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The Dobsonfly Genus *Nevromus* Rambur, 1842 (Megaloptera: Corydalidae: Corydalinae) from Thailand, with Description of a New Species

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ABSTRACT.– *Nevromus* Rambur, 1842 is a megalopteran genus belonging to the family Corydalidae, and endemic to the Oriental faunal region. The Thai species of *Nevromus* are herein revised to include two species: *Nevromus aspoeck* Liu, Hayashi & Yang, 2012, and *Nevromus jeenthongi* **sp. nov.** The larval and pupal stages of *N. aspoeck* are described here for the first time. *Nevromus jeenthongi* **sp. nov.** appears to be closely related to *N. aspoeck* but differs from the latter species the occiput without black spots, the broader posterolateral lobes of male ninth sternum, and the fused male tenth gonocoxite strongly concaved along dorsal outline. Both species inhabit clean, clear flowing streams. The geographical distribution of *Nevromus* is updated with first records of this genus from the Malay Peninsula and Myanmar. A key to species of the genus based on male is provided.

KEY WORDS: ***Nevromus*, COI, stage association, new species, Thailand**

INTRODUCTION

The dobsonfly genus *Nevromus* Rambur, 1842 (Megaloptera, Corydalidae, Corydalinae) was established by Rambur (1842) based on the adult of *Nevromus testaceus* Rambur, 1842 from Java (Indonesia). Members of *Nevromus* are widely distributed in the Oriental region, from the Indian subcontinent to southern China, Indochina, and to the three main islands of the Malay Archipelago (Borneo, Sumatra, and Java) (Rambur, 1842; Yang and Liu, 2010; Liu et al., 2012; Jiang et al., 2015; Hassan et al., 2020). Currently, the genus consists of six extant valid species, i.e., *Nevromus aspoeck* Liu, Hayashi & Yang, 2012 from China and Thailand (Liu et al., 2012); *Nevromus austroindicus* Liu & Viraktamath, 2012 from India (Liu et al., 2012); *Nevromus exterior* (Navás, 1927) from China, Laos, and Vietnam (Liu et al., 2012; Jiang et al., 2015); *Nevromus gloriosoi* Liu, Hayashi & Yang, 2012 from Brunei, Indonesia, and Malaysia (Liu et al., 2012); *Nevromus intimus* (McLachlan, 1869) from India, Nepal, Pakistan, China, and Myanmar (Liu et al., 2012; Hassan et al., 2020); and *Nevromus testaceus* Rambur, 1842 from Indonesia (Liu et al., 2012). Liu et al. (2012) reported that the species of *Nevromus* are allopatric.

The species of *Nevromus* from the Oriental region were revised by Liu et al. (2012), in which only *Nevromus aspoeck* was recorded in Thailand. In this paper, two species of *Nevromus* are reported from

FIGURE 1. Collection sites of *Nevromus* spp. in Thailand. A. Kaeng Sama, Nan River, Chiang Klang District, Nan Province (Photo T. Phutthanurak); B. Mae Ngao River, Sop Moei District, Mae Hong Son Province (1. Larvae of *Nevromus aspoeck* inhibit shallower water of streams; 2. Larvae of *Acanthacorydalis* sp. inhabit fast flowing water in the middle line of stream); C. Haew Narok waterfall, Khao Yai National Park, Pak Phli District, Nakhon Nayok Province; D. Wang Tao waterfall, Thap Lan National Park, Khon Buri District, Nakhon Ratchasima Province; E, F. San Yen, Khao Nan National Park, Nakhon Si Thammarat Province (Photo N. Pinkaew).

Thailand, including one previously undescribed species. *Nevromus aspoeck* is redescribed and compared to closely related species. *Nevromus aspoeck* is newly reported from Cambodia and the new species was also collected in Myanmar thus expanding the known distributional range for the genus in the region. In addition, we used DNA barcoding to associate sexes and life stages of *N. aspoeck*. The larval and pupal stages of *N. aspoeck* are described for the first time.

The specimens studied were collected from clear flowing streams and rivers in Thailand between 2014 and 2020 (Fig. 1), and others were obtained from various museums, listed below under specimen depositories. Sampling was done using an

aquatic net (with 450 μm mesh size), and by hand picking in order to collect larvae for rearing. Adults were collected by placing a light trap (10-W black light fluorescent tube) overnight, adjacent to the water body. In order to induce pupation, some final instar larvae were kept alive separately in a glass box (9 × 11 × 15 cm) that contained moist sediment topped with a flat stone and covered with a net (modified from Cao and Liu, 2013; Piraonapicha et al., 2020). The morphological terminology of sclerotized structures of the immature stages follows Cao and Liu (2013) and Ardila-Camacho and Contreras-Ramos (2018). The terminology of wing venation follows Kukalova-Peck & Lawrence (2004). Male and female genitalia were removed from the abdomen, cleared in 10% potassium hydroxide (KOH) solution for one day, and then in glycerin for detailed observation (see Liu et al., 2016 for terminology of the genitalia). Morphological observations (larvae, pupae and adults) were made using a Nikon SMZ445 stereo-microscope. Images of live specimens were taken using a Canon EF-S 60mm f/2.8 macro lens attached to a Canon 70D digital camera. The holotype and paratypes of *Nevromus jeenthongi* **sp. nov.** are pinned.

Illustrations were created following the Hozenthal (2008, 2018). Digital drawings were prepared with Abode Illustrator® (version CC 2018, Adobe Systems, San Jose, California). Photographs were taken using the Canon 70D digital camera through ocular lens of Nikon SMZ445 stereo-microscope, which served as templates in Adobe Illustrator®. While being drawn, the specimen was also examined under the stereomicroscope for comparison to ensure accuracy.

Only genomic DNA of *Nevromus aspoeck* was extracted. No DNA extraction of *N. jeenthongi* was performed due to non-availability of fresh specimens. The total genomic DNA was extracted from the muscle tissues taken from the right legs of nine specimens (1 male and 2 female adults, 1 pupa, and 5 larvae) using the PureLink Genomic DNA Mini Kit (Invitrogen, Carlsbad, CA, USA) following the protocol for animal tissues and the DNA was stored at -20 °C. We amplified a 511 bp fragment of the mitochondrial gene cytochrome oxidase subunit 1 (COI) using the primers pairs LCO 1490 and HCO 2198 (Folmer et al., 1994). The polymerase chain reaction (PCR) method was followed as described by Piraonapicha and Sangpradub (2019).

Sequences were aligned using BIOEDIT version 7.2.5 (Hall, 1999). Pairwise distances were calculated with MEGA version X (Kumar et al., 2018) using the "Distances" option and "Nucleotide: p-distance" model option for distances. The COI tree was constructed using the MEGA X (Kumar et al., 2018). We selected GTR+G with partial deletion as the most appropriate model for reconstruction (based on the lowest AICc and BIC scores) and conducted a Maximum Likelihood analysis based on the General Time Reversible model with the Kimura 2-parameter (K2P) model (Kimura, 1980). Branch supporting values were assessed using 1,000 bootstrap replications. The COI sequences were deposited at GenBank (https://www.ncbi.nlm.nih.gov/genbank) under accession numbers specified in Table 1. DNA sequences of other ingroup taxa were downloaded from GenBank (https://www.ncbi.nlm.nih.gov/genbank), obtaining sequences for *Nevromus aspoeck* Liu, Hayashi & Yang, 2012, *Nevromus exterior* (Navás, 1927) and *Neoneuromus tonkinensis* (van der Weele, 1907). The alderfly species *Indosialis bannaensis* Liu, Yang & Hayashi, 2006 (Sialidae) was used to root the tree as an outgroup

TABLE 1. Species and specimen information used in the DNA barcoding analysis.

Species	Locality	Stage	Voucher	GenBank accession number
Indosialis bannaensis	Thailand	Larva	KKUM011	MK578525[1]
Neoneuromus tonkinensis	Vietnam			KP126231[2]
Nevromus exterior	Vietnam			KP126232[2]
Nevromus aspoeck				MF281176.1[3]
Nevromus sp.	Thailand	Female pupa	KKUM021	MT309676[4]
Nevromus aspoeck	Thailand	Female	KKUM022	MT309677[4]
Nevromus sp.	Thailand	Larva	KKUM023	MT309678[4]
Nevromus sp.	Thailand	Larva	KKUM024	MT309679[4]
Nevromus sp.	Thailand	Larva	KKUM025	MT309680[4]
Nevromus aspoeck	Thailand	Male	KKUM026	MT309681[4]
Nevromus sp.	Thailand	Larva	KKUM027	MT309682[4]
Nevromus sp.	Thailand	Larva	KKUM028	MT309683[4]
Protohermes xanthodes	South Korea	Female		KJ155797[5]

[1]Piraonapicha et al., 2020; [2]Jiang et al., 2015; [3]Genbank; [4]Present study; [5]Jung et al., 2016.

species (sequence available in GenBank (https://www.ncbi.nlm.nih.gov/genbank)).

