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Review of Dragon Millipedes (Diplopoda, Polydesmida, Paradoxosomatidae) in the Fauna of Vietnam, with Descriptions of Three New Species

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The genus *Hylomus* Cook & Loomis, 1924 is reviewed from Vietnam, with 13 recorded species. Of these, three are described as new, *H. songoku* sp. nov. from Xuan Son National Park, *H. namek* sp. nov. from Cuc Phuong National Park, and *H. saiyans* sp. nov. from Vinh Phuc and Ha Giang Provinces. The new species, *H. songoku* sp. nov., is distinguished by gonopod solenophore with rounded lobuliform lamina medialis, and well-developed lamina lateralis with a densely setose area; tip of gonopod tuberculiform. *H. namek* sp. nov. is separated from its congeners by its gonopod femorite being short, parallel-sided, slightly constricted at the middle; tip of gonopod rounded; and lastly, *H. saiyans* sp. nov. is diagnosable by its gonopod femorite being long and enlarged distally, postfemoral region short, tip bilobuled. The relationship among *Hylomus* species from Vietnam was analyzed using a fragment of the 16S rRNA mitochondrial gene. The analysis supports the monophyly of the genus *Hylomus*. It is recommended that more *Hylomus* species be added in the analysis to better clarify the phylogenetic relationships in the genus.

Key words: Dragon millipedes, Diplopoda, New species, Phylogeny, Vietnam.

BACKGROUND

The name "dragon millipedes" refers to species of five genera: *Desmoxytes* Chamberlin, 1923, *Hylomus* Cook & Loomis, 1924, *Gigaxytes* Srisonchai, Enghoff & Panha, 2018, *Nagaxytes* Srisonchai, Enghoff & Panha, 2018, and *Spinaxytes* Srisonchai, Enghoff & Panha, 2018 (Srisonchai et al. 2018a b c d). Of these genera, the latter three are only known from Thailand (Srisonchai et al. 2018b c d) whereas *Desmoxytes* is known from Thailand and Malaysia (Srisonchai et al. 2018a). The last one, *Hylomus*, consisting of 33 species, are distributed in southern China (19 species), Vietnam (10), Laos (3) and Thailand (1) (Srisonchai et al. 2018a). In Vietnam, 10 dragon millipedes of the genus have been reported, but none are troglobiotic species, while troglobitic *Hylomus* species are already known from China (Attems 1937 1938; Golovatch and Enghoff 1994; Nguyen et al. 2005; Golovatch et al. 2016). All species were previously assigned to the genus *Desmoxytes*, but have recently been allocated to the genus *Hylomus* (Srisonchai et al. 2018a). They are listed in alphabetic order below.

Hylomus asper (Attems, 1937) from Da Nang and Ninh Thuan Provinces.

Hylomus cattienensis (Nguyen, Golovatch & Anichkin, 2005) from Cat Tien National Park, Dong Nai Province.

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Hylomus cervarius (Attems, 1953) from Sa Pa, Lao Cai Province.

Hylomus enghoffi (Nguyen, Golovatch & Anichkin, 2005) from Phong Nha – Ke Bang National Park, Dong Nai Province.

Hylomus grandis (Golovatch, VandenSpiegel & Semenyuk, 2016) from Kon Chu Rang Nature Reserve, Gia Lai Province.

Hylomus hostilis (Golovatch & Enghoff, 1994) from Tam Dao National Park, Vinh Phuc Province.

Hylomus pilosus (Attems, 1937) from Cat Tien National Park, and Hon Ba Mountain.

Hylomus proximus (Nguyen, Golovatch & Anichkin, 2005) from Van Ban commune, Lao Cai Province.

Hylomus specialis (Nguyen, Golovatch & Anichkin, 2005) from Ngoc Linh Mountain, Kon Tum Province.

Hylomus spectabilis (Attems, 1937) from Ba Na – Nui Chua National Park, Da Nang City.

Our work presents a review of this genus in Vietnam and descriptions of three new species including a troglobiotic one. In addition, the study also addresses the relationships among *Hylomus* species from Vietnam, and between *Hylomus* and several other orthomorphinine genera.

MATERIALS AND METHODS

Specimen collecting, imaging and identifying

Material was collected from various parts of Vietnam (Fig. 1) and preserved in 90% ethanol. Morphological examination was performed under an Olympus SZX11 microscope. Gonopods were removed for morphological observation, then coated with gold for SEM (Scanning Electron Microscopy) using Hitachi T3030 in the Vietnam National Museum of Nature (Hanoi) or the JEO system in the Field Museum of Natural History (Chicago). After SEM, gonopods were returned to their specimens in separate vials. Line drawings were made using a camera lucida attached directly to the Olympus SZX11. Digital images were taken using an Infinitv3 Lumenera camera attached to a Leica M205C stereomicroscope and stacked using the software I-Solutions. Images were assembled into plates using Photoshop CS6.

Holotypes, paratypes and voucher specimens are housed in Institute of Ecology and Biological Resources (IEBR), Vietnam Academy of Science and Technology, Hanoi. The terminology follows Golovatch et al. (2012) and Srisonchai et al. (2018a).

