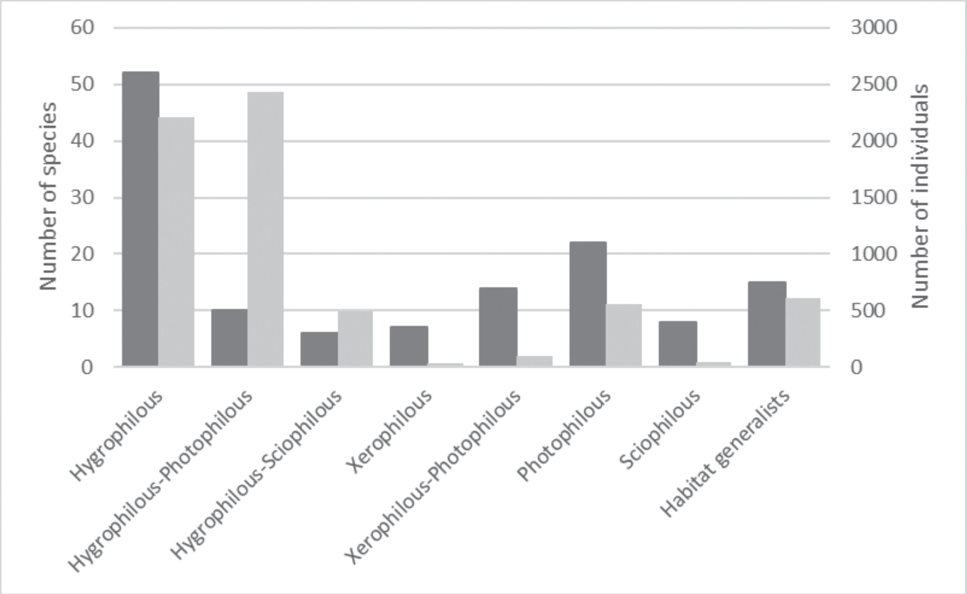

Figure 2. The proportional spider ecological group composition in the calcareous fens of Latvia by the number of species (dark grey columns) and by the number of individuals (light grey columns).

The dominance of these groups in the studied habitats is quite logical since all our studied fens were moist, sun-exposed habitats. Nevertheless, the fen arachnofauna consisted also of different other spider ecological groups, including even some groups which do not normally inhabit wet and alkaline environments, i.e., xerophilous and sphagnophilous species. The reason of the presence of such species within calcareous fens might be related with the fact that fens encompass a much broader range of microhabitat variation than other mire types. Fen surface often has a variable microrelief that consists of hummocks, hollows and pools, and since the tops of the hummocks are much drier than their lower part, they may serve as suitable habitat patches for the xerophilous species. Other researchers have also observed that drought-loving spider species can occasionally be found on raised, dry patches of vegetation within otherwise wet and marshy sites (Roberts 1996; Cattin et al. 2003). Similarly, the presence of sphagnophilous spider species within the studied mires might also be explained by the availability of hummocks. Usually these fen hummocks are dominated by acid-loving plant species (especially *Sphagnum* mosses) which are raised above the water level and thus protected from the influence of the alkaline groundwater (Rydin and Jeglum 2006). Consequently, the sphagnophilous spider species, which normally live in acid environments, especially bogs, and are related with *Sphagnum* mosses (e.g., *Gnaphosa nigerrima*, *Pardosa sphagnicola*, *Pirata piscatorius*), might also be supported in calcareous fens, since the *Sphagnum*-dominated hummocks may serve as discrete habitat patches for them. These findings are supported by several other researchers who have also discovered that spiders can persist in very small microhabitats (Wing 1984; Foelix 2011; Cobbold and MacMahon 2012).

Table 3. List of spider species collected in the calcareous fens of Latvia and description of their habitat preferences. The ecological group(s) of each species are also indicated (**bold**). For some of the species the ecological sub-group is given as well. Genera and species are sorted alphabetically within each family.

Family	Species	Description of the species habitat preferences	Ecological group(s)
Agelenidae	*Agelena labyrinthica* (Clerck, 1757)	It can be found in habitats such as sandy heathlands, banks of ditches (Almquist 2005), sunny forest edges (Nentwig et al. 2012), grasslands (Harvey et al. 2002b), bogs (Vilbaste 1980). This species can also occur in coastal sites – it has been found in coastal dune habitats in Latvia (Cera and Spuņģis 2013), as well as in salt marshes at the North Sea coast (Finch et al. 2007).	Hygrophilous | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist
Araneidae	*Araneus alsine* (Walckenaer, 1802)	It is usually found in damp, sheltered woodland clearings (Roberts 1996; Harvey et al. 2002b). It can also be found in humid forest edges, damp meadows, bogs (Vilbaste 1980; Almquist 2005; Nentwig et al. 2012).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist
	Araneus diadematus Clerck, 1757	It is one of the most common and abundant species (Locket and Millidge 1953) which is rather ubiquitous (Cattin et al. 2003) – it occurs wherever the habitat can provide supports for its large orb web (Harvey et al. 2002b). It can be found in a wide range of habitats, such as all types of woodland, grasslands, hedgerows, heathland, as well as roadside verges, quarries, gardens, buildings and different other places (Nyffeler and Benz 1987; Harvey et al. 2002b; Almquist 2005; Arachnologische Gesellschaft 2018). It, however, seems to prefer forest edges and gardens (Heimer and Nentwig 1991; Nentwig et al. 2012).	Hygrophilous | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist *Sub-group:* Ecotonal forest species
	Araneus quadratus Clerck, 1757	It occurs in grasslands (Nyffeler and Benz 1987, 1989; Harvey et al. 2002b), especially in moist meadows (Almquist 2005; Nentwig et al. 2012). This species is found on vegetation which has sufficient height and strength to support its large orb web, such as tall grasses, heather and bushes such as gorse (Roberts 1996; Harvey et al. 2002b). *A. quadratus* can also be found in bogs (Vilbaste 1980; Almquist 2005) and fens (Vilbaste 1980; Kajak et al. 2000; Cera et al. 2010).	Hygrophilous | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist *Sub-group:* Grassland species
	Araniella cucurbitina (Clerck, 1757)	It is found in a wide variety of situations, for example, in broadleaved deciduous woodland, dry grasslands, hedgerows, thermophile woodland fringes etc. (Arachnologische Gesellschaft 2018). Most commonly, however, the species is found on trees and bushes in woodland, scrub and hedgerows, as well as on nearby low vegetation (Roberts 1996; Harvey et al. 2002b; Nentwig et al. 2012). Harvey et al. (2002b) wrote that the main tree that is inhabited by *A. cucurbitina* is oak, however Almquist (2005) mentions also pine, spruce and birch.	Hygrophilous | Xerophilous; Photophilous | Sciophilous; **Habitat generalist**
	Argiope bruennichi (Scopoli, 1772)	It is obviously associated with different grassland habitats (Nyffeler and Benz 1987, 1989; Harvey et al. 2002b; Spungis 2005; Horváth et al. 2009), especially with moist meadows (Almquist 2005; Nentwig et al. 2012). This species has also been found in gardens, wasteland, wetlands, roadside verges and on house walls (Harvey et al. 2002b; Cattin et al. 2003; Almquist 2005).	Hygrophilous | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist *Sub-group:* Grassland species
	Larinioides cornutus (Clerck, 1757)	This species usually inhabits damp places (Harvey et al. 2002b; Cattin et al. 2003). It occurs in wetlands (Kajak et al. 2000; Cattin et al. 2003; Cera et al. 2010), as well as in meadows and forest edges, mostly near water (Harvey et al. 2002b; Almquist 2005; Nentwig et al. 2012).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist
	Mangora acalypha (Walckenaer, 1802)	It occurs in open woodland, heathland, dry meadows, dune areas and in many other places (Harvey et al. 2002b; Almquist 2005; Arachnologische Gesellschaft 2018). Rėlys and Dapkus (2002) found *M. acalypha* in a pine bog, but Kajak et al. (2000) – in fens. Overall, however, the species seems to prefer warm, dry and sunny places (Harvey et al. 2002b; Nentwig et al. 2012).	Hygrophilous | **Xerophilous**; **Photophilous** | Sciophilous; Habitat generalist

Family	Species	Description of the species habitat preferences	Ecological group(s)
Araneidae	*Neoscona adianta* (Walckenaer, 1802)	It is associated with dry and warm places and can be found in a range of open habitats (Harvey et al. 2002b; Arachnologische Gesellschaft 2018). The species occurs, for example, in heathlands (Harvey et al. 2002b; Almquist 2005), grasslands (Harvey et al. 2002b; Horváth et al. 2009; Cera 2013; Arachnologische Gesellschaft 2018), screes and in other sparsely vegetated habitats (Arachnologische Gesellschaft 2018). *N. adianta* can, however, also be found in marshy areas – in fens and saltmarshes (Kajak et al. 2000; Harvey et al. 2002b; Nentwig et al. 2012).	Hygrophilous | **Xerophilous**; **Photophilous** | Sciophilous; Habitat generalist
	Singa hamata (Clerck, 1757)	It occurs in damp habitats (Roberts 1996; Harvey et al. 2002b), e.g., moist meadows and pastures, reed-beds, fens, bogs, etc. (Vilbaste 1980; Kajak et al. 2000; Harvey et al. 2002b; Almquist 2005; Arachnologische Gesellschaft 2018). The species prefers sunny places – along with the already mentioned open habitats, it can also be found, for example, in open woods, ruderal areas and waysides (Almquist 2005; Nentwig et al. 2012).	**Hygrophilous** | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist
Clubionidae	*Clubiona germanica* Thorell, 1871	It can be found on trees and shrubbery of different habitats, especially in forests and parks (Miller 1971; Nentwig et al. 2012). Komposch (2000) has found this species in alder forest, while Almquist (2006) proposes that this species can be found in damp deciduous woods and damp shores with bog-myrtle *Myrica gale*. This spider species can also be found in hedgerows, reed-beds (Arachnologische Gesellschaft 2018), fens and bogs (Vilbaste 1980).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist
	Clubiona reclusa O. Pickard-Cambridge, 1863	It occurs in a wide range of habitats (Roberts 1996; Harvey et al. 2002b), however most often it can be found in damp or marshy places (Harvey et al. 2002b). It occurs in marshes, borders of bogs, damp meadows, on water borders etc. (Vilbaste 1980; Almquist 2006; Nentwig et al. 2012).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-group:* Hygrophilous generalist
	Clubiona stagnatilis Kulczyński, 1897	It occurs in different damp and marshy situations – in swamps, fens, bogs, shores of lakes, reed-beds etc. (Locket and Millidge 1951; Vilbaste 1980; Kajak et al. 2000; Harvey et al. 2002b; Rėlys and Dapkus 2002; Almquist 2006; Arachnologische Gesellschaft 2018). The species might also be found in damp woodlands (Nentwig et al. 2012).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-group:* Hygrophilous generalist
	Clubiona subsultans Thorell, 1875	It is associated mostly with pine or spruce forests (Roberts 1996; Harvey et al. 2002b; Duffey 2005; Matveinen-Huju et al. 2006; Nentwig et al. 2012; Arachnologische Gesellschaft 2018). This species is found on branches, as well as on and under bark of conifers and in pine litter amongst pine needles (Roberts 1996; Harvey et al. 2002b). Vilbaste (1980) has found this species in fens and bogs of Estonia.	Hygrophilous | Xerophilous; Photophilous | **Sciophilous**; Habitat generalist *Sub-group:* Coniferous forest species
Dictynidae	*Argenna subnigra* (O. Pickard-Cambridge, 1861)	It occurs in sunny, sparsely vegetated localities (Harvey et al. 2002b; Bonte et al. 2004; Nentwig et al. 2012). It is mainly found in dry grasslands, coastal dunes, old quarries, wasteground and railings (Locket and Millidge 1951; Harvey et al. 2002b; Duffey 2005; Almquist 2006; Arachnologische Gesellschaft 2018). Was found in fens by Kajak et al. (2000).	Hygrophilous | **Xerophilous**; **Photophilous** | Sciophilous; Habitat generalist
	Argyroneta aquatica (Clerck, 1757)	This is an aquatic spider that can be found in clean, vegetated freshwater where there is little current (Roberts 1996; Harvey et al. 2002b; Nentwig et al. 2012), for example, ponds, lakes, pools, calm rivers, ditches, canals (Locket and Millidge 1953; Harvey et al. 2002b; Almquist 2005). Vilbaste (1980) found this species in fens and bogs. *A. aquatica*, though air-breathing, is entirely aquatic – it is the only spider that spends its whole life under water (Locket and Millidge 1953; Bromhall 1988; Schütz and Taborsky 2003).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-group:* Aquatic species
Eutichuridae	*Cheiracanthium erraticum* (Walckenaer, 1802)	It inhabits open localities (Nentwig et al. 2012; Arachnologische Gesellschaft 2018). The main habitats of this species in central Europe are chalk grasslands and heathland (Bonte et al. 2003, 2004). It can also be found in fens and bogs (Vilbaste 1980; Arachnologische Gesellschaft 2018).	Hygrophilous | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist

Family	Species	Description of the species habitat preferences	Ecological group(s)
Eutichuridae	*Cheiracanthium punctorium* (Villers, 1789)	It can be found in warm, open habitats (Nentwig et al. 2012). It occurs, for example, in dry grasslands, damp clearings, wasteland, moist meadows, swamps (Roberts 1996; Komposch 2000; Almquist 2006; Arachnologische Gesellschaft 2018).	Hygrophilous | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist
Gnaphosidae	*Drassodes lapidosus* (Walckenaer, 1802)	It is usually found in dry habitats with very sparse or no vegetation (Roberts 1996; Bonte et al. 2003, 2004; Arachnologische Gesellschaft 2018). It occurs in stony areas (e.g. scree), in dry grasslands, the drier parts of shingle beaches and elsewhere (Roberts 1996; Harvey et al. 2002b; Arachnologische Gesellschaft 2018). According to Nentwig et al. (2012), however, *D. lapidosus* can occur from very dry to swampy situations. This species was found in fens by Kajak et al. (2000). In addition, *D. lapidosus* is a synanthropic species – it is associated with human-influenced habitats and can be found, for example, in gardens, waste ground, industrial sites and in buildings (Harvey et al. 2002a; Nentwig et al. 2012; Arachnologische Gesellschaft 2018).	Hygrophilous | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist *Sub-group:* Synanthropic species
	Drassodes pubescens (Thorell, 1856)	It can be found in different situations – from dry to moist habitats (Matveinen-Huju et al. 2006; Nentwig et al. 2012), from grasslands and heathlands to open coniferous and deciduous forests (Locket and Millidge 1951; Harvey et al. 2002b; Almquist 2006; Nentwig et al. 2012; Arachnologische Gesellschaft 2018). *D. pubescens* has been found also in fens (Vilbaste 1980) and bogs (Koponen 2002a,b; Rėlys and Dapkus 2002; Rėlys et al. 2002).	Hygrophilous | Xerophilous; Photophilous | Sciophilous; **Habitat generalist**
	Drassyllus lutetianus (L. Koch, 1866)	It has been recorded from different habitats, for example, moist meadows, water borders, sand dunes, sea shore, alluvial forests etc. (Harvey et al. 2002b; Almquist 2006; Nentwig et al. 2012). It has also been found in fens (Vilbaste 1980) and different bog habitats (Kupryjanowicz et al. 1998; Koponen 2002b, 2003; Rėlys et al. 2002; Oxbrough et al. 2006). Also, *D. lutetianus* occurs in disturbed habitats such as arable land and gardens (Cristofoli et al. 2010; Arachnologische Gesellschaft 2018).	Hygrophilous | Xerophilous; Photophilous | Sciophilous; **Habitat generalist**
	Drassyllus praeficus (L. Koch, 1866)	It can be found in dry and open habitats (Heimer and Nentwig 1991). It occurs in dry grasslands, sparse pine-woods, rocky steppes, shores and in similar habitats (Koponen 2000; Almquist 2006; Nentwig et al. 2012; Arachnologische Gesellschaft 2018). It is also sometimes found on dry heathland, mostly between about 6 to 12 years after fire (Harvey et al. 2002b).	Hygrophilous | **Xerophilous**; **Photophilous** | Sciophilous; Habitat generalist
	Drassyllus pusillus (C. L. Koch, 1833)	It has a preference for dry situations (Locket and Millidge 1951; Roberts 1996; Arachnologische Gesellschaft 2018). It can be found in very different habitats – in chalk grasslands, heathlands, dry meadows, river-floodplains, stony pine and mixed forests etc. (Heimer and Nentwig 1991; Roberts 1996; Bonte et al. 2004; Almquist 2006; Nentwig et al. 2012). It has also been collected in bogs (Koponen 2002a,b; Rėlys et al. 2002).	Hygrophilous | **Xerophilous**; Photophilous | Sciophilous; Habitat generalist
	Gnaphosa bicolor (Hahn, 1833)	A species that favors light forests and other open habitats (Matveinen-Huju et al. 2006; Nentwig et al. 2012). The species has been found, for example, in open pine forests (Pommeresche 2002; Almquist 2006), burnt forests (Moretti et al. 2002), rocky steppes (Heimer and Nentwig 1991; Nentwig et al. 2012), screes (Arachnologische Gesellschaft 2018) and heathlands (Almquist 2006).	Hygrophilous | **Xerophilous**; **Photophilous** | Sciophilous; Habitat generalist
	Gnaphosa lapponum (L. Koch, 1866)	It is a bog-inhabitant, which is quite abundant in bogs of Northern Europe (Koponen 2002a,b, 2003; Almquist 2006). Interestingly, that Koponen (1991) observed that in southern Finland this species occurs only on bogs, while in the northernmost region of Finland it is markedly eurytopic, i.e. able to live in a wide variety of habitats.	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-group:* Bog species

Family	Species	Description of the species habitat preferences	Ecological group(s)
Gnaphosidae	*Gnaphosa nigerrima* L. Koch, 1877	It shows a clear preference for *Sphagnum* mosses (Harvey et al. 2002b; Boyce 2004; Platen 2004; Almquist 2006). It occurs in bogs and swampy places (Roberts 1996; Kupryjanowicz et al. 1998; Koponen 2002b; Rėlys and Dapkus 2002; Oliger 2004; Nentwig et al. 2012).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-group:* Sphagnophilous species
	Haplodrassus moderatus (Kulczyński, 1897)	It is often recorded from peatbogs and fenlands (Vilbaste 1980; Koponen 2002a; Rėlys and Dapkus 2002a; Rėlys et al. 2002). Overall, however, it has been found in a range of damp habitats – humid meadows, moist alder forests, swamps etc. (Almquist 2006; Nentwig et al. 2012).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist
	Haplodrassus signifer (C. L. Koch, 1839)	It has mainly be found in dry habitats (Bonte et al. 2003, 2004; Arachnologische Gesellschaft 2018) – on sand and stony places, heathlands (Harvey et al. 2002b; Nentwig et al. 2012), dry grasslands (Almquist 2006; Nentwig et al. 2012; Arachnologische Gesellschaft 2018), pine forests (Rėlys and Dapkus 2002; Biteniekyté and Rélys 2008). Although this species seems to prefer dry habitats, these can often be found in slightly raised, dry patches within otherwise wet and boggy areas (Roberts 1996). The species is also found in fens (Vilbaste 1980) and bogs (Vilbaste 1980; Kupryjanowicz et al. 1998; Koponen 2002a,b; Rėlys and Dapkus 2002; Rėlys et al. 2002; Bruun and Toft 2004; Biteniekyté and Rélys 2008).	Hygrophilous | **Xerophilous**; Photophilous | Sciophilous; Habitat generalist *Note:* Also within wet habitats on dry, raised patches of vegetation
	Haplodrassus silvestris (Blackwall, 1833)	It is a forest species (Locket and Millidge 1951; Roberts 1996; Harvey et al. 2002b; Nentwig et al. 2012) that can live in different types of forests, including both deciduous and pine forests (Almquist 2006; Arachnologische Gesellschaft 2018). Sometimes it can also be found in dry meadows and bogs (Rėlys et al. 2002; Nentwig et al. 2012).	Hygrophilous | Xerophilous; Photophilous | **Sciophilous**; Habitat generalist *Sub-group:* Forest generalist
	Micaria pulicaria (Sundevall, 1831)	It has been recorded from a variety of situations which are open to sunshine (Heimer and Nentwig 1991; Roberts 1996), but particularly the warm, sunny parts of sandy heaths, chalk downlands, dunes and derelict land (Harvey et al. 2002b). This species has also been found in meadows close to lakes, saltmarshes, open pine forests, broad-leaved woodlands, fens, bogs, as well as in stony, bare and dry habitats (Vilbaste 1980; Harvey et al. 2002b; Rėlys et al. 2002; Almquist 2006; Matveinen-Huju et al. 2006).	Hygrophilous | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist *Sub-group:* Photophilous generalist
	Poecilochroa variana (C. L. Koch, 1839)	It occurs in dry and sun exposed, stony or sandy habitats (Roberts 1996; Nentwig et al. 2012). It can be found in dry meadows, dune heaths and open pine woods (Almquist 2006).	Hygrophilous | **Xerophilous**; **Photophilous** | Sciophilous; Habitat generalist
	Zelotes clivicola (L. Koch, 1870)	This species is associated mainly with open forests (Almquist 2006; Matveinen-Huju et al. 2006; Nentwig et al. 2012). It can be found in pine forests (Pommeresche 2002; Rėlys and Dapkus 2002b), beech woodland, mixed deciduous and coniferous woodland and thermophile woodland fringes (Arachnologische Gesellschaft 2018). This species can be found also in other dry habitats such as heaths (Cattin et al. 2003; Arachnologische Gesellschaft 2018). Also, it can be found in bogs (Kupryjanowicz et al. 1998; Rėlys and Dapkus 2002b; Rėlys et al. 2002).	Hygrophilous | **Xerophilous**; **Photophilous** | Sciophilous; Habitat generalist
	Zelotes latreillei (Simon, 1878)	It prefers open habitats (Harvey et al. 2002b; Oxbrough et al. 2006) and is usually found in dry habitats – in chalk grasslands, heathlands (Gajdoš and Toft 2000; Harvey et al. 2002b; Bonte et al. 2003, 2004), coastal dunes and sandy shores (Arachnologische Gesellschaft 2018), dry pine forests (Rėlys and Dapkus 2002b; Almquist 2006). This species can also be found in dry, raised patches of vegetation within marshy sites (Roberts 1996). Has been recorded from fens (Kajak et al. 2000) and bogs (Koponen 2002a, 2003; Rėlys and Dapkus 2002; Rėlys et al. 2002).	Hygrophilous | **Xerophilous**; **Photophilous** | Sciophilous; Habitat generalist *Note:* Also within wet habitats on dry, raised patches of vegetation
Gnaphosidae	*Zelotes subterraneus* (C. L. Koch, 1833)	This species is able to live in a variety of habitat types – in woods, heathland, boggy areas, dry meadows, screes, stony areas etc. (Almquist 2006; Nentwig et al. 2012; Arachnologische Gesellschaft 2018). The preference of this species, however, seems to be on forests (Rėlys and Dapkus 2002b; Arachnologische Gesellschaft 2018). Also, it can be found in coastal habitats (Harvey et al. 2002b; Bonte et al. 2003; Arachnologische Gesellschaft 2018).	Hygrophilous | Xerophilous; Photophilous | Sciophilous; **Habitat generalist**