Specimens are deposited in the Entomological Museum, China Agricultural University, Beijing (**CAU**); the Royal Belgian Institute of Natural Sciences, Brussels (**IRSNB**); the Freshwater Biology laboratory, Department of Biology, Faculty of Science, Khon Kaen University (**KKU**); the Natural History Museum, London (**NHML**); and the Thailand Natural History Museum of the National Science Museum, Pathum Thani (**THNHM**). The holotype of the new species is deposited in the THNHM.

RESULTS

TAXONOMY

Genus *Nevromus* Rambur, 1842

Nevromus Rambur, 1842: 441. Type species: *Nevromus testaceus* Rambur, 1842: 442, subsequent designated by van der Weele, 1906: 210 (as '*Neuromus* [sic] *testaceus* Rambur'); Oswald and Penny, 1991: 62.

Neuromus Walker, 1853: 201 (in *Hermes* synonymy). Incorrect subsequent spelling of *Nevromus*.

Diagnosis.— Revised from Liu et al. (2012). Body color generally yellow to yellowish brown, with two pairs of black markings near the lateral margins of pronotum; head subquadrate, with a pair of distinct postocular spines; wings hyaline, generally immaculate, except for black stripes or spots on some crossveins; male ninth tergum subtrapezoidal, anteriorly with small median fossa on internal inflection; ninth sternum short and narrow, posteriorly somewhat concave, bearing one pair of lateral lobes; ninth gonostylus unguiform, setose; ectoproct clavate, flatly foliate, or band-like; ovoid cercus with dense trichobothria present near base of ninth gonostylus; fused tenth gonocoxites strongly sclerotized, posteriorly protruding as large subtrapezoidal, or broadly shield-like median plate, with diversified modifications.

Distribution.— Brunei, Cambodia, China, India, Indonesia, Laos, Malaysia, Myanmar,

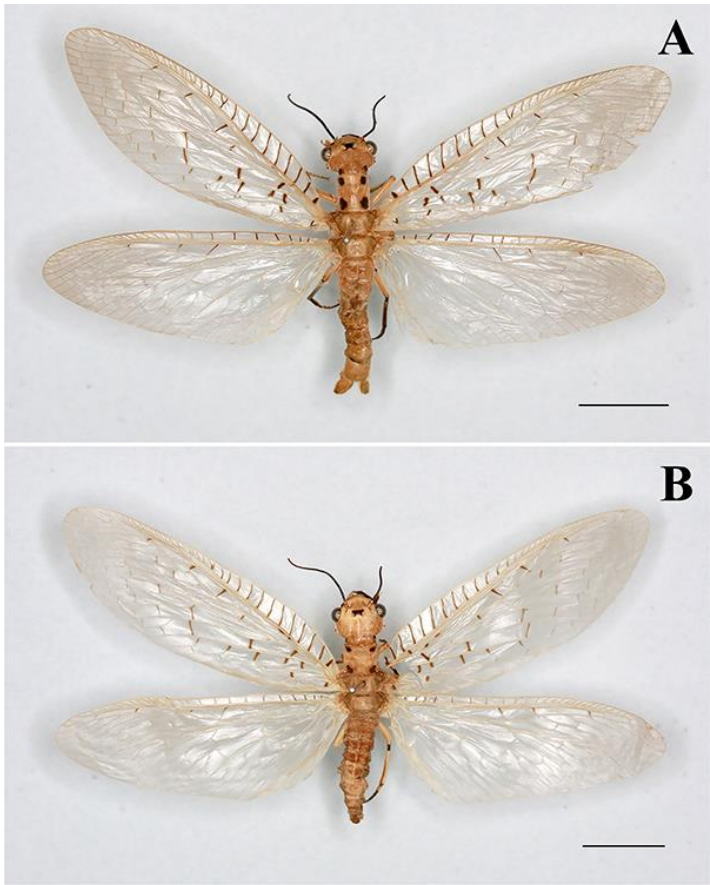

FIGURE 2. *Nevromus aspoeck*, dorsal view. A. male; B. female. Scale bars: 1.00 cm

Nepal, Pakistan, Thailand, and Vietnam (Rambur, 1842; Yang and Liu, 2010; Liu et al., 2012; Jiang et al., 2015; Hassan et al., 2020). Cambodia is a new distributional record for this genus based on the examination of a female specimen of *N. aspoeck* by Liu XY.

Nevromus aspoeck Liu, Hayashi & Yang, 2012

(Figs. 2–10, 16)

Nevromus aspoeck Liu, Hayashi & Yang, 2012: 661. Type locality: China (Yunnan: Xishuangbanna).

Type.— Holotype, male, CHINA, Yunnan Province, Xishuangbanna, Lvshilin (21º51'N, 101º24'E), 22.IV.2011, H.B. Liang & K.Q. Li (CAU, examined).

Non-type material examined.— Cambodia.— 1 female, Pramaoy Forest Edge, Phnom Samkos W.S., Pursat Province, 15.IV.2005, K. Smets & I. Var leg. (IRSNB). **Thailand.—** 4 females, Kaeng Sama, Nan River, Chiang Klang District, Nan Province, 19º13'31.08"N, 100º49'28.52"E, 246 m a.s.l., 19.IV.2017, T. Phutthanurak and P. Buntha leg. (THNHM-I-23401 to THNHM-I-23404, THNHM); 1 male (reared from a pupa), Mae Ngao River, Sop Moei District, Mae Hong Son Province,

FIGURE 3. *Nevromus aspoeck*, living male, lateral view

17º48'31.3"N, 97º59'20.8"E, 166 m a.s.l., 29.II.2020, K. Piraonapicha leg. (THNHM-I-23405, THNHM); 72 larvae, same locality, date and collector (KKU, THNHM); 1 female, Haew Narok waterfall, Khao Yai National Park, Pak Phli District, Nakhon Nayok Province, 14º17'19.74"N, 101º23'32.38"E, 363 m a.s.l., 16.VI.2016, K. Piraonapicha leg. (THNHM-I-23406, THNHM); 2 female pupa, 8 larvae, same locality and collector, 30.II.2019, (KKU, THNHM); 16 males, Wang Tao Waterfall, Thap Lan National Park, Khon Buri District, Nakhon Ratchasima Province, 14º20'13.64"N, 102º14'48.00"E, 223 m a.s.l., 24.V.2014, K. Piraonapicha leg. (THNHM-I-23407 to THNHM-I-23422, THNHM); 9 females, same locality, date and collector (THNHM-I-23423 to THNHM-I-23431, THNHM); 4 larvae, same locality, date and collector (KKU).

Diagnosis.— Head yellow, with a pair of small black markings on lateral portions of occiput; mandibles mostly black; prothoracic black markings transversely broadened in both sexes; male ectoproct flatly foliate with a long and digitiform apex; ninth sternum with posterior lobes strongly produced posterolaterally.

Description.— Male (Figs. 2A, 3, 5A–5E)**.** Measurement. Male (n = 3). Total body length 36.00±2.65 mm (including mouthparts); head width 6.00±0.00 mm, head length 6.33±0.58 mm (excluding labrum and mandibles); right forewing length 11.67±0.58 mm; right forewing width 33.00±1.73 mm; right hindwing length 11.67±0.58 mm; right hindwing width 30.00±1.73 mm. Body

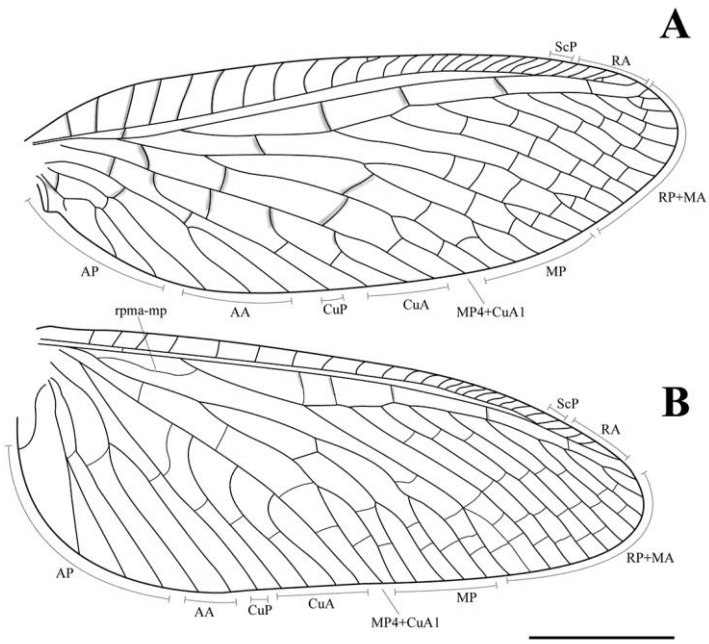

FIGURE 4. *Nevromus aspoeck*, male. A. right forewing; B right hind wing. Abbreviations: ScP, subcostal posterior; RA, radius anterior; RP, radius posterior; MA, media anterior; MP, media posterior; CuA, cubitus anterior; CuP, cubitus posterior; AA, anal posterior; AP, anal posterior. Scale bar: 1.00 cm

yellow to yellowish brown; head yellow, subquadrate, almost as long as broad, with a pair of black markings on posterolateral corners of clypeus, a black spot on ocellar triangle, and a pair of small black markings on occipital corners; postocular spine black, short, acute; in ventral view, cervix with a pair of black markings laterally; compound eyes dark brown, large, roundly convex; scape and pedicel yellow, scape almost twice as long as pedicel, flagellum dark brown; labrum yellow, clearly shorter than broad; mandibles relatively long, with large and sharp apical tooth, followed by medium-sized preapical tooth, small sub-triangular tooth and small subtriangular basal tooth; mandibles reddish brown and covered with sparse short erect setae, in lateral view, mandibles with a narrow yellowish brown stripe on posterior half; clypeus yellowish, clearly shorter than broad. Thorax yellow, covered with sparse yellowish setae; pronotum (excluding anterior and posterior membranes) in dorsal view, subquadrate, with two pairs of broad black markings (anterior black markings slightly smaller than posterior markings); mesonotum in dorsal view, subrectangular, slightly longer than metanotum. Wings hyaline, slightly smoky brown; forewing with black stripes on crossveins and bases of cubital branches; hindwing with black stripes on crossveins of proximal half of costal area and crossveins between RA and RP; longitudinal veins yellow; RP 8-branched; 3–4 crossveins between RA and RP; MA distally bifurcate; MP_{1+2} 4-branched, MP_{3+4} 2-branched (Fig. 4A, B). Legs covered with dense decumbent yellowish brown setae; tibiae dark brown, with a narrow