DNA extraction and sequencing

Total genomic DNA was extracted from leg and head tissues using the DNAeasy Blood & Tissue Kit (Qiagen TM). Fragments of the 16S rRNA and Cytochrome *c* Oxidase subunit I (*COI*) mitochondrial genes was amplified using polymerase chain reaction (PCR). The primer sets and PCR conditions for the amplification of the 16S rRNA and *COI* follow Nguyen et al. (2017). About 20 μ l of successfully amplified PCR products were purified using ExosapIT or QIAquick PCR Purification Kit (Qiagen Inc.). Purified PCR products were sequenced on an Applied Biosystems automatic sequencer (ABI3130 XL) using the same primer sets used for the initial PCR. Unfortunately, we were only successful in amplifying and sequencing the fragment of the 16S rRNA.

Alignment and phylogenetic analysis

Each successful sequence was manually checked using BioEdit ver.7.1 (Hall 1999) and confirmed by BLAST searches (Altschul et al. 1997). All confirmed sequences were aligned with MUSCLE (Edgar 2004).

The TPM2 + F + I + G4 model was selected as the most appropriate maximum likelihood substitution model using the ModelFinder performed in IQTREE ver.1.6.9 (Nguyen et al. 2015). Phylogenetic trees were constructed using both maximum likelihood (ML) and Bayesian Inference (BI) models. Maximum likelihood bootstrap analysis was conducted using IQTREE ver. 1.6.9 with 1,000 replicates. A Bayesian Inference (BI) tree was created using MrBayes ver 3.1.2 (Huelsenbeck and Bollback 2001) with 10 million generations, heating parameter of 0.06, and sampling every 1,000 generations. Several species of the tribe Orthomorphini and Sulciferini were selected as outgroups. All nucleotide sequences were deposited into GenBank.

RESULTS

TAXONOMY

Order Polydesmida Family Paradoxosomatidae Daday, 1889 Tribe Orthomorphini Bröleman, 1916 Genus *Hylomus* Cook & Loomis, 1924

Hylomus Cook & Loomis, 1924: 105; Attems 1937: 126; Jeekel 1968: 51; Jeekel 1980: 655; Srisonchai et al. 2018a: 15. Synonymized with *Desmoxytes* by Golovatch & Enghoff (1994: 46), but revalidated by Srisonchai et al. (2018a). *Type species: Hylomus draco* Cook & Loomis, 1924, by original designation.

Diagnosis: The genus can be recognised by a combination of characters: small to large size (12–35 mm long); often brightly coloured; paraterga strongly to exceedingly well developed, wing-, spineand antler-shaped; metazonal surface often more or less roughly granulate, rarely smooth; epiproct of telson sometimes modified with hypertrophied setiferous tubercles near tip; male leg femora 5/6/7/9 often inflated or humped ventrally; gonopod suberect, seldom subfalcate; solenophore and solenomere usually shortened.

Remarks: The genus is widely distributed in



Fig. 1. Distribution of *Hylomus* species in mainland Vietnam. 1: Hoang Lien National Park (Sa Pa, Lao Cai Province); 2: Nam Xay Commune (Van Ban District, Lao Cai Province); 3: Duc Xuan Commune (Bac Quang District, Ha Giang Province); 4: Xuan Son National Park (Phu Tho Province); 5: Tam Dao (Vinh Phuc Province); 6: Cuc Phuong National Park (Ninh Binh Province); 7: Phong Nha – Ke Bang National Park (Quang Binh Province); 8: Lien Chieu District (Da Nang Province); 9: Ba Na National Park (Da Nang Province); 10: Lo Xo Pass (Kon Tum Province); 11: Ngoc Linh Mt. (Kon Tum Province); 12: Kon Chu Rang Natural Reserve (Gia Lai Province); 13: Buon Ho District (Dak Lak Province); 14: Hon Ba Mt. (Khanh Hoa Province); 15: Phan Rang (Ninh Thuan Province); 16: Cat Tien National Park (Dong Nai Province).

southern China and Vietnam. Few species are found in Laos and Thailand. The distribution of the genus *Hylomus* in Vietnam is shown in figure 1.

Hylomus asper (Attems, 1937)

(Figs. 1–2)

Centrodesmus asper Attems, 1937: 125–126, fig. 162; Attems 1938: 240–241, figs. 75–78.

Pratinus asper: Jeekel 1964: 63; Jeekel 1968: 61.

Desmoxytes aspera: Golovatch & Enghoff 1994: 60; Likhitrakarn et al. 2015: 493, figs. 7–8.

Hylomus asper: Jeekel 1980: 658; Srisonchai et al. 2018a: 10.

Material examined: 1 male (IEBR-68) Kon Tum Province, Ngoc Linh Mt., primary forest, 1,800 m, 21 March – 9 April 2006, coll. Anh D. Nguyen.

Diagnosis: The species can be recognised by the combination of the following characters: paraterga antler-shaped; metaterga smooth, without traces of setae; the fifth sternum with a prominent, rounded, caudal protuberance between coxae 4; male femora without modifications; epiproct unmodified, without conspicuous setiferous knobs near tip; gonopod femorite

long, slightly expanded distad; postfemoral region shortened; solenophore and solenomere extremely short (Fig. 2).

Previous records: Da Nang Province (Ba Na National Park; Hai Van pass); Ninh Thuan Province (Phan Rang) (Attems 1937 1938).

