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A remarkably modified species of the tribe Platynini (Coleoptera, Carabidae) from a limestone cave in Jiangxi Province, eastern China

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Abstract

Morimotoidius zhushandong **sp. n.** is described and illustrated from a limestone cave called Zhushan Dong II in Wanzhai Xian (=County) of western Jiangxi Province, eastern China. This species is the most modified species within the tribe Platynini in China by having very slender body and appendages, extremely elongated head, and especially, narrowed and barrel-liked pronotum which is as wide as head. However, the above derived characters are autapomorphies to adapt the subterranean environment. *M. zhushandong* **sp. n.** must be a troglobite though it has well pigmented body and flat eyes.

Keywords

Morimotoidius, new species, ground beetle, cavernicolous, Jiangxi, China

Introduction

Carabidae is the largest family in the suborder Adephaga of Coleoptera, containing more than 34000 species (subspecies) in the world (Lorenz 2005). They are living in various habitats including in caves. To adapt subterranean environment, the ground beetles generally have several modified morphological characters, such as elongate body and appendages, long and very developed sensory setae, reduced or totally disappeared eyes, and more or less depigmented body (Casale et al. 1998, Faille et al. 2010). Cave-dwelling ground beetles have been reported from over twenty tribes worldwide (Casale et al. 1998), but only four tribes, *viz.*, Tachyini, Trechini, Platynini and Clivinini, recorded in China (Tian 2008, 2013; Deuve and Tian 2011).

In general, species diversity of cavernicolous platynines is much less than that of trechines. For example, about 90 species of trechines in over 30 genera have been reported in China, in contrast to 13 species of platynine in two genera: 12 species in *Jujiroa* Uéno, 1952 (Jedlička 1961; Vigna Taglianti 1995; Uéno and Kishimoto 2001; Deuve 2004; Terada et al. 2005; Uéno 2007), and one in *Xestagonum* Habu, 1978 (Deuve 2001).

During a subterranean biological survey of last year in western Jiangxi Province, a peculiar platynine species was discovered in a limestone cave. On the basis of its pronotal and leg characters, it belongs to the genus *Morimotoidius* Habu, 1954, but represents a lineage which is much different from other congeners. This species is the first record of *Morimotoidius* in mainland China. It is also one of the most modified species of Platynini in the world.

Materials and methods

All specimens for this study are composed of sixteen specimens. They were collected by hands on walls and ceilings in a limestone cave called Zhushan Dong II in eastern Jiangxi Province, and kept in 50% ethanol before study. Dissections were made by using standard techniques. Body was prepared on paper card; pieces of buccal appendages or genital organs were put on small paper cards and then pinned beneath the specimens from which they were removed. Observation and dissections were made under Leica S8AP0 stereo-binocular microscope. Female genitalia were dipped 10% KOH for one day before dissection, then cleaned in lactic acid for one day, and stained in Chlorazol Black dissolved in 70% ethanol for thirty seconds. Digital photographs were taken by a Canon EOS 40D camera, and then processed by using Adobe Photoshop CS5 computer software.

Body length was measured from apex of right mandible (in opened position) to apex of elytra; body width (=width of elytra) was the maximum distance across elytra.

Abbreviations of measurements used in the text are as following:

HL head length, linear distance from apical margin of right mandible (in opened position) to the occipital suture

HW head width, maximum distance across head, including eyes
PL length of pronotum, distance measured from front to basal margins, along midline
PW width of pronotum, maximum distance across pronotum, along the widest point
PWA width of pronotum at apex, linear transverse distance along front margin
PWB width of pronotum at base, linear transverse distance between hind angles
EL length of elytra, measured from base of scutellum to apex of elytra, through suture
EW width of elytra

Terminology for female reproductive tract follows Deuve (1993) and Liebherr and Will (1998).

Taxonomic treatment

Morimotoidius zhushandong **Pang & Tian, sp. n.**
http://zoobank.org/96870F47-6129-474B-AB13-677EDD9D12C4
http://species-id.net/wiki/Morimotoidius_zhushandong
Figs 1–19

Description. Length: 11.5–12.5 mm; width: 3.6–3.7 mm. Habitus as in Figure 1. Body extremely slender and elongate, with very long antennae, legs and mouthpart palps.

Black, but ventral surface, femora (except basal and apical tips), clypeus, labrum and apical half of mandibles dark brown, legs including basal and apical tips of femora, antennae, palps, and basal half of mandibles yellow to yellow brown; elytra with indistinct purplish metallic sheen.

Macrosculpture: Strongly shining, surface glabrous, polish and smooth, but base of pronotum, mesosternum, meso- and metepisterna coarsely and sparsely punctate.

Microsculpture: Engraved meshes moderately transverse on labrum, clypeus and base of frons, and base of pronotum; strongly transverse on head; striate on disc of pronotum and elytra, but clearly isodiametric on scutellum.

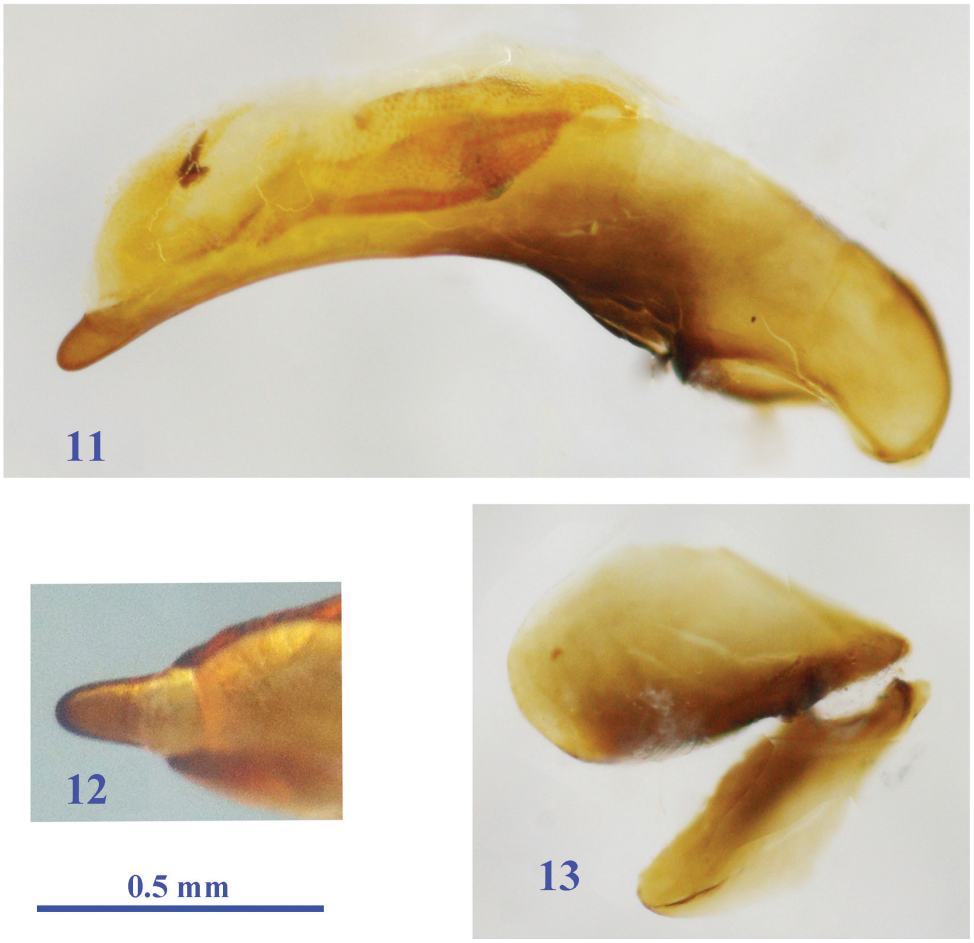
Head very long and narrow, strongly elongated, much longer than wide, HL/HW=2.04–2.15 (mean 2.11); widest at level of eyes, and gradually narrowed backwards to neck constriction which is short but distinct, tempora almost straight but slightly curved just before neck constriction; eyes rather flat, more or less depressed; ventral margins of eye well separated from buccal fissure; supraorbital areas with two pairs of setiferous pores, anterior closer to margin of eye than posterior; posterior pore at about middle of head from clypeal suture to neck; interspaces between anterior pores distinctly wider than that between posterior ones; distance between anterior and posterior pores slightly longer than diameter of eye; distance between eye to buccal fissure distinctly shorter than that between posterior pore to eye, but slightly longer than that between anterior pore to eye; frontal impressions rather shallow and wide, ending before anterior supraorbital pores; frons and vertex moderately convex; clypeus moderately transverse, bisetose, labrum subquadrate, almost straight at front, sexsetose; mandibles elongate,

Figure 1. *Morimotoidius zhushandong* sp. n., habitus of male, paratype.

gently and gradually narrowed towards apex, apical teeth slightly hooked; right mandible with a small but distinct anterior retinacular tooth at about median portion which is far from other teeth; both right and left mandibles with short and blunt terebral and posterior retinacular teeth near base; ligula broad, bisetose at apex; labial suture well developed; mentum bisetose, apical margin biconcave, with a long and simple median

Figures 2–10. Tarsi of *Morimotoidius zhushandong* sp. n., **2** protarsi, dorsal view, male **3** protarsi, ventral view, male **4** protarsi, dorsal view, female **5** protarsi, ventral view, female **6** mesotarsomeres 3–5, dorsal view, male **7** mesotarsomeres 3–5, ventral view, male **8** mesotarsomeres 3–5, lateral view, male **9** metatasomeres 3–5, dorsal view, male **10** metatasomeres 3–5, ventral view, male.

tooth which is widened at apex, epilobes evenly rounded; submentum bearing two pairs of setae, inner ones much long the outer; palps long and slender, subcylindrical, glabrous and asetose except for labial palpomere 2 which is bisetose on inner margin; labial palpomere 2 distinctly longer than 3; maxillary palpomere 3 slightly longer than 4. Antennae long and slender, filiform, extending at about apical 1/5 of elytra in female, but 1/6 in male; antennomeres 1–3 glabrous, antennomere 1 with a long subapical seta, 2 with a short subapical seta, 3 with several apical setae; finely pubescent from antennomere 4, each of 4 to 11 with several apical setae; antennomere 2 the shortest, half as long as 1, antennomeres 3–5 longer than other, each about twice as long as 1; gradually shortened from antennomeres 6 to 11, antennomere 11 almost as long as 1.



Figures 11–13. Male genitalia of *Morimotoidius zhushandong* sp. n., **11** median lobe, lateral view **12** apex of median lobe, dorsal view **13** parameres.

Pronotum narrow and strongly elongate, barrel-like, distinctly shorter than head, almost as wide as head including eyes; much longer than wide, PL/PW=1.59–1.62 (mean 1.60) in male, 1.40–1.43 (mean 1.41) in female; front slightly narrower than base, PWB/PWA=1.11–1.14 (mean 1.13) in male, 1.09–1.12 (mean 1.10) in female; widest at about middle, gently narrowed towards both fore and hind angles; front and base finely bordered, lateral margins unbordered, but with evenly and distinctly explanate-reflexed areas throughout, marginal setae absent; basal foveae wide and long; fore angle nearly rectangular, hind angle broad though somewhat rectangular; both front and base almost straight; median line deep and long; disc slightly convex, basal area rather flat, with lateral areas of basal parts evidently depressed; propleura faintly tumid, faintly visible from above, at least at the widest part; prosternal process unbordered at apex; scutellum moderately sized.

Elytra very slender, elongate-ovate, much wider than head and pronotum; well bordered at base, base small, shoulders indistinct; widest at a little behind middle, EL/EW=1.62–1.78 (mean 1.74), more contracted towards apices than towards base; disc moderately convex though rather flat in basal 1/4; striae very deep, continuous and smooth, weakly punctured; intervals strongly convex, stria 3 with three dorsal setiferous pores, basal one close to stria 3, both middle and subapical ones close to stria 2; other intervals without pore; subapical sinuation rather straight, apex broad; preapical and two apical pores present; marginal series of umbilicate pores not aggregated, which are composed of about nineteen pores, denser in subhumeral and subapical areas, sparser in middle portion; three pores (one at subhumerus, other two at subapical area) bearing much longer setae than others, which is distinctly longer than metatarsomere 4; scutellar pores present; scutellar striae deep and rather long. Hind wings reduced.

Legs very long and slender; fore leg short and stout (Figs 2–5); procoxa asetose, meso- and metacoxae bisetose, inner seta of metacoxa absent; trochanters unisetose; femora very slender, profemora unisetose ventrally, meso- and metafemora with three and two ventral setae respectively; tibiae and tarsomeres 1–3 longitudinal bisulcute dorsally; protarsomeres 1–3 slightly dilated in male, with two rows of short and sparse spongy setae ventrally (Fig. 3), while much narrower and without spongy setae in female (Fig. 5); protarsomeres 4 shortly but distinctly emarginate at apex, with lobes nearly symmetric, each with a row of three setae ventrally; meso- and metatarsomeres 4 without subapical setae (Figs 6–10); tarsomeres 5 glabrous ventrally; claws smooth.

Each of abdominal ventrite IV–VI with pair of paramedian setae in both sexes; ventrite VII with two pairs of marginal setae in female, but only one pair in male.

Male genitalia (Figs 11–13): The median lobe of aedeagus rather stout, basal bulb large, strongly arcuate in middle portion in lateral view, gently and gradually narrowed towards apex, blunt at tip; dorsal opening wide, nearly as half as whole length, reaching 1/3 from base; apical lamella rather long, nearly twice as long as wide, not parallel-sided, rounded at apex; internal sac with a long copulatory piece covered with scales, and a strongly sclerotized spine dorsally; left paramere styloid, not elongated, smaller and shorter than the right.

Female reproductive tract (Fig. 14): Ventrite X sparsely setose; gonosubcoxite bearing about a dozen fringe setae along apical area, gonocoxite strongly curved, sharp at apex, bearing three lateral and one dorsal ensiform setae; bursa copulatrix wide, with middle part evidently folded, basally narrower; spermathecal gland very large, elongate ovate; spermathecal gland duct thin and long, connected below base of spermathecal reservoir, which is shorter than spermathecal duct.

Sexual dimorphisms. Apart from protarsomeres 1–3 and ventrite VII, sexual differences are also shown on antennae and pronotum: a little longer or more elongate in male than in female.

Variability. In general, maxillary palpomere 3 distinctly longer than 4, but reverse in a male specimen which left maxilla with palpomere 3 shorter than 4.

Remarks. Within platynines, the chaetotaxy on pronotum and meso- and metatarsi are important characters (Habu 1978; Liebherr 1991; Schmidt 2001; Liebherr

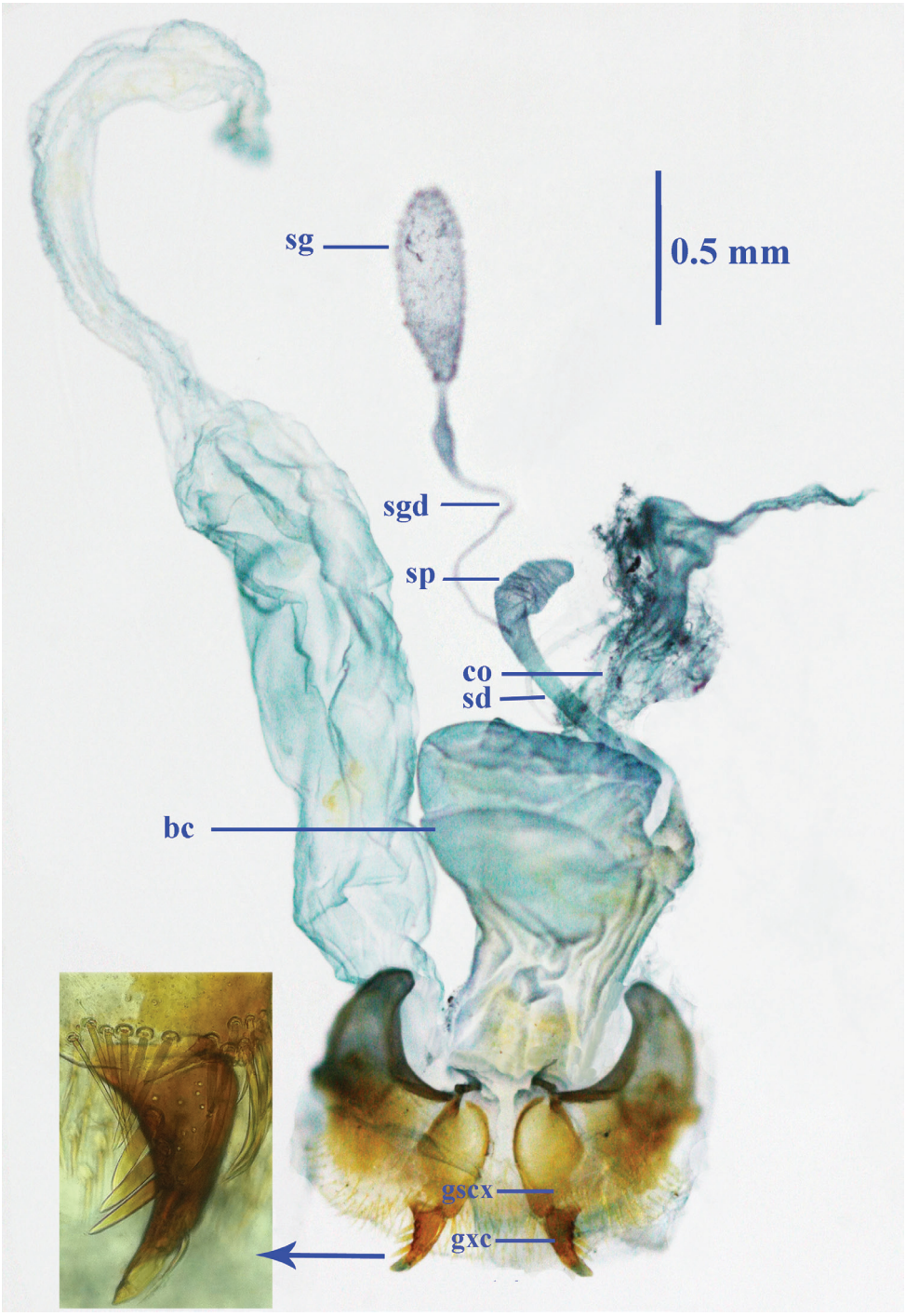


Figure 14. Female reproductive tract of *Morimotoidius zhushandong* sp. n., **bc** bursa copulatrix; **co** common oviduct; **gcx** gonocoxite; **gscx** gonosubcoxite; **sd** spermathecal duct; **sg** spermathecal gland; **sgd** spermathecal gland duct; **sp** spermatheca.

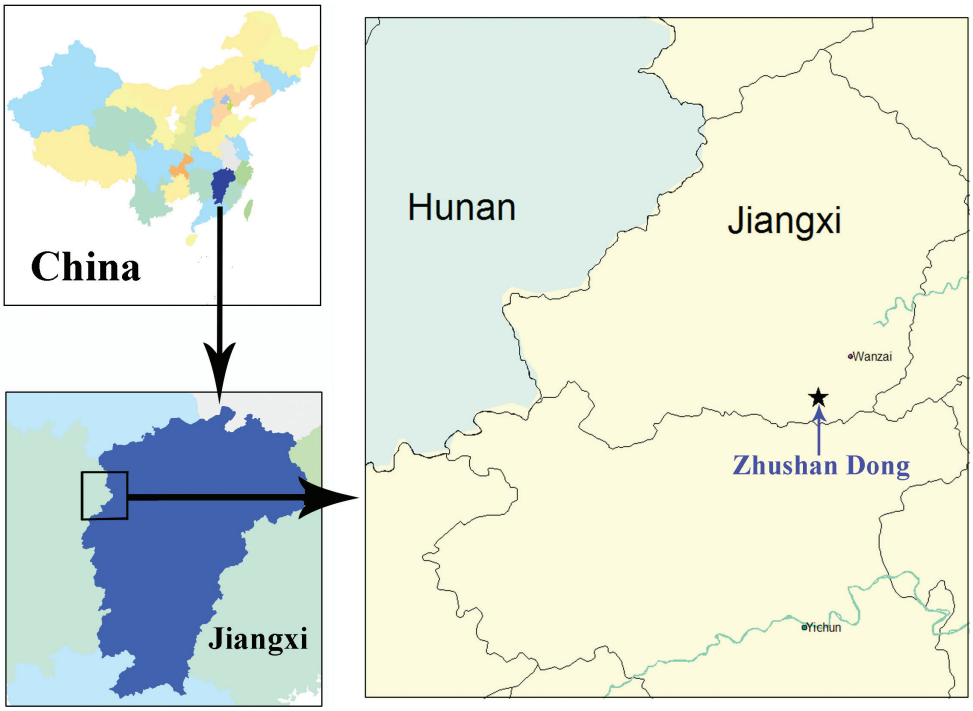
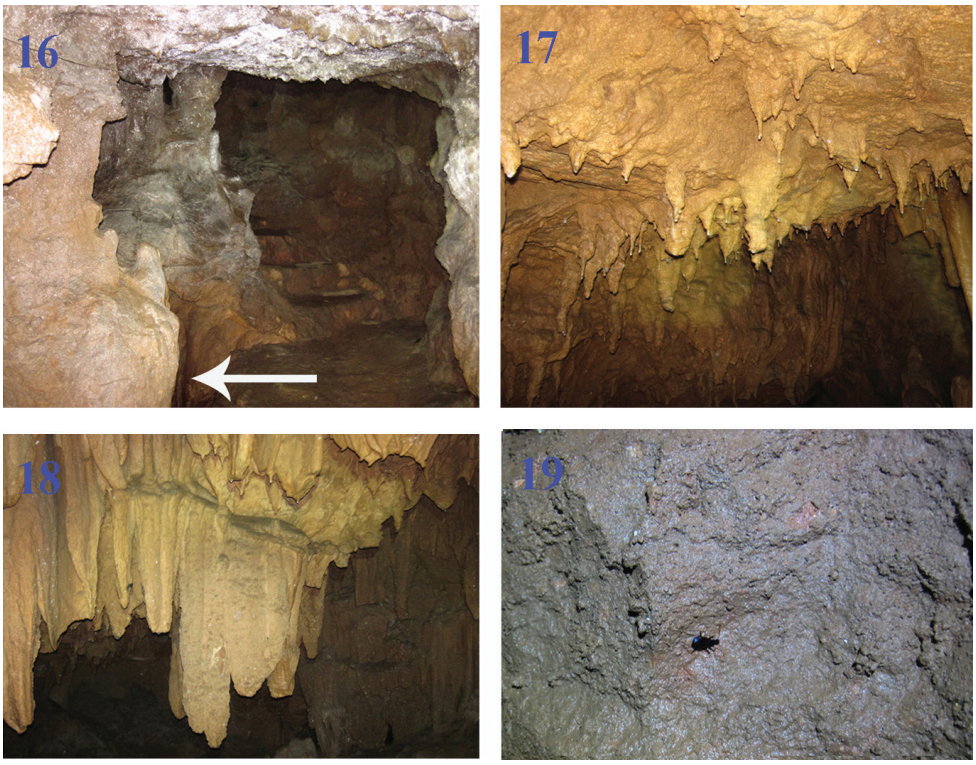


Figure 15. Distribution map of *Morimotoidius zhushandong* sp. n.

and Schmidt 2004). We treat this peculiar species a member of the genus *Morimotoidius* Habu, 1954 due to the fact that it shares the following combined generic characters with other species of this genus: pronotal setae absent, submentum quadrisetose, meso- and metatarsomeres 4 without subapical setae, meso- and metafemora bearing two or three setae, and tarsomeres 5 glabrous ventrally. Certainly, other remarkably modified characters such as the very elongate and rhadinoid body shape, the slender and markedly porrected mandibles, the very thin palps, reduced eyes, the markedly prolonged temples and the very small elytral base must be autapomorphies to adapt the subterranean habitat. *M. zhushandong* sp. n. is the first member of *Morimotoidius* found in mainland China. Other species of the genus are living either in Japan (two species) or in Taiwan Province of China (one species) (Habu 1954, 1978; Terada et al. 2005).

Etymology. This new species is named after its type locality. In Chinese, "Zhushan" means a mountain or hill which is covered with bamboo forest, "Dong" means cave.

Materials examined. Holotype: male, Zhushan Dong II, Dongkou Cun, Mabu Xiang, Wanzhai Xian, western Jiangxi, China, 28°02'880"N/114°22'216"E, 142 m, 2–X-2012, Mingyi Tian & Jingli Cheng leg. in the insect collections of South China Agricultural University, Guangzhou, China (SCAU); paratypes: 6 males and 9 females, ibid. in SCAU, except one male and one female in Muséum National d'Histoire Naturelle, Paris, France, and one male and one female in Coll. J. Schmidt (Admannshagen, Germany), respectively.



Figures 16–19. Zhushan Dong II. **16** entrance **17–18** cave walls where the type specimens were collected **19** an adult of *M. zhushandong* sp. n. running on cave ceiling.

Distribution. China (Jiangxi) (Fig. 15).

Habits. There is unknown about the biology and ecology of *M. zhushandong* sp. n. The beetles move quickly on walls and ceilings, feeding on other small arthropods, probably including eggs of the crickets which are common in the cave. The extremely modified troglomorphic characters mentioned above reveal that this beetle has ability to adapt underground environment and probably a troglobite though it has reduced eyes and pigmented body.

About the locality cave of *M. zhushandong* sp. n. Zhushan Dong is a touristic cave in western Jiangxi Province, located at Dongkou Cun, Mabu Xiang, Wanzai Xian, not far from the border between Wanzhai Xian and Yichun Shi (=City) (Fig. 15). Actually, there are two limestone caves in the Zhushan Dong scenic areas. Zhushan Dong I is a well-developed touristic cave, as long as 3985 m, with an underground river throughout the main passage. Zhushan Dong II is about 50 meters far from Zhushan Dong I. It is a small cave, about 30 m in length, with a small streamlet moving out at about 5 m inside of the entrance (Fig. 16, indicated by arrowhead). It is still closed for visitors. The beetles were collected by hands on walls and ceilings of the cave (Figs 17–19).

Key to species of the genus *Morimotoidius* Habu (modified from Habu 1954)

1 Body slender, head and pronotum extremely elongate, pronotum narrow, barrel-like, as wide as head, interval 3 of elytra with three setiferous pores (Jiangxi Province) ..... ***M. zhushandong* sp. n.**

– Body stout, head and pronotum moderate for *Colpodes*, not very elongate, pronotum much wider than head, interval 3 of elytra without setiferous pores **2**

2 Tarsomere 5 ciliate ventrally (Taiwan Province)..... ***M. formosus* Habu, 1954**

– Tarsomere 5 glabrous ventrally ..... **Japanese species**
(To separate the two Japanese species, see Habu 1978 for detail)

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A new species of *Gadirtha* Walker (Nolidae, Eligminae): a proposed biological control agent of Chinese tallow (*Triadica sebifera* (L.) Small) (Euphorbiaceae) in the United States

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Abstract

Gadirtha fusca **sp. n.**, is described from Guangxi Province, China. *Gadirtha fusca* differs in forewing color and pattern, male and female genitalia, and in larval pattern from all other species of *Gadirtha*. *Gadirtha fusca* has been evaluated as a potential biological control agent for Chinese tallow (*Triadica sebifera* (L.) Small, Euphorbiaceae) in the southeastern United States. Adult, male and female genitalia, larva, and pupa are described, illustrated, and compared with *Gadirtha impingens* Walker.

Keywords

China, Taxonomy, new species, biological control, larva, pupa

Introduction

The genus *Gadirtha* Walker was revised by Holloway (2003) and included three species; the type species *G. impingens* Walker, *G. pulchra* Butler, and *G. inexacta* Walker. *Gadirtha pulchra* and *G. impingens* are the most widespread. *Gadirtha pulchra* ranges from the

Indian Subregion, to the Ryukyu Islands in Japan, and Thailand, Singapore, New Guinea, and Queensland, Australia; *G. impingens* ranges from northern India and southern China to Queensland, the Bismarcks, and Solomons, (Holloway 2003) and from Honshu, Shikoku, Kyushu, and Tsushima in Japan (http://www.jpmoth.org). *Gadirtha inexacta* is found in northern India and Burma, and *G. fusca* in southern China.

A molecular phylogeny of Nolidae used eight genes to produce a stable phylogeny that consisted of eight strongly supported subfamilies (Zahiri et al. 2013). Holloway (2003) originally placed *Gadirtha* in the Collomeninae, but the results of Zahiri et al. (2013) moved all of the Eurasian genera formerly associated with Collomeninae to the subfamily Eligminae. Holloway (2011) preempted the placement of *Gadirtha* in Eligminae based on characters outlined in Zahiri et al. (2013). Members of Eligminae have an elongate and narrow forewing and in some genera the uncus is absent in the male genitalia. Species of *Gadirtha* have an elongate and narrow wing and the uncus is replaced by stiff, hairlike setae.

Gadirtha fusca is being considered as a potential biocontrol agent against Chinese tallow (*Triadica sebifera* (L.) Small, Euphorbiaceae) in the southeastern United States and formal description is critical to this process. Once *G. fusca* is introduced it will be the largest Nolidae in North America and can easily be distinguished by its elongate forewing with a truncate apex, dark gray forewing ground color with reduced pattern, and a dark gray hind wing. These characters will also distinguish it from other *Gadirtha* species in Asia. This paper describes the last instar, pupa, adult, and male and female genitalia.