Family	Species	Description of the species habitat preferences	Ecological group(s)
Hahniidae	*Antistea elegans* (Blackwall, 1841)	It has been recorded from a variety of damp, open habitats, for example, bogs, poor fens, wet heathlands, moist pastures and others (Harvey et al. 2002b; Almquist 2005; Oxbrough et al. 2007; Cristofoli et al. 2010). It seems that *A. elegans* is especially abundant in fens and bogs – Kajak et al. (2000) found it among the dominant spider species in natural fens in Poland; Koponen (2002b, 2003) found this species dominating in peatbogs of Finland; and Rėlys et al. (2002) wrote that *A. elegans* is typically abundant peatbog species in Lithuania. *A. elegans* has been recorded also in other studies where fens and bogs have been investigated (e.g., Vilbaste 1980; Kupryjanowicz et al. 1998; Koponen 2002a).	**Hygrophilous** | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist
Linyphiidae	*Agyneta mollis* (O. Pickard-Cambridge, 1871)	It is associated with damp conditions (Harvey et al. 2002a; Oxbrough et al. 2007). It lives mainly in grasslands (Harvey et al. 2002a; Arachnologische Gesellschaft 2018), but can be found also in woods (Locket and Millidge 1953). Occurs also in mires, including fens and bogs (Vilbaste 1980; Oxbrough et al. 2006).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist
	Agyneta subtilis (O. Pickard-Cambridge, 1863)	This species is a forest generalist (Matveinen-Huju et al. 2006) – it has been found in different types of forest habitats, including broad-leaved woodland (Harvey et al. 2002a), pine forest (Rėlys and Dapkus 2002b), *Sphagnum* birch forest (Arachnologische Gesellschaft 2018). Can be found also in other habitats, for example, meadows, bogs, coastal and heathland habitats (Rėlys and Dapkus 2002b; Nentwig et al. 2012; Arachnologische Gesellschaft 2018). This species is indifferent as regards soil moisture (Matveinen-Huju et al. 2006).	Hygrophilous | Xerophilous; Photophilous | **Sciophilous**; Habitat generalist *Sub-group:* Forest generalist
	Allomengea vidua (L. Koch, 1879)	It is found in a variety of usually very damp and flooded habitats, e.g., different swamps and marshes (Harvey et al. 2002a; Oxbrough et al. 2006; Nentwig et al. 2012). Kajak et al. (2000) has found this species in fens of Poland.	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist
	Bathyphantes gracilis (Blackwall, 1841)	A typical species for moist habitats (Koponen 2002b; Matveinen-Huju et al. 2006). It can be found in grasslands, heathlands, forests (Harvey et al. 2002a; Nentwig et al. 2012), as well as in fens (Vilbaste 1980; Kajak et al. 2000) and bogs (Koponen 2002a,b; Rėlys et al. 2002). Also, *B. gracilis* is an agrobiont – it is very common in open agricultural habitats, for example, meadows and fields (Bonte et al. 2002; Pommeresche 2004; Cristofoli et al. 2010). The species is a common aeronaut (Locket and Millidge 1953; Bonte et al. 2002; Harvey et al. 2002a).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-group:* Agrobiontic species
	Bathyphantes nigrinus (Westring, 1851)	It is a hygrophilous species (Aakra 2002; Matveinen-Huju et al. 2006) which seems to have an affinity for forests (Harvey et al. 2002a; Cristofoli et al. 2010). It mainly occurs in very damp and shadowed places, especially in bog forests (Nentwig et al. 2012). In Latvia it has been found on fens by Cera et al. (2010).	**Hygrophilous** | Xerophilous; Photophilous | **Sciophilous**; Habitat generalist
	Bathyphantes parvulus (Westring, 1851)	It is predominantly a grassland spider that occurs in acid grasslands, chalk grasslands and meadows (Harvey et al. 2002a; Cristofoli et al. 2010). This species, however, can also be found on fens (Kajak et al. 2000), bogs (Koponen 2002a) and forests (Heimer and Nentwig 1991; Nentwig et al. 2012).	Hygrophilous | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist *Sub-group:* Grassland species
	Bolyphanthes alticeps (Sundevall, 1833)	It is indifferent as regards light intensity (Matveinen-Huju et al. 2006) and can be found in a variety of habitats – in grasslands, forest edges, coniferous and broad-leaved woodlands (Harvey et al. 2002a; Nentwig et al. 2012). It can also occur in fens and bogs (Vilbaste 1980; Arachnologische Gesellschaft 2018).	Hygrophilous | Xerophilous; Photophilous | Sciophilous; **Habitat generalist**
	Centromerus semiater (L. Koch, 1879)	It can be found in a wide range of wet habitats, for example, in bogs, fens, reed-beds, humid meadows etc. (Kajak et al. 2000; Stańska et al. 2000; Harvey et al. 2002a). Also, the species can be detected in coastal habitats (Arachnologische Gesellschaft 2018).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-group:* Hygrophilous generalist
	Ceratinella brevipes (Westring, 1851)	It might be found in various habitats, including seasonally wet and wet grasslands (Arachnologische Gesellschaft 2018), wet woodland with *Sphagnum* (Glime and Lissner 2013), reed-beds (Harvey et al. 2002a), open agricultural habitats (Cristofoli et al. 2010), as well as in other situations (Harvey et al. 2002a; Nentwig et al. 2012; Arachnologische Gesellschaft 2018). Kajak et al. (2000) found the species in fens, but Vilbaste (1980) – in fens and bogs.	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-group:* Hygrophilous generalist

Family	Species	Description of the species habitat preferences	Ecological group(s)
Linyphiidae	*Diplostyla concolor* (Wider, 1834)	It can be found in a wide variety of situations – in grasslands, hedgerows, gardens, humid forests, marshes and shadowed watersides (Harvey et al. 2002a; Nentwig et al. 2012). Overall, *D. concolor* seems to prefer forest habitats (Stańska et al. 2000; Pommeresche 2002, 2004; Buchholz 2009; Gallé et al. 2011). Also, this species is quite common in habitats with a high level of human disturbance, such as vineyards (Harvey et al. 2002a; Isaia et al. 2007; Arachnologische Gesellschaft 2018).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist
	Dismodicus elevatus (C. L. Koch, 1838)	A species that is related with trees, particularly with conifers – it occurs in pine forests and in fir and spruce woodlands (Matveinen-Huju et al. 2006; Arachnologische Gesellschaft 2018). *D. elevatus* can be found mostly under pines, on the lower branches of pines, and also on heather, gorse and juniper (Locket and Millidge 1953; Harvey et al. 2002a; Nentwig et al. 2012). Can be also found in fens and bogs (Vilbaste 1980; Rėlys et al. 2002; Cera et al. 2010).	Hygrophilous | Xerophilous; Photophilous | **Sciophilous**; Habitat generalist *Sub-group:* Coniferous forest species
	Erigone arctica (White, 1852)	It prefers humid conditions (Nentwig et al. 2012). This species is mainly associated with coastal habitats (Hänggi et al. 1995) – it occurs on the seashore and the shoreline of estuaries where it can be found amongst stones and seaweed (Locket and Millidge 1953; Harvey et al. 2002a). Irmler et al. (2002) have discovered *E. arctica* in the coastal salt marsh. Inland this species can also be found in saline areas (Harvey et al. 2002a; Duffey 2005).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-groups:* Coastal species, Halophilous species
	Erigone atra Blackwall, 1833 *&* *Erigone dentipalpis* (Wider, 1834)	Both these spiders can be classified as pioneer species (Aakra 2002). *E. atra* is an universally distributed species – it is one of the commonest spiders that often disperse aeronautically in large numbers (Locket and Millidge 1953; Harvey et al. 2002a). The second species – *E. dentipalpis* – occurs in a similarly wide range of habitats as *E. atra*, and is an equally common aeronaut (Locket and Millidge 1953; Harvey et al. 2002a). Both these linyphiids have also been described as ruderal species – they show a high frequency of occurrence in ruderal sites, fields and gardens, i.e., sites of agricultural disturbance (Bonte et al. 2002; Cole et al. 2003). In addition, both of these linyphiids have been found among the most abundant species in different European agroecosystems, and thus are also called agrobiont species (Thomas and Jepson 1997; Feber et al. 1998; Ratschker and Roth 2000; Pommeresche 2004; Thorbek and Bilde 2004; Schmidt and Tscharntke 2005; Öberg et al. 2007; Pommeresche et al. 2013).	Hygrophilous | Xerophilous; Photophilous | Sciophilous; **Habitat generalist** *Sub-group:* Agrobiontic species
	Erigonella hiemalis (Blackwall, 1841)	It has been recorded in a wide variety of habitats (Harvey et al. 2002a; Nentwig et al. 2012; Arachnologische Gesellschaft 2018), but perhaps its main habitat is forest (Locket and Millidge 1953; Harvey et al. 2002a; Oxbrough et al. 2006; Nentwig et al. 2012). The species can also occur in bogs (Vilbaste 1980). According to Matveinen-Huju et al. (2006), *E. hiemalis* is indifferent as regards soil moisture.	Hygrophilous | Xerophilous; Photophilous | Sciophilous; **Habitat generalist**
	Erigonella ignobilis (O. Pickard-Cambridge, 1871)	It usually occurs in damp, swampy habitats, damp litter and low vegetation at the edge of open water (Locket and Millidge 1953; Harvey et al. 2002a; Oxbrough et al. 2006; Nentwig et al. 2012). It has been found in Atlantic hay meadows, seasonally wet and wet grasslands (Arachnologische Gesellschaft 2018), as well as in mires (Vilbaste 1980; Arachnologische Gesellschaft 2018).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist
	Floronia bucculenta (Clerck, 1757)	It occurs in damp places in a variety of habitats (Harvey et al. 2002a). It can be found in mires, reed-beds, grasslands, open woodland, on earthy banks, in damp forest edges and elsewhere (Locket and Millidge 1953; Harvey et al. 2002a; Rėlys and Dapkus 2002; Nentwig et al. 2012; Arachnologische Gesellschaft 2018).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-group:* Hygrophilous generalist
	Gnathonarium dentatum (Wider, 1834)	A strictly hygrophilous species – it is usually found near water (Hänggi et al. 1995; Nentwig et al. 2012). It occurs, for example, by the side of streams (Locket and Millidge 1953), in reed swamps (Duffey 2005) and in other flooded habitats (Harvey et al. 2002a; Cattin et al. 2003). Vilbaste (1980) has found this species in fens and bogs of Estonia.	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist

Family	Species	Description of the species habitat preferences	Ecological group(s)
Linyphiidae	*Gongylidiellum latebricola* (O. Pickard-Cambridge, 1871)	It can be found in wet habitats (Oxbrough et al. 2006). It occurs in damp situations in woodland, grasslands, and bogs (Harvey et al. 2002a). The main habitats of this species seems to be different forests, including fir and spruce woodlands, *Sphagnum* birch woods, beech woodland, pine forests etc. (Locket and Millidge 1953; Matveinen-Huju et al. 2006; Nentwig et al. 2012; Arachnologische Gesellschaft 2018).	**Hygrophilous** | Xerophilous; Photophilous | **Sciophilous**; Habitat generalist
	Kaestneria pullata (O. Pickard-Cambridge, 1863)	It is common in wet habitats such as marshlands, reed-beds, seeps, drainage ditches, wet grasslands etc. (Harvey et al. 2002a; Oxbrough et al. 2006; Arachnologische Gesellschaft 2018). Can be also found in fens (Vilbaste 1980; Kajak et al. 2000; Cera et al. 2010) and bogs (Vilbaste 1980).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-group:* Hygrophilous generalist
	Linyphia hortensis Sundevall, 1830	It can be found in various habitats (Nentwig et al. 2012; Arachnologische Gesellschaft 2018), however, it is mostly found in woods (Locket and Millidge 1953; Roberts 1996; Harvey et al. 2002a; Arachnologische Gesellschaft 2018). It occurs, for example, in broadleaved deciduous woodlands, mixed deciduous-coniferous woodlands, mixed fir-spruce-beech woodlands and in other forest types (Arachnologische Gesellschaft 2018).	Hygrophilous | Xerophilous; Photophilous | **Sciophilous**; Habitat generalist
	Micrargus herbigradus (Blackwall, 1854)	It is usually found in forests (Locket and Millidge 1953; Harvey et al. 2002a; Nentwig et al. 2012; Arachnologische Gesellschaft 2018). It occurs in different forest types – in beech woodlands, fir and spruce woodlands, *Sphagnum* birch woods, broadleaved deciduous woodlands and others (Arachnologische Gesellschaft 2018). This species, however, inhabits also bogs – Šternbergs (1991) has found it in a Baži bog in Latvia, while Spuņģis (2008) has caught it in several different bogs of Latvia. Vilbaste (1980) has found *M. herbigradus* in bogs of Estonia, but Rėlys and Dapkus (2002) collected this species in a pine bog and the surrounding pine forest in Lithuania.	Hygrophilous | Xerophilous; Photophilous | **Sciophilous**; Habitat generalist *Sub-group:* Forest generalist
	Microlinyphia impigra (O. Pickard-Cambridge, 1871)	It inhabits marshy habitats (Roberts 1996; Harvey et al. 2002a; Nentwig et al. 2012). It can be found in the littoral zone of inland surface waterbodies, reed-beds and mires (Arachnologische Gesellschaft 2018). Koponen (2000) has found this species on sandy shores (Koponen 2000).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist
	Microlinyphia pusilla (Sundevall, 1830)	It has an affinity for moist open habitats (Heimer and Nentwig 1991; Nentwig et al. 2012). It can be found in heathland, dune, saltmarsh and other wet habitats, but is perhaps commonest in grasslands (Harvey et al. 2002a; Arachnologische Gesellschaft 2018). It has been found also in bogs (Vilbaste 1980) and fens (Vilbaste 1980; Kajak et al. 2000).	**Hygrophilous** | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist
	Neriene montana (Clerck, 1757)	It can be found on bushes and low vegetation and on tree trunks, logs and a variety of other structures in a range of habitats (Roberts 1996). This species, however, occurs mainly in woodland and other shady places (Harvey et al. 2002a; Oxbrough et al. 2006). It can be found also on bogs (Vilbaste 1980).	Hygrophilous | Xerophilous; Photophilous | **Sciophilous**; Habitat generalist
	Notioscopus sarcinatus (O. Pickard-Cambridge, 1873)	It prefers humid conditions (Locket and Millidge 1953; Nentwig et al. 2012). It occurs in wet, marshy areas, especially in different kinds of mires, including fens (Vilbaste 1980; Kajak et al. 2000; Boyce 2004) and bogs (Vilbaste 1980; Šternbergs 1991; Kupryjanowicz et al. 1998; Pommeresche 2002; Rėlys and Dapkus 2002). The species is mainly found in tall moss (*Sphagnum*, *Polytrichum*), often under pine or other trees in the swampy places (Harvey et al. 2002a; Nentwig et al. 2012). *N. sarcinatus* can also be found in moist grasslands (Hänggi et al. 1995; Arachnologische Gesellschaft 2018).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist
	Pocadicnemis pumila (Blackwall, 1841)	It occurs in a variety of situations, including grasslands, heathlands, forests, marshes (Locket and Millidge 1953; Harvey et al. 2002a; Biteniekytė, Rėlys 2008; Nentwig et al. 2012). Overall, however, it prefers moist habitats (Heimer and Nentwig 1991; Nentwig et al. 2012). It seems to be a typical species in bogs (Vilbaste 1980; Kupryjanowicz et al. 1998; Rėlys and Dapkus 2002; Rėlys et al. 2002; Koponen 2003), and can be found also in fens (Vilbaste 1980; Kajak et al. 2000).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist

Family	Species	Description of the species habitat preferences	Ecological group(s)
Linyphiidae	*Styloctetor compar* (Westring, 1861)	According to Nentwig et al. (2012), the species needs humid conditions. *S. compar* is mainly a grassland spider (Arachnologische Gesellschaft 2018), but it can also be found in peatbogs and weatlands (Miller 1971).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist
	Tallusia experta (O. Pickard-Cambridge, 1871)	A wetland species which inhabits a variety of wet marshy habitats (Harvey et al. 2002a; Oxbrough et al. 2006), including bogs, fens and reed-beds (Harvey et al. 2002a; Koponen 2002a; Rėlys and Dapkus 2002; Rėlys et al. 2002). *T. experta* can also be found in wet meadows and forest edges (Heimer and Nentwig 1991; Nentwig et al. 2012).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-group:* Hygrophilous generalist
	Tenuiphantes cristatus (Menge, 1866)	It can be found in a variety of damp, forested habitats (Harvey et al. 2002a; Matveinen-Huju et al. 2006). It occurs, for example, in beech woodland, broad-leaved swamp woodland on acid peat, birch and pine on *Sphagnum*, juniper scrub on limestone etc. (Harvey et al. 2002a; Arachnologische Gesellschaft 2018). According to Heimer and Nentwig (1991) and Nentwig et al. (2012), *T. cristatus* lives mainly in deciduous forests. It can also be found on bogs (Rėlys et al. 2002; Spuņģis 2008).	**Hygrophilous** | Xerophilous; Photophilous | **Sciophilous**; Habitat generalist
	Trichopternoides thorelli (Westring, 1861)	It is associated with wet conditions but it is not bound to any particular habitat (Oxbrough et al. 2007; Nentwig et al. 2012). It can be found, for example, in wet heathlands, fens and bogs (Vilbaste 1980; Harvey et al. 2002a).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-group:* Hygrophilous generalist
	Typhochrestus digitatus (O. Pickard-Cambridge, 1873)	It inhabits dry and warm locations, for example, sandhills, heathlands, grasslands and other bare or sparsely vegetated habitats (Locket and Millidge 1953; Harvey et al. 2002a; Nentwig et al. 2012; Arachnologische Gesellschaft 2018). This species seems to have a distinct preference for coastal habitats (e.g., grey dunes, coastal grasslands), at least in central Europe (Hänggi et al. 1995; Bonte et al. 2003, 2004).	Hygrophilous | **Xerophilous**; **Photophilous** | Sciophilous; Habitat generalist *Sub-group:* Coastal species
	Walckenaeria alticeps (Denis, 1952)	It inhabits different types of forest habitats – it has been recorded from beech woodland, *Sphagnum* birch woods, fir and spruce forest, pine forest (Rėlys and Dapkus 2002; Biteniekyté and Rélys 2008; Arachnologische Gesellschaft 2018), as well as from forest edges (Duffey 2005). Also, this species is usually found in *Sphagnum* bogs, including both open bogs and pine bogs (Kupryjanowicz et al. 1998; Harvey et al. 2002b; Rėlys and Dapkus 2002; Rėlys et al. 2002; Biteniekyté and Rélys 2008), as well as in other sites with moist and shaded *Sphagnum* (Harvey et al. 2002b; Nentwig et al. 2012). The species can be found also in coastal dunes and sandy shores (Arachnologische Gesellschaft 2018).	**Hygrophilous** | Xerophilous; Photophilous | **Sciophilous**; Habitat generalist
	Walckenaeria atrotibialis (O. Pickard-Cambridge, 1878)	It occurs in various moist habitats (Harvey et al. 2002a; Matveinen-Huju et al. 2006). This species is indifferent as regards light intensity (Matveinen-Huju et al. 2006) – it has been found in different open habitats such as grasslands, fens, bogs (Kupryjanowicz et al. 1998; Harvey et al. 2002a; Koponen 2002b; Rėlys et al. 2002; Spuņģis 2008), as well as in shaded habitats (Stańska et al. 2000; Buchholz 2010; Arachnologische Gesellschaft 2018).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist
	Walckenaeria vigilax (Blackwall, 1853)	It occurs in wet habitats (Harvey et al. 2002a; Matveinen-Huju et al. 2006; Oxbrough et al. 2006; Nentwig et al. 2012). It can be found in grasslands, saltmarshes, arable land, gardens and in other places (Harvey et al. 2002a; Arachnologische Gesellschaft 2018). In Norway, *W. vigilax* is a typical riparian species which is restricted to river banks (Aakra 2002).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-group:* Riparian species (in Norway)
Liocranidae	*Agroeca dentigera* Kulczyński, 1913	In the continental Europe this species can be found in a variety of damp habitats, especially on mires (Kajak et al. 2000; Harvey et al. 2002b; Koponen 2002b; Rėlys and Dapkus 2002a; Rėlys et al. 2002), while in the United Kingdom this species occurs in coastal sand dunes (Harvey et al. 2002b).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Note:* Preferred habitats differ geographically

Family	Species	Description of the species habitat preferences	Ecological group(s)
Liocranidae	*Agroeca proxima* (O. Pickard-Cambridge, 1871)	It has a preference for fairly dry habitats (Roberts 1996; Harvey et al. 2002b). It is one of the commonest species on heathland (Harvey et al. 2002b). It is also a characteristic species of coastal dunes and sandy shores (Almquist 2006; Finch et al. 2007; Arachnologische Gesellschaft 2018). Also, it can be found in woodland clearings, dry pine woods (Roberts 1996; Almquist 2006) and on bogs (Kupryjanowicz et al. 1998; Koponen 2002a,b; Rėlys and Dapkus 2002; Rėlys et al. 2002; Biteniekyté, Rėlys 2008).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-group:* Heathland species
	Liocranoeca striata (Kulczyński, 1882)	It occurs in different moist places with no clear preference for any particular type of wet habitat (Harvey et al. 2002b). It can be found in habitats such as bogs, fens, wet heathlands, wet grasslands, damp woodland sites, forest meadows, stony shores and other similar habitats (Roberts 1996; Kajak et al. 2000; Harvey et al. 2002b; Almquist 2006).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-group:* Hygrophilous generalist
	Scotina palliardi (L. Koch, 1881)	The data of Kupryjanowicz et al. (1998) showed that this species does not occur outside raised peat bogs, so they suggested to classify it as a tyrphobiont (= species that inhabits only bogs). Indeed, many studies confirm that *S. palliardi* is very frequent in bogs (Vilbaste 1980; Šternbergs 1991; Kupryjanowicz et al. 1998 Rėlys and Dapkus 2002; Koponen 2002a,b, 2003; Rėlys et al. 2002; Rėlys and Dapkus 2002a,b; Koponen 2003; Biteniekyté and Rėlys 2008; Spuņģis 2008). Nevertheless, this species can also be found in chalk grasslands and heathlands, at least in central Europe (Roberts 1996; Bonte et al. 2003, 2004; Almquist 2006; Nentwig et al. 2012; Arachnologische Gesellschaft 2018).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-group:* Bog species
Lycosidae	*Alopecosa pulverulenta* (Clerck, 1757)	It has been found in many different open habitat types such as meadows, pastures, heathland, moorland, dunes, open forests, old quarries, urban gardens and cultivated land (Locket and Millidge 1951; Roberts 1996; Harvey et al. 2002b; Almquist 2005; Nentwig et al. 2012). It has also been frequently reported from peat bogs (Vilbaste 1980; Šternbergs 1991; Kupryjanowicz et al. 1998; Koponen 2002a,b; Rėlys and Dapkus 2002; Rėlys et al. 2002; Spuņģis 2008). Kajak et al. (2000) have found this species in fens.	Hygrophilous | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist *Sub-group:* Photophilous generalist
	Arctosa leopardus (Sundevall, 1833)	It favors wet, open habitats (Roberts 1996; Oxbrough et al. 2006). It occurs in wet heathlands, dune slacks (Harvey et al. 2002b), sand dunes, stony shores (Almquist 2005), open agricultural habitats (Cristofoli et al. 2010), reed belts, humid grasslands (Buchholz and Schröder 2013), fens (Kajak et al. 2000) and bogs (Vilbaste 1980). At the same time *A. leopardus* seems to be a halophilous species – in a couple of studies it was associated with salty habitats (Finch et al. 2007; Buchholz 2009).	**Hygrophilous** | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist *Sub-group:* Halophilous species
	Aulonia albimana (Walckenaer, 1805)	It usually prefers sunny and dry habitats (Nentwig et al. 2012; Arachnologische Gesellschaft 2018). It inhabits chalk grasslands, heathlands, sparse and rocky pine-woods, quarries (Harvey et al. 2002b; Bonte et al. 2004; Almquist 2005). It can also be found in bogs (Rėlys and Dapkus 2002; Rėlys et al. 2002; Štambuk and Erben 2002; Koponen 2003).	Hygrophilous | **Xerophilous**; **Photophilous** | Sciophilous; Habitat generalist
	Hygrolycosa rubrofasciata (Ohlert, 1865)	It is found in damp habitats (Harvey et al. 2002b). It mainly occurs in wet forests and in fens (Locket and Millidge 1951; Vilbaste 1980; Roberts 1996; Kajak et al. 2000; Harvey et al. 2002b; Nentwig et al. 2012). According to Štambuk and Erben (2002), *H. rubrofasciata* is an alder forest species. This species can also be found in damp meadows (Almquist 2005) and on bogs (Vilbaste 1980; Kupryjanowicz et al. 1998; Koponen 2002b; Štambuk and Erben 2002; Rėlys et al. 2002; Biteniekyté and Rėlys 2008).	**Hygrophilous** | Xerophilous; Photophilous | **Sciophilous**; Habitat generalist *Sub-group:* Alder forest species
	Pardosa fulvipes (Collett, 1876)	It is mainly associated with grasslands (Holm and Kronestedt 1970; Roberts 1996; Almquist 2005) and arable land (Holm and Kronestedt 1970; Huhta and Raatikainen 1974; Almquist 2005). This species can be found also on wetlands, including fens and bogs (Vilbaste 1980; Komposch 2000).	Hygrophilous | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist

Family	Species	Description of the species habitat preferences	Ecological group(s)
Lycosidae	*Pardosa lugubris* (Walckenaer, 1802)	It is a very common species in woods, especially on forest edges and in woodland clearings (Roberts 1996; Almquist 2005). It never seems to occur very far from woods (Locket and Millidge 1951) and can be found in the habitats edging forests (Aakra 2002; Biteniekyté and Rėlys 2008). Koponen (2005) has recorded this species at the burned forest. *P. lugubris* occurs on mires as well – it has been found in fens (Kajak et al. 2000) and bogs (Vilbaste 1980; Kupryjanowicz et al. 1998; Rėlys et al. 2002).	Hygrophilous | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist *Sub-group:* Ecotonal forest species
	Pardosa prativaga (L. Koch, 1870) & *Pardosa pullata* (Clerck, 1757)	Both these species are often found together (Locket and Millidge 1951; Roberts 1996), however, *P. prativaga* is not so common as *P. pullata* which is one of the commonest species of the genus (Locket and Millidge 1951; Roberts 1996). Both species occur in a wide variety of open habitats, including grasslands, heathlands, woodland clearings, dunes, old quarries and roadside verges, as well as in wet places such as dyke edges, damp meadows, water borders and swampy areas (Locket and Millidge 1951; Harvey et al. 2002b; Almquist 2005; Nentwig et al. 2012; Arachnologische Gesellschaft 2018). Both of these species have been found in fens (Vilbaste 1980; Kajak et al. 2000) and bogs (Vilbaste 1980; Kupryjanowicz et al. 1998; Rėlys et al. 2002). *P. pullata* has been found in bogs also by Koponen (2002a,b) and Spuņģis (2008).	**Hygrophilous** | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist
	Pardosa proxima (C. L. Koch, 1847)	It can be found in a variety of sparsely vegetated habitats but usually in moist and marshy places (Locket and Millidge 1951; Harvey et al. 2002b). This species is most likely to be found at coastal sites including earthy cliffs, saltmarsh, dune slacks and in streamside habitats (Harvey et al. 2002b). It often occurs also in grasslands and fields, in damp situations (Roberts 1996; Nentwig et al. 2012). In addition, *P. proxima* seems to be associated with habitats of anthropogenic disturbances, for example, gardens and arable land (Bonte et al. 2002; Harvey et al. 2002b; Arachnologische Gesellschaft 2018).	**Hygrophilous** | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist
	Pardosa saltans Töpfer-Hofmann, 2000	It occurs mainly in forests (Bonte et al. 2002; Harvey et al. 2002b; Nentwig et al. 2012; Barsoum et al. 2014). It prefers broadleaved deciduous woodland, but can also occur in coniferous woodland (Arachnologische Gesellschaft 2018). The species might also be found in other habitats, for example, in anthropogenic herb stands, hedgerows, vineyards etc. (Arachnologische Gesellschaft 2018).	Hygrophilous | Xerophilous; Photophilous | **Sciophilous**; Habitat generalist
	Pardosa sphagnicola (Dahl, 1908)	It is found in damp or marshy habitats and is related with *Sphagnum* mosses (Roberts 1996; Almquist 2005; Matveinen-Huju et al. 2006; Glime and Lissner 2013). This species can be classified as tyrphobiontic species according to Peus (1928). *P. sphagnicola* has been found in peat bogs by numerous authors, and it is usually among the most common and abundant species in different bog habitats in Europe (Vilbaste 1980; Kupryjanowicz et al. 1998; Koponen 2002a,b, 2003; Rėlys et al. 2002; Rėlys and Dapkus 2002; Spuņģis 2008). In addition, some authors have reported this species also from fens (Vilbaste 1980; Kajak et al. 2000).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-groups:* Bog species, Sphagnophilous species
	Pirata piraticus (Clerck, 1757)	It is a strictly hygrophilous species (Hänggi et al. 1995). It lives near standing or slowly flowing water (Heimer and Nentwig 1991; Cattin et al. 2003; Nentwig et al. 2012). This species might be found in a variety of wet, marshy areas such as pond and stream margins (Harvey et al. 2002b; Graham et al. 2003), fens (Vilbaste 1980; Kajak et al. 2000), bogs (Vilbaste 1980; Koponen 2002a; Pommeresche 2002; Rėlys et al. 2002; Spuņģis 2008) and in other habitats (Arachnologische Gesellschaft 2018). Graham et al. (2003) defined *P. piraticus* as a semi-aquatic spider, since it was strongly associated with moist substrates and was active in the upper littoral zone of a pond.	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-group:* Semi aquatic species