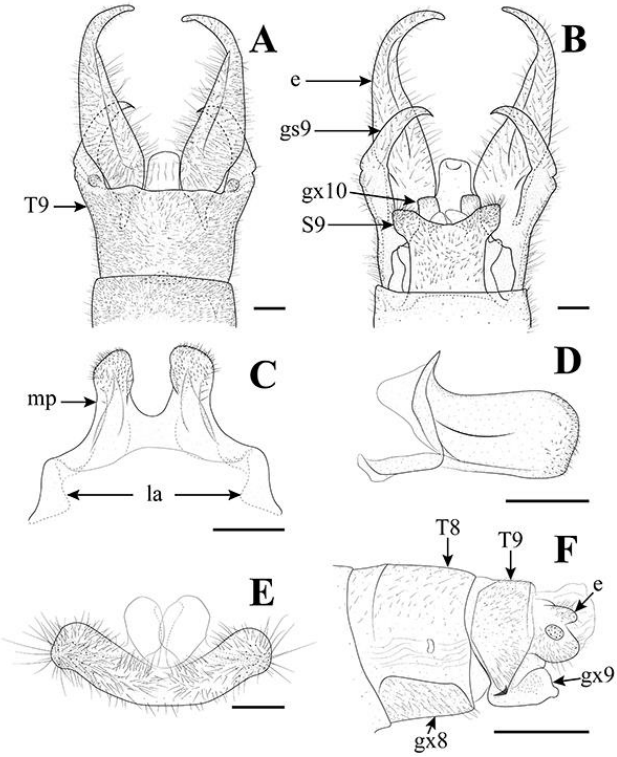

FIGURE 5. *Nevromus aspoeck*. A. male genitalia, dorsal view; B. male genitalia, ventral view; C. male fused tenth gonocoxites, ventral view; D. male fused tenth gonocoxites, lateral view; E. male ninth sternum, caudal view; F. female genitalia, lateral view. Abbreviations: S9, ninth sternum; T8–9, eighth to ninth tergum; gs9, ninth gonostylus; gx8–10, eighth to tenth gonocoxite; e, ectoproct; la, lateral arm; mp, median plate. Scale bars: 1.00 mm (A, B, E); 1.25 (C, D); 2.50 mm (F).

yellow stripe dorsad and with two spurs at apex; tarsi dark brown; pretarsal claws reddish brown. Abdomen yellow to yellowish brown and covered with dense short yellowish brown setae.

Genitalia. Ninth tergum in dorsal view subtrapezoidal, with arcuate anterior incision; internal inflection with a small subtriangular median fossa; ninth sternum in ventral view subquadrate, clearly shorter and narrower than ninth tergum, posteriorly deeply incised, with a pair of obtusely tapered lobes, which are strongly prominent and directed posterolaterally, but not reaching to lateral margin of ninth tergum; in caudal view, ninth sternum distinctly curved dorsad, medially with a pair of small subtriangular processes, which distally bear membrane; ninth gonostylus in ventral view slender and curved inward (unguiform), with a short and sharp distal claw; ectoproct flatly foliate, slightly longer than ninth tergum and ninth gonostylus combined, and thickened along lateral margin, with apex slightly curved, strongly narrowed, and digitiform; fused tenth gonocoxites strongly sclerotized with lateral arms elongated and distally enlarged, median plate anteriorly convex dorsad, lateral margin of median plate distinctly concave; in ventral view, posteromedian incision of fused tenth gonocoxites as broad as posterolateral lobe,

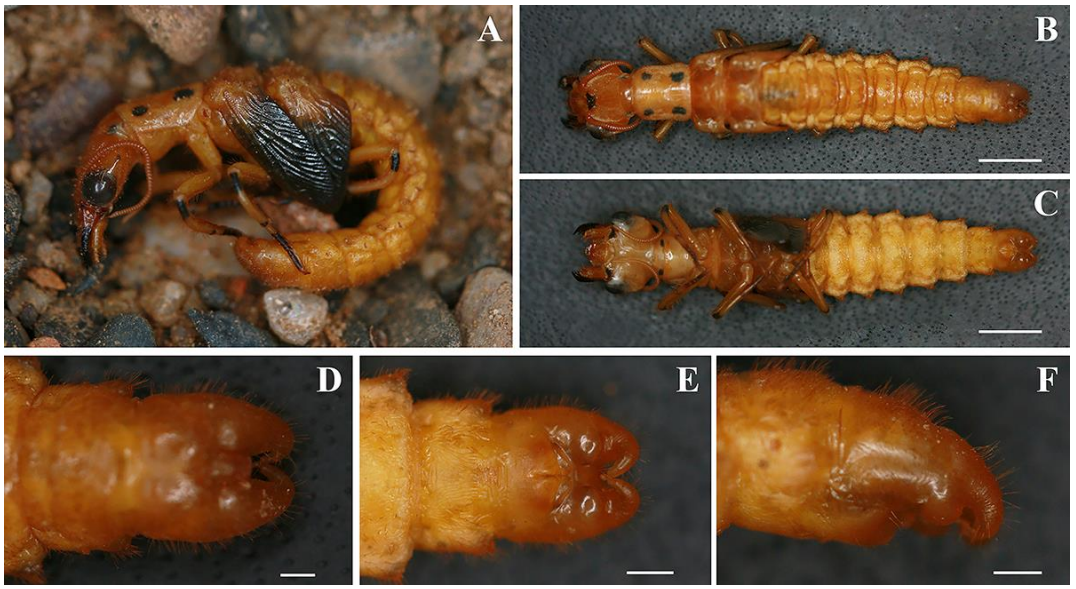

FIGURE 6. Male pupa of *Nevromus aspoeck*. A. lateral view in natural condition; B. dorsal view, with abdomen stretched; C. ventral view, with abdomen stretched; D. apex of abdomen, dorsal view; E. apex of abdomen, ventral view; F. apex of abdomen, lateral view. Scale bar: 5.00 mm (B, C); 1 mm (D–F).

with V-shaped basal margin and broadened distad, and having a pair of broad and flattened posterior lobes, nearly as long as broad, roundly margined, and densely setose (Figs. 5A–5E).

Female (Fig. 2B)**.** Measurement (n = 3). Total body length 33.67±2.31 mm (including mouthparts); head width 7.00±0.00 mm, head length 7.00±0.00 mm (excluding labrum and mandibles); right forewing length 14±1.00 mm; right forewing width 41.33±0.58 mm; right hindwing length 14.67±1.15 mm; right hindwing width 36.67±1.53 mm. Similar to male in structure, sculpture, color, wing venation and pilosity, with the following condition that should be noted: 1) body slightly larger; 2) fused eighth gonocoxites in lateral view subtrapezoidal; 3) ninth gonocoxite broadly valvate, its posterior half subtriangular with a rather small lobe at tip; 4) ectoproct relatively short, with posterior margin medially incised, leaving digitiform dorsal and semicircular ventral lobes slightly shorter than above (Fig. 5F).