Methods and materials

Images of adults and genitalia were taken with a digital camera, macro lenses, and a pulsed xenon flash. Images were enhanced with Adobe Photoshop® CS4.

Genitalia dissections follow Pogue (2002), except the genitalia were mounted in euparol. Vesica was inflated with 99% isopropyl alcohol and stained in Orcein.

Comparisons of forewing ground color and pattern, hind wing color, and male and female genitalic structures were compared with all species of *Gadirtha* using Holloway (2003). The male genitalia of *G. fusca* most closely resembled *G. impingens*, but differences are illustrated by comparing Figures 5 and 6.

Material used in this study is deposited in the following institutions: The Natural History Museum, London (BMNH), Canadian National Collection, Agriculture Canada, Ottawa, Canada (CNC), and National Museum of Natural History, Smithsonian Institution, Washington, DC (USNM).

Key to species of *Gadirtha*

1 Forewing with a distinct, thin, black postmedial line from costa slightly excurved then abruptly angled to tornus; hind wing white with a narrow dark

gray shading along outer margin, wing veins highlighted with dark gray (see plate 9, fig. 25 in Holloway (2003)).....***G. pulchra***

– Forewing with postmedial line indistinct, consisting of only a few black scales; hind wing white with broad gray marginal band or completely gray **2**

2 Forewing dark gray; hind wing dark gray ..... ***G. fusca* sp. n.**

– Forewing pale gray to brownish gray; hind wing white basally with a broad dark marginal band.....**3**

3 Male genitalia with costal arm of valve slightly curved with a dorsal triangulate projection near apex (see fig. 502 in Holloway (2003))..... ***G. inexacta***

– Male genitalia with costal arm bent at a 90° angle (Fig. 5) ..... ***G. impingens***

Descriptions

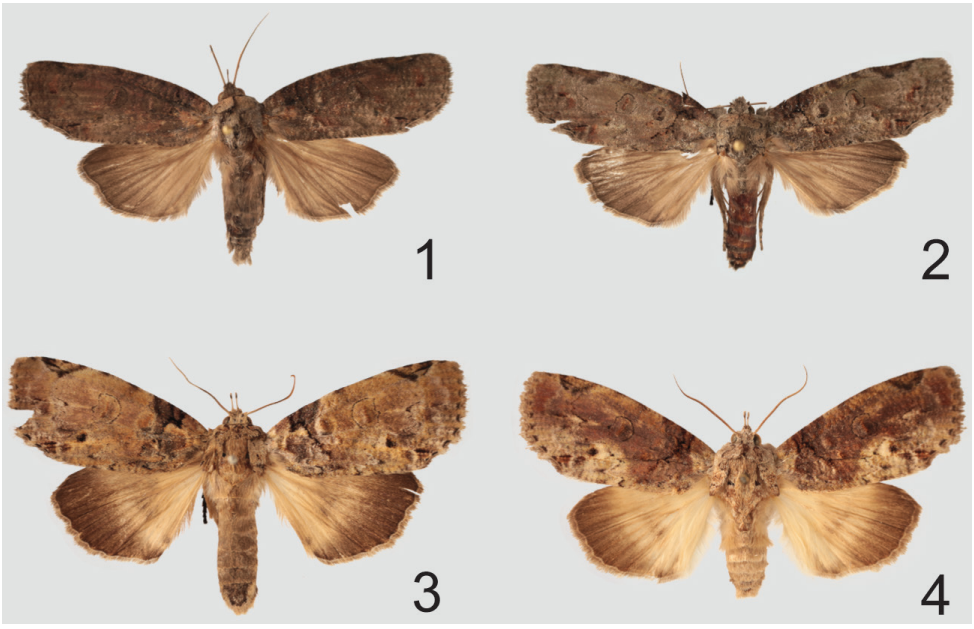
***Gadirtha fusca* Pogue, sp. n.**
http://zoobank.org/9AB88C1D-C3DD-4113-8B75-94656AFDFAA8
http://species-id.net/wiki/Gadirtha_fusca
Figs 1–2, 5, 7, 9, 11–20

Type-locality. China, Guangxi Province, 4.4 km NW Yangshuo, 24.79833°N, 110.45067°E.

Type-specimen. Holotype male, Original label: "China, Guangxi Province, 4.4 km NW Yangshuo, 24.79833°N, 110.45067°E, 8 June 2012" "Reared from leaf *T. sebifera* 10-Sep.-2012 from IPRL colony" USNM ENT 00149216" "HOLOTYPE / *Gadirtha fusca* / Pogue" [red printed label]. Deposited in USNM.

Paratypes. 3 males and 4 females same data as holotype; 2 male genitalia slides USNM 136482, 136485; 2 female genitalia slides USNM 136483, 136484. 5 males and 5 females same data as holotype, from IPRL colony May 2013. USNM, BMNH, CNC.

Diagnosis. In the male genitalia *G. fusca* is most closely related to *G. impingens* as they share the same 90° angle in the apex of the costa in the valve (Figs 5–6). The aedeagus is abruptly bent medially in *G. fusca* (Fig. 7) and curved beyond the midpoint in *G. impingens* (Fig. 8). In *G. pulchra* and *G. inexacta* the costal arm of the valve is slightly bent, not curved at a 90° angle. The costal arm of the valve in *G. inexacta* bears a dorsal triangulate projection near its apex (see fig. 502 in Holloway (2003)) and this projection is absent in *G. pulchra* see fig. 500 in Holloway (2003). In the female genitalia the ostium bursae in *G. fusca* is membranous internally with a thin, sclerotized outer margin shaped like an up-side-down conventional incandescent light bulb (Fig. 9); compared to a heavily sclerotized ostium bursae that is strongly curved ventrally (Fig. 10) in *G. impingens*. *Gadirtha fusca* cannot be confused with any of the other three species of *Gadirtha* with its gray forewings, subdued pattern, and solid dark gray hind wings (Figs 1–2). Forewing ground color is brown to brownish gray in *G. impingens* with distinct black costal spots (Figs 3–4), contrasting with the dark gray forewing and faint costal spots in *G. fusca*. Hind wing in *G. fusca* is dark gray and

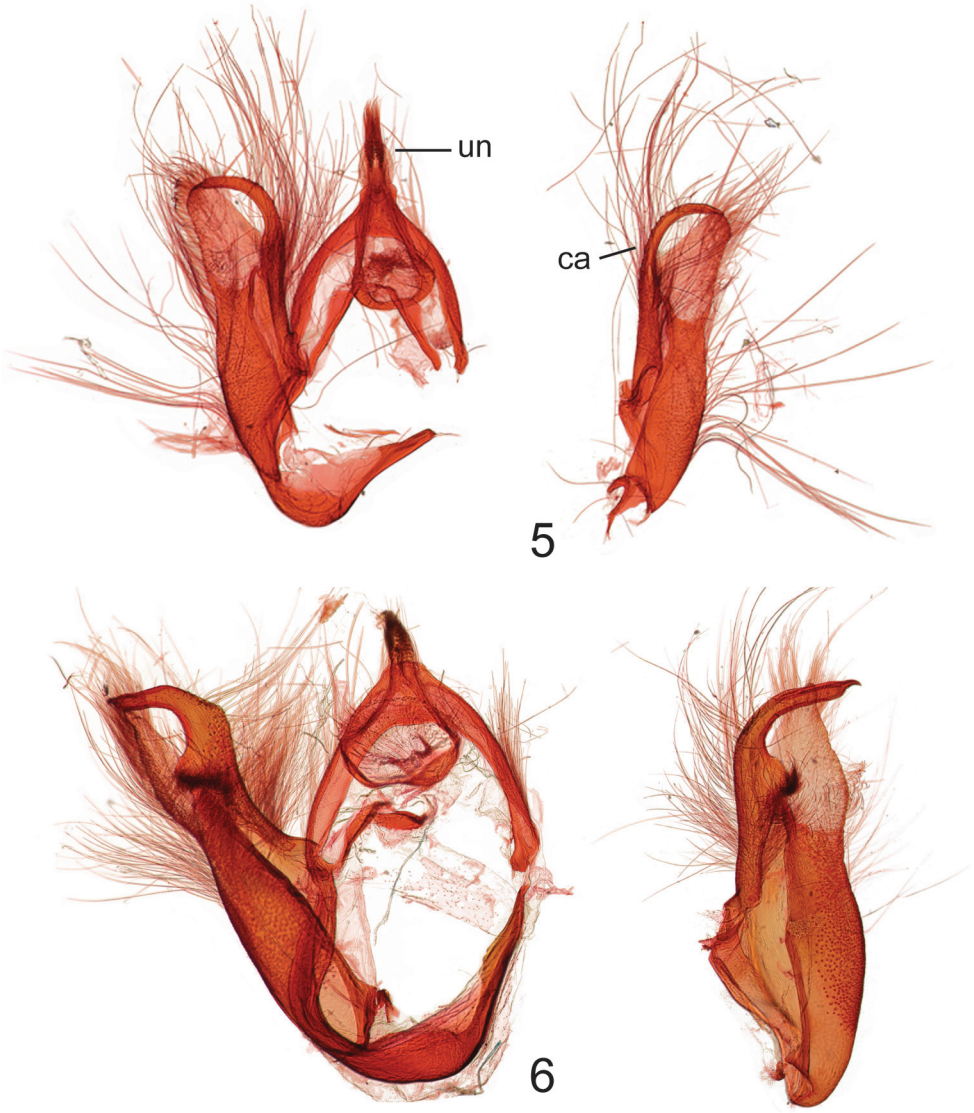


Figures 1–4. Adults of *Gadirtha* species. **1** *Gadirtha fusca* sp. n., Holotype, male **2** *Gadirtha fusca* sp. n., female **3** *Gadirtha impingens* Walker, male **4** *Gadirtha impingens* Walker, female.

white basally and dark brown distally in *G. impingens*. Only *G. fusca* and *G. impingens* are distributed in China.

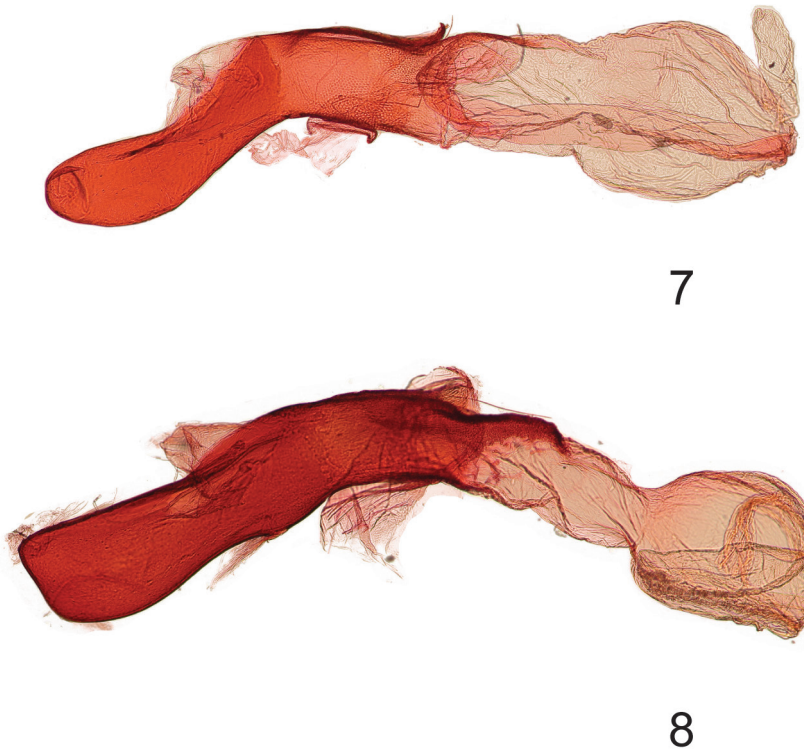
Larvae have a pale green to yellow-green ground color with elongate black and white setae. Pattern differences are distinct between species. *Gadirtha fusca* has a distinct, wide black dorsal stripe with large, ovate, black spots on A1, A2, and A8 (Figs 13–14). In *G. impingens*, the dorsal black stripe can be absent or if present, a thin line on each segment that is not contiguous; black ovate spots on A1 and A2 are smaller than in *G. fusca* and a small black round spot on A8 (http://jpmoth.org/Nolidae/Eligminae/Gadirtha_impingens.html). In *G. pulchra* the black spots are ringed with blue on T2–A4, with the largest spots on T3 and A1 (colour plate 12, fig. F in Murphy 1990).

Description. Adult (Figs 1–4): **Male.** *Head* – labial palp extends well above head, apical segment with slightly bulbous apex, dorsal surface adjacent to eye black, becoming pale gray with apical third dark gray, apex white, ventral surface white; frons and vertex gray; antenna ciliate and bare ventrally, white scales dorsally. *Thorax* – patagium grayish brown, a curved black line from middle to posterior margin; tegulum with pale gray scales tipped white, a few tipped black, black band of scales just proximal to apex; scales of protibia narrow, gray tipped white, greatly expanded laterally and ventrally almost to last tarsal segment, two vertical black spots medially that continue onto tarsal segments 1–4, tarsi concolorous with protibia with laterally expanded scales; mesothoracic tibia concolorous with protibia, scales expanded laterally less than in protibia



Figures 5–6. Male genitalia of *Gadirtha* species; **un** uncus **ca** costal arm of valve. **5** *Gadirtha fusca* sp. n. **6** *Gadirtha impingens* Walker.

and expanded ventrally to basitarsus, tarsi black dorsally, a few brown scales laterally, white ventrally; metathoracic tibia cream colored, tarsi cream colored with black basal bands on segments 2–4. Forewing length 18.5–22.4 mm; ground color brownish gray; varying amounts of indistinct rufous areas distributed over forewing; costa with rectangulate dark gray basal spot and a fainter dark gray triangulate spot proximal to apex; antemedial line black, very thin, angulate from R vein to anal vein; medial line absent; orbicular spot obscure, a round area consisting of a few pale scales bordered either dis-



Figures 7–8. Aedeagi of *Gadirtha* species. **7** *Gadirtha fusca* sp. n. **8** *Gadirtha impingens* Walker.

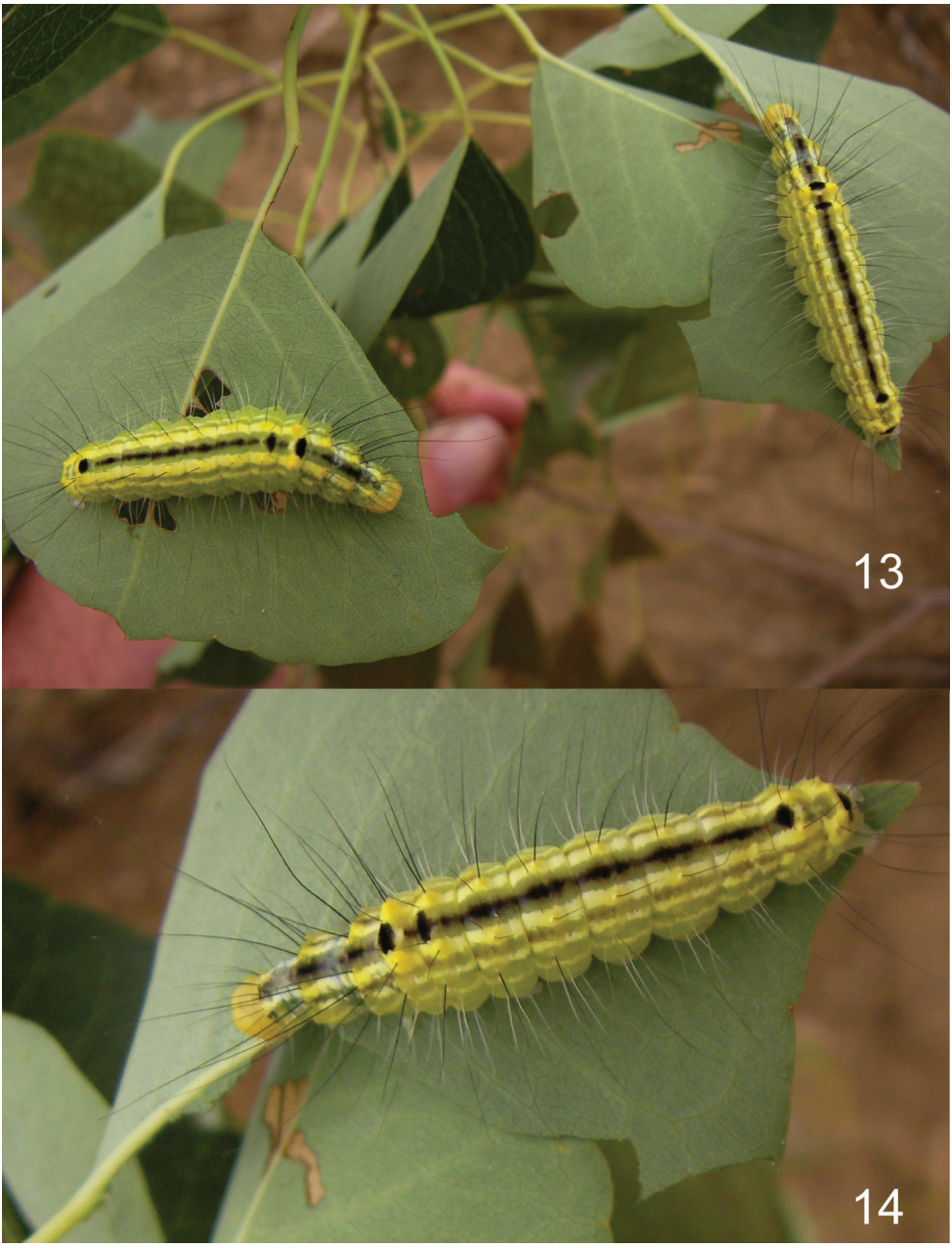
tally or proximally by a crescent-shaped band of dark gray scales; reniform spot round with a slightly produced apex along distal margin, thinly outlined in black, medially a vertical bar shape to ovate spot, rufous to dark gray; postmedial line very thin, black, indistinct, irregular in shape, excurved; black distal line at apex of vein CuA2; terminal line a series of black dashes between wing veins; outer margin angled at tornus to posterior margin; posterior margin a narrow white line with closely spaced black vertical lines, this line can be variable in extent and intensity. Hind wing dark gray. *Abdomen* – Dark gray. *Genitalia* (Figs 5, 7) – Uncus slightly sclerotized with stiff, hair-like setae at apex; subscaphium well developed, a wide U-shape with bottom of U broad; valve bifurcate, costa curved ventrally to just beyond apex of valve, cucullus lightly sclerotized; corona absent; saccus a broad U-shape; aedeagus short, angulate medially, vesica an elongate sac, slightly bulbous apically. **Female.** *Head* – Antenna not ciliate. *Thorax* – Similar to male except forewing length 20.9–23.1 mm; ground color pale brownish gray; antemedial line irregular and minutely wavy extending from costa almost to posterior margin; orbicular spot more pronounced than in male, a central area of pale scales surrounded by a dark gray crescent-shaped border usually disto-ventrally; a subapical elongate triangular spot on costa with two short black dashes near apex of spot. *Genitalia* (Fig. 9) – Papillae anales rectangulate, setose, slightly sclerotized; os-

Figures 9–10. Female genitalia of *Gadirtha* species. **9** *Gadirtha fusca* sp. n. **10** *Gadirtha impingens* Walker.

tium bursae bulb-shaped, narrow at exit of eighth tergite, then bulbous basally; ductus bursae short, sclerotized, and quadrate at exit from ostium bursae, remainder elongate, membranous slightly widens to elongate corpus bursae; signum an elongate, crenulate ribbon almost length of corpus bursae.

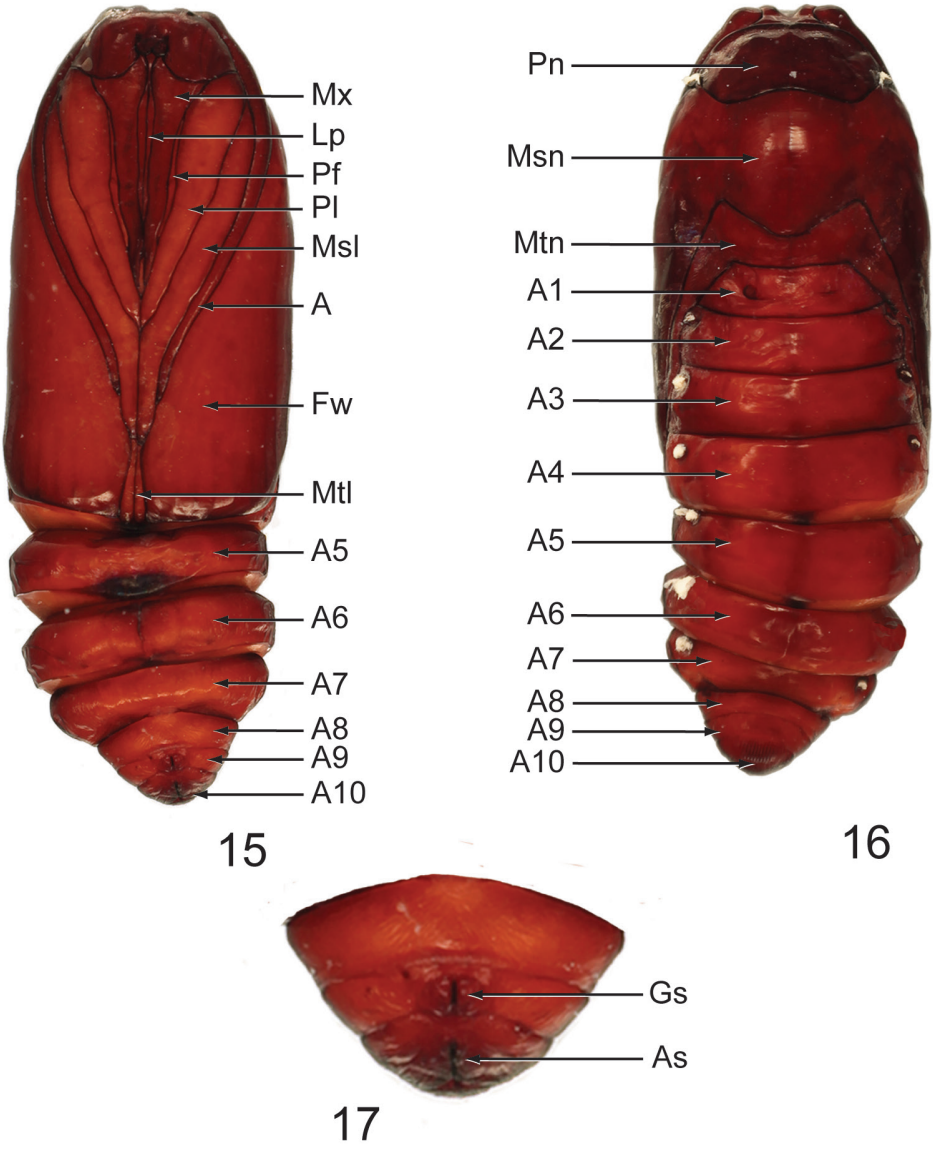
Figures 11–12. Larva of *Gadirtha fusca* sp. n. (preserved in alcohol). **11** dorsal **12** ventral.

Larva (Figs 11–14): Length: 28.0–33.5 mm (*n* = 6). **Coloration and pattern.** *Head* – Yellow. *Thorax* – T1 with medial rectangular black spots surrounding D1, D1 pinnacula yellow, irregular shaped black spot between XD2 and SD1, black spinules distal to all black spots; T2 and T3 with patch of black spinules between D1s, between D2 and SD2, distal to L group, and dorsal to SV group. *Abdomen* – yellow; dorsal line distinct black, ovate spots on A1, A2, and A8, remainder of segments with small round spots, spiculate; subdorsal, lateral, and spiracular lines pale green, spiculate; A10 with D1s surrounded by large, irregular shaped black spot, pinnacula yellow. **Morphology.** *Head* – Front flat; hypognathous; cutting edge of mandible with 3 shallow teeth, dorso-medial internal surface with large molar-like tooth, round and peg-shaped; epicranial suture elongate; epicranial notch moderately emarginated dorsally; F1, AF1 equal in length, AF2 longer; C1 shorter than C2; P1 dorsal to AF2, P2 inline with and dorsal to P1, shorter than P1; L1 fine, shorter than A3; S2 distal to stemma 1, shorter than S1; S1 ventral to stemma 3; stemmata 1–3 large and equal in width, larger than stemmata 4–6; spinneret cylindrical, equal in length to labial palp. *Thorax* – Spiculate; verrucae absent; T1 with D1, D2, XD1, and XD2 elongate, black; SD1 and SD2 on



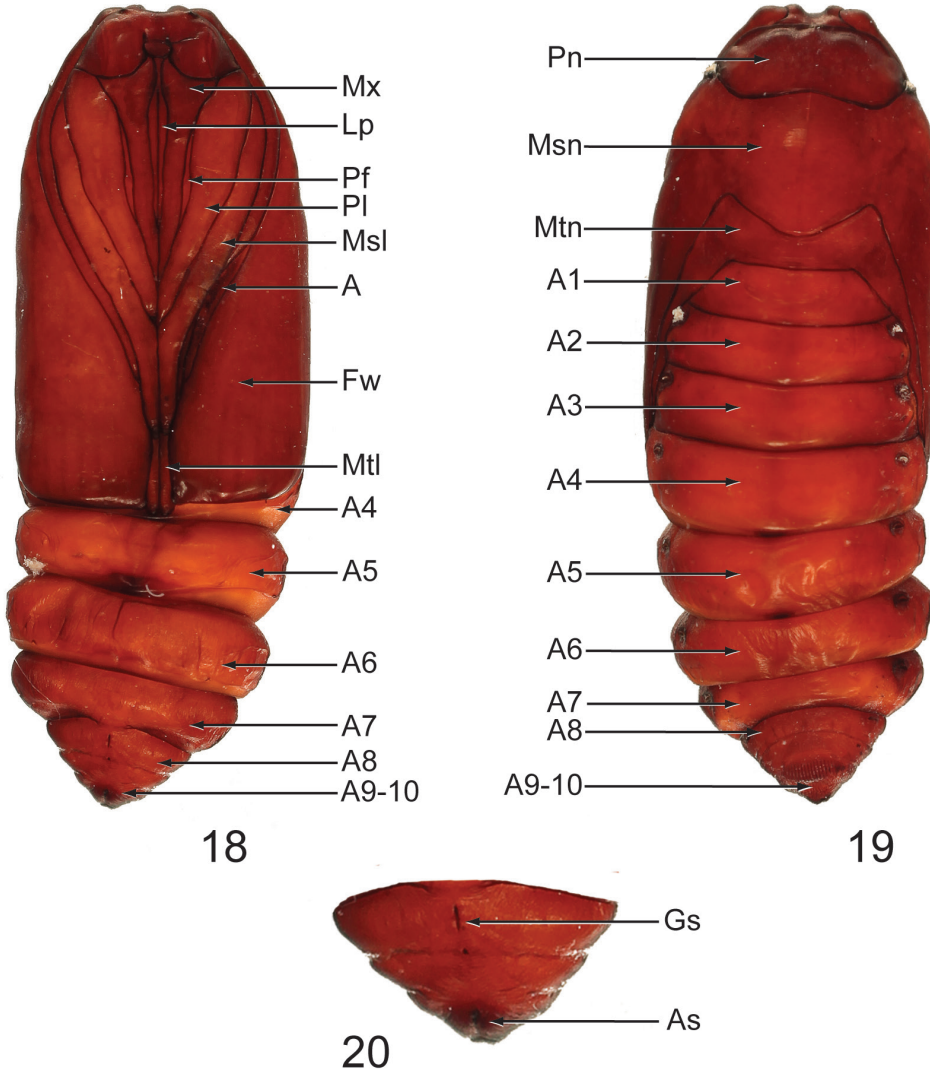
Figures 13–14. Larva of *Gadirtha fusca* sp. n. **13** on Chinese tallow **14** on Chinese tallow.

prothoracic shield, pale, less than half length of other setae; single prespiracular seta; SV1 and SV2 on same pinnacula; ventral projection present. T2 and T3 with D1, D2, SD1, and SD2 elongate, black on separate, conical pinnacula; L1 and L2 on same pinnacula, black (L1 pale on T3), L2 longest, L3 short, pale, and hairlike; SV1 and SV2



Figures 15–17. Male pupa of *Gadirtha fusca* sp. n. (preserved in alcohol). **15** dorsal **16** ventral **17** closeup of A8–A10 (**A** antenna; **As** anal suture; **Fw** forewing; **Gs** genital suture; **Lp** Labial palp; **Msl** mesothoracic leg; **Msn** mesonotum; **Mtl** metathoracic leg; **Mtn** metanotum; **Mx** maxillae; **Pf** prothoracic femur; **Pl** prothoracic leg; **Pn** pronotum).

elongate, white, on same pinnacula. *Abdomen* – Spiculate; A1 with D1, D2, SD1, and L1, elongate, black; D2 on very large conical pinnacula; SD2 white, hairlike, directly caudal to spiracle; L1 brown, posterior to spiracle, L2 and L3 white on separate pinnaculae; SV1 and SV2 present. A2 with D1, D2, SD1, L1, elongate, black; D2 on



Figures 18–20. Female pupa of *Gadirtha fusca* sp. n. (preserved in alcohol). **18** dorsal **19** ventral **20** closeup of A8–A10 (**A** antenna; **As** anal suture; **Fw** forewing; **Gs** genital suture; **Lp** Labial palp; **Msl** mesothoracic leg; **Msn** mesonotum; **Mtl** metathoracic leg; **Mtn** metanotum; **Mx** maxillae; **Pf** prothoracic femur; **Pl** prothoracic leg; **Pn** pronotum).

conical pinnacula, but smaller than on A1; rest of setae as in A1 except L1 posterior and ventral to spiracle. A3–A6 with D1, D2, and SD1 elongate, black; SD2 white, hairlike; L2 and L3 white on separate pinnaculae; 3 SV setae, white; crochets uniordinal mesoseries. A7–A8 with D1 and D2 black, L1 white on A7 and black on A8, elongate; SD2 caudal to spiracle, white, hairlike; on SV seta. A9 with D1, D2, SD1, and L1, elongate, black; L and SV group absent; A9 appears to fuse with A8 ventrally. A10

with D1 and SD1 brown, elongate; SD2 pale brown, elongate; D2 white, elongate; SV1, L2 and L3 brown, elongate; 4 SV setae white; crochets uniordinal mesoseries.