Distribution: Southern part of central Vietnam.

Hylomus cattienensis (Nguyen, Golovatch & Anichkin, 2005)

(Figs. 1, 3–4)

Desmoxytes cattienensis Nguyen, Golovatch & Anichkin, 2005: 252–254, figs. 6–13.

Hylomus cattienensis: Srisonchai et al. 2018a: 10.

Material examined: 1 male (IEBR-27) Dong Nai Province, Cat Tien NP, forest, 23 September 2004, coll. Anh D. Nguyen; 1 male, 1 female (IEBR-40) same data, but 24 September 2004.

Diagnosis: The species can be distinguished from its congeners by the combination of the following characters: colouration pink to reddish; paraterga antler-shaped; metaterga with a row of 1 + 1 short setae; male



Fig. 2. Hylomus asper (Attems, 1937) from Ngoc Linh Mt. Right gonopod, lateral view (A), mesal view (B).

leg femora unmodified; epiproct modified with several setiferous knobs (Fig. 3); gonopod suberect; femorite, solenomere and solenophore subequal in length; postfemoral region not extremely short; tip of lamina medialis pointed (Fig. 4).

Previous records: Dong Nai Province (Cat Tien National Park) (Nguyen et al. 2005).

Distribution: Only known from Vietnam.

Hylomus cervarius (Attems, 1953) (Figs. 1, 5)

Centrodesmus cervarius Attems, 1953: 175–176, figs. 75–80. Pratinus cervarius: Jeekel 1964: 63; Jeekel 1968: 61. Desmoxytes cervaria: Golovatch & Enghoff 1994: 60; Nguyen & Sierwald 2013: 1242; Likhitrakarn et al. 2015: 499, figs. 13–14. *Hylomus cervarius*: Jeekel 1980: 657; Srisonchai et al. 2018a: 10.

Material examined: 3 males, 1 female (IEBR-32) Lao Cai Province, Sa Pa, Ham Rong Mt., limestone mountain, 1,600 m, 16–19 July 2006, coll. Anh D. Nguyen.

Diagnosis: The species can be recognised by the combination of the following characters: paraterga antler-shaped; metaterga rough, dull, granular, with a row of 3 + 3 posterior setiferous spines; male leg femora 6 and 7 humped ventrally; epiproct unmodified, without conspicuous setiferous knobs near tip; gonopod femorite suberect, slightly expanded distad; solenophore long (Fig. 5).



Fig. 3. *Hylomus cattienensis* (Nguyen, Golovatch & Anichkin, 2005) from Cat Tien National Park. Anterior part, lateral view (A), dorsal view (B), ventral view (C); body rings 10–12, dorsal view (D), lateral view (E); posterior part, lateral view (F), ventral view (G); gonopods, ventral view (H); sternite 5, ventral view (I). Anterior part, lateral view (A), dorsal view (B), ventral view (C); body rings 10–12, dorsal view (D), lateral view (A), dorsal view (B), ventral view (C); body rings 10–12, dorsal view (D), lateral view (E); posterior part, lateral view (F), ventral view (G); gonopods, ventral view (H); sternite 5, ventral view (I). No scale bars were inserted while taking photographs for this figure. This figure emphasises colouration, shapes of paraterga (Pa), metaterga (Me), head (He), collum (Co), gonopods (Go), sternal tubercles (st), epiproct (Epi) and hypoproct (Hy).



Fig. 4. *Hylomus cattienensis* (Nguyen, Golovatch & Anichkin, 2005) from Cat Tien National Park. Right gonopod, lateral view (A), mesal view (B). Scale bar = 0.5 mm.



Fig. 5. Hylomus cervarius (Attems, 1953) from Sa Pa. Left gonopod, dorsal view (A), lateral view (B).

Previous records: Lao Cai Province (Sa Pa) (Attems 1953).

Distribution: Only known from northern Vietnam.

Hylomus enghoffi (Nguyen, Golovatch & Anichkin, 2005) (Figs. 1, 6–8)

Desmoxytes enghoffi Nguyen, Golovatch & Anichkin, 2005: 256–257, figs. 26–33. Hylomus enghoffi: Srisonchai et al. 2018a: 10.

Material examined: 1 male, 1 female (IEBR-30) Quang Binh Province, Phong Nha-Ke Bang National Park, secondary forest, July 2003, coll. Pham Duc Tien; 1 male, 2 females (IEBR-217) same locality, but limestone forest, 10–22 August 2011, coll. Anh D. Nguyen; 9 males, 1 female (IEBR-218) and (IEBR-Myr IPE5) same data as sample IEBR–217.

Diagnosis: The species can be distinguished from its congeners by the combination of the following

characters: paraterga antler-shaped; metaterga with transverse rows of 2 + 2 and 1 + 1 setiferous spines; epiproct modified, with 2 + 2 non-setiferous knobs near tip; only male leg femur 7 inflated (Figs. 6–7); postfemoral region of gonopod not extremely short; solenomere subfalcate; tip of lamina medialis with 2 apical lobules; spine z prominent (Fig. 8).

Previous records: Quang Binh Province (Phong Nha - Ke Bang National Park) (Nguyen et al. 2005).

Distribution: Only known from central Vietnam.