Family	Species	Description of the species habitat preferences	Ecological group(s)
Lycosidae	*Pirata piscatorius* (Clerck, 1757)	It is always found in very damp areas (Harvey et al. 2002b; Glime and Lissner 2013), most often near standing or slowly flowing water (Harvey et al. 2002b; Nentwig et al. 2012). Peus (1928) has classified *P. piscatorius* as a tyrphobiontic species. Indeed, this species is more typical for bog habitats (Koponen 2002a,b; Bruun, Toft 2004; Oliger 2004), however it can also be found in other wetlands as well, including fens (Vilbaste 1980; Kajak et al. 2000; Glime and Lissner 2013). This species shows a clear preferences for *Sphagnum* mosses – in bogs it is usually confined to the *Sphagnum* area of the habitat (Bruun, Toft 2004), and, in addition, the species can also be found in *Sphagnum* birch woods (Arachnologische Gesellschaft 2018).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-groups:* Bog species; Sphagnophilous species
	Pirata tenuitarsis Simon, 1876	It is mainly found in *Sphagnum* bogs often in the vicinity of bog pools (Roberts 1996; Harvey et al. 2002b). This species can be found also on fens, in wet heathlands, reed-beds, grasslands, woodland fringes and clearings (Kajak et al. 2000; Komposch 2000; Harvey et al. 2002b; Arachnologische Gesellschaft 2018).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-group:* Bog species
	Pirata uliginosus (Thorell, 1856)	According to Casemir (1976) this species is a true tyrphobiont. The recent evidence, however, shows that although this species is characteristic of bogs, it is not confined to them and thus is not a strict tyrphobiont but rather a tyrphophilous species (Hänggi et al. 1995; Neet 1996; Buchholz 2016). In any case, *P. uliginosus* is usually one of the characteristic and often most abundant species on European peat bogs (e.g., Kupryjanowicz et al. 1998; Koponen 2002a,b, 2003; Rėlys et al. 2002; Rėlys and Dapkus 2002). This species can also be found in fens, grasslands, heathland, woods (Kajak et al. 2000; Harvey et al. 2002b; Almquist 2005; Arachnologische Gesellschaft 2018). Overall, *P. uliginosus* prefers damp, open habitats (Štambuk and Erben 2002; Oxbrough et al. 2006; Nentwig et al. 2012). However, despite that *P. uliginosus* is a hygrophilous species (Štambuk and Erben 2002; Nentwig et al. 2012), in contrast to other species of this genus (e.g., *Pirata piscatorius*, *Pirata piraticus*, *Pirata tenuitarsis*, *Pirata* (*Piratula*) *hygrophilus* and *Pirata* (*Piratula*) *latitans*), *P. uliginosus* is least depending on high humidity and can occur in quite dry situations (Roberts 1985, 1996; Harvey et al. 2002b; Almquist 2005; Nentwig et al. 2012).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-group:* Bog species
	Piratula hygrophilus (Thorell, 1872)	It can be found in damp habitats (Locket and Millidge 1951; Roberts 1996), however it is not normally associated with open water (Harvey et al. 2002b). This species seems to occur mainly in woods (Cristofoli et al. 2010) – it has an affinity to swampy forests and other wet, shady habitats (Kupryjanowicz et al. 1998; Harvey et al. 2002b; Štambuk and Erben 2002; Nentwig et al. 2012). In a couple of studies this species has been reported to be typical for alder forests (Stańska et al. 2000; Štambuk and Erben 2002). It can also be found in *Sphagnum* birch woods very often (Arachnologische Gesellschaft 2018). Nevertheless, *P. hygrophilus* can also occur in wet, open habitats, like damp grasslands (Harvey et al. 2002b; Almquist 2005; Oxbrough et al. 2006). Also, *P. hygrophilus* has been found in fens (Vilbaste 1980), as well as in bogs of Europe (Vilbaste 1980; Šternbergs 1991; Kupryjanowicz et al. 1998; Pommeresche 2002; Rėlys et al. 2002; Spuņģis 2008; Buchholz 2016).	**Hygrophilous** | Xerophilous; Photophilous | **Sciophilous**; Habitat generalist *Sub-group:* Alder forest species
	Piratula knorri (Scopoli, 1763)	It is mainly associated with inland surface waters (Arachnologische Gesellschaft 2018). It inhabits littoral zone of inland surface waterbodies and unvegetated river gravel banks (Nentwig et al. 2012; Arachnologische Gesellschaft 2018), as well as damp areas in woodland (Roberts 1996).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist

Family	Species	Description of the species habitat preferences	Ecological group(s)
Lycosidae	*Piratula latitans* (Blackwall, 1841)	It is associated with wet habitats which are open to sunshine (Cattin et al. 2003; Oxbrough et al. 2006; Nentwig et al. 2012). This species inhabits open marshes, fens, bogs, reed belts, humid grasslands (Roberts 1996; Harvey et al. 2002b; Buchholz and Schröder 2013). Vilbaste (1980) has found *P. latitans* in Estonian fens, while Kajak et al. (2000) have found it among the dominant spider species in natural fens of Poland. *P. latitans* is less associated with *Sphagnum* bogs than other species of the *Pirata* genus, though it can be found on *Sphagnum* (Harvey et al. 2002b).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist
	Trochosa ruricola (De Geer, 1778)	It can be found in a range of different wet habitats (Roberts 1996). It occurs in marshes, reed belts, humid grasslands, on the sides of ditches, on shores and elsewhere (Harvey et al. 2002b; Almquist 2005; Buchholz and Schröder 2013). Kajak et al. (2000) found this species in fens, while Rėlys et al. (2002) – in bogs. In Latvia this species has previously been found in Baži bog (Šternbergs 1991; Spuņģis 2008).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-group:* Hygrophilous generalist
	Trochosa spinipalpis (F. O. Pickard-Cambridge, 1895)	It can be found in a variety of damp habitat types (Roberts 1996), including bogs, fens, wet heathlands and damp meadows (Vilbaste 1980; Kajak et al. 2000; Harvey et al. 2002b; Almquist 2005; Cristofoli et al. 2010; Nentwig et al. 2012). *T. spinipalpis* is usually among the most abundant species in peat bogs of Europe (Kupryjanowicz et al. 1998; Koponen 2002a,b, 2003; Rėlys and Dapkus 2002; Rėlys et al. 2002; Spuņģis 2008).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-group:* Hygrophilous generalist
	Trochosa terricola Thorell, 1856	It is found in a wide variety of habitats, including woodlands, forest edges, grasslands, heathlands, coastal dunes, sandy shores, vineyards, industrial sites and many other places (Harvey et al. 2002b; Almquist 2005; Isaia et al. 2007; Arachnologische Gesellschaft 2018). *T. terricola* can also be found on mire habitats, especially on bogs (Šternbergs 1991; Kupryjanowicz et al. 1998; Komposch 2000; Pommeresche 2002; Spuņģis 2008). It should be noted, however, that there are some contradictions in the literature about the habitat preferences of this species. Some literature sources say that *T. terricola* shows a preference for drier conditions (Locket and Millidge 1951; Rėlys and Dapkus 2002), while other literature says that it is a hygrophilous species, which can be found in a variety of damp habitats (Roberts 1996; Aakra 2002). In addition, some authors suggest that *T. terricola* is typically a forest spider (Rėlys and Dapkus 2002; Štambuk and Erben 2002). Most authors, however, agree that *T. terricola* is a habitat generalist (e.g., Hänggi et al. 1995; Graham et al. 2003; Mallis and Hurd 2005; Oxbrough et al. 2007).	Hygrophilous | Xerophilous; Photophilous | Sciophilous; **Habitat generalist**
	Xerolycosa nemoralis (Westring, 1861)	It seems to prefer dry places – it can be found in heathlands, stony chalk grasslands, forest edges and woodland clearings (Locket and Millidge 1951; Roberts 1996; Harvey et al. 2002b; Nentwig et al. 2012). The species also occurs in forests (Cristofoli et al. 2010; Arachnologische Gesellschaft 2018) and bogs (Vilbaste 1980). In addition, *X. nemoralis* favors open, dry and warm areas, which are human-influenced, e.g., sparsely vegetated ground at post-industrial sites (Harvey et al. 2002b), dried peat bogs (Koponen 1979), burned sites (Harvey et al. 2002b; Moretti et al. 2002; Koponen 2005).	Hygrophilous | **Xerophilous**; Photophilous | Sciophilous; Habitat generalist
Miturgidae	*Zora nemoralis* (Blackwall, 1861)	It is associated mainly with forests – it can be found in or near woods (Harvey et al. 2002b), in woodland clearings (Roberts 1996), in moist forest meadows (Almquist 2006). The species can, however, also occur in heather (Locket and Millidge 1951; Almquist 2006) and in other habitats (Arachnologische Gesellschaft 2018).	Hygrophilous | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist *Sub-group:* Ecotonal forest species

Family	Species	Description of the species habitat preferences	Ecological group(s)
Miturgidae	*Zora spinimana* (Sundevall, 1833)	A widespread and common species (Locket and Millidge 1951; Nentwig et al. 2012). Although it is suggested to be a grassland spider by some authors (Harvey et al. 2002b; Cristofoli et al. 2010), it seems to be indifferent as regards light intensity (Matveinen-Huju et al. 2006), and can be found also in forests (Rėlys and Dapkus 2002; Biteniekytė and Rėlys 2008), as well as in a wide variety of other habitats (Locket and Millidge 1951; Roberts 1996; Harvey et al. 2002b; Biteniekytė and Rėlys 2008; Arachnologische Gesellschaft 2018). Thus, *Z. spinimana* could be classified as an ubiquitous species (Roberts 1996; Koponen 2002b; Cattin et al. 2003). *Z. spinimana* can also be found in fens (Vilbaste 1980; Kajak et al. 2000) and bogs (Vilbaste 1980; Kupryjanowicz et al. 1998; Koponen 2002b; Rėlys and Dapkus 2002; Rėlys et al. 2002).	Hygrophilous | Xerophilous; Photophilous | Sciophilous; **Habitat generalist**
Oxyopidae	*Oxyopes ramosus* (Martini & Goeze, 1778)	It occurs in open, sunny habitats (Arachnologische Gesellschaft 2018), especially in heathlands and similar places, mainly in localities dominated by *Calluna*-heaths (Roberts 1996; Almquist 2005; Aakra and Berggren 2007; Nentwig et al. 2012). The species can also be found in fens and bogs (Vilbaste 1980; Almquist 2005; Aakra and Berggren 2007).	Hygrophilous | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist *Sub-group:* Photophilous generalist
Philodromidae	*Thanatus formicinus* (Clerck, 1757)	It seems to prefer dry habitats (Heimer and Nentwig 1991; Nentwig et al. 2012), especially dry grasslands (Cera 2013; Arachnologische Gesellschaft 2018). It can also be found in forests (Almquist 2006; Arachnologische Gesellschaft 2018), wet heathland (Roberts 1996) and mires (Vilbaste 1980; Harvey et al. 2002b; Koponen 2002a).	Hygrophilous | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist *Sub-group:* Grassland species
	Tibellus maritimus (Menge, 1875)	It occurs in both humid and dry, but sunny habitats (Nentwig et al. 2012). The main habitat types of *T. maritimus* seems to be seashores, coastal sand dunes and marshes with *Carex* and *Cladium mariscus* (Roberts 1996; Bonte et al. 2002; Gajdoš and Toft 2002; Duffey 2005; Almquist 2006). The species can also be found in fens (Vilbaste 1980; Kajak et al. 2000; Cera et al. 2010) and bogs (Vilbaste 1980). *T. maritimus* is usually found close to the sea, however, it can also be detected further inland (Roberts 1996; Duffey 2005).	Hygrophilous | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist *Sub-group:* Coastal species
	Tibellus oblongus (Walckenaer, 1802)	It occurs in situations similar to those of *T. maritimus* (Locket and Millidge 1951), however *T. oblongus* is commoner inland and in damper habitats (Roberts 1996). *T. oblongus* can be found in a variety of dry and damp sunny habitats, including seashores, coastal dunes and grasslands of most types (Hänggi et al. 1995; Harvey et al. 2002b; Almquist 2006; Cera et al. 2010; Nentwig et al. 2012; Cera 2013). The species can also occur on fens (Vilbaste 1980; Cera et al. 2010) and bogs (Vilbaste 1980).	Hygrophilous | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist *Sub-group:* Photophilous generalist
Phrurolithidae	*Phrurolithus festivus* (C. L. Koch, 1835)	It can be found in grasslands, dune heaths, quarries, gardens, and in a variety of similar situations, in both dry and wet conditions (Roberts 1996; Koponen 2000; Harvey et al. 2002b; Almquist 2006; Batáry et al. 2008). Koponen (2005) has recorded it at the burned forest. This species has been found also on bogs (Vilbaste 1980; Rėlys et al. 2002).	Hygrophilous | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist *Sub-group:* Photophilous generalist
Pisauridae	*Dolomedes fimbriatus* (Clerck, 1757)	It occurs in wet, swampy areas (Cattin et al. 2003; Oxbrough et al. 2006; Nentwig et al. 2012). The main habitat of this species is *Sphagnum* bogs and pools, however it can also inhabit moist meadows, alluvial forests, water margins of ditches, ponds, streams and other habitats (Harvey et al. 2002b; Almquist 2005; Nentwig et al. 2012). The literature suggests that *D. fimbriatus* is being found only in those swamps or streams which do not dry up, because this species needs permanent pools of water (Locket and Millidge 1951; Roberts 1996). *D. fimbriatus* can be found in fens and bogs of Europe (Vilbaste 1980; Kajak et al. 2000; Koponen 2002b; Rėlys et al. 2002).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-group:* Semi-aquatic species

Family	Species	Description of the species habitat preferences	Ecological group(s)
Pisauridae	*Dolomedes plantarius* (Clerck, 1757)	A species that is very rarely found (Nentwig et al. 2012), and is thought to be in decline throughout Europe (Collins and Wells 1987). This species is associated with damp places such as mires, wet meadows, ponds, banks of rivers, lakes and ditches (Andrušaitis 1998; Holec 2000; Almquist 2005). The main habitats of *D. plantarius*, however, seems to be fens (Collins and Wells 1987; Helsdingen 1993; Roberts 1996; Andrušaitis 1998) and the littoral zone of inland surface waterbodies (Holec 2000; Arachnologische Gesellschaft 2018). *D. plantarius* strongly depends on the presence of water – a permanent, whole year round water surface is obligatory for this species (Helsdingen 1993).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-group:* Semi-aquatic species
	Pisaura mirabilis (Clerck, 1757)	It is common almost everywhere (Locket and Millidge 1951; Cattin et al. 2003), but seems to prefer open habitats (Nentwig et al. 2012). It can be found in grasslands, heathlands, open woods, woodland clearings, gardens and other places (Locket and Millidge 1951; Roberts 1996; Harvey et al. 2002b; Almquist 2005; Arachnologische Gesellschaft 2018). The species has been found also in fens and bogs (Vilbaste 1980).	Hygrophilous | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist *Sub-group:* Photophilous generalist
Salticidae	*Euophrys frontalis* (Walckenaer, 1802)	It is the commonest species of the genus (Roberts 1996) which can be found in various habitats (Harvey et al. 2002b; Arachnologische Gesellschaft 2018), including forests, meadows and bogs (Vilbaste 1980; Roberts 1996; Rėlys et al. 2002; Almquist 2006). In Latvia this species has previously been found in Baži bog (Šternbergs 1991; Spuņģis 2008).	Hygrophilous | Xerophilous; Photophilous | Sciophilous; **Habitat generalist**
	Evarcha arcuata (Clerck, 1757)	It can be found mostly in open, moist habitats (Cattin et al. 2003; Nentwig et al. 2012). It occurs mainly on heathland in damp areas (Roberts 1996; Harvey et al. 2002b), although it can also be found on dry heathland (Harvey et al. 2002b; Nentwig et al. 2012). *E. arcuata* can occur also in meadows (Nyffeler and Benz 1988; Almquist 2006), fens (Vilbaste 1980; Cera et al. 2010) and bogs (Vilbaste 1980; Šternbergs 1991; Rėlys et al. 2002; Spuņģis 2008).	**Hygrophilous** | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist
	Heliophanus cupreus (Walckenaer, 1802)	It seems to prefer sunny conditions (Harvey et al. 2002b; Arachnologische Gesellschaft 2018). Overall, however, it can be found in a variety of situations – meadows, woods, forest edges, glades, raised bogs, shingle beaches etc. (Roberts 1996; Harvey et al. 2002b; Almquist 2006; Nentwig et al. 2012). It can also be found in disturbed habitats such as wastelands and quarries (Harvey et al. 2002b).	Hygrophilous | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist
	Leptorchestes berolinensis (C. L. Koch, 1846)	It occurs on the bark of trees, on fences, on sunny walls, buildings and on other artificial habitats (Roberts 1996; Nentwig et al. 2012; Arachnologische Gesellschaft 2018).	Hygrophilous | **Xerophilous**; **Photophilous** | Sciophilous; Habitat generalist
	Marpissa radiata (Grube, 1859)	It is associated with wet habitats – it can be found in swamps with *Cladium mariscus* and *Carex elata*, on shores of lakes among *Iris pseudacorus* (Almquist 2006), on cattail in still water (Nentwig et al. 2012), in fens (Vilbaste 1980; Cera et al. 2010) and bogs (Vilbaste 1980). According to Holec (2000) *M. radiata* is a specialist of the eulittoral zone. Overall, in the continental Europe this species is widespread in wet habitats generally, while in the United Kingdom it seems to be confined to fens (Harvey et al. 2002b).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Sub-group:* Hygrophilous generalist
	Sibianor aurocinctus (Ohlert, 1865)	It does not appear to be restricted to any particular habitat type apart from the need for dry, warm and sparsely vegetated places (Heimer and Nentwig 1991; Harvey et al. 2002b; Nentwig et al. 2012; Arachnologische Gesellschaft 2018). The species occurs among short vegetation (grass, heather) and amongst stones (Locket and Millidge 1951; Roberts 1996; Harvey et al. 2002b). This species can also be found in human-influenced sites such as sand or chalk quarries and post-industrial sites (Harvey et al. 2002b).	Hygrophilous | **Xerophilous**; **Photophilous** | Sciophilous; Habitat generalist

Family	Species	Description of the species habitat preferences	Ecological group(s)
Salticidae	*Sitticus caricis* (Westring, 1861)	It seems to have an affinity for swampy areas (Roberts 1996; Harvey et al. 2002b). It has been found in fens, bogs, *Carex*-swamps, damp meadows and moors (Vilbaste 1980; Kajak et al. 2000; Almquist 2006; Nentwig et al. 2012).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist
	Synageles venator (Lucas, 1836)	It occurs in dry and warm localities, amongst low vegetation, on sandy to rocky ground (Nentwig et al. 2012). This species has mainly been found in sand dunes on the coast and among similar vegetation in fens (Locket and Millidge 1951; Roberts 1996; Harvey et al. 2002b; Duffey 2005). Gajdoš and Toft (2002) recorded this species in dune habitats on the Danish North Sea coast, while Perttula (1984) found it on the coastal sand dunes in Finland. Cera et al. (2010) have also detected this species in a couple of coastal habitats in Latvia. *S. venator* can also be found in birch woods, bogs, fens, on cultivated land, on walls of buildings and on other artificial habitats (Roberts 1996; Almquist 2006; Nentwig et al. 2012; Arachnologische Gesellschaft 2018).	Hygrophilous | **Xerophilous**; Photophilous | Sciophilous; Habitat generalist
	Talavera aequipes (O. Pickard-Cambridge, 1871)	It occurs mainly in dry, warm, sunny habitats with bare surfaces (Harvey et al. 2002b; Nentwig et al. 2012). It has been found in dune heaths, grasslands, sandy or stony banks, quarries and old railway embankments (Harvey et al. 2002b; Duffey 2005; Almquist 2006). It has been found also in fens and bogs (Vilbaste 1980).	Hygrophilous | **Xerophilous**; **Photophilous** | Sciophilous; Habitat generalist
Sparassidae	*Micrommata virescens* (Clerck, 1757)	It might be found in quite different habitats (Cattin et al. 2003; Arachnologische Gesellschaft 2018). According to Roberts (1996) and Harvey et al. (2002b) it prefers damp sheltered woodlands and woodland clearings, but according to Nentwig et al. (2012) the species prefers sunny and warm conditions. *M. virescens* has been found also on fens (Vilbaste 1980; Cera et al. 2010) and bogs (Vilbaste 1980; Biteniekyté, Rélys 2008).	Hygrophilous | Xerophilous; Photophilous | Sciophilous; **Habitat generalist**
Tetragnathidae	*Pachygnatha clercki* Sundevall, 1823	It seems to occur mostly near water, e.g., at the edges of ponds, rivers and streams (Harvey et al. 2002b; Nentwig et al. 2012). This species has been found, for example, in damp meadows (Almquist 2005; Nentwig et al. 2012), bogs (Vilbaste 1980; Rėlys et al. 2002), fens (Vilbaste 1980; Kajak et al. 2000), and swamp forests (Stańska et al. 2000).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist
	Tetragnatha nigrita Lendl, 1886	It is most commonly found on trees and shrubs (Roberts 1996; Harvey et al. 2002b; Nentwig et al. 2012). Interestingly, that Glime and Lissner (2013) suggest that this species is largely confined to branches of trees growing on *Sphagnum* bogs and fens, and is only rarely found on the same tree species growing outside bogs and fens. In other literature, however, it is stated that *T. nigrita* can be found on trees in damp woodland (Nentwig et al. 2012), on trees that grow on shores, as well as on fruit trees (Almquist 2005). Although the species is most often found near water (Nentwig et al. 2012), it can also be found in drier situations (Harvey et al. 2002b).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist
Theridiidae	*Crustulina guttata* (Wider, 1834)	It can be found in both deciduous and pine forests (Roberts 1996; Harvey et al. 2002a; Almquist 2005; Arachnologische Gesellschaft 2018), as well as in open habitats such as meadows (Almquist 2005; Matveinen-Huju et al. 2006). *C. guttata* occurs in drier situations than *C. sticta* – while *C. sticta* prefers wet habitats, *C. guttata* can be usually found on dry, sandy soils (Locket and Millidge 1953; Roberts 1996; Harvey et al. 2002a; Bonte et al. 2003).	Hygrophilous | **Xerophilous**; Photophilous | Sciophilous; Habitat generalist
	Crustulina sticta (O. Pickard-Cambridge, 1861)	It lives in wet swampy places such as fens and bogs (Locket and Millidge 1953; Vilbaste 1980; Roberts 1996; Almquist 2005; Nentwig et al. 2012). This species has also been found in several bogs of Latvia (Šternbergs 1991; Spuņģis 2008). Also, *C. sticta* has been recorded from damp heaths, on shingle and amongst marram on dunes (Harvey et al. 2002a).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist

Family	Species	Description of the species habitat preferences	Ecological group(s)
Theridiidae	*Enoplognatha ovata* (Clerck, 1757)	It seems to prefer open and sunny habitats (Harvey et al. 2002a; Nentwig et al. 2012), but still it needs the presence of shrubs, bushes, trees or the vicinity of woods (Almquist 2005; Isaia et al. 2007). This species is typical of open habitats containing low broad-leaved vegetation, for example, road verges, domestic gardens and woodland glades (Harvey et al. 2002a). *E. ovata* might also be found in different kinds of forests, dry grasslands, woodland fringes, vineyards near woods and elsewhere (Isaia et al. 2007; Arachnologische Gesellschaft 2018). The species has also been found in fens (Kajak et al. 2000) and bogs (Vilbaste 1980).	Hygrophilous | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist *Sub-group:* Ecotonal forest species
	Episinus angulatus (Blackwall, 1836)	It occurs in a wide variety of habitats – in grasslands, mires, woodland clearings, forests etc. (Harvey et al. 2002a; Rėlys and Dapkus 2002; Arachnologische Gesellschaft 2018). Overall, however, it seems to prefer damp situations (Harvey et al. 2002a; Oxbrough et al. 2006; Nentwig et al. 2012). The species is usually found on shrubs and bushes (Heimer and Nentwig 1991; Almquist 2005; Nentwig et al. 2012).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist
	Euryopis flavomaculata (C. L. Koch, 1836)	It is reported to be found in damp or boggy places (Locket and Millidge 1953; Roberts 1996; Oxbrough et al. 2006), however, in central Europe it is mainly found in dry habitats, for example, in chalk grasslands, heathlands, coastal dunes (Bonte et al. 2003, 2004; Arachnologische Gesellschaft 2018). The species can also occur in different types of forests – coniferous, deciduous, as well as in mixed forests (Nentwig et al. 2012; Arachnologische Gesellschaft 2018). Koponen (2005) has recoraded *E. flavomaculata* at the burned forest in Finland. In Europe, this species can also be found on fens (Kajak et al. 2000) and bogs (Vilbaste 1980; Kupryjanowicz et al. 1998; Koponen 2002b; Rėlys et al. 2002; Spuņģis 2008).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist *Note:* Preferred habitats differ geographically
	Neottiura bimaculata (Linnaeus, 1767)	It seems to be able to live under variable conditions (Harvey et al. 2002a; Nentwig et al. 2012; Arachnologische Gesellschaft 2018). Most records of this species, however, have been from open habitats, especially meadows (Nyffeler and Benz 1988; Matveinen-Huju et al. 2006). Heimer and Nentwig (1991) suggest that this species occurs mainly in roadsides.	Hygrophilous | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist
	Phylloneta impressa (L. Koch, 1881)	It can be found in forest edges, meadows, heathlands, ruderal areas and in other open places (Almquist 2005; Nentwig et al. 2012; Arachnologische Gesellschaft 2018). This species occurs also in disturbed habitats such as gardens, arable land, intensively grazed grasslands (Almquist 2005; Horváth et al. 2009; Arachnologische Gesellschaft 2018).	Hygrophilous | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist
	Robertus insignis O. Pickard-Cambridge, 1908	It lives in permanent contact with water, and can be found in marshes (Almquist 2005), in very damp meadows (Nentwig et al. 2012) and in fens (Vilbaste 1980; Kajak et al. 2000).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist
	Theridion varians Hahn, 1833	It is found in a variety of different habitats, for example, in forests, grasslands, hedgerows, woodland fringes, mires and in other places (Arachnologische Gesellschaft 2018). This species can be found mainly on trees and shrubs, and also on other structures, for example, buildings and walls (Locket and Millidge 1953; Roberts 1996; Harvey et al. 2002a; Nentwig et al. 2012).	Hygrophilous | Xerophilous; Photophilous | Sciophilous; **Habitat generalist**
Thomisidae	*Ozyptila brevipes* (Hahn, 1826)	It is usually found in damp, marshy areas (Locket and Millidge 1951; Roberts 1996). It has been found in marshes, in damp alder forests and near the sea (Locket and Millidge 1951; Vilbaste 1980; Harvey et al. 2002b; Almquist 2006). It can, however, also be found in heathlands, grasslands and other drier habitats (Harvey et al. 2002b).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist

Family	Species	Description of the species habitat preferences	Ecological group(s)
Thomisidae	*Ozyptila trux* (Blackwall, 1846)	It has a wide habitat niche (Roberts 1996; Harvey et al. 2002b) – it is indifferent as regards light intensity and as regards moisture (Matveinen-Huju et al. 2006). Locket and Millidge (1951) propose that this is perhaps the commonest species of the genus. *O. trux* occurs in all types of wet and dry grasslands, coastal dunes and sandy shores, open pine woods, edges of deciduous forests, open agricultural habitats and other places (Harvey et al. 2002b; Almquist 2006; Cristofoli et al. 2010; Arachnologische Gesellschaft 2018). The species has also been found in fens (Vilbaste 1980; Kajak et al. 2000) and bogs (Vilbaste 1980; Spuņģis 2008).	Hygrophilous | Xerophilous; Photophilous | Sciophilous; **Habitat generalist**
	Xysticus bifasciatus C. L. Koch, 1837	It is found in habitats with good exposure to the sun (Roberts 1996). The main habitats of the species are dry grasslands and heathland (Harvey et al. 2002b; Almquist 2006; Nentwig et al. 2012; Arachnologische Gesellschaft 2018). It can, however, occur also in fens (Cera et al. 2010) and bogs (Vilbaste 1980).	Hygrophilous | **Xerophilous**; **Photophilous** | Sciophilous; Habitat generalist
	Xysticus chippewa Gertsch, 1953	It can be found in moist habitats – fens, bogs, flood plains and damp meadows (Vilbaste 1980; Almquist 2006; Nentwig et al. 2012).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist
	Xysticus cristatus (Clerck, 1757)	It is the commonest and most widespread species of the genus (Locket and Millidge 1951; Roberts 1996). Large numbers of this species can be found in grasslands (both damp and dry) and habitats which have undergone some degree of disturbance, for example, quarries and agricultural fields (Harvey et al. 2002b; Almquist 2006). *X. cristatus* is also found on fens (Vilbaste 1980; Kajak et al. 2000) and bogs (Vilbaste 1980; Koponen 2002b; Rėlys et al. 2002). Some literature sources say that *X. cristatus* is a generalist which can be found in almost every habitat type (Aakra 2000; Nentwig et al. 2012), however, other authors suggest that this species is shade-intolerant and thus is rare in shaded habitats (Harvey et al. 2002b; Rėlys and Dapkus 2002b; Oxbrough et al. 2006).	Hygrophilous | Xerophilous; Photophilous | Sciophilous; **Habitat generalist**
	Xysticus lineatus (Westring, 1851)	It inhabits damp habitats, for example, damp deciduous woods, bog-forest-like habitats, shores with pebbles (Almquist 2006; Nentwig et al. 2012). It has been found in fens and bogs as well (Vilbaste 1980; Koponen 2002a; Rėlys et al. 2002).	**Hygrophilous** | Xerophilous; Photophilous | Sciophilous; Habitat generalist
	Xysticus ulmi (Hahn, 1831)	It can be found in damp, marshy habitats (Locket and Millidge 1951; Roberts 1996), and is preferring those wet habitats which are open (Rėlys and Dapkus 2002; Matveinen-Huju et al. 2006; Oxbrough et al. 2006). *X. ulmi* can be found in grasslands, shores, cultivated land, roadside verges etc. (Heimer and Nentwig 1991; Harvey et al. 2002b; Almquist 2006). The species inhabits also mires (Almquist 2006; Arachnologische Gesellschaft 2018), including fens (Vilbaste 1980; Kajak et al. 2000; Cera et al. 2010) and bogs (Vilbaste 1980; Rėlys et al. 2002).	**Hygrophilous** | Xerophilous; **Photophilous** | Sciophilous; Habitat generalist

Our study also showed that not only the within-habitat diversity but also the features of the landscape (i.e., the composition of the surrounding habitats) might be very important determinants of the spider species composition of the focal habitat. For example, in the studied fens we have collected several forest species, some of which were detected in fens in a rather great abundance. The occurrence of these forest-related species in our fen habitats could be associated with the fact that all our studied fens were surrounded by forested habitats. Similarly, the presence of coastal and halophilous species within our studied fens might also be largely explained by the proximity of appropriate habitats, since all the studied fens lie in the coastal lowland. Other researchers have also suggested that spider composition of a particular habitat is influenced by the quality of adjacent habitats (e.g., Uetz et al. 1999; Cobbold and MacMahon 2012). In addition, the quantity of nearby habitats also seems to be important: Gallé et al. (2011), for example, discovered that the number of forest specialist species increases in open habitats with increasing proportion of surrounding forests. Thereby, we must emphasise that different spatial scales should always be taken into account in the arachnological investigations, since not only local but also landscape variables could affect the spider fauna of the studied habitat.

Spiders in the present study were sampled by two different techniques, pitfall trapping and sweep netting. Both these methods are among the most popular techniques in spider surveys while pitfall traps have been used extensively for studies on surface-dwelling spiders (e.g., Rėlys et al. 2002; Koponen 2003; Seyfulina 2005; Fetykó 2008), the sweep-net is perhaps the most widely used piece of equipment for sampling spiders from vegetation (e.g., Turnbull 1960; Seyfulina 2005; Fetykó 2008; Horváth et al. 2009). It has been shown that pitfall trapping and sweep netting target different species (Samu and Sarospataki 1995). This was also true in our study: overall, quite different spider species (and even families) were collected with each of these methods (see Appendix 1). We need to emphasize, however, that it is quite hard to compare the obtained data, since using various methods in different sites may influence the results. Other studies have shown that the efficiency of pitfall trapping and sweep netting varies greatly with the structure of the surrounding vegetation (Henderson 2003; Sutherland 2006; Samways et al. 2010). Greenslade (1964), for example, has found that taller vegetation in the vicinity of the pitfall traps hinders invertebrate movement. The sweep netting possess some problems as well – although this method can be used on most vegetation, it is ineffective in some vegetation types, e.g. tall reeds, very short vegetation or flattened vegetation (Sutherland 2006; Henderson 2003). Also, sweep netting is relatively ineffective on sparsely vegetated ground (Sutherland 2006). Thus, we must conclude that it is very difficult to compare catches between different calcareous fens, since our studied fens differed quite greatly from each other in terms of the plant species composition and vegetation height (Štokmane et al. 2013; Štokmane and Spuņģis 2014, 2016). Furthermore, pitfall trapping and sweep netting tend to collect spider species that exhibit different foraging strategies. For example, pitfall traps collect mostly surface-living spiders with an active hunter lifestyle, e.g., many lycosids (Topping and Sunderland 1992; Mallis and Hurd 2005), however, some ground web builders such as those from the family Linyphiidae, can also be adequately sampled (Coyle 1981; Standen 2000). Pitfall traps will not efficiently sample spiders which inhabit the upper vegetation layers (Standen 2000). Sweep netting, on the contrary, is used to catch spiders which occur on the top of the vegetation (Southwood and Henderson 2000). This method is appropriate in low vegetation (Sutherland 2006) and it only collects those spiders that do not fall off on the approach of the collector (Henderson 2003). The sweep net captures primarily aerial web builders (e.g., Araneidae), however aerial hunters could also be collected (Coyle 1981). Overall, it can be concluded that pitfall trapping and sweep netting are methods that successfully complement each other.

In the present study we have also sampled several new spider species for the fauna of Latvia. Recording new species could mainly be explained by insufficient studies in calcareous fens, therefore we suggest that these habitats should be investigated further. In the future studies it would be worthwhile to use a combination of different other spider collection methods (e.g., hand collecting, beating, sieving, suction sampling, etc.) so that a greater variety of microhabitats is accessed. Also, it would be desirable to extend the sampling season throughout the spring, summer and autumn as well as to include both day and night collection, since it is known that spiders exhibit different seasonal and diel activity patterns (Coddington et al. 1996; Marc et al. 1999). Ideally, if the researchers could follow a standardized and optimized sampling protocol when collecting spiders (such as already-existing methodology prepared by Cardoso (2009)), because this could allow future studies in cooperation between different research teams.

The main conclusion from the present study is that calcareous fens are very diverse habitats not only structurally and floristically but also from the arachnofaunistic point of view. Our study showed that calcareous fens contain a very wide range of different spider species, including not only those that need wet and open habitats but also those that prefer other types of microhabitats (e.g., dry, shady, acid, salty, etc.). Besides, we found that along with the terrestrial spider ecological groups, calcareous fens can harbour also semi-aquatic and even aquatic spider species. Overall, however, calcareous fens are poorly investigated habitats, and therefore many spider species might still be undiscovered in this unique mire habitat type. Thereby, in order to get a more accurate picture of the spider fauna of the calcareous fens, these habitats should definitely be investigated further.

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Appendix I

List of spider species and the number of adult individuals caught in the calcareous fens of Latvia by pitfall trapping and/or sweep netting in the summers of three consecutive years (2010, 2011, 2012). Genera and species are sorted alphabetically within each family. Morphospecies are excluded from the table. Abbreviations of the fens: A – Apšuciems, K – Kaņieris, E-1 – Engure-1, E-2 – Engure-2, P – Platene, Ķ – Ķirba, J – Ječi, V – Vītiņi, S – Slītere. Spider species which are new for the fauna of Latvia are marked with asterisk (*).

Family	Species	Fens 2010 (pitfalls)					Fens 2011 (sweep)								Apšuciems 2012	
		A	K	E-1	E-2	P	A	K	E	P	V	S	Ķ	J	sweep	pitfalls
Agelenidae	*Agelena labyrinthica* (Clerck, 1757)				2	2										2
Araneidae	*Araneus alsine* (Walckenaer, 1802)														1	
	Araneus diadematus Clerck, 1757						3						1		3	
	Araneus quadratus Clerck, 1757														3	
	Araniella cucurbitina (Clerck, 1757)														3	
	Argiope bruennichi (Scopoli, 1772)							1			2		2			
	Larinioides cornutus (Clerck, 1757)											1				
	Mangora acalypha (Walckenaer, 1802)														1	
	Neoscona adianta (Walckenaer, 1802)														8	
	Singa hamata (Clerck, 1757)														8	
Clubionidae	*Clubiona germanica* Thorell, 1871														6	
	Clubiona reclusa O. Pickard-Cambridge, 1863					2										
	Clubiona stagnatilis Kulczyński, 1897					2										
	Clubiona subsultans Thorell, 1875															2
Dictynidae	*Argenna subnigra* (O. Pickard-Cambridge, 1861)			3												
	Argyroneta aquatica (Clerck, 1757)				2	5										2
Eutichuridae	*Cheiracanthium erraticum* (Walckenaer, 1802)										1					1
	Cheiracanthium punctorium (Villers, 1789) *														2	1
Gnaphosidae	*Drassodes lapidosus* (Walckenaer, 1802)		5	1	10											
	Drassodes pubescens (Thorell, 1856)	2	4	1												
	Drassyllus lutetianus (L. Koch, 1866)	12	8	24	24	69										3
	Drassyllus praeficus (L. Koch, 1866)	1														

Family	Species	Fens 2010 (pitfalls)					Fens 2011 (sweep)								Apšuciems 2012	
		A	K	E-1	E-2	P	A	K	E	P	V	S	Ķ	J	sweep	pitfalls
Gnaphosidae	*Drassyllus pusillus* (C. L. Koch, 1833)		10		1											
	Gnaphosa bicolor (Hahn, 1833)		1		20											
	Gnaphosa lapponum (L. Koch, 1866) *	1														
	Gnaphosa nigerrima L. Koch, 1877 *	1			21											
	Haplodrassus moderatus (Kulczyński, 1897)															1
	Haplodrassus signifer (C. L. Koch, 1839)		3	2												2
	Haplodrassus silvestris (Blackwall, 1833)			9	7	14										1
	Micaria pulicaria (Sundevall, 1831)			2		8										
	Poecilochroa variana (C. L. Koch, 1839)				1											
	Zelotes clivicola (L. Koch, 1870)		1													
	Zelotes latreillei (Simon, 1878)	5	4	4	8											1
	Zelotes subterraneus (C. L. Koch, 1833)															1
Hahniidae	*Antistea elegans* (Blackwall, 1841)	139	1	35	124	28										104
Linyphiidae	*Agyneta mollis* (O. Pickard-Cambridge, 1871)															2
	Agyneta subtilis (O. Pickard-Cambridge, 1863)															1
	Allomengea vidua (L. Koch, 1879)															16
	Bathyphantes gracilis (Blackwall, 1841)			4												12
	Bathyphantes nigrinus (Westring, 1851)															1
	Bathyphantes parvulus (Westring, 1851) *	44	32	16	8	13										11
	Bolyphanthes alticeps (Sundevall, 1833)		1													
	Centromerus semiater (L. Koch, 1879) *															2
	Ceratinella brevipes (Westring, 1851)	3														
	Diplostyla concolor (Wider, 1834)	2		1	3											
	Dismodicus elevatus (C. L. Koch, 1838)					3										
	Erigone arctica (White, 1852)															4
	Erigone atra Blackwall, 1833					36										
	Erigone dentipalpis (Wider, 1834)						2									
	Erigonella hiemalis (Blackwall, 1841)	20		1		46										2
	Erigonella ignobilis (O. Pickard-Cambridge, 1871)				10	13										
	Floronia bucculenta (Clerck, 1757)															2
	Gnathonarium dentatum (Wider, 1834)					4				1						
	Gongylidiellum latebricola (O. Pickard-Cambridge, 1871)															3
	Kaestneria pullata (O. Pickard-Cambridge, 1863)			1										1		1
	Linyphia hortensis Sundevall, 1830														1	
	Micrargus herbigradus (Blackwall, 1854)		1		1											
	Microlinyphia impigra (O. Pickard-Cambridge, 1871) *					1										
	Microlinyphia pusilla (Sundevall, 1830)				1			1				1				
	Neriene montana (Clerck, 1757)		3	2	1											
	Notioscopus sarcinatus (O. Pickard-Cambridge, 1873)				16	4										
	Pocadicnemis pumila (Blackwall, 1841)		4		2											2
	Styloctetor compar (Westring, 1861)	5		5	2	2										

Family	**Species**	**Fens 2010 (pitfalls)**					**Fens 2011 (sweep)**								**Apšuciems 2012**	
		A	**K**	**E-1**	**E-2**	**P**	**A**	**K**	**E**	**P**	**V**	**S**	**Ķ**	**J**	**sweep**	**pitfalls**
	Tallusia experta (O. Pickard-Cambridge, 1871)					1										
	Tenuiphantes cristatus (Menge, 1866)	1	1													
	Trichopternoides thorelli (Westring, 1861)	4		1		12										
	Typhochrestus digitatus (O. Pickard-Cambridge, 1873)					16										
	Walckenaeria alticeps (Denis, 1952)	3		3	12	12										9
Liocranidae	*Walckenaeria atrotibialis* (O. Pickard-Cambridge, 1878)	8	1			4										1
	Walckenaeria vigilax (Blackwall, 1853)			1	3	15										
	Agroeca dentigera Kulczyński, 1913				1	1										2
	Agroeca proxima (O. Pickard-Cambridge, 1871)															1
	Liocranoeca striata (Kulczyński, 1882)	22	2	17	3	9										3
	Scotina palliardi (L. Koch, 1881)		2													
	Alopecosa pulverulenta (Clerck, 1757)		28		1	1										
	Arctosa leopardus (Sundevall, 1833)				17	20										
	Aulonia albimana (Walckenaer, 1805)		2													1
	Hygrolycosa rubrofasciata (Ohlert, 1865)	5	11	43	3	2										98
	Pardosa fulvipes (Collett, 1876)	6		19	12	16									4	34
	Pardosa lugubris (Walckenaer, 1802)		2		2											11
	Pardosa prativaga (L. Koch, 1870)	10	24	122	28	571										
	Pardosa proxima (C. L. Koch, 1847)					3										
	Pardosa pullata (Clerck, 1757)	27		26	101	69										3
	Pardosa saltans Töpfer-Hofmann, 2000	1														
	Pardosa sphagnicola (Dahl, 1908)						2			3	2	1	2	3		66
Lycosidae	*Pirata piraticus* (Clerck, 1757)		2													
	Pirata piscatorius (Clerck, 1757)	1														
	Pirata tenuitarsis Simon, 1876 *	16		78	37	204										86
	Pirata uliginosus (Thorell, 1856)	38	144	29	115	32										28
	Piratula hygrophilus (Thorell, 1872)	9		71	51	51										102
	Piratula knorri (Scopoli, 1763)	13		32	3	196										68
	Piratula latitans (Blackwall, 1841)			807												
	Trochosa ruricola (De Geer, 1778)	1				1										2
	Trochosa spinipalpis (F. O. Pickard-Cambridge, 1895)	9	19	13	19	9										
	Trochosa terricola Thorell, 1856				1											122
	Xerolycosa nemoralis (Westring, 1861)															1
Miturgidae	*Zora nemoralis* (Blackwall, 1861)				4											
	Zora spinimana (Sundevall, 1833)	9	18	17	10	7										99
Oxyopidae	*Oxyopes ramosus* (Martini & Goeze, 1778)														54	1
	Thanatus formicinus (Clerck, 1757)		1													
Philodromidae	*Tibellus maritimus* (Menge, 1875)			1	1	1	9	12	12	9		3	11	24	6	
	Tibellus oblongus (Walckenaer, 1802)														5	
Phrurolithidae	*Phrurolithus festivus* (C. L. Koch, 1835)	1	12	5	3	1										16
	Dolomedes fimbriatus (Clerck, 1757)	14	3	7	6	10	8	27	7	9		1	14	8	409	52
Pisauridae	*Dolomedes plantarius* (Clerck, 1757)							5								
	Pisaura mirabilis (Clerck, 1757)				1	1									18	3
	Euophrys frontalis (Walckenaer, 1802)		1	1												
Salticidae	*Evarcha arcuata* (Clerck, 1757)	1	2		1		11	7		1		1	2	4	90	13
	Heliophanus cupreus (Walckenaer, 1802)														24	

Family	Species	Fens 2010 (pitfalls)					Fens 2011 (sweep)								Apšuciems 2012	
		A	**K**	**E-1**	**E-2**	**P**	**A**	**K**	**E**	**P**	**V**	**S**	**Ķ**	**J**	**sweep**	**pitfalls**
Salticidae	*Leptorchestes berolinensis* (C. L. Koch, 1846) *															9
	Marpissa radiata (Grube, 1859)						3	6				4			4	
	Sibianor aurocinctus (Ohlert, 1865)															2
	Sitticus caricis (Westring, 1861)			1												
	Synageles venator (Lucas, 1836)														14	
	Talavera aequipes (O. Pickard-Cambridge, 1871)	1	1	1	3											2
Sparassidae	*Micrommata virescens* (Clerck, 1757)				1											
Tetragnathidae	*Pachygnatha clercki* Sundevall, 1823					11										1
	Tetragnatha nigrita Lendl, 1886														6	
Theridiidae	*Crustulina guttata* (Wider, 1834)	1														
	Crustulina sticta (O. Pickard-Cambridge, 1861)	1														
	Enoplognatha ovata (Clerck, 1757)												1		2	
	Episinus angulatus (Blackwall, 1836)			1	1										1	2
	Euryopis flavomaculata (C. L. Koch, 1836)	3	6	1	6											10
	Neottiura bimaculata (Linnaeus, 1767)	1	1	1	1											
	Phylloneta impressa (L. Koch, 1881)										2				1	
	Robertus insignis O. Pickard-Cambridge, 1908	1		3	1											
	Theridion varians Hahn, 1833														2	
Thomisidae	*Ozyptila brevipes* (Hahn, 1826)			1												
	Ozyptila trux (Blackwall, 1846)	10	2	20	24	5										3
	Xysticus bifasciatus C. L. Koch, 1837					1										
	Xysticus chippewa Gertsch, 1953					1										
	Xysticus cristatus (Clerck, 1757)					3										
	Xysticus lineatus (Westring, 1851)		1													
	Xysticus ulmi (Hahn, 1831)		1		1	3	3	3	1	1			1	1	11	2
Total number of individuals		**452**	**365**	**1433**	**737**	**1541**	**41**	**62**	**20**	**24**	**7**	**12**	**34**	**41**	**687**	**1033**
Total number of species		**40**	**38**	**43**	**52**	**49**	**8**	**8**	**3**	**6**	**4**	**7**	**8**	**6**	**26**	**57**

Appendix 2

The list of all our collected spider species and their occurrence within mire habitats of Europe in other studies. Only those publications in which the full spider species list was available are included. The information about each species is given as presence/absence data. Genera and species are sorted alphabetically within each family.