Pupa (Figs 15–20): Length: 18.8–19.0 mm in male (*n* = 3) (Figs 15–17), 18.8–19.2 mm in female (*n* = 3) (Figs 18–20). Obtect; adecticous; smooth, dark brown; labial palpus (Lp) extends from clypeus to approximately 0.7 × length of maxillae (Mx); prothoracic leg (Pl) approximately 1.16 × length of maxillae; prothoracic femora (Pf) present, narrow, shorter than maxillae; maxillae short, approximately half the length from clypeus to forewing apex; mesothoracic leg (Msl) approximately 0.8 × length from clypeus to forewing apex; antenna (A) shorter than mesothoracic leg; metathoracic leg (Mtl) visible between mesothoracic leg and apex of forewing; segments A8–A10 separate in male A9–A10 fused in female; genital suture on A9 in male set between two bumps and on A8 in female; anal suture on A10; cremaster absent.

Etymology. The specific epithet refers to the dark grayish brown ground color of the forewing.

Biology. *Gadirtha fusca* overwinter as eggs on leaves and branches of Chinese tallow and hatch in May. Larvae feed on leaves and complete six instars in 15 days and can cause extensive defoliation, especially during the last three instars. There can be 4–5 generations per year in Hubei Province (Wang et al. 2012).

Distribution. East central and southeastern China.

Discussion. It is curious why *G. fusca* was misidentified in the biocontrol literature as *G. inexacta* (Wang et al. 2012). In reviewing Holloway (2003), *G. inexacta* does not occur in China and the life history is unknown. The more obvious misidentification would be with *G. impingens*, which does occur in China, larvae are known to feed on species of Euphorbiaceae, and morphology of the male genitalia are similar.

Acknowledgments

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RESEARCH ARTICLE

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Two new species in the *Echinoderes coulli* group (Echinoderidae, Cyclorhagida, Kinorhyncha) from the Ryukyu Islands, Japan

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Abstract

Two new species belonging to the *Echinoderes coulli* group are described with their external morphologies and sequences of nuclear 18S rRNA and 28S rRNA genes, and mitochondrial COI gene. The first species, *Echinoderes komatsui* **sp. n.**, is characterized by absence of acicular spines, and presence of lateroventral tubules on segments 5 and 8, laterodorsal tubules on segment 10, inverted triangle or wide oval shaped large sieve plates, lateral terminal accessory spines in female, and short tips of ventral pectinate fringe on segment 10. The second species, *Echinoderes hwiizaa* **sp. n.**, is characterized by absence of acicular spines, and presence of lateroventral tubules on segments 5 and 7–9, midlateral tubules on segment 8, laterodorsal tubules on segment 10, large narrow oval shaped sieve plates on segment 9, and thick, short and blunt lateral terminal spines about 10–15% of trunk length. The diagnostic characters and key to species of *E. coulli* group are provided as well.

Keywords

Echinoderes, Kinorhyncha, Meiofauna, Taxonomy, Okinawa, Ishigaki

Introduction

Echinoderes is the most species-rich genus in the marine phylum Kinorhyncha. At present, 82 *Echinoderes* species have been reported worldwide, from the intertidal zone to abyssal depths and from polar to tropical regions (Sørensen and Pardos 2008, Herranz et al. 2013, Neuhaus 2013, Sørensen 2013, 2014). Only a few species have been reported from brackish waters and most of these belong to the *Echinoderes coulli* species group.

The *E. coulli* group was proposed for the first time by Ostmann et al. (2012), as comprising species adapted to highly fluctuating estuarine habitats. Currently the group contains seven species (*Echinoderes applicitus* Ostmann et al., 2012; *Echinoderes coulli* Higgins, 1977; *Echinoderes marthae* Sørensen, 2014; *Echinoderes maxwelli* Omer-Cooper, 1957; *Echinoderes ohtsukai* Yamasaki & Kajihara, 2012; *Echinoderes rex* Lundbye et al., 2011; and *Echinoderes teretis* Brown, 1999) (Omer-Cooper 1957, Higgins 1977, Brown 1985, Adrianov and Malakhov 1999, Lundbye et al. 2011, Ostmann et al. 2012, Yamasaki and Kajihara 2012, Sørensen 2014). These species share the following morphological features: (1) middorsal spines are absent, or reduced to a short spine and occur only on segment 4; (2) lateroventral acicular spines are absent, or if present, very short and occur on segments 6 and 7; (3) lateral tubules are present at least on segments 5 and 8; (4) relatively large sieve plates consisting of a sieve area and a posterior pore are present; (5) lateral terminal accessory spines are absent in both sexes. The large sieve plates, which function in osmotic regulation, appear to be adaptive to estuarine habitats.

Among the seven species in the *E. coulli* group, only *E. rex* has not been reported from an estuarine environment, but instead inhabits subtidal marine waters (Lundbye et al. 2011). Two alternative hypotheses might explain the origin of adaptations to brackish water environments: (1) the adaptive characters arose only once, and *E. rex* has secondarily returned to a fully marine environment, or (2) adaptive characters arose several times independently in the *E. coulli* group (Ostmann et al. 2012, Yamasaki and Kajihara 2012). No phylogenetic analysis has been performed to determine which hypothesis is correct yet.

In this paper we describe two new species of the *E. coulli* group collected from the Ryukyu Islands, southern Japan. In addition to the morphological descriptions, we include the sequences of three genes for each of these species. We also summarize the morphological diagnostic characters for the group and provide a key to species.

Materials and methods

Sediment samples were taken at two stations by hand at low tide (Fig. 1). Station 1 is an intertidal flat with a mangrove area in Oura Bay, Okinawa Island, Japan (26°33.35'N, 128°2.57'E); samples were collected on 26 May 2013 and 8 July 2013. Station 2 is an intertidal flat in Kabira Bay, Ishigaki Island, Japan (24°27.58'N, 124°8.57'E); samples

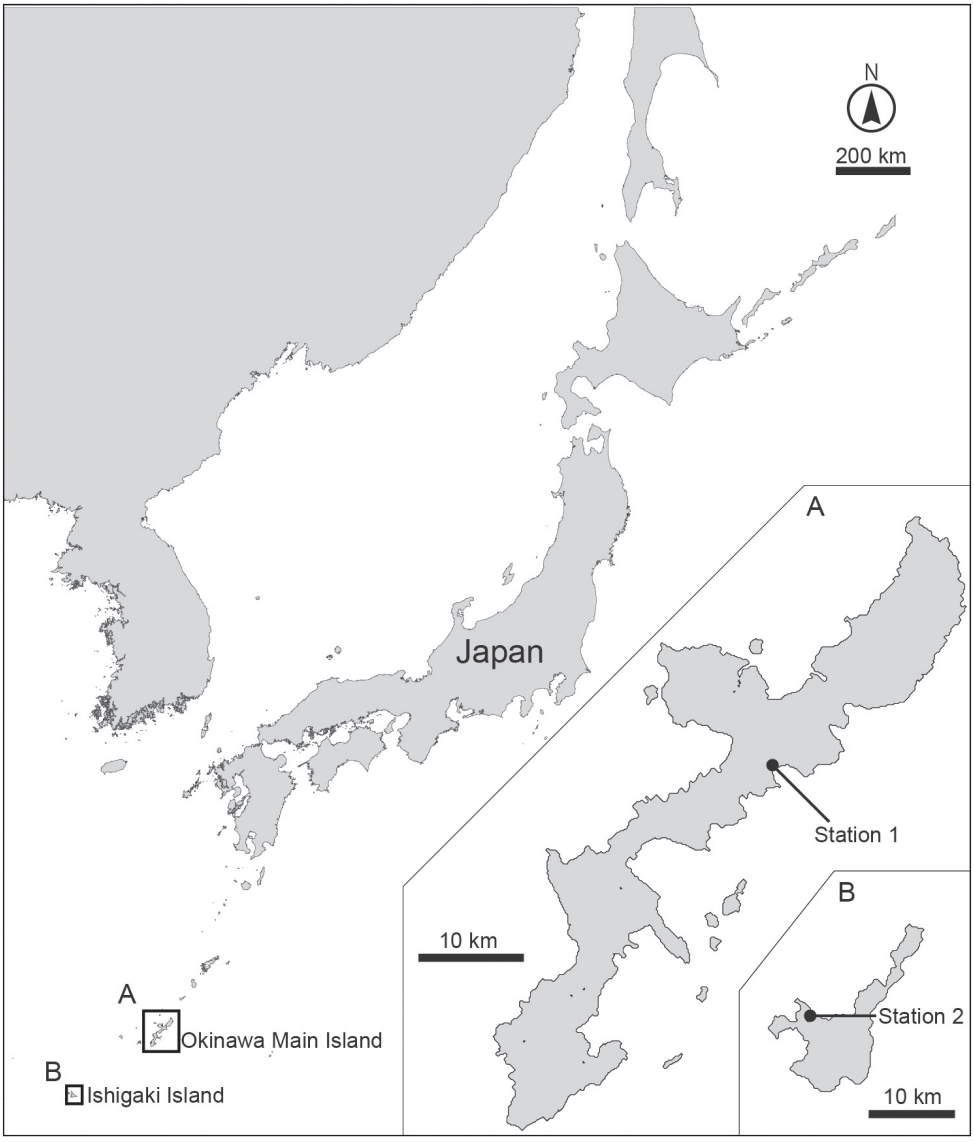


Figure 1. Maps showing the sampling sites. **A** Close-up of the Okinawa main island and **B** Ishigaki island.

were collected on 23 June 2013. All samples consisted of mud mixed with sand, without black sulfide sediments.

Kinorhynchs were extracted from the samples by using the bubbling and blot method (Higgins 1988, Sørensen and Pardos 2008). Extracted animals including kinorhynchs were washed with fresh water and preserved in 99% EtOH. In the laboratory, kinorhynch specimens were sorted under a stereomicroscope. Some specimens were used for DNA extraction. The others were observed by light microscopy (LM) or scanning electron microscopy (SEM).

Table 1. List of PCR and cycle sequencing (CS) primers used in this study.

Gene	Primer name	Reaction	Primer sequence (in 5'–3' direction)	Direction	Source
18S rRNA	F1	PCR & CS	TACCTGGTTGATCCTGCCAG	Forward	Yamaguchi and Endo (2003)
	R9	PCR & CS	GATCCTTCCGCAGGTTCACCTAC	Reverse	Yamaguchi and Endo (2003)
	F2	CS	CCTGAGAAACGGCTRCCACAT	Forward	Yamaguchi and Endo (2003)
	F3	CS	GYGRTCAGATACCRCCSTAGTT	Forward	Yamaguchi and Endo (2003)
	F4	CS	GGTCTGTGATGCCCTYAGATGT	Forward	Yamaguchi and Endo (2003)
	R6	CS	TYTCTCRKGCTBCCTCTCC	Reverse	Yamaguchi and Endo (2003)
	R7	CS	GYYARAACTAGGGCGGTATCTG	Reverse	Yamaguchi and Endo (2003)
	R8	CS	ACATCTRAGGGCATCACAGACC	Reverse	Yamaguchi and Endo (2003)
28S rRNA	28S-01	PCR & CS	GACTACCCCCTGAATTTAAGCAT	Forward	Kim et al. (2000)
	28Sr	PCR & CS	ACACACTCCTTAGCGGA	Reverse	Luan et al. (2005)
	28Sf	PCR & CS	TGGGACCCGAAAGATGGTG	Forward	Luan et al. (2005)
	28S-3KR	PCR & CS	CCAATCCTTTTCCCGAAGTT	Reverse	Yamasaki et al. (2013)
	28S-2KF	PCR & CS	TTGGAATCCGCTAAGGAGTG	Forward	Yamasaki et al. (2013)
	28jj-3'	PCR & CS	AGTAGGGTAAAACTAACCT	Reverse	Palumbi (1996)
	28S-n05R	CS	CTCACGGTACTTGTTCGCTAT	Reverse	Yamasaki et al. (2013)
	28SR-01	CS	GACTCCTTGGTCCGTGTTTCAAG	Reverse	Kim et al. (2000)
	28S-15R	CS	CGATTAGTCTTTCGCCCCTA	Reverse	Yamasaki et al. (2013)
	28S-3KF	CS	AGGTGAACAGCCTCTAGTCG	Forward	Yamasaki et al. (2013)
	28v-5'	CS	AAGGTAGCCAAATGCCTCATC	Forward	Palumbi (1996)
	28S-42F	CS	GAGTTTGACTGGGGCGGTA	Forward	Yamasaki et al. (2013)
COI	LCO1490	PCR & CS	GGTCAACAAATCATAAAGATATTGG	Forward	Folmer et al. (1994)
	HCO2198	PCR & CS	TAAACTTCAGGGTGACCAAAAAATCA	Reverse	Folmer et al. (1994)

Total genomic DNA was extracted from selected single individuals with a DNeasy Tissue Kit (Qiagen, Tokyo), following the protocol of Yamasaki et al. (2013). After DNA extraction, the exoskeleton of each specimen was mounted for LM as described below. Parts of the nuclear 18S and 28S rRNA genes and the mitochondrial COI gene were amplified by PCR using primer sets 18S-F1/18S-R9 for 18S; 28S-01/28Sr, 28Sf/28S-3KR, and 28S-2KF/28jj-3' for 28S; and LCO1490/HCO2198 for COI (see Table 1 for primer references and sequences). PCR conditions for 18S and 28S were 95 °C for 1 min; 35 cycles of 95 °C for 30 sec, 45 °C for 1 min 30 sec, and 72 °C for 3 min; and 72 °C for 7 min. Conditions for COI were 95 °C for 1 min; 35 cycles of 95 °C for 30 sec, 45 °C for 1 min 30 sec, and 72 °C for 90 sec; and 72 °C for 7 min. All nucleotide sequences were determined by direct sequencing with a BigDye Terminator Kit ver. 3.1 (Life Technologies, Co., USA) and a 3730 DNA Analyzer (Life Technologies, Co., USA). Sequence fragments were assembled by using MEGA 5 (Tamura et al. 2011). After assembly, sequences were deposited in GenBank under accession numbers AB899164–AB899171.

Specimens for LM were transferred into dehydrated glycerin to replace the ethanol with glycerin and were then mounted in Fluoromount G® between two cover slips attached to a plastic H-S slide. They were observed, sketched, and photographed with an Olympus BX51 microscope equipped with a Nikon DS-Fi1c camera and a drawing tube. Line illustrations were drawn in Adobe Illustrator CS5, based on scanned camera lucida drawings of mounted specimens. Measurements were made with a Nikon DS-L3 camera control unit.

Specimens for SEM were immersed in 100% butanol for several minutes, freeze dried, mounted on aluminum stubs, sputter-coated with gold-palladium, and observed with a JEOL JSM-6060LV scanning electron microscope at 15 kV accelerating voltage.

The terminology follows Neuhaus and Higgins (2002), Sørensen and Pardos (2008), and Neuhaus (2013). Type material has been deposited in the University Museum, University of the Ryukyus (Fujukan), under accession numbers having the prefix RUMF-ZK-00001–00018.

Results

Order Cyclorhagida Zelinka, 1896
Family Echinoderidae Bütschli, 1876
Genus *Echinoderes* Claparède, 1863

***Echinoderes komatsui* sp. n.**
http://zoobank.org/19C1A89B-5AB4-4886-BE01-B04D55DEEBD1
http://species-id.net/wiki/Echinoderes_komatsui
[New Japanese name: Komatsu togekawa]
Figs 2–6

Material. Holotype: Adult female (RUMF-ZK-00001), collected on 26 May 2013 at station 1 (Fig. 1A) by Dr H. Komatsu (National Museum of Nature and Science, Tokyo, Japan) during a sampling cruise with TR/V *Toyoshio-maru* (Hiroshima University, Japan); mounted in Fluoromount G®.

Allotype: Adult male (RUMF-ZK-00002), collected at the same locality as the holotype; mounted in Fluoromount G®.

Paratypes: Three adult females and two adult males RUMF-ZK-00003–00007); two exoskeletons (RUMF-ZK-00008–00009) from DNA-extracted specimens (one adult female and one adult male); all collected at same locality as the holotype; all mounted in Fluoromount G®. Paratype RUMF-ZK-00003 was collected on 26 May 2013, and the others on 8 July 2013.

Additional material: Six specimens for SEM (one adult female, three adult males, and two adults gender undetermined), collected at same locality as holotype on 8 July 2013, mounted on aluminum stubs.

Sequences: 18S sequence (1778 bp) for paratype RUMF-ZK-00008, GenBank accession AB899164; 28S sequence (3292 bp) for paratype RUMF-ZK-00008, Gen-

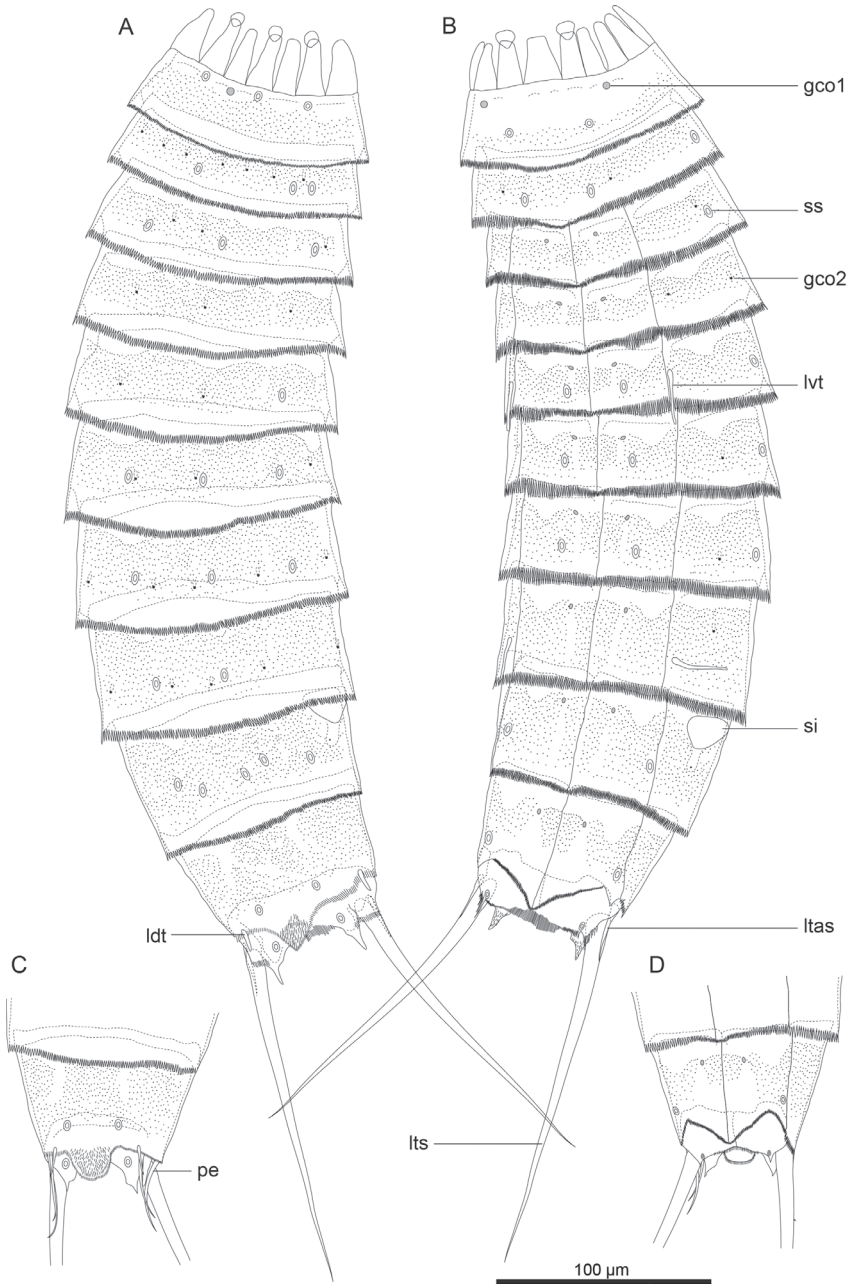


Figure 2. *Echinoderes komatsui* sp. n., camera lucida drawings. **A, B** Holotype, female (RUMF-ZK-00001), entire animal, dorsal and ventral views, respectively **C, D** allotype, male (RUMF-ZK-00002), segments 9–11, dorsal and ventral views, respectively. Double circle, grey circle, and black circle indicate sensory spot, type 1 glandular cell outlet, and type 2 glandular cell outlet, respectively. Abbreviations: gco1, type 1 glandular cell outlet; gco2, type 2 glandular cell outlet; ldt, laterodorsal tubule; ltas, lateral terminal accessory spine; lts, lateral terminal spine; lvt, lateroventral tubule; pe, penile spine; si, sieve plate; ss, sensory spot.

Table 2. Measurements for adult *Echinoderes komatsui* sp. n. (in micrometers). Columns *N* and SD show sample size and standard deviation, respectively. Abbreviations: (f), female condition of sexually dimorphic character; LD, length of laterodorsal tubule; LTAS, length of lateral terminal accessory spine; LTS, length of lateral terminal spine; LV, length of lateroventral tubule; (m), male condition of sexually dimorphic character; MSW, maximum sternal width; S, segment length; SW, standard width; TL, trunk length.

Character	N	Range	Mean	SD
TL	9	304–419	354	45.37
MSW-9	7	49–75	63	11.48
MSW-9/TL	7	15.3–19.8%	17.1%	1.54%
SW-10	7	40–72	58	11.81
SW-10/TL	7	12.7–17.7%	15.6%	1.72%
S1	7	25–41	36	5.82
S2	7	20–35	29	6.27
S3	7	24–33	29	3.97
S4	7	27–37	32	4.42
S5	7	28–38	33	3.83
S6	7	32–42	37	4.15
S7	7	38–48	42	4.47
S8	7	41–55	48	5.55
S9	7	44–59	52	6.39
S10	7	40–50	43	3.54
S11	7	26–38	33	5.48
LV 5	9	19–31	24	4.44
LV 8	9	17–28	23	4.49
LD 10 (m)	4	21–23	22	0.96
LD 10 (f)	5	8–13	10	2.07
LTS	8	145–164	153	6.23
LTS/TL	8	36.6–46.9%	42.3%	3.96%
LTAS (f)	5	12–23	18	5.54

Bank AB899165; COI sequence (658 bp)for paratype RUMF-ZK-00008, GenBank AB899166.

Diagnosis. *Echinoderes* without acicular spines; lateroventral tubules present on segments 5 and 8, laterodorsal tubules on segment 10, and large, sieve plates on segment 9 with an inverted triangular or oval shape; females with lateral terminal accessory spines. Pectinate fringe of the sternal plate on segment 10 with short tips.

Description. Adult with head, neck, and eleven trunk segments (Figs 2A, B, 3A, 4A). See Table 2 for measurements. Table 3 indicates the positions of cuticular structures (sensory spots, glandular cell outlets, and tubules).

Head consists of retractable mouth cone and introvert (Figs 4E, 5). Mouth cone with inner oral styles and nine outer oral styles. Exact number and arrangement of inner oral styles not examined. Each outer oral style consists of rectangular basal part and triangular distal part (Fig. 4B). Basal parts of outer oral styles alternating in size: five large in odd sectors of introvert, and four small in even sectors (Figs 4B, 5). Intro-

Table 3. Summary of location of cuticular structures, tubules, and spines in *Echinoderes komatsui* sp. n. Abbreviations: (f), female condition of sexually dimorphic character; gco1, type 1 glandular cell outlet; gco2, type 2 glandular cell outlet; LD, laterodorsal; ltas, lateral terminal accessory spine; lts, lateral terminal spine; LV, lateroventral; (m), male condition of sexually dimorphic character; MD, middorsal; ML, midlateral; pe, penile spine; SD, subdorsal; si, sieve plate; ss, sensory spot; tu, tubule; VL, ventrolateral; VM, ventromedial.

Position / segment	MD	SD	LD	ML	LV	VL	VM
1	gco1	ss	ss		gco1	ss	
2	ss	gco2, gco2	ss, gco2, ss, gco2		gco2	ss	
3		gco2, ss		ss, gco2			gco1
4		gco2	gco2		gco2		gco1
5		gco2	ss		tu		gco1, ss
6		gco2, ss	ss	gco2			gco1, ss
7		gco2, ss	gco2, ss	gco2			gco1, ss
8		gco2, ss	gco2	gco2	tu		gco1
9		ss, ss	ss	si		ss	gco1
10		ss	tu			ss	gco1
11		ss		ltas (f), pe (m)	lts	ss	

vert composed of seven rings of spinoscalids and one ring of trichoscalids (Figs 4E, 5). Ring 01 includes ten primary spinoscalids each with basal sheath and smooth long end piece (Fig. 4E). Each basal sheath with three overlapping fringes. Proximal fringe extends into three flat projections, like a trident, covering next fringe. Middle fringe with two lateral projections overlapping end piece. Distal fringe with five threads projecting between two projections of middle fringe. End piece of primary spinoscalids is longest unit. Rings 02 and 04 with 10 spinoscalids; rings 03 and 05 with 20 spinoscalids. Spinoscalids of rings 02–05 equal length. Rings 06 and 07 not examined in detail, but ring 06 with at least seven relatively short spinoscalids, and ring 07 with nine leaf-like scalids (Fig. 5). Six trichoscalids attached with trichoscalid plate in sectors 2, 4, 5, 7, 8, and 10.

Neck with 16 placids (Figs 2A, B, 4D, 5). Midventral placid broadest (ca. 18 μm at basal width and ca. 10 μm at tip width). Remaining placids similar in size, but differ alternately in tip width (ca. 12 μm at basal width and ca. 5–6 μm at tip width) (Fig. 4D).

Segment 1 consists of complete cuticular ring with thick pachycyclus at anterior margin. Bracteate cuticular hairs densely cover entire dorsal side, and posterior area of ventral side (Fig. 2A, B). Rounded subdorsal and laterodorsal sensory spots located close to anterior margin of the segment (Fig. 2A). Rounded ventrolateral sensory spots located central between anterior and posterior segment margins (Figs 2B, 4G). Type 1 glandular cell outlets situated anteriorly in middorsal and lateroventral positions (Fig. 2A, B). Posterior part of the segment with pectinate fringe showing longer fringe tips laterally (Fig. 2A, B).