Hylomus grandis (Golovatch, VandenSpiegel & Semenyuk, 2016)

Desmoxytes grandis Golovatch, VandenSpiegel & Semenyuk, 2016: 343, figs. 25–33. Hylomus grandis: Srisonchai et al. 2018a: 10.

Diagnosis: The species is diagnosed by the largest body size (ca. 38–40 mm long), antler-shaped paraterga, relatively stout gonopods with a strongly condensed



Fig. 6. Hylomus enghoffi (Nguyen, Golovatch & Anichkin, 2005) from Phong Nha – Ke Bang National Park. Habitus photo. No scale bars were inserted while taking photographs for this figure. This figure emphasises natural colouration.



Fig. 7. *Hylomus enghoffi* (Nguyen, Golovatch & Anichkin, 2005) from Phong Nha – Ke Bang National Park. Anterior part, dorsal view (A), lateral view (B). Middle part, dorsal view (C). Posterior part, lateral view (D), ventral view (E). Hypoproct (F). No scale bars were inserted while taking photographs for this figure. This figure emphasises colouration, shapes of paraterga (Pa), metaterga (Me), collum (Co), epiproct (Epi) and hypoproct (Hy).

Previous records: Gia Lai Province (Kon Chu Rang Nature Reserve) (Golovatch et al. 2016).

Distribution: Only known from the Highlands of Vietnam.

Hylomus hostilis (Golovatch & Enghoff, 1994) (Figs. 1, 9–10)

Desmoxytes hostilis Golovatch & Enghoff, 1994: 50–51, figs. 11–20. *Hylomus hostilis*: Srisonchai et al. 2018a: 10.

Material examined: 1 male, 1 female (IEBR-Myr 601) Vinh Phuc Province, Tam Dao National Park, on the way to Tam Dao 2, 1,100 m, 25 February 2017, coll. Anh D. Nguyen.

Diagnosis: The species can be recognised by the combination of the following characters: paraterga spine-shaped; metaterga with 2 + 2 posterior tubercles/ spines; antenna short and stout; male leg femora 6 and 7 inflated, with modifications (Fig. 9); gonopod femorite

subequal to postfemoral region in length; solenophore pointed terminally (Fig. 10).

Previous records: Vinh Phuc Province (Tam Dao National Park) (Golovatch and Enghoff 1994).

Distribution: Only known from northern Vietnam. Anterior part, lateral view (A), dorsal view (B), ventral view (C). Midbody part, dorsal view (D). Posterior part, lateral view (E), dorsal view (F), ventral view (G). Hypoproct and epiproct, ventral view (H). No scale bars were inserted while taking photographs for this figure. This figure emphasises colouration, shapes of collum (Co), paraterga, metaterga (Me), pleura (Ple), sterna (Ste), epiproct (Epi) and hypoproct (Hy).

Hylomus pilosus (Attems, 1937) (Figs. 1, 11–12)

Centrodesmus pilosus Attems, 1937: 124–125, figs. 160–161; Attems 1938: 238–240, figs. 71–74.

Pratinus pilosus: Jeekel, 1964: 63; Jeekel 1968: 61.

Desmoxytes pilosa: Golovatch & Enghoff 1994: 59, figs. 66-69;

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Fig. 8. Hylomus enghoffi (Nguyen, Golovatch & Anichkin, 2005) from Phong Nha – Ke Bang National Park. Right gonopod, lateral view (A), mesal view (B).

Nguyen et al. 2005: 251–252; Nguyen & Sierwald 2013: 1242; Likhitrakarn et al. 2015: 495, figs. 9–10. *Hylomus pilosus*: Jeekel, 1980: 658; Srisonchai et al. 2018a: 11.

Material examined: 1 male, 1 female (IEBR-38) Khanh Hoa Province, Hon Ba Mt, primary forest, 1,300 m, 6 April 2003, coll. Anh D. Nguyen; 1 female (IEBR-65) same data, but 15–24 April 2006, coll. Anh D. Nguyen; 4 males, 1 female (IEBR-39) Dong Nai Province, Cat Tien National Park, forest, 23–29 September 2004, coll. Anh D. Nguyen, S.I. Golovatch and A.E. Anichkin; 1 male (IEBR-85) same locality, forest, on the leaves, 26–27 July 2009, coll. Anh D. Nguyen.

Diagnosis: The species can be recognised by its pink to red colouration; paraterga being antler-shaped; metaterga having numerous microsetae and a row of 4 + 4 posterior spines; epiproct modified, with evident setiferous knobs near tip (Fig. 11); gonopod femorite slightly expanded distad; solenomere long (Fig. 12).

Previous records: Ninh Thuan Province (Phan Rang); Dak Lak Province; Khanh Hoa Province (Hon

Ba Mt.); Dong Nai Province (Attems 1937; Golovatch and Enghoff 1994; Nguyen et al. 2005).

Distribution: Only known from Vietnam. The species is widely distributed in southern Vietnam.

Hylomus proximus (Nguyen, Golovatch & Anichkin, 2005)

(Figs. 1, 13)

Desmoxytes proxima Nguyen, Golovatch & Anichkin, 2005: 252, figs. 1-5. Hylomus proximus: Srisonchai et al. 2018a: 11.