Male pupa (Fig. 6)**.** Body length 37 mm and covered with dense setae; exarate, curved inward in natural condition (Fig. 6A). Head subquadrate, yellowish brown, with dense irregular raised scars on posterior half and between compound eyes (Figs. 6B–6C); in dorsal view labrum yellowish brown and triangular; mandibles reddish brown, with large and sharp apical tooth, followed by medium-sized preapical tooth and a small subtriangular basal tooth (smaller than preapical tooth) on inner margin, while outer margin of mandible roundly convex; antennae filiform and yellowish brown; compound eyes black, round and distinctly convex; occiput with four broad raised scars; pronotum yellowish brown, subrectangular, slightly broader than long; mesonotum and metanotum rectangular,

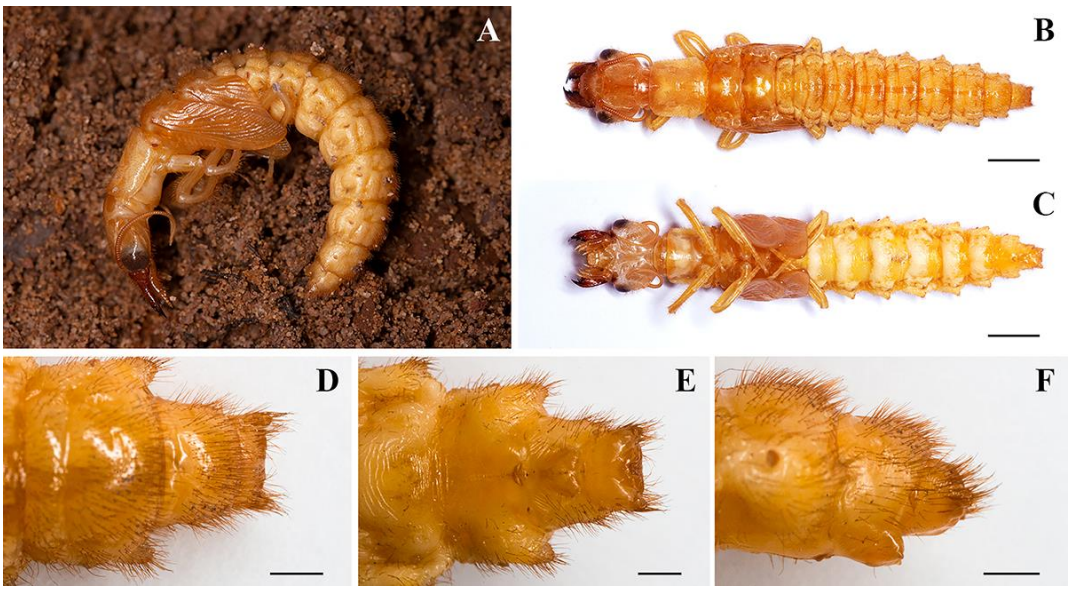

FIGURE 7. Female pupa of *Nevromus aspoeck*, A. lateral view in natural condition; B. dorsal view, with abdomen stretched; C. ventral view, with abdomen stretched; D. apex of abdomen, dorsal view; E. apex of abdomen, ventral view; F. apex of abdomen, lateral view. Scale bar: 5.00 mm (B, C); 1 mm (D–F).

twice as long as broad; wing pads yellowish brown (become darker before emergence), with longitudinal veins; coxae and trochanters yellowish brown; femora, tibiae and tarsi yellow; tergum of abdomen yellowish brown with dark broad band running from 1st to 7th abdominal segments, while sternum white and relatively smooth (segments 1–7); each abdominal segment shorter than broad and clearly separated from each other by constriction.

Female pupa (Fig. 7)**.** Similar to male pupa in structure, sculpture, pilosity and coloration, with the following conditions that should be noted: body much larger (46 mm in female; 37 mm in male); ectoproct indistinct (developing in male pupa, see Figs. 6D–6F and Figs. 7D–7F for comparison); other genital sclerites weakly developed.

Late-instar larva (Figs. 8–10)**.** Measurement (n = 10). Total body length 51.5±4.45 mm (including mouthparts); head width 8.50±0.33 mm; head length 7±0.00 mm (excluding labrum and mandibles); prothorax width 8.45±0.16 mm; prothorax length 7.90±0.21 mm. Campodeiform. Head yellowish brown to reddish brown, subquadrate; antenna reddish brown, with five segments; first antennal segment (scape) very short, about twice broad than long; segment 2 almost as long as segment 3; segment 4 slightly shorter than segment 5 (Figs. 9A, 9B); with six stemmata located anterolateral corners of head; labrum subquadrate, reddish brown, anterior margin extensively convex bearing several long setae mixed with shorter setae (Fig. 9A); clypeus yellowish brown, subtrapezoidal, with its anterior margin straight; mandibles reddish brown to dark brown, smooth and shiny, with long apical tooth, followed by medium-sized preapical tooth, small subtriangular tooth and small subtriangular basal tooth; outer margin of mandible roundly convex (Fig. 9C); in

FIGURE 8. *Nevromus aspoeck*, larva in dorsal view

ventral view, maxillae reddish brown (Fig. 9D), along inner margin of maxillae bearing long setae; gular plate relatively broad, not clearly demarcated from submentum, and covered with sparse short erect setae; cardo relatively round; mentum subrectangular, slightly shorter than broad, its anterior half paler than posterior half (mental plate) (Fig. 9E); anterolateral corners of mental plate truncate; prementum smaller than mentum, subrectangular, its anterior half covered with dense erect setae; labial palp 3-segmented, segment 1 about twice as long as broad, segment 2 narrower than segment 1 but clearly longer, segment 3 about 0.5 times as long as segment 2; occiput reddish brown with four large round yellow markings on posterior portion, posterior margin of occiput roundly convex. Thorax reddish brown covered with sparse short setae; pronotum subquadrate, its posterior half medially with a pair of slender elongate stripes and laterally with many irregular and complex small markings (Fig. 9F); mesonotum and metanotum shorter than pronotum, twice as broad as long; legs yellowish brown with dense dark erect setae; abdomen 10-segmented, reddish brown, with dense short setae; abdominal segments 1–8 baring lateral filaments; segments 1–7 bearing tracheal gills and tufts near lateral filament base; sternum 9 ventrally with a large subquadrate sclerotized plate on segment 9; sternum 10 ventrally with two sclerotized plates; prolegs on abdominal segment 10 with a pair of hook-like terminal claws and lateral filaments; filament on prolegs shorter than on abdominal segments 1–8.

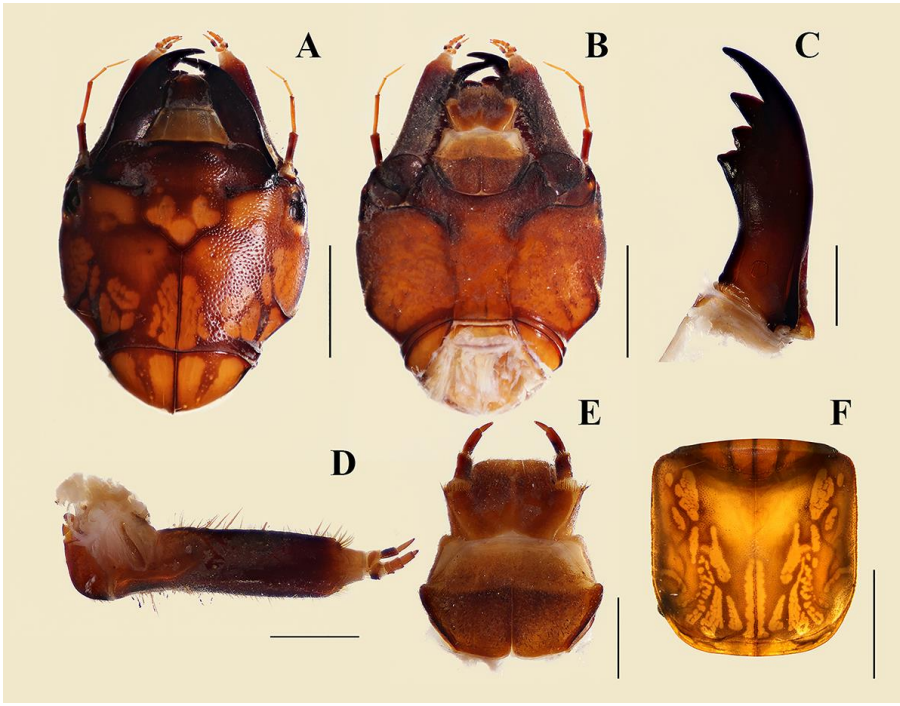

FIGURE 9. *Nevromus aspoeck*, larva, A. head in dorsal view; B. head in ventral view; C. right mandible in dorsal view; D. right maxilla in dorsal view; E. mentum and prementum in ventral view; F. pronotum in dorsal view. Scale bars: 2.50 mm (A, B, F); 1.00 mm (C–E).

Chaetotaxy. Three types of setae present on abdominal segments (Fig. 10): 1) dark elongate-inflated macrosetae setae with dense striations almost along their entire length and with opening at tip; 2) dark brown slender microsetae with dense striations along almost their entire length and with opening at tip; 3) dark brown, short and broad microsetae, with dense striations along almost their entire length and with opening at tip. In addition, each tergum 1–8 with a pair of long setae; each of sternum 1–8 with 2 pairs of long setae, behind them with spare shorter setae.

Distribution.— Cambodia (Pursat Province), China (Yunnan Province), Thailand (Chiang Mai, Mae Hong Son, Nan, Nakhon Ratchasima and Nakhon Nayok Provinces) (Fig. 17).