Family	Species	FENS OF EUROPE			BOGS OF EUROPE						
		Latvia	Estonia	Poland	Latvia	Estonia	Poland	Lithuania		Finland	
		Cera et al. 2010	Vilbaste 1980	Kajak et al. 2000	Šternbergs 1991	Vilbaste 1980	Kupryjanowicz et al. 1998	Rėlys et al. 2002	Rėlys, Dapkus 2002b	Koponen 2002a	Koponen 2002b
Agelenidae	*Agelena labyrinthica* (Clerck, 1757)					×					
Araneidae	*Araneus alsine* (Walckenaer, 1802)					×					
	Araneus diadematus Clerck, 1757	×				×					
	Araneus quadratus Clerck, 1757	×	×	×		×					
	Araniella cucurbitina (Clerck, 1757)		×			×					
	Argiope bruennichi (Scopoli, 1772)										
	Larinioides cornutus (Clerck, 1757)	×		×							
	Mangora acalypha (Walckenaer, 1802)			×					×		
	Neoscona adianta (Walckenaer, 1802)			×							
	Singa hamata (Clerck, 1757)		×	×		×					
Clubionidae	*Clubiona germanica* Thorell, 1871		×			×					
	Clubiona reclusa O. Pickard-Cambridge, 1863					×					
	Clubiona stagnatilis Kulczyński, 1897		×	×		×			×		
	Clubiona subsultans Thorell, 1875		×			×					
Dictynidae	*Argenna subnigra* (O. Pickard-Cambridge, 1861)			×							
	Argyroneta aquatica (Clerck, 1757)		×			×					
Eutichuridae	*Cheiracanthium erraticum* (Walckenaer, 1802)		×			×					
	Cheiracanthium punctorium (Villers, 1789)										
Gnaphosidae	*Drassodes lapidosus* (Walckenaer, 1802)			×							
	Drassodes pubescens (Thorell, 1856)		×					×	×	×	×
	Drassyllus lutetianus (L. Koch, 1866)		×				×	×	×		
	Drassyllus praeficus (L. Koch, 1866)										
	Drassyllus pusillus (C. L. Koch, 1833)							×	×	×	
	Gnaphosa bicolor (Hahn, 1833)										
	Gnaphosa lapponum (L. Koch, 1866)									×	×
	Gnaphosa nigerrima L. Koch, 1877						×	×	×		×
	Haplodrassus moderatus (Kulczyński, 1897)		×			×		×		×	
	Haplodrassus signifer (C. L. Koch, 1839)		×			×	×	×	×	×	×
	Haplodrassus silvestris (Blackwall, 1833)							×			
	Micaria pulicaria (Sundevall, 1831)		×			×		×			

Family	Species	FENS OF EUROPE			BOGS OF EUROPE						
		Latvia	Estonia	Poland	Latvia	Estonia	Poland	Lithuania		Finland	
		Cera et al. 2010	Vilbaste 1980	Kajak et al. 2000	Šternbergs 1991	Vilbaste 1980	Kupryjanowicz et al. 1998	Rėlys et al. 2002	Rėlys, Dapkus 2002b	Koponen 2002a	Koponen 2002b
Gnaphosidae	*Poecilochroa variana* (C. L. Koch, 1839)										
	Zelotes clivicola (L. Koch, 1870)						×	×	×		
	Zelotes latreillei (Simon, 1878)			×				×	×	×	
	Zelotes subterraneus (C. L. Koch, 1833)							×	×		
Hahniidae	*Antistea elegans* (Blackwall, 1841)		×	×		×	×	×	×	×	×
Linyphiidae	*Agyneta mollis* (O. Pickard-Cambridge, 1871)		×			×					
	Agyneta subtilis (O. Pickard-Cambridge, 1863)								×		
	Allomengea vidua (L. Koch, 1879)			×							
	Bathyphantes gracilis (Blackwall, 1841)		×	×				×		×	×
	Bathyphantes nigrinus (Westring, 1851)	×									
	Bathyphantes parvulus (Westring, 1851)			×						×	
	Bolyphanthes alticeps (Sundevall, 1833)		×								
	Centromerus semiater (L. Koch, 1879)			×							
	Ceratinella brevipes (Westring, 1851)		×	×		×					
	Diplostyla concolor (Wider, 1834)										
	Dismodicus elevatus (C. L. Koch, 1838)	×	×			×		×			
	Erigone arctica (White, 1852)										
	Erigone atra Blackwall, 1833	×	×	×		×					×
	Erigone dentipalpis (Wider, 1834)		×	×		×					
	Erigonella hiemalis (Blackwall, 1841)					×					
	Erigonella ignobilis (O. Pickard-Cambridge, 1871)		×								
	Floronia bucculenta (Clerck, 1757)								×		
	Gnathonarium dentatum (Wider, 1834)		×			×					
	Gongylidiellum latebricola (O. Pickard-Cambridge, 1871)										
	Kaestneria pullata (O. Pickard-Cambridge, 1863)	×	×	×		×					
	Linyphia hortensis Sundevall, 1830										
	Micrargus herbigradus (Blackwall, 1854)				×	×			×		
	Microlinyphia impigra (O. Pickard-Cambridge, 1871)										
	Microlinyphia pusilla (Sundevall, 1830)		×	×		×					
	Neriene montana (Clerck, 1757)					×					
	Notioscopus sarcinatus (O. Pickard-Cambridge, 1873)		×	×	×	×	×		×		
	Pocadicnemis pumila (Blackwall, 1841)		×	×		×	×	×	×		
	Styloctetor compar (Westring, 1861)										
	Tallusia experta (O. Pickard-Cambridge, 1871)			×				×	×	×	
	Tenuiphantes cristatus (Menge, 1866)							×			
	Trichopternoides thorelli (Westring, 1861)		×			×					

Family	Species	FENS OF EUROPE			BOGS OF EUROPE						
		Latvia	**Estonia**	**Poland**	**Latvia**	**Estonia**	**Poland**	**Lithuania**		**Finland**	
		Cera et al. 2010	**Vilbaste 1980**	**Kajak et al. 2000**	**Šternbergs 1991**	**Vilbaste 1980**	**Kupryjanowicz et al. 1998**	**Rėlys et al. 2002**	**Rėlys, Dapkus 2002b**	**Koponen 2002a**	**Koponen 2002b**
Linyphiidae	*Typhochrestus digitatus* (O. Pickard-Cambridge, 1873)										
	Walckenaeria alticeps (Denis, 1952)						×	×	×		
	Walckenaeria atrotibialis (O. Pickard-Cambridge, 1878)						×	×	×		×
	Walckenaeria vigilax (Blackwall, 1853)			×							
Liocranidae	*Agroeca dentigera* Kulczyński, 1913			×				×			×
	Agroeca proxima (O. Pickard-Cambridge, 1871)						×	×	×	×	×
	Liocranoeca striata (Kulczyński, 1882)			×							
	Scotina palliardi (L. Koch, 1881)				×	×	×	×	×	×	×
Lycosidae	*Alopecosa pulverulenta* (Clerck, 1757)			×	×	×	×	×	×	×	×
	Arctosa leopardus (Sundevall, 1833)			×		×					
	Aulonia albimana (Walckenaer, 1805)							×	×		
	Hygrolycosa rubrofasciata (Ohlert, 1865)		×	×		×	×	×			
	Pardosa fulvipes (Collett, 1876)		×			×					
	Pardosa lugubris (Walckenaer, 1802)			×		×	×	×			
	Pardosa prativaga (L. Koch, 1870)		×	×		×	×	×	×		
	Pardosa pullata (Clerck, 1757)		×	×		×	×	×	×	×	×
	Pardosa proxima (C. L. Koch, 1847)										
	Pardosa saltans Töpfer-Hofmann, 2000										
	Pardosa sphagnicola (Dahl, 1908)		×	×		×	×	×	×	×	×
	Pirata piraticus (Clerck, 1757)		×	×		×		×		×	
	Pirata piscatorius (Clerck, 1757)		×	×						×	×
	Pirata tenuitarsis Simon, 1876			×							
	Pirata uliginosus (Thorell, 1856)			×		×	×	×	×	×	×
	Piratula hygrophilus (Thorell, 1872)		×		×	×	×	×	×		
	Piratula knorri (Scopoli, 1763)										
	Piratula latitans (Blackwall, 1841)		×	×							
	Trochosa ruricola (De Geer, 1778)			×	×			×			
	Trochosa spinipalpis (F. O. Pickard-Cambridge, 1895)		×	×		×	×	×	×	×	×
	Trochosa terricola Thorell, 1856				×		×				
	Xerolycosa nemoralis (Westring, 1861)					×					
Miturgidae	*Zora nemoralis* (Blackwall, 1861)										
	Zora spinimana (Sundevall, 1833)		×	×		×	×	×	×		×
Oxyopidae	*Oxyopes ramosus* (Martini & Goeze, 1778)		×			×					
Philodromidae	*Thanatus formicinus* (Clerck, 1757)		×			×				×	
	Tibellus maritimus (Menge, 1875)	×	×	×		×					
	Tibellus oblongus (Walckenaer, 1802)	×	×			×					

Family	Species	FENS OF EUROPE			BOGS OF EUROPE						
		Latvia	Estonia	Poland	Latvia	Estonia	Poland	Lithuania		Finland	
		Cera et al. 2010	Vilbaste 1980	Kajak et al. 2000	Šternbergs 1991	Vilbaste 1980	Kupryjanowicz et al. 1998	Rėlys et al. 2002	Rėlys, Dapkus 2002b	Koponen 2002a	Koponen 2002b
Phrurolithidae	*Phrurolithus festivus* (C. L. Koch, 1835)					×		×			
Pisauridae	*Dolomedes fimbriatus* (Clerck, 1757)		×	×		×		×	×		×
	Dolomedes plantarius (Clerck, 1757)										
	Pisaura mirabilis (Clerck, 1757)		×			×					
Salticidae	*Euophrys frontalis* (Walckenaer, 1802)				×	×		×			
	Evarcha arcuata (Clerck, 1757)	×	×		×	×		×			
	Heliophanus cupreus (Walckenaer, 1802)										
	Leptorchestes berolinensis (C. L. Koch, 1846)										
	Marpissa radiata (Grube, 1859)	×	×			×					
	Sibianor aurocinctus (Ohlert, 1865)										
	Sitticus caricis (Westring, 1861)		×	×		×					
	Synageles venator (Lucas, 1836)	×	×			×					
	Talavera aequipes (O. Pickard-Cambridge, 1871)		×			×					
Sparassidae	*Micrommata virescens* (Clerck, 1757)	×	×			×					
Tetragnathidae	*Pachygnatha clercki* Sundevall, 1823		×	×		×		×			
	Tetragnatha nigrita Lendl, 1886										
Theridiidae	*Crustulina guttata* (Wider, 1834)		×	×		×		×			
	Crustulina sticta (O. Pickard-Cambridge, 1861)		×		×	×					
	Enoplognatha ovata (Clerck, 1757)			×		×					
	Episinus angulatus (Blackwall, 1836)								×		
	Euryopis flavomaculata (C. L. Koch, 1836)			×		×	×	×			×
	Neottiura bimaculata (Linnaeus, 1767)										
	Phylloneta impressa (L. Koch, 1881)										
	Robertus insignis O. Pickard-Cambridge, 1908		×	×							
	Theridion varians Hahn, 1833					×					
Thomisidae	*Ozyptila brevipes* (Hahn, 1826)		×			×					
	Ozyptila trux (Blackwall, 1846)		×	×		×					
	Xysticus bifasciatus C. L. Koch, 1837	×				×					
	Xysticus chippewa Gertsch, 1953		×								
	Xysticus cristatus (Clerck, 1757)		×	×		×		×			×
	Xysticus lineatus (Westring, 1851)		×			×		×		×	
	Xysticus ulmi (Hahn, 1831)	×	×	×		×		×	×		

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RESEARCH ARTICLE

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A new genus and species of thorny lacewing from Upper Cretaceous Kuji amber, northeastern Japan (Neuroptera, Rhachiberothidae)

Hiroshi Nakamine[1], Shûhei Yamamoto[2]

[1] *Minoh Park Insect Museum, Minoh Park 1-18, Minoh City, Osaka, 562-0002, Japan* [2] *Integrative Research Center, Field Museum of Natural History, 1400 S Lake Shore Drive, Chicago, IL 60605, USA*

Corresponding author: *Hiroshi Nakamine* (nakamine.konchu@osaka.email.ne.jp)

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Abstract

Kujiberotha teruyukii **gen. et sp. n.**, a remarkable new genus and species of Rhachiberothidae, is described from Upper Cretaceous amber from the Kuji area in northeastern Japan. This discovery represents the first record of this family both from Japan and from East Asia. This fossil taxon has the largest foreleg in the subfamily Paraberothinae found to date and its discovery implies that this group had higher morphological diversity in the Cretaceous than it does now. This finding also stresses the importance of the insect inclusions in Kuji amber, which have not been well explored in spite of their potential abundance.

Keywords

fossil, Japan, Mantispoidea, Paraberothinae, Rhachiberothidae, Santonian

Introduction

Rhachiberothidae, or thorny lacewings, are a small family of Neuroptera, which have 13 extant species assigned to three genera as well as rather abundant fossil records and extinct taxa (Table 1): *Hoelzeliella* Aspöck & Aspöck, 1997, *Mucroberotha* Tjeder, 1959, and *Rhachiberotha* Tjeder, 1959 (Aspöck and Mansell 1994; Aspöck and Aspöck 1997 Makarkin and Kupryjanowicz 2010; Makarkin 2015a; Oswald 2018). This family has sometimes been treated as a subfamily (Rhachiberothinae) of Berothidae (e.g., Winterton et al. 2010; Makarkin 2015a), but here we tentatively follow the familial status of Rhachiberothidae on the basis of recent extensive studies (Winterton et al. 2018; Engel et al. 2018). The distribution of the extant rhachiberothids is restricted to sub-Saharan Africa with records from Ethiopia, Zimbabwe, Angola, Namibia, and South Africa (Aspöck and Aspöck 1997). Rhachiberothidae is known as a sister taxon to Berothidae (Aspöck and Mansell 1994; Aspöck et al. 2001, 2012) or Mantispidae (Liu et al. 2015; Engel et al. 2018). These families and the extinct family Mesoberothidae constitute the superfamily Mantispoidea (Winterton et al. 2018; Engel et al. 2018). Mesoberothidae was established by Riek (1955) based on the two forewing fossils from the Upper Triassic Mount Crosby Formation in Australia. This extinct family is considered to be a stem group of Berothidae or it even forms a sister group to the rest of Mantispoidea (Engel et al. 2018).

Rhachiberothidae comprises two subfamilies, Rhachiberothinae and Paraberothinae. Rhachiberothinae includes 13 extant species and two extinct species from mid-Eocene Baltic amber (Whalley 1983; Engel 2004; Makarkin and Kupryjanowicz 2010). Paraberothinae is a uniformly extinct group, which occurred only in the Cretaceous. To date, it is composed of 13 valid species in 12 extinct genera, as well as a single undescribed species of uncertain generic placement. The subfamily is characterized with a combination of eleven morphological characters, e.g., small body size (forewing 2.9–4.2 mm long); antennal scapus long to very long; forelegs raptorial; at least two spines present on the inner edge of protibia (synapomorphy); ScP and RA fused distally in both fore- and hindwings; loss of the intermediate subcostal crossvein in the distal part of the forewing; CuP present in the hindwing (Nel et al. 2005a; Makarkin and Kupryjanowicz 2010; Makarkin 2015a). This group is known from various Cretaceous amber deposits, namely Burmese, Canadian, French, Lebanese and New Jersey amber (Schlüter 1978; Whalley 1980; Grimaldi 2000; Engel 2004; Nel et al. 2005a; Engel and Grimaldi 2008; McKellar and Engel 2009; Petrulevičius et al. 2010; Shi et al. 2015; Makarkin 2015a; Table 1). The taxonomic position of the monotypic species *Oisea celinea* (Nel et al. 2005) (Nel et al. 2005a, b) from the earliest Eocene Oise amber remains uncertain within Rhachiberothidae (Makarkin and Kupryjanowicz 2010). There is no rhachiberothid compression fossil known from anywhere in the world, possibly because of their small, fragile bodies (Petrulevičius et al. 2010).

Fossil rhachiberothid has never been found from Japan or anywhere else in East Asia. Recently, we examined a rhachiberothid fossil, previously considered as a member of Mantodea (Delclòs et al. 2016), found in Upper Cretaceous amber (Santonian) from the Kuji area of northeastern Japan. Herein, a remarkable new genus and species of Paraberothinae is described based on this specimen. Our finding indicates that this subfamily was also distributed in the eastern part of Laurasia, further reinforcing the idea that the distribution of Paraberothinae was widespread. This discovery also suggests a higher morphological diversity of thorny lacewings than previously documented.

Table 1. List of the fossil Rhachiberothidae of the world.

Taxon	Deposit	Reference
Paraberothinae		
Chimerhachiberotha acrasarii Nel et al., 2005	Neocomian, Lebanese amber	Nel et al. 2005a
Paraberotha acra Whalley, 1980	Neocomian, Lebanese amber	Whalley 1980; Nel et al. 2005a
Raptorapax terribilissima Petrulevičius et al., 2010	Neocomian, Lebanese amber	Petrulevičius et al. 2010
Spinoberotha mickaelacrai Nel et al., 2005	Neocomian, Lebanese amber	Nel et al. 2005a
Alboberotha petrulevicii Nel et al., 2005	late Albian, Charentese amber (France)	Nel et al. 2005a
Creagroparaberotha groehni Makarkin, 2015	earliest Cenomanian, Burmese amber	Makarkin 2015a
Eorhachiberotha burmitica Engel, 2004	earliest Cenomanian, Burmese amber	Engel 2004
Paraberothinae sp.: Engel, 2004	earliest Cenomanian, Burmese amber	Engel 2004
Micromantispa cristata Shi et al., 2015	earliest Cenomanian, Burmese amber	Shi et al. 2015
Scoloberotha necatrix Engel & Grimaldi, 2008	earliest Cenomanian, Burmese amber	Engel and Grimaldi 2008
Retinoberotha stuermeri Schlüter, 1978	early Cenomanian, Bezonnais amber (France)	Schlüter 1978
Rhachibermissa phenax Engel & Grimaldi, 2008	Turonian, New Jersey amber	Engel and Grimaldi 2008
Rhachibermissa splendida Grimaldi, 2000	Turonian, New Jersey amber	Grimaldi 2000
Kujiberotha teruyukii gen. et sp. n.	middle Santonian, Kuji amber	this study
Albertoberotha leuckorum McKellar & Engel, 2009	Campanian, Canadian amber	McKellar and Engel 2009
Rhachiberothinae		
Whalfera venatrix (Whalley, 1983)	mid-Eocene, "British" amber*	Whalley 1983; Engel 2004
Whalfera wiszniewskii Makarkin & Kupryjanowicz, 2010	mid-Eocene, Baltic amber	Makarkin and Kupryjanowicz 2010
subfamily *incertae sedis*		
Oisea celinea (Nel et al., 2005)	earliest Eocene, Oise amber	Nel et al. 2005a, b

*This amber is considered contemporarily with Baltic amber (Jarzembowski 1999).

Materials and methods

The specimen described in this study was found in the Kuji City, Iwate Prefecture, northeastern Japan (Fig. 1). The Kuji amber-bearing deposits are from the Upper Cretaceous Tamagawa Formation of the Kuji Group, the age of Kuji amber matrix from this locality has been estimated to be 83–90 Ma (Umetsu and Kurita 2007; Katagiri et al. 2013; Uno et al. 2018). Recently it was indicated that the age of Kuji amber matrix is dated to the middle Santonian, ca. 85.9 ± 0.7 Ma based on a U–Pb radiometric dating of zircon crystals of the volcaniclastic matrix (Arimoto et al. 2018). Kuji amber is the richest source of amber in Japan and it contains many paleontologically important fossils such as relatively abundant insects and a moss (e.g., Kawakami et al. 1994; Fursov et al. 2002; Katagiri et al. 2013).

The specimen is embedded in a piece of elongated oval amber (18.6 × 8.6 × 4.7 mm) with some bubbles, debris, and deep cracks, covered with opaque substance and therefore only partly visible (Fig. 2). The holotype is housed in the Kuji Amber Museum, Kuji City, Iwate Prefecture, Japan.

We observed the specimen using a stereomicroscope SMZ745T and SMZ800 (Nikon corporation, Tokyo, Japan). The photographic data of the specimen was taken with the systems: Canon EOS 80D (Canon Inc., Tokyo, Japan) with EF–S 60mm

Figure 1. Map of the amber locality in Kuji City, Iwate Pref., northeastern Japan.

F2.8 Macro USM (Canon Inc., Tokyo, Japan) plus Kenko Extension Tubes (Kenko-Tokina Co., Tokyo, Japan). Line drawings were prepared by using Adobe Photoshop CC 2018 and Adobe Illustrator CC 2018.

The terminology of wing venations generally follows Kukalová-Peck and Lawrence (2004) as interpreted by Yang et al. (2012).

Systematic paleontology

Order Neuroptera Linnaeus, 1758
Superfamily Mantispoidea Leach, 1815
Family Rhachiberothidae Tjeder, 1959
Subfamily Paraberothinae Nel et al., 2005

Genus *Kujiberotha* gen. n.

http://zoobank.org/D6F5C38C-7080-40E5-A8B6-6FBC748B309A

Type species. *Kujiberotha teruyukii* sp. n.

Etymology. The new genus name is a combination of Kuji City (type locality of this specimen) and the generic name *Berotha*. Gender feminine.

Figure 2. *Kujiberotha teruyukii* gen. et sp. n., holotype. Overview of the whole inclusion in amber. Scale bar: 5.0 mm.

Diagnosis. Antennae moniliform, with at least 50 flagellomeres; forelegs raptorial, profemur long (ca. 1.9 mm), protibia covered with dense fine setae becoming slightly longer towards distal on dorsal edge, together with at least six short spines on ventral edge, probasitarsus with nine small spine-like setae on external ventral ridge; wings with fine setae densely on surface of each vein.

Differential diagnosis. *Kujiberotha* gen. n. can be distinguished from the six paraberothine genera (*Paraberotha*, *Raptorapax*, *Creagroparaberotha*, *Eorhachiberotha*, *Rhachibermissa*, and *Albertoberotha*) by having much larger number of the flagellomeres of the antenna (*Kujiberotha* has over 50 antennal flagellomeres, while these genera have only 20–32 ones). From *Alboberotha* and *Micromantispa*, our new genus can be separated by having greater number of the spine-like setae on the probasitarsus (*Kujiberotha* has 9 setae on the probasitarsus, but there are only two such setae in *Alboberotha* and *Micromantispa*). *Kujiberotha* can be further discriminated from *Scoloberotha*, *Spinoberotha*, and *Chimerhachiberotha* based on the numbers of spines on the protibia (*Kujiberotha* has at least six spines, whereas *Scoloberotha* has only three; *Spinoberotha* has numerous sharp spines on the inner edge disposed in two rows; and, those of *Chimerhachiberotha* are comprised of numerous short setae). Furthermore, the probasitarsus of *Kujiberotha* is not distinctly elongated, while that of *Scoloberotha* is markedly elongated, even longer than the combined length of succeeding tarsomeres. Finally, *Kujiberotha* can be separated from *Retinoberotha* by the structure of the profemora. Namely, *Kujiberotha* has at least six long spines and numerous short spines on the ventral edge of the profemora; however, *Retinoberotha* alternatively has seven short, thin spines or fine setae on the inner lateral edge and they are restricted to the median area of the protibia (Schlüter 1978: fig. 37).

Systematic placement. When this fossil was originally excavated in 2006 by Mr Kazuhisa Sasaki (the former director of the Kuji Amber Museum), it was identified as a member of the order Mantodea and this assignment has been believed to be correct until our study. In a recent summary of the fossil records of Mantodea (Delclòs et al. 2016), this undescribed fossil was placed as "Family *incertae sedis*" within Mantodea. However, we determined this fossil to be a thorny lacewing (Rhachiberothidae: Paraberothinae) based on the following morphological character states: antennae moniliform (filiform in Mantodea, except some taxa of Coptopterygidae, Empusidae, Hymenopodidae, Mantidae, Stenophyllidae, and Toxoderidae); probasitarsus with its external ventral ridge bearing several small spines and one long spine (Mantodea has a slenderer basal segment of the tarsus, lacking such spines); and simple wing venation (Mantodea usually has many crossveins). It is well known that Rhachiberothidae has a clearly raptorial-shaped foreleg, therefore this family can be easily distinguished from Berothidae (except Mesithoninae) (Aspöck and Mansell 1994). The synapomorphy of Paraberothinae is the presence of at least two spines on the inner edge of the protibia (usually with numerous spines; Nel et al. 2005a; Makarkin 2015a). However, there is no report for the presence of these protibial spines from all fossil and extant species of Mantispoidea (except Paraberothinae; uncertain in Mesoberothidae): namely, Rhachiberothinae, *Oisea*, Berothidae (including Mesithoninae), and Mantispidae (Aspöck and Aspöck 1997; Makarkin and Kupryjanowicz 2010; Makarkin 2015a, b). It is therefore noteworthy that *Kujiberotha* gen. n. has at least six spines on the inner edge of the protibia. This character alone supports the placement of *Kujiberotha* gen. n. within Paraberothinae.

Kujiberotha teruyukii sp. n.

http://zoobank.org/BF91E83A-6B50-4099-BEB2-3D7885D0D674
Figs 2–4

Material. Holotype, incomplete specimen of adult, sex undetermined, deposited in the Kuji Amber Museum, Kuji City, Iwate Prefecture, Japan. This specimen is visible only in lateral view and many of the body parts are originally lost or difficult to observe.

Locality and horizon. Kuji amber from the Kokujicho, Kuji City, Iwate Prefecture, northeastern Japan; Tamagawa Formation of the Kuji Group, middle Santonian (ca. 85.9 Ma; see Arimoto et al. 2018), Upper Cretaceous.

Etymology. This remarkable mantispid-like insect is named in honor of the celebrated kabuki actor Mr. Teruyuki Kagawa. He is known for his love of mantises and is enormously popular with insect-loving children in Japan.

Diagnosis. As for the genus (vide supra).

Description. *Head* entirely not clearly visible due to numerous cracks. Compound eyes partially visible. Antennae (Fig. 3A, B) moniliform, flagellum relatively

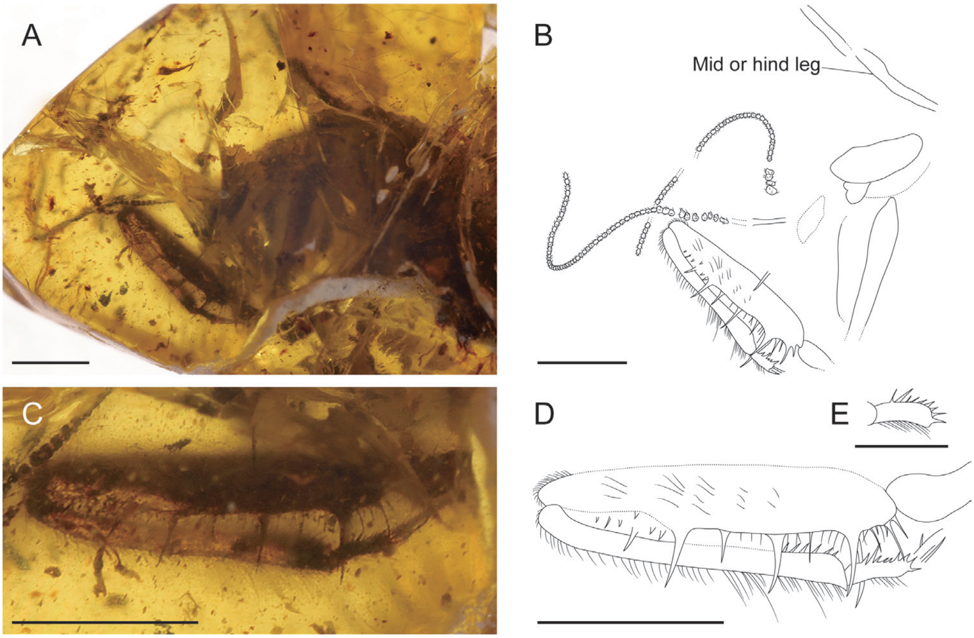

Figure 3. *Kujiberotha teruyukii* gen. et sp. n., holotype. **A** photograph of anterior part **B** line drawing of anterior part **C** photograph of left foreleg **D** line drawing of left foreleg (outer lateral view) **E** line drawing of left probasitarsus (dorsal view). Scale bars: 1 mm (**A, B, C, D**); 0.5 mm (**E**).

long, composed of at least 50 flagellomeres, covered with fine setae on each segment. *Pronotum* elongate, visible only left lateral side, ca. 1.1 mm in length, with scattered setae on dorsal surface. Meso- and metathorax not visible. *Foreleg* (Fig. 3C, D) well preserved. Procoxa very long at least 1.7 mm, not broadened. Protrochanter elongate, slightly curved. Profemur exceedingly long ca. 1.9 mm, slightly broadened, dense fine setae on surface, several long spines and numerous short spines on ventral edge, only slightly curved towards distal. Protibia markedly long ca. 1.7 mm, slender, covered with dense fine setae becoming slightly longer towards distal on dorsal edge, six short spines visible bent towards distal on ventral edge. Protarsus partly preserved, probasitarsus elongate, dense fine setae on surface, with nine small spine-like setae on external ventral ridge (Fig. 3E) and single long curved spine distally. Other tarsomeres not well preserved. Mid- and hindlegs partly visible, slender, covered dense setae. *Abdomen* uniformly lost. *Wings* poorly preserved (Fig. 4), with dense fine setae on veins.