Material examined: 1 male (IEBR-28) Lao Cai Province, Van Ban District, Nam Xay commune, bamboo forest, 1,000 m, 6 April 2005, coll. Anh D. Nguyen; 2 females (IEBR-33) same locality and habitat, 8 April 2005, coll. Anh D. Nguyen; 1 female (IEBR-34) same locality, secondary forest, 850 m, 3 April 2005; 1 male (IEBR-44) Lao Cai Province, Hoang Lien National Park, Sa Pa, forest, 2,000 m, 2 December 2005, coll. Anh D. Nguyen; 2 males, 2 females (IEBR-Myr 243)



Fig. 9. Hylomus hostilis (Golovatch & Enghoff, 1994) from Tam Dao National Park.

same locality, but bamboo forest, near a stream, 1,800 m, 26 March 2007, coll. Anh D. Nguyen; 3 males, 1 female (IEBR-42) same locality, but forest, 2,000 m, April 2003, coll. Nguyen Tri Tien.

Diagnosis: The species differs from its congeners in the transverse sulcus starting from metatergum 2; paraterga antler-shaped; male leg femora 5 and 6 humped ventrally; gonopod femorite subequal to postfemoral region in length; both solenophore and solenomere long; tip of solenophore serrated (Fig. 13).

Previous records: Lao Cai Province (Van Ban District) (Nguyen et al. 2005).

Distribution: Only known from northern Vietnam.

Hylomus specialis (Nguyen, Golovatch & Anichkin, 2005) (Figs. 1, 14)

Desmoxytes specialis Nguyen, Golovatch & Anichkin, 2005: 254-255, figs. 14-19.

Hylomus specialis: Srisonchai et al. 2018a: 11.

Material examined: 1 male (IEBR-29) Kon Tum Province, Ngoc Linh Mt., primary forest, 2,000 m, 25 March 2004, coll. Anh D. Nguyen; 1 male (IEBR-41) same locality, secondary forest, 1,800 m, 11 April 2004, coll. Anh D. Nguyen; 2 males, 1 female (IEBR-67) same locality, primary forest, 1,700–1,900 m, 21 March – 9 April 2006, coll. Anh D. Nguyen.

Diagnosis: The species can be distinguished from its congeners by its darkish brown colouration; antenna being long; metaterga having two transverse rows of spines; paraterga being spine-shaped, long and increasingly pointed, with two additional spines at base caudolaterally; gonopod solenophore and solenomere being very long; spine z modest; femorite slightly curved (Fig. 14).

Previous records: Kon Tum Province (Ngoc Linh Mt.) (Nguyen et al. 2005).

Distribution: Only known from the Highland of

Fig. 10. Hylomus hostilis (Golovatch & Enghoff, 1994) from Tam Dao National Park. Left gonopod, mesal view (A), lateral view (B). Scale bar = 0.5 mm.





Fig. 11. *Hylomus pilosus* (Attems, 1937) from Cat Tien National Park. Anterior part, dorsal view (A), lateral view (B), ventral view (C). Midbody part, dorsal view (D). Posterior part, dorsal view (E), ventral view (F). No scale bars were inserted while taking photographs for this figure. This figure emphasises colouration, shapes of head (He), collum (Co), paraterga (Pa), metaterga (Me), sterna (Ste), epiproct (Epi) and hypoproct (Hy).

Vietnam.

Hylomus spectabilis (Attems, 1937) (Figs. 1, 15)

Centrodesmus spectabilis Attems, 1937: 124, fig. 159; Attems 1938: 235–238, figs. 65–70.

Pratinus spectabilis: Jeekel 1964: 63; Jeekel 1968: 61.

Desmoxytes spectabilis: Golovatch & Enghoff 1994: 61; Nguyen et al. 2005: 255–256, figs. 20–25; Nguyen & Sierwald 2013: 1242; Likhitrakarn et al. 2015: 498, figs. 11–12.

Hylomus spectabilis: Jeekel 1980: 658; Srisonchai et al. 2018a: 11.

Material examined: 1 female (IEBR-36) Da Nang Province, Ba Na National Park, forest, near stream, 26–27 April 2002, coll. Quynh & Lich; 1 male, 1 female (IEBR-37) same locality, summit, 23 April 2002, coll. Quynh & Lich; 1 female, 4 juveniles (IEBR-36) Kon Tum Province, Lo Xo pass, 80km north of Kon Tum, secondary forest, 840 m, 17 April 2004, coll. Anh D. Nguyen; 1 female (IEBR-64), same locality, pitfall trapping, 15–19 April 2002, coll. Anh D. Nguyen.

Diagnosis: The species can be distinguished from its congeners by the paraterga being wing-shaped;

metaterga having two transverse rows of 2 + 2 and 1 + 1 well developed spines; the sternum 5th having two independent, round tubercles between coxae 4; gonopod being slightly expanded distad; demarcation between postfemoral region and femorite being present; spine z being well developed (Fig. 15).

Previous records: Da Nang Province (Ba Na Mt.) (Attems 1937).

Distribution: Only known from southern Vietnam.

Hylomus songoku sp. nov.