Bionomics.— The biology of *N. aspoeck* adult stage is not known. In the field, pupae were found in a dry riverbed under cobbles. In the laboratory, pupation (n = 2) took 30 days at ambient temperature and the period of pupation to emerge for male adults took 6 days. The predacious larvae are nocturnal and can be found clinging to and climbing under cobbles in shallower water of clear, permanent streams. At the Mae Ngao River, Sop Moei District, Mae Hong Son Province, Thailand, larvae of *N. aspoeck* and *Acanthacorydalis* sp. co-occurred in the same stream, while the larvae of *Acanthacorydalis* sp. inhabit fast flowing water in the mid channel of a body of water (Fig. 1B). Larvae of *Nevromus* and the other corydalids are traditionally eaten by hill

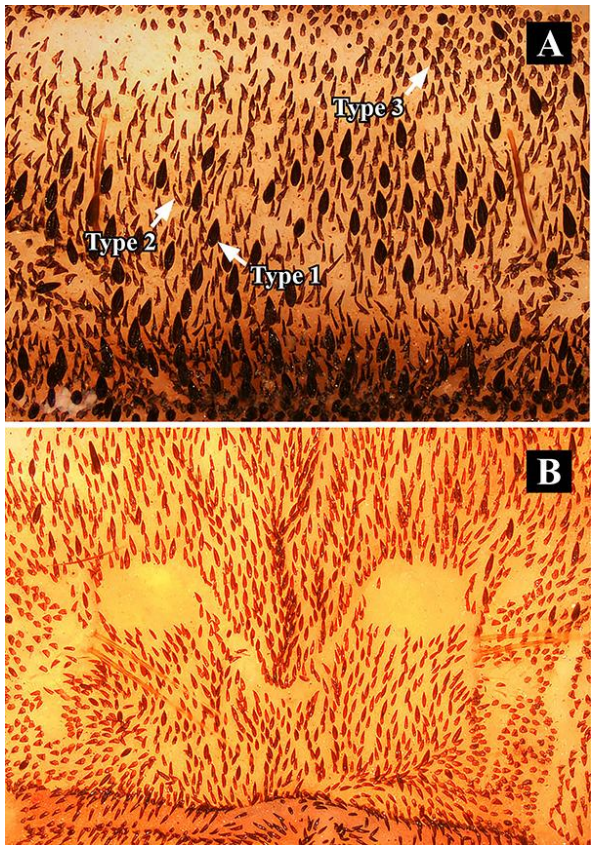

FIGURE 10. Chaetotaxy on an abdominal segment of the last-instar larva of *Nevromus aspoeck*. A. abdominal tergum; B. abdominal sternum. Arrow indicates specific type of macrosetae and microsetae on abdominal segment (see detail description of each type of macrosetae and microsetae in description).

tribes, particularly Pwo Karen and Lua in Northern Thailand.

DNA barcode data.— Genetic distances of the sequences of the mitochondrial COI gene among male and female adults, pupa, and larvae ranged from 0 to 0.010 (Table 1). In the maximum likelihood and neighbor-joining analyses showed the same results as shown in Fig. 11. The male and female adults of *N. aspoeck* were grouped together with five larvae and a single pupa examined here. Consequently, these larvae and a pupa were confirmed to be *N. aspoeck*.

Remarks.— Larvae of genera *Nevromus* and *Neoneuromus* van der Weele, 1909 are very similar in general appearance as they share the V-shape elevated bare area on the ventral surface of sternites of abdominal 1–8; the sclerotized plates on segment 9–10; and having striations on abdominal macrosetae and microsetae. However, the larva of *N. aspoeck* can be distinguished from *Neoneuromus sikkimensis* (van der Weele, 1907) and *Neoneuromus ignobilis* Navás, 1932 (Cao *et al*. 2016, 2018) by two features as following 1) head and pronotum are reddish brown (dark brown or blackish brown in the latter two); and 2) length of the mental plate is half of mentum (two third of mentum in the latter two).

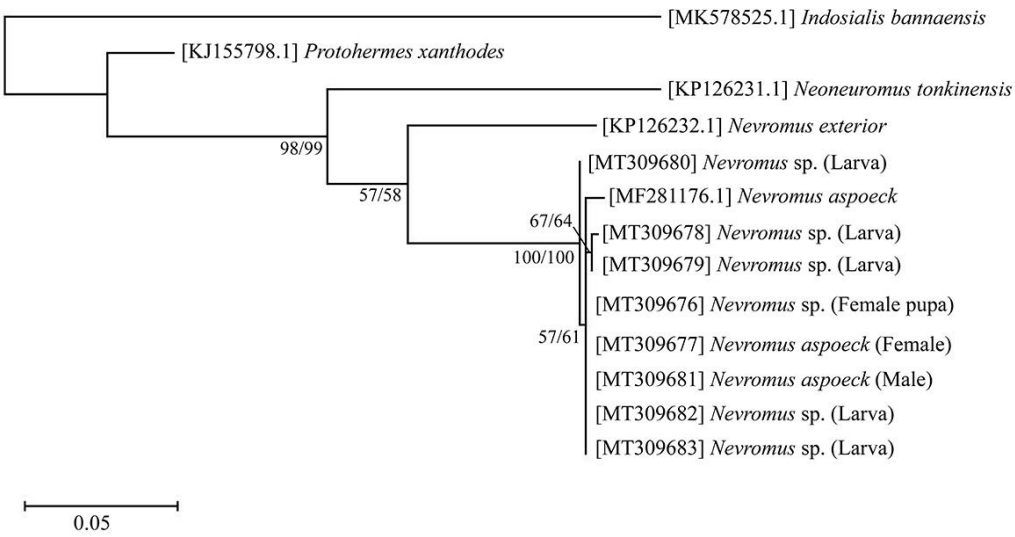

FIGURE 11. Maximum likelihood (ML) and neighbor-joining (NJ) tree of *Nevromus aspoeck* and related genera based on COI sequence data (511 bp). Nodal support values are bootstrap values (percentage of 1000 replicate, left: ML; Right: NJ). Only nodes with bootstrap > 50% are indicated. Scale bar indicates 0.05 nucleotide substitutions.

The adult is most similar to *N. jeenthongi* **sp. nov.** in general appearance (see remarks under *N. jeenthongi* new species for comparison). This species is also similar to *N. exterior* with the male ninth sternum with posterior lobes strongly produced postero-laterally, and with the male tenth gonocoxite with posterior lobes nearly as long as broad in ventral view, whereas in *N. exterior* the posterior lobes of the male ninth sternum are much smaller and the male tenth gonocoxite has posterior lobes much longer than wide in ventral view. The previous record of this species from Thailand was based on only female specimen (Liu et al., 2012). The present material, including the male specimens, further confirms the occurrence of this species in Thailand. In addition, this species is now known from Cambodia.

***Nevromus jeenthongi* sp. nov.**
(Figs. 12–15, 16)

Holotype.— Male, Thailand, Nakhon Si Thammarat Province, Sichon District, Huai Kiew Waterfall, 8º55'09.2"N, 99º40'34.8"E, 1.XI.2008, T. Jeenthong leg. (THAHM-I-21545, THNHM).

Paratypes.— Myanmar.— 1 female, Tenasserim, 95-188 (NHML). **Thailand.—** 2 males, 1 female, Sichon District, Nakhon Si Thammarat Province, 47–360 msl., 21.XI.2006, Jin [Jarujin Nabhitabhata] et al. leg. (THNHM-I-21520, THNHM-I-21521, THNHM-I-21522, THNHM); 1 male, 3 females, same locality and collector, 47 m a.s.l., 22. XI. 2006 (THNHM-I-21523, THNHM-I-21524, THNHM-I-21525, THNHM-I-21526, THNHM); 4 females, same locality and collector, 23.XI.2006 (THNHM-I-21527 to

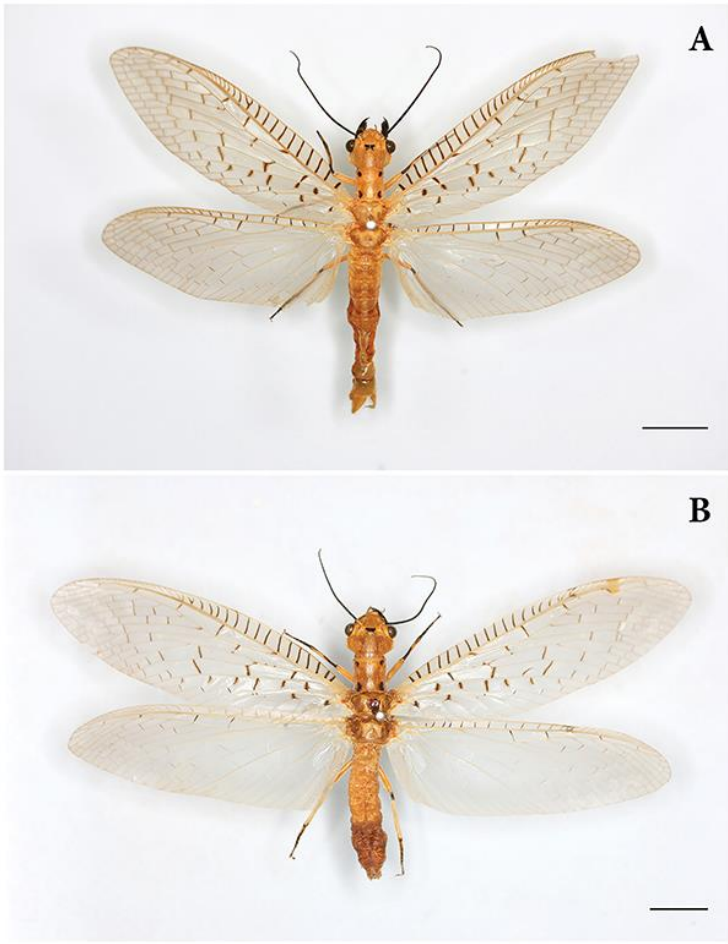

FIGURE 12. *Nevromus jeenthongi* **sp. nov.**, dorsal view. A. male (Holotype, THNHM-I-21545); B. female (Paratype, THNHM-I-2008-0304). Scale bars: 1.00 cm