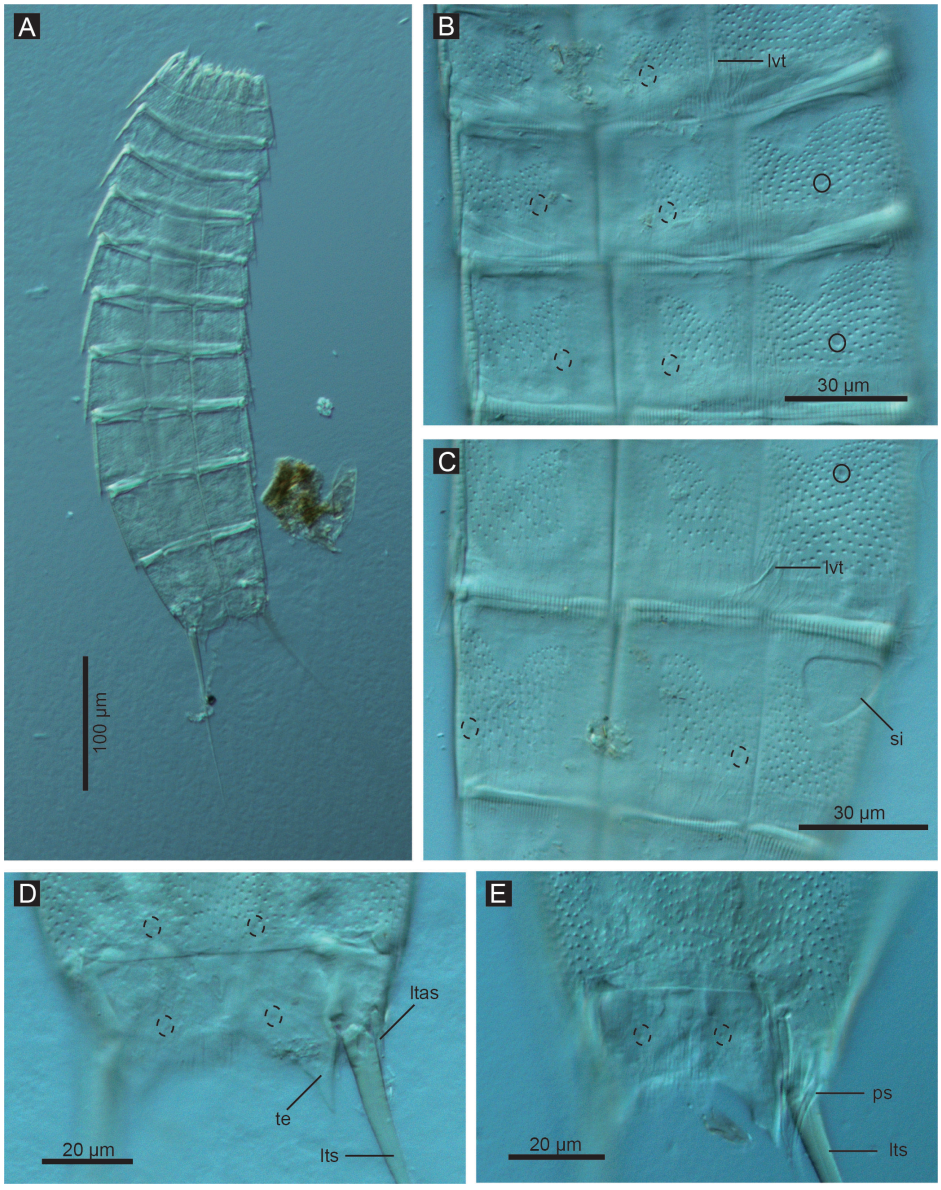


Figure 3. *Echinoderes komatsui* sp. n., Nomarski photomicrographs. **A** Entire animal **B** segments 5–7, ventral view **C** segments 8 and 9, ventral view **D** segments 10 and 11 of female, dorsal view **E** segments 10 and 11 of male, dorsal view. Complete circles indicate type 2 glandular cell outlet; dashed circles indicate sensory spots. Abbreviations: ltas, lateral terminal accessory spine; lts, lateral terminal spine; lvt, lateroventral tubule; ps, penile spine; si, sieve plate; te, tergal extension.

Segment 2 with complete cuticular ring, like segment 1 (Fig. 2A, B). This and following eight segments with thick pachicycli at anterior margins. Bracteate cuticular hairs densely cover whole area. One oval sensory spot in middorsal position, two pairs

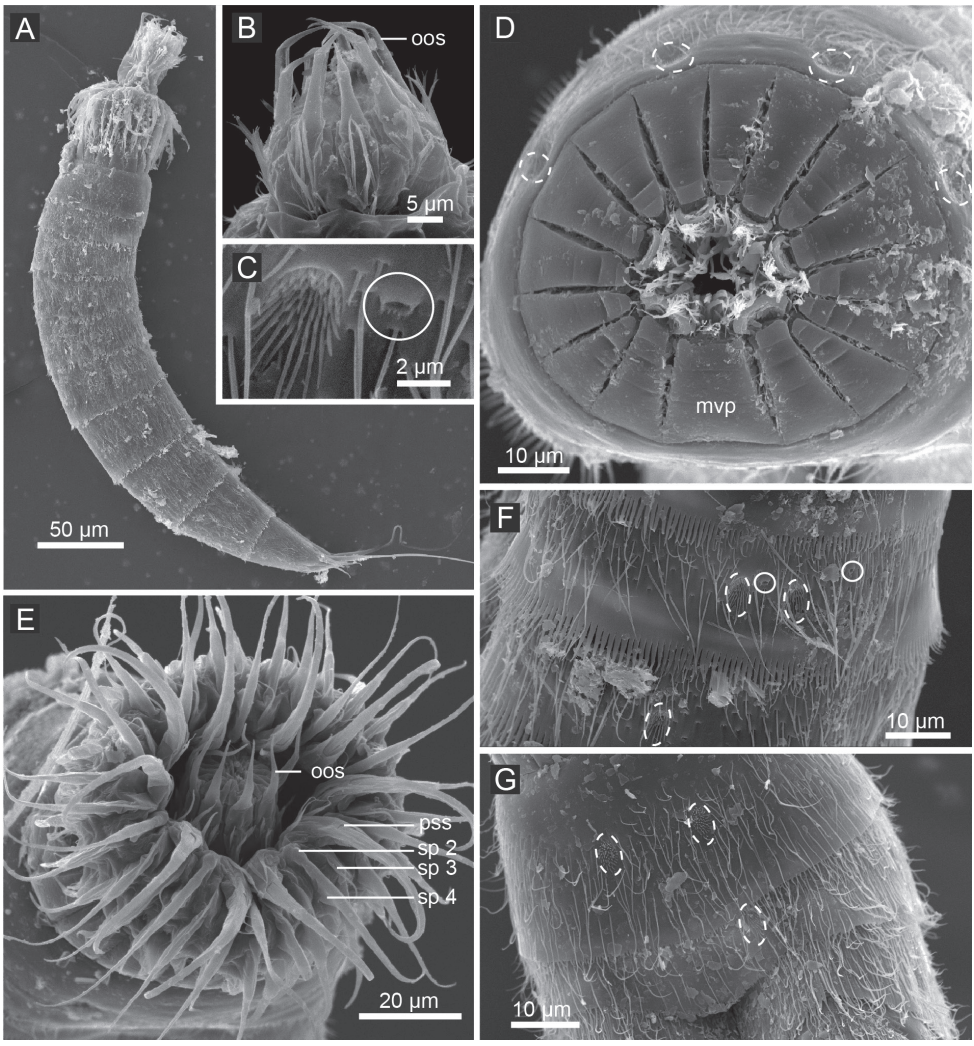


Figure 4. *Echinoderes komatsui* sp. n., scanning electron micrographs. **A** Entire animal, lateral view **B** outer oral styles, lateral view **C** close up of laterodorsal type 2 glandular cell outlet on segment 2 **D** neck, overview **E** partly retracted head, overview **F** segments 2–3, lateral view **G** segments 1–3, ventral view. Complete circles indicate type 2 glandular cell outlets; dashed circles indicate sensory spots. Abbreviations: mvp, midventral placid; oos, outer oral style; pss, primary spinoscalid; sp, spinoscalid followed by ring number.

in laterodorsal position, and one pair in ventrolateral position (Figs 2A, B, 4F, G). All sensory spots central in position. Two pairs of type 2 glandular cell outlets in both subdorsal and laterodorsal positions (Figs 2A, B, 4C, F). Pair of type 2 glandular cell outlets in lateroventral position. All type 2 glandular cell outlets of segment 2 and following six segments situated centrally of the segment. In LM observation, type 2 glandular cell outlets show funnel shaped structure, whereas in SEM observation, they

show single small pore in slightly protruded cuticular surface (Fig. 4C). Posterior margin of the segment ends as pectinate fringe showing longer tips than tips of preceding segment (Figs 2A, B, 4F).

Segment 3 and following eight segments consist of one tergal and two sternal plates (Fig. 2A, B). This and following seven segments entirely covered with bracteate cuticular hairs except for anterior area (Figs 2A, B, 3B, C). Paired sensory spots in subdorsal and midlateral positions (Figs 2A, B, 4F). Type 1 glandular cell outlets of segment 3 and following seven segments situated at anterior part of segment in ventromedial position (Fig. 2B).Pair of type 2 glandular cell outlets in subdorsal and midlateral positions (Fig. 2A, B). Pectinate fringe on segment 3 and five following segments as on segment 2.

Segment 4 without sensory spots. Type 2 glandular cell outlets in subdorsal, laterodorsal, and lateroventral positions (Fig. 2A, B).

Segment 5 with lateroventral tubules (Figs 2B, 3B, 6A). Sensory spots in laterodorsal and ventromedial positions (Figs 2A, B, 3B, 6A). Paired type 2 glandular cell outlets in subdorsal position (Fig. 2A).

Segment 6 with subdorsal, laterodorsal, and ventromedial paired sensory spots (Figs 2A, B, 3B, 6A). Paired type 2 glandular cell outlets in subdorsal and midlateral positions (Figs 2A, B, 3B, 6A).

Segment 7 similar to segment 6 but with additional laterodorsal type 2 glandular cell outlets (Figs 2A, B, 3B, 6A).

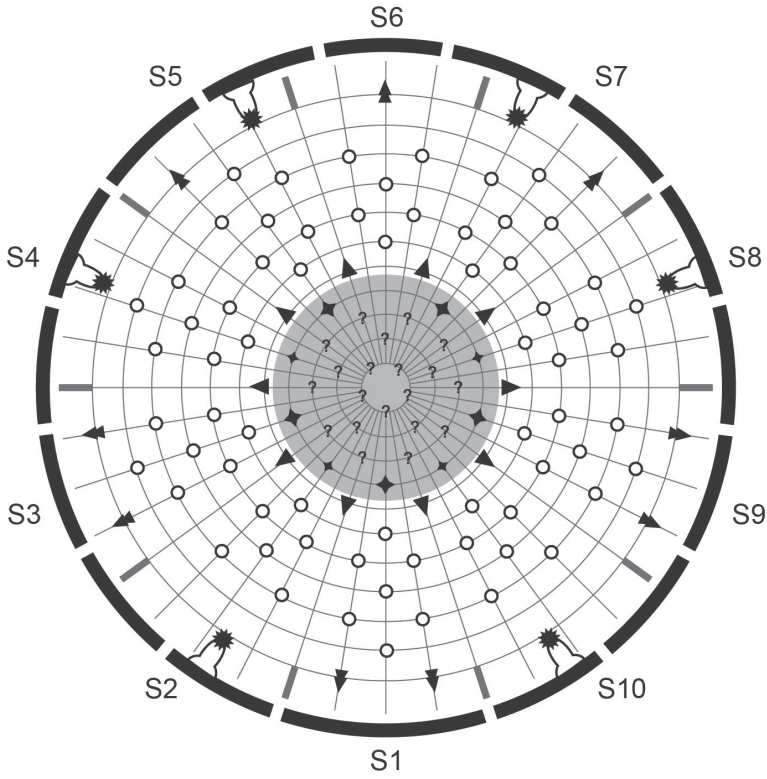
Segment 8 with lateroventral tubules (Figs 2B, 3C, 6A). Paired sensory spots in subdorsal position (Fig. 2A). Positions of type 2 glandular cell outlets as on segment 7.

Segment 9 with two pairs of subdorsal sensory spots and one pair of laterodorsal and ventrolateral sensory spots (Figs 2A, B, 3C, 6B). Pair of sieve plates with wide sieve area and single posterior pore situated in midlateral position. Sieve area variable in shape, forming inverted triangle in some specimens and broad oval in others (Figs 2A, B, 3C, 6B). Tips of pectinate fringe slightly shorter in length than on preceding segment.

Segment 10 with thin laterodorsal tubules (Figs 2A, 6C). Length of laterodorsal tubules in males about twice as long as those in females. Paired subdorsal and ventrolateral sensory spots situated close to posterior margin of segment (Figs 2, 3D, 6C, D). Posterior middorsal margin elongated, extending to segment 11 in some specimens (Figs 2A, 6C), but truncate in other specimens. Posterior margin ends as pectinate fringe with short tips, except in ventrolateral area, which without pectination.

Segment 11 with lateral terminal spines (Figs 2, 3D, E, 6C, D). Short, thin lateral terminal accessory spines present only in females (Figs 2B, 3D, 6D), and three pairs of penile spines only in males (Figs 2C, 3E, 6C). Cuticular hairs absent. Paired sensory spots present in subdorsal position at base of tergal extension (Figs 2A, C, 3D, E, 6C). Ventrolateral paired sensory spots placed close to posterior margin of sternal plate (Figs 2B, D, 6D). Tergal plate projects laterally and ends in short, pointed tergal extensions (Figs 2A, C, 3D, E, 6C, D).

Etymology. The species is named after Dr H. Komatsu (National Museum of Nature and Science, Tokyo, Japan), a taxonomist of brachyuran crabs and the first person to find *Echinoderes komatsui* sp. n.



Scalid and style arrangement

Ring/Section	1	2	3	4	5	6	7	8	9	10	Total
00 outer oral styles ✦	1	1	1	1	1	0	1	1	1	1	9
01 primary spinoscalids ▼	1	1	1	1	1	1	1	1	1	1	10
02 spinoscalids ○	1	1	1	1	1	1	1	1	1	1	10
03 spinoscalids ○	2	2	2	2	2	2	2	2	2	2	20
04 spinoscalids ○	1	1	1	1	1	1	1	1	1	1	10
05 spinoscalids ○	2	2	2	2	2	2	2	2	2	2	20
06 spinoscalids ○	1?	0?	1?	1?	1?	0?	1?	1?	1?	0?	7?
07 spinoscalids ○	2?	0?	2?	0?	1?	1?	1?	0?	2?	0?	9?
07 trichoscalids ✹	0	1	0	1	1	0	1	1	0	1	6

Figure 5. Diagram of mouth cone, introvert, and placids in *Echinoderes komatsui* sp. n. Grey area and heavy line arcs show mouth cone and placids, respectively. The table lists the scalid arrangement by sector.

Remarks. Among congeners, *Echinoderes komatsui* sp. n. is most similar to *E. applicitus*, *E. coulli*, and *E. marthae* in sharing the following combination of characters: (1) lateral (lateroventral or lateral accessory) tubules only on segments 5 and 8, (2) middorsal spines absent on all segments, and (3) large sieve plates present (Higgins 1977, Ostmann et al. 2012, Sørensen 2014). *Echinoderes komatsui* sp. n. additionally shares

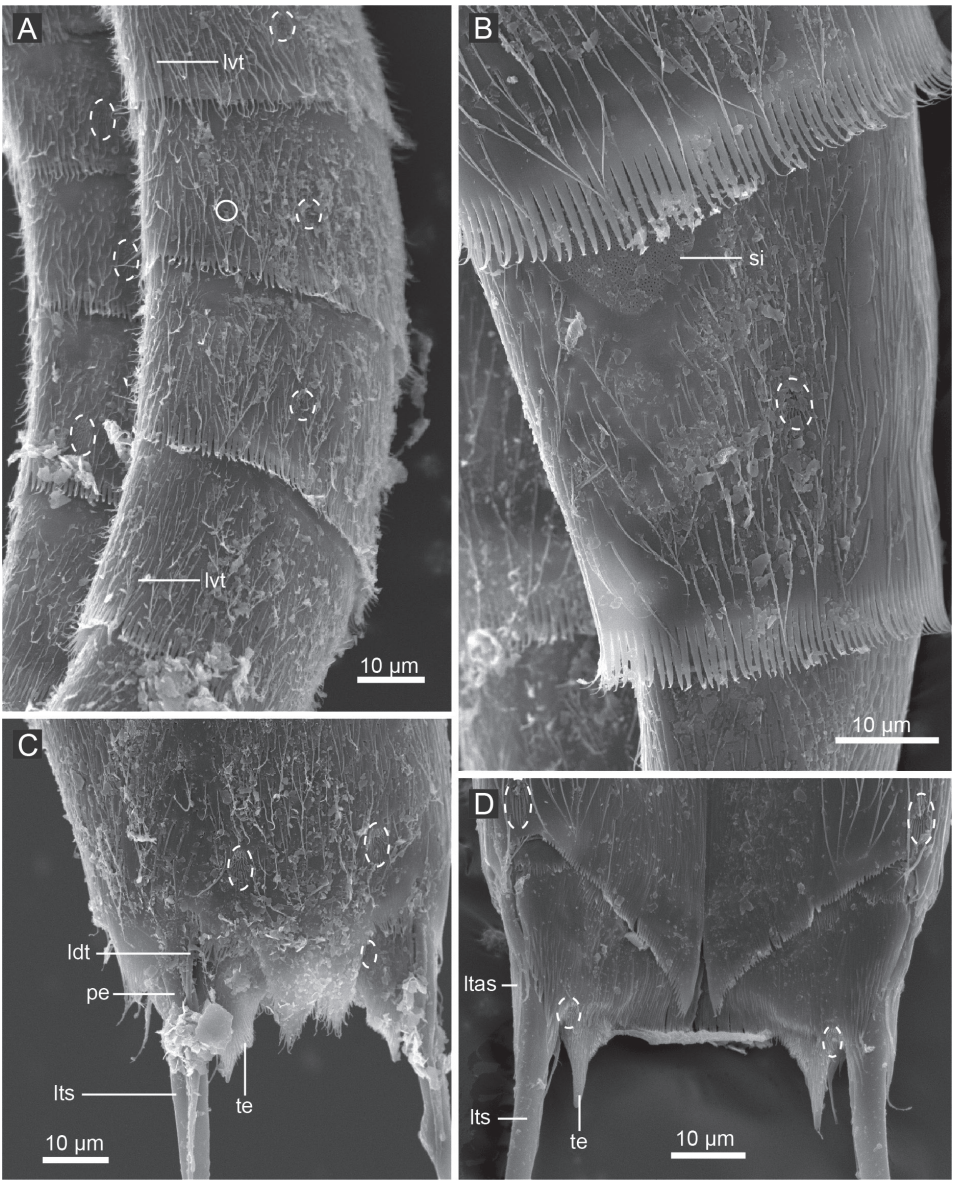


Figure 6. *Echinoderes komatsui* sp. n., scanning electron micrographs. **A** Segments 5–8, lateral view **B** segments 8, lateral view **C** segments 10 and 11, male, dorsal view **D** segments 10 and 11, female, ventral view. Complete circle indicates type 2 glandular cell outlet; dashed circles indicate sensory spots. Abbreviations: ldt, laterodorsal tubule; ltas, lateral terminal accessory spine; lts, lateral terminal spine; lvt, lateroventral tubule; pe, penile spine; si, sieve plate; te, tergal extension.

with *E. applicitus* a pair of laterodorsal tubules and a posteriorly extended margin of the tergal plate on segment 10. The latter character, previously considered diagnostic for *E. applicitus*, is variable in *E. komatsui* sp. n. *Echinoderes komatsui* sp. n. differs from *E.*

applicitus in having (1) lateral terminal accessory spines in females, (2) type 2 glandular cell outlets on several segments, and (3) a pectinate fringe with short, narrow tips on the sternal plate of segment 10 (long wide tips in *E. applicitus*).

Echinoderes komatsui sp. n. is identical to *E. coulli* in the formula of ventral tubules, and both trunk lengths overlap (304–419 μm in *E. komatsui* sp. n.; 248–364 μm in *E. coulli*). *Echinoderes komatsui* sp. n. differs from *E. coulli* in having (1) laterodorsal tubules on segment 10, (2) lateral terminal accessory spines in females, and (3) much longer lateral terminal spines (145–164 μm and 36.6–46.9% of trunk length in *E. komatsui* sp. n.; 18–68 μm and 5.5–23.9% of trunk length in *E. coulli*).

Echinoderes komatsui sp. n. shares with *E. marthae* the presence of tubules on segment 8, however, the number of tubules is different. *Echinoderes komatsui* sp. n. has only lateroventral tubules, whereas *E. marthae* has lateroventral and laterodorsal tubules. Furthermore, *E. komatsui* sp. n. differs from *E. marthae* in having (1) type 2 glandular cell outlets on some segments, (2) lateral terminal accessory spines in females, and (3) three pairs of penile spines in males (two pairs in *E. marthae*).

Echinoderes hwiizaa sp. n.

http://zoobank.org/64C79CE3-861E-43BE-B7BC-F3F0FE6819EA
http://species-id.net/wiki/Echinoderes_hwiizaa
[New Japanese name: Yagitsuno togekawa]
Figs 7–11

Material. Holotype (RUMF-ZK-00010): Adult female, collected by H. Yamasaki on 23 June 2013 at station 2 (Fig. 1B); mounted in Fluoromount G®.

Allotype (RUMF-ZK-00011): Adult male, collected at the same locality as the holotype; mounted in Fluoromount G®.

Paratypes: Two adult females and two adult males (RUMF-ZK-00012–00015); three exoskeletons (RUMF-ZK-00016–00018) from specimens used for DNA extraction (one adult female and two adult males); all collected at the same locality as the holotype; all mounted in Fluoromount G®.

Other material: six specimens for SEM (four adult females, one adult male, and one adult gender undetermined), collected at the same locality as the holotype, mounted on aluminum stubs.

Sequences: 18S sequence (1775 bp) for paratype RUMF-ZK-00017, Genbank accession AB899167; 28S sequence (2233 bp) for paratype RUMF-ZK-00017, GenBank AB899168; COI sequences (all 658 bp) for three paratypes (RUMF-ZK-00016–00018), GenBank AB899169–AB899171, respectively.

Diagnosis. *Echinoderes* without acicular spines; with lateroventral tubules on segments 5, 7, 8, and 9, midlateral tubules on segment 8, laterodorsal tubules on segment 10, and large, narrow oval-shaped sieve plates on segment 9; lateral terminal spines relatively thick, short, with blunt tips, length about 10–15% of trunk length.

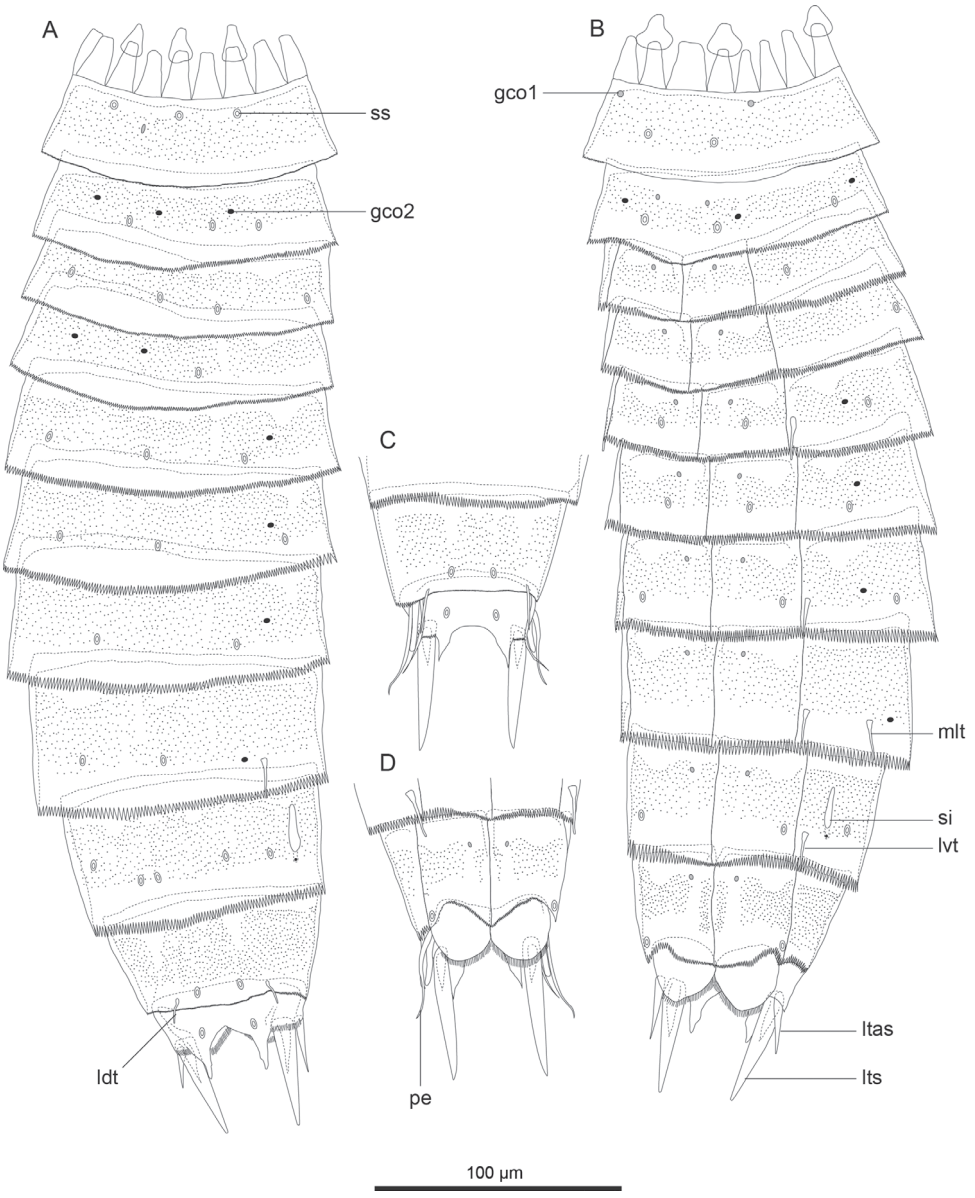


Figure 7. *Echinoderes hwiizaa* sp. n., camera lucida drawings. **A, B** paratype, female (RUMF-ZK-00016), entire animal, dorsal and ventral views, respectively **C, D** allotype, male (RUMF-ZK-00011), segments 9–11, dorsal and ventral views, respectively. Double circle, grey circle, and black circle indicate sensory spot, type 1 glandular cell outlet, and type 2 glandular cell outlet, respectively. Abbreviations: gco1, type 1 glandular cell outlet; gco2, type 2 glandular cell outlet; ldt, laterodorsal tubule; ltas, lateral terminal accessory spine; lts, lateral terminal spine; lvt, lateroventral tubule; mlt, midlateral tubule; pe, penile spine; si, sieve plate; ss, sensory spot.

Table 4. Measurements for adult *Echinoderes hwiizaa* sp. n. (in micrometers). Columns N and SD show sample size and standard deviation, respectively. Abbreviations: (f), female condition of sexually dimorphic character; LD, length of laterodorsal tubule; LTAS, length of lateral terminal accessory spine; LTS, length of lateral terminal spine; LV, length of lateroventral tubule; (m), male condition of sexually dimorphic character; ML, length of midlateral tubule; MSW, maximum sternal width; S, segment length; SW, standard width; TL, trunk length.

Character	N	Range	Mean	SD
TL	8	385–414	400	11.72
MSW-8	9	64–75	69	3.99
MSW-8/TL	8	16.7–19.1%	17.4%	0.75%
SW-10	9	52–65	61	4.08
SW-10/TL	8	13.5–16.1%	15.2%	0.89%
S1	8	38–47	41	2.53
S2	8	30–41	36	3.66
S3	9	28–32	30	1.56
S4	9	31–33	32	0.71
S5	9	31–38	34	1.79
S6	9	37–43	39	1.66
S7	9	43–48	46	1.94
S8	9	46–56	52	3.45
S9	9	46–56	50	3.2
S10	9	43–52	46	3.42
S11	9	34–46	38	4.16
LV 5	9	18–25	20	2.1
LV 7	9	15–22	34	2.42
ML 8	9	16–22	19	2.36
LV 8	9	16–22	19	1.81
LV 9	9	13–19	17	1.71
LD 10 (m)	5	15–21	18	2.39
LD 10 (f)	4	10–14	12	2.06
LTS	9	46–53	51	2.11
LTS/TL	9	11.6–13.5%	12.7%	0.59%
LTAS (f)	4	21–29	26	3.58

Description. Adult with head, neck and eleven trunk segments (Figs 7A, B, 8A). See Table 4 for measurements, and Table 5 for positions of cuticular structures (sensory spots, glandular cell outlets, and tubules).

Head consists of retractable mouth cone and introvert (Figs 9A, B, 10). Mouth cone with inner oral styles and nine outer oral styles. Exact number and arrangement of inner oral styles not observed. Each outer oral style composed of rectangular basal part and triangular distal part. Basal parts of outer oral styles alternate in size: five large in odd sectors of introvert, and four small in even sectors (Fig. 9A). Posterior to basal part of each outer oral style, two spinose hairs project anteriorly, covering outer oral style (Fig. 9A). Introvert composed of seven rings of scalids and one ring of tri-

Table 5. Summary of location of cuticular structures, tubules, and spines in *Echinoderes hwiizaa* sp. n. Abbreviations: (f), female condition of sexually dimorphic character; gco1, type 1 glandular cell outlet; gco2, type 2 glandular cell outlet; LD, laterodorsal; ltas, lateral terminal accessory spine; lts, lateral terminal spine; LV, lateroventral; (m), male condition of sexually dimorphic character; MD, middorsal; ML, midlateral; PD, paradorsal; pe, penile spine; SD, subdorsal; si, sieve plate; SL, sublateral; ss, sensory spot; tu, tubule; VL, ventrolateral; VM, ventromedial.

Position / segment	MD	PD	SD	LD	ML	SL	LV	VL	VM
1	gco1		ss	ss			gco1		ss
2	ss		gco2	ss, gco2, ss				gco2	ss, gco1
3			ss	ss		ss			gco1
4			gco2	ss					gco1
5			ss	ss	gco2		tu		gco1, ss
6			ss		gco2, ss				gco1, ss
7	ss			ss	gco2		tu	ss	gco1
8			ss	gco2	tu		tu		gco1
9		ss		ss	ss	si	tu	ss	gco1
10			ss	tu				ss	gco1
11			ss		ltas (f), pe (m)		lts		

choscalids (Figs 9B, 10). Ring 01 includes ten primary spinoscalids with basal sheath and long, smooth end piece (Fig. 9B). Each basal sheath with three fringes. Proximal fringe extends into three long projections, like a trident, covering next fringe. Middle basal fringe with two lateral projections, overlapping end piece. Distal fringe with five to seven threads projecting between two projections of middle fringe. End piece of primary spinoscalids is longest unit. Rings 02 and 04 with 10 spinoscalids, and rings 03 and 05 with 20 spinoscalids. Spinoscalids of rings 02–05 similar in length. Rings 06 and 07 could not be examined in detail, but at least seven relatively short spinoscalids present in ring 06, and 13 leaf-like scalids in ring 07. Six trichoscalids present each attached with trichoscalid plate in sectors 2, 4, 5, 7, 8, and 10.