(Figs. 1, 16–20) urn:lsid:zoobank.org:act:030505EE-DF75-4832-ABF1-CC70AB989A03

Material examined: Holotype: 1 male (IEBR-Myr 164H) Phu Tho Province, Xuan Son National Park, Lap cave, 11 December 2010, coll. Phung T.H. Luong. Paratypes: 1 male, 3 females (IEBR-Myr 164P) same data as holotype.

Etymology: The name refers to "*songoku*", a main character of the Japanese manga "Dragon balls" by Toriyama Akira (Japan).



Fig. 12. Hylomus pilosus (Attems, 1937) from Cat Tien National Park. Right gonopod, lateral view (A), mesal view (B).

Diagnosis: The species differs from its congeners in suberect gonopod; solenophore with rounded lobuliform lamina medialis, and well developed lamina lateralis with densely setose area; tip of solenophore tuberculiform.

Description: Body length ca. 17.9–25.2 mm (male), 23.9–26.8 mm (female); width of midbody pro- and metazonae 1.1–1.2 mm (male), 2.1–2.3 mm (female) and 1.3–1.4 mm (male), 2.4–2.5 mm (female), respectively. Holotype length 25.2 mm, width of midbody pro- and metazonae 1.2 mm and 1.4 mm, respectively.

Colouration (Figs. 16–18): body generally light yellow. Pleura yellowish brown; head yellowish and somewhat darker on the region between antenna sockets.

Head (Fig. 16A) slightly broader than collum. Clypeolabral region densely setose. Epicranial suture distinct, linear. Antennae (Fig. 16A) slender, thin and extremely long, reaching segment 7 or 8 if stretched posteriorly; antennomere 3 > 4 > 5 > 2 > 6 > 7 > 1 in length; antennomere 7 black.

Collum (Figs. 16A–B) somewhat narrower than segment 2 in width; surface shining, densely microgranulated and wrinkled, with two rows of setiferous spines: one of 10-12 smaller spines close to anterior margin and, one of 4 + 4 larger spines near posterior margin; the posterior spines gradually smaller medially. Paraterga well developed, highly elevated, antler-shaped with three branches.

Width of body segment 4 < 3 < 2 = 5-16, thereafter gradually tapering towards telson. Prozonae



Fig. 13. *Hylomus proximus* (Nguyen, Golovatch & Anichkin, 2005) from Hoang Lien National Park. Right gonopod, lateral view (A), mesal view (B). Scale bars: A = 0.3 mm; B = 0.5 mm.



Fig. 14. Hylomus specialis (Nguyen, Golovatch & Anichkin, 2005). Right gonopod, lateral view (A), mesal view (B). Scale bar = 1 mm.



Fig. 15. Hylomus spectabilis (Attems, 1937) from Ba Na – Nui Ba National Park. Left gonopod, mesal view (A), lateral view (B). Scale bar = 0.5 mm.

shining and shagreened. Metazonae with dense microgranulation. Transverse sulcus starting on metatergum 5, but vague, incomplete, thin and line-shaped. Metaterga densely granulated with two rows of setiferous spines; the anterior spines variable, tiny whereas posterior spines longer and larger, 3 + 3 on metaterga 2-3, 4 + 4 on metaterga 4-5, 5(6) + 5(6) on subsequent metaterga (Figs. 16C-D, 17A, C); metatergum 19 with numerous small setiferous spines, but not arranged in row. Pleurosternal carinae absent. Axial line present, thin and line-shaped. Waist between

pro- and metazonae broad, neither striolate nor beaded.

Paraterga (Figs. 16, 17A–C) well developed, antler-shaped, with 5–6 branches (one main branch, 2–3 anterior ones and 1–2 posterior ones), highly elevated from metatergal surface, sometimes with several very tiny setiferous spines around base. Ozopore on segments 5, 7, 9–10, 12–13, and 15–19, lying under the base of the second anterior branch.

Epiproct (Figs. 17D, 18A–B) strongly modified with two large lateral setiferous tubercles. Tip normal with four spinnerets. Hypoproct (Fig. 18B) trapeziform



Fig. 16. *Hylomus songoku* sp. nov. from Xuan Son National Park. Holotype. Anterior part, laterodorsal view (A), ventral view (B). Middle part, lateral view (C), subdorsal view (D). Scale bar = 1 mm.

with two well separated, distolateral setiferous knobs.

Sterna (Fig. 17D) modestly setose; cross impression vague, without modifications except two separated, setiferous tubeliform processes between coxae 4 (Fig. 18C).

Legs slender and extremely long, about 3-3.5 times as long as midbody height. Prefemora not swollen. Femora without modifications except femora 6 & 7 with a big ventral tubercle at 2/3 its length (Fig. 18D). Tarsal brushes absent.

Gonopod (Figs. 19–20) simple. Coxite (co) about 1/3 as long as telopodite. Prefemorite (prf) about half as long as acropodite, densely setose, demarcated laterally from femorite by a transverse sulcus. Femorite (fe) longer than postfemoral region, slightly enlarged distally, and somewhat curved ventrad. Postfemoral region suberect, consisting of solenophore (sph) and solenomere (sl). The former simple with a rounded lobuform (rl) lamina medialis and well developed lamina lateralis with a densely setose region



Fig. 17. *Hylomus songoku* sp. nov. from Xuan Son National Park. Holotype. Segment 10, dorsal view (A). Posterior part, lateral view (B), dorsal view (C), ventral view (D). Scale bar = 1 mm.