THNHM-I-21529, THNHM-I-21530, THNHM); 1 female, Nakhon Si Thammarat Province, 8º55'09.2"N, 99º40'34.8"E, 1.XI.2006, T. Jeenthong leg. (THAHM-I-21531, THNHM); 2 males, same locality and collector, 1.XI.2008 (THNHM-I-21532, THNHM); 1 female, same locality, date and collector (THNHM-I-21544, THNHM); 4 females, same locality, 10.I.2008, W. Jaitrong leg. (THNHM-I-21534 to THNHM-I-21537, THNHM); 2 females, Nakhon Si Thammarat Province, 240 m a.s.l., 25.XI.2006, Jin [Jarujin Nabhitabhata] et al. leg. (THNHM-I-2007-21538, THNHM-I-21539, THNHM); 2 females, same locality and collector, 22.XI.2008 (THNHM-I-21541, THNHM-I-21542, THNHM); 2 females, Sichon District, Nakhon Si Thammarat Province, 8º54'32.6"N, 99º43'55.3"E, 2.XI.2008, W. Jaitrong leg. (THNHM-I-21544, THNHM-I-21543, THNHM); 1 female, Nakhon Si Thammarat Province, 8.79622N, 99.55311E, 1,363 m a.s.l., 16.IV.2007. W. Jaitrong & T. Jeenthong leg. (THNHM-I-21519, THNHM); 1 female, Nakhon Si Thammarat Province,

FIGURE 13. *Nevromus jeenthongi* **sp. nov.**, living female, lateral view (Photo W. Zhang)

300 m a.s.l., 6.V.2015, Antonio Giudici (CAU); 1 female, Surat Thani Province, 15.III.2013, Weiwei Zhang (CAU).

Etymology.— The species epithet is dedicated to Mr. Tadsanai Jeenthong (National Science Museum, Thailand), who donated the holotype to THNHM.

Diagnosis.— Head yellow to yellowish brown; occiput yellow without black markings; pronotum with two pairs of small black markings near lateral margins of pronotum in both sexes. Male ectoproct flatly foliate with a long and digitiform apex, fused tenth gonocoxites in ventral view strongly curved dorsad; ninth sternum with the posterolateral lobes broad, reaching to the lateral margin of ninth tergum.

Description.— Male (Fig. 12A)**.** Measurement. Male (n = 3). Total body length 42.00±4.36 mm (including mouthparts); head width 7.00±0.00 mm, head length 6.67±0.58 mm (excluding labrum and mandibles); right forewing length 14±0.00 mm; right forewing width 40.00±1.00 mm; right hindwing length 14.33±1.15 mm; right hindwing width 35.67±0.58 mm; wing span 76±1.00 mm. Body yellow to yellowish brown, head yellow, subquadrate, with a black spot on ocellar triangle, occiput without black markings; postocular spine relatively short and acute, mostly yellow, except its apex black; cervix with a pair of small black markings laterally; compound eyes dark brown, large, roundly convex; scape and pedicel yellow, scape almost twice as long as pedicel, flagellum dark brown, subserrate; labrum yellow, sub-rectangular, clearly shorter than broad;

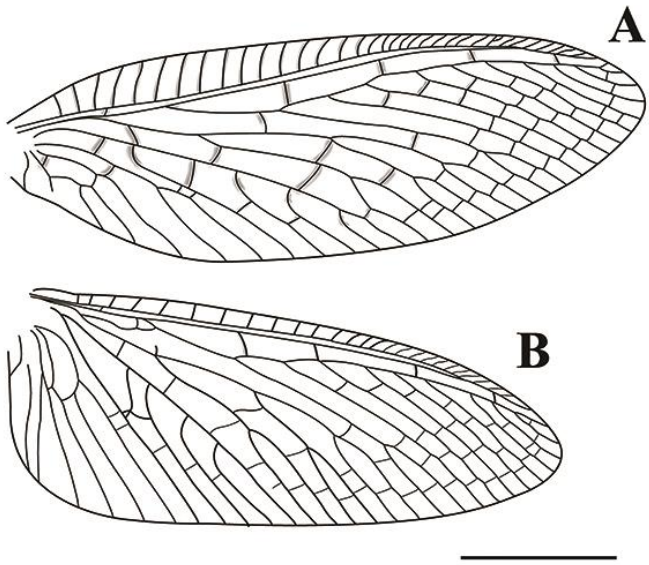

FIGURE 14. *Nevromus jeenthongi* **sp. nov.**, male. A. right forewing; B right hind wing. Scale bar: 1.00 cm

mandibles relatively long, with large and sharp apical tooth, followed by medium-sized preapical tooth, small subtriangular tooth and small subtriangular basal tooth; mandibles dark brown, except for along its inner margin reddish brown and median portion with yellow marking; clypeus yellow, relatively short, and its anterior margin sinuate. Thorax yellow, pronotum in dorsal view, subquadrate, with two pairs of black markings (anterior black markings clearly smaller than posterior markings); pronotum with sparse yellow setae; in dorsal view, mesonotum subrectangular, slightly longer than metanotum, and covered with yellowish brown setae. Wings hyaline, smoky brown; forewing with black stripes on crossveins and bases of cubital branches; hindwing with black stripes on crossveins of costal area and crossveins between RA and RP; longitudinal veins yellow; RP 8-branched; 3–4 crossveins between RA and RP; MA distally bifurcate; MP_{1+2} 4-branched, MP_{3+4} 2-branched (Fig. 14A, B). Legs covered with yellowish brown decumbent setae; tibiae dark brown, with a long and narrow yellow stripe dorsad and with two spurs near apex; tarsi dark brown; pretarsal claws reddish brown. Abdomen pale yellowish brown and covered with dense short yellowish brown setae.

Genitalia. Ninth tergum in dorsal view subtrapezoidal with arcuate anterior incision, internal inflection with a small subtriangular median fossa; ninth sternum in ventral view subquadrate, shorter than ninth tergum, its posteriorly deeply incised, with a pair of obtusely tapered lobes, which are strongly prominent and directed posterolaterally; in ventral view, posterolateral lobes of ninth sternum broad, reaching to lateral margin of ninth tergum; in caudal view, ventral outline of ninth sternum weakly convex or almost straight, while median portion of its dorsal outline with a pair of small subtriangular processes, which distally bear membrane;

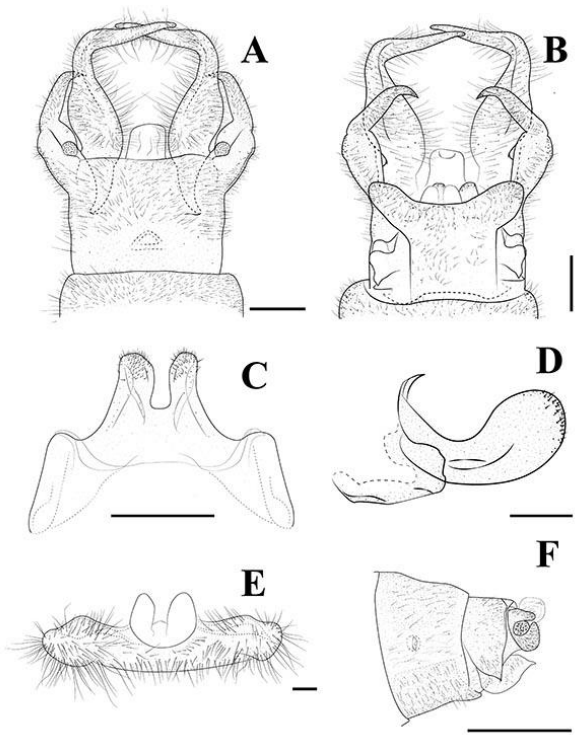

FIGURE 15. *Nevromus jeenthongi* **sp. nov.**, A. male genitalia, dorsal view; B. male genitalia, ventral view; C. male fused tenth gonocoxites, ventral view; D. male fused tenth gonocoxites, lateral view; E. male ninth sternum, caudal view; F. female genitalia, lateral view. Scale bars: 1.00 mm (A–E); 2.50 mm (F).

ninth gonostylus in ventral view slender and curved inward (unguiform), with a short and sharp distal claw; ectoproct flatly foliate, slightly longer than ninth tergum and ninth gonostylus combined, and thickened along lateral margin, with apex strongly curved, narrow and digitiform; fused tenth gonocoxites strongly sclerotized, with lateral arms elongated, median plate concave anteriorly, lateral margin of median plate weakly concave; in lateral view distinctly curved dorsad; in ventral view, posteromedian incision of fused tenth gonocoxites narrower than posterolateral lobe, with truncate basal margin, and narrowed distad and having a pair of broad and flattened posterolateral lobe, which are longer than broad and densely setose (Figs. 15A–15E).