Neck with 16 placids (Figs 7A, B, 8B, 10). Midventral placid broadest (ca. 17 μm at basal width and ca. 11 μm at tip width); remaining placids with similar size (ca. 11 μm at basal width and ca. 5 μm at tip width).

Segment 1 consists of complete cuticular ring with pachycyclus at anterior margin (Figs 7A, B, 8B). Non-bracteate cuticular hairs densely cover entire segment (Fig. 7A, B). Paired rounded subdorsal and laterodorsal sensory spots located close to anterior margin of the segment (Figs 7A, 9C). Rounded ventromedial sensory spots centered between anterior and posterior margins (Fig. 7B). Type 1 glandular cell outlets situated anteriorly in middorsal and lateroventral positions (Fig. 7A, B). Posterior part of the segment with pectinate fringe with very short tips (Fig. 7A, B).

Segment 2 also with complete cuticular ring (Fig. 7A, B), with thick pachycyclus at anterior margin (Fig. 8B). All cuticular surface, except anterior and posterior areas covered with bracteate cuticular hairs (Figs 7A, B, 8B, 9C). Oval sensory spots in

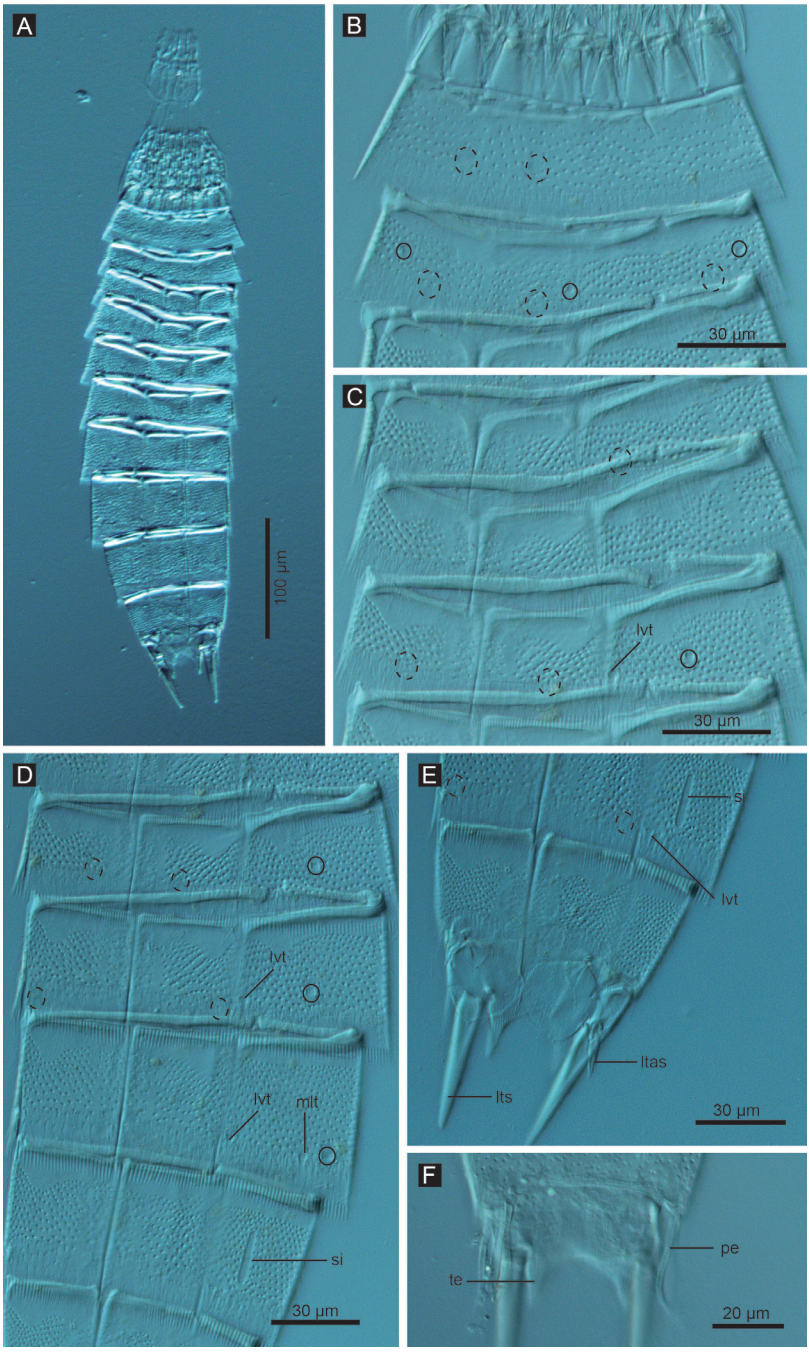


Figure 8. *Echinoderes hwiizaa* sp. n., Nomarski photomicrographs. **A** entire animal **B** segments 1–2, ventral view **C** segments 3–5, ventral view **D** segments 6–9 ventral view **E** segments 9–11 of female, ventral view **F** segment 11 of male, dorsal view. Complete circles indicate type 2 glandular cell outlet; cashed circles indicate sensory spots. Abbreviations: ltas, lateral terminal accessory spine; lts, lateral terminal spine; lvt, lateroventral tubule; mlt, midlateral tubule; pe, penile spine; si, sieve plate; te, tergal extension.

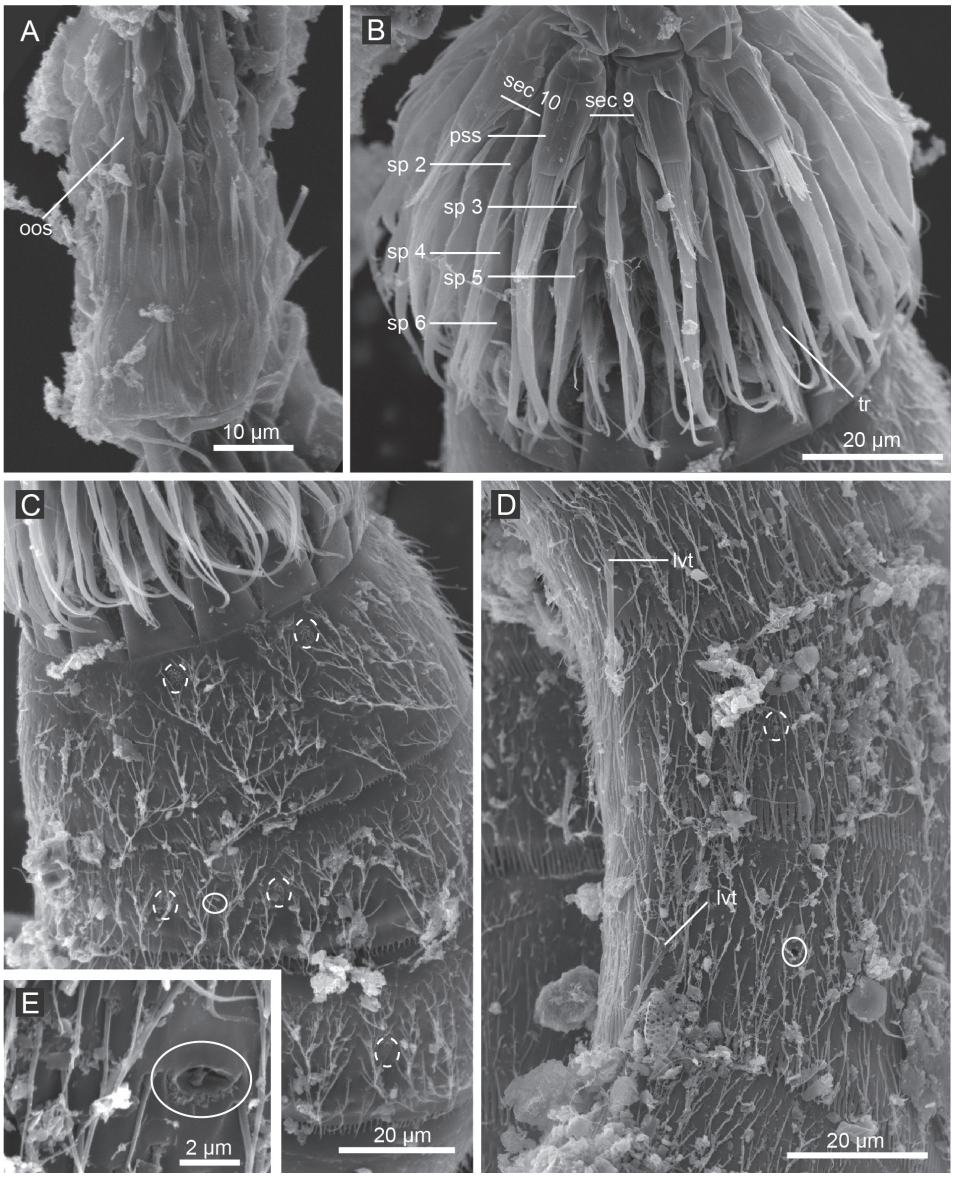
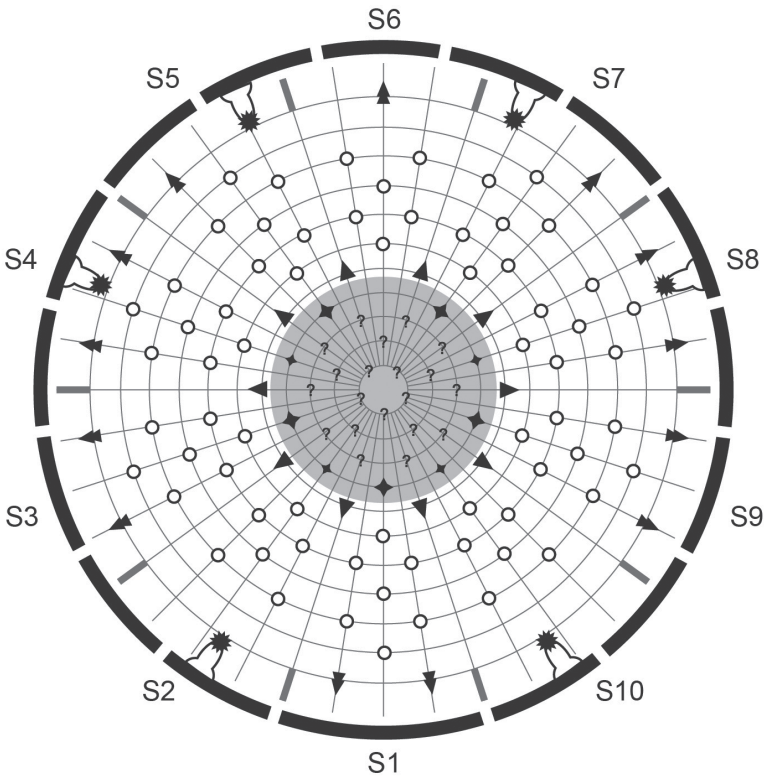


Figure 9. *Echinoderes hwiizaa* sp. n., scanning electron micrographs. **A** Mouth cone **B** introvert, lateral view **C** neck and segments1–3, lateral view **D** segments 5–7, lateral view **E** close up of laterodorsal type 2 glandular cell outlet on segment 2. Complete circles indicate type 2 glandular cell outlet; dashed circles indicate sensory spots. Abbreviations: lvt, lateroventral tubule; oos, outer oral style; pss, primary spinoscalid; sec, introvert sector followed by sector number; sp, spinoscalid followed by ring number.

middorsal, two pairs in laterodorsal, and pair in ventromedial positions (Figs 7A, B, 8B, 9C). Type 2 glandular cell outlets in subdorsal, laterodorsal, and ventrolateral positions (Figs 7A, B, 9C). All type 2 glandular cell outlets of this segment and segment



Scalid and style arrangement

Ring/Section	1	2	3	4	5	6	7	8	9	10	Total
00 outer oral styles ✦	1	1	1	1	1	0	1	1	1	1	9
01 primary spinoscalids ▼	1	1	1	1	1	1	1	1	1	1	10
02 spinoscalids ○	1	1	1	1	1	1	1	1	1	1	10
03 spinoscalids ○	2	2	2	2	2	2	2	2	2	2	20
04 spinoscalids ○	1	1	1	1	1	1	1	1	1	1	10
05 spinoscalids ○	2	2	2	2	2	2	2	2	2	2	20
06 spinoscalids ○	1?	0?	1?	1?	1?	0?	1?	1?	1?	0?	7?
07 spinoscalids ○	2?	0?	2?	2?	1?	1?	1?	2?	2?	0?	13?
07 trichoscalids ✸	0	1	0	1	1	0	1	1	0	1	6

Figure 10. Diagram of mouth cone, introvert, and placids in *Echinoderes hwiizaa* sp. n. Grey area and heavy line arcs show mouth cone and placids, respectively. The table lists the scalid arrangement by sector.

4–7 situated slightly anterior to sensory spots. In LM observation, type 2 glandular cell outlets show oval or box shaped structure, whereas in SEM observation, they show single large pore (Fig. 9E). Type 1 glandular cell outlets placed close to anterior margin in ventromedial position on this and following eight segments (Fig. 7A, B). Posterior margin of segment with pectinate fringe with longer tips than on preceding segment (Figs 7A, B, 9C).

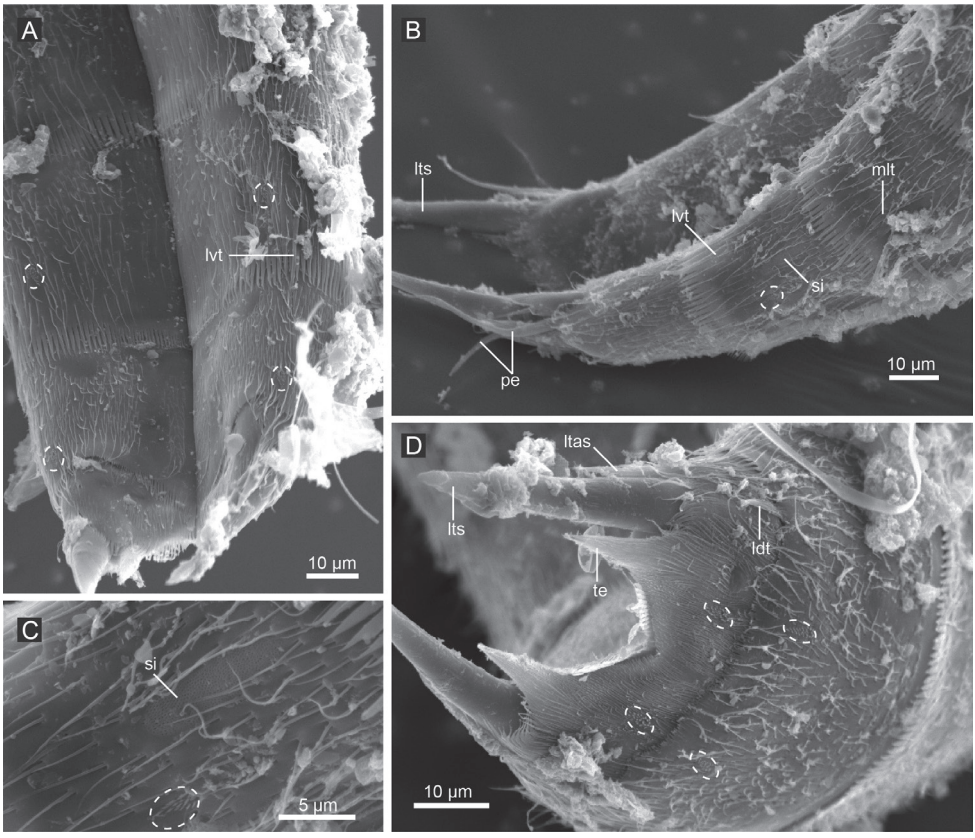


Figure 11. *Echinoderes hwiizaa* sp. n., scanning electron micrographs. **A** segments 8–11, ventral view **B** segments 8–11, lateral view **C** close up showing sieve plate on segment 9 **D** segments 10 and 11, female, dorsal view. Dashed circles indicate sensory spots. Abbreviations: ldt, laterodorsal tubule; ltas, lateral terminal accessory spine; lts, lateral terminal spine; lvt, lateroventral tubule; mlt, midlateral tubule; pe, penile spine; si, sieve plate; te, tergal extension.

Segment 3 and following eight segments consist of one tergal and two sternal plates (Fig. 7A, B). Each plate with thicker pachycycli in anterior areas and articulate areas with other plates. Cuticular hairs on this and following seven segments bracteate, covering entire segment except in anterior, posterior, and paraventral areas (Fig. 7A, B). Sensory spots in subdorsal, laterodorsal, and sublateral positions (Figs 7A, B, 8C). Pectinate fringes as on segment 2.

Segment 4 with pair of laterodorsal sensory spots and paired subdorsal type 2 glandular cell outlets (Fig. 7A, B). Pectinate fringes as on segment 2.

Segment 5 with lateroventral tubules (Figs 7B, 8C, 9D). Paired sensory spots in subdorsal, laterodorsal, and ventromedial positions (Figs 7A, B, 8C). Pair of type 2 glandular cell outlets located in midlateral position (Figs 7A, B, 8C). Tips of pectinate fringes similar in length, and longer than those on three preceding segments on this and following four segments.

Segment 6 with paired subdorsal, midlateral, and ventromedial sensory spots (Figs 7A, 8D, 9D). Pair of type 2 glandular cell outlets present in midlateral position (Figs 7A, B, 8D).

Segment 7 with lateroventral tubules (Figs 7B, 8D, 9D). Middorsal and paired laterodorsal and ventrolateral sensory spots present (Figs 7A, B, 8D). Type 2 glandular cell outlets in midlateral position (Figs 7A, B, 8D, 9D).

Segment 8 with midlateral and lateroventral tubules (Figs 7A, B, 8D, 11B). Paired sensory spots in subdorsal position (Fig. 7A). Paired type 2 glandular cell outlets in laterodorsal position, close to midlateral tubules (Figs 7A, B, 8D).

Segment 9 with lateroventral tubules (Figs 7B, 8E, 11A, B). Paired paradorsal, laterodorsal, midlateral, and ventrolateral sensory spots present (Figs 7A, B, 8E, 11A, B, C). Sieve plates with narrow, oval sieve area and single posterior pore present in sublateral position (Figs7A, B, 8D, E, 11B, C).

Segment 10 with thin laterodorsal tubules in males, and short, thin, hook-shaped laterodorsal tubules in females (Figs 7A, C, 11D). Paired subdorsal and ventrolateral sensory spots situated close to posterior margin of the segment (Figs 7A–D, 11D). Posterior margin ends as pectinate fringe with short tips.

Segment 11 with short and thick lateral terminal spines ending in blunt tip (Figs 7A–D, 8E, 11D). Pair of short lateral terminal accessory spines present only in females (Figs 7A, B, 8E, 11D), and three pairs of penile spines present only in males (Figs 7C, D, 8F, 11B). Cuticular hairs absent. Paired sensory spots situated in subdorsal position (Figs 7A, C, 11D). Tergal plate projects laterally and ends in short, pointed tergal extensions (Figs 7A–D, 8F, 11D).

Etymology. The species name comes from *hwiizaa* ('goat') from one of the Okinawan local languages, referring to the short, thick lateral terminal spines that resemble the horns of goat.

Remarks. Among *Echinoderes* species, only *E. hwiizaa* sp. n. and *E. marthae* (Sørensen 2014) have two pairs of tubules on segment 8 and lack dorsal acicular spines. *Echinoderes hwiizaa* sp. n. differs from *E. marthae* in having (1) lateroventral tubules on segments 7 and 9, (2) very short, thick, blunt lateral terminal spines (46–53 μm long and 11.6–13.5% of trunk length in *E. hwiizaa* sp. n.; 74–103 μm long and 20.4–33.2% of trunk length in *E. marthae*), (3) lateral terminal accessory spines in females, and (4) three pairs of penile spines in males (two pairs in male *E. marthae*).

Discussion

The *Echinoderes coulli* group previously accommodated seven species: *E. coulli*, *E. applicitus*, *E. marthae*, *E. maxwelli*, *E. ohtsukai*, *E. rex*, and *E. teretis* (Omer-Cooper 1957, Higgins 1977, Brown 1985, Lundbye et al. 2011, Ostmann et al. 2012, Yamasaki and Kajihara 2012). These species share the following characters: (1) absence of middorsal acicular spines, or presence of a single spine on segment 4; (2) absence of lateroventral acicular spines, or presence of very short ones only on segments 6 and 7; (3) lateral

tubules on at least segments 5 and 8; (4) relatively large sieve plates consisting of a sieve area and a posterior pore; (5) lateral terminal accessory spines lacking in both sexes. In addition, all species except for *E. rex* were reported from intertidal brackish habitats, such as intertidal flats or mangrove areas, where other echinoderid species are rarely found. These morphological and ecological similarities have been viewed as an evidence to consider the *E. coulli* group a monophyletic group.

Both their morphological characters and habitats suggest that *E. komatsui* sp. n. and *E. hwiizaa* sp. n. are closely related to the seven species which are known as members of the *E. coulli* group, and the two new species also belong to the group. Two new species both lack spines on segments 1–10 completely, have lateroventral tubules on segments 5 and 8 (additionally on segments 7 and 9, and midlateral tubules on segment 8 in *E. hwiizaa* sp. n.), and have relatively large sieve plates. In addition, *E. komatsui* sp. n. was collected in a mangrove area and *E. hwiizaa* sp. n. on an intertidal flat, both areas of variable and often reduced salinity.

Echinoderes komatsui sp. n. and *E. hwiizaa* sp. n. differ from other species in the *E. coulli* group in one particular feature, namely the lack of lateral terminal accessory spines in females. The former two species possess lateral terminal accessory spines in females, however, these spines are very short and seem to be poorly developed. One possibility is that the previous seven species included in the *E. coulli* group are more closely related to one another rather than to any of the two new species. However, the relationships within the group have never been examined with a cladistic analysis. Since the relationships within the group are still open to question, the future phylogenetic studies using more abundant morphological data and/or molecular markers are needed.

Below follows a revised diagnosis of the *E. coulli* group and a dichotomous key to species in the group, modified from Sørensen (2014).

Diagnosis of *Echinoderes coulli* group

Echinoderes without acicular middorsal spines, or with a very short spine only on segment 4; lateral spines very short on segments 6 and 7, or absent; midlateral, sublateral, lateral accessory, or lateroventral tubules on segments 5 and 8; sieve plates relatively large, consisting of oval or inverted-triangular sieve area and single posterior pore; lateral terminal accessory spines poorly developed or completely absent in females.

Dichotomous key to species in the *Echinoderes coulli* group

1 Middorsal spine present on segment 4 ..... **2**
– Middorsal spines absent **5**
2 Lateroventral acicular spines present on segments 6 and 7 ..... **3**
– Lateroventral acicular spines absent **4**

3 Lateral terminal spines conspicuously short, less than 30 μm long; trunk length more than 400 μm long ..... ***E. rex***
– Lateral terminal spines more than 100 μm long; trunk length less than 300 μm long; trunk shows hunch-back-shape ..... ***E. teretis***
4 Type 2 glandular cell outlets absent; segment 10 projecting over segment 11 ... . ***E. maxwelli***
– Type 2 glandular cell outlets present; segment 10 not projecting, not reaching posterior margin of segment 11 ..... ***E. ohtsukai***
5 One pair of tubules on segment 8 ..... **6**
– Two pairs of tubules on segment 8 ..... **8**
6 Laterodorsal tubules present on segment 10; lateral terminal spine measuring more than ca. 30% of trunk length 7
– Laterodorsal tubules absent; lateral terminal spine measuring less than ca. 25% of trunk length ..... ***E. coulli***
7 Type 2 glandular cell outlets present on several segments; pectinate fringes of ventral side of segment 10 with short, narrow tips; lateral terminal accessory spines present in females ..... ***E. komatsui* sp. n.**
– Type 2 glandular cell outlets absent; pectinate fringes of ventral side of segment 10 with long, wide tips; lateral terminal accessory spines absent in females ..... ***E. applicitus***
8 Lateroventral tubules on segments 7 and 9; lateral terminal spines thick, blunt, and measuring less than 15% of trunk length ..... ***E. hwiizaa* sp. n.**
– Lateroventral tubules absent on segments 7 and 9; lateral terminal spines thin, pointed, and measuring more than 20% of trunk length .... ***E. marthae***

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RESEARCH ARTICLE

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Two new species of oribatid mites of the family Galumnidae (Acari, Oribatida) from Vietnam

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Abstract

Two new species of oribatid mites of the family Galumnidae, *Allogalumna monodactyla* **sp. n.** and *Galumna* (*Galumna*) *paracalcicola* **sp. n.**, are described from dark loamy soil under crown of *Ficus* sp. in southern Vietnam. *Allogalumna monodactyla* **sp. n.** is the first identified member of *Allogalumna* recorded for Vietnam. The identification keys to the species of *Allogalumna* from the Oriental region and species of *Galumna* (*Galumna*) from Vietnam and the *calcicola*-group are given.

Keywords

Oribatida, Galumnidae, *Allogalumna*, *Galumna*, new species, key, *calcicola*-group, Vietnam, Oriental region

Introduction

During taxonomic identification of oribatid mites from Dong Nai Biosphere Reserve of southern Vietnam, we found two new species of Galumnidae; one belonging to the genus *Allogalumna* Grandjean, 1936, other to *Galumna* (*Galumna*) Heyden, 1826. The main goal of this paper is to describe these species.

Allogalumna is a genus that was proposed by Grandjean (1936) with *Galumna alamellae* Jacot, 1935 as type species. Currently, it comprises more than 30 species having a cosmopolitan distribution collectively (data summarized by Subías (2004, updated 2013)). In the Vietnamese fauna, *Allogalumna* has been recorded earlier, but some unidentified species has been referred (Vu et al. 1985; Ermilov and Anichkin 2013a). Thus, the new species described here is the first identified member of this genus recorded for Vietnam. We compared our present material with that of previously found one specimen of *Allogalumna* sp. (Ermilov and Anichkin 2013a), and clarified that the latter was the same species.

Galumna is a genus that was proposed by Heyden (1826) with *Notaspis alatus* Hermann, 1804 as type species. Currently, it comprises seven subgenera and more than 180 species having a cosmopolitan distribution collectively (data summarized by Subías (2004, updated 2013)). Among those subgenera, *Galumna* (*Galumna*) is a largest subgenus, comprising about 160 species. At present, this subgenus represented by 10 species in the Vietnamese fauna (Golosova 1983; Mahunka 1989; Krivolutskiy et al. 1997; Ermilov and Anichkin 2010, 2011b, 2013a, 2013b, 2013c, 2013d; Ermilov and Vu 2012; Ermilov et al. 2012; Ermilov and Niedbała 2013).

The generic diagnoses of the genera *Allogalumna* and *Galumna* are summarized earlier by Ermilov et al. (2013b).

Additionally, the identification keys to the *Allogalumna*-species from the Oriental region and *Galumna* (*Galumna*)-species from Vietnam and the *calcicola*-group are given in the present work.

Material and methods

Three specimens (holotype: female; two paratypes: female and male) of *Allogalumna monodactyla* sp. n. and two specimens (holotype and paratypes: both females) of *Galumna* (*Galumna*) *paracalcicola* sp. n. are from: southern Vietnam, 11°26'12"N, 107°24'59"E, Dong Nai Province, Dong Nai Biosphere Reserve, dark loamy soil under crown of large tree (about 40 m height) *Ficus* sp., 30.XI.2013 (collected by A.E. Anichkin and S.G. Ermilov).

Soil samples were collected by taking 10 soil-cores (diameter: 7.8 cm; depth: 10 cm). Samples were left in the metal cores to minimize disturbance during transport from the field to the laboratory. Mites were extracted into 75% ethanol using Berlese's funnels with electric lamps (40 W) for ten days.

Holotypes and paratypes were mounted in lactic acid on temporary cavity slides for measurement and illustration. The body length was measured in lateral view, from the tip of the rostrum to the posterior edge of the ventral plate. The notogastral width refers to the maximum width in dorsal aspect (without pteromorphs). Lengths of body setae were measured in lateral aspect. All body measurements are presented in micrometers. Formulae for leg setation are given in parentheses according to the sequence

trochanter–femur–genu–tibia–tarsus (famulus included). Formulae for leg solenidia are given in square brackets according to the sequence genu–tibia–tarsus. General terminology used in this paper follows that of F. Grandjean (summarized by Norton and Behan-Pelletier 2009).

