



***Zorotypus asymmetricus* sp. nov. from Brunei Darussalam, Borneo (Insecta: Zoraptera)**

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Abstract

A new species of Zoraptera from Borneo is described and figured. *Zorotypus asymmetricus* sp. nov. was discovered in lowland mixed dipterocarp forest in Ulu Temburong, Brunei Darussalam. The species represents the third known species occurring on Borneo and it can be easily distinguished from others by the asymmetrical cerci: the right cercus is strongly enlarged and curved.

Key words: Zoraptera, Zorotypidae, new species, Borneo, Indomalayan region

Introduction

The order Zoraptera is currently one of the least known insect orders (Mashimo *et al.* 2014). Nevertheless, Zoraptera should be relatively common in tropical and subtropical areas of all biogeographical regions, but due to their small size, cryptic lifestyle and overlooking by researchers their diversity remains underexplored (Mashimo *et al.* 2013, 2014). Zoraptera currently contains 41 extant species in the monogeneric family Zorotypidae (Engel & Grimaldi 2000; Mashimo *et al.* 2014; Yin *et al.* 2015; Wang *et al.* 2016). All described species are small insects, generally less than 4 mm in length, with very similar lifestyles and similar habitats. Usually they live subcortically in decaying logs of different trees in wet forests. Zorapterans live in small colonies up to about 120 individuals, which occur in two different forms, an apterous morph and an alate morph, fully winged with well-developed compound eyes and ocelli (Engel 2007; Mashimo *et al.* 2014).

There are only two zorapteran species currently known from Borneo: *Zorotypus caudelli* Karny, 1927 described from Sumatra and recorded also from Peninsular Malaysia (New 2000; Mashimo *et al.* 2013; Wang *et al.* 2016), and *Z. weiweii* Wang, Li & Cai, 2016 recently described from Sabah (Wang *et al.* 2016). No species of Zoraptera has been reported from Brunei Darussalam. During an extensive research of tropical biodiversity by an international team of Czech and Bruneian biologists in the Temburong District of Brunei Darussalam, we discovered a new species of *Zorotypus*, described in this contribution.

Material and methods

The Zoraptera material was collected by with an aspirator under bark of different trees in Ulu Temburong National Park and stored in 96% ethanol. For observation of morphological and anatomical structures, material was placed in a 10% KOH solution at room temperature for 1 h, then washed with distilled water and returned to 96% ethanol for storage. Type specimens were slide-mounted in Euparal (BioQuip Products, Rancho Dominguez, California). or stored in 96% ethanol. Observations and dissections were carried out under an Olympus SZ61 stereo microscope equipped with an ocular grid and Canon D1000 camera. Antennae, mouthparts, legs, and genitalia were dissected

and slide-mounted in Euparal, then observed and documented under an Olympus CX41 microscope equipped with a Canon D1000 camera. Microphotographs of 10–80 layers of focus of the same specimen were combined with Quick Photo Camera 2.3 software. Images of live specimens and habitat were made with a Canon 700D camera equipped with a Canon EF-S 60 Macro Lens. All images were edited and grouped in Adobe Photoshop CS6 Extended (version 13).

Type depositories are abbreviated as follows: NMPC (National Museum, Prague, Czech Republic); BMNH (The Natural History Museum, London, United Kingdom); UBDC (Institute for Biodiversity and Environmental Research, Universiti Brunei Darussalam, Brunei Darussalam); PKCO (collection of P. Kočárek, University of Ostrava, Czech Republic). Each type specimen bears the following red label: 'HOLOTYPE (or PARATYPE), apteron ♂ (or ♀), *Zorotypus asymmetricus* sp. n., det. P. Kočárek 2014'.

Taxonomy

Zorotypus asymmetricus Kocarek, sp. nov.