Female. (Figs. 12B, 13)**.** Measurement. Female (n = 3)**.** Total body length 42.33±2.52 mm (including mouthparts); head width 8.00±0.00 mm; head length 7.33±0.58 mm (excluding labrum and mandibles); right forewing length 16.83±0.29 mm; right forewing width 48.33.50±0.71 mm; right hindwing length 17.50±0.71 mm; right hindwing width 42.00±1.41 mm; wing span 90 mm. Similar to male in structure, sculpture, color, wing venation and pilosity, with the following conditions that should be noted: body slightly larger; fused eighth gonocoxites in lateral view subtrapezoidal; in ventral view, ninth gonocoxite broadly valvate, anteroventral margin strongly convex, posterior half subtriangular with a rather small lobe at tip, ectoproct short, with

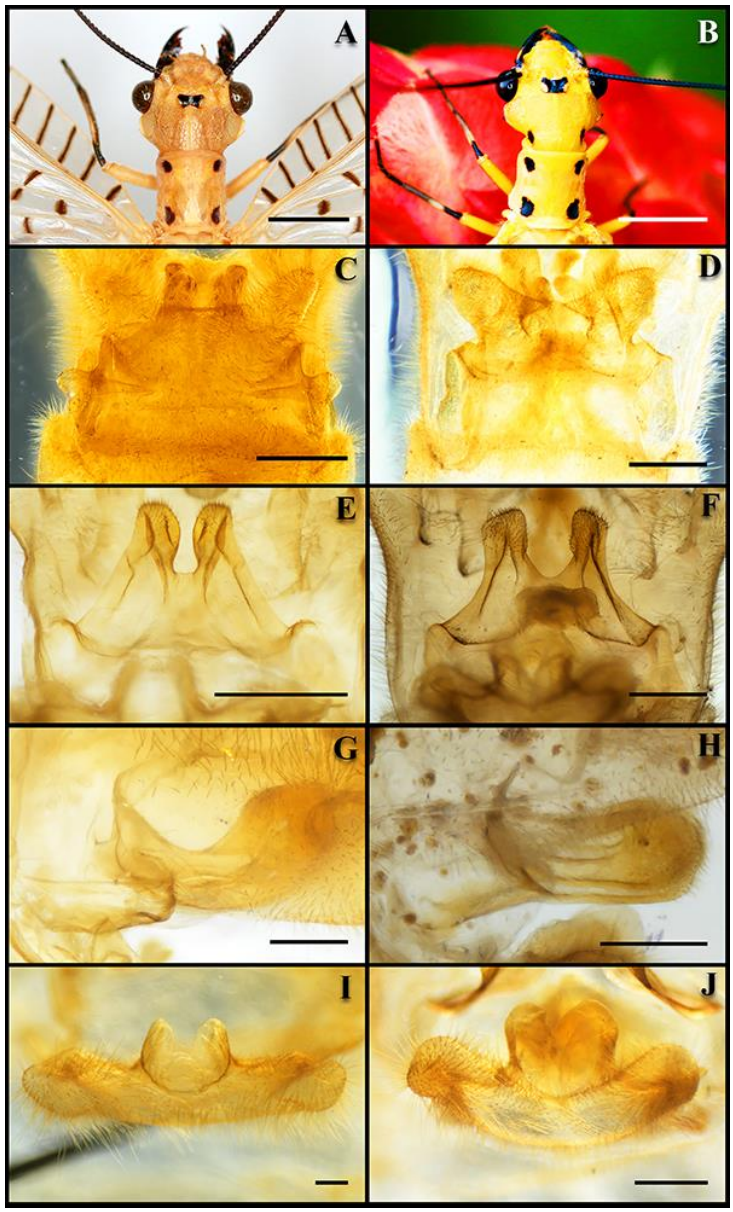

FIGURE 16. Photographs of diagnostic characters in *Nevromus jeenthongi* **sp. nov.** (A, C, E, G, I) and *Nevromus aspoeck* (B, D, F, H, J). A, B. head and pronotum in dorsal view; C, D. male ninth sternum in ventral view; E, F. male fused tenth gonocoxites in ventral view; G, H. male fused tenth gonocoxites in lateral view; I, J. male ninth sternum in caudal view. Scale bars: 5.00 mm (A, B); 1.00 mm (C, E, G, I, J); 1.25 mm (D, F, H).

posterior margin medially incised, with digitiform dorsal, bowl-shaped ventral lobes in lateral view, posterior margin nearly truncate (Fig. 15F).

Distribution.— Thailand (Surat Thani and Nakhon Si Thammarat Provinces); Myanmar (Tenasserim) (Fig. 17).

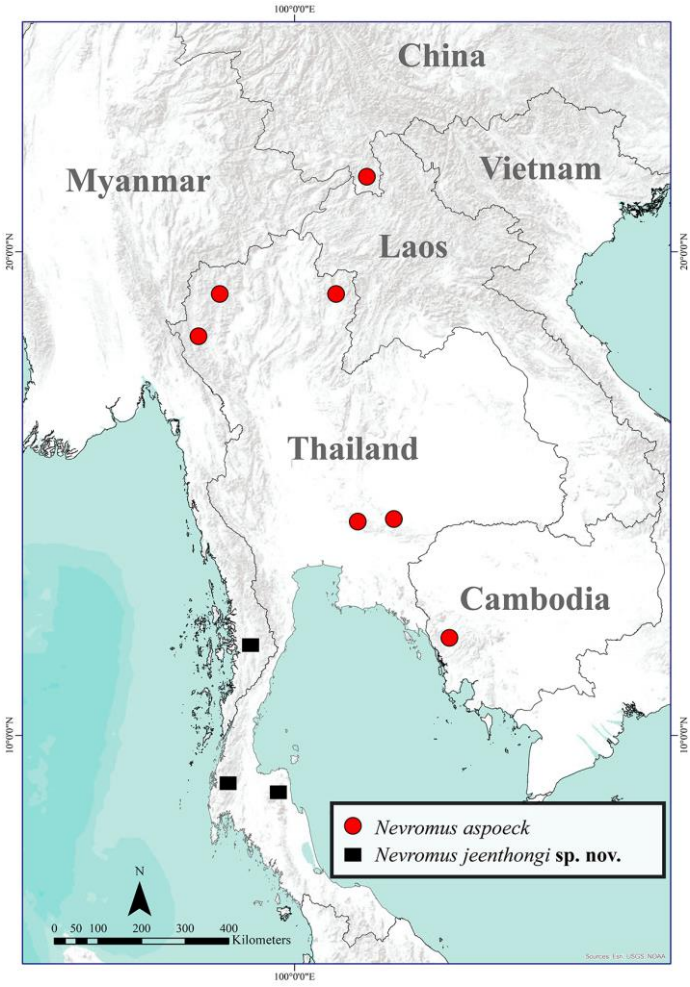

FIGURE 17. The map shows the geographical distribution of two *Nevromus* species. *Nevromus aspoeck* (●); *Nevromus jeenthongi* **sp. nov.** (■). The record from Yunnan Province (China) is from Liu *et al*. (2012).

Remarks.— Among all known species of *Nevromus*, the adult characteristics of *N. jeenthongi* are most similar to *N. aspoeck*, having two pairs of anteroposteriory apart black markings on pronotum and the flatly foliate male ectoproct with strongly narrow and digitiform apex (Table 2). However, *N. jeenthongi* is easily distinguished from *N. aspoeck* by the following characteristics: 1) occiput yellow without black markings (occiput with a pair of small black markings in *N. aspoeck*, see Figs 16A and 16B for comparison); 2) entire postocular spine yellow, except its apex black (entire postocular spine black in *N. aspoeck*, see Figs 16A and 16B for comparison); 3) in ventral view, the posterolateral lobes of the ninth sternum broad and reach to the lateral margin of ninth tergum (the posterolateral lobes that not reach to the lateral margin of ninth tergum in *N. aspoeck*, see Figs 16C and 16D for comparison); 4) in ventral

