RESEARCH ARTICLE



Contribution to the knowledge of the Bulgarian species of the genus Vitrea (Gastropoda, Pristilomatidae) with the description of a new species

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Abstract

A new species of genus *Vitrea* is described: *Vitrea ulrichi* **sp. n.** is the eleventh species within the genus found in Bulgaria, and the largest representative of the Bulgarian *Vitrea*. Some critical notes on the taxonomy of the species *V. bulgarica* and *V. sturanyi* are presented. A key is provided for the determination of the species of *Vitrea* found in the country.

Keywords

New species, Vitrea ulrichi sp. n., Bulgaria

Introduction

The European species belonging to the genus *Vitrea* Fitzinger, 1833 (Gastropoda: Pristilomatidae) number 56 to date, many with local and scattered distribution patterns on the continent (Welter-Schultes 2012). The shell morphology in this

snail group is very important for differentiation of species as they are very diverse (Pintér 1972). In addition, the internal penis structures can be investigated but the external features of the genital organs are not of much taxonomic importance (Riedel 1992). Schileyko (2003) notes that from approximately 50 taxa in the genus known at his time, the anatomy of nearly 30 species is unknown; he also notes that the inner structure of the penis supplies the main differences between the subgenera.

There are eleven species of *Vitrea* reported in the Bulgarian fauna till now (Damjanov and Likharev 1975; Irikov et al. 2004; present study). Some of these have wider distributions and are found widespread on the European continent and/or neighboring parts of Asia or even Northern Africa, such as *Vitrea diaphana* (Studer, 1829), *Vitrea pygmaea* (O. Boettger, 1880), *Vitrea contracta* (Westerlund, 1871), and *Vitrea subrimata* (Reinhardt, 1871). The other group consists of species endemic to restricted territories situated on the Balkan Peninsula such as *Vitrea vereae* Irikov et al., 2004 and *Vitrea sturanyi* (Wagner, 1907), and some of them with distribution ranges extending also to neighboring areas such as Asia Minor (*Vitrea bulgarica* Damjanov & L. Pintér, 1969, *Vitrea neglecta* Damjanov & L. Pintér, 1969, and *Vitrea riedeli* Damjanov & L. Pintér, 1969) or the Carpathians, Central and Western Europe (Southern Germany and Northern Tirol in Austria) like *Vitrea transsylvanica* (Clessin, 1877) (Damjanov and Likharev 1975; Kerney et al. 1983; Welter-Schultes 2012; Deli and Subai 2011).

All species of *Vitrea* living in Bulgaria can well be distinguished by their shell characters (Damjanov and Likharev 1975, Irikov et al. 2004), but many aspects of their autecology are still poorly known. Some more new species in the genus can be expected. In the neighboring country of Greece, for comparison, many more species have been described, most of them representing local endemic species. Interestingly, this is not only caused by the isolation of the Greek Island, many of them are described from the continental parts of the country (Riedel 1992).

In this paper we describe a new species, *Vitrea ulrichi* sp. n. from the Stara Planina Mountain, Bulgaria, which can be distinguished from the most similar species *Vitrea kutschigi* (Walderdorff, 1864) and *V. sturanyi* by its larger size, its angled shell, and very prominent shell sculpture.

Material and methods

The specimens of the new species (and other representatives of the local malacofauna) were collected by hand and with a double sieve system $(1 \times 1 \text{ and } 2 \times 2 \text{ mm})$.

Abbreviations used: Nw-number of whorls, H-height of shell, D-diameter of shell, Du-diameter of umbilicus, Dlw-diameter of last whorl, Dpw-diameter of penultimate whorl; SMF-"Senckenberg Forschungsinstitut und Naturmuseum"; NMNHS-"National Museum of Natural History, Sofia".

Results

Vitrea ulrichi sp. n.

http://zoobank.org/6BD6CA0F-4433-4FA0-A11F-991E6F1619BB http://species-id.net/wiki/Vitrea_ulrichi

Holotype. Nw 6.25, H 2.1 mm, D 4.65 mm, Du 0.9 mm, Dlw 0.75 mm, Dpw 0.55 mm (SMF 341898).

Paratypes. 2 specimens (SMF 341899/2).

The remaining paratypes are stored in the collections of the authors.

Locus typicus. Surroundings of the Benkovskata Cave, near the village of Cherni Vit, Teteven town district, Stara Planina Mts, Bulgaria, 15–16.11.2013, leg. D. Georgiev, 10 adult, 5 juvenile specimens, 42°50'44.2"N, 24°10'29.8"E, 650 m (Fig. 1).

Etymology. The species is named after our colleague and good friend Ulrich Schneppat (Natural History Museum, Chur, Switzerland) with gratitude for his great contribution to the knowledge of Bulgarian gastropods and for providing many literature sources, as well as for long and useful discussions with us on snails and slugs by email or around camp fires during our expeditions throughout Bulgaria.

Diagnosis. Of all the *Vitrea* species reported for Bulgaria, the new species differs by its larger size, large number of whorls, and the intensely radially striated and angular shell. Considering the other European species and those distributed in the neighboring area of Asia Minor, the new species is most similar to *V. kutschigi* known from Dalmatia, Serbia, Kosovo, and Macedonia, from which it differs by its coarsely striated and larger shell, higher spire, and position of the end of aperture edge on the last whorl, located at 1/3 of the last whorl in the *V. ulrichi* sp. n. when compared to *V. kutschigi*, where it is found on the upper side of the last whorl. The shape of the shell somewhat resembles that of *Vitrea saboorii* Neubert & Bössneck, 2013, but *V. ulrichi* is bigger and has wider umbilicus.

Description. The shell is translucent, yellowish-white, with 6.25-7 whorls which are densely and coarsely radially striated. The spire is low, broadly conical and elevated. The last whorl is angled at its periphery. The aperture is straight, moderately wide. In funnel perspective, the upper whorls are visible inside. The umbilicus is wide with a diameter of 0.75-1.05 mm, which represents approx. 1/5 of the shell's diameter. The diameter of the last whorl width is less than $2 \times$ the diameter of the penultimate whorl (Dlw 0.65-0.8 mm; Dpw 0.5-0.6 mm). The height of the shell is 2-2.35 mm. According to Welter-Schultes (2012), the shell of *V. kutschigi* resembles the shell of the freshwater snail *Bathyomphalus contortus* (Linnaeus, 1758), while the shell of *V. ulrichi* sp. n. is lens-like (Fig. 2).

Notes on the ecology. The type locality represents the surrounding area of a limestone water cave, with a small spring flowing below the cave near its entrance, providing constant air and soil moisture. The locality, where the new species was found, is a steep carbonate rock on the right side of the cave, densely covered with broad leaf



Figure 1. The type locality of *Vitrea ulrichi* sp. n.: the cave entrance (above) and the site of collection near the cave (below).



Figure 2. A–D *Vitrea ulrichi* sp. n. Shell of the holotype with view of the embryonic protoconch **E–G** *Vitrea kutschigi* from Montenegro (Dedov coll. no. Mtn 366, ex. coll. P. Subai).

detritus, mainly from *Fagus sylvatica*. The area is occupied by *F. sylvatica* and *Carpinus betulus* trees and bushes, as well as mosses and ferns (mostly *Asplenium scolopendrium*) covering the rocks (Fig. 1).

The terrestrial malacofauna diversity at the type locality was very rich. There were more than 20 species of land gastropods registered, within only on a few square meters of area: *Carychium tridentatum* (Risso, 1826), *Agardhiella* cf. *pirotana* Subai, 2011, *Vallonia pulchella* (O. F. Müller, 1774), *Cochlicopa lubricella* (Porro, 1838), *Laciniaria* cf. *plicata* (Draparnaud, 1801), *Macedonica marginata* (Rossmässler, 1835), *Alinda wagneri* (A. J.Wagner, 1911), *Vestia ranojevici* (Pavlovic, 1912), *Euconulus fulvus* (O. F. Müller, 1774), *Vitrea diaphana* (Studer, 1829), *V. transsylvanica* (Clessin, 1877), *V. bulgarica* Damjanov & L. Pintér, 1969, *V. contracta* (Westerlund, 1871), *Aegopinella pura* (Alder, 1830), *Oxychilus glaber* (Rossmässler, 1838), *Daudebardia brevipes* (Draparnaud, 1805), *Perforatella incarnata* (O. F. Müller, 1774), *Euomphalia strigella* (Draparnaud, 1801), *Cattania balcanica* (Kobelt, 1876), and *Cepaea vindobonensis* (Férussac, 1821).

Discussion

After the description of this new species, the genus *Vitrea* in Bulgaria encompasses eleven species. In this number, we also include some doubtful species such as *V. bulgarica* and *V. sturanyi*. Due to lack of anatomical data, we are not able to confine the new species to one of the existing subgenera.

The problem of V. bulgarica-V. neglecta

Damjanov and Pinter (1969) described the two species *V. neglecta* (locus typicus: Bulgaria, Rhodope Mountains, some kilometers from the Bachkovski Monastery, Chaya river valley) and *V. bulgarica* (locus typicus: Bulgaria, Rhodope Mountains, tributary of Chaya river between Asenovgrad and Bachkovo) in the same work.

Dedov (1998) suggested that the status of both species should be re-evaluated and that internal anatomies should be studied. Irikov (2001), after examination of shell morphology and anatomy of specimens from both type localities, concluded that *V. bulgarica* and *V. neglecta* were synonyms. This opinion was accepted by Welter-Schultes (2012).

The examination of material from genus *Vitrea* stored in the NMNHS revealed the existence of the holotype of *V. bulgarica* (NMNHS 6627, information from the label: Asenovgrad, 24.07.1967, leg.L. Pintér) and a paratype of *V. neglecta* (NMNHS 6704, information from the label: S. of Smolyan, 11.06.1967, leg. S. Damjanov, det. L. Pintér) (Fig. 3).

After studying these specimens, we found some differences existing between *V. bulgarica* and *V. neglecta*, which correspond to the original descriptions of both species



Figure 3. A, B *Vitrea neglecta* Damjanov & L. Pintér, 1969: paratype NMNHS 6704, C, D *Vitrea bulgarica* Damjanov & L. Pintér, 1969: holotype NMNHS 6627.

(Damjanov and L.Pinter 1969). In *V. bulgarica*, the whorls increase faster than in *V. neglecta*; the last whorl is approximately two times larger than the penultimate and the umbilicus is in form of a funnel, respectively. Moreover, in *V. neglecta* the suture looks much deeper if compared to *V. bulgarica*. Because of the poor quality of the shell of the paratype specimen of *V. neglecta*, the radial sculpture of the shell is not clearly visible. At the same time, the more convex lower side of the shell of *V. bulgarica* (Damjanov and L.Pinter 1969; Damjanov and Likharev 1975) is not clearly discernible; in addition, the correlations of the diameters of the umbilicus to diameter of the shells differs from those given by Damjanov and Likharev (1975) (*V. bulgarica* Du/D = 1/9; *V. neglecta* Du/D = 1/10-1/11). According our measurements, the umbilici in both species are wider than the information provided by Damjanov and Likharev (1975). The

parameter of both shells are: *V. bulgarica*–Nw 5.25, D 3.09, Dlw 0.72, Dpw 0.36, Du 0.48, H 1.29, Du/D = 1/6.5; *V. neglecta*–Nw 4.5, D 2.19, Dlw 0.45, Dpw 0.3, Du 0.43, H 1.08, Du/D = 1/5.

Irikov's opinion (2001) "between typical *V. neglecta* and *V. bulgarica* there are many intermediate forms, forming gradual series" could be interpreted as a confirmation of Riedel (1992), who commented on the difficulties recognizing apparent differences between the two species in some populations. The different forms and difficulties in determination exist also in other species of this genus (Pintér 1972, Damjanov and Likharev 1975; Riedel 1992). To our opinion, some forms considered as "intermediate" probably represented juvenile or sub-adult stages of the shell (for *V. bulgarica* and *V. neglecta* it means less than 4.5–5 whorls). Our observations on the shell morphology of adult specimens (4.5 whorls and more) of *V. bulgarica* from western Bulgaria shows populations of typical *V. bulgarica*, with variations in the border of species characters. Thus whenever we speak about intermediate forms within the genus *Vitrea* it is necessary to indicate the size of the studied species, respectively the number of their whorls.

The most important question for a correct determination of the species in genus Vitrea concerns the structures of the sexual system. According to Pintér (1972), the shell morphology in this genus is paramount for differentiation of species, and Riedel (1992) stated that the external features of the genital organs are not of much taxonomic importance. However, the internal structure of the penis provides information that can be used for a sub-generic distinction (Schileyko 2003). Probably this is the reason, despite their comments about the close relationship between V. bulgarica and V. neglecta, why Damjanov and Likharev (1975) and Riedel (1992) accepted both species as separate. The question is "how far can we rely on the structure of the sexual system in this genus when discussing closely related species?" In our opinion, the structure of the sexual system is important, but is not the single character that should form the basis of a taxonomic opinion. In this case, it is important to study the sexual systems of those specimens, who are considered to represent "border" forms. After that, the probably can be determinate more clearly as known species or intermediate forms. Without completely rejecting the conclusion of Irikov (2001) at this stage, we currently consider the problem V. bulgarica-V. neglecta still as open requiring more detailed studies, which are planed by the authors for the near future.

V. sturanyi

The occurrence of *V. sturanyi* in Bulgaria, and even on the East Balkans, is disputable. Wagner (1907) described *V. sturanyi* (as *Crystallus sturanyi* Wagner, 1907) from Bosnia, Krupa spring near Pazarich. Later, Wohlberedt (1911), Hesse (1916) and Jaeckel (1954) reported this species also for Bulgaria. Pintér (1972) challenged these records and referred them to other Bulgarian species like *V. bulgarica*, *V. neglecta*, *V. diaphana*, *V. contracta*, and even *Oxychilus hydatinus* (Rossmässler, 1838) from the family Oxychilidae. Damjanov and Likharev (1975) confirmed the species for Bulgaria from two localities in the Western Rhodope Mountains (Velingrad and Trigrad village), while Welter-Schultes (2012) negates the occurrence of this species in Bulgaria. Our shells from southwestern Bulgaria show some differences when compared to the descriptions of Damjanov and Likharev (1975)–larger diameter of the shell, a smaller number of the whorls, and much more depressed spire. It is currently not clear whether this could be intra-specific variation of *V. sturanyi*, or whether this represents another new species. To clarify this problem it is needed to compare our Bulgarian populations with the type specimens from Bosnia, which is also another activity for the near future.

Summarising the current knowledge on the genus *Vitrea* in Bulgaria, we propose the following key to identify the species within the country:

1	umbilicus entirely closed
_	umbilicus more or less open
2	diameter of the last whorl only slightly wider than penultimate whorl
_	diameter of the last whorl almost 3 times wider than penultimate whorl
4	umbilicus with minute opening, through the umbilicus internal whorls cannot
	be seen, whorls is 4.5-5, diameter of the shell 3.0-4.3 mm V. subrimata
_	umbilicus much wider, the penultimate whorls through the umbilicus could
	be seen
5	diameter of the last whorl almost 2 times wider than penultimate whorl6
-	diameter of the last whorl less wide (1.5 time than penultimate whorl or even
	less)7
6	suture deep, mouth is wider, size smaller (in 3.5-4 whorls, diameter of shell
	1.4-2.1 mm, the height of shell 0.7-0.8 mm) V. pygmaea
-	suture shallow, the mouth is narrowed, size bigger (in 4.5-5.5 whorls, diam-
	eter of shell 2.9-3.2 mm, the height of shell 1.3-1.5 mm) V. bulgarica
7	umbilicus perspective, very wide (about 1/3 from shell diameter), the whorls
	is 3–3.5 V. verae
-	umbilicus perspective, moderately wide, 1/5 or even less from shell diameter,
	the whorls are 4.5 or more
8	umbilicus perspective, about 1/4–1/6 from shell diameter9
-	umbilicus much narrow (about 1/12-1/14 of the shell diameter), the shell
	smooth, finely striated near the suture only, the bottom side of the shell
	rounded
9	shell intensively radially striated, the number of whorls is 6.5-7, diameter of
	the shell big (4.65–5.3 mm), shell with angled periphery V. ulrichi sp.n.
-	shell smooth or finally striated, the number of whorls is smal 4.5–5.75, diam-
	eter of the less than 4.3 mm
10	shell smooth, the spire much conical, the umbilicus much wide $(1/4-1/5)$
	from shell diameter)

-	shell finally striated, the spire much depressed, the	umbilicus much close
	(1/5–1/6 from shell diameter)	11
11	shell bigger (in 5 whorls diameter of the shell is 3.8	8–4.3 mm), umbilicus
	perspective-cylindrical	V. cf. sturanyi
-	shell smaller (in 5 whorls diameter of the shell is 2.9-3	3 mm), umbilicus per-
	spective-conical	V. neglecta

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CHECKLIST



Ground beetles (Coleoptera, Carabidae) of the Hanford Nuclear Site in south-central Washington State

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Abstract

In this paper we report on ground beetles (Coleoptera: Carabidae) collected from the Hanford Nuclear Reservation and Hanford National Monument (together the Hanford Site), which is located in southcentral Washington State. The Site is a relatively undisturbed relict of the shrub-steppe habitat present throughout much of the western Columbia Basin before the westward expansion of the United States. Species, localities, months of capture, and capture method are reported for field work conducted between 1994 and 2002. Most species were collected using pitfall traps, although other capture methods were employed. Trapping results indicate the Hanford Site supports a diverse ground beetle community, with over 90% of the 92 species captured native to North America. Four species collected during the study period are newly recorded for Washington State: *Bembidion diligens* Casey, *Calosoma obsoletum* Say, *Pseudaptinus rufulus* (LeConte), and *Stenolophus lineola* (Fabricius). Based on these data, the Site maintains a diverse ground beetle fauna and, due to its size and diversity of habitats, is an important repository of shrub-steppe biodiversity.

Keywords

Shrub-steppe, DOE, U.S. Department of Energy, pitfall trapping

Introduction

Incidental conservation on government-managed land has become an important component of biodiversity conservation in the United States, particularly on defense-related properties (Boice 2006, Stein et al. 2008). This includes Department of Energy (DOE) properties, which have protected vast tracts of lands in ecosystems that have otherwise been almost completely modified by human activity. DOE sites, though disturbed, have conserved places with high ecological and conservation value, primarily via the vast buffer areas that surround active waste storage or fuel production sites (Brown 1998, Burger 2000). Indeed, ecological research and conservation may be the most valuable legacy of the DOE properties (Dale and Parr 1998). Several large DOE holdings are managed as National Environmental Research Parks in recognition of the biodiversity and ecological value of these properties. The Hanford Site in south central Washington State is a prominent example of accidental preservation of a rare ecosystem and subsequent management for its ecological value.

During the past century of human activity and development much of the Columbia Basin shrub-steppe ecosystem has been converted to shrub-free grasslands and irrigated agriculture (Vale 1974), degraded from over-grazing (Jones 2000), subjected to habitat fragmentation (Welch 2005), and impacted by invasive species (Mack 1981, Knapp 1996). These changes have altered fundamental ecosystem processes and biological communities, from often-overlooked biotic soil crusts (Belnap and Phillips 2001, Ponzetti et al. 2007) to charismatic vertebrates (Connelly and Braun 1997, Van der Haegen 2007). Washington State considers its shrub-steppe ecosystem an at-risk ecological community in need of special, targeted conservation action (Washington Department of Natural Resources 2005). One of the largest contiguous tracts of high-quality shrubsteppe in Washington State is found on the Hanford Site, which encompasses more than 1,600 square kilometers of largely intact shrub-steppe habitat (Fig. 1).

The Site is located in the semi-arid region of Washington State, east of the Cascade Mountain Range. The Cascade rain shadow limits precipitation and drives wind patterns on the site. The sparse rainfall occurs almost entirely in the fall and winter months. Average annual precipitation at low elevations is only 16 cm, 38% of which is snowfall (Hoitink et al. 2005). Temperatures are high in the summer, among the highest recorded in Washington State. On average, 53 days per year have maximum temperatures equal to or exceeding 32 °C, and daily maxima exceeding 40 °C are frequent in summer months. The record high temperature for the site is 45 °C. Winter minimum temperatures average 0 °C between November and March, and below 0 °C in November through January. On average, 23 days per year have a maximum temperature \leq 0 °C (Hoitink et al. 2005). Prevailing winds on site are north-westerly for all months, and high winds are associated with the few yearly thunderstorms experienced on site. Thunderstorm-associated wind speeds have been recorded at 114 km/hr (Neitzel 1996).

The Hanford Site is divided into several different administrative units. Central Hanford is managed by the United States Department of Energy for environmental remediation, research, and storage and processing of nuclear waste. South of Central



Figure 1. Map of the Hanford Site and collection localities.

Hanford is the Fitzner Eberhardt Arid Lands Ecology reserve, currently managed as part of the Hanford Reach National Monument. The national monument also includes the stretch of the Columbia River known as the Hanford Reach, active sand dunes along the river, the White Bluffs north of the Columbia River, the Saddle Mountain National Wildlife Refuge, and the Wahluke Unit Columbia Basin Wildlife Area. Habitats found within the reservation boundaries include loose sand dune fields, freshwater springs, expanses of perennial bunchgrass-dominated communities, shrublands, a lake, vernal pools, and degraded areas associated with human activity.

The Hanford Site has been closed to the public since the 1940s, when private and adjacent public property in the region was commandeered during World War II to create a nuclear research and fuel production area. The Site has a troubled legacy marked by radioactive materials contamination, massive and expensive remediation projects, and concomitant environmental and human health controversies (see Neitzel (1996) and Power (2008) for more discussion of the Site's history). With the end of the Cold War, the importance of nuclear fuel production waned and activities on the Site shifted increasingly toward environmental restoration, research and management.

In 1992, the Nature Conservancy partnered with the U. S. Department of Energy to conduct a biological diversity survey of the Site. The results were intended to inform decision making and the future of the property. The biodiversity survey included plants, biological soil crusts, terrestrial vertebrates, and insects, and was the genesis for the studies reported here (Soll et al. 1999). Other insect surveys and research from the Hanford Site have concentrated on insects in general (Kimberling et al. 2001), darkling beetles (Coleoptera, Tenebrionidae; e.g., Rickard 1970, Rogers et al. 1978), shore flies (Diptera, Ephydridae; Zack 1998), weevils (Coleoptera, Curculionidae; O'Brien and Zack 1997), torymid wasps (Hymenoptera, Torymidae; Grissell and Zack 1996), Neuroptera (Zack et al. 1998) and insects associated with woody shrubs (Rogers 1979). This paper presents a list of ground beetles (Coleoptera, Carabidae, including Cicindelinae) collected on the Site between 1994 and 2002, adding distributional, ecological, and phenological information about a beetle family frequently used in ecological and environmental studies (e.g., Rykken et al. 1997, Purtauf et al. 2004, Prasad and Snyder 2006).

Methods

Ground beetles were collected by various means, although most specimens and species were captured in unbaited pitfall traps. Pitfall traps consisted of 500ml deli cups (circumference 33.3 cm) using a 50:50 propylene glycol/water mixture as a preservative. Two sheet metal baffles (46 cm long, 7.5 cm high) were joined in a "+" shape and placed over each trap to increase effective diameter (after Morrill et al. 1990), and sheet metal lids (30.5 cm square) were added to help prevent vertebrate predation and flooding from precipitation. Pitfall trap transects were established at five sites south of the Columbia River in March, 1998, and maintained through June 1999 or December 1999. Two pitfall transects were installed in February 1999 at two freshwater springs, and maintained through December 1999. Four additional series of pitfall transects were established in April 2002 and maintained through March 2003, in sites north of the Columbia River. A few baited pitfall traps targeting Silphidae and Scarabaeidae were installed haphazardly across the Site in the summer of 1998 and spring of 1999. The traps were baited with opportunistically obtained animal dung or dead rodents, birds, or snakes suspended in cheese-cloth over the trap cup. Trap numbers per site and total trap days varied (Table 1). Trap samples were collected weekly at most sites, although sampling intervals in general were longer during winter 1999, and administrative closures at some sites occasionally lengthened other sampling intervals.

Mercury vapor lights were used between 1995–1997 to collect night-flying insects, resulting in some carabid catches. A few individuals were collected during the study period at incandescent lights on the exteriors of buildings and several specimens were simply hand-collected. Abbreviations for collecting method are found in Table 1.

Samples were cleaned and sorted at the M.T. James Entomological Collection at Washington State University. Specimens were identified to species using keys in Noonan (1991), Lindroth (1961–1969) and Hatch (1953), by comparison with voucher specimens in the James Entomological Collection at Washington State University, or identified by and compared to material in the personal collection of JRL. Species names follow Bousquet (2012). Voucher specimens are deposited in the M. T. James Entomological Collection, Washington State University, Pullman, Washington, and in the William F. Barr Entomological Collection, University of Idaho, Moscow, Idaho.

Graphs of phenology and habitat association are presented for forty-five numerically prominent species collected in pitfall traps from the seven long-term sites in 1998 and 1999. The phenology data are derived from trap catches for the five pitfall sites operating between March 1998 and February 1999, but are presented on a Jan-Dec axis for ease of reading. The data represent the total numbers by month of each species captured across these sites, and provide a simple, generalized picture of when each species was active. Total beetles captured/trap-day of those same species are also presented for the seven long-term pitfall sites.

Locality descriptions

Twenty-two collecting sites were chosen across the reserve to capture a range of environmental and biological diversity (Fig. 1, Fig. 2). The majority of the collecting sites are shrub-steppe communities, reflecting the general character of the Hanford area. Unusual habitats sampled include active sand dunes (two sites), riparian areas and springs (five sites), an alkaline pond (one site), and several significantly disturbed areas. The following list of collecting localities is organized alphabetically and briefly described. Abbreviations used to identify localities in tables and figures are in parentheses following each description. Plant species mentioned in the locality descriptions derive from on-site observations and plant lists found in Sackschewsky and Downs (2001). GPS coordinates, collecting methods, and plant community types for each site are listed in Table 1. The plant community type data are derived from a Pacific Northwest National Laboratory 2001 vegetation map; while generally indicative of habitat type, the scale of the plant community type maps is greater that of the collection sites, and some plant species typical of a mapping unit were not always present at our collecting

	Pitfall Traps/ otal Trap-Days					10 / 6420	15 / 6930	5 / 1735					5 / 1395		10 / 6420	15 / 6930	10 / 3650	10 / 3650
>	Collection methods 1	AD, HC, MV	HC, MV, L	HC	HC	PT	HC, CT, PT	PT	HC	HC, MV	HC	HC	PT	HC	ΡT	HC, PT	ΡT	ΡT
	Hanford Plant Community Type	Bluebunch Wheatgrass - Sandberg's Bluegrass	Bunchgrass/Cheatgrass	Bunchgrass/Cheatgrass	Bluebunch Wheatgrass - Sandberg's Bluegrass	Bunchgrass/Cheatgrass	Big Sage/ Sandberg's Bluegrass	Big Sage-Rigid Sage/ Bunchgrass mosaic	Bluebunch Wheatgrass - Sandberg's Bluegrass	Abandoned Old Agricultural Fields	Threetip Sagebrush/ Bunchgrass Mosaic	Thymeleaf Buckwheat/ Sandberg's Bluegrass	Black Greasewood/ Alkali Saltgrass	Threetip Sagebrush/ Bunchgrass Mosaic	Big Sagebrush - Sandberg's Bluegrass/Cheat- grass	Bitterbrush/ Indian Ricegrass	Bitterbrush/ Indian Ricegrass	Big Sagebrush - Sandberg's Bluegrass/Cheat-
	Elevation (m)	375	375	189	465-288	360	130 - 185	325	420	123	965	1100	210	1100	360	150	134	156
	Coordinates	N46°24.413', W119°33.253'	N46°23.370', W119°32.27'	N46°29.845', W119°39.36'	N46°27.025', W119°36.41'	N46°22.829', W119°31.16'	N46°35.745', W119°26.38'	N46°35.860', W119°27.63'	N46°22.255', W119°32.26'	N46°35.001', W119°23.25'	N46°24.391', W119°36.31'	N46°23.842', W119°35.93'	N46°30.447', W119°41.88'	N46°23.549', W119°35.12'	N46°22.704', W119°31.08'	N46°31.369', W119°21.19'	N46°41.496', W119°35.44'	N46°42.064', W119°38.27'
	Abbreviation	1200FR	HA	BR	BC	CG	IJ	GS	HR	ΗT	NS	RR	RS	RT	SB	SD	SME	SMW
	Site	1200 Foot Road	ALE Headquarters	Benson Ranch	Bobcat Canyon	Cheatgrass Stand, Rattlesnake Slope	Gable Mountain	Gable Summit	Hodges Ranch	Hanford Townsite	North Ridge Spring	Rattlesnake Ridge	Rattlesnake Spring	Radio Telescope	Sagebrush Stand, Rattlesnake Slope	Sand Dunes	Saddle Mtn. East	Saddle Mtn. West

Table 1. Locality information for Hanford collecting sites.

Chris Looney et al. / ZooKeys 396: 13-42 (2014)

Site	Abbreviation	Coordinates	Elevation (m)	Hanford Plant Community Type	Collection methods	Pitfall Traps/ Total Trap-Days
Snively Ranch	SR	N 46°27.134', W119°42.80'	435	Bluebunch Wheatgrass - Sandberg's Bluegrass	HC	
Snively Spring	SS	N46°27.583', W119°43.24'	380	Bluebunch Wheatgrass - Sandberg's Bluegrass	ΡT	5 / 1395
White Bluffs Ferry	WB	N46°40.541', W119°26.94'	128	Bitterbrush/ Indian Ricegrass	ΡT	10 / 3650
Wahluke Sand Dunes	МD	N46°41.935', W119°26.21'	213	Bitterbrush/ Indian Ricegrass	BL, HC	
West Lake	ML	N46°36.066', W119°32.78'	420	Non-Riverine Wetlands & Aquatic Habitats	$\rm PT$	20 / 12,300

Collection Method Abbreviations:

AD = coyote dung-baited pitfall trap

BL = black light trap

CT = carrion-baited pitfall trap

HC = hand collected

L = fluorescent or incandescent lights

MV = mercury vapor light trap

PT = unbaited pitfall traps: number of traps indicated within parentheses



Figure 2. Examples of Hanford plant communities. **A** Site SB, mature sagebrush **B** Site CG, cheatgrassdominated community **C** Site WL, alkaline pond with mixed sagebrush-cheatgrass community (sites GM and GS) in the distance **D** Site RS, freshwater spring system **E** Site SD, typical sand dune habitat.

locality. The plant community types also fail to capture important qualitative details of the different collecting sites (e.g. weediness, presence of water bodies). These factors are better related in the following descriptions.

1200 Foot Road (1200FR)

The 1200 Foot Road is a dirt road running along the northern foot of Rattlesnake Ridge and is typical of the local bunchgrass and sagebrush associations.

ALE Headquarters (AH)

ALE headquarters is a small cluster of buildings used first by military personnel during World War II and later by research scientists. Currently the buildings are unused. Surrounding vegetation is the sagebrush/bluebunch wheatgrass (*Pseudoroegneria spicatum* (Pursh) A. Löve) type. Several colonizing weeds grow near the buildings and large open parking lots surround the complex for several hundred meters.

Benson Ranch (BR)

Benson Ranch was a pre-Hanford Site cattle ranch. Vegetation is primarily abandoned agricultural fields, including extensive cheatgrass (*Bromus tectorum* L.) and hedgemustard (*Sisymbrium* spp.), interspersed with bluebunch wheatgrass.

Bobcat Canyon (BC)

Bobcat Canyon is at the foot of north central Rattlesnake Ridge. This canyon contains a small spring system consisting of a pool only a few meters in diameter.

Cheatgrass Stand, Rattlesnake Slope (CG)

The road ascending Rattlesnake Ridge divides a once large sagebrush stand. Grazing and fires in the mid-1980s destroyed the north-western side of the stand, which is now composed of dense cheatgrass. This site contained no sagebrush, virtually no native shrubs, and any remaining microbiotic crust was obscured by the cheatgrass. Russian thistle (*Salsola iberica* Senne & Pau), associated with disturbed land, was also very common.

Gable Mountain (G)

The ENE slope of the Gable Mountain trapping site lies on a north-facing slope and is dominated by big sagebrush (*Artemisia tridentata* Nutt.), cheatgrass, and bunchgrasses in sandy soils.

Gable Summit (GS)

This rocky basalt outcropping has typical sagebrush/bunchgrass vegetation, and is heavily infested with cheatgrass.

Hanford Townsite (HT)

These remnants of the original township include crumbled foundations and abandoned roads. Vegetation is primarily introduced weeds, especially cheatgrass, with some colonizing natives (e.g., *Chrysothamnus* spp.).

Hodges Ranch (HR)

This area is located at the foot of the northeast slope of Rattlesnake Hills. The dominant community is bluebunch wheatgrass-Sandberg's bluegrass with extensive patches of cheatgrass.

North Ridge Spring (NS)

This small, free-flowing spring lies on the northeast slope of Rattlesnake Ridge approximately 100 m below the ridge crest. The spring emerges from a concrete structure and flows for approximately 10 m downslope. Sparse riparian vegetation is present within a shrub-steppe matrix.

Radio Telescope (RT)

This site is part way up Rattlesnake Ridge and consists of exposed granite with thin, sparse soils and scattered vegetation.

Rattlesnake Ridge (RR)

Rattlesnake Ridge is an anticlinal ridge and is among the most visible features of the Hanford Site. Collections were made at or near peak elevation. This area consists of rock outcrops with thyme-leaf buckwheat (*Eriogonum thymoides* Benth.) and Sandberg's bluegrass. Several plant species typical of ridgetops occur here, including *Phlox hoodii* Rich., *Crepis modocensis* Greene, *Balsamorhiza rosea* Nels. & Macbr., and *Salvia dorii* (Kell) Abrams.

Rattlesnake Spring (RS)

Rattlesnake Springs supports true riparian species, such as mature *Salix amygdaloides* Anders., *Populus trichocarpa* T. & G., and *P. tremuloides* Michx, with extensive bulrush (*Scirpa* spp.). The spring is the largest non-alkaline water body on the site after the Columbia River, and serves as a major water source and habitat for vertebrates.

Sagebrush Stand, Rattlesnake Slope (SB)

The road ascending Rattlesnake Ridge divides a once large sagebrush stand. Sagebrush and Sandberg's bluegrass dominate the southeastern side of the road, and the stand was a pristine example of mature, sage-dominated shrub-steppe. This site had the most well developed cryptogamic crust of all sampling areas, scattered native forbs and Sandberg's bluegrass, and virtually no introduced plant species. Wildfires in 2002 destroyed the sagebrush overstory, which is now largely recovered as bunchgrass and introduced species.

Saddle Mountain East (SME)

This site is semi-disturbed but relatively typical shrub-steppe habitat, dominated by big sagebrush, bunchgrasses, and cheatgrass, in sandy soil, with scattered lupine and balsamroot.

Saddle Mountain West (SMW)

The site is semi-disturbed but relatively typical shrub-steppe habitat, dominated by big sagebrush, bunchgrasses, and cheatgrass, in sandy soil, with scattered lupine and balsamroot.

Sand Dunes (SD)

The sand dune field west of the Columbia River contains vast, active dunes. Vegetation is typical of active dune fields, including needle-and-thread Grass (*Stipa comata* Trin. & Rupr.) and evening primrose (*Oenothera pallida* Lindl.). Dominant shrubs include green and brown rabbitbrush (*Ericameria nauseosa* (Pall. ex Pursh) G.L. Nesom & Baird and *C. viscidiflorus* (Hook.) Nutt.) and bitterbrush (*Purshia tridentata* (Pursh) DC.).

Snively Ranch (SR)

Snively Ranch is located upstream of Snively Springs. Vegetation includes sagebrush and bluebunch wheatgrass, with extensive invasion by cheatgrass.

Snively Spring (SS)

This mid-elevation fresh water stream lies in the Rattlesnake Hills within a matrix of sagebrush/cheatgrass/bunchgrass. Riparian vegetation includes dense stands of nettles (*Urtica dioica* L.) and other annuals, cottonwood (*Populus* spp.), and willow (*Salix* spp.).

Wahluke Sand Dunes (WD)

The Wahluke sand dunes are located on the Wahluke Unit of the Hanford Reach National Monument. It is a large area of sand dunes situated north of the Columbia River. Vegetation is like that described above for the larger series of dunes located on the Hanford Site, south of the river.

West Lake (WL)

West Lake is the only naturally occurring lake on the Hanford Site. It is highly alkaline and surrounded by salt and alkali-tolerant vegetation (e.g., *Distichlis spicata* (L.) Greene) within the larger shrub-steppe matrix. Numerous sedge and rush species are also present, as is an extensive stand of invasive smotherweed (*Bassia hyssopifolia* (Pall.) Kuntz).

White Bluffs Ferry (WB)

This site is located in a shallow depression approximately 50 m from the Columbia River, near the White Bluffs Ferry landing which operated from the 1880s until the early 1940s. There are no remnants of the ferry landing or buildings. Debris litters the site, which is still used as a boat launch. Vegetation consists of scattered sagebrush in a matrix of mixed, weedy vegetation with varying amounts of cheatgrass. The soil is sandy but packed.

Results

Ninety-two species of Carabidae were collected and identified during this study (Table 2). Eighty-six species are native to North America and the region. Six species are adventitious (indicated in Table 2 with an asterisk), all accidentally introduced from Europe (Bousquet

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														Loc	ality									
Species	1200FR	AH	BR	BC	CG	U	GS	HR	ΗT	NS	RR	RS	RT 5	SB S.	D Si	ME	MW	SR	SS 1	WB W	ß	ML	Months captured	Collecting method
Agonoleptus conjunctus (Say)					\times																	×	IV-V	PT
Agonum ferruginosum (Dejean)																						×	V, XI-XII	PT
Agonum fossiger Dejean												×										×	III, VI, VII	ΡT
Agonum melanarium Dejean																				×			VI-III	ΡT
Agonum muelleri (Herbst)*																			×				III	PT
Agonum placidum (Say)		\times			\times							×			×				×	×		×	X-III	L, MV, PT
Agonum suturale (Say)												×										×	IV, VI	ΡT
<i>Agonum thoreyi</i> Dejean																						×	>	PT
Amara apricaria (Paykull)*													· ·	×								×	VII, VIII	PT
Amara blanchardi Hayward																						×	IIX-III	PT
Amara californica californica Dejean					\times		\times					×							\times			×	IIX-I	ΡT
Amara carinata (LeConte)												×							×			×	IIX-III	PT
Amara confusa LeConte	Х			×	×						×				×							X	II-VII	MV
Amara convexa LeConte											×												Λ	HC
Amara discors Kirby					Х	Х								X			Х					x	I, II, V, VI, IX-XII	ΡT
<i>Amara farcta</i> LeConte																						X	I-VIII, X	ΡT
Amara littoralis Dejean					\times							×	· ·	×					×			×	IIV-VII	PT
Amara musculis (Say)												×			×								VIII, IX	MV
Amara obesa (Say)																				X			VI-X	ΡT
Amara quenseli quenseli (Schönherr)	×				×	×	×					×		X	×	×	X		×	×		×	IIX-I	AD, HC, MV, PT
<i>Amara scitula</i> Zimmerman												×										Х	IIV-V	ΡT
Anisodactylus amaroides LeConte														×									V	ΡT
Anisodactylus binotatus (Fabricius)*															_				X	Х		X	IV-VIII, XI	ΡT
Anisodactylus californicus Dejean												×										X	II-X	ΡT
Anisodactylus consobrinus LeConte										×			\mid						\mid				IX	HC
Axinopalpus biplagiatus (Dejean)														×	_							×	VI, VII	ΡT

														L	cality									
Species	1200FR	HΗ	BR	BC	S	G	S	HR	ΗT	NS	RR	RS	RT	SB S	D	ME S	MM	SR	SS	WB	MD	ML	Months captured	Collecting method
Bembidion bifossulatum (LeConte)																						×	III, VI	HC, PT
Bembidion coloradense Hayward																						×	III	PT
Bembidion diligens Casey																						X	III-IX, XI	PT
Bembidion flohri Bates						×																×	III-VIII, XII	CT, HC, PT
Bembidion impotens Casey												Х							Х			Х	III, IV, VI	HC, PT
Bembidion insulatum (LeConte)																						X	VI-III	ΡT
Bembidion mormon Hayward																						×	IIX-II	CT, HC, PT
Bembidion obscurellum obscurellum (Motschulsky)	Х									×		×			×				×			×	IIX-I	MV
Bembidion obtusangulum LeConte																						Х	I-VIII, X	ΡT
Bembidion patruele Dejean																						Х	III-IV, VI	ΡT
Bembidion quadrimaculatum dubitans (LeConte)															×				X			×	VI, VII, XII	HC, PT
Bembidion rupicola (Kirby)	Х		\times		\times							×			×				×			×	I-IX, XI, XII	MV
Bembidion salinarium Casey																						×	I, III-XII	HC, PT
Bradycellus nitidus (Dejean)												×											IIIV-IV	PT
Bradycellus nubifer LeConte												Х							Х				VI, VII, IX	ΡT
Bradycellus politus (Fall)																						×	IIIV-IV	ΡT
Calathus ruficollis ignicollis Casey					\times				×			×		×		×	\times		X	\times		×	IIX-I	ΡT
Calosoma cancellatum Eschscholtz																						Х	IIΛ	ΡT
Calosoma luxatum Say	Х			\times	×	X	×							X	×	Х	X					X	III-VIII	HC, PT
Calosoma obsoletum Say			\times																				IV	ΡT
Carabus taedatus agassii LeConte										\times									\times				IIV-VI	HC, PT
Chlaenius sericeus (Forster)																						Х	V, VI, X	ΡT
Chlaenius tricolor Dejean																						×	III-VII, X, XI	PT
Cicindela hemorrhagica hemorrhagica																						>	VI-IV	CT HC PT
LeConte																						\$	X71-1 A	1101110
Cicindela oregona oregona LeConte																						×	IIV-VII	HC, PT
Cicindela pugetana Casey	×			\times							\times				-	_		\times					V-III	HC
Cicindela tranquebarica vibex Horn																						×	III-V, IX, X	HC, PT

														Local	ity								
Species	1200FR	ΑH	BR	BC	CG	9 9	S F	RE	L	IS R	R R	S R1	SB	SD	SME	SMW	SR	SS	WB	IM	IM	Months captured	Collecting method
Cylindera terricola imperfecta (LeConte)															×						×	IIIA-V	HC, PT
Clivina oregona Fall											×											V-III	ΡT
Cymindis planipennis LeConte	x	×			×	X					×		×	×	×	×		×	\times		X	IIX-V	AD, HC, PT
Dicheirotrichus cognatus (Gyllenhal)											\times								\times		×	I-VII, XII	PT
Dicheirus piceus (Ménétriés)	×	×		×	×	\sim					×		\times				×	\times				IV-VII, X	HC, PT
Discoderus parallelus (Haldeman)					\times																	IV, VI	ΡT
Dyschirius aratus LeConte																					×	III-VIII, X-XII	ΡT
Dyschirius politus politus (Dejean)																					×	IV, VI, VII	ΡT
Elaphrus lecontei Crotch	×																				×	II-VI, X, XII	HC, PT
Euryderus grossus (Say)						×												\times				VI, VII	ΡT
Harpalus affinis (Schrank)*														×					×		×	IV-VI, VIII, XI	ΡT
Harpalus caliginosus (Fabricius)																					Х	VI, VII, IX	ΡT
Harpalus fraternus LeConte	Х	Х	×	×	×	X	~	×		×	×		×	×			X	×			Х	III-IX, XII	HC, PT
Harpalus fuscipalpis Sturm	×		\times	\times	\times	\sim	~		~	\sim	\times	X						\times			×	III, VI, VII	HC, PT
Harpalus opacipennis (Haldeman)																		×			Х	III-VII, XI	ΡT
Harpalus pensylvanicus (DeGeer)											×			×	×						Х	VII-IIV	PT, HC
Lebia viridis Say										×								×				IIV	HC, PT
Loricera pilicornis pilicornis (Fabricius)											×										Х	III, VI, VII	HC, PT
Microlestes linearis (LeConte)											×										Х	IV, VI-VIII	ΡT
Notiophilus nitens LeConte																		×				х	ΡT
Patrobus longicornis (Say)																			Х	Х	Х	VI, VIII, IX	ΡT
Platymus brunneomarginatus (Mannerheim)									~	×	×							×			×	II-VII, XI	HC, PT
Poecilus lucublandus (Say)													\times					\times	\times		×	IIX-III	ΡT
Poecilus scitulus LeConte																					Х	IIV-V	ΡT
Pseudaptinus rufulus (LeConte)																			Х			M	ΡT
Pterostichus adstrictus Eschscholtz																					Х	Ν	ΡT
Pterostichus corvinus (Dejean)																			×		X	III-VIII	ΡT

													-	Loca	lity								
Species	1200FR	ЧH	BR	BC	CG	 	H Si	IR H	Z L	IS RI	R R	S R1	r SB	SL SL	SME	SMW	SR	SS	WB	MD	ML	Months	Collecting
					1	+	+	+	+	+	+	+		\downarrow				1	1	1		captured	method
Pterostichus luctuosus (Dejean)																			×		Х	IV, VI, VII, XI	ΡT
Pterostichus melanarius melanarius (Illiger)*					Х						X		X	X	×			Х	Х		Х	IX-III	ΡT
Rhadine jejuna (LeConte)					×	X	×				×		Х	X				×			×	IX-I	ΡT
Stenolophus anceps LeConte																				X		Ν	BL
Stenolophus comma (Fabricius)																		×			×	III-VIII	ΡT
Stenolophus fuliginosus Dejean											X							Х		Х	Х	IV, V, VII, VIII	PT, BL
Stenolophus lineola (Fabricius)																				X	X	IIV-IV	PT, BL
Stenolophus rugicollis (LeConte)														X								Ŋ	MV
Syntomus americanus (Dejean)																			X		Х	IV, VI-VIII	ΡT
Tachys corax LeConte									_												Х	V, VIII-X	ΡT
Tachys edax LeConte							_	_	_										×			N	ΡT
Trechus obtusus Erichson*																		×	×		×	II-IV, VI, IX- X	ΡT
Species per locality	11	4	4	9	17	8	~	2	1 7	5	5	9 1	14	15	~	5	3	29	18	4	70		
Unique species per locality	0	0	-	0		0		0	0	_	1	0	-	-	0	0	0	7	4	-	24		

2012): Agonum muelleri (Herbst), Amara apricaria (Paykull), Anisodactylus binotatus (Fabricius), Harpalus affinis (Schrank), Pterostichus melanarius melanarius (Illiger), and Trechus obtusus Erichson. Most (sixty) of the species were collected only in unbaited pitfall traps and five species were collected only at mercury vapor lights. Four species were documented from Washington state for the first time (see Bousquet 2012): Bembidion diligens Casey, Calosoma obsoletum Say, Pseudaptinus rufulus (LeConte), and Stenolophus lineola (Fabricius). All these species were previously known from adjacent provinces or states (Bousquet 2012). The record for P. rufulus is the northernmost for this species (see LaBonte 1996).

Only a few species were found in ten or more collecting sites: *Amara quenseli quenseli* (Schönherr) (twelve), *Calosoma luxatum* Say (ten), *Cymindis planipennis* Le-Conte (thirteen), *Dicheirus piceus* (Ménétriés) (ten), *Harpalus fraternus* LeConte (fifteen), and *Harpalus fuscipalpis* Sturm (ten) (Table 2). However, even these species had disproportionate activity/density in just one or two localities (Fig. 4). Only *Bembidion rupicola* (Kirby), *C. luxatum*, *H. fraternus*, and *Rhadine jejuna* (LeConte) had relatively high activity/density at three or more locales (Fig. 4). Most species were only found in or had high activity/density at a single locality, with forty species collected from only a single locality (Table 2, Fig. 4).

For comparison of fauna by site it is important to distinguish sites sampled with relatively efficient pitfall traps from those sampled opportunistically by hand or with light traps. Eleven sites have records that stem only from non pitfall-trap collections (Table 1). Twenty-three species were collected at these sites, ranging from eleven (at the 1200 Foot Road site) to one species per site (Table 2). Five species were unique to these sites, four hand-collected and one captured at a mercury vapor light. Eighty-seven species were collected at sites sampled with pitfall traps, with five to seventy species per site. West Lake had the greatest number of species (seventy), 80% of all species collected with pitfall traps. Two other localities had species counts of twenty-nine each, Rattlesnake Springs and Snively Springs. Twenty-four species were only found at the West Lake site (Table 2, Fig. 4), an order of magnitude of unique species greater than almost all other habitats. More than half (fifty-four) of the species collected with pitfall traps were captured only at riparian habitats–at one of the spring systems, White Bluffs Ferry, or West Lake.

Phenologies based on activity/density were highly variable (Fig. 3). A few species were active throughout the year: *Amara californica californica* Dejean, *A. quenseli quenseli, B. rupicola, B. salinarium* Casey, and *R. jejuna.* Some species had very narrow peaks, with high numbers during only one or a few months, e.g., *Amara carinata* (LeConte), *B. diligens, C. luxatum, Chlaenius sericeus* (Forster), *Cicindela oregona oregona* LeConte, *Cymindis planipennis* LeConte, and *Tachys corax* LeConte. However, all species had distinct, and for the most part, unimodal, peaks. Although defying rigid categorization, there were some basic patterns, arbitrarily defined as: "spring-active" (March through May), e.g., *C. luxatum*; "summer-active" (June through August), e.g., *Cicindela hemorrhagica hemorrhagica* LeConte; "autumn-active" (September and October), e.g., *A. carinata*; and "winter-active" (November through February), e.g., *Amara discors* Kirby. A few species were bimodal, e.g., *A. c. californica, Cicindela tranquebarica vibex* Horn, and *T. obtusus*.



Figure 3. Bar graphs presenting total seasonal abundance for select pitfall-trapped carabid species. Y-axes indicate the total number captured per month, summed across all sites.











Figure 3. Continue



Figure 4. Bar graphs presenting per-trap catches of select pitfall-trapped species from seven collecting sites. Y-axis units for each graph are individuals/trap/day, over the entire collecting period. Locality abbreviations (X-axis) are found in Table 1.







Figure 4. Continue

Discussion

Most, if not all, of the eighty-six indigenous species of Carabidae found at the Hanford Site in this study are typical inhabitants of shrub- and rangelands of the Columbia Basin, and the habitat data generally conform to what is known or expected from these species (Larochelle and Larivière 2003). The discovery of four carabid species previously undocumented from Washington is not surprising, particularly since many of the habitat types found at the Site have not been extensively sampled in the state. Given that there are hundreds of carabid species in adjoining British Columbia (479), Idaho (338), and Oregon (478), (Bousquet 2012), many of which are not yet known from Washington, undoubtedly further species remain to be discovered.

Data from the non-lacustrine and riparian areas of this study resemble those from other projects sampling Carabidae in the region, with the same or similar species and total number of species reported. Hampton (2005) records thirty-four carabid species (and three genera not further identified) from the Idaho National Laboratory (INL) in southeast Idaho, compiled from studies conducted between 1968 and 2001. The INL site has vegetation and soil conditions much like the Hanford Site, in that shrubs and perennial grasses typical of the Great Basin and Columbia Basin dominate the land-scape. Lacustrine and riparian habitats are rare on the INL site, represented primarily by wastewater ponds, which were not specifically sampled for Carabidae (Stafford 1983, Cieminski and Flake 1995). Sampling intensity for ground beetles across the compiled studies was low, with few pitfall traps and trapping sites (Stafford 1983), although diverse collecting techniques were used overall (Stafford et al. 1986).

Blades and Maier (1996) identified thirty species of Carabidae from a single-year survey in the Okanagan Valley in southern British Columbia, also ecologically similar to this part of the Columbia Basin. That study employed a number of collecting techniques, including in-ground aluminum troughs, across six sites. One site near a fresh-water spring was sampled, although sparingly. Despite more intensive sampling, observed species richness from non-lacustrine and riparian habitats on the Hanford sites was similar (38) to richness observed in these other studies. The greater number of species reported from the Hanford Site is due to species collected only at lacustrine or riparian habitats (54), such as West Lake and the freshwater springs (Table 2).

Bodies of water provide critical and unique habitats in arid lands and are consequently biodiversity hotspots within the overall habitat matrix. These features provide more mesic conditions for species not strictly associated with water margins. For instance, of the six exotic carabid species found in this study, most were collected (three exclusively so) at the lake, river, and stream sites (Table 2). To varying degrees, these species are associated with mesic habitats (see Larochelle and Larivière 2003). Many carabid species are lacustro-riparian specialists (see Larochelle and Larivière 2003), frequently displaying surprisingly high species richness and activity/density in those settings in the Pacific Northwest and providing important trophic linkages between the aquatic and terrestrial habitats (e.g., Hering 1998, LaBonte 1998). Together, the lacustro-riparian sites contributed more than fifty species found only at those sites. The West Lake site alone had by far the greatest species richness and the greatest number of unique species (Table 2). The two spring sites were tied for second-greatest species richness, which was almost double that of any other sites (Table 2). However, those two sites shared virtually all of their lacustro-riparian species with West Lake, with only one such species, *Clivina oregona* Fall, unique between them (Table 2). The carabids associated with alkaline water bodies are predominantly lacustrine species comprising a community largely unique to the arid West. Not surprisingly, almost all of those species (*A. blanchardi, B. diligens, B. flohri* Bates, *B. insulatum* (LeConte), *B. mormon* Hayward, *B. salinarium, Poecilus scitulus* LeConte, and *T. corax* - see LaBonte 1996, Larochelle and Larivière 2003) found at the Site were collected primarily from West Lake (Table 2). This further underscores the contribution of West Lake as a critical habitat feature at the Site. The collection of several *B. flohri*, otherwise found only at West Lake, in carrion-baited pitfall traps relatively far from water was an intriguing anomaly, suggesting substantial dispersal capabilities for a species existing in often widely scattered habitats.

Considering only the sites sampled with long-term pitfall traps, absence of nearby water bodies was correlated with fewer carabid species and fewer species unique to a particular site (Table 2). However, the value of the varied habitats in the Site matrix is clear as even widespread and eurytopic species such as *H. fraternus* (Larochelle and Larivière 2003) displayed pronounced peaks of activity/density in at most a few locales (Fig. 4). Even the habitats collected only by hand yielded a few unique species (e.g. *Amara convexa* LeConte from site RR, *Anisodactylus consobrinus* LeConte from site HT; Table 2).

Only six of the ninety-two species recorded here are introduced and these were trapped in low numbers. This is somewhat surprising, given the long history of disturbance and human activity at the Site (Neitzel 1996, Kimberling et al. 2001). Since there are twenty-four species of introduced and established Carabidae documented from Washington (Bousquet 2012), it was expected that the introduced species component would be much greater. Furthermore, much of the habitat would seem to suitable for establishment of many of those species (Larochelle and Larivière 2003, Spence 1990). This is likely a function of isolation and reduced access to the Site, which limits introduction pathways. The function of isolation may be inferred by the even more limited introduced carabid species composition at INL, comprising only A. apricaria (Stafford et al. 1986, Hampton 2005), since INL is even more remote from population centers than is the Hanford Site. It is perhaps not surprising that this species would be found at even INL since it has one of the largest distributions in North America of any introduced carabid species (Bousquet 2012). There is little documentation regarding the quality of shrub-steppe habitat and the indigenous carabid fauna versus vulnerability to introduced carabid incursion. The current paradigm is that most introduced carabid species are open habitat specialists closely associated with human disturbance (e.g., Spence 1990, Spence and Spence 1988), although some species appear to be generalists capable of invading pristine habitats (e.g., LaBonte 2011). This suggests that if introduction pathways become more pronounced it is likely the introduced carabid species component will grow, unless the xeric conditions hinder establishment.
The number and apparent abundance of indigenous versus exotic species is a crude measure of biological integrity. Past disturbance also impacts local carabid communities, notably as changes in the relative abundance of species based on their trophic habits. In a broad study of disturbed and undisturbed communities across the Hanford Site, Kimberling et al. (2001) found that species richness of polyphagous Carabidae (e.g., *Amara, Harpalus* – see Larochelle and Larivière 2003) increased in localities where soil disturbance or fire increased the relative proportion of weedy plant species. Sensitivity of carabids to changes in vegetation is well-known, and increased relative abundance of omnivorous or phytophagous carabid species has also been found in degraded African steppe habitats (Ouchtati et al. 2012) and simplified or weed-impacted landscapes in Europe and North America (Purtauf et al. 2005, Hansen et al. 2009).

While this study did not directly seek to evaluate changes in the carabid communities related to past disturbance, data from two adjacent pitfall trap sites provide strong evidence of such impacts to ground beetle assemblages. The CG/SB sites comprise two localities with identical soil and aspect conditions, but with a very different disturbance history. The CG site had been subject to intensive grazing and subsequent fire, and during this study was dominated extensively by the introduced grass *Bromus tectorum*. The SB site, separated from the CG site by only about twenty-eight meters, was protected from disturbance and retained a plant community rich in native species and a shrub overstory. The change in relative abundance of predatory vs. polyphagous species between these sites was dramatic, particularly visible in the relative activity/density of *A. quenseli quenseli* and *C. planipennis* (Fig. 4; see also Looney and Zack 2008).

Disturbance history varies across the site, both at and below the scale of the broadly defined sampling localities in this paper. The importance of local site variability to carabid diversity in this study is matched by the value of size of many of these community or habitat types. Quinn (2004) found that fragmentation of shrub-steppe habitat near the reservation caused subtle, yet measurable, reductions in total abundance of many arthropod groups and that species richness of predatory carabids was greater in large shrub-steppe patches than in small patches. Thus, both the complexity of habitats across the site and the vast area conserved within the site contribute to carabid biodiversity.

Seasonal activity/density peaks displayed by carabids, such as those in Fig. 3, are presumably indicative of breeding periods, at least in part (e.g., den Boer and den Boer-Daanje 1990, Thiele 1977). Carabids were previously regarded as being either spring or autumn breeders, but this is now regarded as oversimplified and it is recognized that most species cannot be so rigidly categorized (Kotze et al. 2011, den Boer and den Boer-Daanje 1990). The data in Fig. 3 appear to bear this out. Most species at the Site displayed activity/density patterns with spring or spring and summer peaks. Many of these species are known spring breeders, a behavior associated with, but not restricted to, open habitats (Larochelle and Larivière 2003).

In addition to demonstrating activity/density peaks, the data presented in Fig. 3 contribute to our knowledge of carabid seasonality in this shrub-steppe region. For most species (e.g., *A. blanchardi*, *A. quenseli quenseli*, *B. mormon*, and *Dicheirotrichus cognatus* (Gyllenhal)), the phenology data simply expand the known activity periods (c.f. Larochelle and Larivière 2003). For a few, less well-studied species (*Dyschirius aratus* LeConte, *Elaphrus lecontei* Crotch, and *R. jejuna*), the data add considerably to the known seasonality, demonstrating a much longer period of activity than was previously recorded or suggestive of a biennial lifecycle (Matalin 2007). While most species showed relatively narrow activity periods, some had surprisingly prolonged activity and were essentially active throughout the year. Most notable were those demonstrating activity/density peaks in winter (*A. californica californica, A. discors* Kirby, and *B. salinarium*). Winter can be harsh at the Site, with average daily minimum temperatures at or below freezing for much of December-February (Hoitink et al. 2005). Poikilothermic insects, presumably including most if not all of the Site carabids, are normally not active when it is that cold. However, minimum temperatures are rarely below -7 °C, and frequent sunny days may allow sporadic activity peaks. Furthermore, the relatively low winter and high summer temperatures are offset by the large range between daily minimum and maximum temperatures. This difference can be as much as 8 °C in January to 17 °C in July (Hoitink et al. 2005).

These data demonstrate the biological value of the Hanford Site, deriving perhaps not so much from the presence of any particularly unique or pristine habitats, but instead from the matrix of habitats at the Site. The biological value of the Site for these insects may stem primarily from this habitat diversity, its large size, and restricted access, rather then *per se* the quality of the remaining shrub-steppe habitat. The study also emphasizes the contribution of small, local habitats to the biodiversity of the overall Site, especially with regard to water features in this arid landscape and the distinctive insect communities they support. The value of the strictly terrestrial habitats was also evident, with even widely distributed species displaying apparent habitat preference and with most species showing marked habitat fidelity. The research value of the Site was demonstrated, with significant new information provided on carabid ranges, habitat selection and activity. The Hanford Site is clearly a unique repository of the region's natural history and a valuable resource for future research, a fact reflected in the formal designation of the Hanford Reach National Monument (Clinton 2000). As with many defense-related government properties, biological conservation has been a fortunate side-effect of the Hanford Site's otherwise checkered past.

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RESEARCH ARTICLE



First description of the female of Sarcophaga (Sarcorohdendorfia) gracilior (Chen, 1975) (Diptera, Sarcophagidae)

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Abstract

Sarcophaga (Sarcorohdendorfia) gracilior (Chen, 1975) is documented from specimens collected in Hubei Province, China, using morphological characters and wing interference patterns (WIPs). The female of *S. (S.) gracilior* is described for the first time, the male is redescribed, and both sexes are photographed. The distribution of the species is updated.

Keywords

Sarcophagidae, *Sarcophaga* (*Sarcorohdendorfia*) gracilior, female, wing interference patterns, morphology, taxonomy

Introduction

The Sarcophagidae (flesh flies) is a medium-sized family of Diptera with about 2600 known species worldwide, which includes various life history strategies ranging from inhabitants of pitcher plants to bat coprophages, crab saprophages, wasp nest inquilines, and insect parasitoids (Pape 1996). Some species are carrion breeders and therefore forensically important for the estimation of the time since death, i.e., the postmortem interval (Greenberg 1991; Catts and Goff 1992; Amendt et al. 2004), and several species of these flies have been recorded in association with human remains (Sukontason et al. 2001, 2007; Chaiwong et al. 2009; Cherix et al. 2012).

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Sarcorohdendorfia Baranov is a large subgenus of Sarcophaga Meigen (sensu lato), and it currently comprises 61 species known mainly from the Oriental and Australasian/Oceanian Regions (Pape 1996; Meiklejohn et al. 2013; Whitmore et al. 2013). The species Sarcophaga (Sarcorohdendorfia) gracilior (Chen, 1975) was originally described (in Tricholioproctia Baranov) based on eight male specimens from the type locality Mt. Tianmushan, Eastern China. Chen (1975) established the subgenus Hamimembrana with S. gracilior as its type species and only member. Lopes and Kano (1979) treated Tricholioproctia as a junior synonym of Sarcorohdendorfia, and Pape (1996) considered Sarcorohdendorfia as a subgenus of Sarcophaga s.l., and listed the subgenus Hamimembrana as a synonym of Sarcorohdendorfia. Since its description, S. (S.) gracilior has remained unnoticed by the majority of the scientific community and has appeared in the literature mainly through brief citations and catalogue entries (Kano and Shinonaga 1994; Fan and Pape 1996; Pape 1996; Chen et al. 2010; Zhang et al. 2010). Besides, the morphology of the male had not been studied in detail and information on the female of this species was completely absent. During a distribution survey about flies of medical significance around Central China, we discovered three female specimens of S. (S.) gracilior, which to our knowledge represent the first record of reliably identified females. We herewith provide the first description of the female of S. (S.) gracilior, and a redescription of the male.

Wing interference patterns (WIPs) were recently introduced as a potential new character system of extremely thin insect wings (Shevtsova et al. 2011), and it has at this time proven useful for the separation of species in Hymenoptera, Hemiptera and Diptera (Buffington and Sandler 2011; Hansson 2011; Shevtsova and Hansson 2011, Shevtsova et al. 2011; Simon 2012). It might be suspected to provide a useful tool for correctly associating male and female specimens in some Sarcophagidae, and finds support in ongoing studies (Zhang et al., unpublished), and we therefore provide WIPs for both sexes of *S.* (*S.*) *gracilior*. This is the first time that WIPs are applied to a flesh fly.

The primary aims of this article are: 1) to provide the first description of the female of *S*. (*S*.) *gracilior* and a redescription of the male, and 2) to provide the first data on WIPs for flesh flies as a potential tool in associating conspecific males and females.

Material and methods

Flies inhabiting forested areas in the mountainous region of the Hubei Province, China, were attracted by the viscera of grass carps (*Ctenopharyngodon idellus*) obtained from the local market. Viscera were kept frozen until needed, thawed and left to decompose for about two days before being deployed separately in traps consisting of open plastic containers (5.0 cm high, 10.0 cm in diameter). Flies that visited the bait during 1–2 hours from the time of deployment, were collected. Specimens were deposited in the Museum of Beijing Forestry University (MBFU), Beijing. Photographs were taken with a Canon 550D camera mounted on an Olympus SZX16 stereomicroscope. The methods applied to view and document interference colour patterns in the flies' wings

followed Shevtsova et al. (2011) and Shevtsova and Hansson (2011). Image processing softwares used were Adobe Photoshop CS3 (Adobe Systems, Inc., San Jose, CA, USA) and Helicon Focus 3.2 (Helicon Soft Ltd, Kharkov, Ukraine). Terminology of adult morphology follows McAlpine (1981). Distributional data was mainly taken from Pape (1996), with additional records obtained from major entomological catalogues (Chen et al. 2010; Zhang et al. 2010). The single male specimen was identified using Xue and Chao (1998) and by checking against the original description (Chen 1975). The female specimens were identified through careful comparisons with the male, supported by the fact that one pair (male + female) was collected *in copula*.

Taxonomic account

Sarcophaga (Sarcorohdendorfia) gracilior (Chen, 1975) http://species-id.net/wiki/Sarcophaga_gracilior

Tricholioproctia (Hamimembrana) gracilior Chen, 1975: 115. Type-locality: China, Zhejiang, Mt. Tianmushan.

Sarcorohdendorfia gracilior: Ye 1982: 22, 1992: 662; Fan and Pape 1996: 256; Xue and Chao 1998: 1646; Zhang et al. 2010: 360.

Sarcophaga (Sarcorohdendorfia) gracilior: Pape 1996: 397.

Female. Description. Body length about 13.0 mm. Eyes bare. Fronto-orbital and parafacial plates black with golden yellow pollinosity, postocular strip black with silvery pollinosity; parafacial bristles in one row, fronto-orbital plate with rows of fine setulae. Frontal vitta black, about as broad as fronto-orbital plate at the narrowest point; frons at vertex $0.3 \times$ head width; frontal row of 9–14 strong bristles; outer vertical bristle differentiated from postocular bristles, one reclinate and two proclinate orbital bristles. One pair of strong ocellar bristles, directed antero-laterally. Gena ground colour black, with black setulae in anterior 2/3, white setulae in posterior 1/3; height $0.3 \times$ eye height in lateral view, postgena with white setulae. Antennal first flagellomere brown, not reaching the level of vibrissal insertion, $3.4 \times$ as long as wide and $2.3 \times$ as long as pedicel, pedicel black; arista long plumose in basal 2/3. Palpus black, expanded in distal part.

Thorax ground colour black, with yellow pollinosity; scutum with three black dorsal vittae. Chaetotaxy: acrostichals 5(6) + 1, dorsocentrals 4 + 4, intra-alars 1 + 2 (3), supra-alars 3 or 4, postpronotals 3, scutellum with 1 discal and 4 marginal bristles. Meropleurals 10 or 11, katepisternal bristles 1: 1: 1, prosternum, metasternum, proepisternum and postalar wall with dense black fine setulae. Wing hyaline; subcostal sclerite yellowish brown, bare; tegula black, with black setulae; basicosta light yellow, bare; costal spine not differentiated; vein R₁ bare, three ventral setulae at node of R₄₊₅-R₂₊₃, vein R₄₊₅ setulose dorsally from junction of R₂₊₃ halfway to crossvein r-m; wing WIP (Fig. 5C) with clearly demarcated magenta and blue bands, and one large and almost triangular blue area on the apical part (shown with an arrow in Fig. 5C).



Figure 1. *Sarcophaga (Sarcorohdendorfia) gracilior* (Chen, 1975). Female. **A** Habitus, left lateral view **B** Abdomen, dorsal view **C** Head, anterior view **D** Head, left lateral view. Scale bars: $\mathbf{A} = 5.00$ mm; $\mathbf{B} = 2.00$ mm; **C** and $\mathbf{D} = 1.00$ mm.



Figure 2. Photomicrographs of the female terminalia of *Sarcophaga (Sarcophaga (Sarcophaga gracilior* (Chen, 1975). **A** Sternites 1–7, ventral view **B** Tergite 6, dorsal view **C** Terminalia, posterior view **D** Spermathecae **E** Terminalia, tergites 7+8, cerci and epiproct, dorsal view **F** Terminalia, cercus, hypoproct and sternite 8, ventral view. Scale bars: **A**–**C** = 1.00 mm; **D**–**F** = 0.25 mm. Abbreviations: cercus (cerc); epiproct (epiprct); hypoproct (hyprct); sternite (st); tergite (tg).

Legs dark, with grayish black pollinosity; fore femur with one row of dorsal bristles, one row of posteroventral bristles and one row of posterodorsal bristles, fore tibia with four anterodorsal and one posterior bristles; mid femur with four median anterior, one apical posterior and one apical posterodorsal bristles, mid tibia with two anterodorsal, one ventral and one subapical posterior bristles, and with one row of



Figure 3. Sarcophaga (Sarcorohdendorfia) gracilior (Chen, 1975). Male. **A** Habitus, left lateral view **B** Abdomen, dorsal view **C** Head, anterior view **D** Head, left lateral view. Scale bars: $\mathbf{A} = 5.00$ mm; $\mathbf{B} = 2.00$ mm; **C** and $\mathbf{D} = 1.00$ mm.



Figure 4. *Sarcophaga (Sarcorohdendorfia) gracilior* (Chen, 1975). Male. **A** Phallus and gonites, lateral view **B** Terminalia, lateral view. Scale bar: **A** = 0.50 mm; **B** = 1.00 mm.

posterodorsal bristles (one strong); hind femur with one row of anterodorsal bristles, and with one apical posterodorsal and two apical posterior bristles, hind tibia with one row of anterodorsal bristles (among them three strong), and with one anteroventral and four posterodorsal bristles.

Abdomen oval with yellow pollinosity; tergite 3 without median marginal bristles, tergite 4 with one pair of median marginal bristles, tergite 5 with strong marginal bristles; sternite 2 with six long bristles along posterior margin. Terminalia: tergite 6 undivided (Fig. 2B), tergites 7+8 fused together (Figs 2C, 2E), sternite 2 with a small isolated sclerite on the posterior margin, sternites 5 and 6 rectangular in ventral view (Fig. 2A), sternite 8 represented by a membranous fold, hypoproct well developed but not particularly sclerotized and with numerous setulae (Fig. 2F), epiproct with only two strong bristles (Fig. 2E).

Male. Redescription. Body length 16.0–17.0 mm. Frontal vitta 1.6 × as broad as fronto-orbital plate at the narrowest point; frons at vertex $0.22 \times$ head width; frontal row of 11–13 bristles; outer vertical bristle not differentiated from postocular bristles, one reclinate orbital bristle. Antennal first flagellomere 4.1 × as long as wide and 3.1 × as long as pedicel.

Thorax: fore femur with slender ventral setulae in basal 1/2, fore tibia with three anterodorsal bristles; mid tibia with one anterodorsal bristle; hind femur with one row of anterior bristles, and with one apical posterior and three apical posterodorsal bristles, hind tibia with two posterodorsal bristles, and with slender and dense setulae along anteroventral and posteroventral surfaces.

Abdomen long oval; epandrium black; sternites 1–4 with dense setulae, sternite 4 with a dark spot consisting of dense short setulae on posterior margin (see Chen 1975: fig. 5). Terminalia (see Chen 1975: figs 6–9): cercus straight in profile, with numerous



Figure 5. *Sarcophaga (Sarcorohdendorfia) gracilior* (Chen, 1975). **A** Male, right wing interference patterns, dorsal view **B** Male, right wing, dorsal view **C** Female, right wing interference patterns, dorsal view **D** Female, right wing, dorsal view. Scale bars = 2.00 mm **E** Schematic illustration of the distinctive clearly demarcated magenta and blue bands, and one large and almost triangular area on the apical part, which is blue in the WIP. Arrows in **A** & **C** show the most similar patterns and marginal colour bands of both sexes.

strong setulae on mid lateral margin and with a sharp apex in lateral and dorsal view. Surstylus almost triangular but with a slightly convex anterior (or ventral) margin (Fig. 4B). Pregonite with a broad base, slightly longer than postgonite, and distal half almost perpendicular to basal half, postgonite long triangular with slightly curved apex; vesica large; juxtal extensions small with a sharp tip in lateral view; lateral stylus slender, with recurving teeth in the distal half and situated under the arched juxta (Fig. 4A). Other morphological characteristics are the same as for the female.

Material examined. CHINA, Hubei, Yichang City, Dalaoling (31°5'00"N, 110°56'00"E): 1 \bigcirc , Panlongling, 1600–1700 m, 17.VII.2013; 1 \bigcirc , 1 \bigcirc , Mt. Tianzhushan, 2000 m, 19.VII.2013; 1 \bigcirc , Panlongling, 1600–1700 m, 22.VII.2013; all collected by Zhang D. & Zhang M.

Remarks. The specimens of this species have been taken in traps baited with fish viscera, indicating that this species may be saprophagous like the majority members of the genus *Sarcophaga*.

Distribution. China (Chongqing, Hubei [first record], Hunan, Guangdong, Guizhou, Sichuan, Taiwan, Xizang, Zhejiang), Nepal.

Discussion

Females of most species of flesh flies are very similar in appearance and difficult to identify (Ye 1992; Pape 1996; Xue and Chao 1998), which represents a problem, e.g., for forensic investigators, because most specimens collected at death scenes are gravid females or larvae. Correct identification of females in the large genus *Sarcophaga* is very important, as it would be a prerequisite for many detailed ecological studies (e.g., Bänziger and Pape 2004; van der Niet et al. 2011), forensic investigations (e.g., Cherix et al. 2012), or cladistic analyses (e.g., Giroux et al. 2010). Morphological studies of *Sarcophaga* spp. have traditionally focused on the male sex, but Richet et al. (2011) and Meiklejohn et al. (2013) showed females are fully identifiable in many cases. To facilitate the identification of females in studies including *S. (S.) gracilior*, we provide the first description of the female and bring further distributional records of the species in China.

WIPs may arise in transparent insect wings due to their double layer of very thin cuticle (Shevtsova et al. 2011). The interference pattern caused by the ultra-thin but uneven wing membrane can be visualized against a dark background. WIPs have already proven to be of value in generic and even species-level identifications of several insect groups (Buffington and Sandler 2011; Hansson 2011; Shevtsova et al. 2011; Shevtsova and Hansson 2011; Simon 2012), and ongoing studies found WIPs to be species-specific and showing no sexual dimorphism in some taxa of Miltogramminae (Zhang et al. unpublished). We employed this method for comparisons between both sexes of *S.* (*S.*) gracilior, and the WIPs show no sexual dimorphism (Figs 5A, 5C). Studies of WIPs from other species of *Sarcophaga* are still needed to test if WIPs might serve as an appropriate way to confirm conspecificity of male and female specimens in the subfamily Sarcophaginae.

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RESEARCH ARTICLE



A second species of *Tyloceridius* Malaise (Hymenoptera, Tenthredinidae)

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Abstract

Tyloceridius Malaise, 1945 and *T. dorsatus* (Mocsáry, 1883) are redescribed. *Tyloceridius stictocephalus* **sp. n.** from China and Nepal is described. *Tyloceridius* is recorded in China for the first time.

Keywords

Symphyta, Tenthredininae, China, Nepal, new species, identification key

Introduction

Malaise (1945) described the monotypic *Tyloceridius* from Kashmir and the Himalaya and designated *Allantus dorsatus* Mocsáry, 1883 as the type species, with *Rhogogastera bituberculata* Cameron, 1906 placed as a junior synonym. Since then, Muche (1983) recorded this species from India (Uttaranchal), and Togashi (1989) from Pakistan (Islamabad). Saini et al. (2006) listed the provinces Himachal Pradesh, Jammu and

Kashmir, and Uttaranchal for the distribution in India. Saini (2007) redescribed the genus and both sexes of the species and illustrated the lancet, penis valve and gonoforceps. No further species of the genus was hitherto known (Taeger et al. 2010).

During a survey of the sawfly fauna of Tibet in the summer of 2003, a specimen of *Tyloceridius* was collected at Yadong. The examination of the lectotype of *T. dorsatus* showed that the specimen from Tibet belongs to an undescribed species. Later, a series of the new taxon from Nepal was found in unidentified material at the SDEI.

Material and methods

Terminology of sawfly genitalia follows Ross (1945). Wing venation follows Niu and Wei (2010, Plate 1).

The images were obtained using a Leica S8APO digital camera and Motic BA400 microscope and further processed with Helicon Focus 5.1(©HeliconSoft) and Adobe Photoshop CS6 software. The images based on specimens from Nepal were taken at the DEI with a Leica DFC 495 digital camera and M205 C microscope and processed with CombineZ5.3 and PhotoImpact X3.

Abbreviations used are: OOL = distance between the eye and outer edge of lateral ocellus; POL = distance between the mesal edges of the lateral ocelli; OCL = distance between a lateral ocellus and the occipital carina or hind margin of the head; ED = the ratio of the distance between anterior-lower corner of eyes and the greatest diameter of an eye. CSCS = Central South University of Forestry and Technology, Changsha, P. R. China; SDEI = Senckenberg Deutsches Entomologisches Institut, Müncheberg, Germany; HNHM = Hungarian Natural History Museum, Budapest, Hungary; NHRS = Naturhistoriska riksmuseet, Stockholm, Sweden; NKME = Naturkundemuseum Erfurt, Germany; USNM = National Museum of Natural History, Washington D. C., USA.

Taxonomy

Tyloceridius Malaise, 1945

http://species-id.net/wiki/Tyloceridius

Tyloceridius Malaise, 1945: 171. Type species: *Allantus dorsatus* Mocsáry, 1883, by original designation.

Diagnosis. Distinguished from other genera of Tenthredininae by deep furrow on ventral side of antennal flagellum and the very large, protruding and isolated supraantennal tubercles.

Description. Body robust (Figs 1, 8). Clypeus transversely subconvex at basal third, anterior margin sharp, quarter-circularly incised with acute lateral teeth; apical

third of labrum deflexed, and labrum thus truncate at apex in front view (Figs 5, 11); mandibles strongly bent at apical third, asymmetric (Figs 2, 3), right one with 1 basal tooth, 3 inner teeth; one of them placed on the dorsal side (Fig. 3); left mandible with 1 basal tooth and 2 inner teeth, without dorsal tooth (Fig. 2); malar space longer than diameter of median ocellus; inner margins of eyes very feebly S-curved and converging downwards, distance between eyes much longer than height of eye (Figs 5, 11); supraantennal tubercles large, highly elevated and quite free-standing (Figs 4, 10, 12); head elongated behind eves, occipital carina low but distinct; interocellar furrow broad and deep, postocellar furrow broad and shallow. Antennae stout and uniformly thick; 2nd antennomere about as long as broad, flagellum with a very deep and sharp longitudinal furrow along the outer-side from apex of the 3rd antennomere to 9th antennomere, 3rd antennomere distinctly longer than 4th (Figs 6, 9). Anterior lobe of pronotum broad, without marginal carina, with broadest part about $3 \times$ diameter of an ocellus; ventral margins of propleura narrowly but distinctly meeting; mesoscutellum flattened, mesoscutellar appendage with an obtuse middle ridge. anterior basin of metascutellum narrow, furrow like; dorsal lobe of metepimeron long and linear; mesosternal thorns wanting; posterior corner of metepimeron round, without appendage. Basal plates (first tergite) of abdomen contiguous on meson, without large membranous blotch (Fig. 8). Inner tibial spur of fore leg bifurcate at apex; hind coxa small, hind femur not reaching apex of abdomen, distinctly shorter than hind tibia, hind tibial spur shorter than half length of metabasitarsus; metabasitarsus about as long as or slightly longer than following 3 tarsomeres together; claw cleft, inner tooth shorter than outer tooth. Venation similar to *Tenthredo*, anal cell of forewing with a short and erect cross vein at basal 2/5; hind wing with 2 closed middle cells, anal cell sessile or shortly petiolate (Figs 1, 8).

Distribution. Himalaya: China (Tibet), India (Jammu & Kashmir, Uttaranchal, Himachal Pradesh), Nepal, Pakistan (Islamabad).

Key to species

Tyloceridius stictocephalus sp. n.

http://zoobank.org/49ED98B4-BA75-4E93-9CC4-68B8DDA26C44 http://species-id.net/wiki/Tyloceridius_stictocephalus Figs 1–10

Description. Holotype \bigcirc (Fig. 1).

Body length 11mm. Greenish yellow, following parts black: apex of each mandible; antennae entirely; supra-antennal tubercle, frons and adjacent area of upper inner orbit except a stripe on frontal ridge, postocellar area, a broad band from upper hind corner of each eye to postocellar area (Figs 1, 4); a medial band on pronotum; meso- and metanotum, except mesoscutellum and 2 small triangular spots on mesoscutal lateral lobe and 2 linear spots on mesoscutal median lobe; abdomen above, except for tergites 8–10 and a broad band on posterior margin of tergites 3–4 (in the middle covering about two thirds, laterally about one third of the length of the tergite); depressed upper corner of mesepimeron and a minute and roundish dot in lower posterior corner of mesepisternum. Legs greenish yellow, following parts black: a small dot on extreme apex of each femur; a narrow dorsal stripe on each tibia and tarsus. Wings hyaline with very faint yellow tinge, vein C and stigma yellow brown, other veins pale brown. Body hairs silver.

Body shiny; labrum without large punctures; central area of clypeus, outer sides of mandibles with some large punctures, head above antenna including supra-antennal tubercle with large and deep punctures, interspaces between punctures about as large as a puncture, surface smooth and shiny; punctures on postorbit sparser but distinct; punctures on mesoscutal median lobe and mesoscutal lateral lobe smaller than punctures on head, interspaces shiny; posterior margin of mesoscutellum densely punctured, dorsal side of mesoscutellum hardly punctured; mesoscutellar appendage impunctate, parapsis of mesothorax microsculptured; metascutellum with some minute punctures; mesepisternum densely punctured, narrow interspaces smooth, strongly shiny; metepisternum densely punctured, mesepimeron and metepimeron polished, with scattered punctures. Abdominal tergites 1–2 strongly shiny, tergite 3 weakly microsculptured in basal half, tergites 4–7 distinctly microsculptured and punctured in basal half.

Clypeus and labrum as Fig. 5; left mandible as Fig. 2, right mandible as Fig. 3; ED=1.7; supra-antennal tubercle larger than scape (Fig. 4), clearly above top of ocelli in lateral view; a distinct tubercle present on anterior margin of middle fovea and almost in line with anterior margins of supra-antennal tubercles; frontal walls broad and flat, parallel to each other; postocellar area $1.2 \times$ as broad as long; lateral furrows deep, distinctly divergent backwards; POL : OOL : OCL = 1 : 2.5 : 2.5; head behind eyes about as long as eyes in dorsal view, lateral edge roundly curved (Fig. 4); occipital carina distinct in entire length. Antennae stout, weakly compressed, $0.9 \times$ length of head and thorax combined, antennomere 3 $0.9 \times$ length of antennomeres 4 and 5 combined, antennomeres $6-8 1.7 \times$ as long as broad (Fig. 6). Anal cell of hind wing sessile. Ovipositor sheath $1.1 \times$ length of fore tibia. Lancet with 21 serrulae, serrulae 5–6 as Fig. 7.

Variability (females). Body length 10–11 mm. Punctation on upper head varies from sparse to dense; supra-antennal tubercle sometimes only with few punctures and



Figures 1–7. *Tyloceridius stictocephalus* sp. n., holotype, female 1 Adult, dorsal view 2 Left mandible 3 Right mandible 4 Head, dorsal view 5 Head, frontal view 6 Antenna 7 The 5th and 6th serrulae of lancet.

/ or smaller than scape; tergites 1–2 smooth to rather densely punctured laterally and on basal half; POL : OOL : OCL = 1 : 2.0–2.7 : 2.0–2.6; postocellar area 1.2–1.4 × as broad as long; head behind eyes 0.8–1.0 × as long as eyes in dorsal view. Ratio of length and breadth of antennomeres 6–8: 1.5–1.9. Black spot on lower mesepisternum may be indistinct or missing; pale color on tergite 4 may be reduced to a triangular spot; greenish color may alter (in dried specimens) to yellow.

Male. (Figs 8–10) Body length 8–9 mm. Color and structure similar to female. Generally darker than the female: pale stripe on upper inner orbit very narrow and only exceptionally nearly extending toward postocellar area; frontal ridges black or pale marked; hind tibia and tarsus entirely black; pale macula on mesoscutellum more or less reduced; mes-



Figures 8–10. *Tyloceridius stictocephalus* sp. n., paratype, male **8** Adult, dorsal view **9** Adult, lateral view **10** Penis valve (scale bar = 200µm).

oscutal median lobe usually entirely black, without pale lateral stripe; tegula black, basally pale; lower mesepisternum usually with broad black stripe, sometimes anteriorly reduced to a large spot; tergites 3-4 dorsally usually only with faintly indicated pale hind margin, sometimes completely black; subgenital plate apical margin rounded. Penis valve Fig. 10.

Pictures of several paratypes are given in original resolution at doi: 10.6084/ m9.figshare.781286

Etymology. The specific epithet, an adjective, refers to the distinctly punctured head. **Distribution.** China (Tibet), Nepal (Karnali).

Holotype. ♀, **China**: Tibet, Yadong, Naiduilashan, 27°24'51"N, 88°56'08"E, 3100m, 2003.VIII.29, Wei Meicai leg. Coll. CSCS.

Paratypes. (7 ♀♀, 10 ♂♂, DEI-GISHym 17227–17243, in coll. CSCS, DEI, NHRS, NKME). Nepal, Prov. Karnali: 1 ♀, Umg. Churta 3000–3400 m, 31.V.2007 (DEI-GISHym 17228, BOLD:ACG2198); 1 ♀, Umg. Churta E Hochtal 3500–4000 m, 02.VI.–04.VI.2007; 4 ♂♂, Umg. Churta E Hochtal 3500–3800 m, 02.VI.2007; 1 ♀, Gothichaur, 29°12'10"N, 82°18'56"E, 2850 m, 09.VI.1997; 1 ♀, Gothichaur, Thymian-Wiese, 3100 m, 26.V.2007; 1 ♀ 2 ♂♂, Gothichaur, 29°11'54"N, 82°18'36"E, 2850 m, Sumpfwiese, 26.V.–05.VI.2007; 4 ♂♂, Gothichaur, 29°11'54"N, 82°18'36"E, 2850 m, Umg. Lager, 26.V.–05.VI.2007; all specimens F. Creutzburg leg.; 1 ♀, Gothichaur 2 km W, 2700 m; 20.-21.V.1995, M. Hartmann leg.; 1 ♀, Gothichaur, Wald, 29°12'10"N, 82°18'56"E, 2850 m, 08.VI.1997, M. Hartmann leg.

Tyloceridius dorsatus (Mocsáry, 1883)

http://species-id.net/wiki/Tyloceridius_dorsatus Figs 11–15

Allantus dorsatus Mocsáry, 1883: 4, ♀, India orientalis. Taeger 1991: 76, lectotype designation.

Tenthredo aliena Enslin, 1912: 103. New name for *Allantus dorsatus* Mocsáry, 1883. *Tyloceridius dorsatus*: Malaise 1945: 171.

Rhogogastera bituberculata Cameron, 1906: 289 [sex not given], Kashmir at 6000 ft. Synonymy by Malaise 1945: 171.

Description. Lectotype of *A. dorsatus* $\stackrel{\frown}{\rightarrow}$ (Fig. 11), additions based on other specimens are given in brackets [].

Body length 11 mm. Greenish yellow, following parts black: apex of each mandible; antennae entirely (Fig. 14); supra-antennal tubercle, frons and adjacent area of upper inner orbit except a short stripe on frontal ridge, postocellar area, a broad band from upper hind corner of each eye to postocellar area (Figs 12, 13); a medial band on pronotum; meso- and metanotum, except mesoscutellum and 2 small triangular spots on mesoscutal lateral lobe and 2 linear spots on mesoscutal median lobe (the latter sometimes absent); abdomen above, except for tergites 8–10 and posterior 2/5 of tergites 3–4; depressed upper corner of mesepimeron and a small and roundish spot in lower posterior corner of mesepisternum. Legs greenish yellow, following parts black: a small dot on extreme apex of each femur; a narrow dorsal stripe on fore and middle tibiae, dorsal side of hind tibia; a narrow stripe on fore and middle tarsi above (sometimes interrupted), hind tarsus entirely. Wings hyaline with faint yellowish tinge, veins and stigma pale brown, base of stigma slightly darkened. Body hairs silver.

Body shiny; labrum and outer side of mandible with some large punctures, head otherwise almost impunctate, frontal basin feebly microsculptured; mesoscutal median lobe and mesoscutal lateral lobe sparsely punctured, interspaces smooth and shiny; posterior margin of mesoscutellum densely punctured, dorsal side of mesoscutellum hardly punctured; mesoscutellar appendage and parapsis impunctate; metascutellum with some minute punctures; mesepisternum shallowly but distinctly punctured, surface smooth, strongly shiny; metepisternum densely punctured, mesepimeron and metepimeron polished, with scattered punctures. Abdominal tergites 1–2 strongly shiny, tergite 3 weakly microsculptured in basal half, tergites 4–7 distinctly microsculptured and punctured in basal half.

Clypeus, labrum, mandibles as Fig. 11; ED=1.3; supra-antennal tubercle distinctly smaller than scape (Figs 12, 13), clearly lower than top of ocelli in lateral view; a small tubercle present in bottom of middle fovea and in line with posterior margins of supra-antennal tubercles; frontal walls broad and flat, weakly divergent forwards; postocellar area broader than long as 7:5; lateral furrows deep, weakly divergent backwards; POL:OOL:OCL = 15:29:27; head behind eyes about 0.7 × length of eyes in dorsal view, indistinctly narrowed (Fig. 12); occipital carina distinct in lower 2/3 and rather weak in dorsal 1/3. Antennae weakly compressed, as long as head and thorax combined, antennomere 3 0.9 × length of antennomeres 4 and 5 together, [antennomeres 6–8 1.5–2.4 × as long as broad (Fig. 14)]. Anal cell of hind wing with a very short petiole. Ovipositor sheath as long as fore tibia. [Lancet with 20 serrulae, serrulae 5–6 as Fig. 15].

Male. Body length 8mm. Similar to female except head distinctly narrowed behind eyes in dorsal view, malar space slightly longer than diameter of median ocellus; pale stripe from upper inner orbit to postocellar area missing; subgenital plate rounded



Figures 11–15. *Tyloceridius dorsatus* (Mocsáry, 1883), female **11** Adult, dorsal view **12** Head, dorsal view **13** Head, frontal view **14** Antenna **15** The 5th and 6th serrulae of lancet **11** lectotype **12–15** a specimen from North India (SDEI).

at apex; penis valve simple, valviceps weakly bent; harpe about $2 \times as$ long as broad (see figs 678 and 680 in Saini 2007).

Distribution. India: Himachal Pradesh, Jammu & Kashmir, Uttaranchal (Saini et al. 2006); Pakistan: Islamabad (Togashi 1989). It is ambiguous whether these records

actually base on *T. dorsatus* or on the new *T. stictocephalus*. We studied material from Himachal Pradesh, Jammu & Kasmir and Uttaranchal. Referring to Muche (1983), Saini (2007) recorded *T. dorsatus* also from Nepal and Bhutan, but Muche mentioned only $1 \$ (!) from India ("Chaurengi" located in former Uttarpradesh).

Lectotype (Fig. 11): 1° , "Himalaya, Plasow"; "*Allantus dorsatus* Mocs., India Oriental"; "Lectotypus *Allantus dorsatus* Mocs., design. A. Taeger, 1988"[red]; "*Tyloceridius dorsatus* (Mocs.), det. A. Taeger, 88". (HNHM). Left antenna, apical 3 antennomeres of right antenna, right foreleg below femur, left middle tarsus, right hind tarsus and left leg below femur are missing.

Paralectotype. 1 ♀, "Himalaya, Plasow"; "Typus *Allantus dorsatus* Mocs."; "Syntype [sic!] *Allantus dorsatus* Mocsáry, 1883. teste A. Taeger, 2011" [red]; "*Tylocerus* [sic!] gen. n. *bituberculatus* Cam., Malaise det. 1935"; "DEI-GISHym 10877" (HNHM, figs see doi: 10.6084/m9.figshare.781292).

Other specimens examined. 1 \bigcirc (Figs 12–15), India, Uttaranchal (former N Uttar Pradesh), 5. 7. 1989, Rishikesh [30.117°N, 78.317°E], A. Riedel leg. (SDEI); 1 \bigcirc same data (see doi: 10.6084/m9.figshare.903712); 2 \bigcirc \bigcirc , India, Kalatop, (H.P.), 8200', 11.7.83, M.S. Saini (USNM); 1 \bigcirc 1 \bigcirc , India, Himachal Pradesh, Kalatop, 2400m, July 1983, M.S. Saini collector, Tyloceridius *dorsatus Malaise (!)* (USNM); 1 \bigcirc 2 \bigcirc \bigcirc , kept in NHRS, data unrecorded; 1 \bigcirc 1 \bigcirc India, Uttarakhand, Joshimath, 14.6.1983, leg. Balbir (NHRS, photo documentation by H. Vårdal).

Remarks. Saini (2007) described both sexes and illustrated the lancet, penis valve and gonoforceps. This species is widely distributed at higher altitudes in Uttaranchal & Himachal Pradesh (Saini 2007).

Discussion

The two species of *Tyloceridius* are very similar, and as *T. stictocephalus* seems to be also rather variable in sculpture and color, the species are to be identified by consideration of the character sets given in the key. The genitalia of the taxa are not suitable for identification. According to the present data, *T. dorsata* seems to be a species from the western Himalayas, whereas *T. stictocephalus* is hitherto only known from the central Himalayas.

The type of *Rhogogastera bituberculata* Cameron, 1906 could not be found in the course of the present study. Cameron's description disagrees in several aspects with *T. dorsatus* and *T. stictocephalus*. But as Malaise (1945) synonymized the taxon after examination of the types of *A. dorsatus* and *R. bituberculata*, and we could not find any other specimens that fit with Cameron's description, we assume that Malaise's synonymization is correct. This is supported also by the type locality (Kashmir, western Himalayas).

Goulet (1996) considered *Tyloceridius* to be the sister group of *Rhogogaster* Konow, 1884. This is based on three shared derived characters (green color, not expressed submarginal furrow of the pronotum, and very narrow apical lobe of the metepimeron). Currently, there is no additional evidence to support this hypothesis. The only available COI barcode for *Tyloceridius* (DEI-GISHym 17228, BOLD:ACG2198) is rather distant (about 10 %) from its nearest neighbors *Tenthredo aaliensis* (Strand, 1898) and *Tenthredo xanthoptera* Cameron, 1876), while the distance to *Rhogogaster* species is about 13–14 %.

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Our cordial thanks are due to Ms. Suzanne Ryder of the Natural History Museum, London, for information about the type of *Rhogogastera bituberculata* Cameron, 1906. We are also very thankful to Dr. Sándor Csősz and Dr. Lajos Zombori of the Hungarian Natural History Museum, Budapest, Hungary, and Dr. Hege Vårdal, curator of the Hymenoptera collection, the Natural History Museum, Stockholm, Sweden, for allowing examination of relevant sawfly types and specimens, and providing several images of specimens. Thanks to Mr. A.D. Liston (SDEI) who checked the English of the paper. This work was supported by the National Natural Science Foundation of China (no. 31172142). A. Taeger's work was supported by an Integrated Activities grant SYNTHESYS (HU-TAF 996) from the European Union. Support was provided by the Government of Canada through Genome Canada and the Ontario Genomics Institute to the International Barcode of Life Project. This funding enabled staff at the Canadian Centre for DNA Barcoding (University of Guelph) to carry out sequence analysis of the new species. The Ontario Ministry of Economic Development and Innovation is thanked for informatics support provided through BOLD.

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RESEARCH ARTICLE



A survey of oonopid spiders in Taiwan with descriptions of three new species

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Abstract

The oonopid spiders of Taiwan are surveyed. Seven genera and 13 species are recognized, including 3 new species: *Ischnothyreus kentingensis* **sp. n.**, *Xyphinus hwangi* **sp. n.** and *Xestaspis shoushanensis* **sp. n.** Seven species are newly recorded from this region: *Brignolia parumpunctata* (Simon, 1893), *Opopaea apicalis* (Simon, 1893), *Opopaea cornuta* Yin & Wang, 1984, *Opopaea deserticola* Simon, 1891, *Orchestina sinensis* Xu, 1987, *Pseudotriaeris karschi* (Bösenberg & Strand, 1906) and *Xestaspis loricata* (L. Koch, 1873).

Keywords

Taxonomy, haplogyne, diagnosis, litter, island

Introduction

Goblin spiders are small (1–4 mm), haplogyne, litter or canopy-dwelling, free hunting spiders. They are distributed nearly worldwide and are abundant in the tropics. Currently, the family includes 1325 described species in 97 genera (Platnick 2014).

The island of Taiwan is situated some 180 km off the southeastern coast of mainland China, and has an area of 35,883 km². The oonopid spider fauna of this region has been poorly studied. To date, only four species, *Gamasomorpha cataphracta* Karsch, 1881,

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Ischnothyreus narutomii (Nakatsudi, 1942), *I. peltifer* (Simon, 1891) and *Opopaea sauteri* Brignoli, 1974, have been recorded from Taiwan (Brignoli 1974; Saaristo 2001). Our survey of the oonopid spiders of Taiwan was carried out from June 25 to July 3, 2013. The present paper expands the oonopid diversity of Taiwan to 8 genera and 14 species, including 3 new to science (described here) and 7 already-described species which are recorded from Taiwan for the first time. All the specimens were collected by sifting leaf litter.

Material and methods

The specimens were examined using a Leica M205C stereomicroscope. Details were studied with the use of an Olympus BX51 compound microscope. All illustrations were made using a drawing tube and inked on ink jet plotter paper. Photos were made with a Canon EOS 550D zoom digital camera (18 megapixels). Vulvae were cleared in lactic acid. Scanning electron microscope images (SEM) were taken with a Hitachi S-4800. Measurements were taken using an Olympus BX51 compound microscope and are in millimeters.

The following abbreviations are used in the text: ALE = anterior lateral eyes; PLE = posterior lateral eyes; PME = posterior median eyes.

All specimens are deposited in the Institute of Zoology, Chinese Academy of Sciences in Beijing (IZCAS) and Shenyang Normal University in Shenyang (SYNU).

Taxonomy

Family Oonopidae Simon, 1890 Genus *Brignolia* Dumitrescu & Georgescu, 1983

Brignolia parumpunctata (Simon, 1893)

http://species-id.net/wiki/Brignolia_parumpunctata

Brignolia cubana: Dumitrescu and Georgescu 1983: 107, pl. 22; Saaristo 2001: 343, figs 139–141, 142A–B, 143, 144A–B, 145.
Brignolia parumpunctata: Platnick et al. 2011: 14, figs 1–94.

Material examined. CHINA: *Taiwan*: Pingtung County, Kenting, seaside near the Howard Beach Resort, 21°56'27.00"N, 120°48'26.68"E, elevation ca. 34 m, 25–28 June 2013, S. Li & Y. Tong leg., $1 \diamondsuit, 1 \supsetneq$ (SYNU-13); $1 \diamondsuit, 1 \supsetneq$ (SYNU-31).

Comments. This species has been well described by many authors (i.e., Dumitrescu and Georgescu (1983), Saaristo (2001)). According to Platnick et al. (2011), this species widely distributed in North America, South America, South Asia, Southeast Asia, Seychelles Islands, Aurstalia and some Islands in South and West Pacific.

Distribution. Pantropical. Newly recorded from Taiwan.

Genus Gamasomorpha Karsch, 1881

Gamasomorpha cataphracta Karsch, 1881

http://species-id.net/wiki/Gamasomorpha_cataphracta

Gamasomorpha cataphracta: Brignoli 1974: 74, figs 1-6.

Material examined. Not examined.

Comments. Brignoli (1974) recorded this species from Akau (old name of Pingtung County), Taiwan.

Distribution. China, Japan, Korea, Philippines.

Genus Ischnothyreus Simon, 1893

Ischnothyreus kentingensis sp. n. http://zoobank.org/4E4779BF-82D5-470A-AE0C-4D5383D5CB1B http://species-id.net/wiki/Ischnothyreus_kentingensis

Figs 1–3

Material examined. Holotype \Im (IZCAS AR 27808): CHINA: *Taiwan*: Pingtung County, Kenting, hills near the Howard Beach Resort, 21°56'27.00"N, 120°48'26.68"E, elevation ca. 34 m, 27 June 2013, S. Li & Y. Tong leg. Paratypes: same data as holotype, 1 \Im , 2 \Im (SYNU-20); same data as holotype, 1 \Im , 5 \Im (SYNU-58); same data as holotype, 1 \Im , 1 \Im (SYNU-21).

Etymology. The specific name is taken from the type locality; adjective.

Diagnosis. The new species is similar to *I. spineus* Tong & Li, 2012, but can be distinguished by the male chelicerae which each bear two strong, short thorn-like processes (tlp in Figs 1H, 3C) and the female genital area possessing a large goblet-like atrium (Fig. 2G–K). The males of *I. spineus* bear only one long, curved thorn-like process on each of the chelicerae (see Tong and Li 2012: Figs 3H, 5C) and no visible atrium, with only a simple winding tube in female genital area (see Tong and Li 2012: Figs 4G, H, 5D, E).

Description. Male (holotype). Total length 1.26; carapace 0.69 length, 0.54 width; abdomen 0.61 length, 0.33 width. Habitus as in Fig. 1A, C, E. *Carapace*: orange-brown, with brown egg-shaped patches behind eyes, oval in dorsal view, pars cephalica strongly elevated in lateral view, surface and sides strongly reticulate (Fig. 1B, D). *Eyes*: six, in one group, well developed, ALE largest, PME and PLE nearly equal sized; posterior eye row straight from above, procurved from front (Fig. 1G). *Mouthparts:* chelicerae slightly divergent, with a slightly sclerotized process at base of fangs (ssp) and two strong, thorn-like processes (tlp) in the middle of the retrolateral margin; fang groove with a few small denticles (Figs 1H, 3C). Anterior margin of labium not indented at middle. Anteromedian tip of endites with one strong, tooth-like projection (Fig. 1F). *Abdomen:* posterior



Figure 1. *Ischnothyreus kentingensis* sp. n., male. **A, C, E** habitus, dorsal, lateral and ventral views **B, D, F, G** prosoma, dorsal, lateral, ventral and anterior views **H** left chelicera, frontal view **I–K** left palp, retrolateral, dorsal and prolateral views. Scale bars: **A, C, E** = 0.4 mm; **B, D, F, G** = 0.2 mm; **H–K** = 0.1 mm.



Figure 2. *Ischnothyreus kentingensis* sp. n., female. **A, C, E** habitus, dorsal, lateral and ventral views **B, D, F** prosoma, dorsal, lateral and ventral views **G, J** genital area, ventral view **H** genital area, ventral view (cleared in lactic acid) **I, K** genital area, dorsal view (cleared in lactic acid). Scale bars: **A, C, E** = 0.4 mm; **B, D, F** = 0.2 mm; **G–K** = 0.1 mm. Abbreviations: a = apodeme; gla = goblet-like atrium; wt = winding tube.



Figure 3. *Ischnothyreus kentingensis* sp. n., male. **A**, **B** left palp, prolateral and retrolateral views **C** left chelicera, frontal view **D** left palpal bulb, dorsal view. Scale bars: 0.1 mm. Abbreviations: meo = membranous outgrowth; ml = membranous lobe; ssp = slightly sclerotized process; tlp = thorn-like processes; vp = ventral projection; vpr = ventral protuberance.

spiracles not connected by groove. Pedicel tube short, unmodified, scutum extending far dorsal of pedicel. Dorsal scutum covering about 4/5 of abdomen, about equal to the abdomen width, not fused to epigastric scutum. Epigastric and postepigastric scutum well sclerotized, pale orange, fused. *Leg spine formula*: femur I with 2 prolateral and 1 small retrolateral spine, tibia I with 4 pairs, metatarsus I with 2 pairs of long ventral
spines. Spination of leg II similar to leg I except femur with only one prolateral spine. Legs III and IV spineless. *Genitalia*: sperm pore situated at level of anterior spiracles. Palp strongly sclerotized, trochanter with ventral projection (vp); patella about as long as femur, not enlarged; cymbium brown, not fused with bulb, bulb brown, more than twice as long as cymbium, stout, tapering apically, with two small ventral protuberances (vpr), at the bending site with a membranous lobe (ml), distal part of bulb with membranous outgrowth (meo) (Figs 1I–K, 3A, B, D).

Female (paratype). Total length 1.51; carapace 0.64 length, 0.52 width; abdomen 0.87 length, 0.56 width. Habitus as in Fig. 2A, C, E. As in male except as noted. *Carapace:* without any pattern, pars cephalica slightly elevated in lateral view (Fig. 2B, D). *Mouthparts*: chelicerae and endites unmodified (Fig. 2F). *Abdomen*: dorsal scutum covering about 2/3 of abdomen, about 1/2 of abdomen width. Postepigastric scutum elongated hexagonal, not fused to epigastric scutum, with short posteriorly directed lateral apodemes (a) (Fig. 2G, H, J). *Genitalia*: at the middle of the anterior edge of the postepigastric scutum runs a dark, strongly winding tube posteriorly (wt), ending in a large goblet-like atrium (gla) close to posterior edge of scutum (Fig. 2I, K).

Distribution. Known only from the type locality.

Ischnothyreus narutomii (Nakatsudi, 1942)

http://species-id.net/wiki/Ischnothyreus_narutomii

Gamasomorpha narutomii: Nakatsudi 1942: 287, figs 1.1–6. *Ischnothyreus narutomii*: Lee 1966: 22, fig. 4c–e; Tong and Li 2008: 60, fig. 5A–D; Ono 2009: 103, figs 18–24; Tong 2013: 32, fig. 47A–D.

Material examined. CHINA: *Taiwan*: Nantou County, Ren'ai Town, Songgang Village, 24°05'13.30"N, 121°10'20.07"E, elevation ca. 2067 m, 2 July 2013, S. Li, G. Zheng & Y. Tong leg., 1 \Diamond , 1 \bigcirc (SYNU-23); 4 \Diamond , 5 \bigcirc (SYNU-24); 5 \Diamond , 10 \bigcirc (SYNU-49).

Comments. Lee (1966) recorded this species in Taichung City of Taiwan; this species has also been found in the Hainan Province of China and in Japan.

Distribution. China, Japan.

Ischnothyreus peltifer (Simon, 1891)

http://species-id.net/wiki/Ischnothyreus_peltifer

Ischnothyreus peltifer: Saaristo 2001: 345, figs 146A, 147A–C, 148A–B, 149–150, 152–153, 154,155A, 156, 157A–B; Saaristo and van Harten 2006: 135, figs 15a–b, 16a–c, 17.

Material examined. CHINA: *Taiwan*: Pingtung County, Kenting, seaside near Howard Beach Resort, 21°56'27.00"N, 120°48'26.68"E, elevation ca. 34 m, 25–28 June 2013, S. Li & Y. Tong leg., 1 \bigcirc (SYNU-22); 3 \bigcirc (SYNU-52).

Comments. Brignoli (1974) described *I. formosus* from Akau (old name of Pingtung County), Taiwan. Saaristo (2001) synonymized this species with *I. peltifer* and considered it to be a widely-distributed species in the tropics.

Distribution. Pantropical, Canada and Europe (introduced).

Genus Opopaea Simon, 1891

Opopaea apicalis (Simon, 1893)

http://species-id.net/wiki/Opopaea_apicalis

Epectris apicalis: Simon 1893: 74; Platnick and Dupérré 2009: 30, figs 105–160. *Opopaea lena*: Saaristo 2001: 337, figs 112A–C, 113–117. *Opopaea apicalis*: Baehr et al. 2013: 109.

Material examined. CHINA: *Taiwan*: Pingtung County, Kenting, seaside near Howard Beach Resort, 21°56'27.00"N, 120°48'26.68"E, elevation ca. 34 m, 25–28 June 2013, S. Li & Y. Tong leg., $3 \stackrel{?}{\triangleleft}, 3 \stackrel{?}{\subsetneq}$ (SYNU-12); $8 \stackrel{?}{\triangleleft}, 14 \stackrel{?}{\subsetneq}$ (SYNU-33).

Comments. This species has been well described by Platnick and Dupérré (2009). **Distribution.** Pantropical. Newly recorded from Taiwan.

Opopaea cornuta Yin & Wang, 1984

http://species-id.net/wiki/Opopaea_cornuta

Opopaea cornuta: Yin and Wang 1984: 52, fig. 2A–F; Tong and Li 2010: 24, figs 1B, K, 2A–E, 9A–F; Tong 2013: 37, figs 25B, K, 53A–E, 54A–F.

Material examined. CHINA: *Taiwan*: Nantou County, Huisun Forest Area, 24°05'16.74"N, 121°02'04.69"E, elevation ca. 788 m, 30 June to 1 July 2013, S. Li, G. Zheng & Y. Tong leg., $1 \ (SYNU-44)$.

Comments. Yin and Wang (1984) reported this species from Hunan and Yunnan Provinces. Tong and Li (2008) redescribed this species from Hainan Province. This species seems to be widely distributed in southern China and the adjacent areas.

Distribution. China, Laos. Newly recorded from Taiwan.

Opopaea deserticola Simon, 1891

http://species-id.net/wiki/Opopaea_deserticola

Opopaea deserticola: Simon 1891: 560, pl. 42, fig. 5; Saaristo 2001: 333, figs 93A–98A, 99–101; Platnick and Dupérré 2009: 4, figs 1–72; Tong and Li 2010: 35, figs 1Q, S–T, 7A–C; Tong 2013: 37, fig. 25Q, S–T.

Material examined. CHINA: *Taiwan*: Kaohsiung City, Shoushan Mountain, 29 June 2013, S. Li, G. Zheng & Y. Tong leg., $4 \stackrel{\circ}{\circ}$, $4 \stackrel{\circ}{\circ}$ (SYNU-14); Pingtung County, Kenting, hills near Howard Beach Resort, 27 June 2013, S. Li & Y. Tong leg., $1 \stackrel{\circ}{\circ}$, $1 \stackrel{\circ}{\circ}$ (SYNU-15); Nantou County, Huisun Forest Area, 24°05'16.74"N, 121°02'04.69"E, elevation ca. 788 m, 30 June to 1 July 2013, S. Li, G. Zheng & Y. Tong leg., $6 \stackrel{\circ}{\circ}$, $6 \stackrel{\circ}{\circ}$ (SYNU-16); 15 $\stackrel{\circ}{\circ}$, 21 $\stackrel{\circ}{\circ}$ (SYNU-28); 18 $\stackrel{\circ}{\circ}$, 22 $\stackrel{\circ}{\circ}$ (SYNU-48); Pingtung County, Kenting, Sheding Nature Park, 21°57'25.15"N, 120°49'06.29"E, elevation ca. 221 m, 26 June 2013, S. Li & Y. Tong leg., $1 \stackrel{\circ}{\circ}$, $2 \stackrel{\circ}{\circ}$ (SYNU-50).

Comments. This species has been well described by Platnick and Dupérré (2009). **Distribution.** Pantropical. Newly recorded from Taiwan.

Opopaea sauteri Brignoli, 1974

http://species-id.net/wiki/Opopaea_sauteri

Opopaea sauteri: Brignoli 1974: 82, figs 19–21; Tong and Li 2010: 35, figs 1G, N, P, R, U, 6A–G; Tong 2013: 42, figs 25G, N, P, R, U, 61A–G.

Material examined. CHINA: *Taiwan*: Pingtung County, Kenting, seaside near Howard Beach Resort, 21°56'27.00"N, 120°48'26.68"E, elevation ca. 34 m, 25–28 June 2013, S. Li & Y. Tong leg., 1 \Diamond , 1 \bigcirc (SYNU-17); 2 \bigcirc (SYNU-32).

Comments. Brignoli (1974) described this species from Takao (old name of Kaohsiung City), Taiwan. Tong and Li (2010) redescribed this species from Hainan Province of China.

Distribution. China.

Genus Orchestina Simon, 1882

Orchestina sinensis Xu, 1987

http://species-id.net/wiki/Orchestina_sinensis

Orchestina sinensis: Xu 1987: 256, figs 1-6.

Material examined. CHINA: *Taiwan*: Pingtung County, Kenting, hills near Howard Beach Resort, 27 June 2013, S. Li & Y. Tong leg., $1 \bigcirc (SYNU-40)$; Nantou County, Huisun Forest Area, 24°05'16.74"N, 121°02'04.69"E, elevation ca. 788 m, 30 June to 1 July 2013, S. Li, G. Zheng & Y. Tong leg., $2 \bigcirc (SYNU-45)$; Kaohsiung City, Shoushan Mountain, 29 June 2013, S. Li, G. Zheng & Y. Tong leg., $1 \oslash (SYNU-53)$.

Comments. This species has been recorded from the Anhui and Zhejiang Provinces of China. It seems to be widely distributed in southern China.

Distribution. Southern China. Newly recorded from Taiwan.

Genus Pseudotriaeris Brignoli, 1974

Pseudotriaeris karschi (Bösenberg & Strand, 1906)

http://species-id.net/wiki/Pseudotriaeris_karschi

Gamasomorpha karschi: Bösenberg and Strand 1906: 117, pl. 16, fig. 455. *Pseudotriaeris karschi*: Brignoli 1974: 77, figs 7–11; Song 1987: 96, fig. 60. *Pseudotriaeris echinatus*: Yin and Wang 1984: 55, fig. 4A–K.

Material examined. CHINA: *Taiwan*: Pingtung County, Kenting, seaside near Howard Beach Resort, 21°56'27.00"N, 120°48'26.68"E, elevation ca. 34 m, 25–28 June 2013, S. Li & Y. Tong leg., $2 \stackrel{\circ}{\circ}, 2 \stackrel{\circ}{\subsetneq}$ (SYNU-19); $4 \stackrel{\circ}{\circ}, 2 \stackrel{\circ}{\subsetneq}$ (SYNU-41).

Comments. Brignoli erected the genus *Pseudotriaeris* in 1974, based on the type species *P. karschi* from Japan. Yin and Wang (1984) described *P. echinatus* from Hunan, China, but it was synonymized with the type species by Song (1987). Currently, this species is known from Anhui, Hunan and Zhejiang Provinces of China and from Japan. However, the species *P. karschi* has never been studied in detail. The specimens from China have not been compared with the type specimens, and may belong to one or more different species. The generic characters, such as the male palps with complicated apophyses and the male endites with a backwards folded ridge, are very similar to those of the genus *Xyphinus* Simon, 1893 (see Deeleman-Reinhold 1987). We suspect that this genus can be synonymized with *Xyphinus*. A thorough investigation of the type species *P. karschi* is now required.

Distribution. China, Japan. Newly recorded from Taiwan.

Genus Xyphinus Simon, 1893

Xyphinus hwangi sp. n.

http://zoobank.org/DCCD5A23-F3B9-44F5-A361-1D8499B77D09 http://species-id.net/wiki/Xyphinus_hwangi Figs 4–7

Material examined. Holotype 3° (IZCAS AR 27809): CHINA: *Taiwan*: Kaohsiung City, Shoushan Mountain, 29 June 2013, S. Li, G. Zheng & Y. Tong leg. Paratypes: same data as holotype, 3° , 5° (SYNU-18); same data as holotype, 12° , 23° (SYNU-36); same data as holotype, 2° , 1° (SYNU-47).

Etymology. The specific name is a patronym honoring Dr. Chung-Chi Hwang (National University of Kaohsiung), who is a leading taxonomist of terrestrial snails in Taiwan.

Diagnosis. The new species is similar to *Pseudotriaeris karschi* (see Brignoli 1974), but can be distinguished by the long, slender and strongly curved ventral apophysis (va in Fig. 6F) in the male palp and the large nose-shaped protuberance (nos in Figs 6L, 7D) in the female epigastric area.



Figure 4. *Xyphinus hwangi* sp. n., male. **A, C, E** habitus, dorsal, lateral and ventral views **B, D, F, G** prosoma, dorsal, lateral, ventral and anterior views **H–J** left palp, retrolateral, prolateral and dorsal views. Scale bars: **A, C, E** = 0.4 mm; **B, D, F–J** = 0.2 mm.

Description. Male (holotype). Total length 1.87; carapace 0.81 length, 0.63 width; abdomen 0.99 length, 0.61 width. Habitus as in Fig. 4A, C, E. *Carapace:* orange, dorsal scutum yellow-brown, chelicerae, sternum, legs and ventral scutum light yellow. Carapace dorsally smooth, covered with rows of short hairs; sides finely reticu-



Figure 5. *Xyphinus hwangi* sp. n., female. **A, C, E** habitus, dorsal, lateral and ventral views **B, D, F, G** prosoma, dorsal, lateral, ventral and anterior views **H, I** abdomen, ventral and lateral views **J, K** genital area, ventral and dorsal views (cleared in lactic acid). Scale bars: **A, C, E** = 0.4 mm; **B, D, F–I** = 0.2 mm; **J, K** = 0.1 mm.



Figure 6. *Xyphinus hwangi* sp. n., SEM. **A** male prosoma, anterior view **B**, **C**, **M** male chelicerae, frontal view (arrow shows the small granules) **D**, **G**, **I** male left palp, prolateral, retrolateral and dorsal views **E**, **H** male left palpal bulb, prolateral and retrolateral views **F** distal part of male left palpal bulb, prolateral view **J** female abdomen, ventral view **K**, **L** female genital area, ventral view. Abbreviations: da = dorsal apophysis; ma = medial apophysis; nos = nose-shaped protuberance; pa = prolateral apophysis; ra = retrolateral apophysis.

late; carapace margin with two rows of small denticles on either side and some larger denticles on the posterior slope (Fig. 4B, D). No fovea. Posterior pits lacking. Eyes six, ALE largest, PLE smallest; posterior eye row slightly recurved from above, straight from front. Clypeus with sinuous anterior margin; clypeus height about 1.5 times the diameter of anterior eyes (Figs 4G, 6A). *Mouthparts:* chelicerae toothless, with many small granules on the promargin (Fig. 6B, C, M). Endites with backwards folded ridge.



Figure 7. *Xyphinus hwangi* sp. n. **A–C** male left palp, prolateral, retrolateral and dorsal views **D**, **E** female genital area, ventral and dorsal views. Scale bar: 0.1 mm. Abbreviations: nos = nose-shaped protuberance; tss = thin stick-shape sclerite.

Sternum smooth (Fig. 4F). Legs spineless. *Abdomen:* shape of abdomen normal, not overlapping the carapace. Dorsal scutum ovoid, smooth, nearly entirely covering the abdomen. Booklung covers ovoid, large. Pedicel tube ribbed. Scuto-pedicel region unmodified. Posterior spiracles connected by groove. Postepigastric scutum strongly sclerotized; spinneret scutum present as an incomplete ring. *Genitalia*: sperm pore oval, medium sized, situated at level of anterior spiracles. Palp (Figs 4H–J, 6D–I, 7A–C):

femur inserted near the middle of patella; patella about as long as femur; cymbium strongly protruding prolaterally; bulb with complicated apophyses, ventral apophysis very slender and strongly curved (va in Fig. 6F).

Female (paratype). Total length 1.84; carapace 0.81 length, 0.62 width; abdomen 0.95 length, 0.92 width. Habitus as in Fig. 5A, C, E. As in male except as noted. Endites unmodified (Fig. 5F). Postepigastric scutum rectangular, not fused to epigastric scutum, with long posteriorly directed lateral apodemes. *Genitalia*: with a large nose-shaped protuberance (nos in Figs 6L, 7D) at the middle of the anterior edge of the postepigastric scutum; in dorsal view, a thin stick-shape sclerite extending anteriorly (tss in Figs 5K, 7E).

Distribution. Known only from the type locality.

Genus Xestaspis Simon, 1884

Xestaspis loricata (L. Koch, 1873)

http://species-id.net/wiki/Xestaspis_loricata

Gamasomorpha loricata: Saaristo 2001: 311, figs 1B, 2B, 3B.

Xestaspis loricata: Tong and Li 2009: 26, figs 1G–I, 2G–I, 5A–D; Tong 2013: 51, figs 17G–I, 18G–I, 69A–D.

Material examined. CHINA: *Taiwan*: Pingtung County, Kenting, seaside near Howard Beach Resort, 21°56'27.00"N, 120°48'26.68"E, elevation ca. 34 m, 25–28 June 2013, S. Li & Y. Tong leg., 2 \bigcirc (SYNU-30); Nantou County, Huisun Forest Area, 24°05'16.74"N, 121°02'04.69"E, elevation ca. 788 m, 30 June to 1 July 2013, S. Li, G. Zheng & Y. Tong leg., 2 \bigcirc (SYNU-43).

Comments. Well described in above mentioned papers. **Distribution.** Australia, China, Laos, Micronesia. Newly recorded from Taiwan.

Xestaspis shoushanensis sp. n.

http://zoobank.org/D9171ACC-20CA-437F-8836-A9D5CCA61EA3 http://species-id.net/wiki/Xestaspis_shoushanensis Figs 8–10

Material examined. Holotype \mathcal{J} (IZCAS AR 27810): CHINA: *Taiwan:* Kaohsiung City, Shoushan Mountain, 29 June 2013, S. Li, G. Zheng & Y. Tong leg. Paratypes: same data as holotype, 1 \mathcal{Q} (SYNU-11); same data as holotype, 2 \mathcal{Q} (SYNU-57).

Etymology. The specific name is taken from the type locality; adjective.

Diagnosis. The new species is similar to *Xestaspis paulina* (see Eichenberger et al. 2012), but can be distinguished by the sternum with short radial furrows between coxae I–II, II–III and III–IV (Figs 8F, 9E), by the lateral carapace surface, which is



Figure 8. *Xestaspis shoushanensis* sp. n., male. **A, C, E** habitus, dorsal, lateral and ventral views **B, D, F, G, H** prosoma, dorsal, lateral, ventral, anterior and posterior views **I** booklung covers, lateral view **J, K** abdomen, anterior and anteroventral views. Scale bars: **A, C, E, K** = 0.4 mm; **B, D, F–J** = 0.2 mm. Abbreviations: boc = booklung covers; sr = scutal ridge.



Figure 9. *Xestaspis shoushanensis* sp. n., female. **A, C** habitus, dorsal and lateral views **B, D, E, F** prosoma, dorsal, lateral, ventral and posterior views **G** abdomen, ventral view **H** genital area, ventral view **I, J** genital area, ventral and dorsal views (cleared in lactic acid). Scale bars: **A, C, G** = 0.4 mm; **B, D–F, H–J** = 0.2 mm.



Figure 10. *Xestaspis shoushanensis* sp. n. **A** male left palp, prolateral view **B** male left palpal bulb, dorsal view **C** genital area, dorsal view. Scale bar: 0.1 mm. Abbreviations: ce = conical extension; psc = paddle-like sclerite; re = receptaculum.

strongly striated (Figs 8B, D, 9B, D), by the abdominal scuto-pedicel region with only one straight scutal ridge, without a second, upper, semicircular ridge (Fig. 8J, K), and by the male palp with strongly pointed conical extension (ce in Fig. 10A, B).

Description. Male (holotype). Total length 1.87; carapace 0.82 length, 0.65 width; abdomen 1.09 length, 0.84 width. Habitus as in Fig. 8A, C, E. Body yellow or reddish brown, chelicerae and sternum lighter, legs yellow. *Carapace:* pars cephalica slightly elevated in lateral view. Carapace dorsally smooth, with two rows of short, finely hairs laterally; sides strongly striated; lateral margin with a row of finely hairs. All eyes oval, about subequal; clypeus height about equal to the diameter of anterior eyes (Fig. 8B, D, G). Sternum with narrow, transverse palpal groove, covered with thin hairs standing in small pits, radial furrows present (Fig. 8F). *Abdomen:* dorsal scutum ovoid, punctate, densely covered with short hairs. Booklung covers very small, anterolateral edge with tubercle. Pedicel tube short, without dorsolateral extension, scuto-pedicellar region with straight scutal ridge (Fig. 8J, K). Colulus very small, bearing two setae. *Genitalia:* sperm pore narrow, slit-like. Palp (Fig. 10A, B): cymbium and bulbus yellow. Bulbus distally tapering, ending as pointed conical extension (ce). Cymbium not extending beyond distal tip of bulb. Embolus-conductor complex, mesially bent in dorsal view.

Female (paratype). Total length 2.11; carapace 0.86 length, 0.69 width; abdomen 1.28 length, 1.05 width. Habitus as in Fig. 9A, C. As in male except as noted. *Genita-lia*: ventral view: simple, externally without special features (Fig. 9H, I). Dorsal view: vulva with a small receptaculum and complicated sclerites (Figs 9J, 10C).

Distribution. Known only from the type locality.

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