Remarks. The profemur of *Kujiberotha teruyukii* gen. et sp. n. is the longest among the Paraberothinae fossils found to date. The length of the profemur in this subfamily ranges from ca. 0.5 mm in *Spinoberotha mickaelacrai* Nel et al., 2005 to ca. 1.14 mm in *Raptorapax terribilissima* Petrulevičius et al., 2010. Meanwhile, that of *K. teruyukii* is notably longer, ca. 1.9 mm.

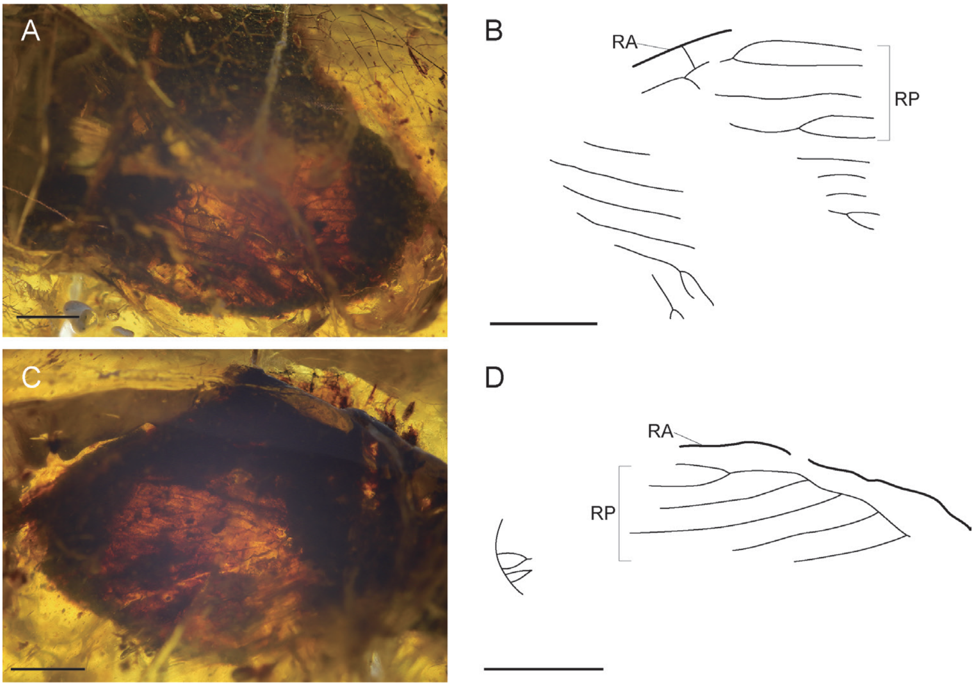

Figure 4. *Kujiberotha teruyukii* gen. et sp. n., holotype. **A** photograph of forewing **B** line drawing of forewing **C** photograph of hindwing **D** line drawing of hindwing. Abbreviations: RA, anterior radius; RP, posterior sector. Scale bars: 1.0 mm.

Discussion

Kujiberotha gen. n. represents the first discovery of Rhachiberothidae from Japan and from East Asia, providing key insights into the past distribution and morphological diversity of thorny lacewings. In fact, the distribution of modern rhachiberothids is limited biogeographically to sub-Saharan Africa (Aspöck and Aspöck 1997). Although fossils of Rhachiberothidae have been reported from major amber deposits ranging from the Lower Cretaceous to the mid-Eocene, the localities of these fossil findings have previously been limited geographically (Table 1). This bias in fossil records is probably better explained by the locations of amber deposits than by the past distribution of rhachiberothids, based on the discovery of *Kujiberotha* gen. n. from Kuji amber. Our finding demonstrates that Paraberothinae was also distributed in the eastern part of Laurasia during the Cretaceous.

With 15 fossil genera, including *Kujiberotha* gen. n., Rhachiberothidae clearly possessed much greater generic diversity in the past than it does now. Indeed, the modern rhachiberothids are composed of only three genera. The discovery of *Kujiberotha* gen. n. adds further evidence for the potentially higher diversity of Rhachiberothidae during the Cretaceous. It seems reasonable to conclude that the remarkable morphological traits among the Cretaceous paraberothines were more diverse than those of other extinct and extant Rhachiberothidae (e.g., numerous long spines on the inner edge of the protibia, whereas all other rhachiberothids bear no spines). As mentioned above, the structures of the foreleg, particularly the presence of nine small spine-like setae on the external ventral ridge of the probasitarsus, have never before been reported from this family. Furthermore, the markedly large profemur of *Kujiberotha* gen. n. is quite unexpected and noteworthy. By contrast, some insects from Upper Cretaceous Burmese amber are miniaturized compared to modern taxa; for example, *Nicrophorus* and *Colon* beetles from this amber deposit are much smaller than their recent counterparts (Cai et al. 2014; Yamamoto and Takahashi 2018). Nonetheless, the true diversity of fossil Rhachiberothidae has not yet been adequately explored. Investigations into this subject should be conducted for amber from minor localities, such as Kuji, and for the Burmese amber due to its exceptionally abundant and diverse insect inclusions.

Kuji amber, with its long mining history, is the largest amber deposit in Japan. In spite of its importance, few studies have explored its insect inclusions (e.g., Kawakami et al. 1994; Fursov et al. 2002). More than 800 insect inclusions from Kuji amber still await formal descriptions (Kawakami et al. 1994). We hope that this paper will provide a foundation for studies of fossil insects in Kuji amber. Finally, we also expect that more fossil rhachiberothids will be discovered in the future, providing direct evidence of their distribution and morphological evolution to corroborate the hypothesis that thorny lacewings in the past were far more diverse than they are now.

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RESEARCH ARTICLE

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A revision of *Syngalepsus* Beier, with the description of two new species from the Central African Republic and Malawi (Mantodea, Tarachodidae)

Nicolas Moulin[1]

1 *82, route de l'école, Saveaumare, 76680, Montérolier, France*

Corresponding author: *Nicolas Moulin* (nmentomo@gmail.com)

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Abstract

The praying mantis subgenus *Syngalepsus* Beier, 1954 occurs in sub-Saharan region and represents the least diverse subgenus of *Galepsus* in Africa (Ehrmann 2002). All species included within the subgenus *Syngalepsus* are comprehensively revised with a distribution stretching from North of Congo Basin to South Africa. Two new species of *Galepsus* (*Syngalepsus*) Beier, 1954 (Mantodea, Tarachodidae) from the Central African Republic (CAR) and Malawi are described. Among several *Galepsus* specimens collected during scientific expeditions of SANGHA, Biodiversité en Terre Pygmée, in CAR's Dzanga-Ndoki National Park, a specimen differed by genitalia conformation and other morphological characters. Two specimens collected in Malawi proved to differ by genitalia morphology. *Galepsus* (*Syngalepsus*) *bucheti* **sp. n.** and *Galepsus* (*Syngalepsus*) *dudleyi* **sp. n.** are described. An identification key for the six species of the subgenus is provided.

Résumé

Les mantes du sous-genre *Syngalepsus* Beier, 1954 se rencontrent en région sub-saharienne et représentent le sous-genre le moins diversifié des *Galepsus* en Afrique (Ehrmann 2002). L'ensemble des espèces du sous-genre *Syngalepsus* sont révisées avec leur distribution s'étirant du nord du bassin du Congo à l'Afrique du Sud. Deux nouvelles espèces de *Galepsus* (*Syngalepsus*) Beier, 1954, provenant de République centrafricaine et du Malawi (Mantodea, Tarachodidae) sont décrites. Parmi les différents spécimens de *Galepsus* rapportés des missions scientifiques du programme SANGHA, Biodiversité en Terre Pygmée, situées au sein du Parc National Dzanga-Ndoki, un individu diffère des autres par la conformation de sa morphologie et ses genitalia. Durant des recherches au Muséum national d'Histoire naturelle, Paris, deux spécimens collectés au Malawi diffèrent par la morphologie de leurs genitalia. *Galepsus* (*Syngalepsus*) *bucheti* **n. sp.** et *Galepsus* (*Syngalepsus*) *dudleyi* **n. sp.** sont décrites. Une clé dichotomique est proposée pour l'identification des six espèces du sous-genre *Syngalepsus* maintenant connues.

Keywords

Africa, Dictyoptera, Dzanga-Ndoki National Park, Key, Malawi, Tarachodinae

Introduction

Subgenus *Syngalepsus* was erected by Max Beier in 1954 to organise some species from the genus *Galepsus* Stål, 1876: *G.* (*S.*) *bipunctatus* described in 1931 and *G.* (*S.*) *denigratus* Beier 1954. Beier also described *G.* (*S.*) *birkenmeierae* in 1969. Kaltenbach described a fourth species, *G.* (*S.*) *beieri,* from South Africa in 1996. In total, four species are currently known (Ehrmann 2002, Otte and Spearman 2005). All species of the subgenus have the vertex, straight or slightly arched, without bump or incision near the eyes and a right phallomere with the posterior apical region rounded and toothless, unlike *Onychogalepsus*. The prosternum has two circular black spots, more or less covered by a black patch. Three of the species are present in Southern Africa: South Africa (Natal) for *G.* (*S.*) *beieri* Kaltenbach (1996: 233); Mozambique and South Africa for *G.* (*S.*) *bipunctatus* Beier (1931: 3) (Type species) and Malawi for *G.* (*S.*) *birkenmeierae* Beier (1969b: 201). The fourth species, *G.* (*S.*) *denigratus* Beier (1954: 19), was collected in Angola (Beier 1969a), Gabon, Republic of Congo, Democratic Republic of Congo and Uganda (Beier 1957, Roy 1968).

The discovery of a specimen in CAR that seems close to *Syngalepsus* led me to gather all the existing information concerning this subgenus (Moulin et al. 2017). The old descriptions have been revised and the figures of the genitalia grouped. Examination of its morphology and that of other specimens preserved in the collection has highlighted a second new species, native to Malawi. This paper aims to provide additional knowledge about Mantodea from Africa. Here we provide details about morphology and distribution of known species of the subgenus *Syngalepsus* and describe two new species.

Taxonomy

After the examination of several specimens of *Galepsus* genus in the Muséum national d'Histoire naturelle, Paris (MNHN) and a bibliographic survey (Beier 1931, 1954, 1957, 1969a, 1969b; Roy 1968; Kaltenbach 1996, 1998; Ehrmann 2002; Otte and Spearman 2005), the genus *Galepsus* (*Syngalepsus*) appears to include six species. Two of these are unknown and are described in this subgenus revision. The genitalia were illustrated from types for all existing species, which served as the central distinguishing feature for the treated species.

Materials and methods

During the scientific expedition named "SANGHA, Biodiversité en terre Pygmée" (2012) in CAR, some *Galepsus* individuals were collected. Two species were identified: *G.* (*Galepsus*) *globiceps* Beier, 1942 and *G.* (*Galepsus*) *laticeps* Werner, 1907. But one specimen was atypical of the others and its genital characters were similar to those of *Syngalepsus*. In my comparisons to collection specimens, two undetermined specimens from Malawy were found in the material of the Muséum national d'Histoire naturelle, Paris, France. The specimens exhibit the diagnostic characters of the subgenus *Syngalepsus* (sensu Beier 1954) and differ from the RCA specimen and the four known species.

The specimens were photographed with a Dynax 5D Konica Minolta camera and a Leica MC 120 HD camera mounted on a S8APO Leica stereomicroscope. The freeware Combine ZP (Hadley 2008) was used to process images.

Taxonomy relied on Mantodea Species File website (Otte et al. 2018) as well as recent works on praying mantis molecular phylogenetics (Svenson and Whiting 2009, Wieland 2013, Roy 2014, Svenson et al. 2015). All morphological descriptions and measurements (in millimeters) refer to the material studied here unless explicitly stated otherwise. Terminology follows Brannoch et al. (2017) and Shcherbakov (2017). A total of 12 measurement classes were captured including:

1. Body length = length of body from central ocelli to posterior tip of wing or abdomen (intraspecifically variable measurement, primarily for general size estimation).
2. Forewing length = from proximal margin of axillary sclerites to distal tip of the discoidal region.
3. Pronotum length = from anterior margin to posterior margin.
4. Pronotum width = from lateral margins at the widest point, the supra-coxal bulge.
5. Head width = from lateral margins of the eyes at widest point.
6. Prothoracic coxae length = from proximal margin abutting pronotum to trochanter.
7. Prothoracic femur length = from proximal margin abutting trochanter to distal margin of genicular lobe.
8. Prothoracic tibiae length = from distal margin of genicular lobe to distal terminal spur.
9. Prothoracic femur width = at the widest point.
10. Anteroventral femoral spine count = all inner marginal ridge spines but excluding the genicular spine.
11. Anteroventral tibial spine count = all inner marginal ridge spines but excluding the distal terminal spur.
12. Posteroventral tibial spine count = all outer marginal ridge spines but excluding the distal terminal spur.

List of abbreviations:

age	anterior groove;
apa	posterior process of phalloid apophysis;
bm	medial arm of sclerite R1A;
fda	main lobe of the right phallomere;
L2	sclerite L2;
L4A	sclerite L4A;
L4B	sclerite L4B;
ldp	left distal process;
paa	apical process;
pda	distal process;
pia	sclerotization pia;
pva	sclerotization pva;
R1A	sclerite R1A;
R3	sclerite R3.

A map was created in QGIS 3.0.0. with administrative areas from GADM, the database of Global Administrative Areas website (https://gadm.org/).

As part of the revision of *Syngalepsus*, the descriptions of the four known species are repeated here, according to the original texts, translated into English. The questioning of the identity of the female allotype referred to *G.* (*S.*) *denigratus* by Beier between 1957 and 1969 is re-evaluated here with the examination of two females, conserved at the MNHN, from the Republic of the Congo. The genitalia illustrated in the original documents are reproduced here (Figs. 1, 2).

Results

***Galepsus* (*Syngalepsus*) *bipunctatus* Beier, 1931**

Figures 1A, 6A, 7A, 8

Galepsus bipunctatus: Beier 1931: 3; Beier 1954: 19; Kaltenbach 1996: 233; Kaltenbach 1998: 40; Ehrmann 2002: 154; Otte and Spearman 2005: 336.

Holotype. Male deposited in ZMUH Hamburg; Type locality: Quilimane, Mozambique. **Paratype**: Male deposited in NHM Wien.

Diagnosis. Pronotum with a blackened median line. Right phallomere without a process at the apex of the main lobe (fda); apical process on left phallomere (paa) rounded at the apex, having a small lateral process unlike other species.

Original description of *Galepsus bipunctatus* by Beier (1931: 3). "*Galepsus bipunctatus* n. sp. ♂. Gelblichbraun. Frontalschild etwas breiter als hoch. Scheitel leicht gerundet, ohne Höckerchen neben den Augen. Augen flach, seitlich kaum konvex, fast parallelseitig, mit deutlich ausgeprägtem, schmal abgerundetem oberen Eck. Der Scheitel ohne Winkel in den oberen Rand der Augen übergehend. Pronotum gut 2,5mal so lang als breit, fast parallelseitig, vorne kaum breiter als hinten, die Supracoxalerweiterung nicht ausgeprägt. Prosternum mit zwei runden, scharf, begrenzten schwarzen Punkten basal von der Mitte. Elytren kürzer als das Abdomen, hyalin. Alae hyalin, nur die Basis sehr leicht angeraucht und etwas irisierend. Vordercoxen einfarbig, basal leicht gebräunt. Trochanter ohne Fleck. Vorderfemora vollkommen einfarbig

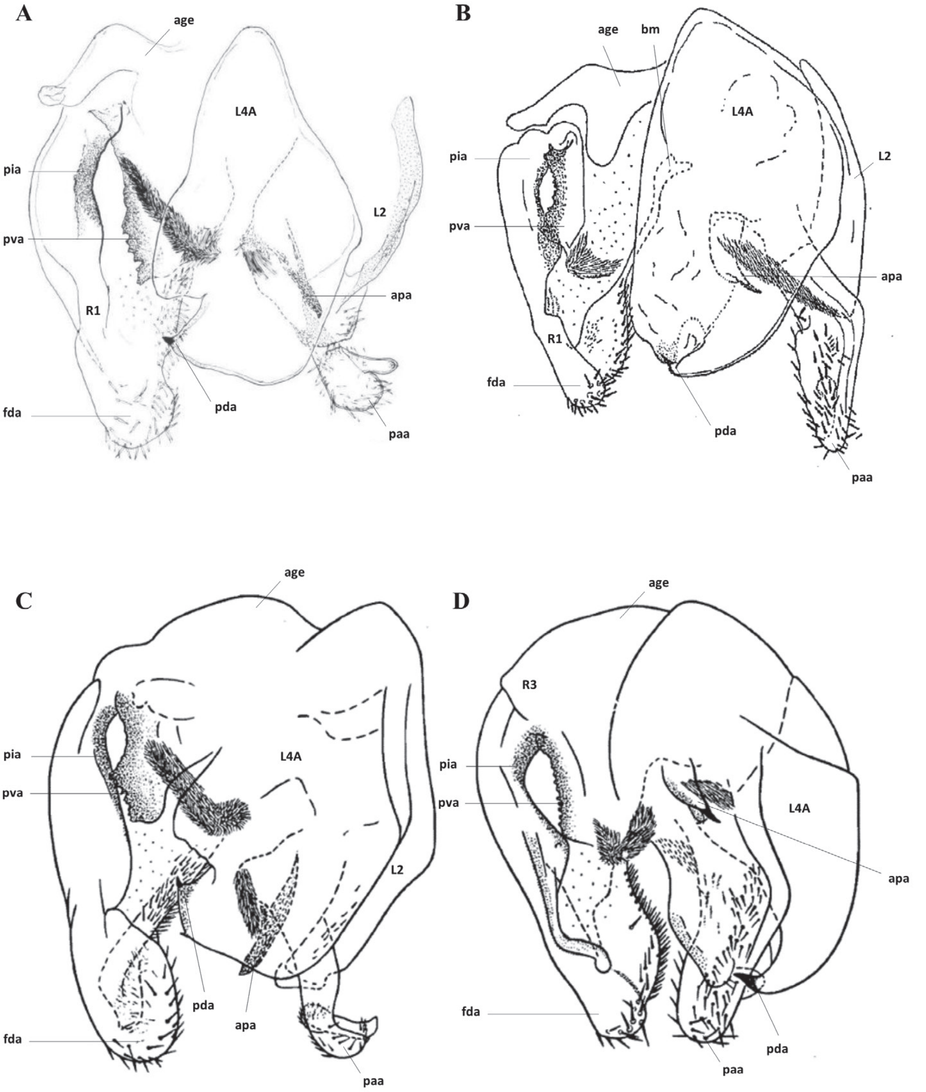

Figure 1. Genitalia: **A** *Galepsus* (*S.*) *bipunctatus* (modified from Kaltenbach 1996) **B** *Galepsus* (*S.*) *denigratus* (modified from Beier 1957) **C** *Galepsus* (*S.*) *bipunctatus* (modified from Beier 1954) **D** *Galepsus* (*S.*) *denigratus* (modified from Beier 1954). No scale. For abbreviations see Brannoch et al. (2017) and the text.

gelb, die Dornen nur an der Spitze dunkel. Tibien und Tarsenglieder einfarbig. Cerci flach, das letzte Glied lang und schmal, etwa viermal so lang als breit. Körperlänge 29 mm, Pronotum 6,8 mm, breit 2,5 mm, Metazone 4,3 mm, Elytren 18 mm."

Translation. "*Galepsus bipunctatus* n. sp. ♂. Yellowish brown. Lower frons slightly wider than high. Vertex slightly rounded, without juxtaocular bulges near the eyes. Eyes flat, hardly convex on the sides, almost parallel, with a pronounced, narrow rounded upper corner. The vertex without angle merging into the upper edge of the eyes. Pronotum more than 2.5 times as long as wide, margins almost parallel, scarcely wider at the front than at the back, the lateral pronotal expansion not pronounced. Prosternum with two rounded, sharp, limited black spots, basal from the middle. Forewings shorter than abdomen, not coloured. Hindwings not coloured, only the base slightly smoked and slightly iridescent. Forecoxae monochrome, slightly brown at the base. Trochanter without colour spot. Forefemora yellow, anteroventral femoral spines only dark at the apex. Tibiae and tarsi monochrome. Cerci flat, the distal cercomeri long and narrow, about 4 times as long as wide. Body length 29 mm, pronotum length 6.8 mm, width of pronotum 2.5 mm, metazone length 4.3 mm, forewing length 18 mm."

***Galepsus* (*Syngalepsus*) *denigratus* Beier, 1954**

Figures 1B, 1D, 6B, 6D, 6E, 6F, 7B, 7D, 7E, 8

Galepsus (*Syngalepsus*) *denigratus*: Beier 1954: 19; Beier 1957: 141; Roy 1968: 318; Ehrmann 2002: 154; Otte and Spearman 2005: 336.

Holotype. Male deposited in NHM Wien; Type locality: Lemfu, Democratic Republic of Congo. **Allotype**: Female deposited in Musée Royal de l'Afrique Centrale, Tervuren, Belgium. **Type locality**: Shamba, Kasai, Republic of the Congo.

Material examined. 2 females: Republic of the Congo, Voka, 4°40'16"S, 14°40'25"E, 611 m, end of year 1979 and 02.III.1980, Onore G. col. (MNHN).

Diagnosis. One of the largest species of the subgenus *Syngalepsus*. Close to *G.* (*S.*) *bipunctatus* but larger. Prosternum largely blackened. Hind wings brown. Genitalia mainly different from other species by apical process (paa) of left phallomere more massive; with many large bristles.

Original description of *Galepsus* (*Syngalepsus*) *denigratus* by Beier (1954: 19). "*Galepsus* (*Syngalepsus*) *denigratus* n. sp. Körper dorsal einfarbig gelblichbraun. Frontal schild ein wenig breiter als hoch, dorsal flach gerundet. Scheitel flach gewölbt, ganzrandig, nur in der Nähe der Augen mit einer seichten Furche. Augen länglich, flach, mit breit verrundetem Dorsaleck. Fühler einfarbig bräunlich. Pronotum schlank, etwa 3 mal so lang wie breit, die Metazone nur sehr wenig schmäler als die Prozone, Supracoxalerweiterung kaum angedeutet. Elytren des Männchens das Abdomenende nicht ganz erreichend, ziemlich stark rauchbraun getrübt, subhyalin, die Längs- und Queradern bräunlich, die falschen Längsadern weitgehend erhalten, aber zart. Alae wie die Elytren. Prosternum mit Ausnahme der Seitenränder und des Basalteiles in der Metazone geschwärzt, in dieser Schwärzung jedoch noch zwei tiefschwarze, kreisrunde Makeln erkennbar. Fangbeine medial einfarbig rötlich gelbbraun, der Trochanter lateral mit einer schwarzen Punktmakel. Vorderfemora mit 4 Aussendornen. Vordertibien mit 10 Aussen- und 11 Innendornen. Mittel- und Hinterbeine einfarbig, nicht punktiert, die Tarsenglieder apical schmal angedunkelt. Männliches Genitalorgan: Rechter Epiphallus stumpf, apikal abgerundet und medial bis zum Apex mit Spinderlborsten besetzt; linker Epiphallus ebenfalls stumpf und parallelseitig, der Apikalteil nicht abgebogen; linkes Basalsklerit klaunenförmig, mit kräftigen Endhaken; Hypophallus reduziert, weichhäutig; Phallus kurz. Körper L. ♂ 30 mm; Kopf B. 3 mm; Pronotum L. 7 mm, B. 2,2 mm; Elytren L. 19,5 mm."

Translation. "*Galepsus* (*Syngalepsus*) *denigratus* n. sp. Body dorsally monochrome yellowish brown. Lower frons slightly wider than high, dorsally flat rounded. Vertex flat arched, entire, only near the eyes with a shallow furrow. Eyes oblong, flat, with dorsal part broad and rounded. Antennae monochrome brownish. Pronotum slender, about 3 times as long as wide, metazone only very slightly narrower than prozone, supracoxal sulcus hardly indicated. Forewings of the male not quite reaching the abdomen apex, rather cloudy smoky-brown, clear, the longitudinal (anterior cubitus) and transverse veins brownish, the false longitudinal veins (media and radius) largely preserved, but tender. Hind wings similar to forewings. Prosternum blackened except lateral and basal boarder of metazone, but in this blackening there are two deep-black, circular spots. Fore legs monochrome with reddish ventral surface, trochanter with a lateral black spot. Fore femora with 4 posteroventral femoral spines. Fore tibia with 10 posteroventral tibial spines and 11 anteroventral tibial spines. Meso- and metathoracic legs monochrome, not punctuated, segments of the tarsi darkened apically. Male genitalia: Right phallomere blunt, main lobe (fda) apically rounded, with thick bristles near the middle. Apical process (paa) (titillator) blunt, with parallel sides, with its apex not bent; sclerite L4B claw-shaped, with strong end hook; ventral phallomere reduced, membranous. Posterior process of phalloid apophysis (apa) short. Body length ♂ 30 mm; width of head 3 mm; pronotum length 7 mm; width of pronotum 2.2 mm; hindwings length 19.5 mm."