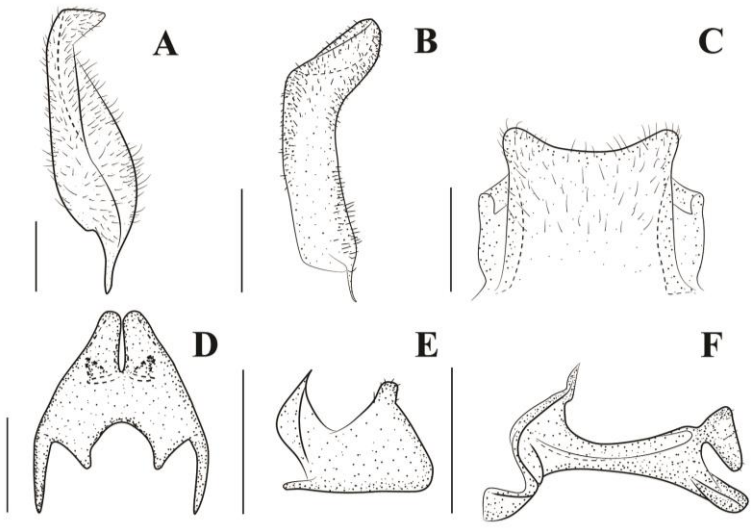

FIGURE 18. *Nevromus* spp. A. left male ectoproct of *Nevromus intimus* in ventral view; B. left male ectoproct of *N. testaceus* in ventral view; C. male ninth sternum of *N. exterior* in ventral view; D. male fused tenth gonocoxites of *N. austroindicus* in ventral view; E. male fused tenth gonocoxites of *N. gloriosoi* in lateral view; F. male fused tenth gonocoxites of *N. testaceus* in lateral view (modified from Liu et al., 2012). Scale bars: 1.00 mm

view, posteromedian incision of the fused tenth gonocoxites narrower than the posterolateral lobe, with truncated basal margin and narrowed distad (posteromedian incision of fused tenth gonocoxites as broad as the posterolateral lobe, with V-shaped basal margin and broadened distad in *N. aspoeck*, see Figs 16E and 16F for comparison); 5) in lateral view, male tenth gonocoxite strongly curved dorsad (almost straight posteriorly in *N. aspoeck*, see Figs 16G and 16H for comparison); 6) in caudal view, ventral outline of male ninth sternum weakly convex or almost straight (distinctly convex in *N. aspoeck*, see Figs 16I and 16J for comparison). The new species is also similar to *N. exterior* but can be differentiated from the latter species by the male ninth sternum with posterior lobes strongly produced and the fused tenth gonocoxites distinctly curved dorsad in lateral view (posterior lobes of male ninth sternum slightly produced and the fused tenth gonocoxites not curved dorsad in *N. exterior*) (see fig. 5 in Liu et al. (2012) and Figs. 15B, 16C for comparison).

DISCUSSION

The present findings provide new data on species diversity, morphology, and distribution of the Oriental endemic dobsonfly genus *Nevromus*. As noted in Liu et al. (2012), even though *Nevromus* has less diversity than its sister genus *Neoneuromus*, it is distributed in a broader range of the Oriental region, including the southern and northern Indian subcontinent, southern China, Indochina, and the three main islands of the Malay Archipelago. The present new records of *Nevromus* from the southwestern Indochina Peninsula and northern Malay Peninsula fill the previous gap on the

TABLE 2. Comparison of adult morphological characteristics among species of *Nevromus*

Character/ Source	*N. aspoeck*	*N. austroindicus*	*N. exterior*	*N. gloriosoi*
	Liu et al. (2012); present study	Liu et al. (2012)	Liu et al. (2012)	Liu et al. (2012)
Presence of black markings on lateral portions of occiput	present	absent	present	present
Shape of male ninth sternum in ventral view	subquadrate, with a pair of obtusely tapered lobes	subrectangular, with a pair of broad and rounded lobes	subquadrate with a pair of produced obtusely angulate lobes	subtrapezoidal, with a pair of obtusely produced lobes
Posterolateral lobe of male ninth sternum in ventral view	obtusely tapered lobe, narrower than ninth tergum	rounded lobe, narrower than ninth tergum	obtusely produced lobe, narrower than ninth tergum	obtusely produced lobe, narrower than ninth tergum
Posteromedian incision of the fused tenth gonocoxites in ventral view	broad as the posterolateral lobe, with V-shaped basal margin and broadened distad	narrow than the posterolateral lobe, and deep basal margin medially	broad as the posterolateral lobe, with U-shaped basal margin and narrowed distad	broader than the posterolateral lobe, with concave basal margin
Shape of male tenth gonocoxite in lateral view	broader than long	broader than long	broader than long	as long as broad
Apex of male ninth gonostylus	short and sharp	short and sharp	short and sharp	long and sharp
Shape of male ectoproct in ventral view	foliate with a long and digitiform apex	flatly band-like	foliate with a long and digitiform apex	clavate

TABLE 2. (Continued)

Character/ Source	*N. intimus*	*N. jeenthongi* **sp. nov.**	*N. testaceus*
	Liu et al. (2012)	present study	Liu et al. (2012)
Presence of black markings on occipital corners	present	absent	present
Shape of male ninth sternum in ventral view	subquadrate with a pair of produced obtusely angulate lobes	subquadrate, with a pair of obtusely tapered lobes	subquadrate, with a pair of produced obtusely angulate lobes
Posterolateral lobe of male ninth sternum in ventral view	obtusely produced lobe, narrower than tergum 9	obtusely tapered lobe, broad, that reach to tergum 9	obtusely produced lobe, narrower than tergum 9
Posteromedian incision of the fused tenth gonocoxites in ventral view	broader than the posterolateral lobe, with U-shaped basal margin and broadened distad	narrower than the posterolateral lobe, with truncate basal margin and narrowed distad	narrower than the posterolateral lobe, with U-shaped basal margin and narrowed distad
Shape of male tenth gonocoxite in lateral view	broader than long	broader than long	broader than long
Apex of male ninth gonostylus	short and sharp	short and sharp	short and sharp
Shape of male ectoproct in ventral view	flatly foliate with a short and subtriangular apex	flatly foliate with a long and digitiform apex	clavate

distribution of this genus between northern Indochina and the Malay Archipelago. The presently known restricted range of *N. jeenthongi* (i.e., northernmost Malay Peninsula) also corresponds to the allopatric distribution pattern of *Nevromus* proposed in Liu et al. (2012). *Neurhermes sumatrensis* (van der Weele, 1909) is the only dobsonfly species previously known from this region (Liu et al., 2015), while the other sympatric corydalids

belong to the fishfly genus *Neochauliodes* van der Weele, 1909. Thus, *N. jeenthongi* represents the second dobsonfly species from the Malay Peninsula. However, *N. jeenthongi* is confined to the northern part of the Malay Peninsula and does not overlap in distribution with *N. sumatrensis*, which is found in the southern part of this peninsula. In previous studies, some corydalid species (*Neochauliodes peninsularis* Liu, Hayashi & Flint, 2010; *Neochauliodes sundaicus* (van der Weele, 1906); and *Neurhermes sumatrensis*) from the southern Malay Peninsula were found to have biogeographical affiliations with the Malay Archipelago (Liu et al., 2010, 2015). Nevertheless, the aforementioned similar morphological characters in *N. jeenthongi*, *N. aspoeck*, and *N. exterior* suggest close phylogenetic relationships among these three species and imply that the distribution of *Nevromus* from the northern Malay Peninsula might have been due to certain dispersal of the common ancestor of *N. jeenthongi* and its relatives from Indochina. Phylogenetic and biogeographical analyses based on molecular data are essential for further investigation on the evolutionary history of *Nevromus*.

A key to the species of *Nevromus* based on male (modified from Liu et al., 2012)

1. Clypeus laterally with a pair of black markings; cervix ventrally with a pair of black markings laterally; male ectoproct flatly foliate in ventral view (Fig. 18A)……..……....**2**
– Clypeus and cervix immaculate; male ectoproct clavate or flatly band-like in ventral view (Fig. 18B)……**5**
2. Male ectoproct flatly foliate with a short and subtriangular apex in ventral view (Fig. 18A) ……..……..……... ***N. intimus* (McLachlan)**
– Male ectoproct flatly foliate with a long and digitiform apex in ventral view (Figs. 5A, B; 15A,B)……..……**3**
3. Male ninth sternum subquadrate with a pair of produced obtusely angulate lobes in ventral view (Fig. 18C)……..……..... ***N. exterior* (Navás)**
– Male ninth sternum subquadrate, with a pair of obtusely tapered lobe in ventral view (Figs. 5B; 15B). ……..……**4**
4. Occiput yellow with a pair of small black markings; (Figs. 2, 3, 16B); male tenth gonocoxite almost straight posteriorly in lateral view (Figs. 5D,16H)……..…….. ***N. aspoeck* Liu, Hayashi & Yang**
– Occiput yellow without black markings (Figs. 12, 13, 15A); male tenth gonocoxite strongly curved dorsad in lateral view (Figs. 15D, 16G)……..……. ***N. jeenthongi* sp. nov.**
5. Forewing proximally with broad black spots on crossveins; male ectoproct flatly band-like; male tenth gonocoxite with deep posterior incision in ventral view (Fig. 18D)……..... ***N. austroindicus* Liu & Viraktamath**
– Forewing proximally with only crossveins black; male ectoproct clavate (Fig. 18B); male tenth gonocoxite with shallow posterior incision……..……..……**6**
6. Mandibles mostly yellow, with apex blackish brown; male tenth gonocoxite broadly shield-like, posteriorly with a pair of small and tubercle-formed lateral lobes (Fig. 18E)…… ***N. gloriosoi* Liu, Hayashi & Yang**
– Mandibles mostly black; male tenth gonocoxite narrowly subtrapezoidal, posteriorly with two pairs of lobes, which are different in shape (Fig. 18F)..……...…….. ***N. testaceus* Rambur**

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