Descriptions of new species

Allogalumna monodactyla **Ermilov & Anichkin, sp. n.**
http://zoobank.org/7E80EBC2-CED5-4D18-996C-A08195970871
http://species-id.net/wiki/Allogalumna_monodactyla
Figs 1–6

Diagnosis. Body size 180–188 × 114–123. Body and legs covered by the microgranular cerotegument. Rostral, lamellar and interlamellar setae minute; lamellar setae little longer. Sensilli with disk-like head, having seven cilia. Anterior notogastral margin not developed. Four pairs of porose areas small, rounded, punctiform. Median pore located in centrodorsal part of notogaster. Postanal porose area absent. Legs monodactylous.

Description. *Measurements*. Small species. Body length: 188 (holotype), 180, 184 (two paratypes); notogaster width: 123 (holotype), 114, 118 (two paratypes).

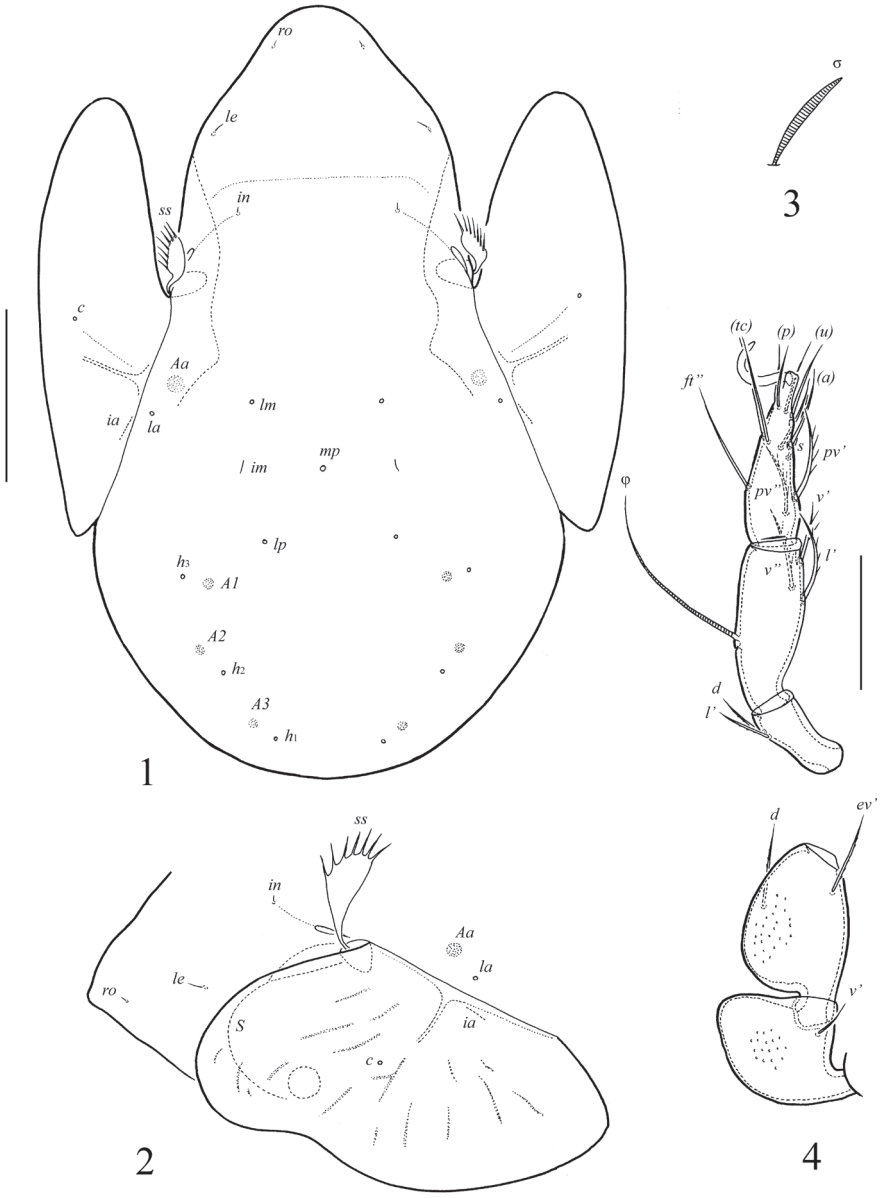
Integument. Body color yellowish-brown to brown. Body and legs covered by the microgranular cerotegument. Granules (up to 1) visible only under high magnification. Body surface smooth. Pteromorphs with distinct radiate wrinkles.

Prodorsum. Rostrum widely rounded. Rostral (*ro*, 2), lamellar (*le*, 4) and interlamellar (*in*, 2) setae thin, smooth. Sensilli (*ss*, 24–28) with short stalk and well-developed disk-like head, having seven cilia (all inserted in one row) of medium size. Exobothridial setae absent. Sublamellar lines (*S*) distinct, typical for *Allogalumna*: long, curving backwards. Porose areas *Ad* not founded.

Notogaster. Anterior notogastral margin not developed. Dorsophragmata absent. Notogastral setae represented by 10 pairs of alveoli. Four pairs of porose areas small, round (*Aa*, 4–6; *A1–A3*, 4), poorly visible, punctiform, without distinct borders. Alveoli of setae *la* inserted latero-posteriorly to *Aa*. Lyrifissures *im* located between *lm* and *lp*. Opisthonotal gland openings not evident. Median pore (*mp*) present in all specimens, located in centrodorsal part of notogaster between the virtual lines connecting *lm* and *lm*, *lp* and *lp*.

Gnathosoma. Morphology of subcapitulum, palps and chelicerae typical for most Galumnidae (for example: Ermilov and Anichkin 2010, 2011a, 2013b; Ermilov et al. 2011, 2013a). Subcapitular setae *h* minute (4), thin, smooth.

Epimeral and lateral podosomal regions. Apodemes (1, 2 sejugal, 3) well visible. Four pairs of epimeral setae observed ventrally; *1a*, *3a*, *3b*, *4a* short (4), thin, smooth. Discidia (*dis*) triangular, circumpedal carinae (*cp*) distinct.



Figures 1–4. *Allogalumna monodactyla* sp. n., adult: **1** dorsal view **2** dorso-lateral view of prodorsum, pteromorph and anterior part of notogaster **3** solenidion of leg genu III **4** leg IV, left, antiaxial view. Scale bar (**1, 2**) 50 μm, (**3, 4**) 20 μm.

Anogenital region. Six pairs of genital (g_1–g_6), one pair of aggenital (*ag*), two pairs of anal (an_1, an_2) and three pairs of adanal (ad_1–ad_3) setae little differs in size, minute (3–4), thin, smooth. Anterior edge of genital plates with two setae. Adanal setae ad_3 inserted laterally to adanal lyrifissures *iad*. Postanal porose area absent.

Table 1. Leg setation and solenidia of adult *Allogalumna monodactyla* sp. n. (same data for *Galumna* (*Galumna*) *paracalcicola* sp. n.)

Leg	Trochanter	Femur	Genu	Tibia	Tarsus
I	*v'*	*d*, *(l)*, *bv"*	*(l)*, *v'*, σ	*(l)*, *(v)*, φ_1, φ_2	*(ft)*, *(tc)*, *(it)*, *(p)*, *(u)*, *(a)*, *s*, *(pv)*, *v'*, *(pl)*, *l"*, *e*, ω_1, ω_2
II	*v'*	*d*, *(l)*, *bv"*	*(l)*, *v'*, σ	*(l)*, *(v)*, φ	*(ft)*, *(tc)*, *(it)*, *(p)*, *(u)*, *(a)*, *s*, *(pv)*, ω_1, ω_2
III	*v'*	*d*, *ev'*	*l'*, σ	*l'*, *(v)*, φ	*(ft)*, *(tc)*, *(it)*, *(p)*, *(u)*, *(a)*, *s*, *(pv)*
IV	*v'*	*d*, *ev'*	*d*, *l'*	*l'*, *(v)*, φ	*ft"*, *(tc)*, *(p)*, *(u)*, *(a)*, *s*, *(pv)*

Roman letters refer to normal setae (*e* to famulus), Greek letters to solenidia. Single prime (') marks setae on anterior and double prime (") setae on posterior side of the given leg segment. Parentheses refer to a pseudosymmetrical pair of setae.

Legs. Monodactylous; claw of each leg smooth. Morphology of leg segments, setae and solenidia typical for most Galumnidae (for example: Ermilov and Anichkin 2010, 2011a, 2013b; Ermilov et al. 2010, 2011), but solenidion of genua III weakly dilated in medial part. Formulae of leg setation and solenidia: I (1–4–3–4–20) [1–2–2], II (1–4–3–4–15) [1–1–2], III (1–2–1–3–15) [1–1–0], IV (1–2–2–3–12) [0–1–0]; homology of setae and solenidia indicated in Table 1.

Type deposition. The holotype is deposited in the collection of the Zoological Institute of the Russian Academy of Sciences, St. Petersburg, Russia; one paratype in deposited in the collection of the Siberian Zoological Museum, Novosibirsk, Russia; one paratype is deposited in the collection of the Tyumen State University Museum of Zoology, Tyumen, Russia.

Etymology. The specific name "*monodactyla*" refers to the monodactylous legs of the new species.

Comparison. *Allogalumna monodactyla* sp. n. differs from other known species of the genus *Allogalumna* by the median pore located in centrodorsal part of notogaster (versus in posterior part) and monodactylous legs (versus tridactylous).

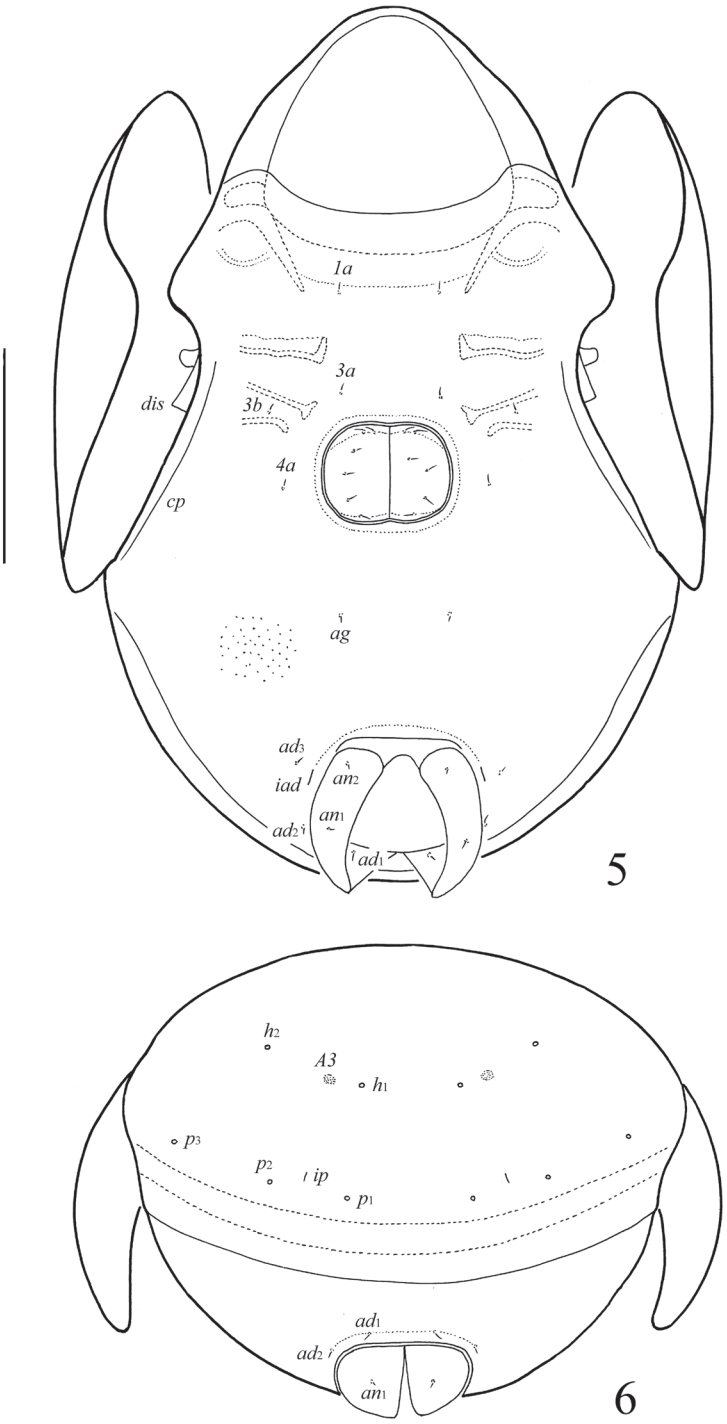
Key to species *Allogalumna* of the Oriental region

1 Sensilli with disk-like head, having seven cilia of medium size; median pore located in centrodorsal part of notogaster, legs monodactylous ... ***Allogalumna monodactyla* sp. n.** (body size: 180–188 × 114–123; distribution: Vietnam)

– Sensilli without disk-like head; median pore located in posterior part of notogaster, legs tridactylous **2**

2 Rostrum pointed; anterior notogastral margin developed; three pairs of porose areas present ..... ***Allogalumna gedaii* Mahunka, 1995** (body size: 449–505 × 312–346; distribution: Thailand; see Mahunka 1995)

– Rostrum rounded; anterior notogastral margin not developed medially; four pairs of porose areas present **3**



Figures 5–6. *Allogalumna monodactyla* sp. n., adult: **5** ventral view (gnathosoma and legs not illustrated) **6** posterior view. Scale bar 20 μm.

3 Sensilli setiform; anal plates striate longitudinally; only rostral setae present, and lamellar and interlamellar setae represented by alveoli .....***Allogalumna asetosa* Ermilov & Kalúz, 2014**
(body size: 564–581 × 415; distribution: India; see Ermilov and Kalúz 2014)

– Sensilli with dilated head; anal plates not striate; all prodorsal setae present or represented by alveoli.....**4**

4 Sensilli with long (longer than head), ciliate stalk; rostral, lamellar and interlamellar setae present; porose areas *Aa* similar to *A1–A3* in size ....***Allogalumna incomplecta* Mahunka, 1988**
(body size: 277–307 × 198–218; distribution: Borneo; see Mahunka 1988)

– Sensilli with short (not longer than head), smooth stalk; rostral, lamellar and interlamellar setae represented by alveoli; porose areas *Aa* larger than *A1–A3* ... .***Allogalumna quadrimaculata* Mahunka, 1988**
(body size: 389–405 × 275–300; distribution: Borneo; see Mahunka 1988)

***Galumna* (*Galumna*) *paracalcicola* Ermilov & Anichkin, sp. n.**
http://zoobank.org/86204514-8F54-4F36-80FA-558D69E90651
http://species-id.net/wiki/Galumna_paracalcicola
Figs 7–10

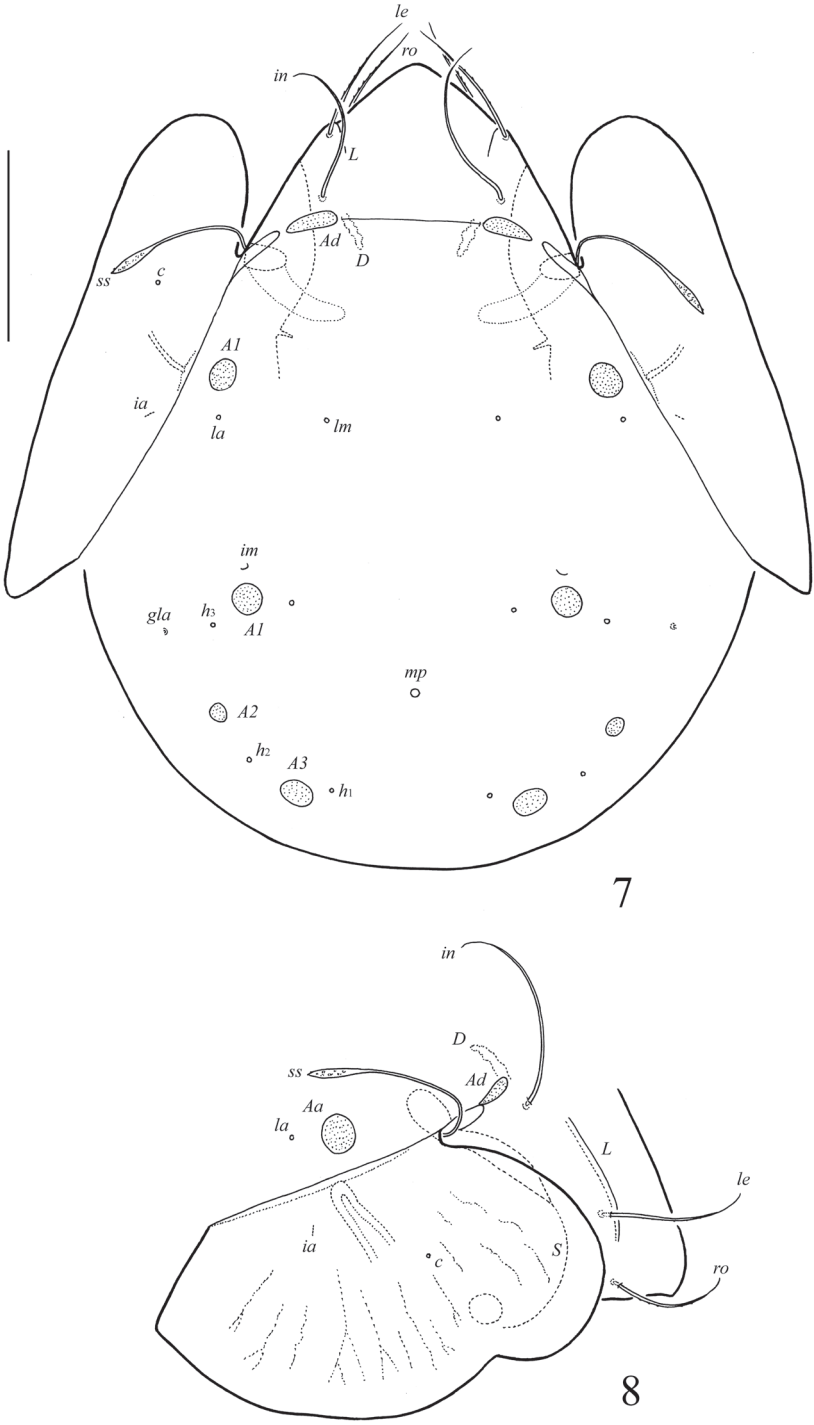
Diagnosis. Body size 398–415 × 298–332. Lamellar lines short, almost straight. Prodorsal setae long, setiform; rostral and lamellar setae slightly barbed, interlamellar setae smooth. Sensilli with long stalk and shorter, lanceolate, indistinctly barbed head. Anterior notogastral margin weakly developed. Four pairs of porose areas rounded. Median pore and postanal porose area present.

Description. *Measurements*. Body of medium size. Body length: 398 (holotype), 415 (paratype); notogaster width: 298 (holotype), 332 (paratype).

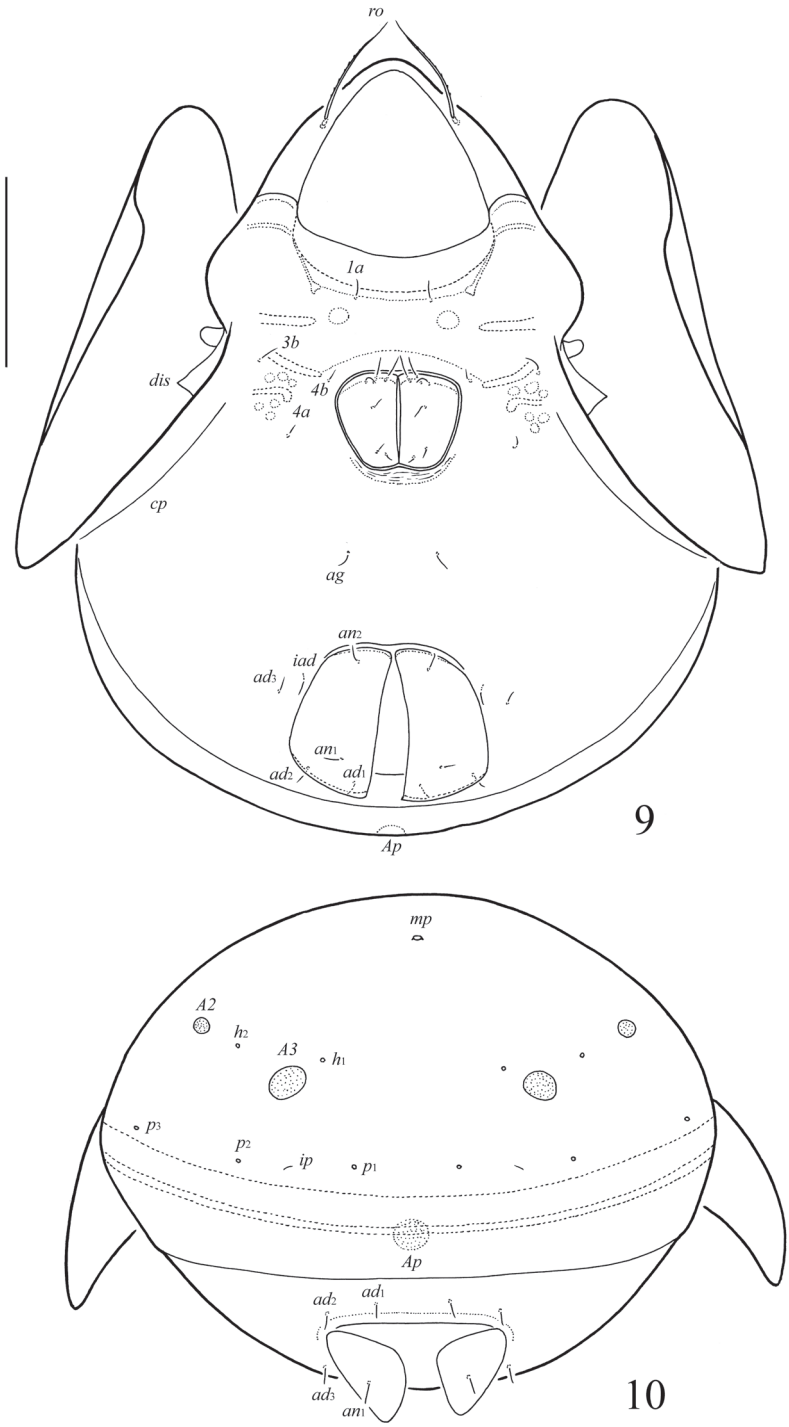
Integument. Body color yellowish-brown. Body surface smooth, but some transverse stria located posteriorly to the genital apertures. Pteromorphs with distinct radiate wrinkles.

Prodorsum. Rostrum widely rounded. Rostral (61–65) and lamellar (73–77) setae setiform, weakly barbed. Interlamellar setae (102–110) setiform, smooth. Sensilli (86–90) with long stalk and shorter, lanceolate, indistinctly barbed head. Exobothridial setae absent. Sublamellar lines distinct, typical for *Galumna* (*Galumna*): long, curving backwards. Lamellar lines (*L*) specific: rather short (not reaching the insertions of rostral setae), amost straight. One pair of porose areas *Ad* large, oval, located posterior to interlamellar setae.

Notogaster. Anterior notogastral margin weakly developed. Dorsophragmata (*D*) of medium size, elongate. Notogastral setae represented by 10 pairs of alveoli. Four pairs of porose areas round (*Aa*, *A3*, 18–20; *A1*, 16; *A2*, 10–12), with distinct borders. Alveoli of setae *la* inserted posteriorly to *Aa*. Lyrifissures *im* located anteriorly to *A1*. Opisthonotal gland openings (*gla*) poorly visible. Median pore represented as large alveolus, located in posterior part of notogaster between the virtual lines connecting *A2–A2*.



Figures 7–8. *Galumna* (*Galumna*) *paracalcicola* sp. n., adult: **7** dorsal view **8** dorso-lateral view of prodorsum, pteromorph and anterior part of notogaster. Scale bar 100 μm.



Figures 9–10. *Galumna* (*Galumna*) *paracalcicola* sp. n., adult: **9** ventral view (gnathosoma and legs not illustrated) **10** posterior view. Scale bar 100 μm.

Gnathosoma. Morphology of subcapitulum, palps and chelicerae typical for most Galumnidae (for example: Ermilov and Anichkin 2010, 2011a, 2013b; Ermilov et al. 2011, 2013a). Subcapitular setae *h* (16) thin, smooth.

Epimeral and lateral podosomal regions. Apodemes (1, 2 sejugal, 3) well visible. Four pairs of epimeral setae observed ventrally; *1a*, *3b* (14–16) longer than *4a*, *4b* (10–12), all thin, smooth. Discidia triangular, circumpedal carinae distinct.

Anogenital region. Six pairs of genital (g_1–g_2, 14–16; g_3–g_6, 10–12), one pair of aggenital (14–16), two pairs of anal (14–16) and three pairs of adanal (14–16) setae thin, smooth. Anterior edge of genital plates with three setae. Adanal setae ad_3 inserted laterally to adanal lyrifissures *iad*. Postanal porose area (*Ap*) rounded (18–20).

Legs. Three claws of each leg smooth. Morphology of leg segments, setae and solenidia typical for most Galumnidae (for example: Ermilov and Anichkin 2010, 2011a, 2013b; Ermilov et al. 2010, 2011). Formulae of leg setation and solenidia: I (1–4–3–4–20) [1–2–2], II (1–4–3–4–15) [1–1–2], III (1–2–1–3–15) [1–1–0], IV (1–2–2–3–12) [0–1–0]; homology of setae and solenidia indicated in Table 1.

Type deposition. The holotype is deposited in the collection of the Zoological Institute of the Russian Academy of Sciences, St. Petersburg, Russia; paratype is deposited in the collection of the Tyumen State University Museum of Zoology, Tyumen, Russia.

Etymology. The prefix *para* is Latin meaning "near" and refers the similarity between the new species and the species *Galumna calcicola* (Aoki & Hu, 1993).

Comparison. *Galumna* (*Galumna*) *paracalcicola* sp. n. can be included in *calcicola*-group. Species of this group have the short (clearly not reaching the insertions of rostral setae), almost straight lamellar lines.

Key to species of *calcicola*-group of the subgenus *Galumna* (*Galumna*)

1 Porose areas *Aa* wedge-shaped or boot-shaped; anterior edge of genital plates with two setae ..... ***Galumna* (*Galumna*) *lanceosensilla* Ermilov, Sidorchuk & Rybalov, 2011** (body size: 547–564 × 381–415; distribution: Ethiopia; see Ermilov et al. 2011)

– Porose areas *Aa* rounded; anterior edge of genital plates with three setae..... **2**

2 Sensilli setiform, with weakly dilated apical half; median pore absent .... ***Galumna* (*Galumna*) *calcicola* (Aoki & Hu, 1993)** (body size: 284–288 × 220–227; distribution: southern China; see Aoki and Hu 1993)

– Sensilli with well-developed lanceolate head; median pore present ..... ***Galumna* (*Galumna*) *paracalcicola* sp. n.** (body size: 398–415 × 298–332; distribution: Vietnam)

Key to species of *Galumna* (*Galumna*) of Vietnam

1 Rostrum pointed **2**

– Rostrum rounded **3**

2 Lamellar lines straight, not parallel to sublamellar lines; rostral setae thickened, ciliate; porose areas *Aa* triangular ..... ***Galumna* (*Galumna*) *kebangica* Ermilov & Vu, 2011** (body size: 547–581 × 381–415; distribution: Vietnam; see Ermilov and Vu 2012)

– Lamellar lines curving backwards, parallel to sublamellar lines; rostral setae thin, slightly barbed; porose areas *Aa* rounded .... ***Galumna* (*Galumna*) *acutirostrum* Ermilov & Anichkin, 2010** (body size: 747–846 × 630–680; distribution: Vietnam; see Ermilov and Anichkin 2010)

3 Lamellar lines short (clearly not reaching the insertions of rostral setae) .... ***Galumna* (*Galumna*) *paracalcicola* sp. n.** (body size: 398–415 × 298–332; distribution: Vietnam)

– Lamellar lines long, reaching the insertions of rostral setae, or curving backwards, parallel to sublamellar lines **4**

4 Interlamellar setae minute or represented by alveoli **5**

– Interlamellar setae well developed, long or medium size..... **8**

5 Anterior margin of notogaster not developed; porose areas *A3* ribbon-shaped ..... ***Galumna* (*Galumna*) *aba* Mahunka, 1989** (body size: 338–413 × 240–274; distribution: Vietnam; see Mahunka 1989)

– Anterior margin of notogaster present; porose areas *A3* rounded or oval 6

6 Porose areas *Aa* boot-shaped; sensilli with weakly-developed, elongate head..... ***Galumna* (*Galumna*) *obvia* (Berlese, 1914)** (body size: 705–898 × 584–647; distribution: semicosmopolitan; see Weigmann 2006; Bayartogtokh 2011; Ermilov et al. 2013a)

– Porose areas *Aa* rounded, oval or triangular; sensilli clavate..... **7**

7 Interlamellar setae represented by alveoli; sensillar head smooth .... ***Galumna* (*Galumna*) *levisensilla* Ermilov & Anichkin, 2010** (body size: 295–328 × 225–246; distribution: Vietnam; see Ermilov and Anichkin 2010)

– Interlamellar setae minute; sensillar head ciliate ..... ***Galumna* (*Galumna*) *flabellifera* Hammer, 1958**[1] (body size: 303–348 × 204–220; distribution: Pantropic and Subtropic regions; see Hammer 1958; Aoki 1964, 1965, 1982)

8 Postanal porose area represented by one pair; lyrifissures *im* located latero-posteriorly to porose areas *A1* ....***Galumna* (*Galumna*) *triquetra* Aoki, 1965** (body size: 469–540 × 327–342; distribution: Oriental region and Australia; see Aoki 1965)

– Only single postanal porose area present; lyrifissures *im* located latero-anteriorly to porose areas *A1* **9**

9 Sensilli setiform, without developed head..... ... ***Galumna* (*Galumna*) *pseudokhoii* Ermilov & Anichkin, 2011** (body size: 498–531 × 365–415; distribution: Vietnam; see Ermilov and Anichkin 2011b)

[1] Aoki (1965) described *Galumna flabellifera orientalis* Aoki, 1965 from Thailand. However, later he (1982) has come to opinion that the subgeneric status of *G. flabellifera orientalis* is impossible, and has counted it as a junior synonym of the type species.