(ds). Solenomere flagelliform, partly sheathed by solenophore. Seminal groove running entirely mesally, directed distodorsad before entering the solenophore. Tip (tp) of solenophore tuberculiform.

Remarks: The species was found in the Lap cave, and it is the first troglobitic species of the genus *Hylomus* recorded in Vietnam.

Hylomus saiyans sp. nov.

(Figs. 1, 21–25) urn:lsid:zoobank.org:act:949D8441-0F5F-421E-84B1-7B3688AA04DD

Material examined: Holotype: 1 male (IEBR-Myr 219H) Ninh Binh Province, Cuc Phuong National Park, limestone forest, 11–13 April 2012, coll. Anh D. Nguyen. Paratypes: 1 male, 5 females (IEBR-Myr 219P) same data as for holotype.

Non-types: 1 male (IEBR-Myr 44) Ninh Binh Province, Cuc Phuong National Park, limestone forest, April 2006, coll. Thu-Anh T. Nguyen; 1 female (IEBR-Myr 63) Ninh Binh Province, Cuc Phuong National Park, limestone forest, 30 April 2006, coll. Luong Van Hien.

Etymology: The name refers to naturally aggressive warriors in the Japanese manga "Dragon Ball" by Toriyama Akira (Japan).

Diagnosis: The species differs from its congeners by the second metatergal row having 1 + 1 setiferous spines, others being setiferous knobs. Femora 6 and 7 with a ventral hump, sometimes femur 5 inflated. Gonopod femorite slightly curverd ventrad, enlarged distad; distal part with mesal shelf. Demarcation between femorite and postfemoral region absent. Tip of gonopod acute.

Description: Length ca. 14.2–15.8 mm (male), 13.8–14.2 mm (female); width of midbody pro- and metazonae 0.8–0.9 mm (male), 1.1–1.2 mm (female) and 1.0–1.1 mm (male), 1.2–1.3 mm (female), respectively. Holotype length ca. 15.8 mm, width of



Fig. 18. *Hylomus songoku* sp. nov. from Xuan Son National Park. Holotype. Epiproct, dorsal view (A). Hypoproct and epiproct, ventral view (A). Sternal process between coxae 4, subventral view (C). Leg 6-7 (D). Scale bar = 1 mm.



Fig. 19. *Hylomus songoku* sp. nov. from Xuan Son National Park. Holotype. Right gonopod, lateral view (A), mesal view (B, C). Scale bars: A-B = 1 mm; C = 0.1 mm. (Note: solenophore in figure 16C was broken while taking SEM image)



Fig. 20. *Hylomus songoku* sp. nov. from Xuan Son National Park. Holotype. Right gonopod, lateral view (A), mesal view (B), dorsal view (C). Scale bar = 1 mm.

midbody pro- and metazonae 0.8 mm and 1.0 mm, respectively.

Colouration (Figs. 21–23): body generally light brown in male, but darker in female. Legs and sterna brownish yellow.

Head (Fig. 21A–C) slightly broader than collum in width; surface with dense tiny setiferous spines. Clypeolabral region densely setose. Epicranial suture clearly distinct. Antennae (Fig. 21A–C) slender and long, reaching segment 6 if stretched posteriorly; antennomere 2 > 3 > 4 = 5 = 6 > 1 > 7 in length; antennomere 7 blackish, with four sensory cones at tip.

Collum slightly broader than segment 2 in width, subtrapeziform; surface with dense microgranulation, and two rows of well-developed setiferous spines: 3 + 3 anterior and 1 + 1 posterior. Paraterga spiniform, slightly longer than posterior metatergal spines, directed dorsad.

Width of body segment 3 < 4 < 2 = 5-17 in width, thereafter gradually tapering towards telson. Prozonae

shining and shagreened. Metazonae (terga and pleura) with dense microgranulations. Metaterga with two rows of 1 + 1 anterior small setiferous knobs and 2 + 2 posterior setiferous knobs/spines including well developed, median setiferous spines (Figs. 21A, 21D, 22A, 22C). Pleurosternal carinae absent. Waist between pro- and metazonae broad, not deep, neither striolate nor beaded at bottom. Transverse sulcus incomplete, starting on metatergum 4. Axial line vague.

Paraterga (Figs. 21, 22A, 22C) well developed, antler-shaped, highly elevated from metatergal surface, directed dorsad on segments 2–18, and directed caudad on segment 19. Paraterga with 2 branches on segment 2, 3 branches on segments 3–8, 11, 14, and 18, four branches on segments 9–10, 12–13, 15–17, and spiniform on segment 19. Ozopore on segments 5, 7, 9–10, 12–13, and 15–19, lying at the base of the second branch, invisible from dorsal view.

Epiproct (Fig. 22B–D) broadly truncated, dorsally inflated, with two lateral setiferous tubercles; tip with



Fig. 21. *Hylomus saiyans* sp. nov. from Cuc Phuong National Park. Holotype. Anterior part, dorsal view (A), lateral view (B), ventral view (C). Body rings 10–11, dorsal view (C). Scale bar = 1 mm.