(Figs. 1–17)

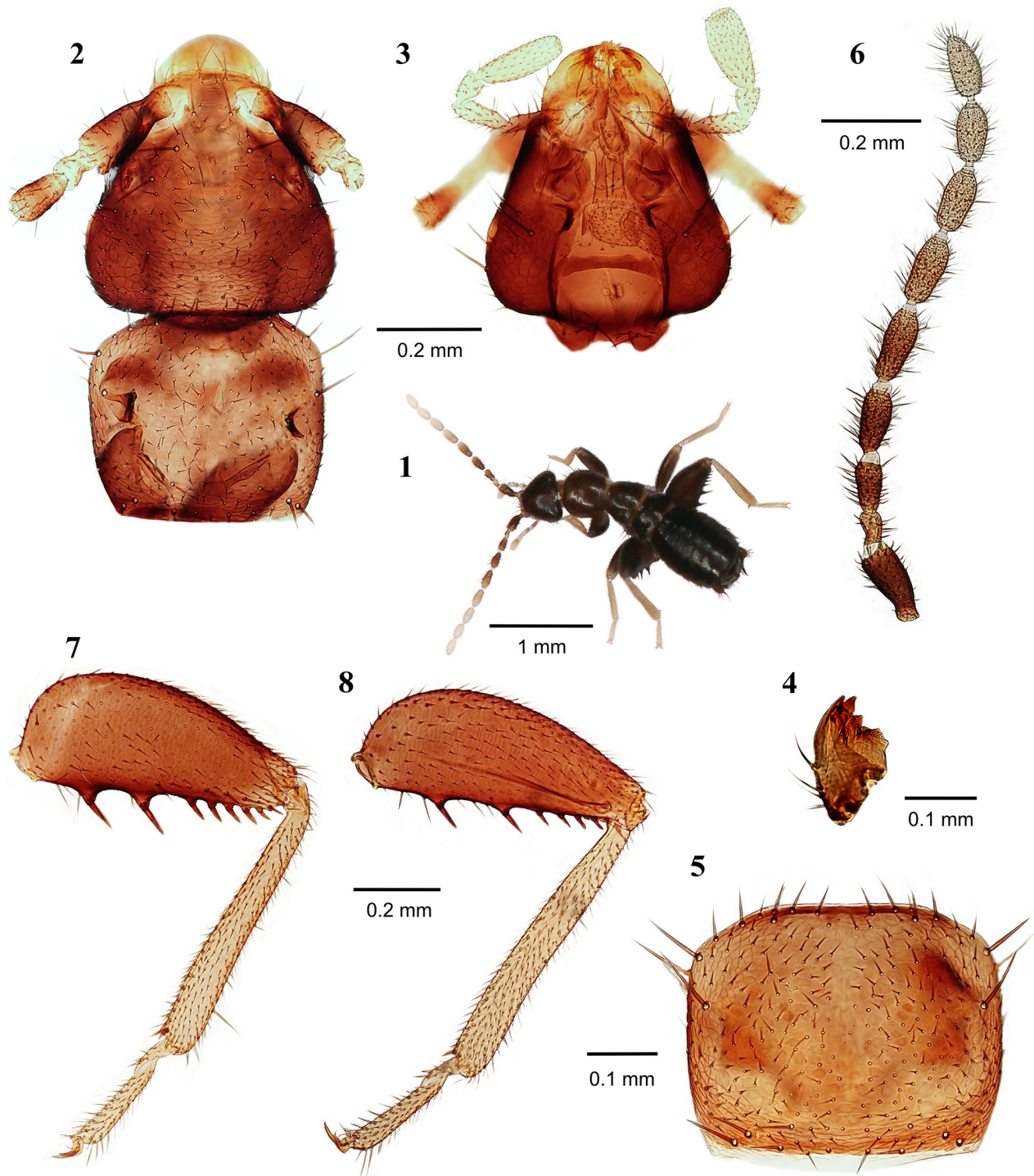
Type material. Holotype apterous male, labelled 'Brunei Darussalam, 9.i.2014, Ulu Temburong NP, Sungai Esu stream, 150 m a.s.l., GPS: 04°32'14.1"N, 115° 9'47.1"E, P. Kočárek leg.' (NMPC), under bark of rotting log. Paratypes: same data as for holotype, 1 apterous female (NMPC), 1 apterous male, 1 apterous female (UBDC), 1 apterous male, 1 apterous female (BMNH), 3 apterous males, 4 apterous females (PKCO).