– Sensilli with well-developed lanceolate head ..... ***Galumna* (*Galumna*) *lanceata* (Oudemans, 1900) (? = *Galumna* (*Galumna*) *khoii* Mahunka, 1989)**[2] (body size: 528–670 × 363–460; distribution: Palaearctic region and Vietnam; see Pérez-Íñigo 1993; Weigmann 2006; Bayartogtokh 2011)

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[2] Mahunka (1989) described *Galumna khoii* Mahunka, 1989 from Vietnam. However, it is very similar morphologically to *Galumna lanceata* (Oudemans, 1900). Only distinction is body size, obviously (*G. khoii* smaller: 425–482 × 306–344). Hence, specimens of both these species should be studied and compared for final conclusion.

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RESEARCH ARTICLE

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Taxonomy of the genus *Peyerimhoffia* Kieffer from Mainland China, with a description of seven new species (Diptera, Sciaridae)

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| *http://zoobank.org/4D9B3A38-09F7-46CB-B9A9-9A540951C496*

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Abstract

The taxonomy of the genus *Peyerimhoffia* Kieffer in China was studied. Eight species were recognized, including seven new species that are herein described and illustrated: *P. hamata* **sp. n.**, *P. obesa* **sp. n.**, *P. sparsula* **sp. n.**, *P. longiprojecta* **sp. n.**, *P. brachypodua* **sp. n.**, *P. yunnana* **sp. n.**, and *P. shennongjiana* **sp. n.** In addition, *P. vagabunda* (Winnertz, 1867) is reported for the first time from China. A key to these Chinese species is provided.

Keywords

Diptera, Sciaridae, new species, new record, China

Introduction

Peyerimhoffia Kieffer, 1903 was described as a monotypic genus (type species *Peyerimhoffia brachyptera* Kieffer, 1903 = *Sciara vagabunda* Winnertz, 1867). Tuomikoski (1960) regarded the taxon as a subgenus within *Plastosciara* Berg, 1899 = *Cratyna* Winnertz, 1867 (type species *Cratyna atra* Winnertz), followed by Mohrig and Mamaev (1974) and Menzel and Mohrig (1998, 2000). However, current phylogeny study based on 64 morphological characteristics of adult males (Vilkamaa and Hippa 2005) suggests that *Peyerimhoffia* deserves a generic status.

We herein follow the redefined concept of *Peyerimhoffia* from Vilkamaa and Hippa (2005). The taxon is similar to *Mohrigia* and *Cratyna* (*Spathobdella*) Frey in having a group of setae inside the gonostylus, a visible aedeagal margin of the tegmen, and in having slightly elongated necks of antennal flagellomeres. *Peyerimhoffia* differs in having strongly elongated dorsomesial setae on the gonostylus, and in having strongly angulate margin of tegmen. The species earlier placed in *Peyerimhoffia* and the species of the *Corynoptera crassistylata* group sensu Menzel and Mohrig (2000) proved to form a monophyletic group in two cladistic analyses using adult morphological characters (Vilkamaa and Hippa 2004, Hippa and Vilkamaa 2005). In the latter, the monophyly was supported by five character states, two of which unique: "Mesial side of gonostylus with additional elongated setae" and "apicoventral part of gonostylus with nonsetose area" (Hippa and Vilkamaa 2005).

The concept of *Peyerimhoffia* sensu Vilkamaa & Hippa was crisized by Menzel et al. (2011) but without any argumentation or analysis. A recent molecular phylogeny of Shin et al. (2013) placed *Spathobdella* and *Peyerimhoffia* as sister groups, but of *Peyerimhoffia*, only the type species was in the ingroup of the analysis. Accordingly, there is no molecular evidence against the monophyly of *Peyerimhoffia* in the present sense.

The genus has never been recorded from China. In this study, we taxonomically revise the genus based on specimens collected in recent years by Zhejiang A&F University, China. Detailed illustrations, differential diagnoses, distributional information of each species, and a key to the Chinese species are provided.

Material and methods

All specimens were collected by sweeping, malaise trapping, and yellow trapping and were preserved in 75% ethanol. All were mounted on microscope slides in xylol-based Canada balsam after clearing in xylol. The slides were made under a Nikon SMZ1500 stereo microscope. The specimens were observed, measured, and illustrated under a Leica DM2500 microscope. This study was based on males only because most species characteristics of *Peyerimhoffia* are based on the male morphology, whereas females are not generally identifiable to the species level. The terminology follows Vilkamaa and Hippa (2005). All of the type specimens in this study were deposited at the Institute of Forest Protection, Zhejiang A&F University, Hangzhou, Zhejiang Province, China (ZAFU).

Taxonomy

Key to the *Peyerimhoffia* species from China (males)

1 Maxillary palp 1-segmented (Figs 1C, 2C)..... **2**
– Maxillary palp 3-segmented (Figs 3C, 4C, 5C, 6C, 7C) **4**
2 Hypopygium with a lobe-like projecting intercoxal area, tegmen slightly and smoothly curved and sclerotized (Fig. 1B) ..... ***P. hamata* sp. n.**
– Hypopygium without lobe-like projecting intercoxal area, tegmen strongly curved and sclerotized (Fig. 2B)..... **3**
3 Gonostylus very tumid, broadest on apical part, apical tooth short (about half as long as width of gonostylus) (Fig. 2A)..... ***P. obesa* sp. n.**
– Gonostylus slightly tumid, broadest on mesial part, apical tooth long (as long as width of gonostylus) ..... ***P. vagabunda* (Winnertz, 1867)**
4 Gonostylus narrowed, without apical lobe except a tooth on its apex (Figs 3A, 4B) **5**
– Gonostylus inflated, with an distinct apical lobe bearing a tooth (Figs 5A, 6A, 7A)..... **6**
5 Apical tooth long (as long as width of gonostylus), tegmen almost truncate on the apical margin with a weak process (Fig. 3A, B) ..... ***P. sparsula* sp. n.**
– Apical tooth short (about half as long as width of gonostylus), tegmen greatly projected in the middle of apical margin (Fig. 4A, B)..... ***P. longiprojecta* sp. n.**
6 Basal palpomere with a sensory pit and one seta, gonostylus relatively narrowed, with apex densely setose (Fig. 5A, C) ..... ***P. brachypoda* sp. n.**
– Basal palpomere without sensory pit and with four setae, gonostylus inflated, with apex sparsely setose or bare (Figs 6A, C, 7A, C)..... **7**
7 Apex of the gonostylus sparsely setose, and its apical tooth light and not sclerotized, tegmen narrowed abruptly on the middle and almost equilateral in ventral view (Fig. 6A, B) ..... ***P. yunnana* sp. n.**
– Apex of the gonostylus bare, and its apical tooth dark and sclerotized, tegmen narrowed evenly and almost triangular in ventral view (Fig. 7A, B) ..... ***P. shennongjiana* sp. n.**

***Peyerimhoffia hamata* Shi & Huang, sp. n.**
http://zoobank.org/84B856A9-D5D6-45CB-9125-2118E425E230
http://species-id.net/wiki/Peyerimhoffia_hamata
Figs 1, 8A, 9

Specimens examined. *Holotype*, male. CHINA. Zhejiang Province, Linan, Jincheng, Mt. Xijingshan, sweep-net, 29.IV.2011, Kai Shi [SM01563]. *Paratype*, ZHEJIANG. 1 male, Qingyuan, Mt. Baishanzu, Wanli-linchang, sweep-net, 24.VII.2012, Lu-Jing Yang [SM01732].

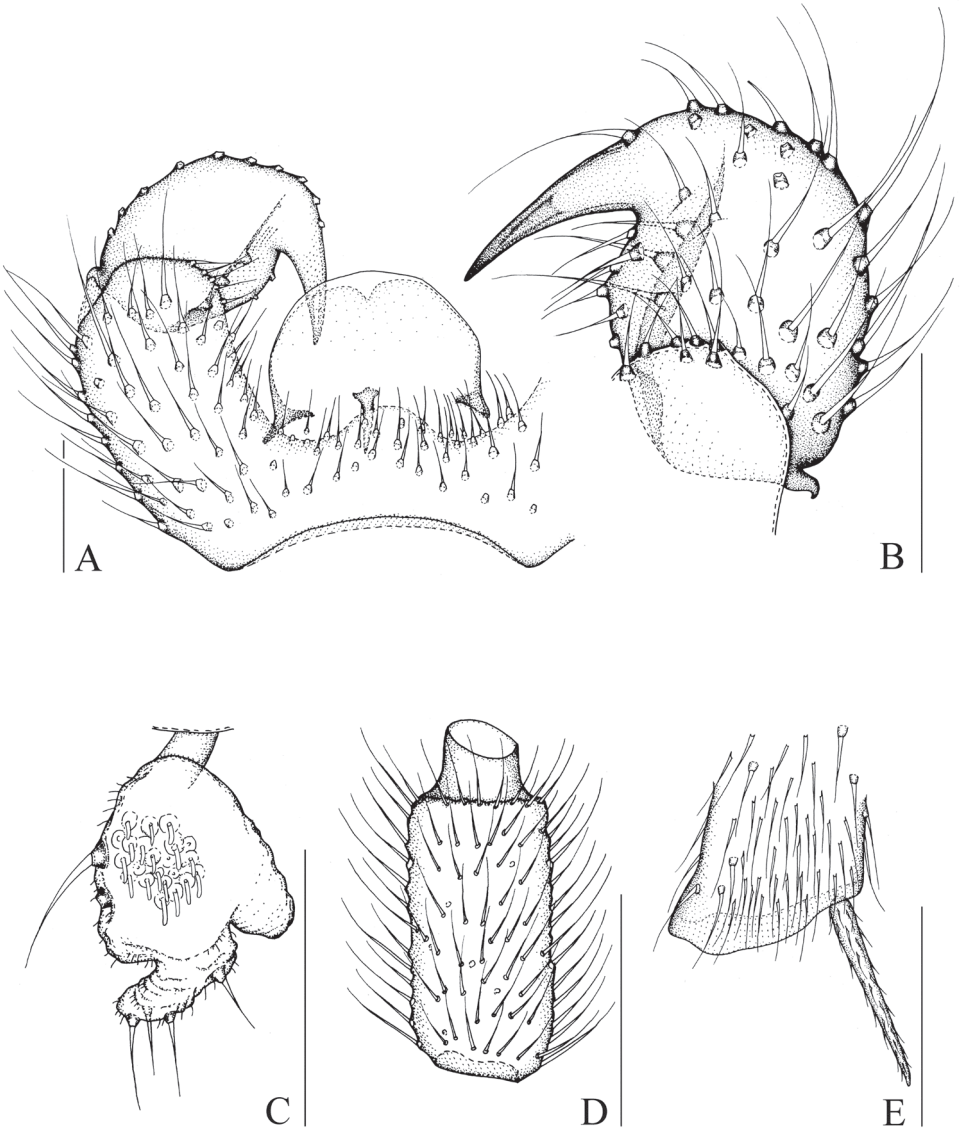

Figure 1. *Peyerimhoffia hamata* Shi & Huang, sp. n., male, holotype. **A** Part of hypopygium, ventral view **B** Right gonostylus, ventral view **C** Palp, lateral view **D** Fourth flagellomere, lateral view **E** Apex of foretibia, prolateral view. Scale, 0.10 mm.

Description (male). Head dark brown; antenna, thorax, abdomen, and hypopygium brown; palp pale brown; legs pale yellowish-brown; wings fumose. **Head** (Fig. 1C, D). Eye bridge with 3 rows of facets. Prefrons with 4 setae. Clypeus non-setose. Maxillary palp 1-segmented, with 6 setae. Length/width of fourth flagellomere: 2.07–2.16.

Thorax. Anterior pronotum with 3 setae, episternum 1 with 3 setae. **Wings** (Fig. 8A). Wing length 1.88–2.21 mm, width/length: 0.38–0.41. c/w: 0.61–0.73. R1/R: 0.68–0.90. M, Cu, stM, and r-m non-setose. **Legs** (Fig. 1E). Front tibia with non-bordered prolateral patch of modified setae. Length of spur/width of foretibia 1.18–1.23. Length of femur/length of metatarsus: foreleg 1.24–1.38. Length of metatarsus/length of tibia: foreleg 0.49–0.56, hind leg 0.44–0.49. Length of hind tibia/length of thorax 1.30–1.42. **Hypopygium** (Fig. 1A, B). Sternite 10 with one seta on each half.

Distribution. China, Zhejiang (Fig. 9).

Remarks. Based on the form of the gonostylus, the new species is similar to *P. vagabunda* (Winnertz, 1867). However, the new species can be distinguished in having an irregularly shaped palp (Fig. 1C), the gonostylus distinctly and mesially constricted on dorsal side, the tegmen slightly and smoothly curved, and a lobe-like projecting intercoxal area on the hypopygium. In contrast, *P. vagabunda* has a regularly shaped palp, the gonostylus is evenly rounded on the dorsal side, the tegmen is strongly curved, and no lobe-like projecting intercoxal area occurs on the hypopygium.

Etymology. This species is named after its hook-like gonostylus (Latin adjective *hamatus* = hooked).

***Peyerimhoffia obesa* Shi & Huang, sp. n.**
http://zoobank.org/FD68BA82-6A0C-4B21-8516-C7B9DFE8BA27
http://species-id.net/wiki/Peyerimhoffia_obesa
Figs 2, 8B, 9

Specimens examined. *Holotype*, male. CHINA. Shanxi Province, Qinshui, Xiachuan-cun, Fuyuhe, sweep-net, 26.VII.2012, Kai Shi [SM01795].

Description (male). Head dark brown; antenna and thorax brown; palp, abdomen, and hypopygium pale brown; legs yellowish-brown; wings fumose. **Head** (Fig. 2C, D). Eye bridge with 3 rows of facets. Prefrons with 3 setae. Clypeus non-setose. Maxillary palp 1-segmented, with 4 setae. Length/width of fourth flagellomere: 1.92. **Thorax**. Anterior pronotum with 6 setae, episternum 1 with 3 setae. **Wings** (Fig. 8B). Wing length 1.81 mm, width/length: 0.39. c/w: 0.73. R1/R: 0.70. M, Cu, stM, and r-m non-setose. **Legs** (Fig. 2E). Front tibia with a non-bordered prolateral patch of modified setae. Length of spur/width of foretibia 1.15. Length of femur/length of metatarsus: foreleg 1.29. Length of metatarsus/length of tibia: foreleg 0.51, hind leg 0.46. Length of hind tibia/length of thorax 1.32. **Hypopygium** (Fig. 2A, B). Sternite 10 with one seta on each half.

Distribution. China, Shanxi (Fig. 9).

Remarks. Based on the form of the gonostylus, the new species is similar to *P. alpina* (Mohrig 1978). However, the new species differs in having palp is 1-segmented, the tegmen is strongly curved and greatly sclerotized, and the intercoxal area is simple

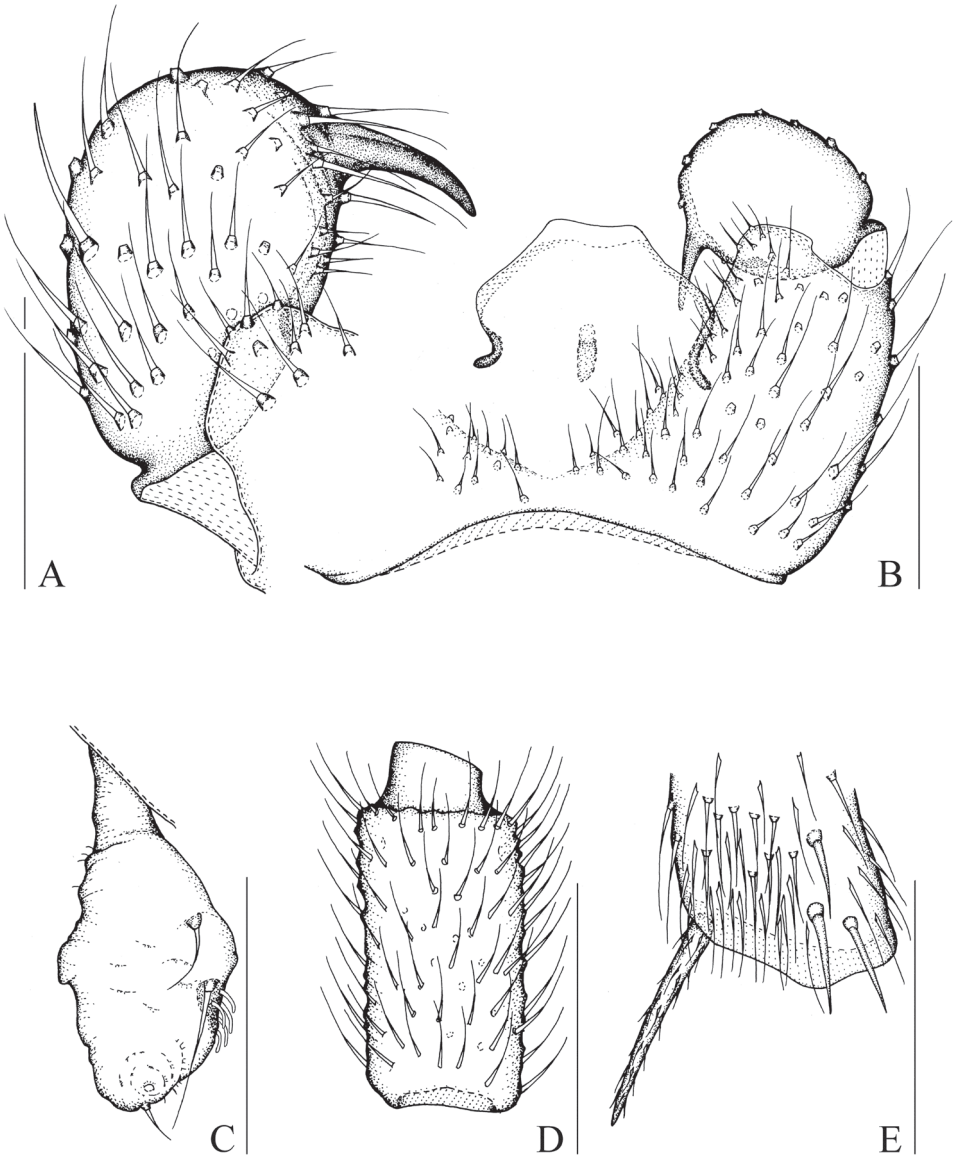

Figure 2. *Peyerimhoffia obesa* Shi & Huang, sp. n., male, holotype. **A** Left gonostylus, ventral view **B** Part of hypopygium, ventral view **C** Palp, lateral view **D** Fourth flagellomere, lateral view **E** Apex of foretibia, prolateral view. Scale, 0.10 mm.

in *P. obesa*. In contrast, in *P. alpina*, the palp is 3-segmented, the tegmen is slightly curved and weakly sclerotized, and the intercoxal area bears a lobe-like projection.

Etymology. This species is named after its globally inflated gonostylus (Latin adjective *obesus* = obese).

***Peyerimhoffia vagabunda* (Winnertz, 1867)**
http://species-id.net/wiki/Peyerimhoffia_vagabunda

Sciara vagabunda Winnertz, 1867: 230.
Peyerimhoffia brachyptera Kieffer, 1903: 198.
Peyerimhoffia alata Frey, 1948: 72, 88.
Plastosciara (*Peyerimhoffia*) *brachyptera* (Kieffer, 1903): Tuomikoski 1960: 40, 41.
Cratyna (*Peyerimhoffia*) *vagabunda* (Winnertz, 1867): Menzel and Mohrig 2000: 285, 286.

New materials. CHINA. HEILONGJIANG. 1 male, Haerbin, Shangzhi, Maoershan Nature Park, sweep-net, 26.VII.2008, Su-Jiong Zhang [SM00193]. SHAANXI. 1 male, Huxian, Laoyu, Baliping Zhuque Nature Park, sweep-net, 13.VII.2012, Junhao Huang [SM01656]. SHANXI. Qinshui: 2 males, Xiachuancun, Putonggou, yellow trap, 24.VII.2012, Kai Shi [SM017760–1777]; 1 male, Xiachuancun, Zhuweigou, sweep-net, 23.VII.2012, Kai Shi [SM01738]; 1 male, Xiachuancun, Zhuweigou, sweep-net, 25.VII.2012, Kai Shi [SM01770]; 1 male, Dahecun, Nanshenyu, sweep-net, 28.VII.2012, Kai Shi [SM01780]. ZHEJIANG. 1 male, Linan, Mt. Qingliangfeng, Qianqingtang, malaise trap, 15.V.2012 [SM01719].

Diagnosis. The species is characterized by the 1-segmented palp, the gonostylus evenly narrowed toward the apex, the apical tooth as long as the width of the gonostylus, and the tegmen very strongly curved and sclerotized.

Distribution. China (Heilongjiang, Shaanxi, Shanxi, Zhejiang – new record) (Fig. 6); Finland, Sweden, Italy, Russia (Primorsky Kray).

Remarks. This species is new to China. The Chinese specimens examined show no obvious differences.

***Peyerimhoffia sparsula* Shi & Huang, sp. n.**
http://zoobank.org/41E8EFCF-E77D-4802-828B-127614361356
http://species-id.net/wiki/Peyerimhoffia_sparsula
Figs 3, 8C, 9

Specimens examined. *Holotype*, male. CHINA. Shaanxi Province, Huxian, Laoyu, Baliping Zhuque Nature Park, sweep-net, 12.VII.2012, Kai Shi [SM01712].

Description (male). Head dark brown; antenna, thorax, abdomen, and hypopygium brown; palp pale brown; legs yellowish-brown; wings fumose. **Head** (Figs 3C, D). Eye bridge with 3 rows of facets. Prefrons with 5 setae. Clypeus with 1 seta. Maxillary palp 3-segmented, segment 1 with one seta. Length/width of fourth flagellomere: 2.30. **Thorax**. Anterior pronotum with 2 setae, episternum 1 with 4 setae. **Wings** (Fig. 8C). Wing length 1.46 mm, width/length: 0.39. c/w: 0.54. R1/R: 0.61. M, Cu, stM, and r-m non-setose. **Legs** (Fig. 3E). Front tibia with proximally bordered prolateral patch of modified setae. Length of spur/width of foretibia 1.28. Length of femur/length of

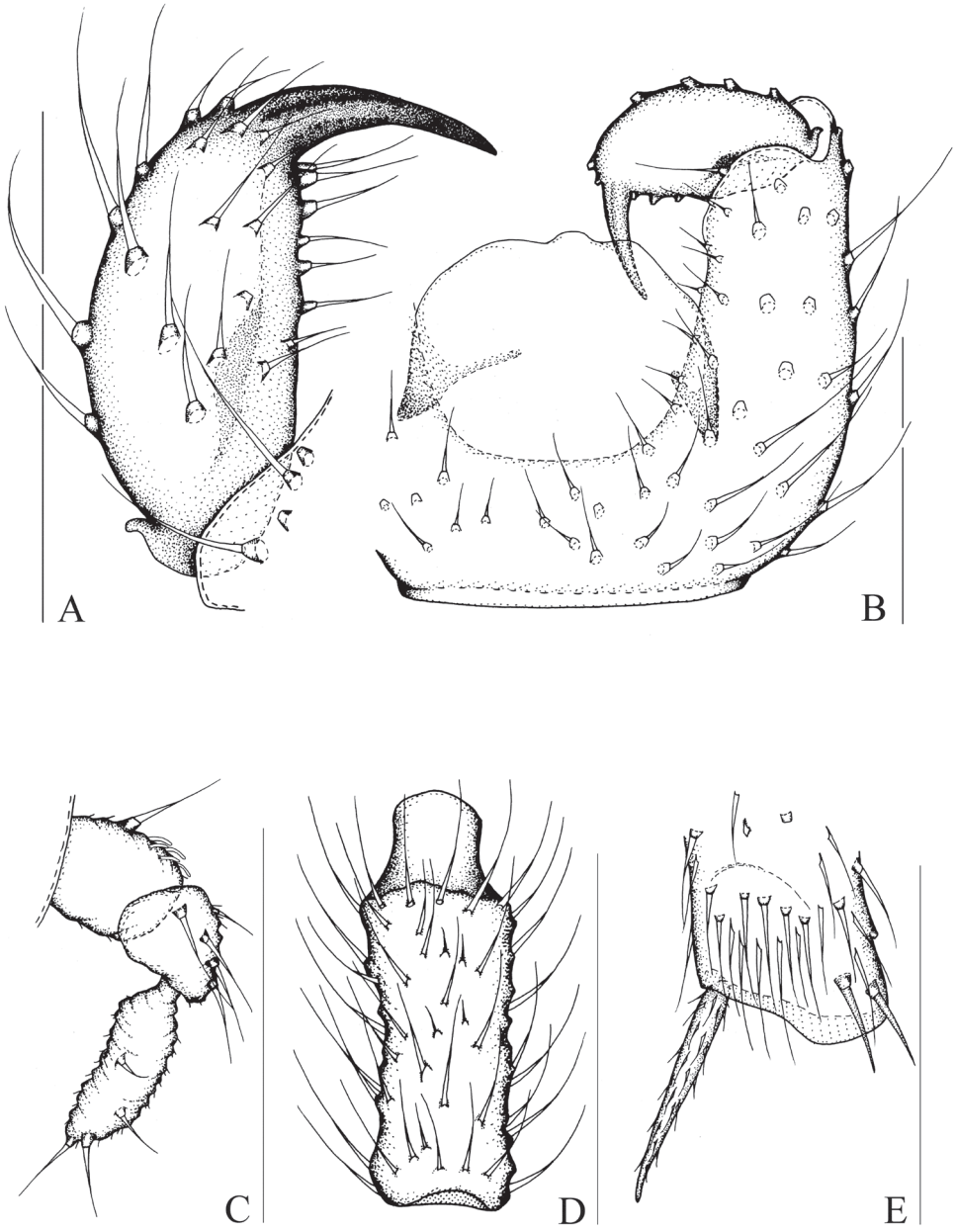

Figure 3. *Peyerimhoffia sparsula* Shi & Huang, sp. n., male, holotype. **A** Left gonostylus, ventral view **B** Part of hypopygium, ventral view **C** Palp, lateral view **D** Fourth flagellomere, lateral view **E** Apex of foretibia, prolateral view. Scale, 0.10 mm.

metatarsus: foreleg 1.48. Length of metatarsus/length of tibia: foreleg 0.52, hind leg 0.50. Length of hind tibia/length of thorax 1.29. **Hypopygium** (Fig. 3A, B). Sternite 10 with one seta on each half.

Distribution. China, Shaanxi (Fig. 9).

Remarks. Based on the form of the gonostylus, the new species is similar to *P. ultima* Vilkamaa & Hippa, 1998. However, the new species can be distinguished by the front tibia with a proximally bordered prolateral patch of modified setae, the gonostylus with few short subapical setae, and the tegmen sub-truncate apically. In contrast, *P. ultima* has an indistinct row of setae on the front tibia, a gonostylus with numerous long subapical setae, and a tegmen moderately curved apically.

Etymology. This species is named after its sparse setosity on the gonocoxite (Latin adjective *sparsulus* = sparse).

***Peyerimhoffia longiprojecta* Shi & Huang, sp. n.**
http://zoobank.org/82672F3F-A9D4-4D7E-BCE8-9802B01E9CBF
http://species-id.net/wiki/Peyerimhoffia_longiprojecta
Figs 4, 8D, 9

Specimens examined. *Holotype*, male. CHINA. Shanxi Province, Qinshui, Xiachuan-cun, Putonggou, sweep-net, 24.VII.2012, Kai Shi [SM01737]. *Paratype*, SHANXI. 1 male, the same data as holotype [SM01736].

Description (male). Head dark brown; antenna, thorax, and abdomen brown; palp and hypopygium pale brown; legs yellowish-brown; wings fumose. **Head** (Fig. 4C, D). Eye bridge with 3 rows of facets. Prefrons with 7–8 setae. Clypeus non-setose. Maxillary palp 3-segmented, segment 1 with 2 setae. Length/width of fourth flagellomere: 3.86–4.07. **Thorax**. Anterior pronotum with 2 setae, episternum 1 with 3 setae. **Wings** (Fig. 8D). Wing length 1.80 mm, width/length: 0.39. c/w: 0.81. R1/R: 0.43. M, Cu, stM, and r-m non-setose. **Legs** (Fig. 4E). Front tibia with an indistinct row of seven spinose setae. Length of spur/width of foretibia 1.27–1.39. Length of femur/length of metatarsus: foreleg 1.34–1.43. Length of metatarsus/length of tibia: foreleg 0.46–0.50, hind leg 0.46–0.47. Length of hind tibia/length of thorax 1.40–1.35. **Hypopygium** (Fig. 4A, B). Sternite 10 with one seta on each half.