Additional description of *Galepsus* (*Syngalepsus*) *denigratus* by Beier (1957: 141). "Zur Beschreibung des männlichen Kopulationsorgans ist folgendes nachzutragen: Der linke Epiphallus hat dorsal einen oralwärts gerichteten scheibenförmigen Anhang, medial einen stumpfen Haken; sein Basalsklerit ist kurz; der Phallus ist kurz, pfriemenförmig, mit relativ grossem Basalack; der Hypophallus hat einen derben, kahnförmigen Lateralteil und einen häutigen Lobus. Das Endglied der Cerci ist in der Regel lang und schmal. – Körper L. ♀ 26–30 mm; Kopf B. 2,9–3,1 mm; Pronotum L. 6,9–7 mm, B. 2,2 mm; Elytren L. 17,5–19,5 mm. Das Weibchen dieser Art, das in einem Stück (Allotype) von Kasai, Shamba, vorliegt, war noch unbekannt. Es ist dorsal fast einheitlich braun gefärbt, nur der Scheitelbogen ist geschwärzt und die Metazone des Pronotums trägt zwei grosse schwarze Flecke. Dorsalrand des etwas queren Frontalschildes fast gerade. Scheitel flach gewölbt. Elytren schwärzlich-rötlichbraun, ventral entlang dem R geschwärzt. Alae grösstenteils schwärzlich, mit rötlichbraunen Rändern. Prosternum wie beim Männchen. Vordercoxen präapikal mit schwärzlicher Querbinde. Trochanter medial grösstenteils schwarz. Femur medial in der Ventralhälfte Schwarz, mit schwarzen Dornen. Vordertibien medial bräunlich, die Tarsenglieder geschwärzt. Fang- und Schreitbeine lateral bezw, dorsal braun punktiert. Supraanalplatte breit dreieckig, gekielt. – Körper L. 27 mm; Kopf B. 3,3 mm; Pronotum L. 7 mm, B. 2,7 mm; Elytren L. 4 mm. – Es ist in der Färbung dem Weibchen von femoratus G.-Tos aus dem Betschuanaland sehr ähnlich, unterscheidet sich aber von diesem durch helle Vordertibien und die Körpermasse, vor allem durch schlankeres Pronotum und relative kürzere Elytren."

Translation. “To describe the male genitalia, the following is to be added: The left phallomere has a dorsally directed disc-shaped appendage (L4B), medially a blunt hook; sclerite L4A is short; the posterior process of phalloid apophysis (apa) is short, belt-shaped, with a relatively large basal coat; ventral phallomere has a rough, posterior lateral part and a membranous lobe. Distal cercomere are usually long and narrow. – Body length ♀ 26–30 mm; width of head 2,9–3,1 mm; pronotum length 6,9–7 mm; width of pronotum 2,2 mm; forewing length 17,5–19,5 mm.

The female of this species, of which there is one specimen (allotype) collected at Kasai, Shamba, was previously unknown. It is dorsally almost uniformly brown, only the vertex is blackened and metazone carries two large black spots. Dorsal margin transverse, lower frons almost straight. Vertex flat arched. Forewings blackish-reddish brown, blackened ventrally along anterior radius. Hindwings mostly blackish, with reddish brown edges. Prosternum as in the male. Forecoxae with blackish pre-apical bandage. Trochanter mostly black. Forefemora half black in ventral face, with black thorns. Fore tibiae half brownish, tarsus blackened. Meso- and metathoracic legs lateral and dorsal brown dotted. Supra-anal plate wide, triangular and keeled. – Body length 27 mm; width of head 3,3 mm; pronotum length 7 mm; width of pronotum 2,7 mm; forewings length 4 mm. It is very similar in colour to the female of *Galepsus* (*Onychogalepsus*) *femoratus* Giglio-Tos collected from Bechuana land (Botswana), but differs from it in terms of its bright fore tibiae and body mass, above all by a slimmer pronotum and relatively shorter forewings.”

The female symbol in the description of Beier, in 1957, is a mistake. He wanted to indicate the measurements for the males.

Additional description of *Galepsus* (*Syngalepsus*) *denigratus* by Beier (1969a: 21). “Das von mir seinerzeit (1957) für das Weibchen von denigratus gehaltene Exemplar gehört offensichtlich nicht dieser Art an. Es liegen nun 4 Weibchen vor, die ich mit Bestimmtheit dieser Art zuzählen möchte. Sie lassen sich folgendermassen charakterisieren: Weibchen. Ober- und Unterseite einschliesslich der kurzen Elytren braun, der Scheitel in Längsstreifen schwach angedunkelt, Occiput bisweilen mit einem schwarzen Punkt; Pronotum mit zwei Paaren kleiner brauner Punkte in der vorderen Hälfte der Metazone, Prosternum wie beim Männchen, meist jedoch etwas breiter geschwärzt; Vordercoxen medial mit zwei schwarzen Apikalmakeln, Trochanter mit schwarzer Medialmakel, Vorderfemora medial vor und hinter der Krallenfurche mit einer grösseren schwarzen Makel, weiter distal mit einigen braunen Punktmakeln, an der Basis der hellen grossen Innendornen ebenfalls mit je einer braunen Punktmakel; Beine braun gesprenkelt. Seiten des Pronotums äusserst fein körnchenförmig gezähnelt. – Körper-L. 32–34 mm; Kopf-B. 3,8–4 mm; Pronotum-L. 7,5–8 mm, B. 2,9–3,1 mm; Elytren-L. 4,5–5 mm; Hinterfemora 6–6,5 mm. – Die Weibchen sind an der charakteristischen Fleckung der Voderbeine leicht kenntlich. Die Art ist neu für Angola. Sie war bisher nur aus dem Congo bekannt.”

Translation. “The specimen I held at that time (1957) of the female *denigratus* obviously does not belong to this species. There are now 4 females that I want to count with certainty of this kind. They can be characterised as follows: Female. The upper and lower side including stigma of forewings, brown, the apex of the head dimly darkened in longitudinal stripes, gena sometimes with a black dot; pronotum with two pairs of small brown dots in the anterior half of the metazone, prosternum as in the male, but usually a little more blackened; fore coxae with two apical black spots, trochanter with a medial black spot, forefemora with a, medial and behind the claw furrow, larger blackish spot, further distal with a little brown spot, at the base of the larger anteroventral femoral spines also each with a brown spot; Legs speckled brown. Margins of pronotum extremely fine granulated serrated. – Body length 32–34 mm; width of head 3,8–4 mm; pronotum length 7,5–8 mm; width of pronotum 2,9–3,1 mm; forewings length 4,5–5 mm; metathoracic femora length 6–6,5 mm. – The females are easily recognizable by the characteristic patch on the forelegs.

The species is new to Angola. It was previously known only from the Congo."

Note: The female described in 1957 from Shamba in Kasai (Republic of the Congo) is confirmed to be *G.* (*S.*) *denigratus,* after examination.

Redescription of female. Fine *body*, brown, length 33.0 mm from head to apex of abdomen. Wings reduced, brown or more or less bicoloured according to examined specimens.

Head. Vertex slightly convex, brownish at the top. Parietal sulcus well marked. A brown-black spot on the vertex, against the parietal sulcus, near the juxtaocular bulge. Lower frons almost square, slightly wider than long. Eyes slightly prominent on the side, almost square head, front view. Antennae broken in both examined females. Maxillary palps with the base of the last segment brown-black.

Thorax. Pronotum with prozone almost as wide as metazone. Two small depressions, stained brown, on each side of the midline of the metazone, behind the supracoxal sulcus. Two parallel black spots in the middle of the metazone; closer to the edge than the median line. Two small black-brown bands, parallel to the median line, near the posterior border. Margin of pronotum serrated along its entire length. Prosternum with a large black-brown spot, not reaching the edges of the pronotum. Two depressions characteristic of the subgenus, not very visible because of this dark spot.

Fore legs. Femora with 12 anteroventral femoral spines, 4 posteroventral femoral spines, 4 discoidal spines; tibiae with 11–12 anteroventral tibial spines, 11–12 posteroventral tibial spines. Coxae with a big black-brown spot at the apex, in the posterior margin and a smaller one in a more anterior position. Trochanter with a smaller, black-brown spot, very close to the junction with the femora. Anteroventral face of femora with several dark brown spots of various sizes and shapes forming a band along the ventral half. Dark brown spots at the base of the big spines. Apex of anteroventral femoral spines dark brown. Tibiae with a darker longitudinal line inside. Meso- and metathoracic legs stained with dark-brown little spots as forelegs. *Wings*. Forewings and hindwings, short, not reaching the beginning of the 1st abdominal segment. Forewings light brownish red, with a dark spot taking all the discoidal area. Costal area of the same colour as the first part of the discoidal area. Hind wings brownish. *Abdomen*. Stained with brown markings. Triangular supra-anal plate, as wide as the abdomen. Cerci relatively long, 4.5 mm, flattened, the last two distal cercomeri longer than wide.

Measurements (mm). Body length 30.2–33.0, pronotum length 7.2–8.2, fore wings length 4.1–5.0, fore coxae length 4.0–4.1, fore femora length 4.9–5.4, fore tibiae length 3.4–3.8; width of pronotum 2.6–2.7, width of head 3.4–3.9, width of fore femora 1.4–1.6.

***Galepsus* (*Syngalepsus*) *birkenmeierae* Beier, 1969**

Figures 2B, 6G, 7G, 8

Galepsus (*Syngalepsus*) *birkenmeierae*: Beier 1969a: 201; Ehrmann 2002: 154; Otte and Spearman 2005: 336.

Holotype. Male deposited in NMW Vienne. **Type locality**: Fort Johnston, Malawi.

Diagnosis. The smallest species of the subgenus *Syngalepsus*. Very close to *G.* (*S.*) *bipunctatus* by genitalia conformation, but smaller, head wider, eyes more rounded laterally, forewings shorter and prosternum with a black patch.

Original description of *Galepsus* (*Syngalepsus*) *birkenmeierae* by Beier (1969a: 201). "*Galepsus* (*Syngalepsus*) *birkenmeierae* n. sp. ♂. Relativ klein. Allgemeinfärbung gelblich braun, dunkler braun gesprenkelt. Kopf verhältnismäßig breit, viel breiter als das Pronotum. Scheitel fast gerade. Augen seitlich ziemlich stark gebaucht, dorsal breit abgerundet, ohne Kerbe in den Scheitel übergehend. Frontalschild deutlich etwas breiter als hoch. Fühler basal hell, distalwärts allmählich dunkler. Pronotum fast 3mal länger als breit, dunkelbraun gefleckt oder mit dunkler Medianlinie, die Metazone nur wenig schmäler als die Prozone. Prosternum mit großem, ovalem schwarzen Fleck, der bisweilen noch die für die Untergattung charakteristischen paarigen schwarzen Makeln erkennen läßt. Elytren das Abdomen nicht ganz bedeckend, ebenso wie die Alae leicht angeraucht, das Costalfeld mit hellen, das Discoidalfeld mit braunen Adern, die Queradern ziemlich derb, im Medialis- und Radius-Bereich an den falschen Längsadern wie diese hell und daher unterbrochen erscheinend. Fangbeine medial gelbbraun, nur das Femur mit kleiner schwarzer Basalmakel, lateral braun gesprenkelt, der Trochanter lateral mit drei schwarzen Makeln. Vordercoxen den Hinterrand des Prosternums fast erreichend. Mittel- und Hinterbeine dicht braun gesprenkelt. Cerci flach. Kopulationsorgan: Hypophallus mit kurzer medialer Endklaue, kleinem Subapikalzähnchen und breit verrundetem, in der Anlage rechtwinkeligem Lateraleck; rechter Epiphallus stumpf, am Ende leicht verdickt, mit kräftigen Spindelborsten; rechte Apophysenlippe mit einer Reihe granulierter Zäpfchen, linke Apophysenlippe mit stumpfem Basalzahn und gehöckertem Apikallobus; linker Epiphallus schlank, terminal stumpf gegabelt; Pseudophallus glatt, scharf zugespitzt, mit lang behaartem Basalsack. - Körper-L. 24–25 mm; Kopf-B. 3–3,1 mm; Pronotum-L. 5,8–6 mm; B. 2–2,1 mm, Metazonen-L. 4,2–4,3 mm; Elytren-L. 15–16 mm. ♀ unbekannt."

Translation. "*Galepsus* (*Syngalepsus*) *birkenmeierae* n. sp. ♂. Relatively small. General colour yellowish brown, dark brown speckled. Head relatively wide, wider than pronotum. Vertex almost straight. Eyes relatively bulging laterally, dorsally rounded, without notching vertex. Lower frons wider than high. Base of antennae (flagellum) brilliant, gradually becoming darker towards the apex. Pronotum almost 3 times longer than broad, dark brown spotted or with a dark median line, metazone slightly narrower than prozone. Prosternum with a large oval black spot, which occasionally reveals the paired black spots characteristic of the subgenus. Forewings not completely covering the abdomen, just as Alae, slightly smoked. Costal field bright.

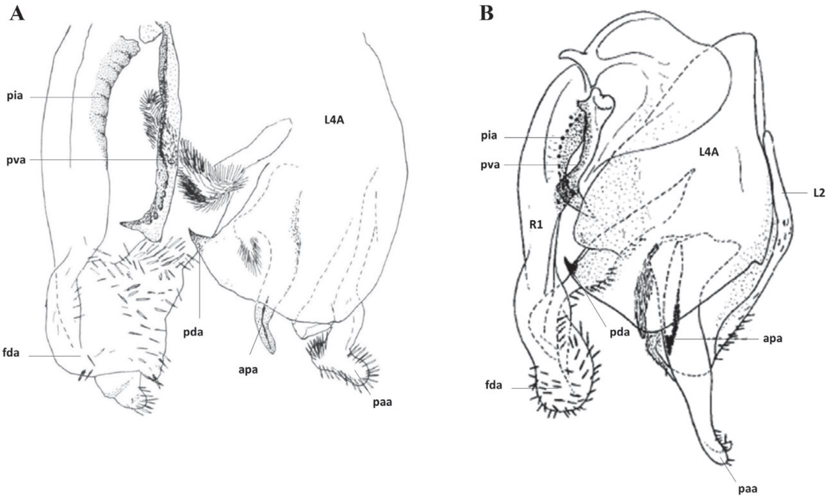

Figure 2. Genitalia: **A** *Galepsus* (*S.*) *beieri* (modified from Kaltenbach, 1996) **B** *Galepsus* (*S.*) *birkenmeirae* (modified from Beier 1969b). No scale. For abbreviations see Brannoch et al. (2017) and the text.

Discoidal field with brown veins, quite rough, crossing anterior cubitus veins. Media and radius veins very clear and therefore interrupted. Forelegs light brown on ventral surface, with a little black spot, laterally marbled brown, trochanter with three black spots. Fore coxae almost reaching the posterior border of the prosternum. Meso- and metathoracic legs speckled brown. Cerci flat. Genitalia: ventral phallomere with short and more medial end claw, smaller subapical tooth (pda) and widely rounded corner pointing to the right. Ventral phallomere of rectangular general shape. Right phallomere, blunt, slightly thickened and with strong bristles at the apex; ventral plate (pia) with a series of granules, ventral process (pva) with a blunt basal tooth and an apical lobe. Apical process (paa) of left phallomere, slender, with the terminal part in the shape of an obtuse fork; posterior process of phalloid apophysis (apa) smooth, pointed, with a large hairy area.

Body length 24 – 25 mm; width of head 3 – 3.1 mm; pronotum length 5.8 – 6 mm, width of pronotum 2 – 2.1 mm; metazone length 4.2 – 4.3 mm; forewings length 15 – 16 mm.

♀ unknown.”

Galepsus (*Syngalepsus*) *beieri* Kaltenbach, 1996

Figures 2A, 6I, 7I, 8

Galepsus (*Syngalepsus*) *beieri*: Kaltenbach 1996: 233; Ehrmann 2002: 154; Otte and Spearman 2005: 336.

Holotype. Male deposited in ZMAN Amsterdam. **Type locality**: Lake St. Lucia, False Bay, Natal, South Africa. **Paratype**: Male deposited in NHM Wien.

Material examined. 1 male. South Africa, Mpumalanga, Blyde River Canyon, Swadini Resort, 24°30'54.7"S, 30°48'8.64"E, 600 m, 18.XI.2017 (SA17-05 field code), Decaëns T. & Rougerie R. leg., genitalia prep. Moulin NM200 (RCNM).

Diagnosis. *Galepsus* (*S.*) *beieri* is very similar to *Galepsus* (*S.*) *bipunctatus* and *G.* (*S.*) *birkenmeirae*. *G.* (*S.*) *beieri* is distinguished from *G.* (*S.*) *birkenmeirae* and *G.* (*S.*) *denigratus* by the presence of two black spots on prosternum. Kaltenbach, in 1996, speaks of not blackened pronotum in 'Differentialdiagnose' but he confuses with the prosternum. Right phallomere with a process on the main posterior lobe; ventral plate (pia) with a tooth turned to the right at the apex; Left phallomere with posterior process of phalloid apophysis (apa) (pseudophallus) ended with rounded apex, distal process (paa) (titillator) with apex in mallet form at the apex, covered by thick bristles.

Original description of *Galepsus* (*Syngalepsus*) *beieri* by Kaltenbach (1996: 233). *"Galepsus (Syngalepsus) beieri* sp. n. (♂; ♀ unbekannt): Kopf deutlich breiter als das Pronotum. Vertex fast gerade, nur gegen die Augen zu schwach nach frontal abfallend. Komplexaugen lateral flach gekrümmt. Frontalschild 1,4mal so breit wie hoch. Antennen mit bräunlichen Basalgliedern und ockerfarbener Geißel. Pronotum 2,6–2,7mal so lang wie über den Coxen breit. Metazone etwas schmäler als Prozone. Prosternum mit paarigen schwarzen Makeln. Elytren etwa 3mal so lang wie das Pronotum, das Abdomenende nicht erreichend. Aderung hell bräunlich. Alae hyalin. Coxae und Femora der Vorderbeine ohne auffällige Flecken. Vordertibien mit 11 Außendornen. Cerci etwas abgeflacht. Gesamtfärbung bräunlich. Kopulationsorgan: Rechter Epiphallus distal verbreitert, Apex mit aufgesetztem Zapfen. Mediale Apophysenlippe mit einem großem Apikalzahn, Innenrand glatt, nur distal mit einer kurzen Reihe auf die Lippenfläche verlagerter, kleiner, breiter Zähnchen. Linker Epiphallus mit fußartigem Anhang, ähnlich wie bei manchen Arten von *Lygdamia*. Dieser Anhang ist dicht mit nadelartigen Borsten besetzt. Pseudophallus fingerartig, mit stumpfem Apex. Der Hypophallus trägt eine spitze Endklaue wie *G. bipunctatus* (Beier, 1954: fig. 4A) und *G. birkenmeierae* (Beier, 1969b: Abb. 2). Maße in mm (♂): Long. corp.: 30,0 – 31,5; Long. pronoti: 7,4 – 7,5, Lat. pronoti: 2,7 – 2,8; Long. elytr.: 21,5 – 22,0."

Translation. "*Galepsus* (*Syngalepsus*) *beieri* sp. n. (♂; ♀ unknown): Head significantly wider than the pronotum. Vertex almost straight, weakly collapsed near the eyes. Eyes slightly rounded laterally. Lower frons 1.4 times wider than high. Antennae with brownish flagellum (first segments) and another segments ocher. Pronotum 2.6–2.7 times longer than its width above the coxae. Metazone barely narrower than prozone. Prosternum with two paired black spots. Forewings about 3 times longer than pronotum, not reaching the end of abdomen. Brownish veins, shiny. Hindwings not coloured. Coxae and femora of forelegs without visible spots. Foretibiae with 11 posteroventral tibial spines. Cerci slightly flattened. General brownish colour. Male Genitalia: Right phallomere widened distally, apex with a process. Ventral process (pva) with a big tooth, ventral plate (pia) smooth, with just a row of small teeth, outer wall with wider teeth. Left phallomere with a mallet form apical process (paa) (titillator), similar to that in some *Lygdamia*. Apical process (paa) densely covered with hair, like needles. Posterior process of phalloid apophysis (apa) (pseudophallus) finger-shaped, with blunt end. Ventral phallomere with a pointed claw (pda) at the apex as in *G. bipunctatus* (Beier, 1954: fig. 4A) et *G. birkenmeierae* (Beier, 1969b: fig. 2). Dimensions in mm (♂): body length 30.0 – 31.5; pronotum length 7.4 – 7.5, width of pronotum 2.7 – 2.8; forewings length 21.5 – 22.0."

The two new species have the following diagnostic characteristics of the subgenus: Always small and delicate appearance; head rounded pentagonal; vertex almost straight or only slightly convex; lower frons wider than high; Prosternum with two rounded black spots near the middle of the metazone, sometimes also largely blackened, so that the spots are occulted; wings of males not protruding abdomen, clear or slightly brownish; wings of females shortened; small dark spots on trochanter and at the base of the anteroventral femoral spines, occasionally fore coxae basally browned; left phallomere with elongated apical process (paa), more or less wide at the apex but always covered with thick silks, posterior process of phalloid apophysis (apa) short; right phallomere obtuse.

***Galepsus* (*Syngalepsus*) *bucheti* sp. n.**

http://zoobank.org/369C429F-5AC5-411F-99E6-4AE232422FE9
Figures 3A–D, 4A–B, 6H, 7H, 8

Type material. Holotype male: CAR, Dzanga-Ndoki National Park, Mboki, bank of the Sangha River, 02°28'09"N, 16°04'44"E, 367m, Mercury Vapor light trap, 24.I.2012 (RP field code), N. Moulin leg., genitalia prep. Moulin NM0103 (MNHN, ex Moulin coll.), DNA barcoding BOLD NMMAN11-0518.

Unique male known.

Type locality. The type specimen was collected at Mboki, on the banks of the Sangha River, the border between the Central African Republic and Cameroon, in the territory of the Dzanga-Ndoki National Park. The vegetation close to Sangha River is a mosaic of a semi-evergreen forest that contains swamp-forest areas along the rivers and shrubby areas in disturbed environments.

Etymology. Named for Sergej Buchet, researcher participating at "SANGHA, Biodiversité en Terre Pygmée" on CAR, in 2008 and 2010; large contributor in the Author's crowdfunding "A la recherche de la Biodiversité des Mantes d'Afrique", KissKissBankBank platform (April 2015).

Diagnosis. Close to *Galepsus* (*Syngalepsus*) *denigratus* Beier and even more to *Galepsus* (*Syngalepsus*) *birkenmeierae* Beier with the large black patch on prosternum but different by genitalia conformation. Head wider than the pronotum; vertex slightly convex; prosternum with a large black patch.

Description male. Fine *body*, brown, length 32.7 mm from head to subgenital plate. Hind wings with venation brown. *Head*. Vertex straight or slightly convex with the region between the parietal sutures and the eyes convex. Two black spots near of the eyes, on the posterior face of the head. Lower frons transverse. Maxillary and labial

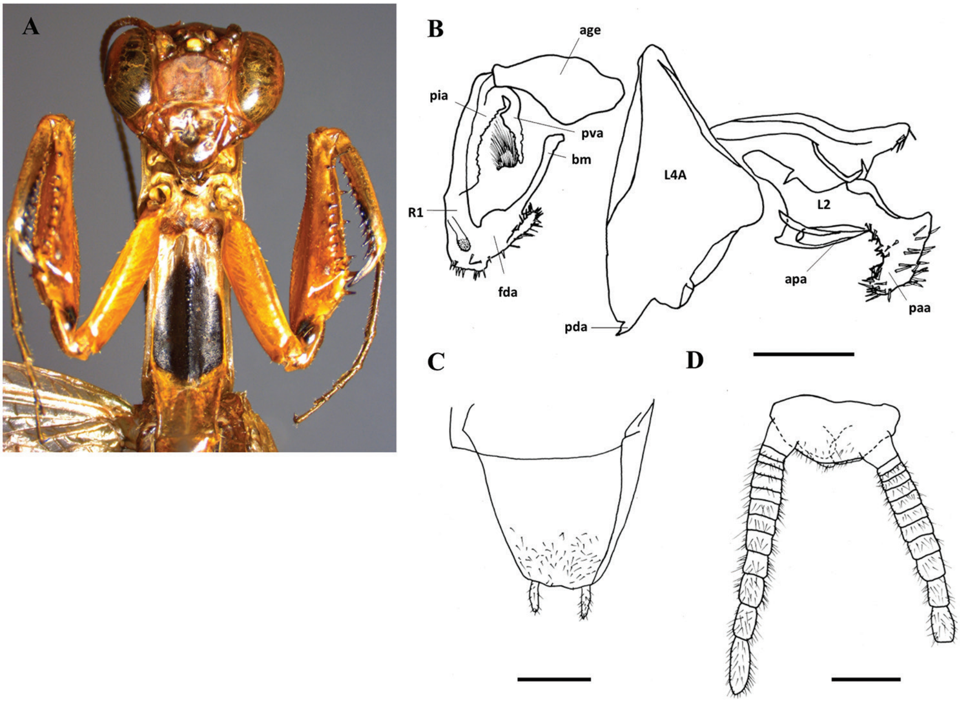

Figure 3. *Galepsus* (*S.*) *bucheti* sp. n., holotype male. **A** Prosternum and forelegs details **B** Genitalia **C** Subgenital plate **D** Cerci. For abbreviations see Brannoch et al. (2017) and the text. Scale bar: 1.00 mm.

palps with base of penultimate and last segment with black patch. Below of the last segment black. Antennae brown-black. *Thorax*. Pronotum. Smooth lateral margins. Surface smooth. Prozone broader than metazone. Pronotum 2.8 times longer than broad. Covered by small dark-brown spots, diffuses. Prosternum with a large black patch covering the posterior ¾ of the surface. Place of the spot within the other species visible. *Forelegs*. Femora with 12 anteroventral spines, four posteroventral spines, four discoidal spines; tibiae with eleven anteroventral spines. ten-eleven posteroventral spines. Legs globally of same colour of pronotum. Coxae without coloured patch. Trochanter with a black spot. Base of femora with a black patch, in extension of the one of trochanter. Tibiae with an elongated black patch at base of anteroventral tibial spines, from the 3rd to 11th. All tarsomere black below. Meso- and metathoracic legs stained with dark-brown. All tarsomere black at the distal end. *Wings*. Forewings and hindwings are uniformly translucent pale brown with brown veins. Reaching tip of abdomen. *Abdomen*. Flattened. Supra-anal plate: two times wider than length, distal margin rounded, pubescent. Cerci: relatively longs, flattened, the last three distal cercomeri longer than wide. Subgenital plate: pubescent, posterior edge almost straight. Styles: long, relatively thin, hairy.