Diagnosis. The new species is similar to *Z. sinensis* Hwang, 1974, *Z. medoensis* Hwang 1976, *Z. impolitus* Mashimo, Engel, Dallai, Beutel & Machida 2013 and *Z. weiwei* (Hwang 1974, 1976; Mashimo 2013; Wang *et al.* 2016), but it can be easily distinguished from them by the asymmetrical cerci, with the right cercus noticeably enlarged and sickle-shaped (Figs. 9–11), the species-specific shape of the male genitalia (Fig. 13), and the presence of 7–8 stout, long spines on the ventral surface of metafemur. The body is typically matte dark brown with the exception of pale yellowish gray tibiae and tarsi on all legs and antennomeres VI–IX.

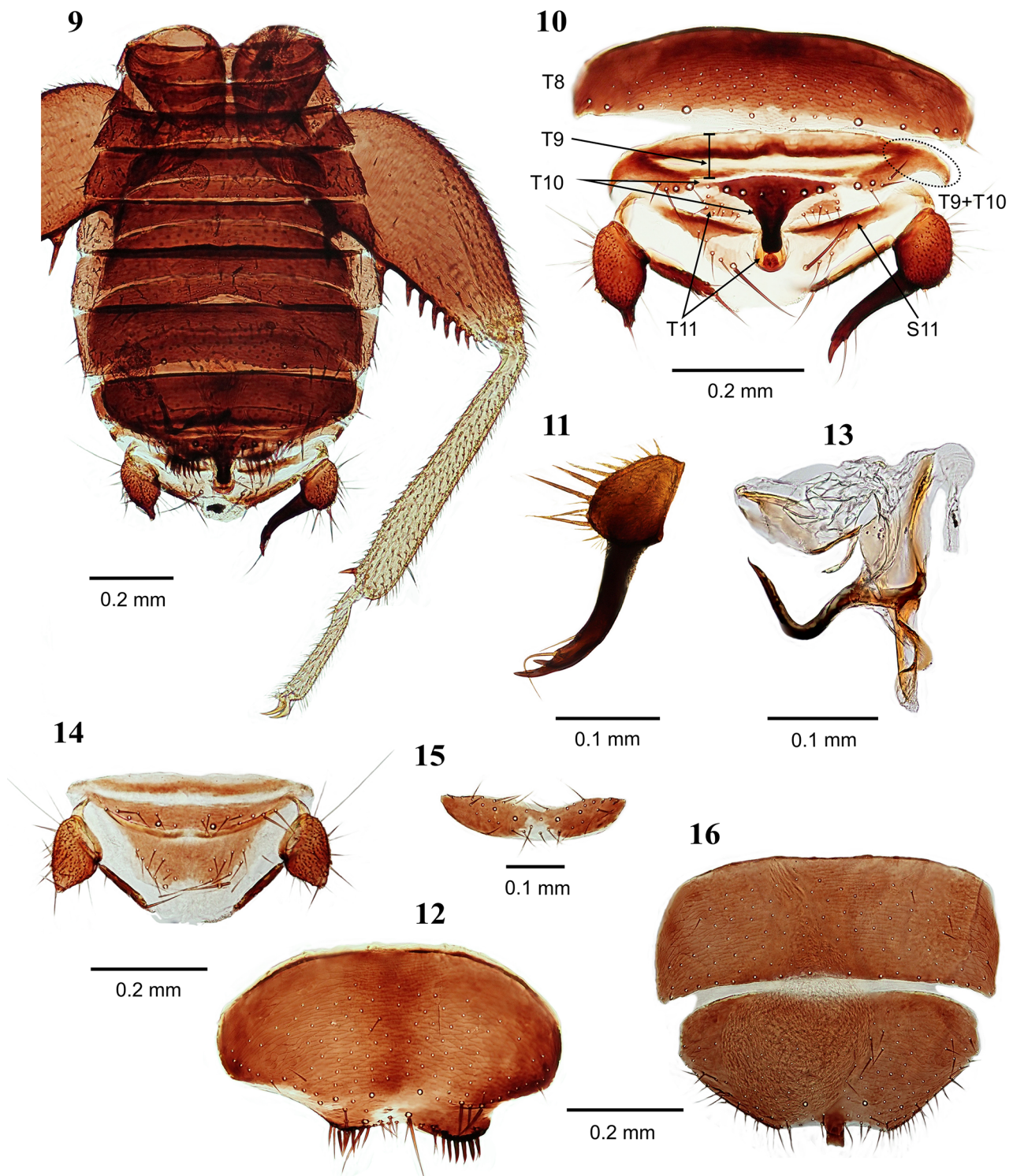
Description of apterous male (Figs. 1–4, 6, 7, 9–13, 17). Total body length 2.39 mm, head width 0.43 mm, antenna length 1.45 mm, pronotal width 0.41 mm, pronotal length 0.36 mm, metafemur length 0.644 mm. Body color matte dark brown except membranous regions; antennal flagellomeres VI–IX and tibiae and tarsi of all legs pale yellowish gray (Figs. 1, 17). Head subtriangular, slightly wider than pronotum (Figs. 2, 3); cephalic setae (Fig. 2) short and sparse, not grouped; compound eyes and ocelli absent; antennae 9-segmented, distal four antennomeres paler (Figs. 1, 6), antennomere I slightly curved outward, antennomere II slightly curved, short, about one-half length of antennomere III, antennomeres III–IX longer than wide, length subequal to that of antennomere I (Fig. 6). Mandibles asymmetrical, each mandible with four apical teeth