Distribution. China, Shanxi (Fig. 9).

Remarks. This species is unique within the genus in having its tegmen greatly projected in the middle of the apical margin. Based on the form of the gonostylus, it is similar to *P. menzeli* Vilkamaa & Hippa, 2005, but differs in having a very slender fourth flagellomere that is about four times longer than its width and a tegmen that is strongly projected apically. In contrast, in *P. menzeli*, the fourth flagellomere is about twice longer than its width and the tegmen is truncate apically.

Etymology. This species is named after the great middle projection of the apical tegmen (Latin adjective *longiprojecta* = long projection).

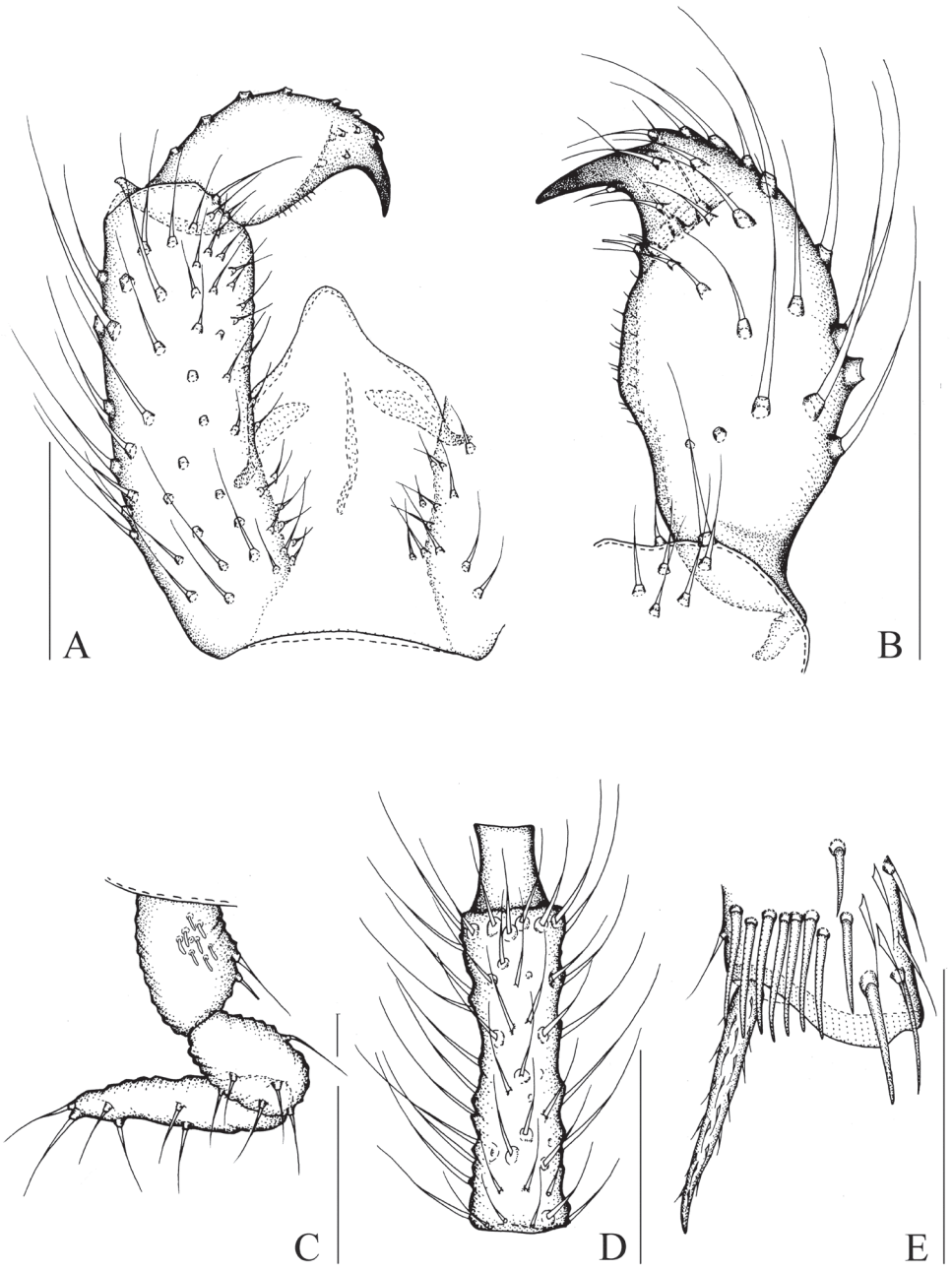

Figure 4. *Peyerimhoffia longiprojecta* Shi & Huang, sp. n., male, holotype. **A** Part of hypopygium, ventral view **B** Right gonostylus, ventral view **C** Palp, lateral view **D** Fourth flagellomere, lateral view **E** Apex of foretibia, prolateral view. Scale, 0.10 mm.

***Peyerimhoffia brachypoda* sp. n.**
http://zoobank.org/E39D802B-D633-44EE-A527-83B4E39B6828
http://species-id.net/wiki/Peyerimhoffia_brachypoda
Figs 5, 8E, 9

Specimens examined. *Holotype*, male. CHINA. Zhejiang province, Anji, Mt. Longwangshan, sweep-net, 31.III.2012, Kai Shi [SM01588]. *Paratype*, SHANXI. 1 male, Qinshui, Dongchuancun, Dongxia, sweep-net, 25.VII.2012, Kai Shi [SM01791].

Description (male). Head dark brown; antenna, thorax, abdomen and hypopygium brown; palp pale brown; legs yellowish-brown; wings fumose. **Head** (Fig. 5C, D). Eye bridge with 2 rows of facets. Prefrons with 4 setae. Clypeus with 2 setae. Maxillary palp 3-segmented, segment 1 with 1–2 setae. Length/width of 4th flagellomere: 2.36–2.74. **Thorax**. Anterior pronotum with 2 setae, episternum 1 with 4–5 setae. **Wings** (Fig. 8E). Wing length 1.34–1.46 mm, width/length: 0.41–0.44. c/w: 0.52–0.55. R1/R: 0.51–0.53. M, Cu, stM and r-m nonsetose. **Legs** (Fig. 5E). Front tibia with bordered prolateral patch of few strong modified setae. Length of spur/width of foretibia 1.13–1.19. Length of femur/length of metatarsus: foreleg 1.37–1.75. Length of metatarsus/length of tibia: foreleg 0.51–0.54, hind leg 0.45–0.49. Length of hind tibia/length of thorax 1.47–1.50. **Hypopygium** (Fig. 5A, B). Sternite 10 with one seta on each half.

Distribution. China (Shanxi, Zhejiang, Fig. 9).

Remarks. The new species is similar to *P. infera* Vilkamaa & Hippa, 2005 in the shape of the gonostylus. However, the new species can be distinguished by the three-segmented maxillary palp, the gonostylus having much inflated apex and short subapical setae (two-segmented maxillary palp, the gonostylus slightly inflated at apex and bearing long subapical setae in *P. infera*).

Etymology. This species is named in reference to its short apical lobe, from the-Greek adjective *brachypodus*, meaning short base.

***Peyerimhoffia yunnana* sp. n.**
http://zoobank.org/7FEE26A1-7F74-462F-8C00-6E045E6DC32E
http://species-id.net/wiki/Peyerimhoffia_yunnana
Figs 6, 8F, 9

Specimens examined. *Holotype*, male. CHINA. Yunnan province, Honghe, Lvcun, Mt. Huanglianshan, Yakou, 1950 m, sweep-net, 8.V.2011, Yan Li [SM01589].

Description (male). Head dark brown; antenna, thorax, abdomen and hypopygium brown; palp pale brown; legs yellowish-brown; wings fumose. **Head** (Fig. 6C, D). Eye bridge with 3 rows of facets. Prefrons with 11 setae. Clypeus with 1 seta. Maxillary palp 3-segmented, segment 1 with 4 setae. Length/width of 4th flagellomere: 4.37. **Thorax**. Anterior pronotum with 6 setae, episternum 1 with 4 setae. **Wings** (Fig. 8F). Wing length 2.06 mm, width/length: 0.44. c/w: 0.59. R1/R: 0.67. M, Cu, stM and

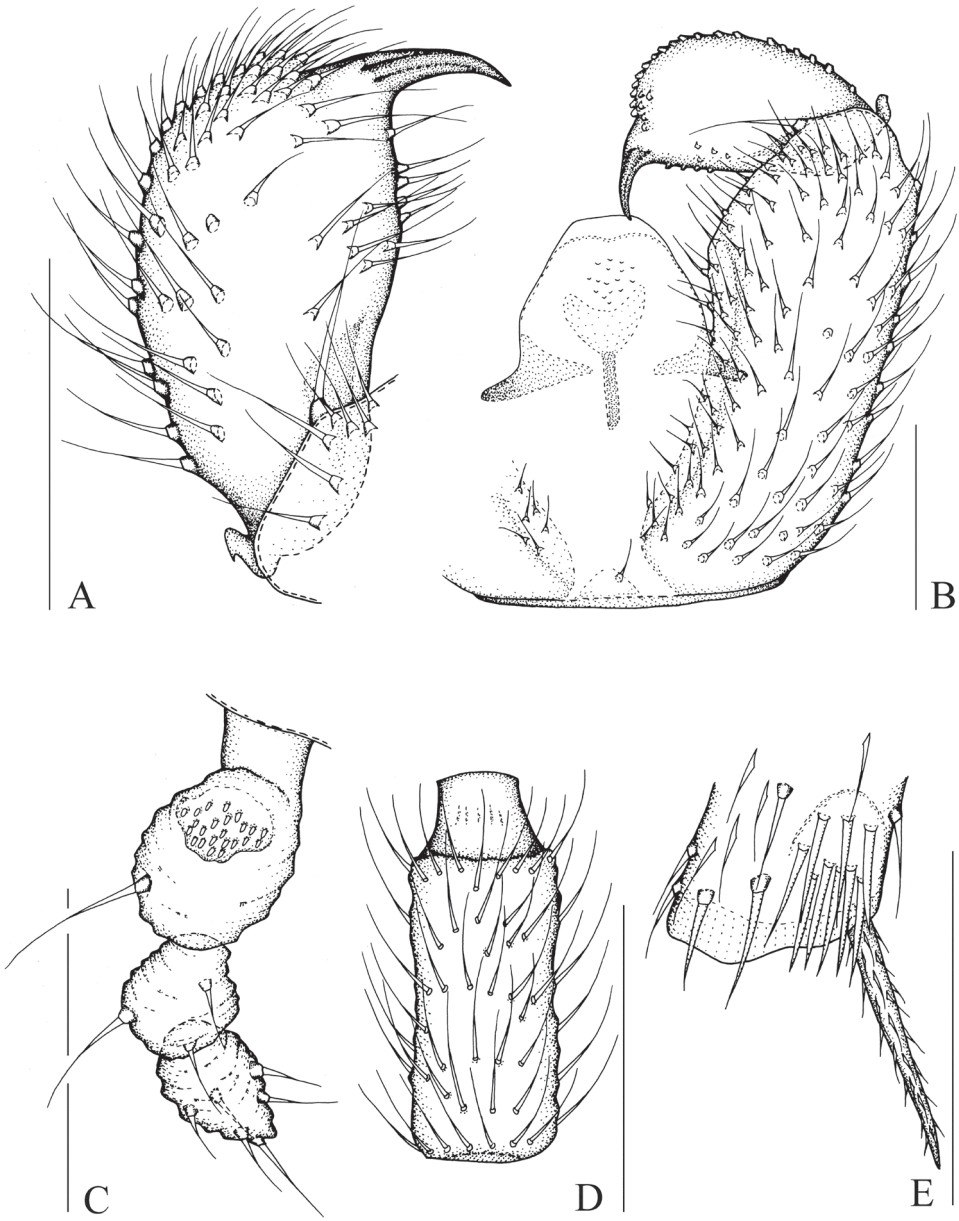

Figure 5. *Peyerimhoffia brachypoda* Shi & Huang, sp. n., male, holotype. **A** Left gonostylus, ventral view **B** Part of hypopygium, ventral view **C** Palp, lateral view **D** Fourth flagellomere, lateral view **E** Apex of foretibia, prolateral view. Scale, 0.10 mm.

r-m nonsetose. **Legs** (Fig. 6E). Front tibia with non-bordered prolateral patch of 4 modified setae in low. Length of spur/width of foretibia 1.38. Length of femur/length of metatarsus: foreleg 1.34. Length of metatarsus/length of tibia: foreleg 0.54, hind leg

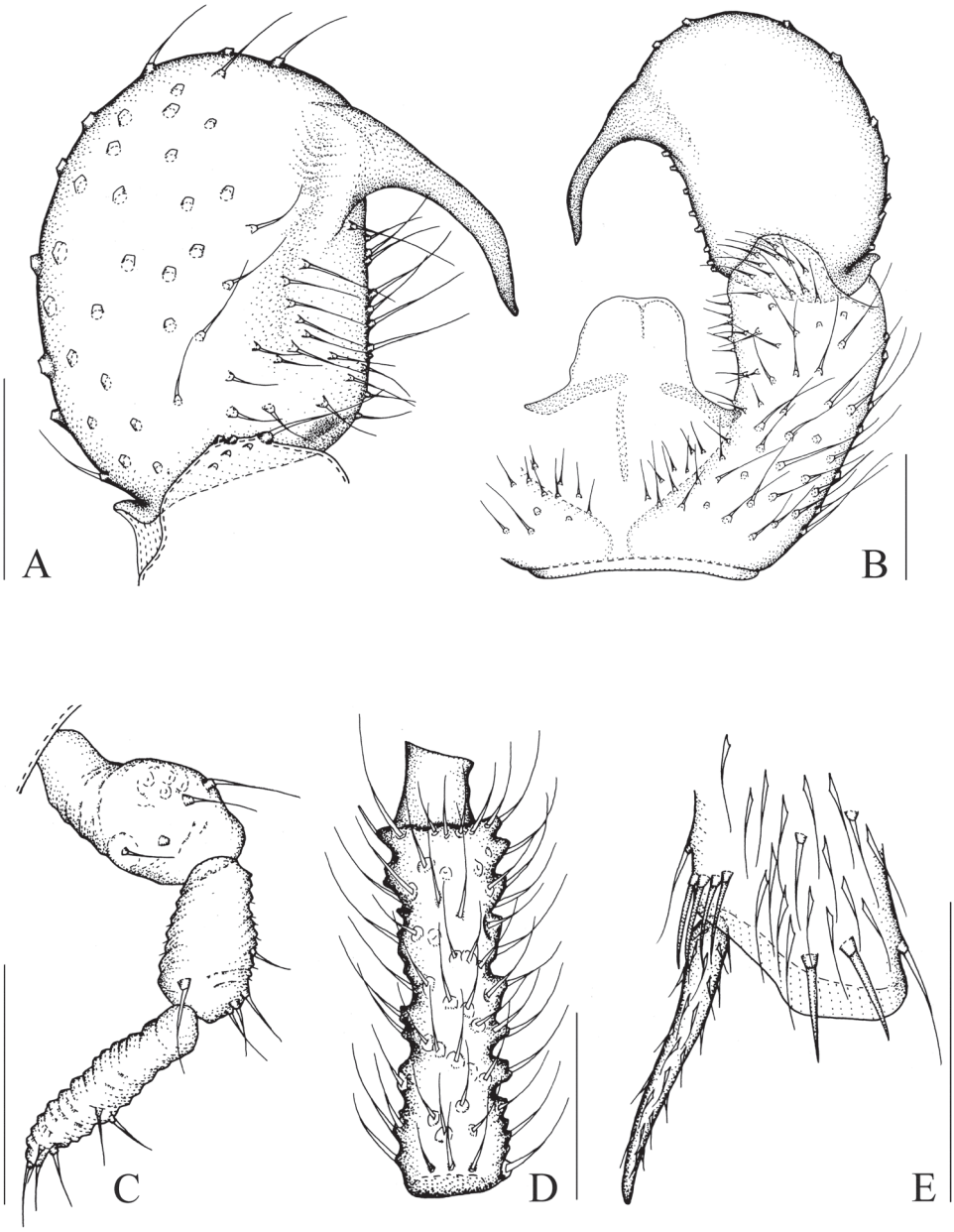

Figure 6. *Peyerimhoffia yunnana* Shi & Huang, sp. n., male, holotype. **A** Left gonostylus, ventral view **B** Part of hypopygium, ventral view **C** Palp, lateral view **D** Fourth flagellomere, lateral view **E** Apex of foretibia, prolateral view. Scale, 0.10 mm.

0.49. Length of hind tibia/length of thorax 1.68. **Hypopygium** (Fig. 6A, B). Sternite 10 with one seta on each half.

Distribution. China (Yunnan, Fig. 9).

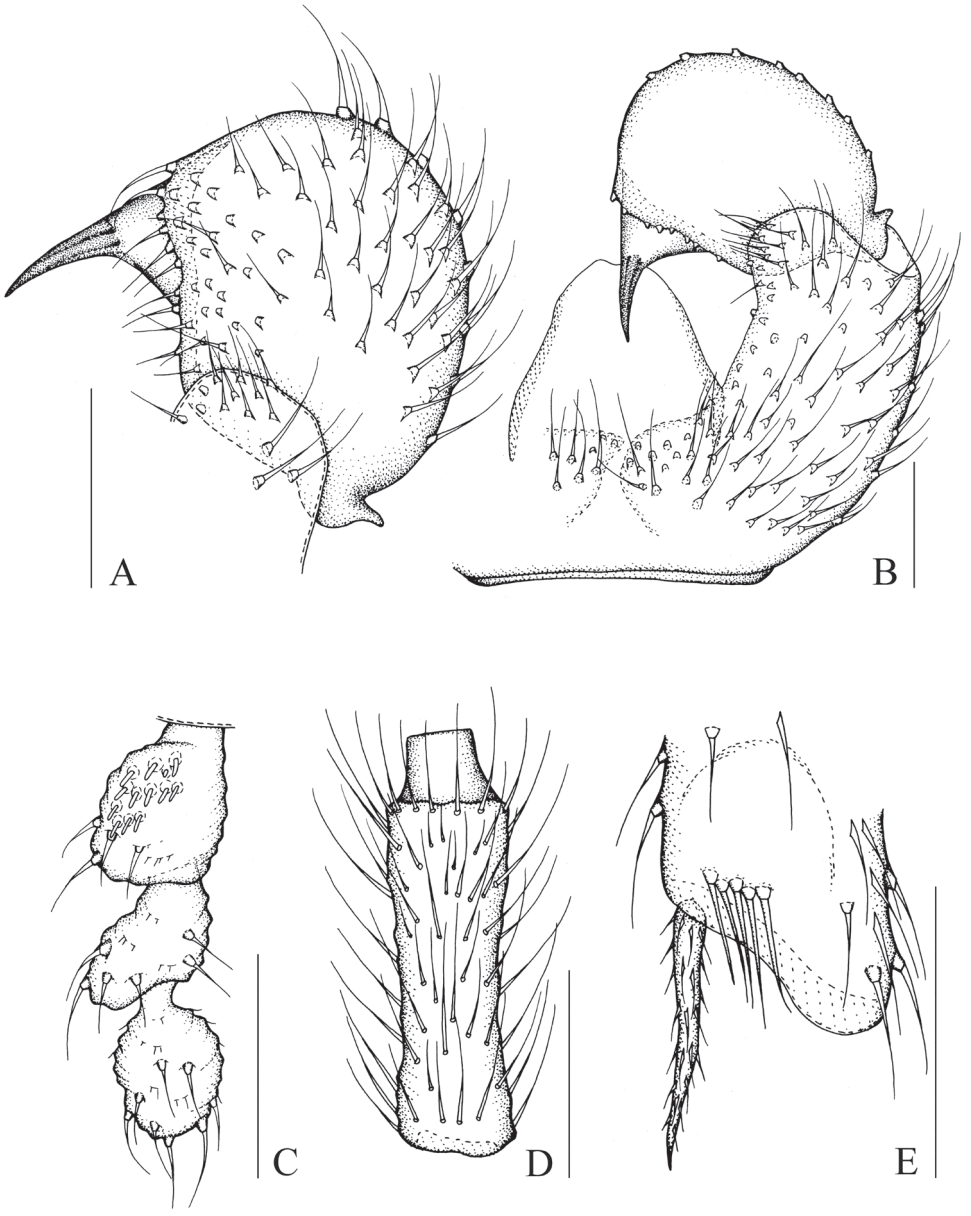

Figure 7. *Peyerimhoffia shennongjiana* Shi & Huang, sp. n., male, holotype. **A** Right gonostylus, ventral view **B** Part of hypopygium, ventral view **C** Palp, lateral view **D** Fourth flagellomere, lateral view **E** Apex of foretibia, prolateral view. Scale, 0.10 mm.

Remarks. This species is unique in having the light-colored gonostylar apical tooth, which is not scleritised.

Etymology. This species is named after its type locality, Yunnan province, China.

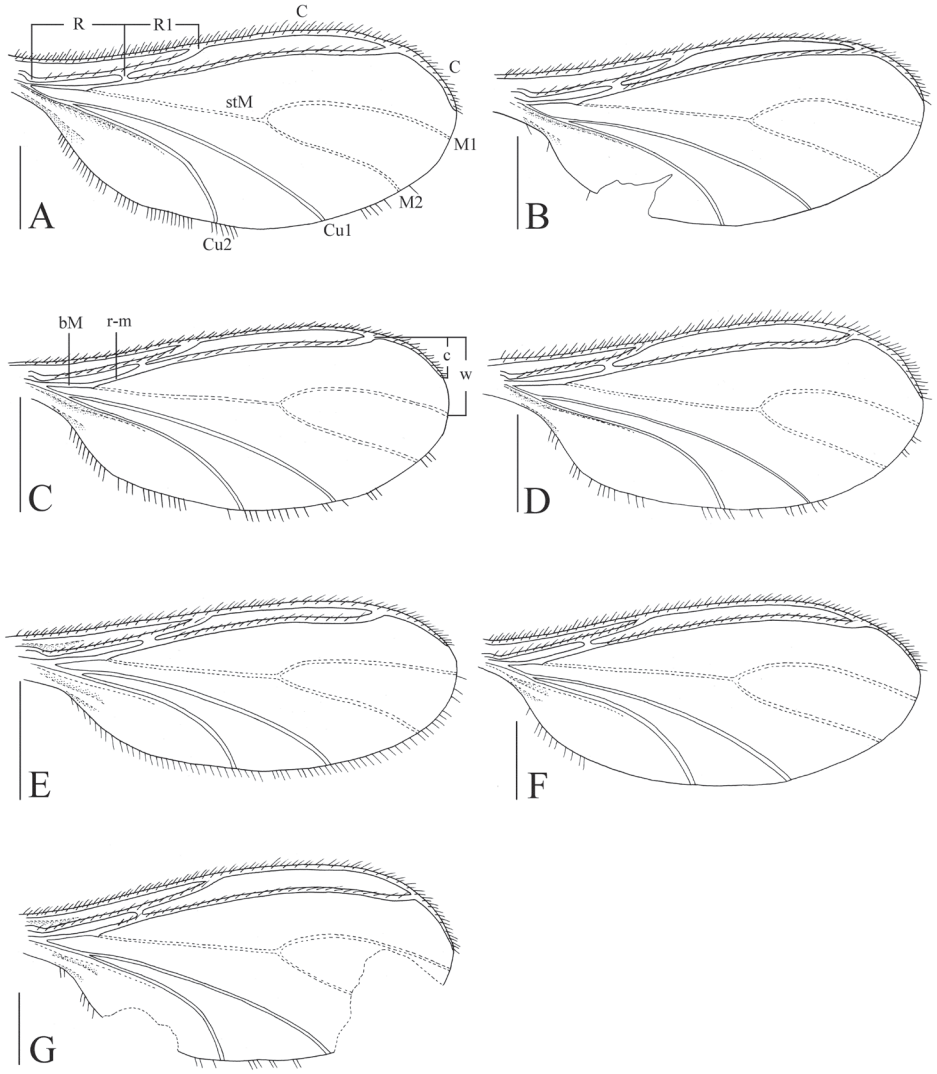

Figure 8. Wings, dorsal view. **A** *P. hamata* sp. n. (holotype) **B** *P. obesa* sp. n. (holotype) **C** *P. sparsula* sp. n. (holotype) **D** *P. longiprojecta* sp. n. (holotype) **E** *P. brachypoda* sp. n. (holotype) **F** *P. yunnana* sp. n. (holotype) **G** *P. shennongjiana* sp. n. (holotype). Scale, 0.50 mm.

***Peyerimhoffia shennongjiana* sp. n.**
http://zoobank.org/8F2367D5-2651-4AC4-A181-983F09875DCB
http://species-id.net/wiki/Peyerimhoffia_shennongjiana
Figs 7, 8G, 9

Specimens examined. *Holotype*, male. CHINA. Hubei province, Shennongjia, Dalongtan, sweep-net, 20.V.2012, Kai Shi [SM01662].

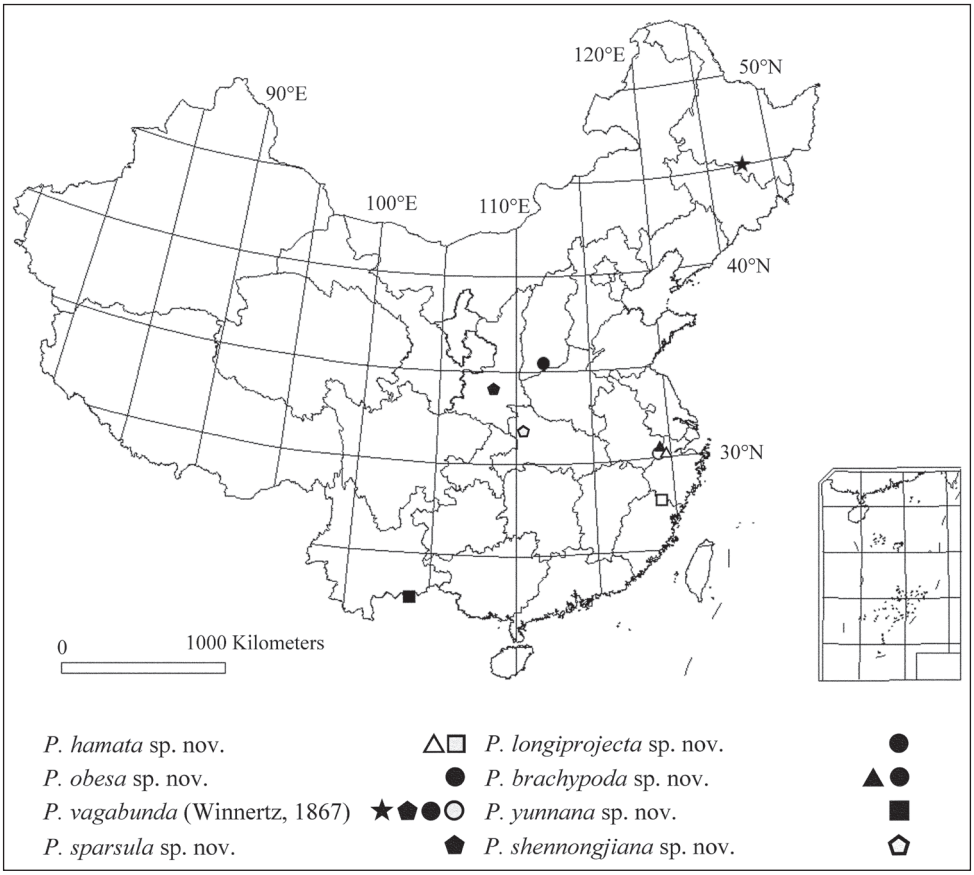

Figure 9. Geographical distribution of *Peyerimhoffia* from China.

Description (male). Head dark brown; palp, antenna, thorax, abdomen and hypopygium brown; legs yellowish-brown; wings fumose. **Head** (Fig. 7C, D). Eye bridge with 3 rows of facets. Prefrons with 26 setae. Clypeus with 1 seta. Maxillary palp 3-segmented, segment 1 with 4 setae. Length/width of 4th flagellomere: 2.83. **Thorax**. Anterior pronotum with 2 setae, episternum 1 with 4 setae. **Wings** (Fig. 8G). Wing length 2.25 mm, width/length: 0.46. c/w: 0.79. R1/R: 0.88. M, Cu and stM nonsetose. r-m with 4 setae. **Legs** (Fig. 7E). Front tibia with bordered prolateral patch of 5 modified setae. Length of spur/width of foretibia 1.06. Length of femur/length of metatarsus: foreleg 1.69. Length of metatarsus/length of tibia: foreleg 0.48, hind leg 0.50. Length of hind tibia/length of thorax 1.45. **Hypopygium** (Fig. 7A, B). Sternite 10 with one seta on each half.

Distribution. China (Hubei, Fig. 9).

Remarks. This species can be readily recognized by having two unique characteristics: the gonostylar apex bare, and a dorsally located lobe on its inflated gonostylus.

Etymology. This species is named after its type locality, Shennongjia at Hubei province, China.

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