Genitalia. Right phallomere with ventral process (pva) and ventral plate (pia) sclerotised; posterior process of phalloid apophysis (apa) long, with sclerotised denticles, ventral plate (pia) sclerotised with a rectangular form in anterior part and

Figure 4. A, B Habitat of *Galepsus* (*Syngalepsus*) *bucheti* sp. n. Arboreal stratum on bank of the Sangha river in CAR. Micro-habitat couldn't be described because the only specimen known was captured by a light trap on the river bank.

a hairs tuft at the posterior part. Apex of right phallomere rectangular covered on apex and left side with thick bristles. Ventral phallomere elongated, with a tooth (pda) on posterior margin, distant of the left margin. Left phallomere with a posterior process of phalloid apophysis (apa) pointed shorter than apical process (paa) and sclerotised at apex. Apical process (paa) large, hammer form at apex. Thick bristles on posterior process of phalloid apophysis (apa) apex and main lobe (fda) of the right phallomere apex.

Female unknown.

Measurements (mm). Holotype: body length 32.7, pronotum length 7.1, fore wings length 23.2, fore coxae length 4.3, fore femora length 4.9, fore tibiae length 2.9; width of pronotum 2.5, width of head 4.3, width of fore femora 1.5.

Galepsus (*Syngalepsus*) *dudleyi* sp. n.

http://zoobank.org/EFCF48A0-33E1-4F62-9973-CE6D7C436DDA
Figures 5A–D, 6C, 7C, 8

Type material. Holotype male: MALAWI, Mount Soche [15°50'29.0"S - 35°01'21.0"E], Alt. 1500m, 13.I.1973, code M1787, C. O. Dudley leg., genitalia prep. Roy 3312 (MNHN). **Paratype** male: MALAWI, Zomba, Mlunguzi East [15°23'S - 35°20'E], Alt. 938m, 05.II.1975 (1♂), H. R. Feijen, genitalia prep. Roy 3575 (MNHN).

Type localities. The type specimen was collected at Mount Soche, South of Blantyre, in the Southern region of Malawi. The altitude of this geological formation is approximately 1500 m. It's surrounded by urbanization, except in the south where agricultural practices take place. Paratype was also collected in the southern region of Malawi, at Zomba, Mlunguzi East.

Etymology. Named for the first collector, Cornell O. Dudley, Professor of botanic and entomology in Malawi.

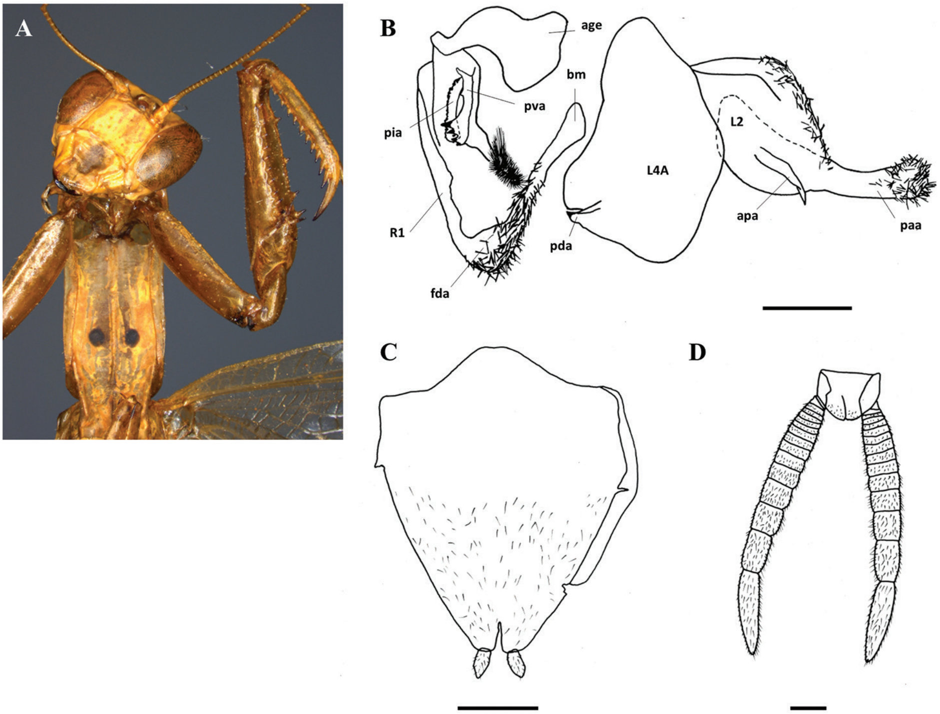

Figure 5. *Galepsus* (*S.*) *dudleyi* sp. n., holotype male. **A** Prosternum and forelegs details **B** Genitalia **C** Subgenital plate **D** Cerci. For abbreviations see Brannoch et al. (2017) and the text. Scale bar: 1.00 mm.

Diagnosis. Close to *Galepsus* (*Syngalepsus*) *beieri* Kaltenbach and *Galepsus* (*Syngalepsus*) *bipunctatus* Beier with the two black spots on prosternum but different by genitalia conformation: ventral process (pva), of right phallomere, end with several pointy teeth; left phallomere with apical process (paa) without a bump that gives a spoon or mallet appearance. Head as wide as the pronotum; vertex straight; prosternum with two black spots.

Description male. Fine *body*, light brown, length 32–34 mm from head to subgenital plate. Hindwings with venation light brown. *Head*. Slightly wider than pronotum. Vertex: straight, slightly convex. Frontal shield transversal, wider than high. Labial palps with the last two segments stained black at the base on both segments, and below for the apical segment. Maxillary palps broken. Antennae light brown. *Thorax*. Pronotum, three times longer than its largest width, prozone broader than metazone, lateral margins and surface smooth; median line of the pronotum blackened. Prosternum, same colour of the pronotum, with two black spots closed to centre of prosternum, on both sides of the median line. *Forelegs*. Coxae without coloured patch, two-three very small tubercles on the anteroventral border. The dark spot on the left trochanter is not a spot of colour on the cuticle but blackened material inside the tegument. Femora: with 11–12 anteroventral spines, four discoidal spines, four posteroventral spines, all spines with black-brown

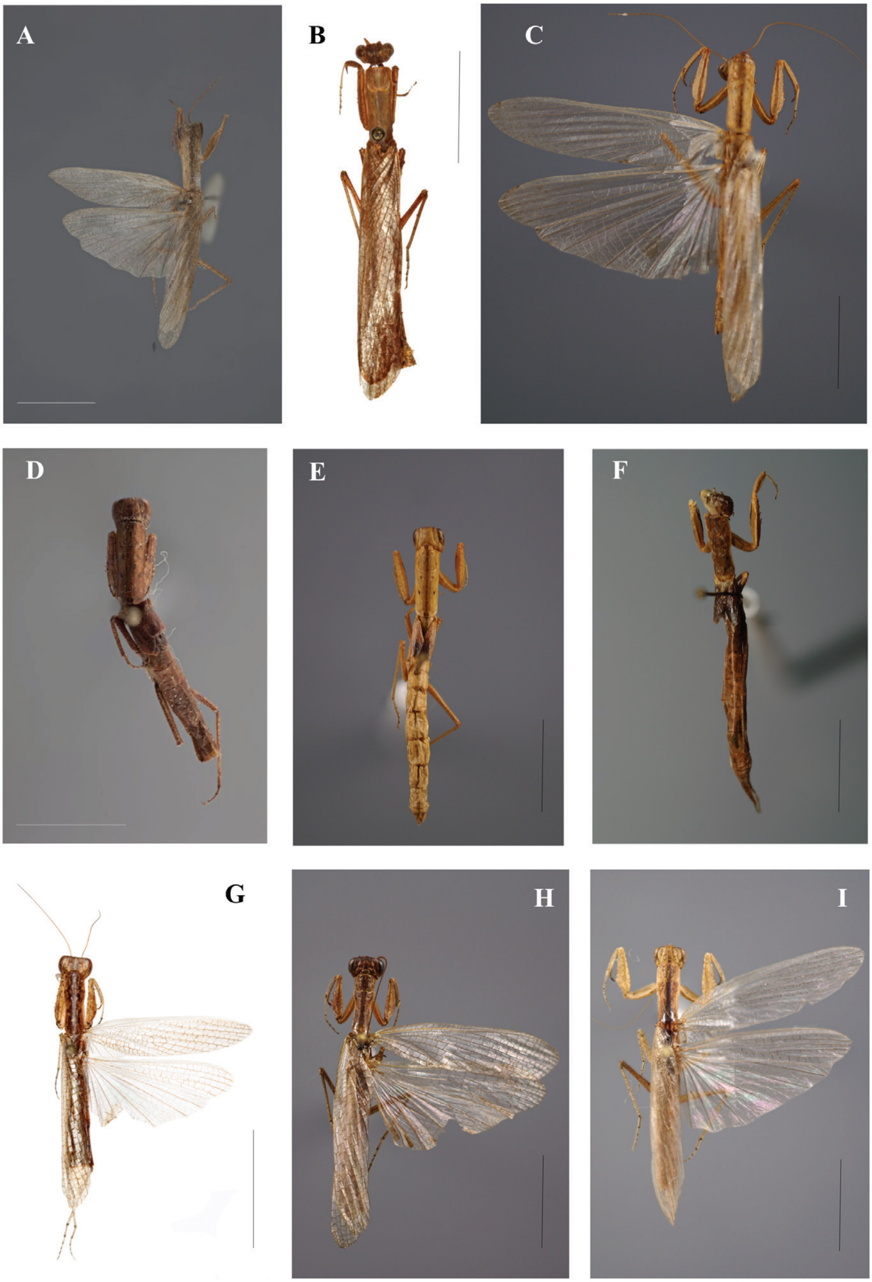

Figure 6. *Galepsus* (*Syngalepsus*), dorsal habitus: **A** *G.* (*S.*) *bipunctatus*, holotype male, Quilimane, Mozambique (G. Svenson) **B** *G.* (*S.*) *denigratus*, male, Kasai, Republic of Congo (H. Bruckner) **C** *G.* (*S.*) *dudleyi* sp. n., holotype male, Mount Soche, Malawi (N. Moulin) **D** *G.* (*S.*) *denigratus*, allotype female, Kasai, Republic of Congo (G. Svenson) **E, F** *G.* (*S.*) *denigratus*, females, Voka, Republic of Congo (N. Moulin) **G** *G.* (*S.*) *birkenmeirae*, holotype male, Mangochi (Fort Johnston), Malawi (H. Bruckner) **H** *G.* (*S.*) *bucheti* sp. n., holotype male, Mboki, Dzanga-Ndoki NP, Central African Republic (N. Moulin) **I** *G. (S.) beieri*, male, Mpumalanga (Swadini resort), South Africa (N. Moulin). Scale bar: 10.00 mm.

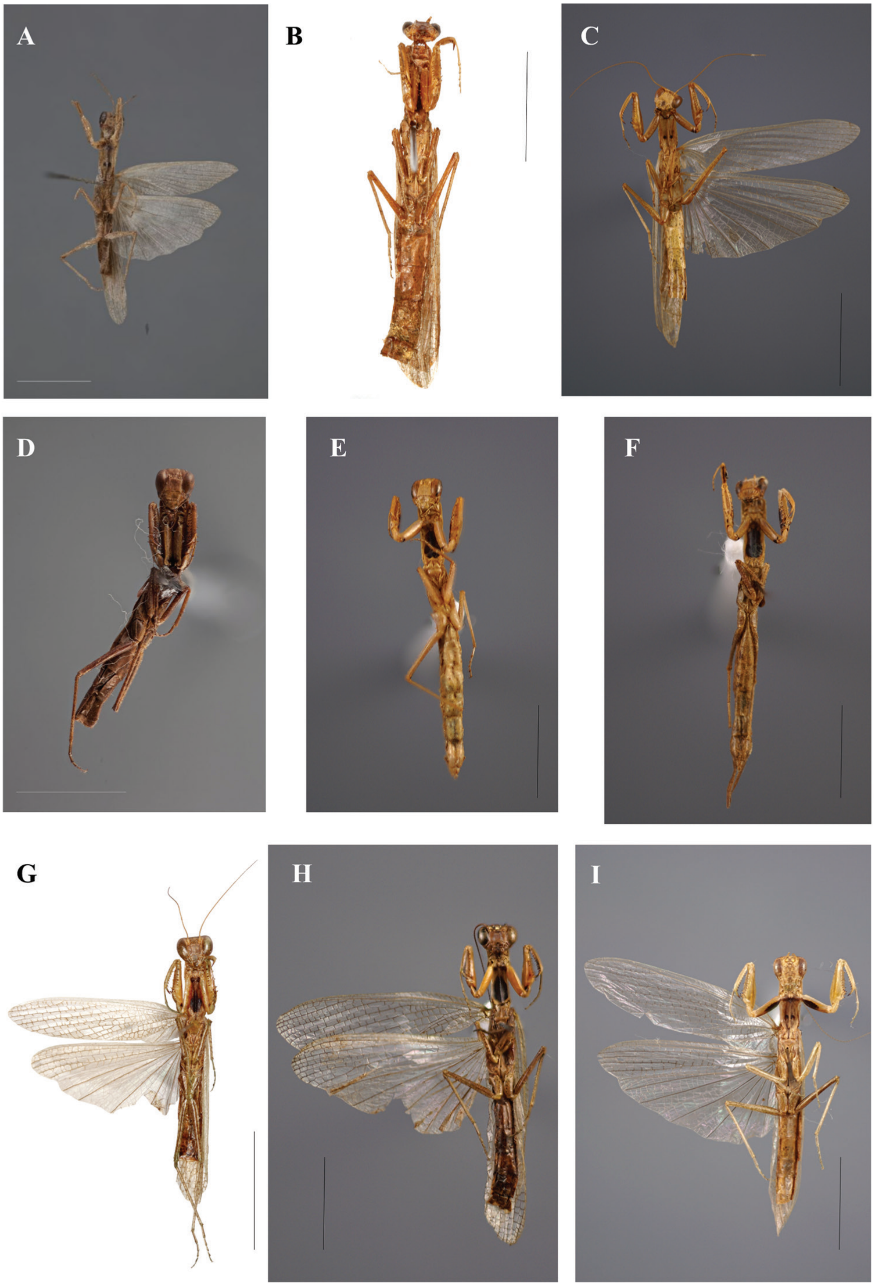

Figure 7. *Galepsus* (*Syngalepsus*), ventral habitus: **A** *G.* (*S.*) *bipunctatus*, holotype male, Quilimane, Mozambique (G. Svenson) **B** *G.* (*S.*) *denigratus*, male, Kasai, Republic of Congo (H. Bruckner) **C** *G.* (*S.*) *dudleyi* sp. n., holotype male, Mount Soche, Malawi (N. Moulin) **D** *G.* (*S.*) *denigratus*, allotype female, Kasai, Republic of Congo (G. Svenson) **E, F** *G.* (*S.*) *denigratus*, females, Voka, Republic of Congo (N. Moulin) **G** *G.* (*S.*) *birkenmeirae*, holotype male, Mangochi (Fort Johnston), Malawi (H. Bruckner) **H** *G.* (*S.*) *bucheti* sp. n., holotype male, Mboki, Dzanga-Ndoki NP, Central African Republic (N. Moulin) **I** *G. (S.) beieri*, male, Mpumalanga (Swadini resort), South Africa (N. Moulin). Scale bar: 10.00 mm.

apex. Tibiae: with 11–12 anteroventral spines, eleven posteroventral spines, tarsus with blackened underside. *Wings*. Forewings and hindwings are uniformly translucent pale brown with light-brown veins. Reaching tip of abdomen.

Abdomen. Flattened. Supraanal plate: almost wider than length, distal margin rounded, pubescent. Cerci: relatively longs, flattened, the last two cercomeri longer than wide. Subgenital plate: triangular shape, pubescent. Styles: relatively short, thick, hairy. *Genitalia*. Right phallomere with ventral process (pva) and ventral plate (pia) sclerotised; ventral process (pva) margin with large denticles. Apex of the right phallomere rounded, covered on apex and left side with thick bristles; hairs tuft at the posterior part. Ventral phallomere large, with a sharp process on posterior margin, towards the right. Left phallomere with a posterior process of phalloid apophysis (apa) long and sharp, slightly sclerotised at apex. Apical process (paa) long and round at apex, covered at apex by thick bristles; left margin of left phallomere covered by thick bristles.

Female unknown.

Measurements (mm). Holotype: body length 32, pronotum length 8.6, fore wings length 24.3, fore coxae length 4.2, fore femora length 6.4, fore tibiae length 3.7; width of pronotum 2.9, width of head 3.5, width of fore femora 1.7.

Paratype: body length 33.7, pronotum length 8.0, fore wings length 26.3, fore coxae length 5.0, fore femora length 6.0, fore tibiae length 3.8; width of pronotum 3.0, width of head 4.0, width of fore femora 2.0.

Identification key to species of *Galepsus* (*Syngalepsus*) using males

1 Prosternum with two black spots **2**

– Prosternum with a large black patch **4**

2 Cerci flattened with distal cercomere long and narrow. Right phallomere with ventral process (**pva**) with denticules **3**

– Cerci slightly flattened with distal cercomere not long and narrow. Right phallomere with a small process at the apex and ventral process (pva) without denticules. Left phallomere with apical process (paa) shaped like a small mallet, covered of bristles .... ***G.* (*S.*) *beieri***

3 Right phallomere with some big teeth towards right on ventral process (pva), left phallomere with apical process (paa) not shaped like a spoon, long, with rounded apex and covered of thick bristles .... ***G.* (*S.*) *dudleyi* sp. n.**

– Right phallomere without big sharp teeth on ventral process (pva), but a regular rough margin. Left phallomere with apical process (paa) shaped like a spoon, with a little lateral process .... ***G.* (*S.*) *bipunctatus***

4 Body length more than 27 mm. Left phallomere with apical process (paa) large, covered of numerous and thick bristles **5**

– Body length less than 26 mm. Ventral face of forelegs with black spots on femora and trochanter. Left phallomere with apical process (paa) long and narrow, bristles only at apex .... ***G.* (*S.*) *birkenmeierae***

5 Forelegs without black patches on ventral face. Left phallomere with a large apical process (paa), with rounded apex, covered of thick bristles..... ***G.* (*S.*) *denigratus***

– Forelegs with black patches on ventral face of femora and trochanters. Left phallomere with apical process (paa) shaped like a hammer, covered of thick bristles ... . ***G.* (*S.*) *bucheti* sp. n.**

Clé d'identification des espèces de *Galepsus* (*Syngalepsus*) d'après les mâles

1 Prosternum avec deux points noirs...**2**

– Prosternum avec une grande tache noire **4**

2 Cerci aplatis avec le dernier segment long et étroit. Epiphallus droit avec le processus ventral (pva) portant des dents...**3**

– Cerci légèrement aplatis avec le dernier segment pas long et étroit. Epiphallus droit avec un petit prolongement à son extrémité et le processus ventral (pva) sans dents. Epiphallus gauche avec l'extrémité du titillateur en forme de petit maillet couvert de soies.. ***G.* (*S.*) *beieri***

3 Epiphallus droit avec quelques grandes dents orientées vers la droite sur l'apophyse, epiphallus gauche avec le titillateur pas en forme de cuillère, long, avec le bout arrondi et couvert de soies épaisses........................... ***G.* (*S.*) *dudleyi* n. sp.**

– Epiphallus droit sans de grosses dents pointues sur l'apophyse, mais une cannelure presque régulière, epiphallus gauche avec le titillateur en forme de cuillère, avec un petit prolongement latéral .... ***G.* (*S.*) *bipunctatus***

4 Longueur du corps supérieure à 27 mm. Epiphallus gauche avec un titillateur large, couvert de nombreuses et épaisses soies..**5**

– Longueur du corps inférieure à 26 mm, intérieur des pattes antérieures avec des taches noires sur les fémurs et trochanters. Epiphallus gauche avec le titillateur long et fin, des soies uniquement vers l'extrémité .... ***G.* (*S.*) *birkenmeierae***

5 Pattes antérieures sans taches noires sur la face intérieure. Epiphallus gauche avec le titillateur large, au bout arrondi, couvert de soies épaisses .... ***G.* (*S.*) *denigratus***

– Pattes antérieures avec des taches noires sur la face interne des fémurs et trochanters. Epiphallus gauche avec le titillateur en forme de marteau couvert de soies épaisses.. ***G.* (*S.*) *bucheti* n. sp.**

Checklist of species of *G.* (*Syngalepsus*) (Fig. 8)

Galepsus (*Syngalepsus*) *beieri* Kaltenbach, 1996: Natal, South Africa.

Galepsus (*Syngalepsus*) *bipunctatus* Beier, 1931: Mozambique, Natal, Transvaal, South Africa.

Galepsus (*Syngalepsus*) *birkenmeierae* Beier, 1969b: Malawi.

Galepsus (*Syngalepsus*) *bucheti* sp. n.: Dzanga-Ndoki National Park, Central African Republic.

Galepsus (*Syngalepsus*) *denigratus* Beier, 1954: Angola, Democratic Republic of Congo, Gabon, Republic of the Congo, Uganda.

Galepsus (*Syngalepsus*) *dudleyi* sp. n.: Malawi.

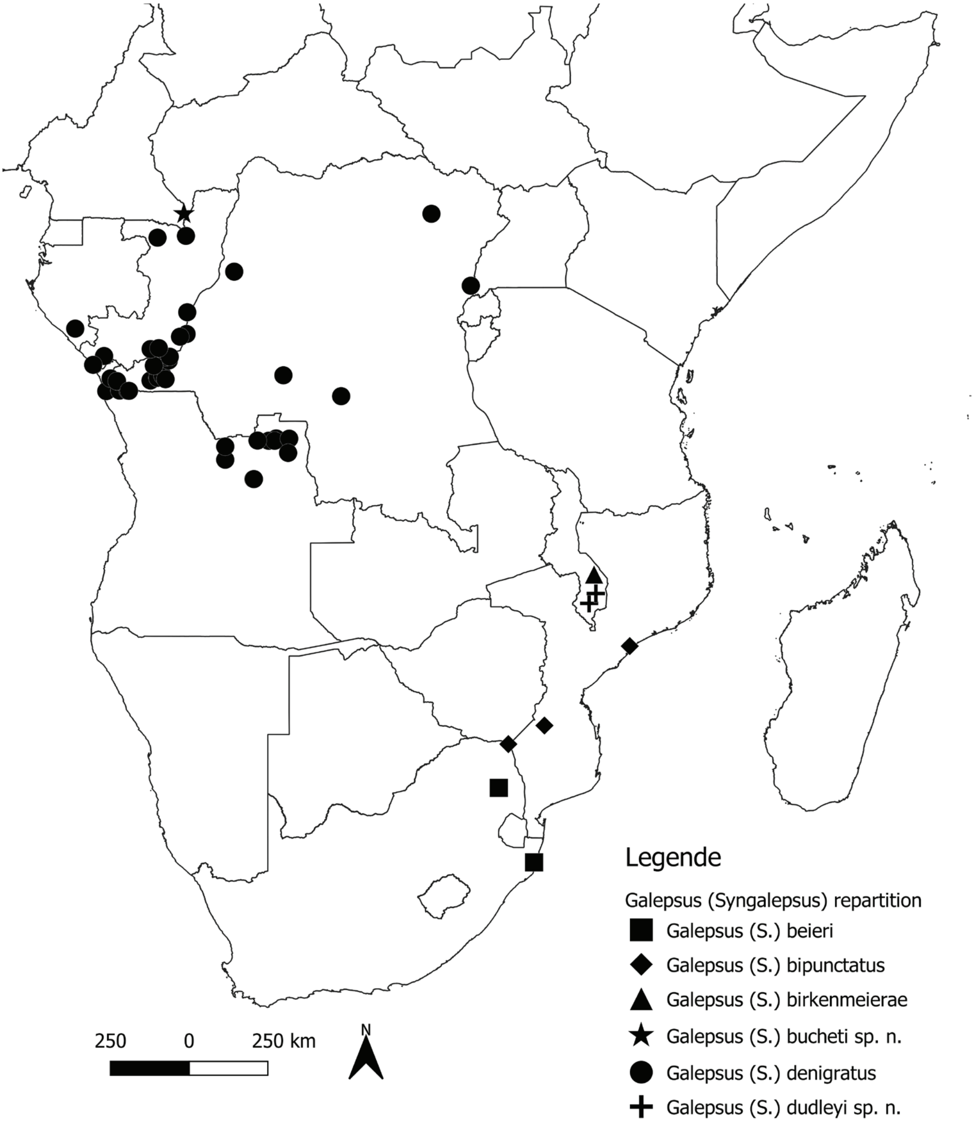

Figure 8. Distribution map of *Galepsus* (*Syngalepsus*) species. Source: http://www.gadm.org GADM database of Global Administrative Areas.

Discussion

The present study led to the description of two new species, *Galepsus* (*Syngalepsus*) *bucheti* sp. n. and *Galepus* (*Syngalepsus*) *dudleyi* sp. n. Males are easily identifiable using the characters of both habitus and male genitalia. However, females are unknown, which is common for mantises because studies with light trap sampling fail to attract females. Here, only females of *G.* (*S.*) *denigratus* are known (Beier 1969a). They are brachypterous and likely live on tree trunks and branches. Sweep nets and visual searching should be used more broadly in Mantodea studies to ensure more females can be collected. Furthermore, this method will also reveal mantises' micro-habitat preferences. In CAR, no female of *G.* (*S.*) *bucheti* sp. n. were collected, although all known modern sampling techniques were implemented (sweeping, beating, tree climbing, light trap). With brachypterous females it a likely the distribution of each species could be restricted to small geographic ranges, which could indicate many species remain to be discovered in remote areas of Africa and other parts of the world.

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