Fig. 22. *Hylomus saiyans* sp. nov. from Cuc Phuong National Park. Holotype. Posterior part, dorsal view (A), ventral view (B). Telson and epiproct, dorsal view (C). Hypoproct and epiproct, ventral view (D). Scale bars: A-B = 1 mm; C-D = 0.5 mm.



Fig. 23. *Hylomus saiyans* sp. nov. from Cuc Phuong National Park. Holotype. Sternal process between coxae 4, subposterior view (A). Legs 5-6-7 (B). Scale bars: A = 0.5 mm; B = 1 mm.

four spinnerets. Hypoproct (Fig. 22D) trapeziform, with two well separated, distolateral, setiferous knobs.

Sterna (Fig. 22B) densely setose, cross impression distinct, without modifications except a setiferous trapeziform process between coxae 4 (Fig. 23A).

Legs slender and long, ca. 2-3 times as long as midbody height. Prefemora not swollen. Femora 6 and 7 with a ventral hump, femur 5 sometimes inflated (Figs. 21B, 23B). Tarsal brushes absent.

Gonopod (Figs. 24–25) simple. Coxite short, ca. 1/3 as long as femorite length; distoventral part sparsely setose. Prefemorite densely setose, separated laterally from femorite by a transverse sulcus. Femorite slightly curved ventrad, enlarged distad; distal part with mesal shelf (ms). No demarcation between femorite and postfemoral region. The postfemoral region short, consisting only of solenophore and solenomere. Solenomere flagelliform, partly sheathed by solenophore. Seminal groove running entirely mesally, directed distodorsad before entering the solenophore. Tip of solenophore acute.

Hylomus namek sp. nov. (Figs. 1, 26–30) urn:lsid:zoobank.org:act:AEDAF341-76F4-4D37-BB94-3F564724CDCB

Material examined: Holotype: male (IEBR-Myr



Fig. 24. Hylomus saiyans sp. nov. from Cuc Phuong National Park. Holotype. Right gonopod, lateral view (A), mesal view (B). Scale bar = 1 mm.

514H) Ha Giang Province, Bac Quang District, Duc Xuan commune, Na Po village, limestone forest, 14–15 April 2013, coll. Anh D. Nguyen. Paratypes: 1 male, 2 females (IEBR-Myr 514P) same data as holotype.

Etymology: The name refers to the planet "namek", a home of the dragon balls, in the Japanese manga "Dragon Ball" by Toriyama Akira (Japan).

Diagnosis: The species is diagnosed by paraterga being antler-shaped; metaterga with two rows of setiferous spines; gonopod erect; femorite and postfemoral region subequal in length; tip of gonopod broadly rounded lobuliform.

Description: Length ca. 16.0–17.4 mm (male), 20.2–23.4 mm (female); width of midbody pro- and metazonae 0.7–0.9 mm (male), 1.5–1.6 mm (female) and 0.9–1.1 mm (male), 1.6–1.9 mm (female), respectively. Holotype length ca. 16.0 mm, width of midbody pro- and metazonae 0.9 mm and 1.1 mm, respectively.

Colouration (Figs. 26-28): body generally darkish

brown, but legs, paraterga and sterna paler.

Head (Fig. 26A–C) slightly broader than collum in width. Clypeolabral region densely setose. Epicranial suture clearly distinct, divided frons into two equal, slightly convex parts. Frons with dense setiferous microgranulations. Antennae slender, extremely long, reaching segment 9 or 10 if stretched posteriorly. Antennomere 3 > 4 = 5 > 2 > 6 > 1 > 7; antennomere 7 blackish, with four sensory cones at tip.

Collum subequal to segment 2 in width, semicircular; surface shining and with dense setiferous microgranulations, and with three rows of well-developed setiferous spines: 3 + 3 anterior, 1 + 1 intermediate and 2 + 2 posterior. Paraterga antler-shaped with three branches, highly elevated from dorsum.

Body submoniliform, segments 2–16 subequal in width, thereafter gradually tapering towards telson. Prozonae faintly micro-alveolate and shagreened. Metazonae with dense setiferous microgranulations. Metaterga (Figs. 26D, 27A–B) with two rows of well-



Fig. 25. Hylomus saiyans sp. nov. from Cuc Phuong National Park. Holotype. Right gonopod, lateral view (A), mesal view (B).

developed setiferous spines: 2 + 2 anterior and 1 + 1 posterior on segments 2-5, 2 + 2 anterior and 2 + 1 posterior on segment 6, 2 + 2 anterior and 2 + 2 posterior on segments 7-17, 2 + 2 anterior and 3 + 3 posterior on segments 18-19; the posterior spines much developed than anterior ones.

Paraterga (Fig. 26A, C–D) well developed, antler-shaped, highly elevated from metatergal surface, with four branches (one main branch, two anterior ones and a largest one located posteriorly at base of paraterga). Paraterga slightly directed caudad. Ozopore on segments 5, 7, 9–10, 12–13 and 15–19, lying at base of the second branch, and visible from dorsal view. Transverse sulcus incomplete, starting on metatergum 5. Pleurosternal carinae absent. Axial line thin, line-shaped but clearly distinct.

Epiproct (Fig. 28A–B) long, broadly truncated, and dorsally inflated, with two well developed lateral setiferous tubercles. Tip with four spinnerets. