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Fish, fans and hydroids: host species of pygmy seahorses

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Abstract

An overview of the octocoral and hydrozoan host species of pygmy seahorses is provided based on literature records and recently collected field data for *Hippocampus bargibanti*, *H. denise* and *H. pontohi*. Seven new associations are recognized and an overview of the so far documented host species is given. A detailed re-examination of octocoral type material and a review of the taxonomic history of the alcyonacean genera *Annella* (Subergorgiidae) and *Muricella* (Acanthogorgiidae) are included as baseline for future revisions. The host specificity and colour morphs of pygmy seahorses are discussed, as well as the reliability of (previous) identifications and conservation issues.

Keywords

Acanthogorgiidae, Alcyonacea, *Annella*, Anthozoa, *Hippocampus*, host specificity, Hydrozoa, Indo-Pacific, *Muricella*, new associations, Octocorallia, Subergorgiidae

Introduction

Pygmy seahorses (*Hippocampus* spp.) (Pisces: Syngnathidae) are diminutive tropical fish that live in close association with octocorals, colonial hydrozoans, bryozoans, sea grass and algae (Lourie and Kuiter 2008), but little information is available about their host specificity. Most host organisms are notoriously hard to identify because of a lack of clear morphological characters, which leads to the risk of obtaining erroneous identifications. Therefore there is an urgent need for taxonomic revisions of these host species.

The first discovered pygmy seahorse was described as *Hippocampus bargibanti* Whitley, 1970 (redescribed by Gomon 1997) as an associate of the gorgonian *Muricella* sp. In recent years, six other new pygmy seahorse species have been described: *H. colemani* Kuiter, 2003; *H. denise* Lourie and Randall, 2003; *H. pontohi* Lourie & Kuiter, 2008; *H. satomiae* Lourie & Kuiter, 2008; *H. severnsi* Lourie & Kuiter, 2008 and *H. waleananus* Gomon & Kuiter, 2009. An additional species from Japan awaits description (Kuiter 2009). Žalohar et al. (2009) described two fossil seahorse species, one of which (*H. slovenicus* Žalohar, Hitij & Križnar, 2009) has body ornamentations resembling those of *H. bargibanti*, *H. denise*, and *H. colemani*. It is expected that additional species will be described in the near future (Lourie and Kuiter 2008, Gomon and Kuiter 2009, Kuiter 2009). The diminutive *H. debelius* Gomon and Kuiter, 2009 belongs to the non-pygmy seahorse species despite its small size and possible association with alcyonarians and/or hydroids. This grouping is based on distinctive characters, i.e. the males' external tail pouch and separate gill-openings (Gomon and Kuiter 2009, Kuiter 2009), but is not reflected in the classification above species level.

This study deals with the octocoral (Cnidaria: Anthozoa: Octocorallia) and hydrozoan (Cnidaria: Hydrozoa) hosts of the pygmy seahorses *H. bargibanti*, *H. denise*, and *H. pontohi*. The taxonomic problems in the octocoral host genera *Muricella* (Acanthogorgiidae) and *Annella* (Subergorgiidae) are addressed, and type material is re-examined and depicted. In addition, a literature review of all documented host species is provided, as well as accounts on newly recorded associations. The distribution records of pygmy seahorses are updated with four localities in Indonesia and Malaysia.

Material and methods

The majority of the pygmy seahorse records in the present study was obtained during fieldwork in Raja Ampat, West Papua, Indonesia (2007). Additional observations were made in Bunaken National Marine Park, North Sulawesi (2008), Ternate and Halmahera, North Moluccas (2009) in Indonesia, and Semporna, eastern Sabah, in Malaysia (2010) (Fig. 1).

Soft corals, gorgonians and hydrozoans were thoroughly searched for pygmy seahorses to a maximum depth of 40 m (using SCUBA), with the help of local dive guides where available (Raja Ampat, Bunaken). *In situ* photographs were taken of both the hosts and the associated seahorses (Fig. 2). The total number of seahorses per host colony was counted, the height of each host colony was estimated and a sample was taken for identification and as voucher material. All material is stored on 70% ethanol in the collections of NCB Naturalis, Leiden (catalogue numbers RMNH Coel.). Subsamples of the Ternate material are deposited in the collections of Museum Zoologicum Bogoriense (Java, Indonesia).

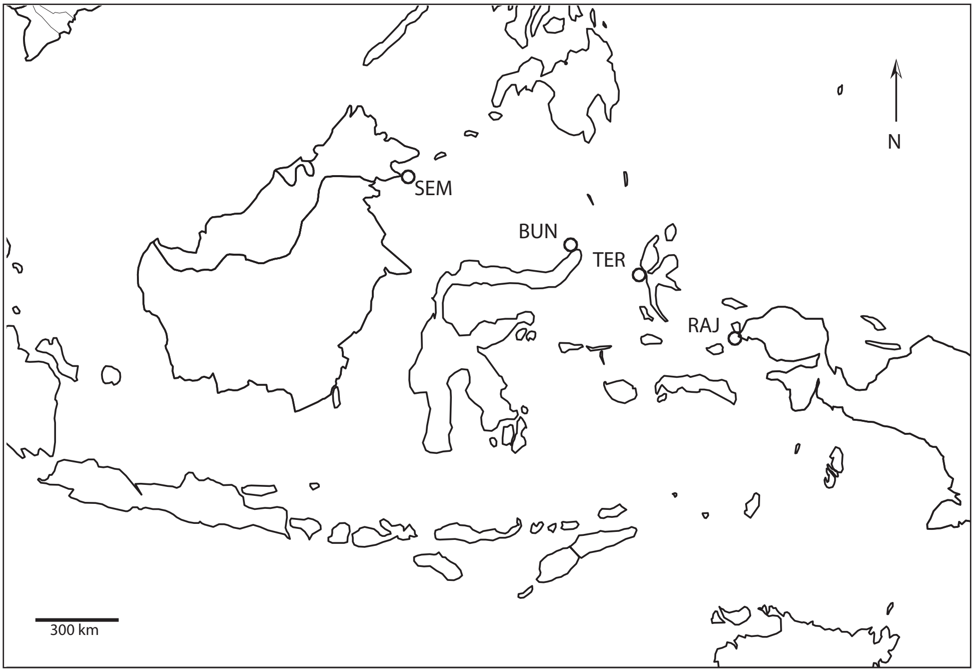

Figure 1. Map showing the fieldwork localities in Indonesia and Malaysia; BUN (Bunaken), RAJ (Raja Ampat), SEM (Semporna) and TER (Ternate).

For the identification of the octocoral hosts, microscope slides and SEM photographs of the sclerites were made. These were obtained by dissolving the octocoral tissue in 10% sodium hypochlorite, after which they were rinsed five times with tap water and five times with double-distilled water. The sclerites were subsequently dried on glass microscope slides on a hot plate. After drying, the sclerites were brushed on a SEM stub and coated with platinum. A JEOL JSM6480LV electron microscope operated at 10 kV was used for the SEM photography. The hydrozoans were identified using a dissecting microscope.

Results

In the literature eight pygmy seahorse species have been recorded as associates of hydroids and octocorals (Table 1). During the fieldwork a total of 10 observations of *H. bargibanti*, 10 of *H. denise*, four of *H. pontohi* and one of *H. severnsi* was made. The total number of encountered pygmy seahorse individuals is 52 (Table 2), in which 10 host species were involved. For *H. bargibanti* and *H. denise* there is overlap in host species with the previous records. The present host records of *H. pontohi* do not correspond with previous ones (Table 1). On one occasion *H. severnsi* was observed, but the host organism was not sampled.

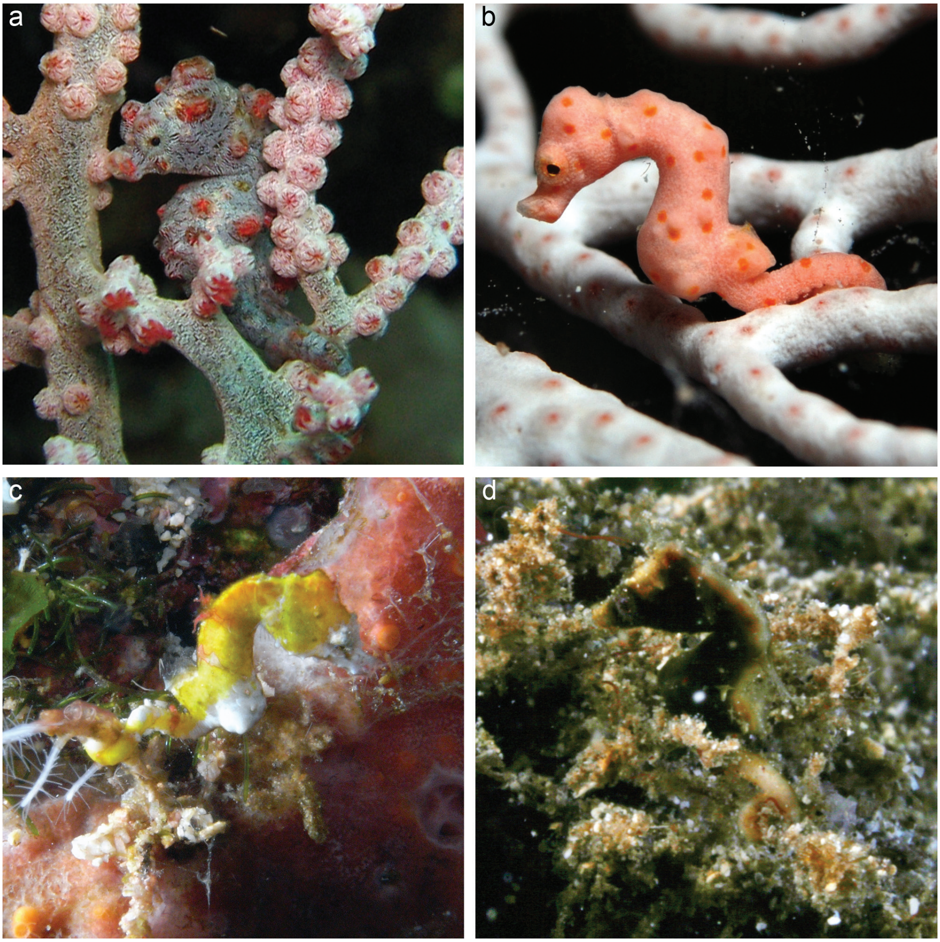

Figure 2. *In-situ* photographs **A** *Hippocampus bargibanti* on *Muricella* sp. 3 (RMNH Coel. 39866, see Fig. 7), Turtles Reef, Raja Ampat (photo F.R. Stokvis) **B** *H. denise* on *Annella reticulata* (RMNH Coel. 39880, see Fig. 10); W Mansuar, Raja Ampat (photo B.W. Hoeksema) **C** *H. pontohi* (host not collected) Timur I, Bunaken (photo S.E.T. van der Meij) **D** *H. severnsi* (host not collected) Siladen I, SE Siladen (photo B.T. Reijnen).

Anthozoa: Alcyonacea

Family Acanthogorgiidae Gray, 1859

Genus *Muricella* Verrill, 1869

Muricella Verrill, 1869: p. 450
Muricella Bayer, 1981: p. 920, 945
Muricella Grasshoff, 1999: p. 33

In the remarks of the species descriptions of *M. plectana* Grasshoff, 1999, and *M. paraplectana* Grasshoff, 1999, from New Caledonia, Grasshoff (1999) already mentioned

Table 1. Distribution ranges of pygmy seahorses and their host species associations as obtained from literature.

Species	Confirmed distribution	Host species	Reference
H. bargibanti	Australia, New Caledonia, Indonesia, Japan, Papua New Guinea, Philippines	*Muricella paraplectana* Grasshoff, 1999	Whitley 1970, Gomon 1997, Grasshoff 1999, Lourie 2001, Lourie and Randall 2003, Fricke 2004, Lourie et al. 2004, Baine et al. 2008, Lourie and Kuiter 2008
		Muricella plectana Grasshoff, 1999	
		Muricella sp.	
H. colemani	Australia (Lord Howe Isl.)	*Halophila* sp.	Kuiter 2003
		Zostera sp.	
H. denise	Indonesia, Malaysia, Micronesia, Palau, Papua New Guinea, Philippines, Solomon Isl., Vanuatu	*Annella mollis* (Nutting, 1910)	Lourie 2001, Lourie and Randall 2003, Lourie et al. 2004, Lourie and Kuiter 2008, Smith and Tibbetts 2008
		Annella reticulata (Ellis & Solander, 1786)	
		Muricella sp.	
		?*Acanthogorgia* spp.	
		?*Echinogorgia* sp.	
		?*Subergorgia* sp.	
H. pontohi	Indonesia (widespread)	*Aglaophenia cupressina* Lamouroux, 1812	Lourie and Kuiter 2008, Kuiter 2009
		Halimeda sp.	
H. satomiae	Indonesia (E Kalimantan, N Sulawesi), Malaysia (N Borneo)	?*Carijoa* sp.	Lourie and Kuiter 2008, Kuiter 2009
		Nephthea sp.	
H. severnsi	Indonesia, Japan, Papua New Guinea, Solomon Isl., Fiji	*Antennellopsis integerrima* Jäderholm, 1919	Kuiter 2000, Lourie and Kuiter 2008
		Catenicella sp.	
		Halicordyle disticha [*Halocordyle disticha* (Goldfuss, 1820) = *Pennaria disticha* (Goldfuss, 1820)]	
		Halimeda sp.	
		Lytocarpus phoeniceus (Busk, 1852)	
		Muricella sp.	
		?*Menella* sp.	
H. waleananus	Indonesia (Walea Isl., Togian Isl.)	*Nephthea* sp.	Gomon and Kuiter 2009
H. sp. A	Japan (Hachijo Isl., Izu Isl.)	unknown	Kuiter 2009

Table 2. Host-species associations as recorded in this study, no. = the number of observed pygmy seahorses per colony. Observations recorded in Raja Ampat, unless otherwise stated.

Species	No.	Host species	RMNH Coel.	Colony height	Depth	Locality	Lat.	Long.
H. bargibanti	1	*Muricella* sp. 1	39868	30 cm	16 m	S Friwin Isl.	0°28’54.54”S	130°41’54.06”E
	2	*Muricella* sp. 1	39871	100 cm	21 m	Mike’s Point, SE Gam Kerupiar Isl.	0°30’57.06”S	130°40’22.14”E
	6	*Muricella* sp. 1	39874	100 cm	22 m	Maitara NW (Ternate)	0°44’19.21”N	127°20’59.99”E
	1	*Muricella* sp. 2	39869	70 cm	21 m	S Friwin Isl.	0°28’54.54”S	130°41’54.06”E
	1	*Muricella* sp. 3	39864	30 cm	18 m	Mike’s Point, SE Gam Kerupiar Isl.	0°30’57.06”S	130°40’22.14”E
	4	*Muricella* sp. 3	39865	60 cm	14 m	Sorido wall, E Kri	0°33’13.20”S	130°41’16.91”E
	1	*Muricella* sp. 3	39866	70 cm	12 m	Turtles Reef	0°32’35.16”S	130°41’51.06”E
	1	*Muricella* sp. 3	39867	25 cm	18 m	Mike’s Point, SE Gam Kerupiar Isl.	0°30’57.06”S	130°40’22.14”E
	5	*Muricella* sp. 3	39870	70 cm	23 m	Mike’s Point, SE Gam Kerupiar Isl.	0°30’57.06”S	130°40’22.14”E
	1	*Muricella* sp. 3	39872	80 cm	23 m	NW Batanta	0°47’45.78”S	130°30’21.24”E
H. denise	1	*A. mollis*	39875	50 cm	20 m	Mike’s Point, SE Gam Kerupiar Isl.	0°30’57.06”S	130°40’22.14”E
	1	*A. mollis*	39876	80 cm	20 m	Sleeping barracuda	0°32’43.14”S	130°42’01.62”E
	1	*A.* cf. *mollis*	39877	100 cm	22 m	S Kri, Kri Isl.	0°33’32.26”S	130°41’15.48”E
	1	*A.* cf. *mollis*	39881	50 cm	22 m	Mike’s Point, SE Gam Kerupiar Isl.	0°30’57.06”S	130°40’22.14”E
	4	*A. reticulata*	39878	60 cm	24 m	W Mansuar	0°30’41.76”S	130°33’35.34”E
	3	*A. reticulata*	39879	40 cm	22 m	W Mansuar	0°30’41.76”S	130°33’35.34”E
	4	*A. reticulata*	39880	30 cm	24 m	W Mansuar	0°30’41.76”S	130°33’35.34”E
	4	*A. reticulata*	39882	30 cm	22 m	Yeffam Isl., NW Pulau Keruo	0°35’15.36S”	130°17’42.66”E
	1	*A. reticulata*	39952	60 cm	22 m	Timba Timba Isl. (Semporna)	4°33’37.70”N	118°55’30.40”E
	1	*Muricella* sp. 2	39873	100 cm	20-25 m	Yeffam Isl., NW Pulau Keruo	0°35’15.36”S	130°17’42.66”E

Species	No.	Host species	RMNH Coel.	Colony height	Depth	Locality	Lat.	Long.
H. pontohi	2	not collected	–	–	–	Timur I (Bunaken)	1°36’38.46”N	124°46’58.74”E
	1	*Thyroscyphus fruticosus* (Esper, 1793)	39883	20 cm	8 m	Nikson, SE Mansuar	0°34’51.42”S	130°38’31.62”E
	1	*Thyroscyphus fruticosus* (Esper, 1793) / *Lytocarpia phyteuma* (Kirchenpauer, 1876)	39884 / 39886	–	26 m	S Kri, Kri Isl.	0°33’32.26”S	130°41’15.48”E
	1	*Clytia* cf. *gravieri* (Billard, 1904)	39885	–	20 m	Mioskon Isl.	0°29’48.48”S	130°43’37.38”E
H. severnsi	3	not collected	–	–	–	Siladen I, SE Siladen (Bunaken)	1°37’30.66”N	124°47’53.88”E

that both species are hosts to *Hippocampus bargibanti*. Since the species descriptions of *M. plectana* and *M. paraplectana* are not in accordance with the depicted sclerites (Grasshoff, 1999; Figs 50–51), the holotypes have been re-examined by microscope slides and SEM photography (Figs 3–4). The material included in the present study was compared with these holotypes, but clearly does not belong to these two species. Consequently, three additional host species can be recognized for *H. bargibanti*. A total of 35 nominal species are currently accepted within the genus *Muricella* (Ofwegen 2010). Since a revision of this genus is lacking, the species names cannot be given. Therefore the sclerite morphology of *M. plectana*, *M. paraplectana* and *Muricella* sp. 1–3 is provided (figs 3–7).

Firstly, *Muricella* sp. 1 (RMNH Coel. 39868, 39871, 39874) is characterized by wide, plump, capstans from the adaxial layer, up to 0.12 mm long (Fig. 5). Secondly, *Muricella* sp. 2 (RMNH Coel. 39869, 39873) is characterized by small, slender adaxial capstans, up to 0.05 mm long (Fig. 6). Thirdly, *Muricella* sp. 3 (RMNH Coel. 39864-67, 39870, 39872), is characterized by adaxial capstans intermediate in shape between the first two, up to 0.10 mm long, and big spindles with rounded ends (Fig. 7). The latter are lacking in the first two species. *Muricella plectana* has similar plump spindles in the coenenchyme but differs from the present material by lacking the bent spindles from the polyp (Fig. 3). *M. paraplectana* differs from all other material by having spindles with pointed ends (Fig. 4).

Family Subergorgiidae Gray, 1859
Genus *Annella* Gray, 1858

Annella Gray, 1858: p. 287
Suberogorgia Stiasny, 1937: p. 83
Subergorgia Bayer, 1981: p. 910
Annella Grasshoff, 1999: p. 16

According to Grasshoff (1999), *Annella* comprises reef-dwelling Indo-Pacific subergorgiids that form netlike fans. Two species are currently recognized, *A. mollis* (Nutting, 1910) and *A. reticulata* (Ellis and Solander, 1786). These species can be distinguished by their growth form: *A. mollis* by elongated meshes in the central part of the fan and *A. reticulata* by having small polygonal meshes.

The taxonomic history of the genus *Annella* is puzzling. Ellis and Solander (1786) described *Gorgonia reticulata* and added a drawing of the habitus without further description or indication of its type locality. The type specimen of *Gorgonia reticulata* is presumably lost. Subsequently, Gray (1857[1858]) described the genus *Annella*, with *A. reticulata* as type species, but it is unknown whether he associated this species with *Gorgonia reticulata*. Later, Nutting (1910) described *Euplexaura reticulata* (Fig. 8), probably without considering a possible homonymy involving *A. reticulata* and *G. reticulata*. Stiasny (1937) synonymised *Gorgonia reticulata* and *Euplexaura reticulata*, based on the external morphology, and transferred the species to *Suberogorgia reticu-*

lata. Grasshoff (1999) eventually placed *G. reticulata*, *A. reticulata*, *E. reticulata* and *S. reticulata* in the genus *Annella*. The species is therefore currently known as *Annella reticulata* (Ellis and Solander, 1786). Here the holotype of *E. reticulata* is re-examined and considered different from *A. reticulata*, based on the morphology of the double head sclerites (Figs 8, 10). Due to the netlike structure of these gorgonians, it is not surprising that the different authors independently chose 'reticulata' as epithet, so adding to the confusion.

Nutting (1910) described a different species as *Euplexaura mollis* (type locality Moluccas). Stiasny (1937) transferred this species to *Suberogorgia* [= *Subergorgia*] (Bayer, 1981), and subsequently Grasshoff (1999) placed it in the genus *Annella*. The species is therefore currently known as *A. mollis* (Nutting, 1910).

A taxonomic revision of *Annella* has not yet been made, but Grasshoff (2001) provided an overview of the sclerite diversity observed within this genus. He suggests that the morphological diversity of the sclerites within these two species is correlated with their geographical distribution in the Indo-Pacific. To the best of our knowledge this would be the first and only case in octocoral taxonomy, in which sclerite morphology varies geographically. Following Grasshoff's (2001) overview of the sclerites, the *Annella* specimens were compared with the nearest region used by Grasshoff (2001), *viz*. the Moluccas. Based on those characters five specimens are identified as *A. reticulata* (RMNH Coel. 39878-80, 39882, 39952; Fig. 10). Likewise, two specimens are identified as *A. mollis* (RMNH Coel. 39875-76; Fig. 11), although the double heads of the examined specimens are less developed compared to Grasshoff's *A. mollis* from the Moluccas. Two of the specimens with an *A. mollis* colony form had sclerites like the ones depicted for specimens from the Maldives (Grasshoff 2001). These two specimens are provisionally identified as *A.* cf. *mollis* (RMNH Coel. 39877, 39881; Fig. 12) and share similarities with the holotype of *E. reticulata* (Fig. 8).

The sclerites of the holotype of *Euplexaura mollis* from the Moluccas (= *Annella mollis* sensu Grasshoff 1999, 2000) (Fig. 9) were also examined and compared with those pictured by Grasshoff (2001). These sclerites resemble the sclerites in drawings of *A. reticulata* from the Moluccas instead of those of *A. mollis*, whereas the habitus resembles *A. mollis*. Based on our presented material and additional material from the NCB Naturalis collection it seems unlikely that the sclerites of the two *Annella* species differ according to locality. Most varieties, as described by Grasshoff concerning the geographic areas, are also found in Indonesian and Malaysia's seas (unpublished data). Additional material from other locations is needed to test Grasshoff's hypothesis on geographically determined sclerite morphotypes.

Hydrozoa

On four occasions specimens of *Hippocampus pontohi* were observed and three of their hosts were collected. Two records of *H. pontohi* individuals are from a colony of *Thyroscyphus fruticosus* (Esper, 1793) (RMNH Coel. 39883-4), a common littoral species on coral reefs with a distribution range throughout Indonesia (Prof. W. Vervoort, pers. comm.). A single individual from Kri Island (Raja Ampat) was found on a specimen of *T. fruticosus* intertwined with a specimen of the hydroid *Lytocarpia phyteuma* (Kirchenpauer, 1876) (RMNH Coel. 39886), therefore both co-host species are listed in Table 2. *Lytocarpia phyteuma* is an uncommon hydrozoan, which can be found at 0–50 m depth, especially in eastern Indonesia (Prof. W. Vervoort, pers. comm.). The *H. pontohi* individual from Mioskon Island was found on specimens of *Clytia* cf. *gravieri* (Billard, 1904) (RMNH Coel. 39885), a common hydrozoan on coral reefs with a wide (sub-) tropical distribution range. Due to the small amount of collected material, a positive identification is not possible. This hydroid species was also recorded during previous expeditions in Indonesia, such as the Snellius II expedition (1983–84) (unpublished data Prof. W. Vervoort). The host of *H. severnsi* was unfortunately not sampled and therefore its identity remains unknown.

Discussion

Many sessile marine organisms contribute to the high marine biodiversity in the so-called Coral Triangle by acting as host for many associated organisms (Hoeksema 2007). Gorgonians are hosts to a variety of species, such as sponges, molluscs, hydroids, crustaceans, brittle stars and fish (Munday et al. 1997, Goh et al. 1999, McLean and Yoshioka 2007, Neves et al. 2007, Puce et al. 2008, Sih and Chouw 2009, Reijnen et al. 2010). The 'persistence' of the relationship (intermittent occurrence on host) between the associated fauna and the host organism is often largely unknown (Goh et al. 1999).

Pygmy seahorses were observed to remain on a single gorgonian for periods of at least 3–40 weeks. Information on the pygmy seahorse whereabouts after this period is lacking, and movement between different hosts was not directly observed (Baine et al. 2008). The claim that pygmy seahorses appear to parasitize their hosts (Kuiter 2000, Teske et al. 2004) has not been substantiated, just like the observations that species were seen moving over a mushroom coral (*Fungia* sp.) and encrusting sponges (Lourie and Kuiter 2008) do not seem to be related to real host specificity.

Host specificity

In the case of *Hippocampus bargibanti* two host species have been recorded in the literature, *M. plectana* and *M. paraplectana*. Three additional *Muricella* species from the Indo-Pacific, different from *M. plectana* or *M. paraplectana*, were found during the present study. *H. bargibanti* is therefore associated with at least five different *Muricella* spp. Unfortunately, the genus *Muricella* is in need of a revision (Samimi and Ofwegen 2009). The latest overview of the genus *Muricella* was made by Kükenthal (1924), in which species-specific characters are usually missing. This makes it impossible to identify specimens to species level.

Since Kükenthals' overview only three additional *Muricella* species have been described (Grasshoff 1999, 2000), which are considered endemic to New Caledonia and the Red Sea. Although the current status of the taxonomy of this gorgonian genus is a large obstacle in identifying species, the results herein indicate that *Muricella* sp. 1, *M.* sp. 2 and *M.* sp. 3 are new host records for *H. bargibanti*, each based on their own unique characters (Figs 5–7).

Individuals of *H. denise* primarily occur on colonies of *Annella* spp., which they strongly resemble in colour pattern, resulting in an optimal camouflage. Based on our results *Hippocampus denise* lives in association with at least three different *Annella* species: *A. reticulata*, *A. mollis* and *A.* cf. *mollis*. No other *Annella* species are currently recognized, and a revision of the genus *Annella* is needed. This will most likely show that additional *Annella* species await description. One individual of *H. denise* was found on *Muricella* sp. 2 (Fig. 13). This association was already known (Table 1), but appears quite unusual. Additional host genera for *H. denise* are expected, based on published photographs (Kuiter 2009). A study by Sih and Chouw (2009) showed that other fish species (*Bryaninops amplus* Larson, 1985) associated with gorgonian hosts, select their habitat on physical properties, such as the host's size and surface area, rather than the species to which it belongs. This may explain why *H. denise* was encountered on a *Muricella* sp., instead of on its far more common host genus *Annella*. Fish species may generally be more associated with certain host gorgonians, but they can still be found on other hosts if the preferred host is not available.

Colour morphs

Different colour morphs are recorded for the gorgonian-associated species *H. bargibanti*, and *H. denise* (Lourie et al. 2004, Kuiter 2009), resulting in the most optimal camouflage considering the colour and the polyp structure of the gorgonians, which are perfectly mimicked by the pygmy seahorses. According to Lourie et al. (2004) the pale grey, purple with pink, and red tubercles colour morphs of *H. bargibanti* are found on *Muricella plectana*, whereas species showing yellow with orange tubercles are found on *M. paraplectana*. Unfortunately, it remains uncertain whether this is a valid assumption, without examining the host's sclerites. Neither *M. plectana* nor *M. paraplectana* were encountered during our field studies and all our specimens of *H. bargibanti* belonged to the pale grey / purple colour morph. The strict association between colour morph and specific host species can therefore not be confirmed. Based on the present data such strict associations seem unlikely, since identically coloured host species are in fact often different species.

For other pygmy seahorse species new colour morphs may be encountered, since pygmy seahorses are enigmatic species that are popular objects for divers and underwater photographers. As a result they often appear in dive magazines and field guides. Occasionally these pictures show new colour morphs or maybe even new species. For future research such observations and sightings can contribute to the general knowledge and ecology of pygmy seahorses, especially when the host organisms are collected for taxonomic studies.

Reliability of identifications

Previous identifications of the hosts of *H. bargibanti* may well be in error since they were made by non-gorgonian specialists, except for the identifications in Lourie and Randall (2003) which were done by Dr F.M. Bayer. Based on the herein presented data and re-examination of the holotypes, it seems plausible that the published coral host records contain several errors. For the genus *Annella* the literature records (see Table 1) show the same host species as found in the present study (Table 2, Figs 8–12), but previous identifications were based on the growth form (mesh shape) and not on the sclerites. These identifications should be re-assessed based on sclerite morphology.

Lourie and Kuiter (2008) mention *Acanthogorgia* spp. as hosts for *H. denise*, based on a photograph (Lourie and Randall 2003: image 10; pers. comm. Sara Lourie). This identification seems erroneous, since the polyps shown in the photograph are not characteristic for the genus *Acanthogorgia*. Although no certain identification can be made based on a photograph, the image most likely depicts a zoanthid (Dr James Reimer, pers. comm.), which would be the first indication that pygmy seahorses might be associated with zoanthids as well. Associations with *Echinogorgia* sp. and *Subergorgia* sp. cannot be confirmed based on material in the present study.

For many organisms molecular methods can be of help to identify species, but so far barcoding of Octocorallia for the COI gene has not been successful. Even when sequences are obtained, information on species level is very limited. Most research is currently limited to three genes, which are still unsatisfactory to identify species (McFadden et al. 2011). For Octocorallia the ‘traditional’ taxonomy based on morphological characters remains of primary importance. When new species of pygmy seahorses are described a photograph of the whole host colony, and a close-up of its polyps and branches should also be provided, which is normally enough to identify the host to family or possibly genus level. Preferably also tissue samples of the host should be collected for taxonomic studies.

Conservation

The distribution ranges of the pygmy seahorses are largely situated within the Coral Triangle (Lourie 2001, Hoeksema 2007), which receives much attention with regard to coral reef conservation. The entire genus *Hippocampus* is listed in Appendix II of CITES and *H. bargibanti* and *H. denise* are listed as data deficient in the IUCN Red List (Lourie et al. 2004), whereas the other five pygmy seahorse species have not yet been assessed. One of the main threats to seahorse populations concerns habitat loss and degradation, especially for the species depending on specific host coral species. Seahorses have been increasingly used as flagship species in local and regional conservation programs to promote the protection of both the seahorses and their habitats (Scales 2010). Knowledge on the distribution of the host species can be beneficial for conservation efforts of their associated organisms.

Conclusion

This paper shows that pygmy seahorses are associated with more gorgonian and hydrozoan hosts than previously assumed, resulting in new associations; *H. bargibanti* is associated with five species of the genus *Muricella*, *H. denise* is associated with three *Annella* species, and *H. pontohi* with four hydrozoan and one algae species. No new records are available for *H. severnsi*. The presumed association of colour morphs of *H. bargibanti* with certain *Muricella* species cannot be confirmed based on our present results. Future work on pygmy seahorses should preferably include more attention for their hosts, including taking tissue samples for identification by an octocoral taxonomist.

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Dr Bert W. Hoeksema (NCB Naturalis) and Mrs. Yosephine Tuti (RCO-LIPI) jointly organized the Raja Ampat (2007) and Ternate (2009) expeditions. Fieldwork in Bunaken (2008) was conducted by the first and second author. LIPI (in 2007 and 2008) and RISTEK (in 2009) granted the research permits for the work in Indonesia. The research was accommodated by Papua Diving, Bunaken Village and the LIPI-Ternate field station. The Semporna Marine Ecological Expedition (SMEE2010) was jointly organized by WWF-Malaysia, Universiti Malaysia Sabah's Borneo Marine Research Institute, NCB Naturalis and Universiti Malaya's Institute of Biological Sciences. Research permission for SMEE2010 was granted by Economic Planning Unit, Prime Minister's Department, Economic Planning Unit Sabah, Sabah Parks and Department of Fisheries Sabah. The MV Celebes Explorer accommodated the research. Frank R. Stokvis photographed many of the pygmy seahorses and collected coral hosts in Raja Ampat. Additional pygmy seahorses were recorded by Dr Bert W. Hoeksema, Dr Willem Renema, and Eva M. van der Veer. Prof. Dr Wim Vervoort (NCB Naturalis) identified the hydrozoan hosts of *H. pontohi*. Dr James D. Reimer (University of the Ryukyus) helped with information on zooanthids, and Dr Sara Lourie (McGill University) checked our pygmy seahorse identifications, and provided extra background information. Dr Rob W.M. van Soest and Ms. Elly Begliner (NCB Naturalis, section ZMA) provided us with the holotypes of *Euplexaura mollis* and *E. reticulata* and Dr A. Andouche and Dr N. Ameziane (Muséum nationale d'Histoire naturelle) provided the holotypes of *Muricella plectana* and *M. paraplectana*. Funding for the various expeditions was provided by the Van Tienhoven Foundation for International Nature Protection, Schure-Beijerinck-Popping Fund (KNAW), a National Geographic Young Explorers Grant, Stichting Fonds Dr C. van Tussenbroek (Nell Ongerboerfonds), Alida M. Buitendijkfonds, Stichting L.B. Holthuisfonds, Jan-Joost ter Pelkwijkfonds (all NCB Naturalis), and Leiden University Funds. Singapore Airlines and SilkAir provided logistical support. Dr Yehuda Benayahu and an anonymous reviewer provided valuable comments on the manuscript.

References

Baine MSP, Barrows APW, Ganiga G, Martin-Smith KM (2008) Residence and movement of pygmy seahorses, *Hippocampus bargibanti*, on sea fans (*Muricella* spp.). Coral Reefs 27: 421. doi:10.1007/s00338-007-0352-5

Bayer FM (1981) Key to the genera of Octocorallia exclusive of Pennatulacea (Coelenterata: Anthozoa), with diagnoses of new taxa. Proceedings of the Biological Society of Washington 94: 902–947.

Fabricius KE, Alderslade P (2001) Soft corals and sea fans: A comprehensive guide to the tropical shallow water genera of the central-west Pacific, the Indian Ocean and the Red Sea. Australian Institute of Marine Science, Townsville, i-viii, 264 pp.

Fricke R (2004) Review of the pipefishes and seahorses (Teleostei: Syngnathidae) of New Caledonia, with descriptions of five new species. Stuttgarter Beiträge zur Naturkunde, Serie A Biologie 668: 1–66.

Goh NKC, Ng PKL, Chou LM (1999) Notes on the shallow water gorgonian-associated fauna on coral reefs in Singapore. Bulletin of Marine Science 65: 259–282.

Gomon MF (1997) A remarkable new pygmy seahorse (Syngnathidae: *Hippocampus*) from South-Eastern Australia, with a redescription of *H. bargibanti* Whitley from New Caledonia. Memoirs of Museum Victoria 56: 245–253.

Gomon MF, Kuiter RH (2009) Two new pygmy seahorses (Teleostei: Syngnathidae: *Hippocampus*) from the Indo-West Pacific. Aqua 15: 37–44.

Grasshoff M (1999) The shallow water gorgonians of New Caledonia and adjacent islands (Coelenterata: Octocorallia). Senckenbergiana Biologica 78: 1–245.

Grasshoff M (2000) The gorgonians of the Sinai coast and the Strait of Gubal, Red Sea (Coelenterata, Octocorallia). Courier Forschungsinstitut Senckenberg 224: 1–123.

Grasshoff M (2001) Taxonomy, systematics, and octocorals: to Frederick M. Bayer, October 31st 2001. Bulletin of the Biological Society of Washington 10: 3–14.

Hoeksema BW (2007) Delineation of the Indo-Malayan Centre of Maximum Marine Biodiversity: The Coral Triangle. In: Renema W (Ed) Biogeography, Time and Place: Distributions, Barriers and Islands. Springer, Dordrecht, 117–178. doi:10.1007/978-1-4020-6374-9_5

Kuiter RH (2000) Seahorses, Pipefishes and their Relatives - A Comprehensive Guide to Syngnathiformes. TMC Publishing, Chorleywood, UK, 240 pp.

Kuiter RH (2003) A new pygmy seahorse (Pisces: Syngnathidae: *Hippocampus*) from Lord Howe Island. Records of the Australian Museum 55: 113–116. doi:10.3853/j.0067-1975.55.2003.1382

Kuiter RH (2009) Seahorses and their relatives. Aquatic Photographics, Seaford, 334 pp.

Larson HK (1985) A revision of the gobiid genus *Bryaninops* (Pisces), with a description of six new species. The Beagle 2: 57–93.

Lourie SA (2001) Seahorses (Genus *Hippocampus*) of Indonesia (field survey report). McGill University, Montreal, 25 pp.

Lourie SA, Foster SJ, Cooper EWT, Vincent CJ (2004) A guide to the identification of seahorses. Project Seahorse and TRAFFIC North America. University of British Columbia and World Wildlife Fund, Washington DC, i-ii, 114 pp.

Lourie SA, Kuiter RH (2008) Three new pygmy seahorse species from Indonesia (Teleostei: Syngnathidae: *Hippocampus*). Zootaxa 1963: 54–68.

Lourie SA, Randall JE (2003) A new pygmy seahorse, *Hippocampus denise* (Teleostei: Syngnathidae), from the Indo-Pacific. Zoological Studies 42: 284–291.

McFadden CS, Benayahu Y, Pante E, Thoma JN, Nevarez PA, France SC (2011) DNA Barcoding limitations of mitochondrial gene barcoding in Octocorallia. Molecular Ecology Resources 11: 19–31. doi:10.1111/j.1755-0998.2010.02875.x

McLean EL, Yoshioka PM (2007) Associations and interactions between gorgonians and sponges. In: Custódio MR, Lôbo-Hajdu G, Hajdu E, Muricy G (Eds) Porifera research: biodiversity, innovation and sustainability, Museu Nacional, Rio de Janeiro 233–237.

Munday PL, Jones GP, Caley JM (1997) Habitat specialisation and the distribution and abundance of coral-dwelling gobies. Marine Ecology Progress Series 152: 227–239. doi:10.3354/meps152227

Neves BM, Lima EJB, Pérez CD (2007) Brittle stars (Echinodermata: Ophiuridae) associated with the octocoral *Carijoa riisei* (Cnidaria: Anthozoa) from the littoral of Pernambuco, Brazil. Journal of the Marine Biological Association of the United Kingdom 87: 1263–1267. doi:10.1017/S0025315407056263

Ofwegen L, van (2010) *Muricella* Verrill, 1868. Accessed through: World Register of Marine Species at http://www.marinespecies.org/aphia.php?p=taxdetails&id=267602 [visited 31 March 2011]

Puce S, Giola di Camillo C, Bavastrello G (2008) Hydroids symbiotic with octocorals from the Sulawesi Sea, Indonesia. Journal of the Marine Biological Association of the United Kingdom 88: 1643–1654. doi:10.1017/S0025315408001094

Reijnen BT, Hoeksema BW, Gittenberger E (2010) Host specificity and phylogenetic relationships among Atlantic Ovulidae (Mollusca: Gastropoda). Contributions to Zoology 79: 69–78.

Samimi Namin K, Ofwegen LP van (2009) Some shallow water octocorals (Coelenterata: Anthozoa) of the Persian Gulf. Zootaxa 2058: 1–52.

Scales H (2010) Advances in the ecology, biogeography and conservation of seahorses (genus *Hippocampus*). Progress in Physical Geography 34: 443–458. doi:10.1177/0309133310364928

Sih J, Chouw J (2009) Fish and whips: Use of gorgonians as a habitat by the large whipcoral goby, *Bryaninops amplus* (Larson). Raffles Bulletin of Zoology, Supplement 22: 145–157.

Smith RE, Tibbetts IR (2008) Mating and birth of Denise's pygmy seahorses (*Hippocampus denise*) observed in the wild. Coral Reefs 27: 617. doi:10.1007/s00338-008-0373-8

Stiasny G (1937) Die Gorgonacea der Siboga Expedition. Supplement II. Revision der Scleraxonia mit Ausschluss der Melitodidae und Coralliidae. Siboga Expedition 13: 1–138.

Teske PT, Cherry MI, Matthee CA (2004) The evolutionary history of seahorses (Syngnathidae: *Hippocampus*): molecular data suggest a West-Pacific origin and two invasions of the Atlantic Ocean. Molecular Phylogenetics and Evolution 30: 273–286. doi:10.1016/S1055-7903(03)00214-8

Whitley GP (1970) Abstract of proceedings. Ordinary general meeting 26th November 1969. Proceedings of the Linnean Society of New South Wales 94: 292–295.

Žalohar J, Hitij T, Križnar M (2009) Two new species of seahorses (Syngnathidae, *Hippocampus*) from the Middle Miocene (Sarmatian) Coprolitic Horizon in Tunjice Hills, Slovenia: The oldest fossil record of seahorses. Annales de Paléontologie 95: 71–96. doi:10.1016/j.annpal.2009.03.002

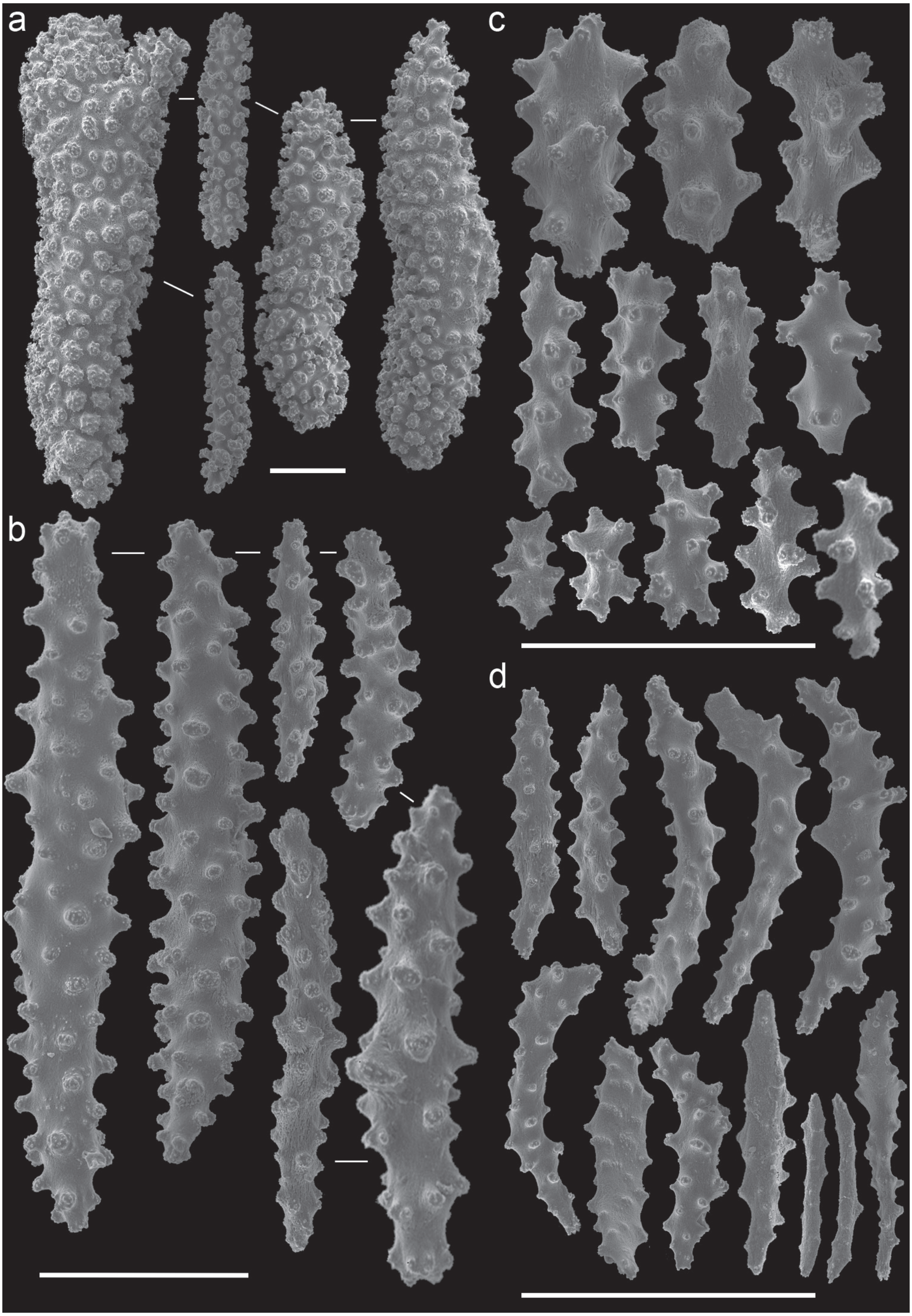

Figure 3. *Muricella plectana* (MNHN, HG-100 - holotype) **A** spindles from coenenchyme and polyp **B** smaller spindles from coenenchyme and polyp **C** capstans from adaxial layer **D** rods from tentacle. Scale bars represent 0.1 mm.

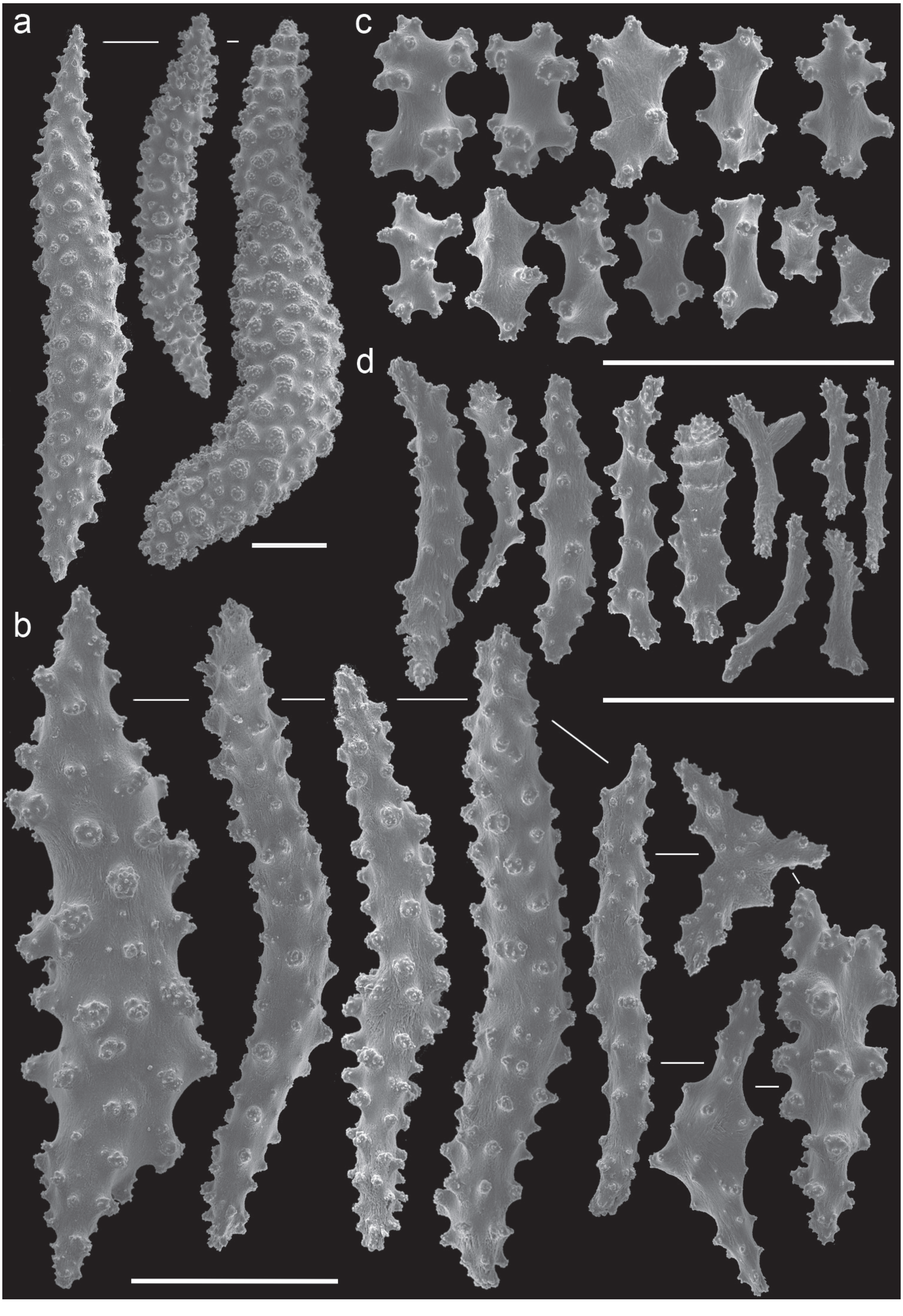

Figure 4. *Muricella paraplectana* (MNHN, HG-121 - holotype) **A** spindles from coenenchyme and polyp **B** smaller spindles from coenenchyme and polyp **C** capstans from adaxial layer **D** rods from tentacle. Scale bars represent 0.1 mm.

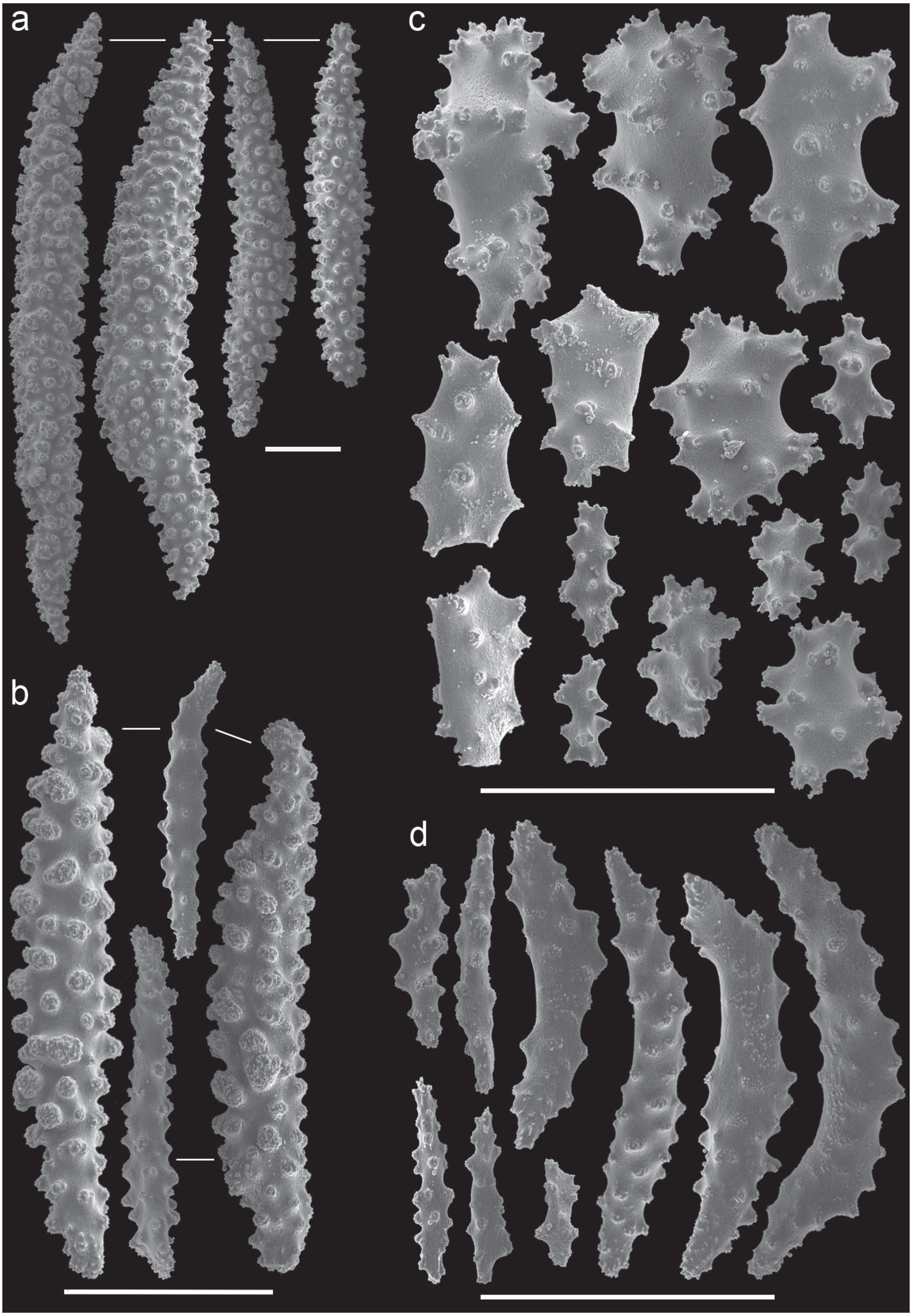

Figure 5. *Muricella* sp. 1 (RMNH Coel. 39871) **A** spindles from coenenchyme and polyp **B** smaller spindles from coenenchyme and polyp **C** capstans from adaxial layer **D** rods from tentacle. Scale bars represent 0.1 mm.

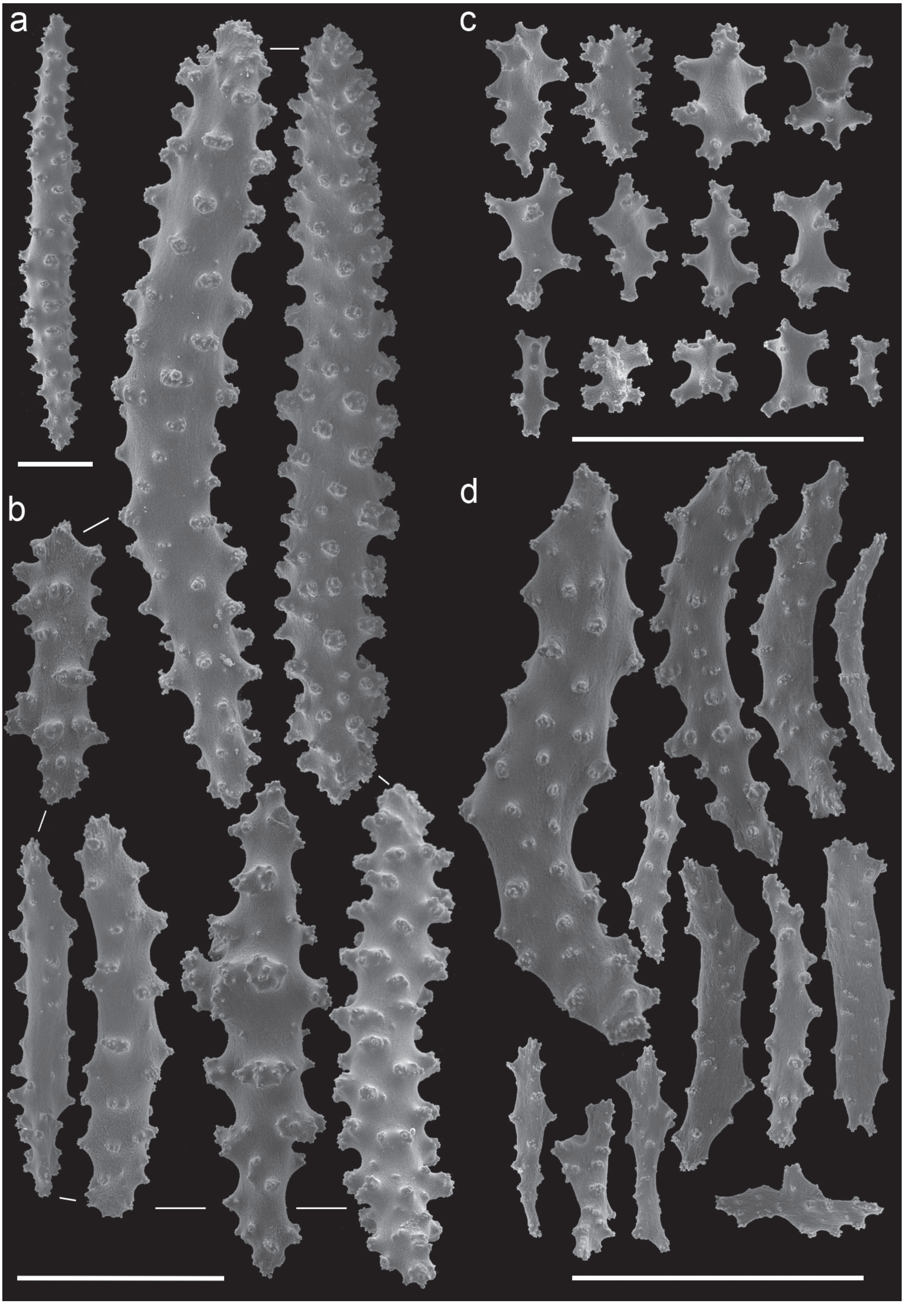

Figure 6. *Muricella* sp. 2 (RMNH Coel. 39873) **A** spindle from coenenchyme **B** smaller spindles from coenenchyme and polyp **C** capstans from adaxial layer **D** rods from tentacle. Scale bars represent 0.1 mm.

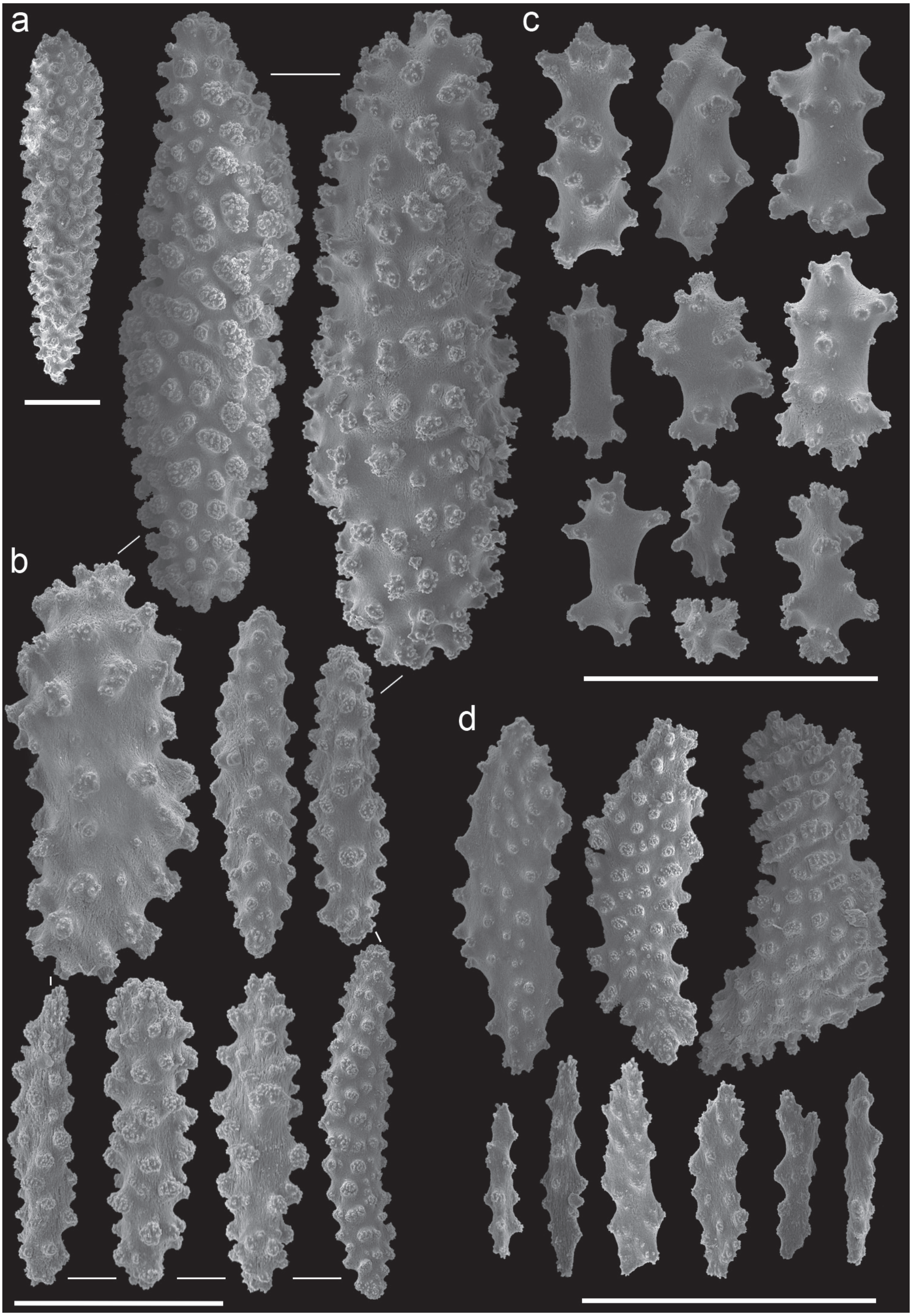

Figure 7. *Muricella* sp. 3 (RMNH Coel. 39865) **A** spindle from coenenchyme **B** smaller spindles from coenenchyme and polyp **C** capstans from adaxial layer **D** rods from tentacle. Scale bars represent 0.1 mm.

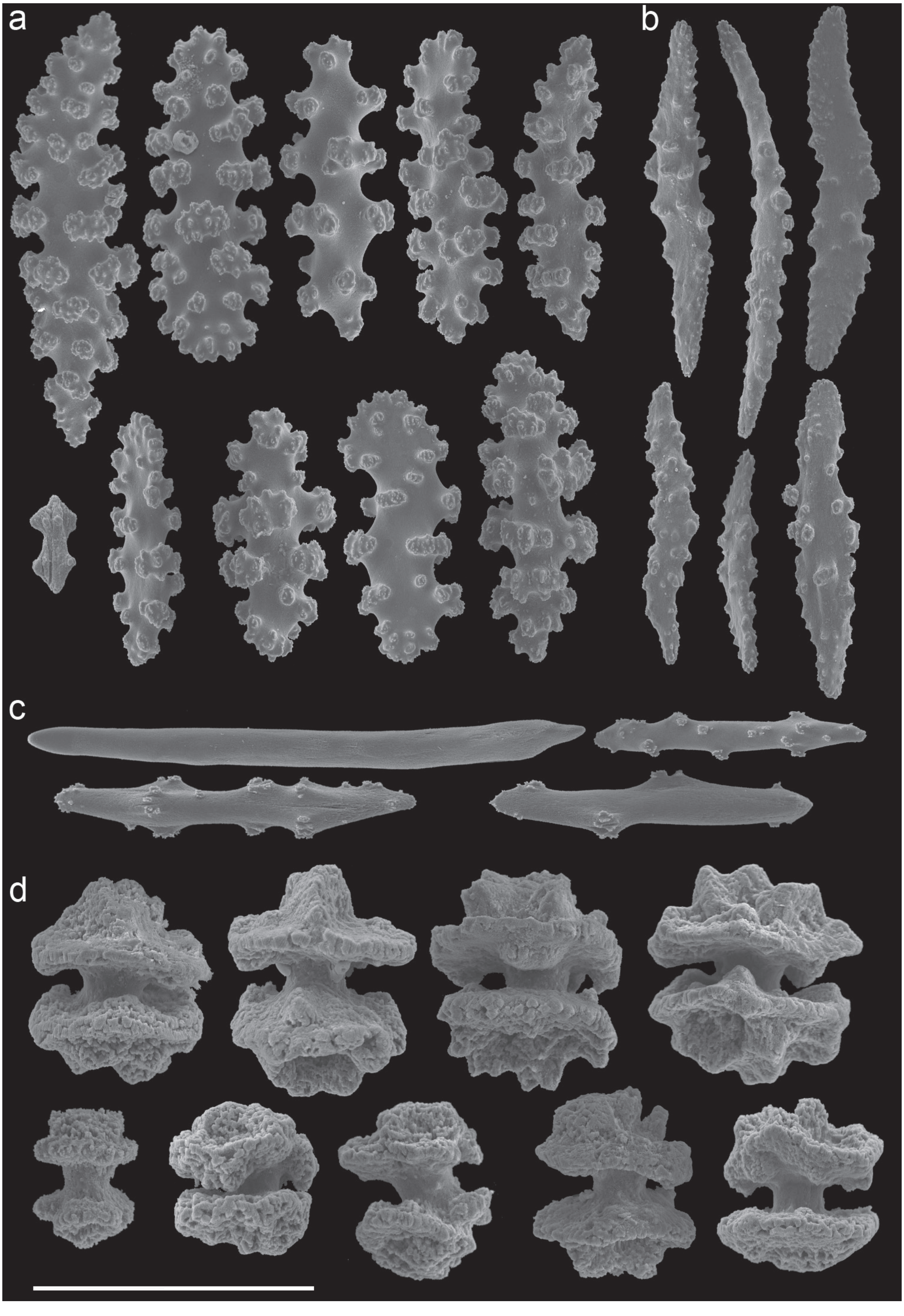

Figure 8. *Euplexaura reticulata* (ZMA Coel. 3504 - holotype) **A** spindles from the coenenchyme **B** tentacle rods **C** medulla spindles from the axis **D** double heads from the surface layer. Scale bar represents 0.1 mm, except for **D** which is 0.05 mm.

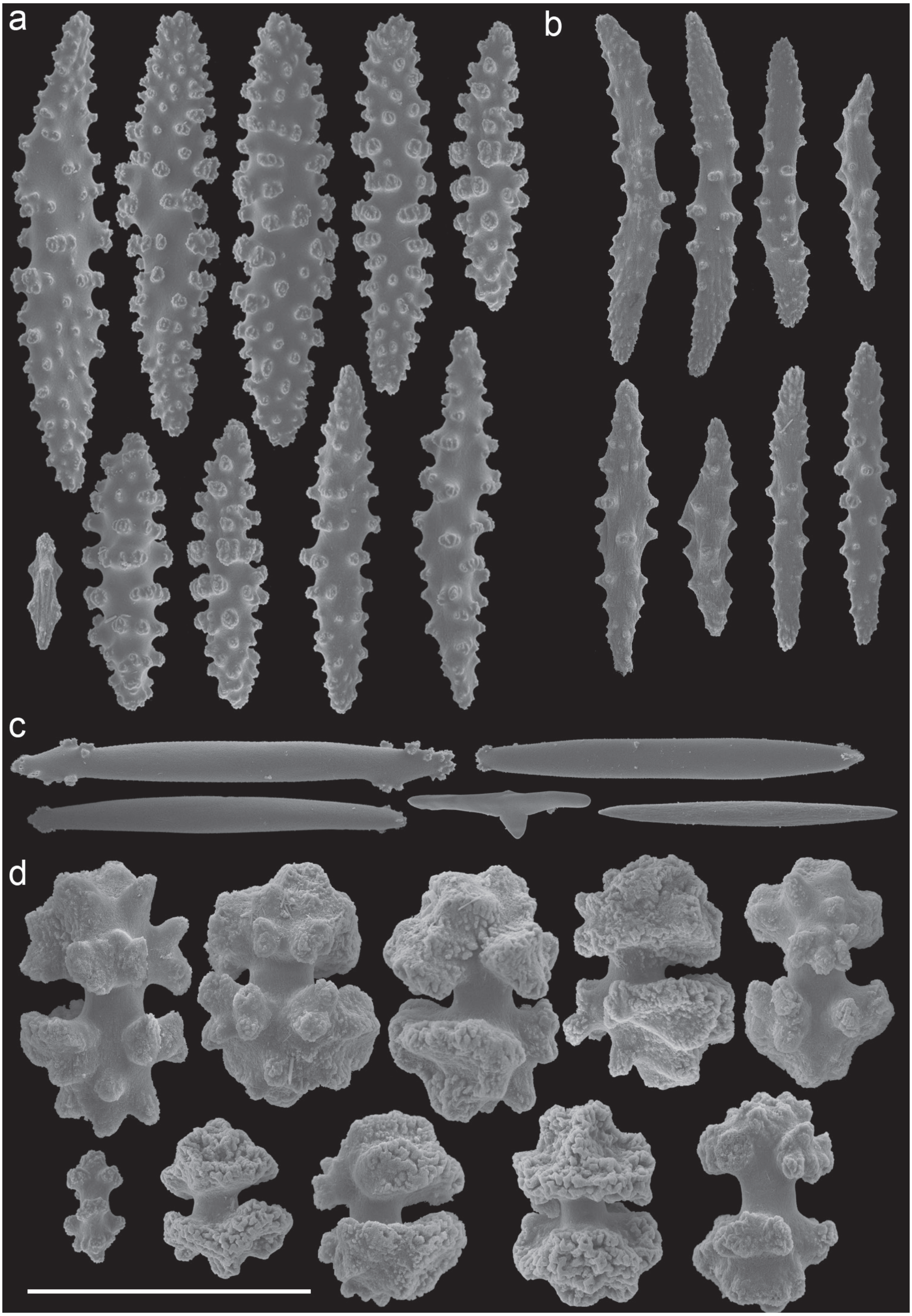

Figure 9. *Euplexaura mollis* (ZMA Coel. 3498 - holotype) **A** spindles from the coenenchyme **B** tentacle rods **C** medulla spindles from the axis **D** double heads from the surface layer. Scale bar represents 0.1 mm, except for **D** which is 0.05 mm.

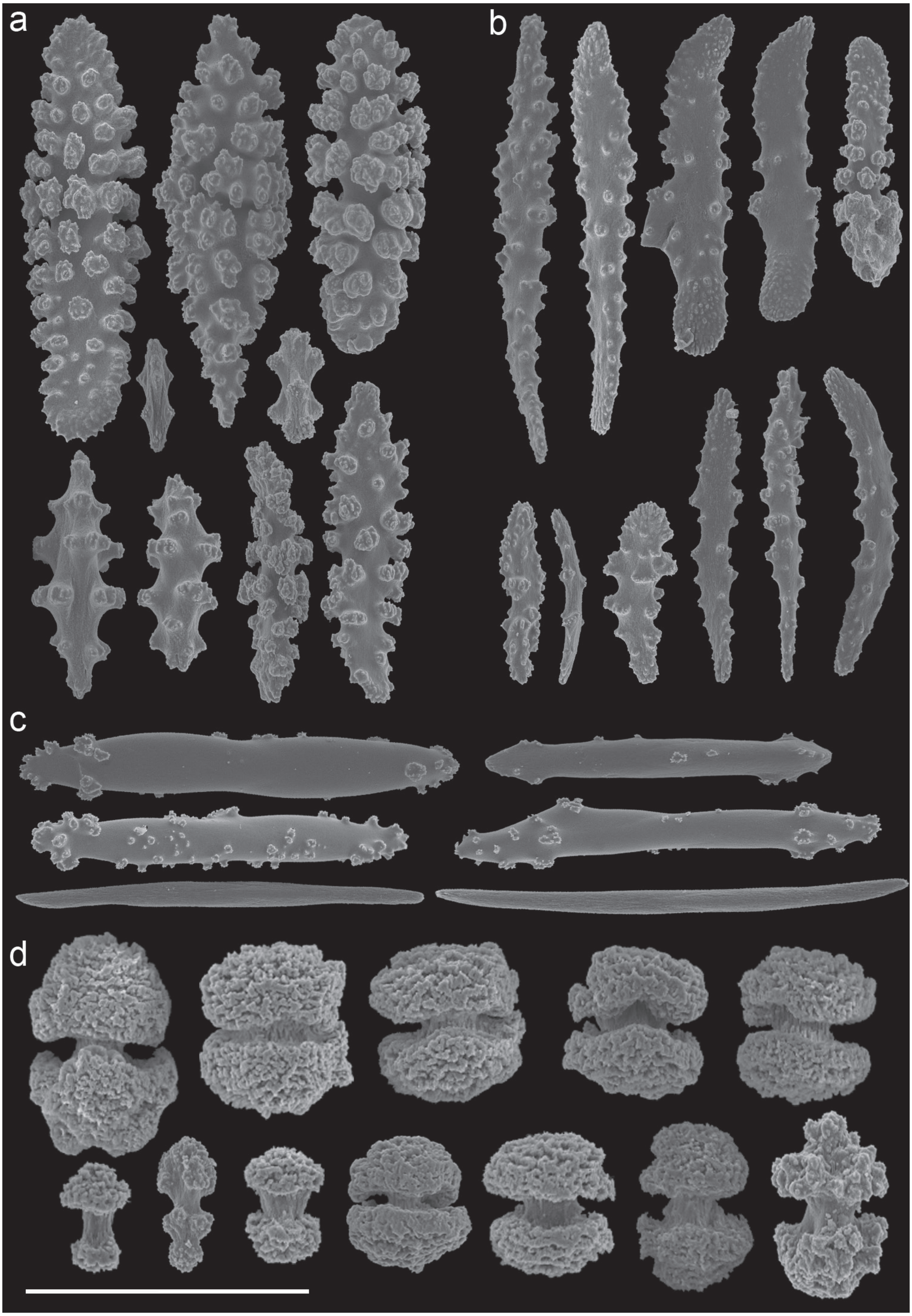

Figure 10. *Annella reticulata* (RMNH Coel. 39882) **A** spindles from the coenenchyme **B** tentacle rods **C** medulla spindles from the axis (d) double heads from the surface layer. Scale bar represents 0.1 mm, except for **D** which is 0.05 mm.

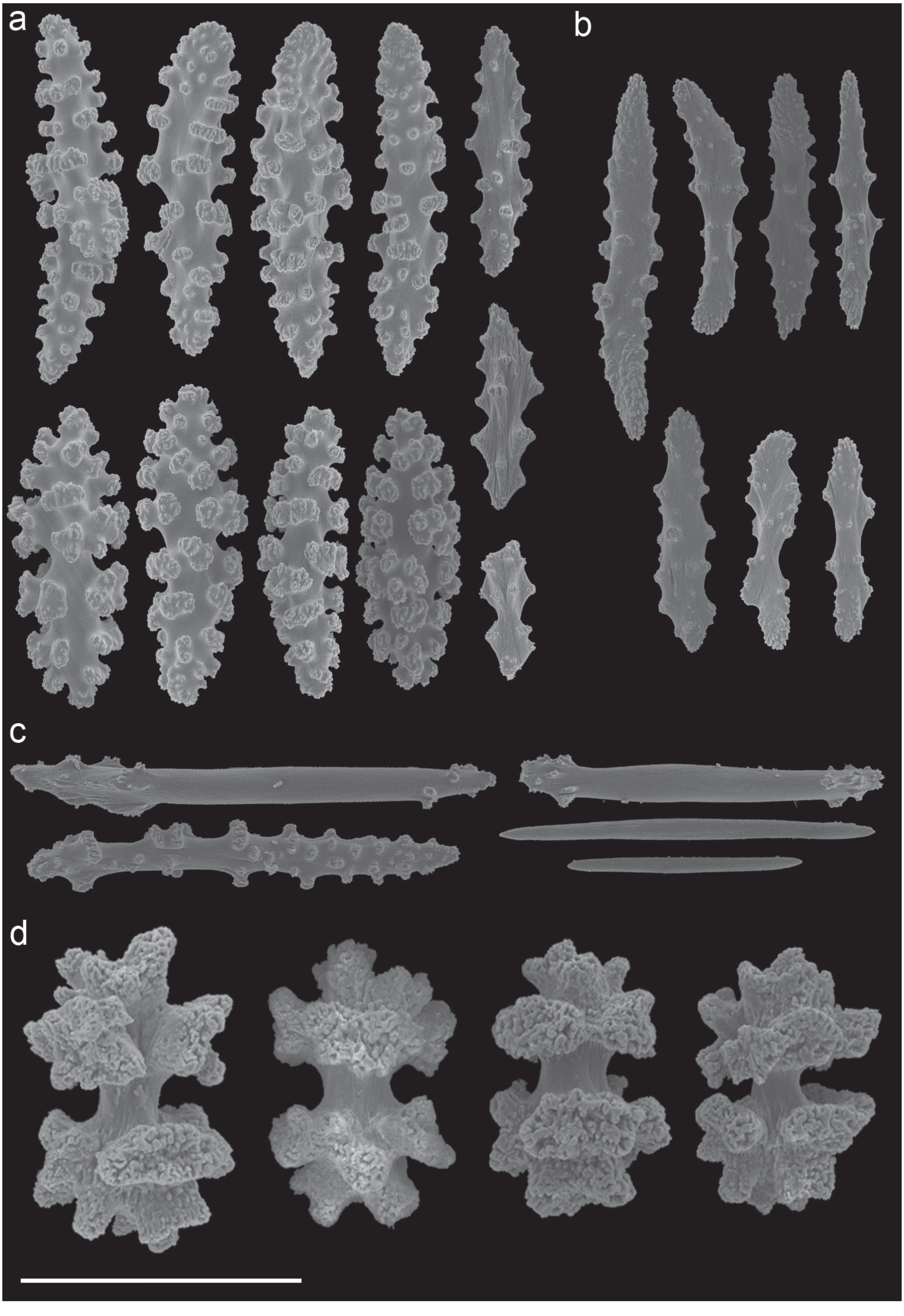

Figure 11. *Annella mollis* (RMNH Coel. 39875) **A** spindles from the coenenchyme **B** tentacle rods **C** medulla spindles from the axis **D** double heads from the surface layer. Scale bar represents 0.1 mm, except for **D** which is 0.05 mm.

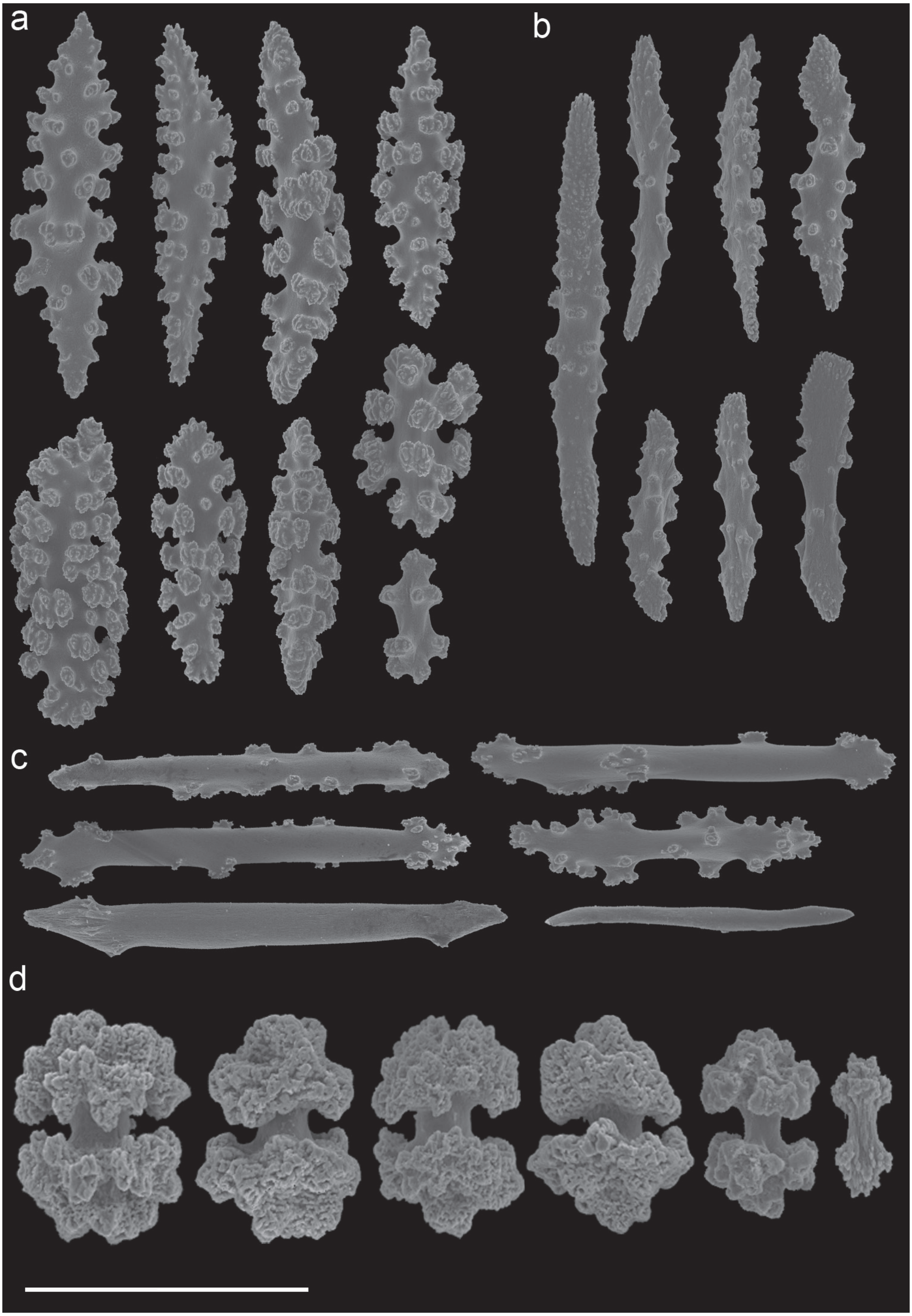

Figure 12. *Annella* cf. *mollis* (RMNH Coel. 39877) **A** spindles from the coenenchyme **B** tentacle rods **C** medulla spindles from the axis **D** double heads from the surface layer. Scale bar represents 0.1 mm, except for **D** which is 0.05 mm.

Figure 13. A rare occurrence, *H. denise* on *Muricella* sp. 2 (RMNH Coel. 39873) at Raja Ampat (photo F.R. Stokvis).

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RESEARCH ARTICLE

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A new *Chorizococcus* species (Coccoidea, Pseudococcidae) from Taiwan with transferring of *Chorizococcus mirzayansi* Moghaddam to genus *Spilococcus* Ferris

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Abstract

A new mealybug species, *Chorizococcus zoysiae* **sp. n.**, feeding on *Zoysia tenuifolia* (Poaceae), is described from Taiwan. Adult female, third-instar female, second-instar female and first-instar nymph were described and illustrated in this article. Keys are provides to (a) separate this new species from similar species of *Chorizococcus* and those of same genus on zoysia grasses and (b) to identify instars of the new species. In addition, *Ch. mirzayansi* Moghaddam is transferred to the genus *Spilococcus* as *S. mirzayansi* (Moghaddam), **comb. n.**

Keywords

Chorizococcus zoysiae sp. n., *Zoysia tenuifolia*, Pseudococcidae, Taiwan, *Spilococcus mirzayansi* comb. n.

Introduction

Zoysia grasses (*Zoysia* spp.) are creeping grasses native to southeastern and eastern Asia and Australasia. Because of high tolerance to temperature, sunlight, and water, they are widely used for lawns in different climate regions. According to Ben-Dov et al. (2010), there are nine scale insects found on zoysia grasses, and five of them belong to the family Pseudococcidae. Among these species, *Chorizococcus rostellum* (Lobdell) was found on an undetermined *Zoysia* species.

The mealybug genus *Chorizococcus* includes 56 described species, half of them from the Nearctic region and others from another five regions (Ben-Dov et al. 2010). Although the genus is of worldwide distribution, many of the species are restricted to a limited area, except *Ch. rostellum* which is distributed in four biogeographic regions. Although six *Chorizococcus* species are known from the Oriental region and occurred in India and Sri Lanka, so far there is no species have been reported from Southeast Asia. This genus has been reported on 117 plant species belonging to 25 plant families. Among them Poaceae and Asteraceae are major host plant families (Tang 1992, Ben-Dov 1994, Ben-Dov et al. 2010, Fallahzadeh et al. 2010, Moghaddam 2010). There are very specific discussions on the genera *Chorizococcus*, *Spilococcus* and *Vryburgia* on cerarii numbers and other characters of these genera. In the other hand, the generic status of *Ch. mirzayansi* Moghaddam is questionable due to the number of cerarii, and some taxonomic works should be made.

In this paper, we provide taxonomic descriptions and illustrations of the adult female, third-instar female, second-instar female and first-instar nymph of a new *Chorizococcus* species. In addition, a key is provided to separate this new species from *Ch. kandyensis* and *Ch. rostellum* which are occurred around the Southeast Asia and another key is proposed for distinguishing different stages of this new species. We here transfer *Ch. mirzayansi* Moghaddam to the genus *Spilococcus* as *S. mirzayansi* (Moghaddam) concerning to the original description of this species.

Materials and methods

All mealybug specimens were slide-mounted in Euparal using the method outlined in Williams and Granara de Willink (1992), except that xylene was used instead of clove oil.

The morphological terms used in the descriptions are explained by Williams (2004) and Williams and Granara de Willink (1992). The descriptions and measurements are based on more than 10 slide-mounted specimens, all in good condition, except for second instar female and first instar nymph of which eight and four specimens were available, respectively. All measurements are given as minimum and maximum. Holotype measurement is also provided in parentheses. Tarsal lengths excluded the claw. Setal lengths included the setal base. Each figure shows a generalized individual based on some specimens used for the description. The enlargements around the central drawing are not drawn to the same scale as each other.

All type specimens of the new species are deposited at Department of Entomology, National Taiwan University, Taipei, Taiwan (NTU), except for three female paratypes deposited in the insect collection of the Taiwan Agricultural Research Institute, Wufeng, Taichung, Taiwan (TARI), and another three female paratypes deposited at the Natural History Museum, London, UK (BMNH).

Taxonomy

Key to *Chorizococcus* species on zoysia grasses and *Ch. kandyensis*

1 Circulus present **2**

– Circulus absent .... ***Chorizococcus zoysiae* sp. n.**

2 Ventral oral rim tubular ducts present; many dorsal oral rim tubular ducts present and extend from marginal areas to medial areas of head and thorax .. .. ***Chorizococcus kandyensis***

– Ventral oral rim tubular ducts absent; seldom dorsal oral rim tubular ducts present in marginal areas of head and thorax only... ***Chorizococcus rostellum***

Key to instars of *Chorizococcus zoysiae* sp. n.

1 Antennae 6-segmented.. **2**

– Antennae 7- or 8-segmented **3**

2 Oral rim tubular ducts present.................................. **second-instar female**

– Oral rim tubular ducts absent .... **first-instar nymph**

3 Antennae 7-segmented; without multilocular disc pores; without vulva........ .... **third-instar female**

– Antennae 8-segmented; with multilocular disc pores; with vulva .... **adult female**

Chorizococcus McKenzie, 1960

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

Chorizococcus McKenzie 1960: 692; 1967: 86; Miller and Mckenzie 1971: 569; Williams 1970: 124; Williams 1985: 75; Williams 2004: 106; Williams and Watson 1988: 31; Williams and Granara de Willink 1992: 100; Ben-Dov 1994: 82.

Diagnosis. Body elongate oval to broadly oval; membranous. With 1–5 pairs of cerarii present on posterior segments of abdomen and sometimes a pair on head also, each cerarius bearing 2 conical setae; auxiliary setae present on anal lobe pair only. Oral rim ducts, sometimes of 2 sizes, present on dorsum and commonly also on venter. Oral collar tubular ducts present, at least on venter; if present on dorsum, then restricted to marginal areas. Antennae each with 7 or 8 segments. Legs well developed, with translucent pores on hind coxae, sometimes absent. Claw stout, without a denticle. Claw digitules knobbed. Tarsal digitules minutely knobbed. Multilocular disc pores present on venter, rarely found on dorsum. Circulus present or absent, when present usually divided by intersegmental line. Anal ring normal, bearing 6 setae. Anterior and posterior ostioles present.

Comments. *Chorizococcus* McKenzie comes close to *Vryburgia* De Lotto in possessing dorsal oral collar tubular ducts. Oral collar tubular ducts on dorsum in *Chorizococcus* occur on margin only, whereas in *Vryburgia*, those ducts occur in transverse rows on dorsum (Williams 2004). *Spilococcus* Ferris is almost identical with *Chorizococcus* McKenzie but possesses 6–17 pairs of cerarii, six or more of which present on the abdomen. Miller and Mckenzie (1973) discussed the difficulties of assigning species to either *Chorizococcus* or *Spilococcus*. Danzig (1998) did not accept *Chorizococcus* and included all species with 1–17 pairs of cerarii in *Spilococcus sensu lato*. Here we follow the definition of Wiliiams (2004) and accept the usage of *Chorizococcus* McKenzie.

Spilococcus mirzayansi **(Moghaddam, 2010), comb. n.**

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

Chorizococcus mirzayansi Moghaddam 2010: 64.

Comments. According to the descriptions of *Ch. mirzayansi*, it should not be placed in genus *Chorizococcus* based on possessing more than 5 pairs of cerarii, a major diagnostic character in distinguishing genus *Chorizococcus* from genus *Spilococcus* in Williams's definition (2004) or it should be included in genus *Spilococcus sesu lato* proposed by Danzig (1998). A new combination is made here for *Ch. mirzayansi* as above.

Chorizococcus zoysiae **Tsai, sp. n.**

urn:lsid:zoobank.org:act:F243D130-D94E-4650-B741-5AD0FB364531
http://species-id.net/wiki/Chorizococcus_zoysiae

Material studied. Holotype: adult female, Taiwan, Tainan City, East district, on leaf sheaths of Korean velvet grass (*Zoysia tenuifolia*), 7.XI.2006, S. K. Chen (NTU): 1/1 in good condition.

Paratypes: 13 adult females, 13 third-instar females, 8 second-instar females, 4 first-instar nymphs, same data as holotype (NTU); 3 adult females, same data as holotype (TARI); 3 adult females, same data as holotype (BMNH).

Description of the Adult Female. Field Features. Body color dark-brownish, covered with thin white mealy wax. Adult female and older nymphs with white, filamentous wax secretion resembling "fur" and covering both mealybug and host plant (Fig. 1). All stages of this mealybug stayed beneath the leaf sheath.

Slide-Mounted Features (measurements based on 20 specimens). Body elongate oval, 1.57–2.56 (2.44) mm long and 0.76–1.33 (1.17) mm wide (Fig. 2). Antennae each 233–267 (247) µm long, with 8 segments, occasionally 7 segments. Clypeolabral shield about 119–151 (144) µm long. Labium about 111–122 (117) µm long, shorter than clypeolabral shield. Legs well developed, stout; fore legs: coxa ca. 61–111 (94) µm long, trochanter + femur 206–233 (217) µm long, tibia + tarsus 178–206 (194) µm long, ratio

Figure 1. Live adult female of *Chorizococcus zoysiae* Tsai, sp. n., on *Zoysia tenuifolia*.

of lengths of tibia + tarsus to trochanter + femur 0.81–0.95 (0.90), ratio of lengths of tibia to tarsus 1.49–2.00 (1.69); mid legs: coxa ca. 94–117 (97) µm long, trochanter + femur 222–250 (217) µm long, tibia + tarsus 189–217 (194) µm long, ratio of lengths of tibia + tarsus to trochanter + femur 0.81–0.90 (0.83), ratio of lengths of tibia to tarsus 1.64–2.09 (1.96); hind legs: coxa ca. 97–133 (111) µm long, trochanter + femur 239–269 (256) µm long, tibia + tarsus 217–250 (244) µm long, ratio of lengths of tibia + tarsus to trochanter + femur 0.87–0.98 (0.96), ratio of lengths of tibia to tarsus 1.78–2.50 (2.14); claw stout, without denticle, about 25–26 (25) µm long. Translucent pores numbering 11–20 (13), present on posterior surface of hind coxa. Circulus absent. Both anterior and posterior ostioles present, not well developed, each lip with a few trilocular pores and 1–4 setae. Cerarii numbering usually 2 pairs, situated on posterior abdominal segments, occasionally 3 pairs. Anal lobe cerarii (C_{18}) each bearing 2 slender conical setae, each seta about 18–25 (21) µm long, with 6–9 auxiliary setae and 16–20 trilocular pores. Penultimate cerarii (C_{17}), each containing 2 slender conical setae, about 15–22 (19) µm long, and few triocular pores. Antepenultimate cerarii (C_{16}), if present, each bearing 2 slender conical setae, about 14–18 (16) µm long, and few trilocular pores. Each cerarius situated on a membranous area. Anal lobes moderately developed, each ventral surface membranous, bearing an apical seta 111–144 (139) µm long. Anal ring about 46–68 (62) µm long and 57–73 (65) µm wide, bearing 6 setae, each seta about 99–138 (112) µm long.

Dorsum. Dorsal surface with slender but stiff setae present, mostly each 13–28 (18) µm long, associated by shorter setae of different sizes, about 5–7 (7) µm long,

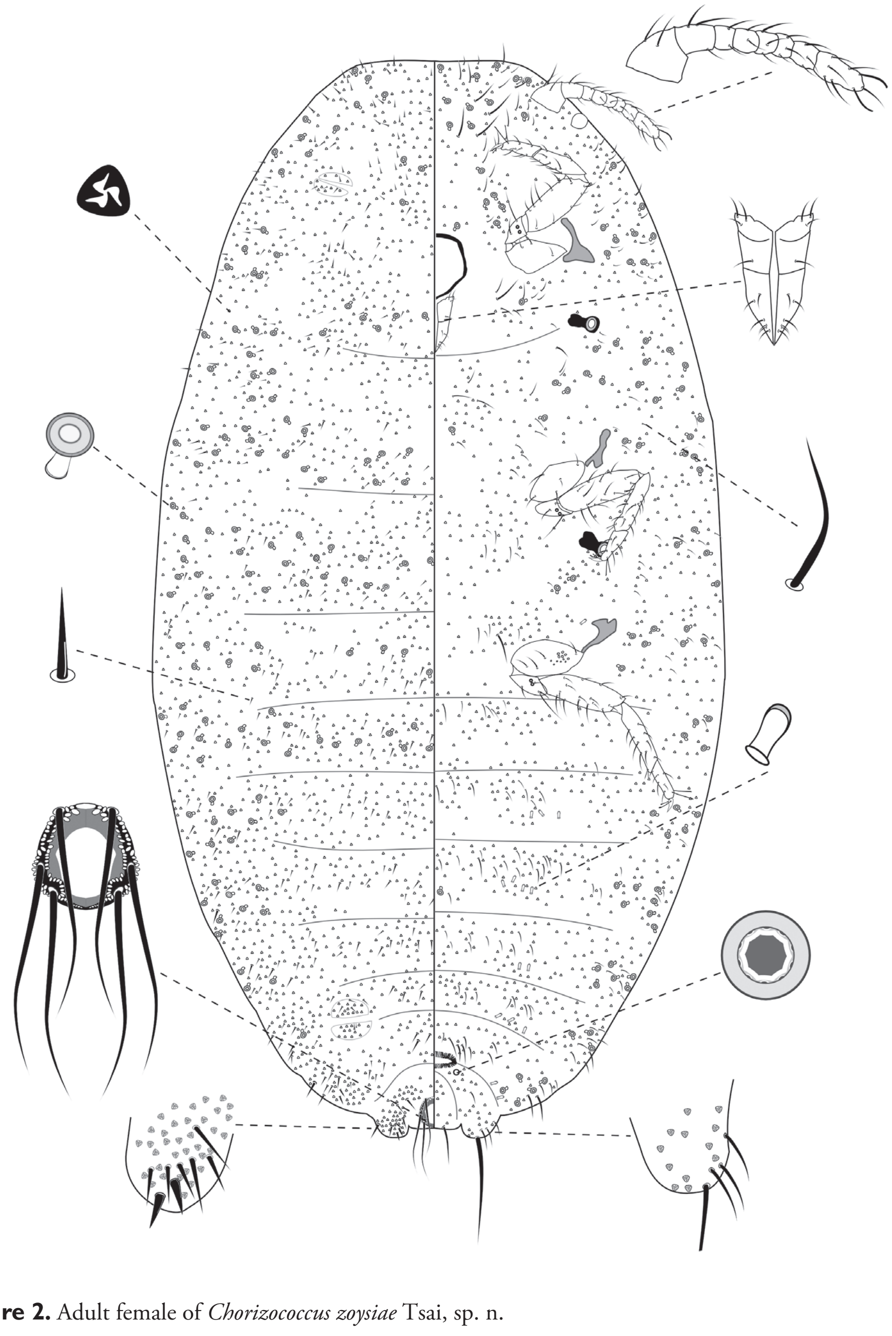

Figure 2. Adult female of *Chorizococcus zoysiae* Tsai, sp. n.

except for longer setae on abdominal segment VI and VII, each about 35–38 (36) µm long. Triocular pores present, each ca. 4 µm in diameter, scattered over dorsum. Multilocular disc pores absent. Oral rim tubular ducts, each with rim about 6–10 (6) µm in diameter and tube about 6–8 (8) µm long, present around lateral margins forwards from abdominal VI to head; extending across head, thorax and abdominal I and II, forming double to triple rows in each segment. Oral collar tubular ducts absent.

Venter. Ventral surface with normal flagellate setae present, mostly each 22–51 (30) µm long, many of them longer than those on dorsum, associated by shorter setae of different sizes, about 5–11 (11) µm long, except for longer setae on head, each about 65–152 (67) µm long. Trilocular pores present, each ca. 4 µm in diameter, similar to those on dorsum, scattered over venter. Multilocular disc pores small, each about 5–7 (6) µm in diameter, present around vulva only, few in number, totaling no more than 4. Oral rim tubular ducts, each with rim about 6–9 (9) µm in diameter and tube about 6–8 (6) µm long, similar to those on dorsum, each with rim wider than multilocular disc pores, distributed sparsely in marginal and submarginal zones, occasionally found in median zone. Oral rim tubular ducts absent from abdominal segment VIII. Oral collar tubular ducts about 5–7 (6) µm long and 2–3 (3) µm wide, present from abdomen III to VII, each segment with 4 to 8, located in submedial zone.

Comments. This new species comes close to *Chorizococcus kandyensis* (Green, 1922) from Sri Lanka (redescribed by Williams 2004). Both species possess dorsal oral rim tubular ducts extending across head, thorax and abdominal I and II, and ventral multilocular disc pores around vulva only. However, the new species possesses 3 pairs of cerarii (*Ch. kandyensis* possesses only one pair) and oral rim tubular ducts of a single size on venter (*Ch. kandyensis* possesses oral rim tubular ducts of two sizes), and lack of circulus (present in *Ch. kandyensis*).

The adult female can be distinguished from all other instars by presence of a vulva opening between abdominal segments VII and VIII and by the presence of multilocular disc pores posterior to the vulva and oral collar tubular ducts on ventral abdominal segments.

It is unclear whether this new species is native or introduced from other country. According to approved facilities list for import of Bureau of Animal and Plant Health Inspection and Quarantine, Taiwan, no imports of Korean velvet grass (*Zoysia tenuifolia*) from other countries were recorded, therefore probably this species is native species to Taiwan. But this new mealybug species apparently occurs in a limited area in Taiwan, and only few parasitoid wasps were collected or observed around them, therefore it seems that this species was possibly introduced with its host plants, with other *Zoysia* species, or with other plant species.

Distribution. Taiwan (Tainan City).

Etymology. The specific epithet is based on the Latin genitive of the host-plant generic name *Zoysia*.

Description of the Third-Instar Female. Slide-Mounted Features (measurements based on 13 specimens). Body elongate oval, 1.06–1.50 mm long and 0.53–0.78 mm wide (Fig. 3). Antennae each 161–211 µm long, with 7 segments. Clypeolabral shield about 106–122 µm long. Labium about 83–106 µm long, shorter than clypeolabral shield. Legs well developed, stout; fore legs: coxa ca. 50–72 µm long, trochanter + femur 133–156 µm long, tibia + tarsus 128–150 µm long, ratio of lengths of tibia + tarsus to trochanter + femur 0.85–1.00, ratio of lengths of tibia to tarsus

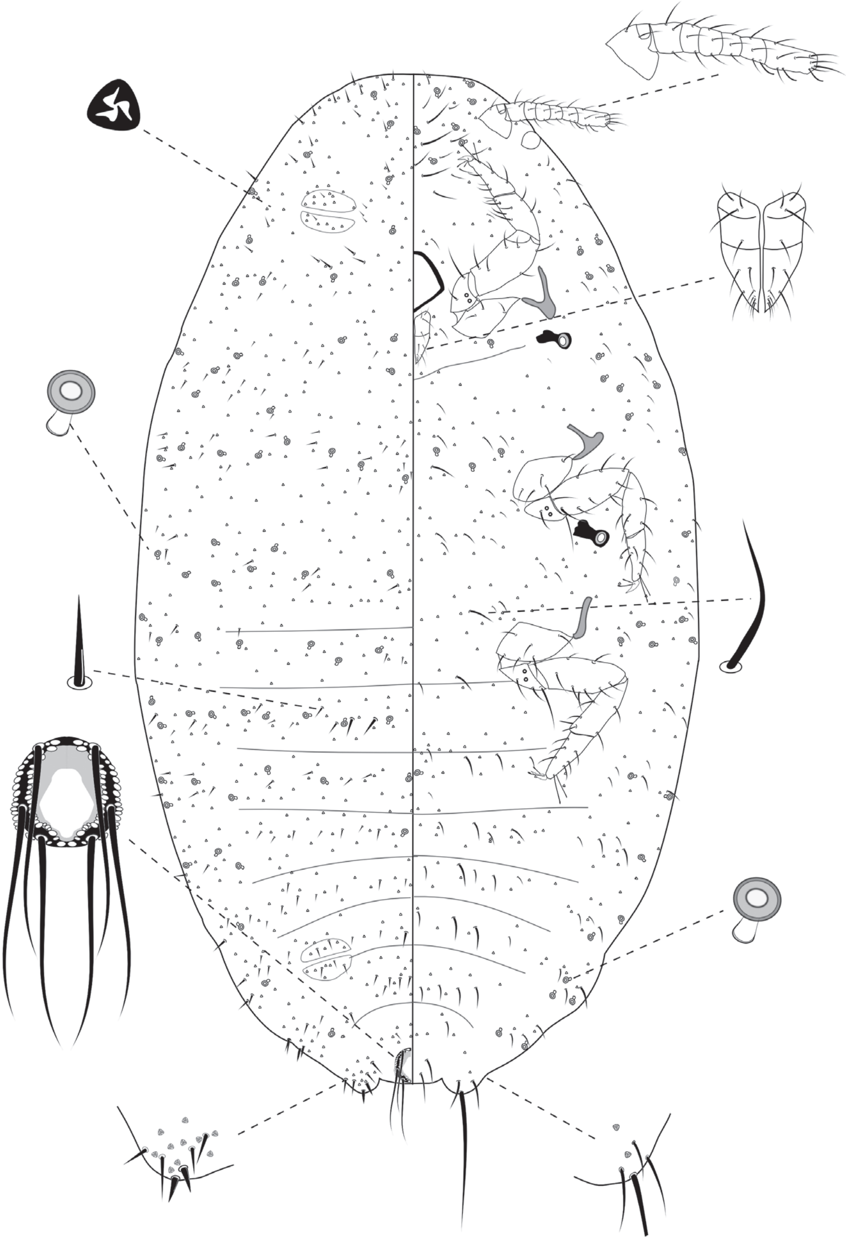

Figure 3. Third-instar female of *Chorizococcus zoysiae* Tsai, sp. n.

1.01–1.18; mid legs: coxa ca. 56–94 μm long, trochanter + femur 150–164 μm long, tibia + tarsus 139–176 μm long, ratio of lengths of tibia + tarsus to trochanter + femur 0.89–1.02, ratio of lengths of tibia to tarsus 1.09–1.31; hind legs: coxa ca. 61–86 μm long, trochanter + femur 150–175 μm long, tibia + tarsus 150–172 μm long, ratio of lengths of tibia + tarsus to trochanter + femur 0.93–1.15, ratio of lengths of tibia to tarsus 1.11–1.50; claw stout, without denticle, about 20–21 µm long. Translucent pores absent. Both anterior and posterior ostioles present, not well developed, each lip with a few trilocular pores and 2–3 setae. Cerarii numbering usually 2 pairs, situated on posterior abdominal segments, occasionally 3 pairs. Anal lobe cerarii (C_{18}) each bearing 2 slender conical setae, each seta about 16–22 µm long, with 2–6 stiff setae and 6–11 trilocular pores. Penultimate cerarii (C_{17}), each containing 2 slender conical setae, each seta about 14–19 µm long, and 3–5 triocular pores. Antepenultimate cerarii (C_{16}), if present, each bearing 2 slender conical setae, each seta about 11–18 µm long, and 2–5 trilocular pores. All cerarii on a membranous areas. Anal lobes moderately developed, each ventral surface membranous, bearing an apical seta 88–110 µm long. Anal ring about 33–45 µm long and 46–52 µm wide, bearing 6 setae, each seta about 79–92 µm long.

Dorsum. Dorsal surface with short, stiff setae, mostly each 10–28 µm long, accompanied by shorter setae of different sizes, about 4–7 µm long. Triocular pores present, each ca. 3 µm in diameter, scattered over dorsum. Multilocular disc pores absent. Oral rim tubular ducts, each with rim about 5–8 µm in diameter and tube about 5–8 µm long, present around lateral margins forwards from abdominal VII to head; extending across head, thorax and abdominal I to III, forming single row in each segment; usually only 1 on abdominal segments IV to VII.

Venter. Ventral surface with normal flagellate setae present, mostly each 13–43 µm long, many of them longer than those on dorsum, accompanied by shorter setae of different sizes, about 5–7 µm long, except for longer setae on head, each about 48–70 µm long. Trilocular pores present, each ca. 3 µm in diameter, similar to those on dorsum, scattered over venter. Multilocular disc pores absent. Oral rim tubular ducts, each with rim about 5–7 µm in diameter and tube about 6–8 µm long, similar to those on dorsum, distributed in marginal and submarginal zones, occasionally found in median zone, usually in groups of 4 to 7 on head and thorax and 2 or 3 on each side of each abdominal segment. Oral rim tubular ducts absent from abdominal segment VIII.

Comments. The third-instar female can be distinguished from the adult female by lacking a vulva, multilocular disc pores, and oral collar tubular ducts; and from earlier instars by bearing seven-segmented antennae.

Description of the Second-Instar Female. Slide-Mounted Features (measurements based on eight specimens). Body elongate oval, 0.61–0.94 mm long and 0.38–0.44 mm wide (Fig. 4). Antennae each 133–161 µm long, with 6 segments. Clypeolabral shield about 78–94 µm long. Labium about 61–72 µm long, shorter than clypeolabral shield. Legs well developed, stout; fore legs: coxa ca. 39–44 µm long, trochanter + femur 103–111 µm long, tibia + tarsus 94–117 µm long, ratio of lengths of tibia + tarsus to trochanter + femur 0.89–1.08, ratio of lengths of tibia to tarsus 0.89–1.25; mid legs: coxa ca. 44–50 µm long, trochanter + femur 100–117 µm long, tibia + tarsus 111–117 µm long, ratio of lengths of tibia + tarsus to trochanter + femur 1.00–1.17, ratio of lengths of tibia to tarsus 1.00–1.41; hind legs: coxa ca. 44–50 µm

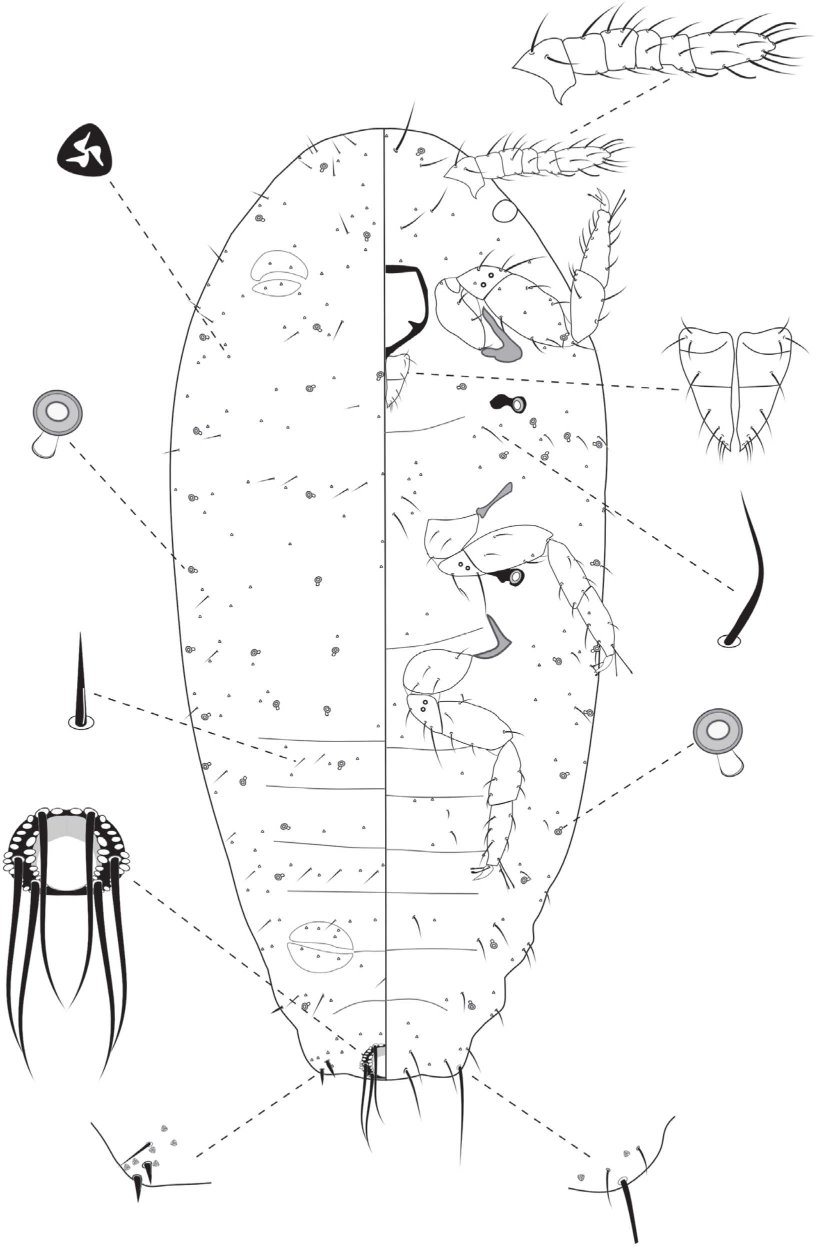

Figure 4. Second-instar female of *Chorizococcus zoysiae* Tsai, sp. n.

long, trochanter + femur 111–117 µm long, tibia + tarsus 117–128 µm long, ratio of lengths of tibia + tarsus to trochanter + femur 1.05–1.15, ratio of lengths of tibia to tarsus 1.04–1.30; claw stout, without denticle, about 17–19 µm long. Translucent pores absent. Circulus absent. Both anterior and posterior ostioles present, not well developed, each lip with a few trilocular pores. Cerarii numbering usually 1 pairs on anal lobes. Anal lobe cerarii (C_{18}) each bearing 2 slender conical setae, each seta about 14–16 µm long, with a stiff seta and 3–5 trilocular pores. All cerarii on a membranous areas. Anal lobes slightly developed, each ventral surface membranous, bearing an apical seta 75–94 µm long. Anal ring about 22–33 µm long and 39–44 µm wide, bearing 6 setae, each seta about 61–78 µm long.

Dorsum. Dorsal surface with short, stiff setae present, mostly each 5–13 µm long. Triocular pores present, each ca. 4 µm in diameter, scattered over dorsum. Multilocular disc pores absent. Oral rim tubular ducts, each with rim about 5–9 µm in diameter and tube about 6–7 µm long, present around lateral margins forwards from abdominal VII to head; extending across head, thorax and abdominal I to III, forming 4 longitudinal lines on marginal and submedial areas of head and thorax; usually only 1 on abdominal segments IV to VII. Oral collar tubular ducts absent.

Venter. Ventral surface with normal flagellate setae present, mostly each 9–33 µm long, many of them longer than those on dorsum, except for longer setae on head, each about 38–52 µm long. Trilocular pores present similar to those on dorsum, scattered over venter. Multilocular disc pores absent. Oral rim tubular ducts, each with rim about 6–8 µm in diameter and tube about 6–7 µm long, similar to those on dorsum, distributed in marginal zones, usually in groups of less than 6 on head and thorax and only one on each side of each abdominal segment. Oral rim tubular ducts absent from abdominal segment VIII. Oral collar tubular ducts absent.

Comments. The second-instar female can be distinguished from the third-instar female and adult female by its six-segmented antennae; and from the first-instar nymph by having oral rim tubular ducts.

Description of the First-Instar Nymph. Slide-Mounted Features (measurements based on four specimens). Body oval, 0.49–0.64 mm long and 0.21–0.32 mm wide (Fig. 5). Antennae each 100–128 µm long, with 6 segments. Clypeolabral shield about 61–72 µm long. Labium about 42–56 µm long, shorter than clypeolabral shield. Legs well developed, stout; fore legs: coxa ca. 28–33 µm long, trochanter + femur 67–83 µm long, tibia + tarsus 86–94 µm long, ratio of lengths of tibia + tarsus to trochanter + femur 1.07–1.42, ratio of lengths of tibia to tarsus 0.72–0.88; mid legs: coxa ca. 31–33 µm long, trochanter + femur 72–83 µm long, tibia + tarsus 92–100 µm long, ratio of lengths of tibia + tarsus to trochanter + femur 1.10–1.55, ratio of lengths of tibia to tarsus 0.78–0.89; hind legs: coxa ca. 31–33 µm long, trochanter + femur 72–89 µm long, tibia + tarsus 100–111 µm long, ratio of lengths of tibia + tarsus to trochanter + femur 1.13–1.54, ratio of lengths of tibia to tarsus 0.89–1.38; claw stout, without denticle, about 11–14 µm long. Translucent pores absent. Circulus absent. Both anterior and posterior ostioles present. Cerarii numbering one pairs, situated on anal lobes. Anal lobe cerarii (C_{18}) each bearing 2 slender conical setae, each seta about 10–17 µm long, with 1 or 2 trilocular pores. All cerarii on a membranous areas. Anal lobes slightly developed, each ventral surface membranous, bearing an apical seta 56–75 µm long. Anal ring about 17–22 µm long and 28–33 µm wide, bearing 6 setae, each seta about 39–56 µm long.

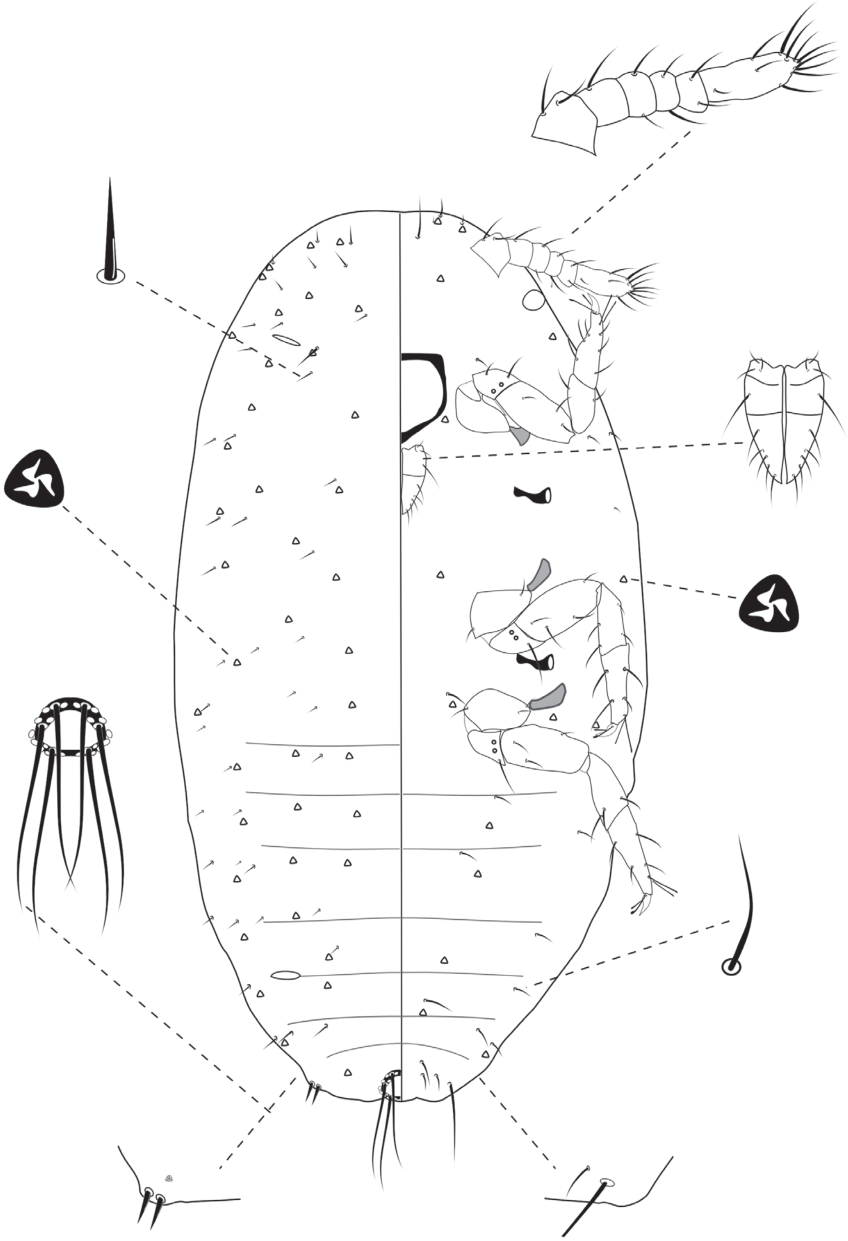

Figure 5. First instar nymph of *Chorizococcus zoysiae* Tsai, sp. n.

Dorsum. Dorsal surface with short, stiff setae present, mostly each 6–10 μm long. Triocular pores present, each ca. 3 μm in diameter, scattered over dorsum. Multilocular disc pores absent. Oral rim tubular ducts absent. Oral collar tubular ducts absent.

Venter. Ventral surface with normal flagellate setae present, mostly each 11–19 µm long, many of them longer than those on dorsum, except for longer setae on head, each about 23–30 µm long. Trilocular pores present, each ca. 3 µm in diameter, similar to those on dorsum, scattered over venter in a few number. Multilocular disc pores absent. Oral rim tubular ducts absent. Oral collar tubular ducts absent.

Comments. The first-instar nymph can be distinguished from all instars by lacking oral rim and tubular ducts. It shares six-segmented antennae with the second instar, but its antennae are shorter than 130 µm (133–161 µm in second-instar females).

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References

Ben-Dov Y (1994) A systematic catalogue of the mealybugs of the world (Insecta: Homoptera: Coccoidea: Pseudococcidae and Putoidae) with data on geographical distribution, host plants, biology and economic importance. Intercept Limited, Andover, UK, 686 pp.

Ben-Dov Y, Miller DR, Gibson GAP (2010) ScaleNet: a database of the scale insects of the world. http://www.sel.barc.usda.gov/scalenet/scalenet.htm [accessed 9.XII.2010]

Danzig EM (1998) Revision of mealybugs (Homoptera, Pseudococcidae) with oral rim tubular ducts of the fauna of Russia and neighbouring countries. Entomological Review 78: 54–78.

Fallahzadeh M, Kaydan MB, Kozár F (2010) Description of a new species of *Chorizococcus* (Hemiptera: Coccoidea: Pseudococcidae) infesting *Vitis vinifera* in Iran. Turkiye Entomoloji Dergisi 34: 157–163.

McKenzie HL (1960) Taxonomic study of California mealybugs with descriptions of new species (Homoptera: Coccoidea: Pseudococcidae). Hilgardia 29: 681–770.

McKenzie HL (1967) Mealybugs of California with taxonomy, biology, and control of North American species (Homoptera: Coccoidea: Pseudococcidae). University of California Press, Berkeley, 525 pp.

Miller DR, McKenzie HL (1971) Sixth taxonomic study of North American mealybugs, with additional species from South America (Homoptera: Coccoidea: Pseudococcidae). Hilgardia 40: 565–602.

Miller DR, McKenzie HL (1973) Seventh taxonomic study of North American mealybugs (Homoptera: Coccoidea: Pseudococcidae). Hilgardia 41: 489–542.

Moghaddam M (2010) Two new species and a new record of mealybugs (Hemiptera, Coccoidea, Pseudococcidae) from Iran. Zootaxa 2619: 63–68.

Tang FT (1992) The Pseudococcidae of China. Shanxi Agricultural University, Taigu, Shanxi, China, 686 pp.

Williams DJ (1970) The mealybugs (Homoptera, Coccoidea, Pseudococcidae) of sugarcane, rice and sorghum. Bulletin of Entomological Research 60: 109–188. doi:10.1017/S0007485300034209

Williams DJ (1985) Australian mealybugs. British Museum (Natural History), London, 431 pp.

Williams DJ (2004) Mealybugs of southern Asia. The Natural History Museum, London, UK, Southdene SDN. BHD, Kuala Lumpur, Malaysia, 896 pp.

Williams DJ, Granara de Willink MC (1992) Mealybugs of Central and South America. CAB International, London, England, 635 pp.

Williams DJ, Watson GW (1988) The scale insects of the tropical south Pacific region. Part 2: The mealybugs (Pseudococcidae). CAB International Institute of Entomology, London, 260 pp.

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RESEARCH ARTICLE

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Two new species of *Stenandra* Lameere, 1912 (Coleoptera, Cerambycidae, Parandrinae) from the Oriental Region

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Abstract

Two new species of the genus *Stenandra* Lameere, 1912 are described: *Stenandra saitoae* from Sulawesi of Indonesia and *Stenandra asiatica* from Vietnam. A key to the species of the *Stenandra* is given.

Keywords

New species, Sulawesi, Vietnam

Introduction

Lameere (1912) erected *Stenandra* as a subgenus of *Parandra* Latreille, 1802, for *Parandra kolbei* Lameere, 1903 (Figs 5, 6) from the Ethiopian Region. Quentin and Villiers (1972) considered *Stenandra* as a genus distinct from *Parandra*, and described the second species: *Stenandra vadoni* (Fig. 4) from Madagascar.

Recently, Santos-Silva et al. (2010) published a revision of the Parandrinae of the Hawaiian, Australasian, Oriental, and Japanese regions. In that paper, the authors misidentified a specimen collected in Vietnam as *S. kolbei*, incorrectly believing that the species was introduced into this country with imported wood.

Stenandra differs from all other genera of Parandrini, except *Neandra* Lameere, 1902, by the absence of a paronychium. From *Neandra*, an exclusively North American genus, it differs by the presence of setae on the elytra (glabrous in *Neandra*).

In the redescription of the genus in Santos-Silva et al. (2010) wrote: "Antennae (Fig. 215) surpassing base of elytra; ventral sensorial area of antennomeres III-XI visible from side, divided by strong carina; dorsal sensorial area of antennomere XI large, deep, well delimited". However, nearly all information agrees with the species from the Oriental Region, but not with the species from the Ethiopian Region, except length of antenna. Thus, it is necessary to amend as: ventral sensorial area of antennomeres III-XI visible or not in lateral view, divided by distinct carina; dorsal sensorial area of antennomere XI, deep and well delimited.

The presence of *Stenandra* in Vietnam and Sulawesi suggests that the genus probably occurs in other areas of the Oriental zoogeographical region, possibly in Borneo. However, specimens of the genus from Africa are poorly represented in collections. The Muséum National d'Histoire Naturelle (Paris, France) apparently has the largest collection of *Stenandra* and researchers that have collected extensively in Africa in the last several years, such as Norbert Delahaye and Karl Adlbauer, have got very few specimens. Outside of Africa and Madagascar, the two females studied here are all that are so far. According to Tavakilian (pers. comm.) the males of the genus seem to be particularly rare but we are looking forward to the first male, as well as additional females, from the Oriental region.

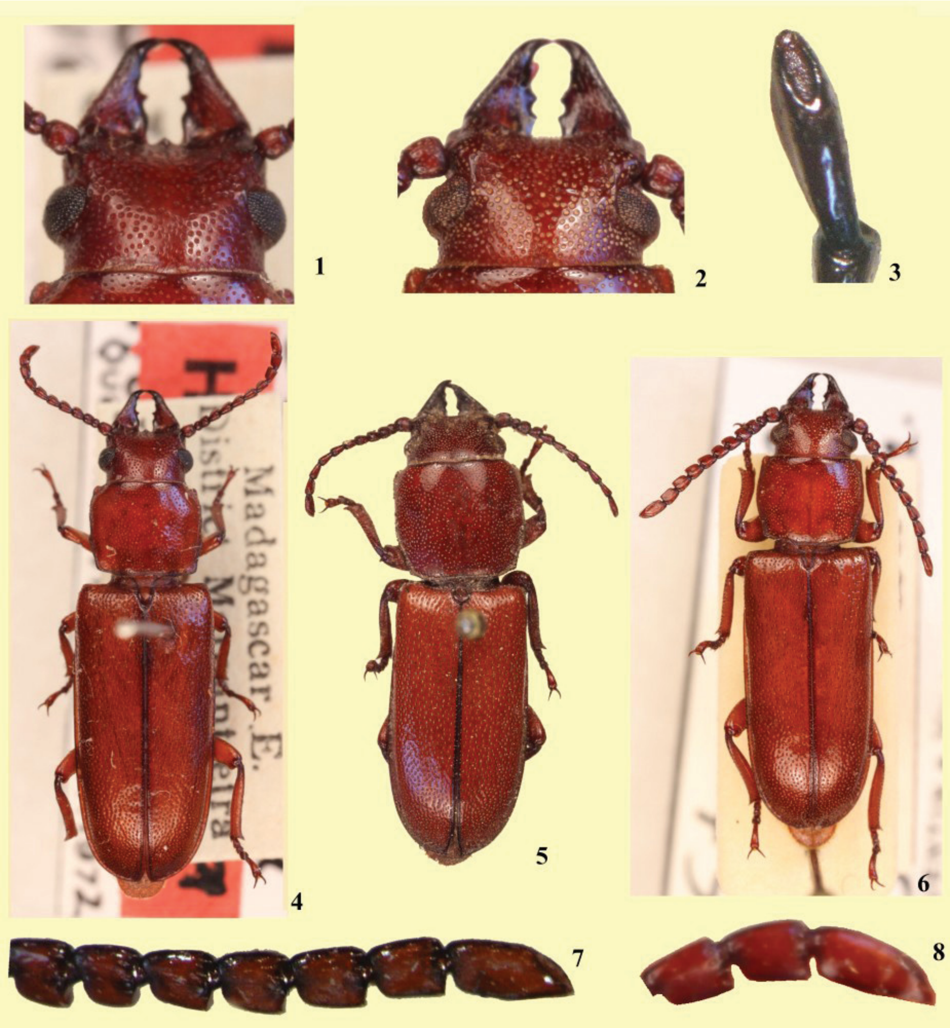
In this paper, we describe two new species of *Stenandra* and provide a key to the species in the genus.

The collection acronyms used in the text are as follows:

MZSP	Museu de Zoologia, Universidade de São Paulo, São Paulo, Brazil;
NSMT	National Museum of Nature and Science, Tokyo, Japan.

Key to the species of *Stenandra*

1	Distance between anterior apex of upper eye lobe and posterior end of antennal insertion equal to the length of scape (Fig. 1). Madagascar .... ***S. vadoni* Quentin & Villiers, 1972**
–	Distance between anterior apex of upper eye lobe and posterior end of antennal insertion much shorter than the length of scape (Fig. 2) **2**
2 (1)	Carina of ventral sensorial area of antennomeres III-XI not visible in lateral view (Figs 7, 8) (sometimes slightly visible at apical antennomeres). Intertropical Africa .... ***S. kolbei* (Lameere, 1903)**



Figures 1–8. *Stenandra vadoni* Quentin & Villiers, 1972, holotype male **1** Head, dorsal view **4** Habitus **8** Antennomeres, lateral view. *Stenandra kolbei* (Lameere, 1903) **2** Head, dorsal view, female **3** Antennomere XI, dorsal view **5** Male, habitus **6** Female, habitus **7** Antennomeres, lateral view, female. Photos from Gérard Tavakilian (MNHN), except figure 3 (from Kiyoshi Matsuda, Japan – specimen from MNHN).

– Carina of ventral sensorial area of antennomeres III-XI distinctly visible in lateral view (primarily the apical antennomeres) (Figs 11, 14)....................**3**

3 (2) Dorsal sensorial area of antennomere XI shorter than one-sixth of total length (Fig. 10); elytral suture divergent apically. Indonesia (Sulawesi) ....***S. saitoae* sp. n.**

– Dorsal sensorial area of antennomere XI longer than one-fourth of total length (Fig. 13); elytral suture not divergent apically. Vietnam.. ***S. asiatica* sp. n.**

Taxonomy

Stenandra saitoae sp. n.

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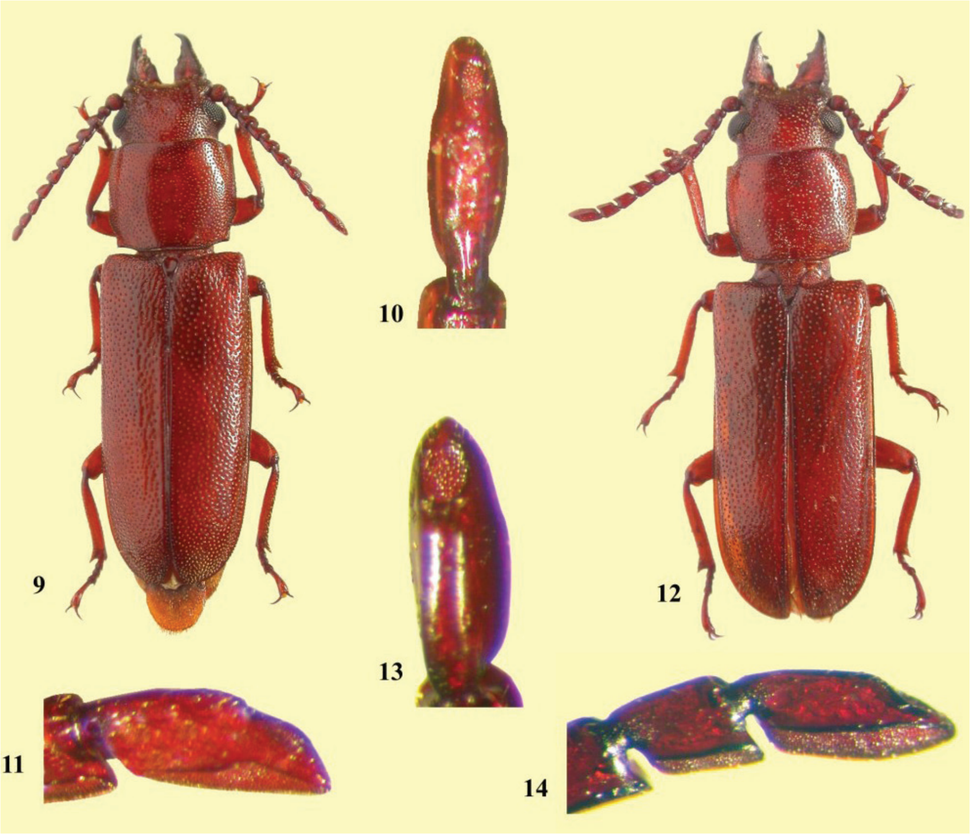
http://species-id.net/wiki/Stenandra_saitoae
Figs 9–11

Etymology. Dedicated to Dr. Akiko Saito of the Natural History Museum and Institute, Chiba, who collected the holotype.

Diagnosis. *Stenandra saitoae* sp. n. (Fig. 9) differs from *S. vadoni* Quentin & Villiers, 1972 (Fig. 4), mainly by anterior upper eye edge (Fig. 9) placed close to base of antennae (distant from base of antennae in *S. vadoni* – Fig. 1). From *S. kolbei* (Lameere, 1903) (Fig. 6) it differs by the carina of ventral sensorial area of antennomeres III-XI distinctly visible in lateral view (Fig. 11), dorsal sensorial area of antennomere XI small (Fig. 10), antennomeres enlarged towards inferior edge (Fig. 10), and suture of the elytra apically divergent. In *S. kolbei,* the carina of ventral sensorial area of antennomeres III-XI is not or very slightly visible in lateral view (Fig. 7), the dorsal sensorial area of antennomere XI is large (Fig. 3), antennomeres not distinctly enlarged towards inferior edge (Fig. 3), and the elytral suture is not divergent at the apex. From *S. asiatica* sp. n. it differs mainly by the small sensorial area of antennomere XI (Fig. 10), the more sparse elytral punctation, and by the elytral suture divergent apically.

Female: Integument dark-brown; parts of the mandibles, margins of the pronotum, elytral suture, pro- and mesosternal process, trochanters, extreme ventral apex of tibiae blackish; elytra laterally and apically darker than the remaining surface.

Dorsal area of head coarsely punctate; punctures sparser at central area, coarser, more abundant and confluent at side; punctures between upper eye lobes with short, apically spatulate setae; punctures between posterior eye margin and margin of pronotum with very short, thick setae. Area behind eyes coarsely, confluently punctate near apices of upper eye lobes, sparsely near lower eye lobes; nearly all punctures with single, very small, thick seta. Clypeus coarsely, densely punctate, except at smooth central area; punctures with short, spatulate setae. Labrum smooth, glabrous laterally; coarsely punctuate; with short, spatulate setae around central projection. Upper eye lobe not notably separated from base of antenna. Submentum coarse; densely punctate near anterior margin (confluently centrally), sparsely and coarsely near gena; each puncture with a small, spatulated seta; anterior edge slightly elevated throughout. Mentum with dense, spatulate setae, somewhat longer laterally. Mandibles punctate; external punctures coarse, deep, dense and accompanied with spatulate setae; internal punctures sparse. Carina of ventral sensorial area of antennomeres elevated and visible in lateral view (Fig. 11), mainly after antennomere VIII; dorsal sensorial area of the antennomere XI (Fig. 10) elliptic, small, not reaching apex of antennomere; antennomere XI distinctly and abruptly sloped dorsally just after middle; antennomeres distinctly enlarged towards inferior edge (Fig. 10), more distinctly after antennomere IV.



Figures 9–14. *Stenandra saitoae* sp. n., holotype female **9** Habitus **10** Antennomere XI, dorsal view **11** Antennomere XI, lateral view. *Stenandra asiatica* sp. n., holotype female **12** Habitus **13** Antennomere XI, dorsal view **14** Antennomere XI, lateral view.

Pronotum finely, sparsely punctate; punctures gradually becoming coarser and more abundant near lateral margin; lateral punctures with very small, spatulate seta. Prosternum coarsely, moderately densely punctate; nearly all punctures with small, spatulate seta. Prosternal process sparsely punctate (punctures with same type setae as prosternum). Mesosternum strongly, densely, deeply, confluently punctate, with a few very small, spatulated setae. Mesosternal process subglabrous and smooth. Mesepisterna coarsely, moderately densely punctate. Metasternum finely and sparsely punctate centrally; punctures gradually becoming coarser and denser towards lateral area; punctures close to metacoxae with small, spatulate setae. Elytra coarse; punctures dense on lateral parts and apical one-fourth; lateral punctures with very small thick setae, more conspicuously towards apices; punctures of apical one-third with small, spatulate setae; suture divergent at apex.

Urosternites densely punctate, mainly laterally; setae short, dense and spatulate, thick laterally; urosternite V with somewhat long, dense setae at margin, more conspicuous centrally (each seta apically spatulate). Coxae moderately sparsely punctate.

Tibiae somewhat flat dorsally and sulcated laterally. Metatarsomere V (excluding claws) longer than I-III together.

Dimensions in mm (♀). Total length (including mandibles), 13.4; prothorax: length, 2.5; anterior width, 2.9; posterior width, 2.7; humeral width, 3.4; elytral length, 7.9.

Type material. Holotype ♀ from INDONESIA, Sulawesi, *South East Sulawesi*: Konda (Kendari, Telkom Popalia; 1600 m; at light), 31.XII.2001, Akiko Saito col. (NSMT).

Stenandra asiatica sp. n.

urn:lsid:zoobank.org:act:09AFC79D-E410-447C-B434-F78D31627F99
http://species-id.net/wiki/Stenandra_asiatica
Figs 12–14

Stenandra kolbei; Santos-Silva *et al.* 2010: 73 (misidentification).

Etymology. The name refers to the continent where the species occurs.

Diagnosis. *Stenandra asiatica* sp. n. (Fig. 12) differs from *S. vadoni* (Fig. 4) and *S. kolbei* (Fig. 6) by the same characters of *S. saitoae* sp. n. from Sulawesi, except the size of the dorsal sensorial area of the antennomere XI, which is large, and by the elytra not divergent apically (both similar to *S. kolbei*). See diagnosis on *S. saitoae* sp. n.

Female: Integument dark-brown; parts of mandibles, margins of pronotum, elytral suture, pro- and mesosternal process, trochanters, extreme ventral apices of tibiae blackish.

Dorsal face of head punctate coarsely for the most part; punctures sparser at central area, and coarse, dense and confluent near each side; punctures on area between upper eye lobes with short setae (lateral ones apically spatulate), more abundant near clypeus; punctures on area between posterior eye lobe and pronotum without setae. Area behind eyes coarsely punctate near the apices of upper eye lobes, sparsely near lower eye lobes; most punctures at the area close to upper eye lobe with a very small seta, slightly thicker at apex. Clypeus coarsely and densely punctate; punctures with short, spatulate setae. Labrum smooth and subglabrous except area near central projection with coarse punctures and short setae, in part spatulate, some only thick or acute apically. Upper eye lobe not notably distant from the base of antenna. Submentum coarse, moderately, densely punctate near anterior margin (confluently so centrally), gradually becoming sparse and coarse towards gena; each puncture with single, small seta (nearly all thicker apically; some of them spatulate; some acute apically); anterior margin slightly elevated throughout. Mentum with moderately sparse spatulate setae which somewhat longer laterally. Mandibles coarse; external punctures deep and dense, with small setae (very few spatulate); internal ones sparse. Carina of ventral sensorial area of antennomeres elevated and visible in lateral view (Fig. 14), mainly after antennomere VI; dorsal sensorial area of antennomere XI (Fig. 13) elliptic, large, almost reaching apex of antennomere; antennomere XI not abruptly sloped dorsally beyond middle; antennomeres distinctly enlarged towards inferior edge (Fig. 13), more distinctly after the antennomere IV.

Pronotum finely, sparsely punctate centrally, gradually becoming more coarsely and densely punctate laterally; lateral punctures with very small, spatulate seta. Prosternum coarsely, moderately, densely punctate, and nearly all punctures with small, apically spatulate seta. Prosternal process with small and spatulate setae. Mesosternum, densely, deeply, confluently punctate, and with small, spatulate setae. Mesepisterna coarsely, moderately, densely punctate. Metasternum finely and sparsely punctate centrally; punctures gradually becoming coarse, moderately abundant towards lateral area; lateral punctures close to metacoxae with small setae some of which spatulate. Elytra coarse; punctures dense on lateral parts and apical third; lateral punctures with very small seta, thicker towards apex and conspicuous from base to apex; nearly all punctures with small seta, more distinct towards apex (many spatulate, at least apically); suture not divergent at apex.

Urosternites densely punctate, mainly laterally; setae short, dense and spatulate (at least apically), mainly laterally; urosternite V with somewhat long, dense setae at margin, more conspicuous centrally (very few of them apically spatulate). Coxae moderately, sparsely punctate. Tibiae somewhat flat dorsally, and sulcate laterally. Metatarsomere V (excluding claws) longer than I-III together.

Dimensions in mm (♀). Total length (including mandibles), 17.4; prothorax: length, 3.2; anterior width, 3.5; posterior width, 3.2; humeral width, 4.4; elytral length, 9.8.

Type material. Holotype ♀ from VIETNAM, *Vinh Phuc*: Tam Dao National Park, VII.14-27.1992, N. Katsura col. (MZSP).

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References

Lameere AA (1912) Révision des Prionides. Vingt-deuxième Mémoire. - Addenda et Corrigenda. Mémoires de la Société Entomologique de Belgique 21: 113–188.

Quentin RM, Villiers A (1972) Un nouveau Parandrinae de Madagascar [Col. Cerambycidae]. Bulletin de la Société Entomologique de France 77: 208–209.

Santos-Silva A, Heffern D, Matsuda K (2010) Revision of Hawaiian, Australasian, Oriental, and Japanese Parandrinae (Coleoptera, Cerambycidae). Insecta Mundi 130: 1–120.

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RESEARCH ARTICLE

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A new endogean, anophthalmous species of *Parazuphium* Jeannel from Northern Morocco (Coleoptera, Carabidae), with new molecular data for the tribe Zuphiini

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Abstract

A new species of the genus *Parazuphium* (Coleoptera, Carabidae, Zuphiini), *Parazuphium aguilerai* **sp. n.**, is described from the Tingitan peninsula in North Morocco. The only known specimen was found under a large deeply buried boulder, and belongs to an anophthalmous, depigmented and flattened species. This is the second species of blind *Parazuphium* known so far, the other being *P. feloi* Machado 1998 from a lava tube in the Canary Islands. Molecular data of the only known *P. aguilerai* sp. n. specimen are provided, and a reconstructed phylogeny based on these molecular data confirms its inclusion inside Zuphiini within Harpalinae. Identification keys to the Mediterranean and Macaronesian species of *Parazuphium* are provided.

Keywords

Taxonomy, new species, *Parazuphium*, identification key, endogean fauna, molecular phylogeny

Introduction

The genus *Parazuphium* Latreille (Coleoptera, Dryptinae, Zuphiini) is characterized by the presence in the aedeagus of a strong ventral constriction between the basal and the distal part of the median lobe, a unique structure within the Carabidae (Antoine 1962, Mateu 1993). The genus currently includes ca. 40 species (Lorenz 2005) in the Old World and Australia (Mateu 1993), arranged in three subgenera: 1) *Neozuphium* Hürka, with a single species, *P.* (*Neozuphium*) *damascenum* (Fairmaire) (Mateu 1988), with a wide Palaearctic distribution from Central Asia and the Mediterranean to the Canaries (Hürka 1982, Mateu 1988, Machado 1992, Lencina and Serrano 1995); 2) *Austrozuphium* Baehr, with five Australasian species (Baehr 1985) and 3) *Parazuphium* s.str. Jeannel, with 32 species distributed through the Old World (Mateu 1993). The recent catalogues of Löbl and Smetana (2003) and Lorenz (2005) do not include the synonymies of *P.* (*Neozuphium*) *bactrianum* (K. Daniel & F. Daniel) and *P.* (*N.*) *novaki* (G. Müller) with *P. damascenum* (Mateu [1988]).

The species of the genus seem to be associated with deep soil or the soil crevices near rivers or temporary flooded areas (Baehr 1985, Machado 1992), and generally show a flattened habitus, some degree of depigmentation and microphthalmy. Some species are known from caves, one of them being the only previously known blind species of the genus (*P. feloi* Machado, from the Canary islands) (Machado 1998).

During an entomological expedition to North Morocco we found the single specimen of a new species of *Parazuphium*, anophthalmous and with strong modifications apparently related to its endogean habitat. Despite an attempt to collect additional material the following year no other specimen was found, possibly due to the endogean habits of this species. We describe the species here, and provide some molecular data to characterize it and to postulate its phylogenetic position among the Zuphiini for which genetic data are available (Ribera et al. 2006).

Material and methods

The unique specimen was killed and stored in absolute ethanol in the field, and total DNA was extracted using the QIAGEN Dneasy tissue kit (Qiagen, Hilden, Germany), without destroying the external cuticle. The extracted specimen was mounted in DMHF (Dimethyl Hydantoin-Formaldehyde) on a transparent acetate label. For the morphological study and photographs we used a Zeiss Stemi 2000C Trinocular Zoom Stereomicroscope with Spot Insight Firewire digital camera and software.

Molecular methods

Total genomic DNA for the single specimen of *Parazuphium aguilerai* sp. n. was extracted using QIAGEN Dneasy tissue kit (Qiagen, Hilden, Germany). To characterize the new species we amplified fragments of six genes, four mitochondrial and two nuclear: 3' end of cytochrome c oxidase subunit (*cox1*); a single fragment including the 3' end of the large ribosomal unit (*rrnL*), the whole tRNA-Leu gene (*trnL*) and the 5' end of the NADH dehydrogenase 1 (*nad1*); 5' end of the small ribosomal unit, 18S rRNA (*SSU*); and an internal fragment of the large ribosomal unit, 28S rRNA (*LSU*). Primers used are given in Table 1. Additionally, we extracted DNA from one specimen of *Parazuphium* cf. *baeticum* (K. and J. Daniel 1898), *Zuphium olens* Rossi 1790, *Ildobates neboti* Español 1966 and several other outgroups among Carabidae (Table 2), which were amplified for the same molecular gene fragments. PCR reactions were made using PuReTaq Ready-To-Go PCR beads (GE Healthcare, UK) and standard conditions [39 cycles using 48–50°C as annealing temperature]. New sequences have been deposited in GenBank (NCBI) with Acc. Nos JF778779-JF778845. Each individual gene matrix was aligned in MAFFT with the Q-ins-i option and default parameters. The four genes fragments were concatenated to get a final dataset of 20 taxa and 3376 bp that was employed in phylogenetic analyses. Table 2 shows taxa information, source and accession number for each DNA sequence.

Phylogenetic methods

Bayesian phylogenetic analyses (BA) were performed with MrBayes v.3.1. (Huelsenbeck and Ronquist 2001, Ronquist and Huelsenbeck 2003), partitioning by gene with a GTR+G model applied to each partition. Two independent runs of 20,000,000 generations were conducted, each with three hot and one cold chain, whereby trees were sampled every 100 generations. Sampled trees were analysed with Tracer v.1.5 (Rambaut and Drummond 2007) and their half compact consensus tree was calculated with a burning value of 10% with node posterior probabilities used as support values, checking for an appropriate degree of convergence between chains with the effective sample size in Tracer v.1.5. MrBayes was run on-line at the freely available computational service of Bioportal (www.bioportal.uio.no). Trees were visualized in FigTree v.1.3.1 (Rambaut 2008).

Species treatment

Parazuphium aguilerai Andújar, Hernando & Ribera sp. n.

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http://species-id.net/wiki/Parazuphium_aguilerai
Figs 1–3

Type locality. Souk-Khemis-des-Anjra, Tetuan, Morocco (Fig. 4).

Type specimen. Holotype: 1♂, "MOROCCO 28-III-2008 / Souk-Khemis-des-Anjra, Tetuan / 123m N35°43'18" W5°31'23" / Andújar, Hernando, Ribera & Agu-

Table 1. Primers used in the study. F, forward; R, reverse. Length refers to the aligned matrix.

Type DNA	Gene	Length	Primer	S	Primer sequence (5'- 3')	Described in:
Mitochondrial protein coding	*cox1*	755	Jerry (M202)	F	CAACATTTATTTTGATTTTTTGG	(Simon et al. 1994)
			Pat (M70)	R	TCCA(A)TGCACTAATCTGCCATATTA	(Simon et al. 1994)
Mitochondrial ribosomal	*rrnL*	744	16SaR (M14)	F	CGCCTGTTTAWCAAAAACAT	(Simon et al. 1994)
			16s-ND1a (M223)	R	GGTCCCTTACGAATTTGAATATATCCT	(Simon et al. 1994)
Nuclear ribosomal	*LSU*	1240	LS58F (D1)	F	GGGAGGAAAAGAAACTAAC	(Ober 2002)
			LS998R (D3)	R	GCATAGTTCACCATCTTTC	(Ober 2002)
Nuclear ribosomal	*SSU*	625	5' b5.0	F	GACAACCTGGTTGATCCTGCCAGT	(Shull et al. 2001)
				R	TAACCGCAACAACTTTAAT	(Shull et al. 2001)

ilera leg."; voucher number label "31_EN"; plus red holotype label. Type specimen mounted in DMHF in a transparent acetate label, genitalia dissected and mounted in DMHF in a separate label pinned with the specimen. Deposited in the Museu de Ciències Naturals de Barcelona (MCNB), DNA aliquots deposited in the IBE (CSIC) and Univ. Murcia (ZAFUMU col.).

Diagnosis. Total Length 2.7 mm (from apex of mandible to apex of elytra). Body depressed, flattened, light brown (Fig. 1). Eyes absent (Fig. 2b). First antennomere (0.41mm) as long as antennomeres 2–4 combined (0.37 mm) (Fig. 2e). Pronotum cordiform (Fig. 1). Elytra flat, not fully covering abdomen (Figs 1, 2a). Umbilicate lateral series of elytra with 5+5 spatuliform setae (Figs 2f-h). Apex of elytra divergent (Figs 1, 2a). Metafemora with an acute tooth on interior margin (Fig. 2m).

Description. Length of holotype: 2.7 mm. Body depressed, flattened and depigmented, light brown. Surface microreticulate, with mesh pattern regular polygonal (observed on the dried specimen) and scattered short setae.

Head (Fig. 1) with trapezoidal shape. No trace of eyes or ocular scars (Fig. 2b). Length of head (from apex of mandible to base) 0.63 mm; maximum width close to base (0.51 mm). Surface microreticulate, microlines deeper on sides. Neck pedunculate. With three long setae, two lateral and one basal. Appendages: antennae (Fig. 2e) with first antennomere (0.41mm) as long as total length of antennomeres 2–3-4 together (0.37 mm); second antennomere pedunculate (0.1 mm), slightly shorter than third (0.13 mm) and fourth (0.14 mm); from fifth to tenth with same length (0.16–0.17 mm); last antennomere longer (0.23mm). Antennomeres from 3° to 11° cylindrical. Labial and maxillary palpi as in Figs 2c, d.

Pronotum cordiform (Fig. 1), longer (0.60 mm) than wide (0.51–0.27 mm), maximum width (0.51 mm) close to anterior angles, almost double minimum width (0.27

Table 2. Species, locality of collection, voucher reference and accession numbers for each sequence.

Especie	**Locality**	**Voucher**	***cox1***	***rrnL***	***LSU***	***SSU***
Laemostenus terricola	Alicante, Spain	1583BG	JF778779	JF778796	JF778812	JF778829
Leistus spinibarbis	Albacete, Spain	1581BG	JF778780	JF778797	JF778813	JF778830
Calosoma sycophanta	Albacete, Spain	1590BG	JF778781	JF778798	JF778814	JF778831
Carabus (Eucarabus) deyrollei	Lugo, Spain	1553BG	JF778782	JF778799	JF778815	JF778832
C. (Limnocarabaus) clathratus	Susuz, Turkey	1600BG	JF778783	JF778800	JF778816	JF778833
Dixus capito	Albacete, Spain	1578BG	JF778784	N/A	JF778817	JF778834
Pseudotrechus mutilatus	Cádiz, Spain	36_EN	JF778785	JF778801	JF778818	JF778835
Licinus punctatulus	Alicante, Spain	1582BG	JF778786	JF778802	JF778819	JF778836
Elaphropus (Tachyura) parvulus	Pays Zaer Zaine, Morocco	64_EN	JF778787	JF778803	JF778820	JF778837
Bembidion (Peryphus) hispanicum	Pays Zaer Zaine, Morocco	62_EN	N/A	JF778804	JF778821	JF778838
B. (Emphanes) latiplaga	Pays Zaer Zaine, Morocco	65_EN	JF778788	N/A	JF778822	JF778839
Perileptus aerolatus	Agadir, Morocco	MNHN-AF113	GQ293688	FR729593	GQ293625	GQ293503
Trechus quadristriatus	Huesca, Spain	MNHN-AF96	FR733908	GQ293743	GQ293619	GQ293534
Typhloreicheia laurentii	Sardinia, Italy	56_EN	JF778789	JF778805	JF778823	JF778840
Dyschiriodes sp.	Pays Zaer Zaine, Morocco	63_EN	JF778790	JF778806	JF778824	JF778841
Nebria salina	Albacete, Spain	1579BG	JF778791	JF778807	JF778825	JF778842
Ildobates neboti	Castellón, Spain	MNCN-6409	JF778792	JF778808	AM051084	DQ130051
Drypta dentata	Ciudad Real, Spain	98_EN	N/A	JF778809	N/A	N/A
Zuphium olens	Murcia, Spain	97_EN	JF778793	N/A	JF778826	JF778843
Parazuphium cf. baeticum	Castellón, Spain	87_EN	JF778794	JF778810	JF778827	JF778844
Parazuphium aguilerai	Tanger, Morocco	31_EN	JF778795	JF778811	JF778828	JF778845

mm), at the posterior angles. Anterior angles obtuse, rounded. Anterior margin regularly convex. Median line apparent, marked with two depressions. Two lateral setae at anterior and posterior angles. Lateral margin sinuate before posterior angles.

Elytra (Figs 1, 2a) flattened, short, not totally covering abdomen, wider apically (maximum width, 0.90mm, close to apex); width at humeral angle 0.65mm. Punctuation forming longitudinal series, more evident at basal third, disappearing towards apex. Entire surface with short pubescence. Anterior umbilicate series with 5 spatuliform setae (Figs 2f-g, numbers 1–5), deeply inserted in small marginal indentations, with some other minor setae over them (Fig. 2g, arrows). Posterior umbilicate series with 5 spatuliform setae, the last one just before apex (Fig. 2h, numbers 6–10), with three smaller setae over them (Fig. 2h, arrows). Margin of elytra from 5° umbilical anterior to 2° umbilical posterior seta with a marginal carina (Fig. 2f). Apices divergent (Figs 1, 2a).

Legs. Pro- and meso-femora dilated proximally, forming an obtuse interior angle (Figs 2i, k). Metafemora with a strong acute tooth on the interior margin (Fig. 2m). Front tibia with antennal cleaner (toilette organ), as reported in other species of the genus (Fig. 2i). Meta-tibia long and straight, with an internal spine at apex. Meso and meta tibiae with a circle of seta round the apex. Pro-tarsomeres 1–4 dilated (Fig. 2j). First meso- and meta-tarsomeres as long as 2° to 4° combined (Figs 2l, n). Fourth tarsomere cordiform. Trochanters without tooth or any other special structure.

Aedeagus. Median lobe as in Fig. 3, short and robust with a ventral constriction between the basal and the distal part as described for the genus. Basal margin arcuate, bisinuate, with the apex rounded. Internal sac with two small sclerites. Parameres asymmetric, as in other species of the genus.

Habitat. The single known specimen of *Parazuphium aguilerai* sp. n. was found under a large, deeply buried boulder, in the humid soil on a hillside with herbaceous vegetation (*Chamaerops humilis*, *Nerium oleander* and *Pistacia lentiscus*, Fig. 4). The same sample included some endogean ants (*Leptanilla* sp, *Amblyopone* sp.) and remains of anendogean weevil, *Torneuma* sp. (Curculionidae, Cryptorhynchinae).

Etymology. The specific epithet is a Latinized eponym, genitive case, based on the name of our late friend Pedro Aguilera, who collected the specimen with us during his last trip to Morocco.

Recognition and comparisons. *Parazuphium aguilerai* sp. n. can be clearly distinguished from any other species of the genus through the combinations of the following characters: lack of eyes, reduced size (2.7 mm), length and proportions of 2°, 3° and 4° antennomeres (0.1, 0.13 and 0.14mm respectively) and the presence of a tooth on metafemora. *Parazuphium feloi* from the Canary Islands is also anophthalmous, but it is larger than *P. aguilerai* sp. n. and without a tooth on the hind femora (Machado 1998). *Parazuphium ramirezi* J. and E. Vives from south Spain shows the same tooth on the metafemora, but is also larger, and with reduced eyes (Vives and Vives 1976). There are also some differences in the shape of the head and pronotum: in *P. aguilerai* sp. n. the head is more parallel-sided, the anterior angles of the pronotum are less rounded, and the anterior margin not straight.

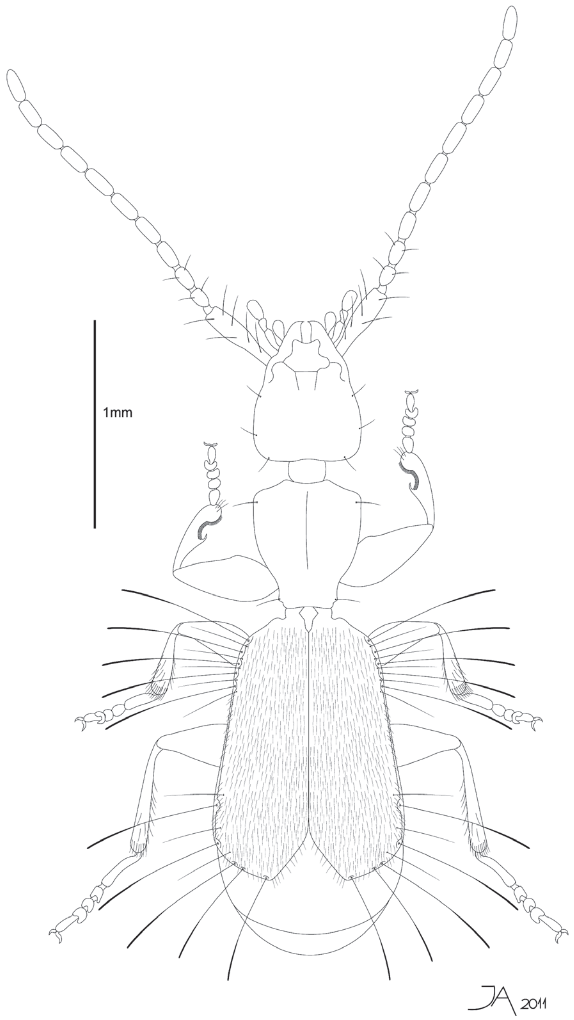

Figure 1. Line drawing of habitus of *Parazuphium aguilerai* sp. n. Total length 2.7 mm.

Identification key

Key to adults of the West Mediterranean and Macaronesian *Parazuphium* species, modified from Antoine (1962) and Hürka (1982):

1 Eyeless **2**
– With eyes.. **3**
2 Third antennal segment only slightly longer than 2nd and slightly shorter than 4th, anterior margin of pronotum trapezoidal, presence of a tooth on metafemora. Length 2.7mm. North Morocco.................. ***P. aguilerai* sp. n.**

– Third antennal segment more than twice longer than 2nd and similar to 4th. Anterior margin of pronotum bisinuate, without tooth on metafemora. Length 4.9–5.1mm. Canary Islands.................................. ***P. feloi* Machado**

3 Third antennal segment not twice as long as 2nd and distinctly shorter than 4th, legs short and robust, metaibiae curved, strongly so in male. North Africa, Middle East, Iberian Peninsula.................. ***P. damascenum* (Fairmaire)**

– Third antennal segment at least twice as long as second and similar to 4th, metatibiae straight **4**

4 Third antennal segment three times longer than 2nd. Length 7 mm. Algeria, Morocco .... ***P. punicum* (K. & J. Daniel)**

– Third antennal segment at most twice longer than 2nd. Length 2.8–6mm.. **5**

5 Eyes convex, as long as temporae, pronotum as long as wide. Length 5–5.5mm. Morocco, Tunisia.................................... ***P. vaucheri* (Vauloger)**

– Eyes flattened.. **6**

6 Head darker than pronotum and elytra... **7**

– Head concolorous with pronotum and elytra, body entirely yellowish brown... **8**

7 Eyes well developed, distance between hind margin of head and hind margin of eyes at most 2 times longer than diameter of eyes. Apical part of aedeagus short and robust, with slightly curved ventral margin. Length 4.5–6mm. Central and southern Europe, Turkmenistan .... ***P. chevrolati* (Castelnau)**

– Eyes reduced, distance between hind margin of head and hind margin of eyes at least 2.5 times longer than diameter of eyes. Apical part of aedeagus long and narrow. Morocco... ***P. angusticullum* Hürka**

8 Apical part of aedeagus straight, long and narrow. Length 4–5mm. Spain..... .... ***P. ramirezi* J. and E.Vives**

– Apical part of aedeagus sinuate, curved, robust and hooked. Length 3.8–5.4mm. North Africa, Italy, Spain.................. ***P. baeticum* (K. & J. Daniel)**

Phylogenetic analysis of molecular data

The *cox1* gene fragment was aligned with no gaps, and its correct translation to amino acids confirmed. Alignment of the three ribosomal markers resulted in several gaps, which were included in the analyses as obtained from MAFFT without further modifications. Bayesian analysis reached a convergence value of 0.0005 after 20 million generations. The initial 10% saved trees were removed as a burning value and the half consensus tree was built with the "sumt" option in MrBayes v.3.1. Figure 5 represents the obtained phylogeny, were most of nodes showed very high Bayesian posterior probabilities, which are interpreted as Bayesian support.

We recovered a monophyletic Zuphiini, with the two studied species of *Parazuphium* as sisters, and sister to *Zuphium* (Fig. 5). Zuphiini was sister to *Drypta*, in a monophyletic Dryptinae (sensu Serrano 2003).

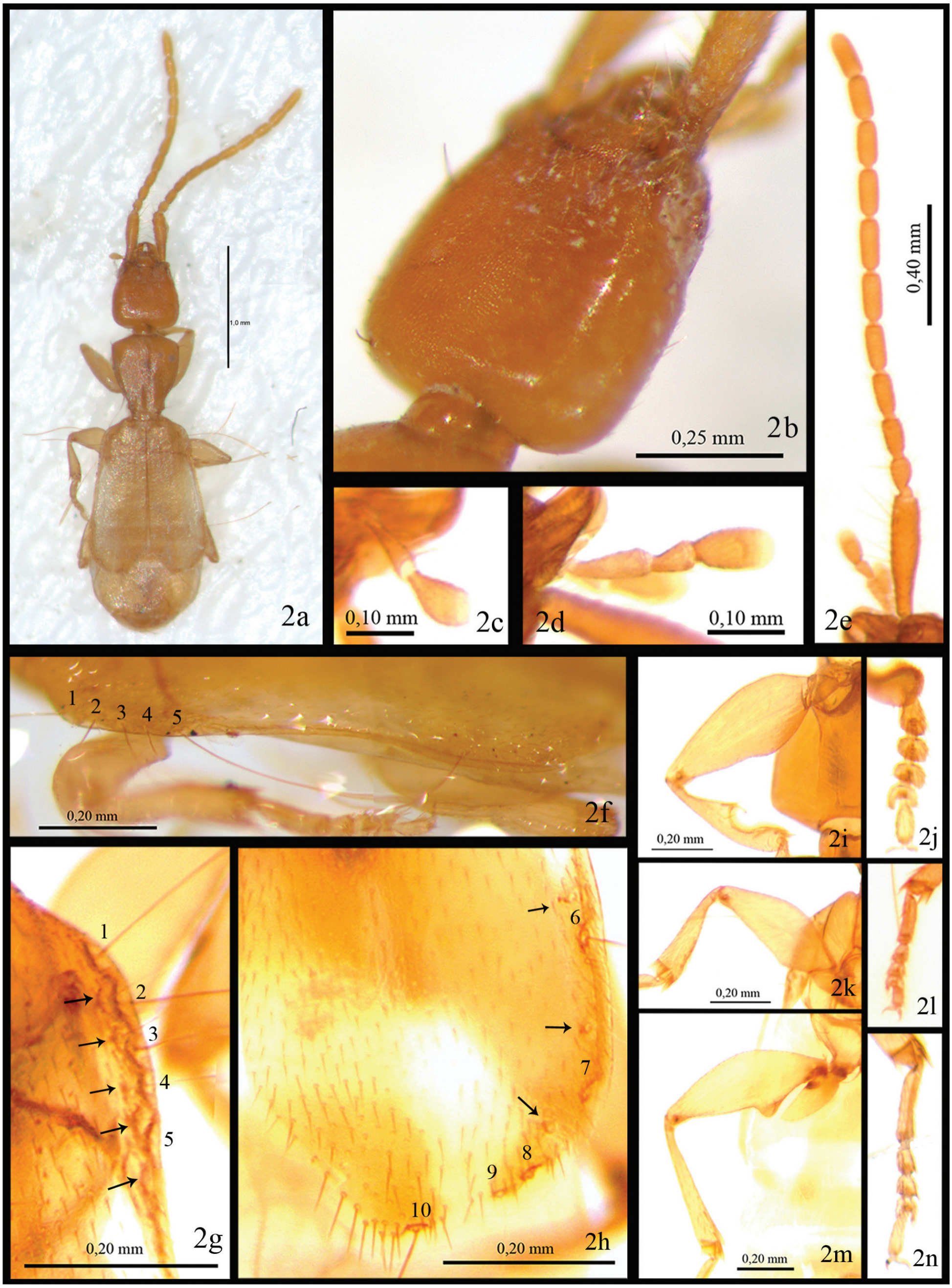

Figure 2. Photographic images of *Parazuphium aguilerai* sp. n. **A** whole specimen **B** head in dorso-lateral view **C** labial palpus; (d), maxillary palpus **C** antenna **F** margin of left elytron in lateral view **G** margin of right elytron, detail for anterior umbilicate setae, numbers 1 to 5 **H** margin of right elytron, detail of posterior umbilicate setae, numbers 6 to10, arrows over them point other smaller setae **I–N** details of anterior, median and posterior legs respectively.

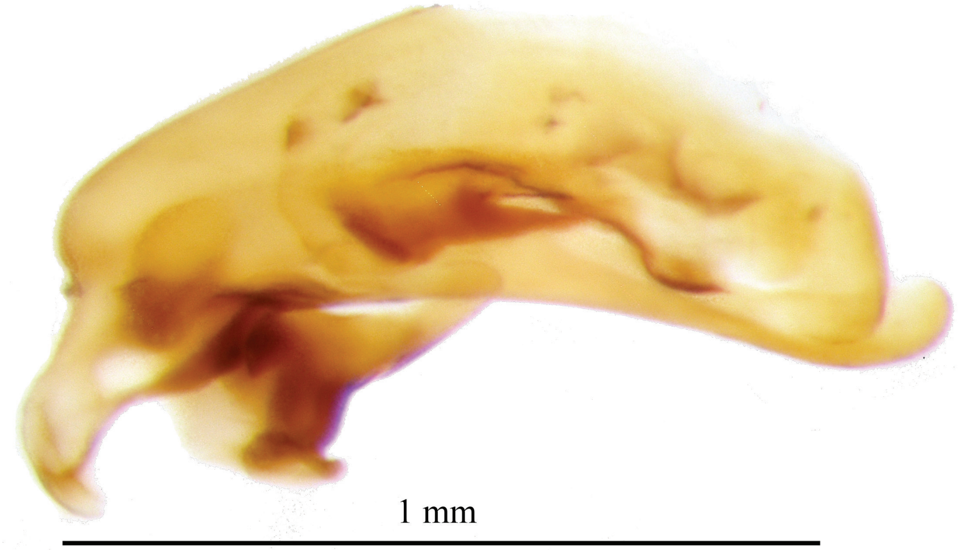

Figure 3. Photographic image of median lobe of *Parazuphium aguilerai* sp. n. Left lateral aspect.

Discussion

Relationships of Parazuphium

The genus *Parazuphium* is currently included in subtribe Zuphiina (tribe Zuphiini), together with *Ildobates*, *Zuphium* and *Polistichus* among the Palaearctic fauna (Baehr 2003). Although the scarcity of data does not allow a comprehensive study, our molecular results support this taxonomic position, with both studied *Parazuphium* species clustered together as a sister group of *Zuphium* (Fig. 5). *Zuphium* and *Parazuphium* species are recovered as related to *Ildobates neboti*, which was found as belonging to the Zuphiini by Ribera et al. (2006). Our data confirm the close relationship of *Zuphium* and *Parazuphium*, while a more detailed phylogeny would be needed to establish the position of *Ildobates* within Zuphiini.

Classification of Parazuphium

Parazuphium has traditionally been divided in three subgenera, *Neozuphium*, with only one valid species, *P. damascenum* (Mateu 1988) (note that Baehr 2003 does not include the synonymisation of *P. varum*, *P. bactrianum* and *P. novaki* by Mateu 1988); *Parazuphium* s.str., with 12 Palaearctic (Baehr 2003) and 20 Ethiopian species; and *Austrozu-*

Figure 4. Habitat of *Parazuphium aguilerai* sp. n.

phium, with five Australasian species (Baehr 1985, Lorenz 2005). The latter species are of dubious affiliation, and maybe not directly related to the Palaearctic and Ethiopian species (Mateu 1993 and pers. comm. 2008).

The subgenus *Neozuphium* was described by Hürka (1982) based on the relative length of the 2nd to 4th antennomeres and the shape of the legs, more robust and with curved tibia and enlarged femora in the males in *Neozuphium*. *Parazuphium aguilerai* sp. n. has the third antennomere only slightly longer than the 2nd and slightly shorter than the 4th (Fig. 2e), so it would agree with *Neozuphium* (species of *Parazuphium* s.str. have the 3rd antennomere double than the 2nd, and similar to the 4th, Hürka 1982, Mateu 1988). However, the shape and size of the legs do not agree with the diagnostic characters of *Neozuphium*, as the males have straight metatibia (Fig. 2m) and they are in general slender and long in comparison to *P.* (*Neozuphium*) *damascenum* (Figs 2i-n). These are, in any case, characters with dubious phylogenetic information, so instead of redefining the subgenera, or describing additional taxa, we opt to follow Serrano (2003),treating the subgenus *Neozuphium* Hürka as consubgeneric with *Parazuphium* Jeannel, and the former name as a junior synonym of the latter.

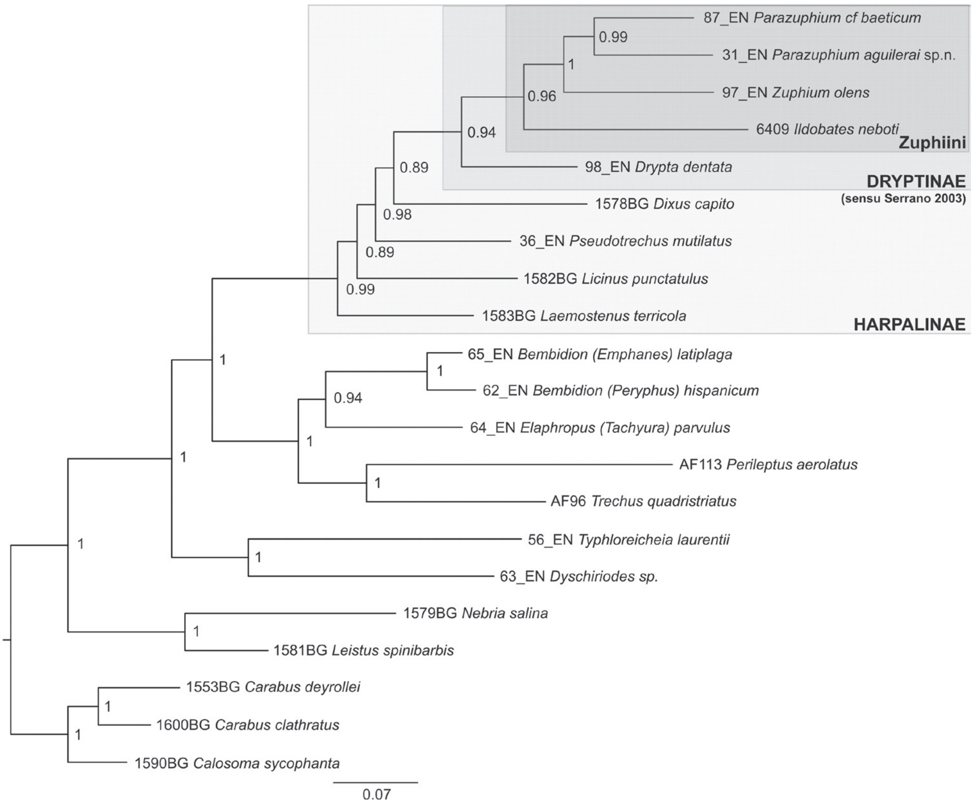

Figure 5. Phylogenetic tree obtained with MrBayes for the combined dataset (*cox1, rrnL, LSU, SSU*). Numbers in nodes correspond to Bayesian posterior probabilities. Zuphiini and Dryptinae (sensu Serrano 2003) indicated with bars.

Endogean way of life in Zuphiini

Parazuphium aguilerai sp. n. differs from all other known species of the genus in its clear adaptations to an endogean way of life. Other species are regularly found in soil crevices, specially among the cracks of the dried substratum of areas which are regularly inundated (Baehr 1985, Machado 1992, Lencina and Serrano 1995). These species have some modifications suggesting an adaptation to this cryptic way of life (small size, flattened body, some degree of depigmentation, microphthalmy, Jeannel 1942), but not to the extent of *P. aguilerai* sp. n., which was found in company of other typical endogean insects (*Leptanilla* sp., *Amblyopone* sp., *Torneuma* sp.) below a deeply buried large stone in a hillside. The only other anophthalmous species of the genus (*P. feloi*) was found in a cave, and it is larger and with longer appendages (Machado 1998), as is typical of cave fauna inhabiting larger open spaces. *Parazuphium aguilerai* sp. n. shares with *P. feloi*, *P. chevrolati* and *P. vaucheri* the presence of a spine in the metatibia (Machado 1998), although at the moment it is not possible to assert the phylogenetic value of this character.

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References

Antoine M (1962) Coléoptères Carabiques du Maroc, V Partie. Mémoires de la société des Sciences Naturelles et Physiques du Maroc. Zoologie 9: 637–644.

Baehr M (1985) Revision of the Australian Zuphiinae. 4. The genus *Parazuphium* Jeannel. Spixiana 8(3): 295–321.

Baehr M (2003) Subfamily Siagoninae; tribes Dryptini, Galeritini, Licinini, Panagaeini, Zuphiini. In: Löbl I, Smetana A (Eds) Catalogue of Palearctic Coleoptera 1. Archostemata - Myxophaga - Adephaga. Apollo Books, Stenstrup, 218, 358–360, 439–443, 446–448, 573–796.

Huelsenbeck JP, Ronquist F (2001) MrBayes: Bayesian inference of phylogenetic trees. Bioinformatics 17(8): 754–755. doi: 10.1093/bioinformatics/17.8.754

Hürka K (1982) Taxonomic notes on *Parazuphium*, with descriptions of three new taxa (Coleoptera, Carabidae). Acta entomologica Bohemoslovaca 79: 281–288.

Jeannel R (1942) Coléoptères carabiques, deuxième partie. Faune de France. 40: 573–1173.

Lencina JL, Serrano J (1995) Sobre la presencia de *Parazuphium* (*Neozuphium*) *damascenum* Fairmaire en la Península Ibérica (Coleoptera, Carabidae). Nouvelle Revue d'Entomologie(N.S.) 8(4): 423–426.

Löbl I, Smetana A (Eds) (2003) Catalogue of Palearctic Coleoptera 1. Archostemata - Myxophaga - Adephaga. Apollo Books, Stenstrup, 218, 358–360, 439–443, 446–448, 573–796.

Lorenz W (2005) Systematic list of extant ground beetles of the world (Insecta coleopteran Geadephaga: Trachypachidae, and Carabidae incl. Paussinae, Cicindelinae, Rhysodinae). Second edition, published by the author, Tutzing, 126 pp.

Machado A (1992) Monografía de los Carábidos de las Islas Canarias. Instituto de Estudios Canarios La Laguna, 734 pp.

Machado A (1998) Un nuevo *Parazuphium* Jeannel anoftalmo de La Palma, islas Canarias (Coleoptera, Carabidae). Vieraea 26 163–167.

Mateu J (1988) Nouvelles Synonymies (Col. Carabidae). Nouvelle Revue d'Entomologie(N.S.) 5(4): 388.

Mateu J (1993) Contribution à la connaissance du genre *Parazuphium* Jeannel en Afrique noire (Coleoptera Carabidae). Journal of African zoology 107(5): 485–503.

Ober KA (2002) Phylogenetic relationships of the carabid subfamily Harpalinae (Coleoptera) based on molecular sequence data. Molecular Phylogenetics and Evolution 24: 228–248. doi:10.1016/S1055–7903(02)00251–8

Rambaut A (2008) Molecular evolution, phylogenetics and epidemiology, FigTree v.1.3.1. Available from: http://tree.bio.ed.ac.uk/software/figtree/ [Accessed 01/10/2011]

Rambaut A, Drummond AJ (2007) Molecular evolution, phylogenetics and epidemiology, Tracer v.1.5. Available from: http://tree.bio.ed.ac.uk/software/tracer/ [Accessed 12/01/209]

Ribera I, Montagud S, Teruel S, Bellés X (2006) Molecular data supports the inclusion of *Ildobates neboti* Español in Zuphiini (Coleoptera: Carabidae: Harpalinae). Entomologica Fennica 17(3): 207–213.

Ronquist F, Huelsenbeck JP (2003) MrBayes 3: Bayesian phylogenetic inference under mixed models. Bioinformatics 19(12): 1572–1574. doi: 10.1093/bioinformatics/btg180

Serrano J (2003) Catálogo de los Carabidae (Coleoptera) de la Península Ibérica. Monografías de la Sociedad Entomológica Aragonesa, Zaragoza, 130 pp.

Shull VL, Vogler AP, Baker MD, Maddison DR, Hammond PM (2001) Sequence alignment of 18S ribosomal RNA and the basal relationships of Adephagan beetles: evidence for monophyly of aquatic families and the placement of Trachypachidae. Systematic Biology50(6): 945–969. doi: 10.1080/106351501753462894

Simon C, Frati F, Beckenbach A, Crespi B, Liu H, Flook P (1994) Evolution, weighting, and phylogenetic utility of mitochondrial gene-sequences and acompilation of conserved polymerase chain-reaction primers. Annals of the Entomological Society of America 87(6): 651–701.

Vives J, Vives E (1976) Caraboidea de la provincia de Cádiz (2ª nota). Miscelanea zoologica 3(5): 109–119.

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Review of the continental Oriental species of *Lilioceris* Reitter (Coleoptera, Chrysomelidae, Criocerinae) closely related to *Lilioceris impressa* (F.)

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Abstract

Criocerine leaf beetles found in Nepal feeding on *Dioscorea bulbifera* (L.), an invasive weed of Asian origin, were identified as *Lilioceris cheni* Gressitt and Kimoto based on a synopsis of the Oriental *Lilioceris* species and review of the *Lilioceris impressa* species group. All the continental, Oriental species included in the group are diagnosed and illustrated, and a key for their identification is provided. Species status of *Lilioceris thibetana* Pic, 1916 is resurrected. The following new synonyms are proposed: *L. coomani* (Pic, 1928) = *L. egena* (Weise, 1922), and *L. subcostata* (Pic, 1921a), *L. laticornis* (Gressit, 1942), *L. inflaticornis* Gressit & Kimoto, 1961, and *L. maai* Gressit & Kimoto, 1961 = *L. impressa* (Fabricius, 1787). Lectotypes of the following species are designated: *L. coomani* Pic, 1928; *L. impressa* (Fabricius, 1787); *L. laosensis* (Pic, 1916); *L. malabarica* (Jacoby, 1904); *L. ruficornis* (Pic, 1921b); *L. subcostata* (Pic, 1921a); *L. thibetana* (Pic, 1916); and *L. unicolor* (Hope, 1831).

Keywords

Coleoptera, Chrysomelidae, Criocerinae, *Lilioceris,* key, Oriental Region, new synonyms, *Dioscorea bulbifera*, air potato, biology, *Lilioceris cheni*

Introduction

This study was initiated by the need to identify leaf beetles that were feeding on *Dioscorea bulbifera* L. (Dioscoreaceae) in Nepal. *Dioscorea bulbifera* (air potato) is a herbaceous, perennial twining vine that attains lengths of 20 m or more, rendering it capable of climbing over and smothering native vegetation (e.g., Schmitz et al. 1997; Langeland and Craddock Burks 1998; Gordon et al. 1999). The species was introduced to Florida from tropical Asia or Africa in 1905 (Morton 1976). By the 1980s, air potato vines were growing in thickets, waste areas, and hedges or fencerows in many parts of south and central Florida (Bell and Taylor 1982). By 1999, *D. bulbifera* was recognized as an invasive exotic capable of altering plant communities by displacing native species and altering community structure and ecological functions (FLEPPC 2003). Vegetative propagation occurs primarily through aerial bulbils (hence the name “air potato”) that form in leaf axils during late summer, and may weigh up to 1 kg. These bulbils drop to the ground during the cooler months when the vines die back. Vines resprout during spring from subterranean tubers or from bulbils. Seed production is unknown in Florida and spread occurs mainly through anthropogenic dispersal of the bulbils (Schultz 1993). In order to find natural enemies of air potato, field explorations were conducted in Nepal and other Asian countries (Wheeler et al. 2007).

Leaf beetles that were found feeding on air potato in Nepal were not identifiable to species using existing keys (Gressit and Kimoto 1961, Kimoto and Gressit 1979), which are generally incomplete and often use unreliable characters. There are about 110 species of *Lilioceris* in the Oriental Region, about 80 of which occur on the continent. Synoptic study involving examination of the original descriptions and major leaf beetle collections (see list below) allowed us to identify a set of features that separated a relatively small group of species, including a species in question that is a potential air potato biocontrol agent, from the rest of the continental, Oriental *Lilioceris*. We refer to this group as the *Lilioceris impressa* species group and treat it in this paper, providing distinguishing characters of the group, a key to its species, and illustrations of characters, including the internal sac of the aedeagus.

Material and methods

Specimen observation and preparation follow the methods of Konstantinov (1998). Specimens were examined from the following collections:

BBM	Bernice Bishop Museum, Honolulu, HI
BMNH	The Natural History Museum London, United Kingdom
CAS	California Academy of Sciences, San Francisco, CA
HUB	Museum für Naturkunde, Berlin, Germany
MNHN	Muséum National d’Histoire Natural, Paris, France
UCD	Zoological Museum, University of Copenhagen, Copenhagen, Denmark

USNM	National Museum of Natural History, Smithsonian Institution, Washington, DC
ZMUH	Zoologisches Intsitute und Zoologisches Museum, Universität Hamburg, Hamburg, Germany

The most reliable characters for discrimination of *Lilioceris* species are those of the internal sac of the aedeagus. In Criocerinae, these characters were used previously for separation of *Lilioceris* species from Iran (Berti and Rapilly 1976) and *Oulema* species related to *O. melanopus* (L.) (Berti 1989). Terminology for the sclerites of the internal sac is not overly complicated. Berti and Rapilly (1976) called the longer, dorsally situated structure in the everted internal sac, the "pièce terminale". We recognize three major sclerites in the internal sac of the aedeagus: dorsal [="pièce terminale" of Berti and Rapilly (1976)], median, and ventral (Fig. 23). All these three parts differ from species to species within the *L. impressa* group, but the most reliable and easily observed characters are those of the dorsal sclerite.

Dissection and preparation of the sclerites of the internal sac of the aedeagus are relatively simple. We used slightly bent #1 entomological pins to extract the internal sac from the dorsal opening of the aedeagus that was soaked in hot 10% KOH solution for 15–20 minutes and washed in excess of water. Figures were generated using a Camera Lucida attached to a Zeiss Stemi SV 11 dissecting microscope. They were scanned and edited with Adobe Photoshop.

Systematics of *L. impressa* species group

Species of the *Lilioceris impressa* group share the following characters: 1) glabrous scutellum almost completely lacking setae, with only a few setae occasionally present near the base (Fig. 7); 2) antennomeres 5–10 distinctly flattened, quadrate or even transverse (antennomere 5 often slightly elongate) and covered with dense, short, appressed setae (in clear contrast with more basal antennomeres bearing longer, more erect and much sparser setae, not obscuring the view of glabrous cuticle) (Fig. 6); and 3) structure of the sclerites of the internal sac of the aedeagus. The dorsal and ventral sclerites are roughly plank-like in shape, the dorsal one being longer and more complex shaped, especially anteriorly where it bears two relatively long lateral processes that vary in shape.

To a lesser extent color (traditionally often used in distinguishing and keying out *Lilioceris* species) is helpful to recognize representatives of the species group. Typically, they have a black head, thorax, abdomen and legs, and brownish-yellow to reddish elytra. Black legs and pale unspotted elytra are consistent throughout all species group members, while the head and thorax may be partially or entirely brown, reddish-brown or reddish; these paler colors are variably present around the abdominal apex.

The three characters mentioned above, in combination, define the group. As to the similar species, there are, on one hand, several similar looking black and red (yellow) species with a glabrous scutellum and similar structure of male genitalia, which have distinctly, often substantially elongate (never close to quadrate or transverse) antennomeres 5–10. On the other hand, a group of mostly entirely reddish species with the antennal characters identical to those of the *impressa*-group possess consistently a completely setose scutellum and differently shaped sclerites of the aedeagal internal sac (in particular, the dorsal sclerite is narrow, elongate and thread-like, at least apically). A few species with consistently spotted elytra (e.g., *L. bakewelli* Baly, *L. ruficollis* Baly) possess all of the characters in agreement with the *impressa*-group as it is outlined above.

Below, we are introducing several new synonymies and rearranging several previously proposed synonyms. There are two primary reasons for these changes in taxonomy of the Oriental *Lilioceris*. First, in the course of this study we introduced for the first time the use of male genitalia characters into the diagnostics of the species, in particular focusing on the sclerites of the internal sac of the aedeagus. In general, male genitalia morphology in the Oriental species appeared to be quite conservative. However, minor differences in the shape of the aedeagus and characters of the aedeagal sclerites of the internal sac are stable and consistent across vast species ranges and among multiple individuals within populations. This consistent set of aedeagal characters provides reliable diagnostics among species that are otherwise monotonous with respect to color and punctation. As a result, some misidentifications were corrected and species identities clarified. Second, the accepted concept of *L. impressa* (Gressit and Kimoto 1961, Kimoto and Gressit 1979), considered to be the most widespread and variable species, was found to be erroneous after the study of Fabricius' authentic material. Contrary to the opinion of Gressit and Kimoto (1961) and illustrations in their monographs, the true *L. impressa* has an isolated oblique setose band on the posterior part of the outer metasternal disc (see Fig. 13c and Fig. 14c in Gressit and Kimoto 1961 and Kimoto and Gressit 1979, respectively). Consequently, their concept of *L. impressa* corresponds primarily to *L. laosensis*, with some *L. egena* specimens identified as *L. impressa* occasionally.

Key to the species of *Lilioceris impressa*-group

1 Outer parts of metasternal disc mostly free of setae; isolated latero-posterior setose patches or lateral extensions of anterior setose margins present in some species and widely scattered single setae may present on unworn individuals **3**

– Outer parts of metasternal disc or its lateral side mostly covered with dense setae; other characters variable **2**

2 Internal sac of aedeagus with posterior part of dorsal sclerite in lateral view directed ventrally .... ***L. cheni* Gressit & Kimoto**

– Internal sac of aedeagus with posterior part of dorsal sclerite in lateral view directed dorsally.. ***L. unicolor* Hope**

3 Outer parts of metasternal disc without isolated posterior setose patches **4**

– Outer parts of metasternal disc with isolated posterior setose patches; pronotum with scattered large punctures, elytral punctures not weakened posteriorly, elytral interval in pre-apical area distinctly convex .... ***L. impressa* (Fabricius)**

4 Pronotal disc completely covered with scattered large punctures **5**

– Large punctures on pronotal disc present only as a row along mid-line, at least on anterior half, the rest of the disc utmost with only some tiny punctures.... **6**

5 Elytral punctures on posterior third not weakened, more or less the same size and depth as on anterior half; pronotum posteriorly with single weak, regularly transverse impression; posterior part of dorsal sclerite of aedeagus in dorsal view directed laterally (Fig. 29) .... ***L. thibetana* (Pic)**

– Elytral punctures on posterior third variably, but distinctly, weakened; pronotum posteriorly with two weak, but distinct transverse irregular impressions; posterior part of dorsal sclerite of aedeagus in dorsal view directed medially (Fig. 27) .... ***L. laosensis* (Pic)**

6 Occipital area with shallow furrow sometimes reduced to deep small fovea at midpoint; elytral intervals in preapical area flat 7

– Occipital area without longitudinal furrow, only with weak impression and thin, indistinct suture; elytral intervals in preapical area distinctly convex .... ***L. egena* (Weise)**

7 Anterior setose fringe of metasternum expanded on antero-lateral corner; lateral side of pronotum around constriction impunctate; most of metepisternal disc densely covered with setae .... ***L. malabarica* (Jacoby)**

– Anterior setose fringe of metasternum narrow, not expanded; lateral side of pronotum around constriction with several large punctures; setae on metepisternal disc present only as narrow strip along inner margin .... ***L. yunnana* (Weise)**

Species accounts

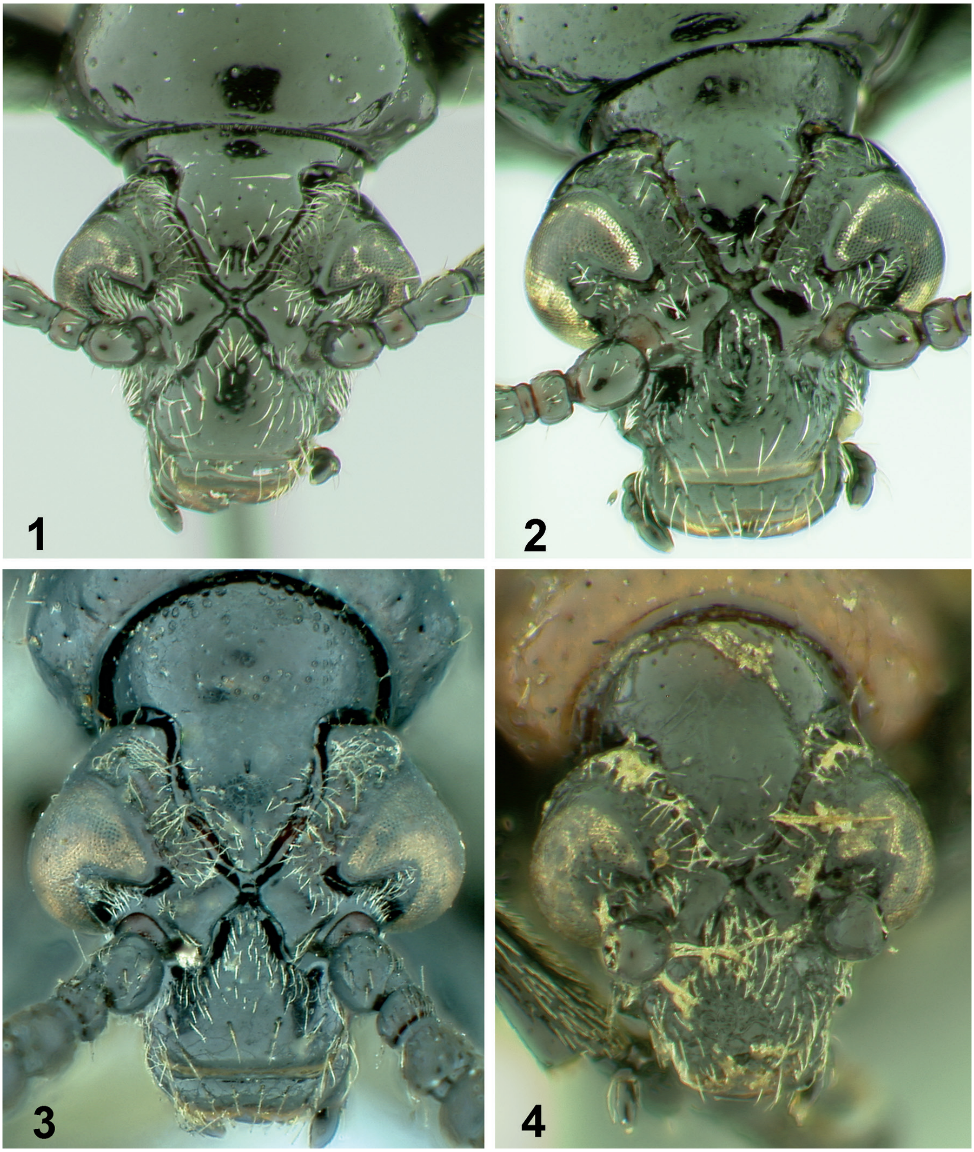
Lilioceris cheni Gressit & Kimoto, 1961

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

Figs 1, 6, 8, 14, 21, 23, 24

Lilioceris cheni Gressit & Kimoto, 1961:46 (type locality: SE China Fukien, E. Kwangtung. Type depository: BBM).

Diagnosis. Occipital area with a shallow furrow, at least with a deep small fovea at mid-point. Apical elytral punctures strong. Pronotal disc with scattered larger punctures, mid-line alignment of punctures usually evident, at least in anterior half. Pronotum posteriorly with single weak, irregular, variable, transverse impression. Lateral sides of pronotum around constriction with large punctures. Outer metasternal disc



Figures 1–4. Heads of *Lilioceris* species, frontal view. **1** *L. cheni* **2** *L. egena* **3** *L. impressa* **4** *L. thibetana.*

almost completely covered with setae. At least half of metepisternal disc covered with setae. Apical elytral intervals distinctly raised. Internal sac of aedeagus with posterior part of dorsal sclerite in dorsal view more or less parallel-sided, directed medially. Posterior part of dorsal sclerite in lateral view more or less parallel-sided, bent ventrally, directed ventrally.

Comments. The holotype of *L. cheni* is housed in the Bishop museum collection. This collection contains 5 more specimens of this species all identified as *L. cheni* by Kimoto in 1967 and 1977, none of them are marked as paratype.

Biology. Pale white, oblong eggs of *L. cheni* are deposited in loosely aggregated clusters on leaves of its host plant, *Dioscorea bulbifera* (air potato: Dioscoreaceae). Females deposit, on average, more than 1200 eggs during their lifetime. The eggs become yellowish as the embryo develops and dark reddish eye spots appear mid-way through the incubation period. The entire incubation period requires about 4 days. The larvae are yellowish at first, becoming grayish in later instars, with black legs, head capsule, and prothoracic shield. They are often covered with a slimy substance to which fecal material adheres. Larvae feed gregariously and skeletonize the leaves from the underside. Young leaves are preferred but they also consume older, tougher leaves and are able to feed on the aerial bulbils. Complete development of the four larval instars requires about 8 days, with each instar lasting about 2 days each. When fully grown, larvae drop from the host plant to the soil which they quickly enter. They then produce a whitish oral exudate that hardens into a foam-like cocoon. Pupation often occurs gregariously, with several pupae clumped together within a matrix of this material. Adults emerge in about 16 days, begin mating in about 10 days following emergence, and initiate oviposition about 5 days later. The adults live 3 months or more and can survive a month without food.

In the Katmandu Valley of Nepal, the host plant drops its leaves during the cool, dry winter forcing the adult beetles to over-winter beneath debris on the ground. The adults emerge during mid-May to early June. Oviposition begins during late May and continues till mid-June. Females lay about 90 eggs/day during a 13-day period of ovipositional activity. Overwintered adult beetles live until mid-July, for about 76 days after emergence.

Type material examined. *L. cheni*: Holotype male: 1) Fukien, S. China, Shaowu city to Kaoyang, T. C. Maa Coll.; 2) July 30, 1945; 3) Holotype Lilioceris cheni J. L. Gressitt + K.; 4) L. cheni sp. n. Det. S. Kimoto (BBM).

Material examined. CHINA. Yunnan: Ma-Chang, 1000 m, 1 specimen (USNM); Tche-Ping-Tcheou, 1 specimen (USNM); 13–18.X.2010, RCVDIPRL 25. Oct. 10, M. Percell (USNM). **INDIA.** Indie orientales, 1 specimen (USNM). **Assam**: Chabua, 8.V.1944, G. Butler, 1 specimen (USNM). **LAOS. Sayaboury Prov.**, Sayabouri, 30.V.1965, native collector, 1 specimen (BBM); **Vientianne Prov.**, Vientianne, 21.IV.1965, J. A. Rondon, 1 specimen (BBM). **NEPAL.** On road to Dhunche, 5 km SW Ranipawa, 27°48.92'N, 85°13.41'E, 1700 m, 28.IV.2000, A. Konstantinov, S. Lingafelter & M. Volkovitch, 1 specimen (USNM); Gairigaon below Nagarkot, Kathmandu Valley, host *Dioscorea bulbifera*, 27.VIII.2002, Pemberton & Rayamhji, 1 specimen (USNM); Env. of Kathmandu, Palchoki Mount, 27°34.65'N, 85°24.04'E, 2300–2730 m, sweeping, 14.V.2000, A. Konstantinov, S. Lingafelter & M. Volkovitch, 1 specimen (USNM); Lalitpur, Kathmandu, 4.VIII.-15.X.2007, Yukawa & Junichi, 29 specimens (USNM); Seutikhola Dharan road, Sunsan, host *Dioscorea bulbifera*, 4.IX.2002, Pemberton & Rayamhji, 1 specimen (USNM); Tarai Reg., Narayangarh, along Rapti River, 27°42.31'N, 84°21.11'E, beating, 26.IV.2000, A. Konstantinov, S. Lingafelter & M. Volkovitch, 1 specimen (USNM).

Lilioceris egena (Weise, 1922)

http://species-id.net/wiki/Lilioceris_egena
Figs 2, 9, 15, 25

Crioceris egena Weise, 1922:41 (Type locality: Fukien. Type depository, unknown).
Crioceris coomani Pic, 1928:88 (Type locality: Vietnam, Tonkin. Lectotype designated here, MNHN). New synonym

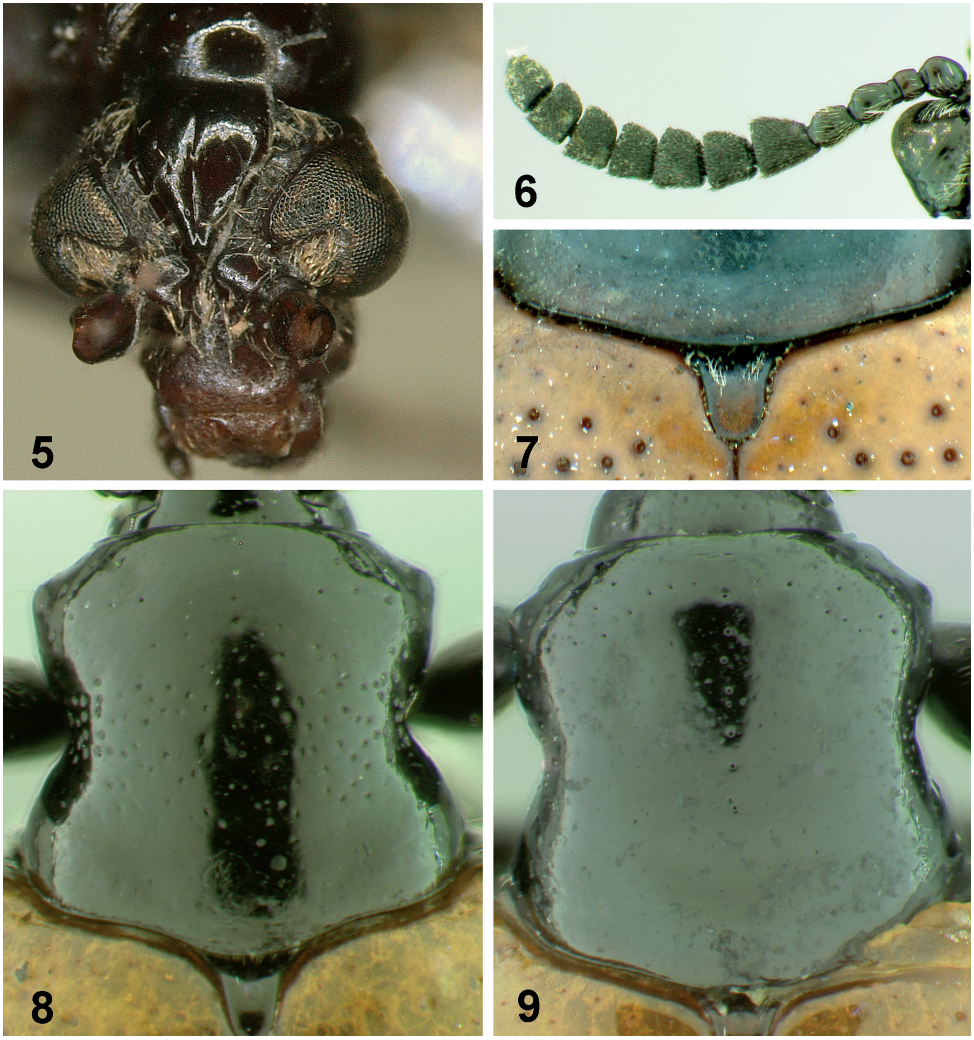
Diagnosis. Occipital area without longitudinal furrow. Pronotal disc without or with few small punctures, larger punctures present only along pronotal mid-line at least in anterior half. Lateral sides of pronotum around constriction with large punctures. At least half of metepisternal disc covered with setae. Outer metasternal disc mostly free of setae. Anterior setose fringes not expanded in antero-lateral corners.

Apical elytral punctures strong. Apical elytral intervals distinctly raised. Internal sac of aedeagus with posterior part of dorsal sclerite in dorsal view more or less triangular, directed forward. Posterior part of dorsal sclerite in lateral view more or less triangular, directed forward.

Comments. We were not able to find type material for this species. The type specimens were not found in Berlin (HUB) nor in Hamburg (ZMUH) (Peters, personal communication, August-September 2009). There is a strong possibility that the types were destroyed in Hamburg during World War II. However, two specimens identified as *L. egena* by J. Weise himself (including a male) were available for the study, and we based our concept of the species on these specimens. However, we are reluctant to designate the neotype at this moment, since an exhaustive search in other potential depositories has not been undertaken during the preparation of this manuscript. The male holotype of *L. coomani* perfectly corresponds to males of *L. egena* as we understand it now. This species is collected feeding on *Dioscorea subclava* Prain & Burkill in China.

Type material examined. *L. coomani*: Lectotype male [dissected on mounting cardboard] 1) [illegible] concave glabre; 2) 785 Crioceris sp.; 3) type; 4) TYPE; 5) coomani n sp; 6) Lectotype Lilioceris coomani Pic A. Tishechkin & A. Konstantinov des. 2010 (MNHN); paralectotype female on the same pin with "156" written on mounting cardboard; paralectotype designation label put on the same pin.

Material examined: CHINA. Kiang Li, Tengan, 2 specimens (USNM). **Anhui:** Taipingshien, X.1932, G. Liu, 1 specimen (USNM); **Yunnan**, Dali City,20.VIII.2010 (USNM). **Fujian:** Shaowu, Shui Pei Kai, T.C. Maa, 1 specimen (BBM); same locality and collector, but 25.III.1942, 1 specimen (USNM); without precise locality, G. Siemssen, 4.IX.1913, 2 specimens identified by J. Weise (USNM); with the same label, but 1.IV.1914, 1 specimen (USNM). **Hong Kong:** May 6 1940, P. K. To (1 BBM); Circa 1,600 ft, 24.IX.1937, Miss Harford. B.M. 1938-426 (1 BBM). Kieniyang Liutuan, T. C. Maa, 22.VIII.1942 (1 BBM). **Sichuan:** Shin Kai, 4400 feet, VIII.1922, D. C. Graham, 1 specimen (USNM); Wen-ch'uan, 4000–6000 feet, VII.1938, D. C. Graham, 1 specimen (USNM). **INDIA. Assam:** Darjeeling (Himalayas), 1 specimen (USNM). **Karnataka:** Mysore, 2 specimens (USNM). **Uttarhand:** Dehra



Figures 5–9. Body parts of *Lilioceris* species. **5** head of *L. unicolor*, frontal view **6** antenna of *L. cheni* **7** scutellum of *L. impressa;* **8–9** pronotum **8** *L. cheni* **9** *L. egena*.

Dun, 600 m, 18.VII.1973, G. Ekis, 2 specimens (USNM); 3 km NW Rishikesh, 10.V.1975, J. L. Petty, 1 specimen (USNM). **LAOS. Vientianne Prov.**, Ban Van Eue, 1–15.IX.1967, native collector, 1 specimen (BBM); Phou-kow-kuei N of Vientianne, 17.IV.1965, J. L. Gressit, 1 specimen (BBM). **NEPAL.** Env. of Kathmandu, Bonipa, 27°40’N 85°25’E, 8.V.2000, A. Konstantinov, S. Lingafelter & M. Volkovitch, 1 specimen (USNM); Jiri-Kathmandu road, high pass between Sikri and Kabre (Mudee), 27°42’7”N 85°56’24”E, 2632 m, V.2000, A. Konstantinov, S. Lingafelter & M. Volkovitch, 1 specimen (USNM); Tarai, env. Chitwan Park, 27°28.79’N 84°52.54’E, 300 m, 25.IV.2000, beating, A. Konstantinov, S. Lingafelter & M. Volkovitch, 1 specimen (USNM); Tarai Reg., Narayangarh, along Rapti River, 27°42.31’N 84°21.11’E, beating, 26.IV.2000, A. Konstantinov, S. Lingafelter & M. Volkovitch, 1 specimen (USNM). **SINGAPORE.** Without precise location, Coll. Baker, 19 specimens (USNM). **VIETNAM.** Saigon, 1 specimen (USNM); Trang Bom, 30 mi NW of Saigon, 18.VII.1932, M. Poilane, 1 specimen (USNM).

Lilioceris impressa **(Fabricius, 1787)**

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

Figs 3, 7, 10, 16, 26

Crioceris impressa Fabricius, 1787:88 (Type locality: "Siam". Lectotype designated here, BMNH).

Crioceris subcostata Pic, 1921a:2 (Type locality: China, "Shin-guey-fu". Lectotype designated here, MNHN). New synonym

Crioceris ruficornis Pic, 1921b: 136 (Type locality: China, "Pe Yen Tsing (Yunnan)". Lectotype designated here, MNHN). Gressitt and Kimoto 1961:59 (synonymy).

Crioceris laticornis Gressit, 1942:300 (Type locality: Hainan, Kwantung. Type depository: unknown). New synonym

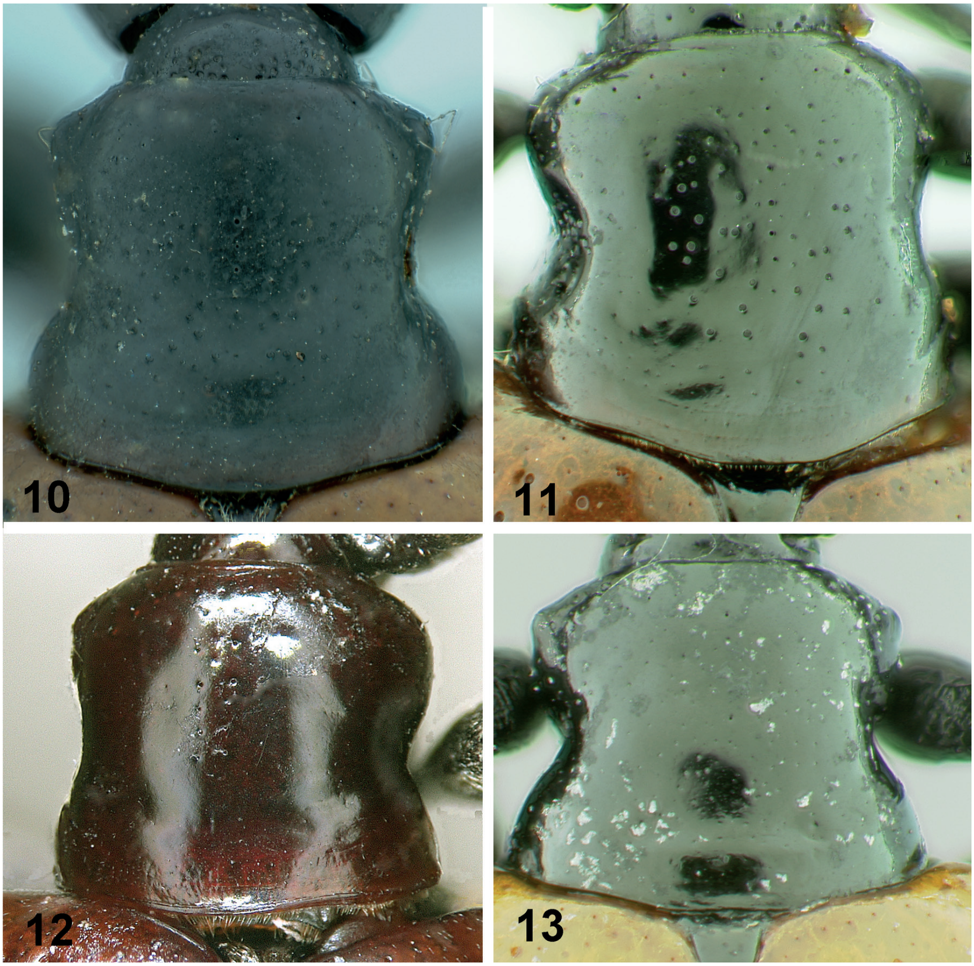
Lilioceris inflaticornis Gressit and Kimoto, 1961:50 (Type locality: "SE China [Kwantung, Fukien]. Type depository: CAS). New synonym

Lilioceris maai Gressit and Kimoto, 1961:53 (Type locality: "Ta-chu-lan, near Shaowu, NW Fukien". Type depositary: BBM). New synonym

Diagnosis. Occipital area with shallow furrow, at least with deep small fovea at midpoint. Pronotum posteriorly with single weak, regular, transverse impression. Pronotal disc with scattered larger punctures, mid-line alignment of punctures usually still evident, at least on anterior half. Lateral side of pronotum around constriction with large punctures. Outer metasternal disc only with oblique setose patch. Anterior setose fringe not expanded in antero-lateral corner. At least half of metepisternal disc covered with setae. Apical elytral punctures strong. Apical elytral intervals distinctly raised. Internal sac of aedeagus with posterior part of dorsal sclerite in dorsal view elongate, narrowing posteriorly, directed slightly laterally. Posterior part of dorsal sclerite in lateral view widening and round at apex, directed forward.

Comments. All five species put here into synonymy with *L. impressa* correspond to it well. There is slight variability in the size of the outer metasternal setose patch, and color varies from almost completely reddish-brown to typical black and yellow, but pronotal and elytral punctuation and sculpture as well as aedeagus characters are consistent between specimens. We did not observe any meaningful variability in the shape of the expanded distal antennomeres, which was used by Gressit and Kimoto in describing *L. inflaticornis* and *L. laticornis*. However, even these authors had some doubts about the use of these characters, even in the reference to the type series (Gressit and Kimoto 1961).

We did not thoroughly search for *L. impressa*-group specimens originating from outside of the area of interest, in particular from the islands and archipelagoes of the



Figures 10–13. Pronotums of *Lilioceris* species, dorsal view. **10** *L. impressa* **11** *L. laosensis* **12** *L. unicolor* **13** *L. yunnana.*

Oriental Region. However, all the island specimens in the USNM identified as *L. impressa* do not belong to this species and all lack the outer metasternal setose patch. So, the prevailing concept of *L. impressa*, being widely distributed across almost the entire Oriental Region, seems to be at least questionable. All the USNM *L. impressa*-group specimens originating from Sri Lanka, Andaman Islands, Greater and Lesser Sunda Islands, and Philippines were not identified as any of the species dealt with in this study and might indeed represent undescribed species closely related to other *L. impressa*-group species.

Type material examined. *L. impressa:* Lectotype, male. Labels. 1) Cr. impressa Fabr. Mant. Ind. n. 24; 2) Sir Joseph Banks Collection 1743–1820 ex. Linn. Soc. 1863 BM(NH) 1863-46; 3) ‘Type’ Crioceris impressa Fab. 1787; 4) Lectotype Crioceris impressa Fabricius des Konstantinov and Tishechkin 2010 (BMNH).

L. inflaticornis: Paratype, male, Fujian: Gang-keu, 26.VII.1936, J. L. Gressitt, 1 male (BBM).

L. laticornis: Paratype, Hainan: nr. Nodoa, Tan-hsien (Distr.), 17–22.VIII.1928, Lingnan Univ. 5th Hainan Island Expedition, 1 female (USNM).

L. maai: Holotype male: 1) Fukien S. China, Shaowun Tachulan 1000 m. T. Maa; 2) May 7, 1942; 3) Holotype Lilioceris maai J. L. Gressitt + Kim; 4) Lilioceris maai Gres. Kim. J. L. Gressitt det.; 5) Lilioceris sp. 1 maai; 6) Lilioceris impressa (F.) det. A. Konstantinov 2010. (BBM). Paratypes CHINA. Fujian: Shaowu, Tachulan, 26.IV.1942, T.C. Maa, 2 females (BBM), same locality and collector, but 1000m, 7.6.1943 female (BBM); same locality and collector, but 17.V.1942, 1 female (USNM); same locality, but 17.V.1945, K. C. Lin, 1 female (BBM).

L. ruficornis, Lectotype, female. Labels. 1)"Pe yen Tsing Yunnan; 2) type; 3) TYPE; 4) *ruficornis n sp*; 5) Lectotype Crioceris ruficollis Pic des Konstantinov and Tishechkin 2010 (MNHN).

L. subcostata, Lectotype, male. Labels. 1) Shin-Guy-Foo CHINE ; 2) octobre; 3) n sp; 4) type; 5) TYPE; 6) *subcostata n sp*; 7) Lectotype Crioceris subcostata Pic des Konstantinov and Tishechkin 2010 (MNHN).

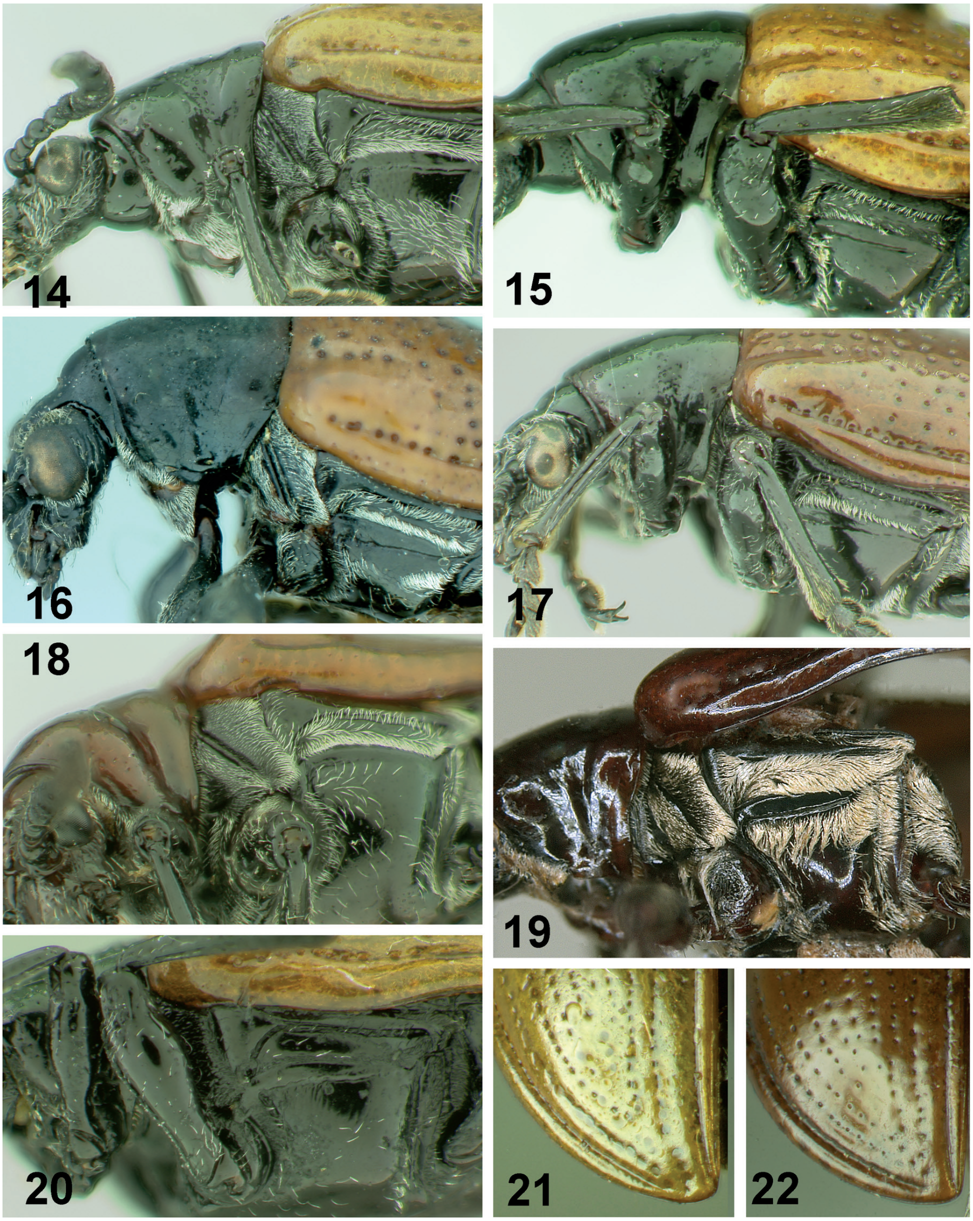
Material examined. CHINA. **Hainan:** Dwa Bi, 20.VII. 1935, L. Gressitt, identified as *L. laticornis* by S. Kimoto, 1959, 1 female (BBM); same locality, but 22.VII.1935 (1 BBM); Pan Heang 8.VI.1935, L. Gressitt (1 BBM). **Sichuan:** between Yachow and Kiating, 19–22.VI.1929, 1200–1500 feet, D. C. Graham, 1 specimen (USNM). **Yunnan:** Pe Yen Tsing, 1 specimen (USNM); Tche-Ping-Tcheou, 8 specimens (USNM); no precise locality, 1 specimen (USNM). **INDIA. Haryana**: Kalka, 1 specimen (USNM). **LAOS. Sayaboury Prov.** Sayaboury 30.V.1065, (1 BBM); **Khammouane Prov.** Phon Tiou, 6.VII.1965 (3 BBM). **MALAYSIA.** Malacca, 1 specimen (USNM). **THAILAND.** Trong, lower Siam, W. L. Abbott, 2 specimens (USNM). **VIETNAM.** Hanoi, 24.XII.1961, at lights, O. N. Kabakov, 1 specimen (USNM); Trang Bom, 30 mi NW of Saigon, 18.VII.1932, M. Poilane, 1 specimen (USNM); same locality and collector, but 26.VII.1932, 1 specimen (USNM); Nord Annam, Than-Hoa, V.1942, R. Dessom, 1 specimen (USNM); mountains 50 km NE Thai Nguen, 300 m, 13.IX.1962, O. N. Kabakov, 1 specimen (USNM).

Lilioceris laosensis (Pic, 1916)

http://species-id.net/wiki/Lilioceris_laosensis
Figs 11, 17, 22, 27

Crioceris laosensis Pic, 1916:16 (Type locality: "Laos". Lectotype designated here, MNHN). Kimoto and Gressitt, 1979:227 (resurrected from synonymy).

Diagnosis. Occipital area with a shallow furrow, at least with a deep small fovea at midpoint. Pronotum posteriorly with two weak, but distinct transverse irregular impressions. Pronotal disc with larger, scattered punctures, mid-line alignment of punc-



Figures 14–22. Thorax of *Lilioceris* species, **14–20** lateral view; **21, 22** elytral apex. **14** *L. cheni* **15** *L. egena* **16** *L. impressa* **17** *L. laosensis* **18** *L. malabarica* **19** *L. unicolor* **20** *L. yunnana* **21** *L. cheni* **22** *L. laosensis.*

tures usually still evident, at least in anterior half. Lateral sides of pronotum around constriction with large punctures. Outer metasternal disc mostly free of setae. Anterior setose fringes not expanded in antero-lateral corners. At least half of metepisternal disc covered with setae.

Apical elytral punctures weakened. Apical elytral intervals not raised. Internal sac of aedeagus with posterior part of dorsal sclerite in dorsal view more or less widely triangular, directed slightly medially. Posterior part of dorsal sclerite in lateral view more or less widely triangular, directed forward.

Type material examined. *L. laosensis*: Lectotype, male. Labels: 1) TAKEK LAOS COLL. LE MOULT; 2) [illegible] roux; 2) type; 3) TYPE; 4) *laosensis* Pic; 5) Lectotype *Lilioceris laosensis* Pic A. Tishechkin & A. Konstantinov des. 2010" (MNHN); paralectotype, male, the same labels as lectotype (MNHN).

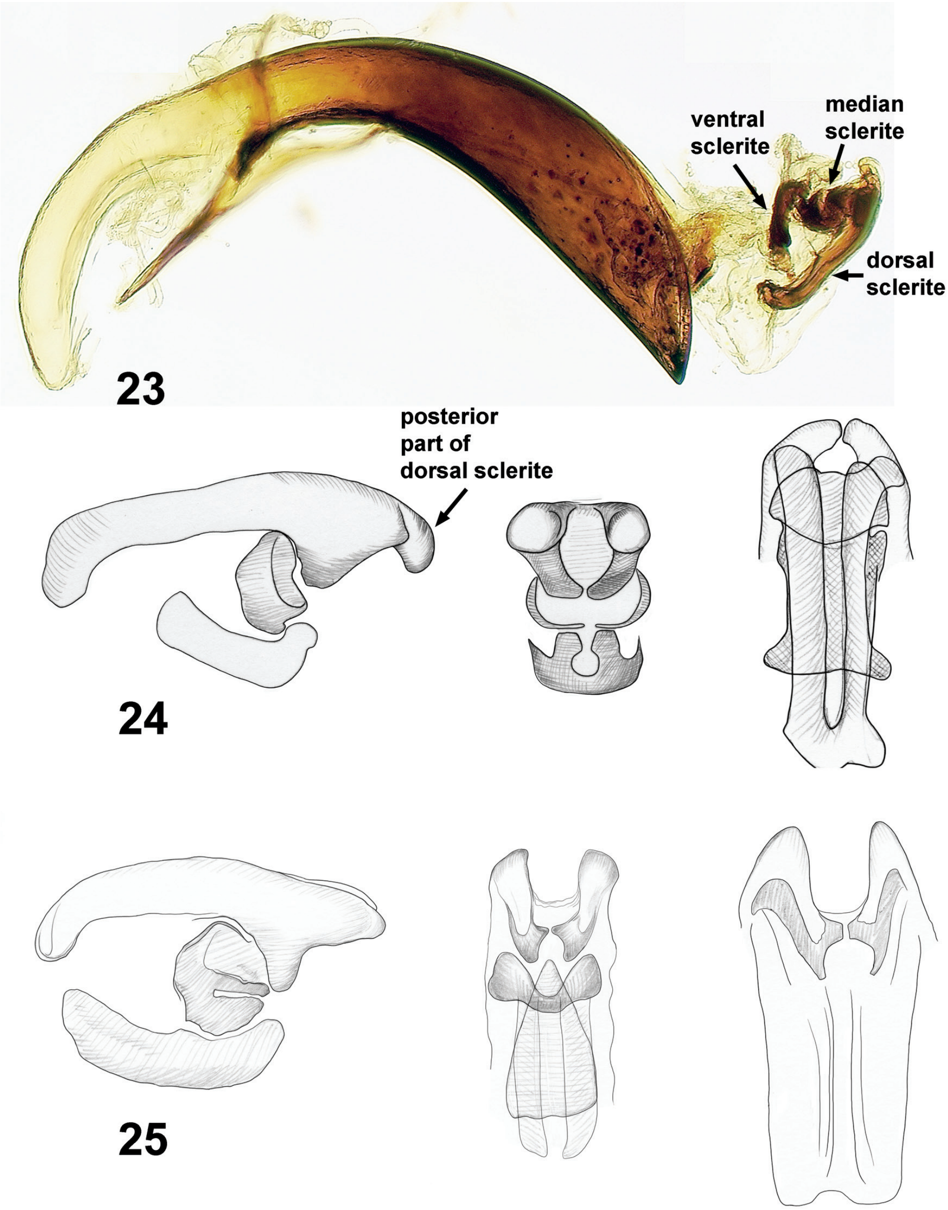
Material examined. CHINA. **Fujian:** near Foochow, 1921, C. R. Kellogg, 1 specimen (USNM); **Yunnan:** Ma-Chang, 1000 m, 1 specimen (USNM); Tche-Ping-Tcheou, 1 specimen (USNM). **INDIA.** Inde or, 1 specimen (USNM). **Assam:** Chabua, 8.V.1944, G. Butler, 4 specimens (USNM); Doom Dooma, VI.1943, D. E. Hardy, 1 specimen (USNM). **Karnataka:** Malabar, 1 specimen (USNM); Western Ghats, 7 km N Chickmagular, 13°23'23"N 75°42'9"E, 1800 m, 15.XI.2003, A. Konstantinov, K. Prathapan & S. Saluk, 1 specimen (USNM). **Sikkim:** Rungbong Vall., Gopaldhara, 1916, H. Stevens, 1 specimen (MNHN); without precise locality, IX.1957, G. W. Angalet, 1 specimen (USNM). **LAOS**. **Borikhane Prov.** Pakkading 29.IV.1966 (1 BBM). **MYANMAR.** Carin Cheba, 1000 m, V.1888, L. Fea, 2 specimens (USNM); Tenasserim, Meetan, IV.1887, L. Fea, 1 specimen (USNM). **NEPAL.** Jiri Reg., Shivalaya-Jiri, 27°36.61'N 86°17.55'E, 1770–1900 m, pass, 2200m, 12.V.2000, A. Konstantinov, S. Lingafelter & M. Volkovitch, 1 specimen (USNM); Sankhua Sabha Dist., Arun Valley, Chichila, 1900–2000 m, 18–20.VI.1988, J. Martens & W. Schawaller, 1 specimen (USNM). **THAILAND.** Doi Sutep, 26.VIII.1951, 1 specimen (USNM); Trong, lower Siam, W. L. Abbott, 4 specimens (USNM). **VIETNAM.** Bao Lac (Tonkin), 2 specimens (USNM); Nord Annam, Than-Hoa, V.1942, R. Dessom, 1 specimen (USNM); Trang Bom, 30 mi NW of Saigon, 23.VII.1932, M. Poilane, 1 specimen (USNM).

Lilioceris malabarica (Jacoby, 1904)

http://species-id.net/wiki/Lilioceris_malabarica
Figs 18, 28

Crioceris malabarica Jacoby, 1904:381 (Type locality: "Malabar". Lectotype designated here, BMNH).

Diagnosis. Occipital area with a shallow furrow, at least with a deep small fovea at midpoint. Pronotum posteriorly with single weak, regular, transverse impression. Pronotal disc without or with few small punctures, larger punctures present only along pronotal mid-line, at least in anterior half. Lateral sides of pronotum around constriction impunctate. Outer metasternal disc mostly free of setae. Anterior setose fringes expanded in antero-lateral corners. At least half of metepisternal disc covered with setae. Apical elytral punctures weakened. Apical elytral intervals not raised. Internal sac of aedeagus with posterior part of dorsal sclerite in dorsal view more or less widely



Figures 23–25. Aedeagi of *Lilioceris* species, **23** aedeagus in lateral view with internal sac everted **24–25** sclerites of internal sac. **23, 24** *L. cheni* (lateral, frontal and dorsal views) **25** *L. egena* (lateral, frontal and dorsal views).

triangular, directed forward. Posterior part of dorsal sclerite in lateral view more or less widely triangular, directed forward.

Type material examined. *L. malabarica*: Lectotype, male. Labels: 1) Type H.T.; 2) 432; 3) Mahe Malabar; 4) Jacoby Coll. 1909-28a; 5) Crioceris malabarica Jac.;

6) Lectotype Lilioceris malabarica (Jacoby), des. Konstantinov and Tishechkin 2010 (BMNH). Paralectotype, female, same label as lectotype (BMNH). Paralectotype, male. Labels: 1) Nilgiri Hills; 2) 810; 3) Crioceris semipunctata Fab.; 4) Crioceris malabarica HEA Jac; 5) Andrewes Bequest B.M. 1922-221; 6) Paralectotype Lilioceris malabarica (Jacoby), des. Konstantinov and Tishechkin 2010 (BMNH).

Material examined. INDIA. Kerala: Mahé, Malabar, 1 specimen (USNM); Malabar, gift of F. C. Bowditch, 4 specimens (USNM).

Lilioceris thibetana (Pic, 1916)

http://species-id.net/wiki/Lilioceris_thibetana
Figs 4, 29

Crioceris thibetana Pic, 1916:18 (Type locality: "Thibet". Lectotype designated here, MNHN). Gressitt and Kimoto, 1961:59 (valid species). Kimoto and Gressitt 1979:229 [synonymy with *L. laosensis* (Pic)]. Status resurrected

Diagnosis. Occipital area with a deep small fovea at midpoint. Pronotum posteriorly with single weak, regular, transverse impression. Lateral sides of pronotum around constriction with large punctures. Pronotal disc with scattered larger punctures, mid-line alignment of punctures usually still evident, at least in anterior half. Outer metasternal disc mostly free of setae. Anterior setose fringes not expanded in anterolateral corners. About half of metepisternal disc covered with setae. Apical elytral punctures strong. Apical elytral intervals not raised. Internal sac of aedeagus with posterior part of dorsal sclerite in dorsal view very short, widely rounded, directed laterally. Posterior part of dorsal sclerite in lateral view very short, widely rounded, directed forward.

Type material examined. *L. thibetana*: Lectotype, male. Labels: 1) Thibet Tianatung; 2) n sp; 3) type; 4) TYPE; 5) thibetana Pic; 6) Lectotype Crioceris thibetana Pic des. A. Konstantinov & A. Tishechkin 2010 (MNHN).

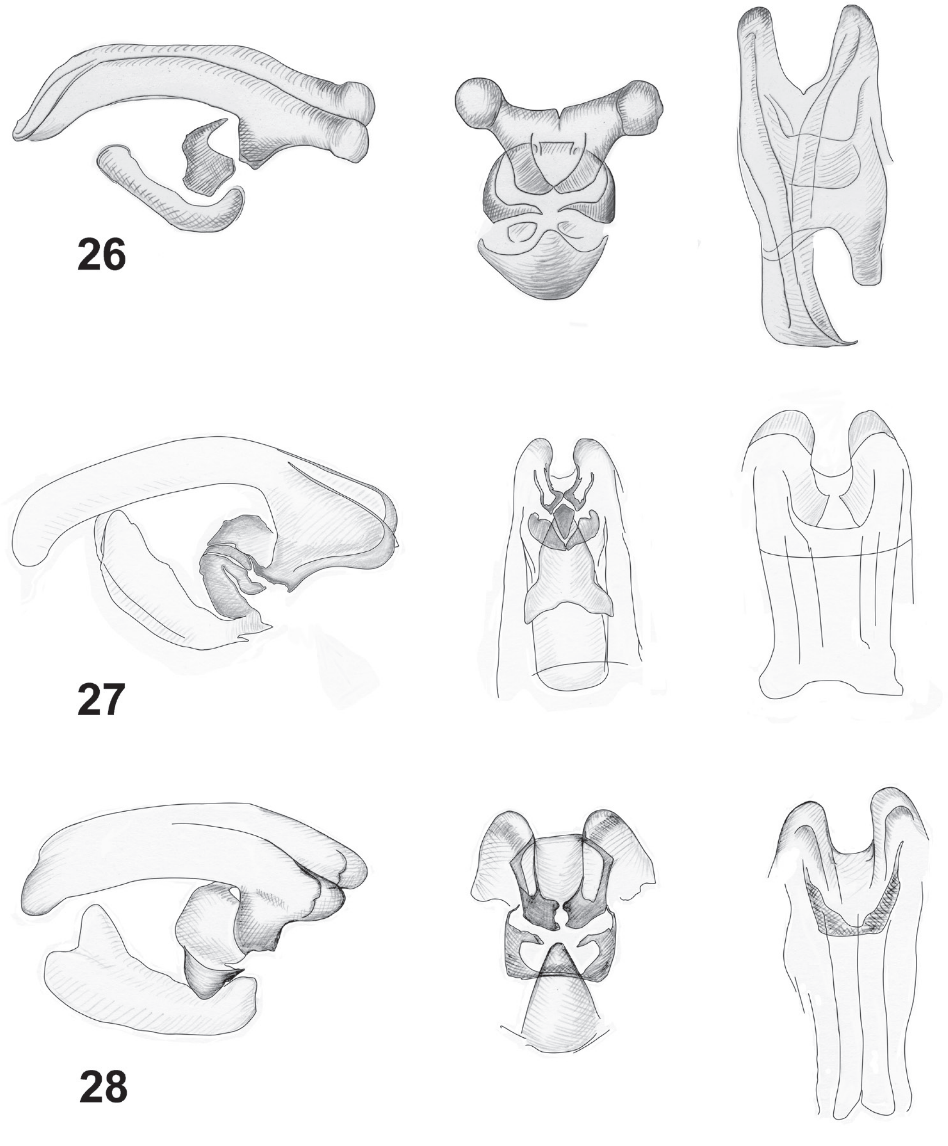
Lilioceris unicolor (Hope, 1831)

http://species-id.net/wiki/Lilioceris_unicolor
Figs 5, 12, 19, 30

Crioceris unicolor Hope, 1831:28 (Type locality: Nepal. Lectotype designated here, BMNH)

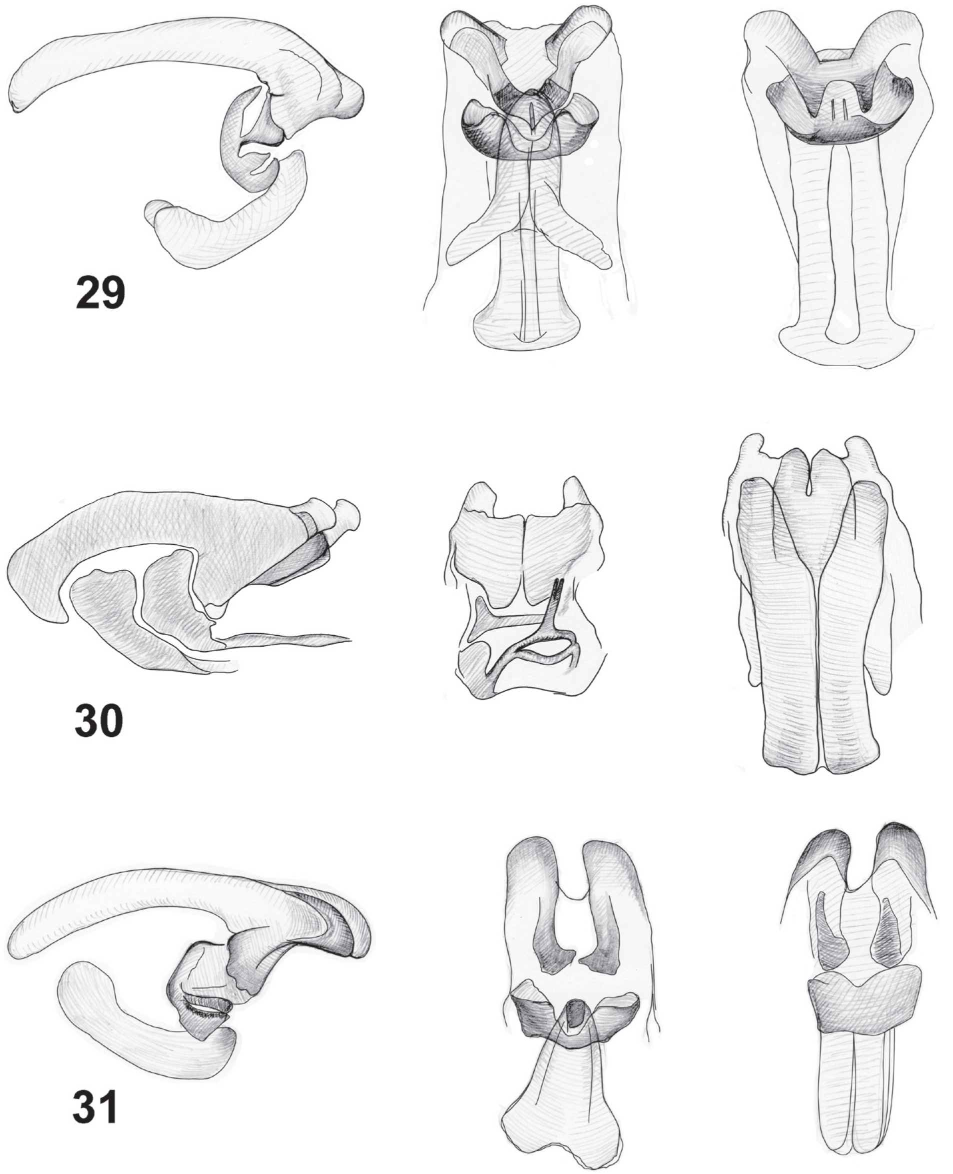
Crioceris badia Lacordaire, 1845:560 (Type locality: Siam. Type, not found). Clavareau (1913) (synonymy).

Diagnosis. Occipital area with shallow but sharp furrow. Pronotum posteriorly with single weak, regular, transverse impression. Pronotal disc with small punctures situated



Figures 26–28. Internal sacs of aedeagi of *Lilioceris* species (lateral, frontal and dorsal views), **26** *L. impressa* **27** *L. laosensis* **28** *L. malabarica.*

in middle in two rows. Lateral sides of pronotum around constriction without punctures. Outer metasternal disc only with oblique setose patch or covered with dense setae along its lateral side. Anterior setose fringes expanded in antero-lateral corners, which are covered with dense yellow setae. Metepisternal disc completely covered with setae. Apical elytral punctures weak. Apical elytral intervals flattened. Internal sac of aedeagus with posterior part of dorsal sclerite in dorsal view with two apices, lateral



Figures 29–31. Internal sacs of aedeagi of *Lilioceris* species (lateral, frontal and dorsal views), **29** *L. thibetana* **30** L. *unicolor* **31** *L. yunnana*.

longer than median, directed medially. Posterior part of dorsal sclerite in lateral view more or less parallel-sided, slightly swollen at apex, directed dorsally.

Comments. We were not able to find the type of *L. badia*, but found a specimen in the BMNH from the Baly collection with a label identifying it as *L. badia*. The specimen is conspecific with *L. unicolor*.

Type material examined. *L. unicolor*: Lectotype, male. Labels: 1) Nepal; 2) Type; unicolor Hope; 3) Hardwicke Bequest; 4) Lectotype Lilioceris unicolor Hope des. A. Konstantinov & A. Tishechkin 2010 (BMNH).

Material examined. *L. badia*: Labels: 1) "illegible" 2) Baly Coll.; 3) Crioceris badia Lac. Siam, "illegible" (BMNH).

Lilioceris yunnana (Weise, 1913)

http://species-id.net/wiki/Lilioceris_yunnana
Figs 13, 20, 31

Crioceris crassicornis Fairmaire, 1887:136 (Type locality: "Yunnan". Type depository: unknown) nec Olivier 1808.

Crioceris yunnana Weise, 1913:220 [new name for *L. crassicornis* (Fairmaire, 1887) nec Olivier 1808].

Diagnosis. Occipital area with a shallow furrow, at least with a deep small fovea at midpoint. Pronotum posteriorly more or less convex, no distinct impressions present. Pronotal disc without or with few small punctures, larger punctures present only along pronotal mid-line, at least in anterior half. Lateral sides of pronotum around constriction impunctate. Outer metasternal disc mostly free of setae. Anterior setose fringes of metasternum not expanded in antero-lateral corners. Setae on metepisternae occupy only narrow line along inner margin. Apical elytral punctures weakened. Apical elytral intervals not raised. Internal sac of aedeagus with posterior part of dorsal sclerite in dorsal view wide and short, slightly triangular, directed forward. Posterior part of dorsal sclerite in lateral view widely triangular with dorsal side longer than ventral, directed forward, but at the same time posteroventrally.

Comments. We were unable to find the type of *L. crassicornis* or specimens of it identified by Weise. We based our concept of this species on the 3 specimens from HUB identified by Heinze.

Material examined. CHINA. Hubei: Lichuan Distr., Suisapa, 1000 m, 21.VIII.1948, J. L. Gressit, 1 specimen (BBM); Lichuan Distr., Leong-ho-kow, 1000 m, 7.IX.1948, Gressit & Djou, 1 specimen (BBM). **Sichuan:** W of Yachou, 16–20.VI.1923, D. C. Graham, 1 specimen (USNM). **Yunnan:** env. Xiaguan, 25°26'29"N 100°12'51"E, 1821 m, A. Konstantinov & M. Volkovitch, 1 specimen (USNM); Yunnan, 3 specimens (HUB). **INDIA. Sikkim:** Hou He, 1 specimen (USNM). **VIETNAM.** Nord Annam, Than-Hoa, V.1942, R.Dessom, 1 specimen (USNM); Cochinchine, 1 specimen (USNM).

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References

Bell CR, Taylor BJ (1982) Florida Wild Flowers and Roadside Plants. Laurel Hill Press, Chapel Hill, N.C., 332 pp.

Berti N (1989) Contribution a la Faune de France. L'indentite d'*Oulema* (*O.*) *melanopus* (L.) [Col. Chrysomelidae Criocerinae]. Bulletin de la Société Entomologique de France 94(1–2): 47–57.

Berti N, Rapilly M (1976) Faune d'Iran. Liste d'especes et revision du genre *Lilioceris* Reitter [Col. Chrysomelidae]. Annales de la Société Entomologique de France (N.S.) 12(1): 31–73.

Clavareau H (1913) Coleopterorum Catalogus. Pars 51. Chrysomelidae: 1. Sagrinae, 2. Donaciinae, 3. Orsodacninae, 4. Criocerinae. W. Junk, Berlin W 15. 1–103.

Fabricius JC (1787) Mantissa insectorum, sistent eorum species nuper detectas adiectis characteribus genericis, differentiis specificis, emendationibus, observationibus. Tomus I. Hafniae, 348 pp.

Fairmaire L (1887) Coléoptères de l'intérieur de la Chine. Annales de la Société Entomologique de Belgique 31: 87–136.

FL EPPC Plant List Committee (2003) Florida Exotic Pest Plant Council's 2003 list of invasive species. Wildland Weeds 6: suppl.

Gordon DR, Gann GD, Carter E, Thomas K (1999) Post-hurricane vegetation response in South Florida Hammocks with and without *Dioscorea bulbifera* L. control. In: Jones DT, Gamble BW (Eds) Florida's Garden of Good and Evil. South Florida Water Management District, West Palm Beach, 309–326.

Gressit JL (1942) Plant-beetles from south and west China. II. Criocerinae (Chrysomelidae). Lingnan Science Journal 20: 295–323.

Gressitt JL, Kimoto S (1961) The Chrysomelidae (Coleopt.) of China and Korea. Pacific Insect Monograph 1A: 1–299.

Hope FW (1831) Synopsis of the new species of Nepal Insects in the collection of Major General Hardwicke. In: Gray JE The Zoological Miscellany. London. 1831: 21–32.

Jacoby M (1904) Another contribution to the knowledge of Indian phytophagous Coleoptera. Annales de la Société Entomologique de Belgique 48: 380–406.

Kimoto S, Gressitt JL (1979) Chrysomelidae (Coleoptera) of Thailand, Cambodia, Laos and Vietnam. I. Sagrinae, Donaciinae, Zeugophorinae, Megalopodinae and Criocerinae. Pacific Insects 20(2–3): 191–256.

Konstantinov AS (1998) Revision of the Palearctic species of *Aphthona* Chevrolat and cladistic classification of the Aphthonini (Coleoptera: Chrysomelidae: Alticinae). Memoirs on Entomology, International, "Associated Publishers", Gainesville, 429 pp.

Lacordaire JT (1845) Monographie des Coléoptères subpentamères de la famille des Phytophages. Tome I. Mémoires de la Société Royale des Sciences de Liége 3(1): 1–740.

Langeland KA, Craddock Burks K (1998) Identification and Biology of Non-native Plants in Florida's Native Areas. University of Florida, Gainesville, 165 pp.

Morton JF (1976) Pestiferous spread of many ornamental and fruit species in south Florida. Proceedings Florida State Horticultural Society 89: 348–353.

Pic M (1916) Espèces et variétés nouvelles. Mélanges Exotico-Entomologiques 19: 6–20.

Pic M (1921a) Nouveautés diverses. Mélanges Exotico-Entomologiques 33: 1–33.

Pic M (1921b) Deux nouveaux *Crioceris* Geoffr. asiatiques. Bulletin de la Société Entomologique de France 1921: 136–137.

Pic M (1928) Six nouveaux coléoptères du Tonkin et mutation. Bulletin Bi-Mensuel de la Société Linnéenne de Lyon 7: 87–88.

Schmitz DC, Simberloff D, Hofstetter RL, Haller WT, Sutton D (1997) The ecological impact of nonindigenous plants. In: Simberloff D, Schmitz DC, Brown TC (Eds) Strangers in Paradise: Impact and Management of Nonindigenous Species in Florida. Island Press, Washington, D.C., 39–61.

Schultz GE (1993) Element stewardship abstract: *Dioscorea bulbifera*--air potato, [Online]. In: Control methods--plants. In: Global Invasive Species Team (GIST). Arlington, VA: The Nature Conservancy. Available: http://www.invasive.org/gist/esadocs/documnts/diosbul.pdf [accessed 2009, November 2]

Wheeler GS, Pemberton RW, Raz L (2007) A biological control feasibility study of the invasive weed-Air Potato, Dioscorea bulbifera L. (Dioscoreaceae); an effort to increase biological control transparency and safety. Natural Areas Journal 27: 269–279. doi:10.3375/0885-8608(2007)27[269:ABCFSO]2.0.CO;2

Weise J (1913) Synonymische Mitteilungen. Wiener Entomologische Zeitung 32: 218–220.

Weise J (1922) Chrysomeliden der Indo-Malayischen Region. Tijdschrift voor Entomologie 65: 39–130.