and well-developed molar region (Fig. 4); maxillary palpus five-segmented, labial palpus three-segmented. Pronotum subrectangular, only slightly wider than long, slightly narrowed posteriorly and setose (Fig. 2); mesonotum trapezoidal, slightly shorter than pronotum; metanotum trapezoidal, distinctly wider than long, shorter than mesonotum. Legs with short setae; tibiae and tarsi of all legs pale yellowish gray (Fig. 1); posterior surface of profemur covered with short setae, anterior and dorsal surfaces covered with longer setae; protibia with short setae, spines arranged as comb in distal two-thirds along ventral surface, with two apical spurs; mesofemur slightly narrower than profemur, anterior surface broadly setose, posterior and dorsal surfaces covered with setae only distally; mesotibia covered with short setae and two apical spurs; metafemur broader than profemur, swollen proximally (Figs. 7, 8), anterior surface broadly setose, posterior surface sparsely setose, middle part without setae, distal half of lower edge lined with one row of longer setae (Figs. 7, 9), ventral surface with 7–8 stout spines, proximal first and second spines (spine I and II) longer than others (Fig. 7), distance between spine I and II and between spines II and II equal to length of spines I and 2; spines III–VIII shorter and closer to each other (Fig. 7); metatibia with short setae, subapically with one strong spine ventrally and one finer spine dorsally; basal tarsomere with stronger two spurs ventrally (Figs. 7, 9).

Abdominal tergite 1 (T1) with single transverse row of setae flanking distal edge, and one pair of short setae in antero-posterior margin; T2 with two parallel rows of setae in distal third of the tergite with regular distances between individual setae; T3 with three irregular rows of setae in distal half; T4–5 with 4–5 irregular rows of setae filling distal half of the tergite, setae in the most distal row longer; T6–7 with 6–7 irregular rows of setae occupying

two-thirds of the tergite, setae in the most distal row longer; T8 with 4 irregular rows of setae in posterior half of tergite and with ten longer setae on the posterior edge (Fig. 10); T9 short, strongly sclerotized anteriorly and scarcely sclerotized posteriorly, well delimited from T10 in the middle, but fused with T10 in lateral fifths (Fig. 10); T10 separated into anterior and posterior parts, anterior part scarcely sclerotized, with setae laterally, posterior half strongly sclerotized with medial spatula-like upcurved projection, several short setae on the base of projection and two short setae on the obtuse top (Fig. 10); T11 with long and strongly upcurved median projection with a tiny apical hook (Fig. 10) and two smaller, lateral sclerites each bearing two longer setae; projection of T11 narrower in the middle and longer than that of T10 (Fig. 10); epiproct and paraproct unsclerotized.



FIGURES 1–8. *Zorotypus asymmetricus* sp. nov. 1, male habitus of living specimen; 2, head and pronotum of apterous male, dorsal view; 3, head of apterous male, ventral view; 4, left mandible of male; 5, pronotum of apterous female, dorsal view; 6, left antenna of male; 7, right metaleg of apterous male, posterior view; 8, left metaleg of apterous female, anterior view.



FIGURES 9–16. *Zorotypus asymmetricus* sp. nov. 9, abdomen and right metaleg of apterous male, dorsal view; 10, posterior segments of male abdomen, dorsal view; 11, right male cercus, ventral view; 12, abdominal sternum S8+S9 of male, ventral view; 13, male genitalia, lateral view, posterior to the bottom and dorsal to the left; 14, posterior segments of female abdomen, dorsal view; 15, abdominal sternum S9 of female; 16, posterior segments of female abdomen, ventral view. T8–T11—abdominal tergites; S8–11—abdominal sternites.

Cerci (Figs. 9–11) unsegmented, left cercus conical with pointed apex, right cercus enlarged with sickle-shaped, pointed appendage terminating in one larger apical tooth and one smaller subapical tooth on outer margin; right cercus with two long distal setae, the more apical seta longer than and extending past distal tooth (Fig. 11). Outer basal margin of both cerci with short setae and several long and fine setae (Figs. 9–10); surface covered with numerous minute spicules except base and apex; pointed appendage of right cercus without spicules.

Abdominal sternite 1 (S1) scarcely sclerotized; S2 weakly sclerotized with a few short setae on each side and four setae in the middle posterior margin; S3 with two irregular parallel rows of short setae in distal third of the sternite; S4 with three irregular rows of short setae in distal half; S5 with four irregular rows of short setae occupying posterior two-thirds of the sternite; S6 with five irregular rows of short setae occupying all but anterior fourth; S7 with 4–5 irregular rows of short setae on posterior two-thirds; S8 and S9 fused (Fig. 12), with shallow, partly visible furrow, S8 with evenly scattered fine setae, posterior margin with moderate-length to long setae, S9 asymmetrical with two posterior lobes, left lobe more prominent, each lobe with one row of strong setae; S10 invaginated beneath S8+S9, not visible externally; sternite S11 with two lateral sclerites, each with one row of small setae.

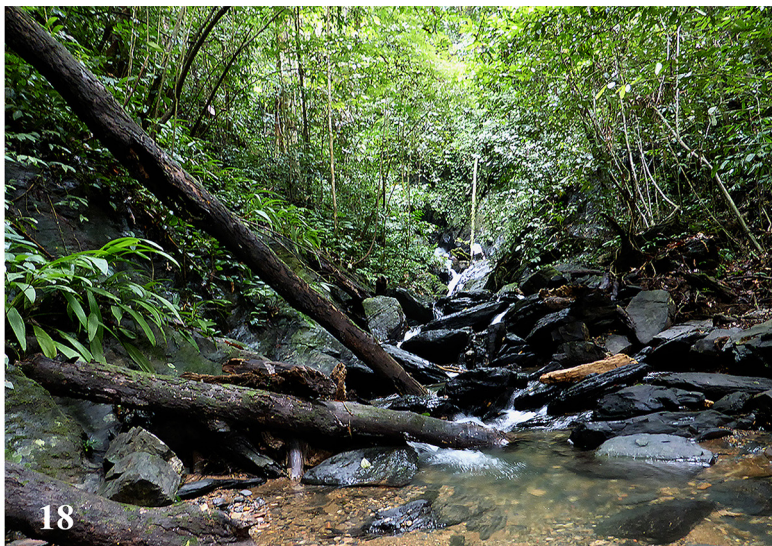
Genitalia asymmetrical, with hooked and strongly sclerotized aedeagus, without elongate coiled flagellum; spatula-like basal plate present beneath aedeagus (Fig. 13).

Apterous female. Generally as in male except as follows: pronotum transverse, apparently wider than long and only slightly narrowed posteriorly (Fig. 5); metafemur slender, ventral surface with 7 stout spines, thinner than in males, proximal first and second spines longer than others, but the distance between them twice the length of spines 1 and 2; distance between second and third bristles equal to length of spine 2 (Fig. 8); Abdominal T10 uniformly sclerotized with 6–8 short setae on each side and a pair of longer setae (Fig. 14); T11 trapezoidal, weakly sclerotized at distal end, with small setae laterally and one pair of longer setae (Fig. 14); both cerci short, conical with slightly pointed distal apex, surface covered with numerous minute spicules except on base and apex, and shorter and longer setae (Fig. 14); S8 strongly trapezoidal, wider than long, with short setae evenly scattered and longer setae flanking the distal and lateral edges; distal end slightly concave with peg-like projection in the middle (Fig. 16); S9 short and trapezoidal with several small setae along posterior margin (Fig. 15).

Alate males and females. Unknown.

Etymology. The name refers to the asymmetrical cerci and asymmetrical abdominal sternite S9 in males.

Distribution and occupied habitat. *Zorotypus asymmetricus* **sp. nov.** was collected under the bark of rotting logs in shade in the valley of Sungai Esu stream (Fig. 18). The species is currently known only from Ulu Temburong National Park in Brunei Darussalam, but we expect its occurrence in similar habitats throughout Borneo.



FIGURES 17, 18. Living status and occupied habitat of *Zorotypus asymmetricus* **sp. nov.** 17, living apterous male; 18, rotting logs in Sungai Esu stream valley where *Z. asymmetricus* **sp. nov.** was collected.

Key to species of *Zorotypus* known from Borneo

- 1 Male right cercus asymmetrical, strongly enlarged and curved. Ventral surface of metafemur with 7–8 long, stout spines *Z. asymmetricus* **sp. nov.**

- Both cerci in males and females short, conical and symmetrical. Ventral surface of metafemur with more or fewer spines . . . 2
- 2. Ventral surface of metafemur with four long, stout spines. Male genitalia symmetrical, with coiled flagellum *Z. caudelli*
- Ventral surface of metafemur with 10 long, stout spines. Male genitalia asymmetrical, without coiled flagellum . . . *Z. weiweii*

Acknowledgements

We thank the staff of the Kuala Belalong Field Studies Centre for their service and support during the stay of our research team at KBFSC and we also thank Universiti Brunei Darussalam for permission to conduct the research. We thank Ivona Horká (Ostrava) for the help and collecting effort in the field, and an anonymous reviewer for helpful comments and critical reading of the manuscript. This study was supported by the project CZ.1.07/2.200/28.0149 ("Innovation of ecological studies by complementary fusion of courses between Palacký University and University of Ostrava") financed by the Structural Funds of the European Union.

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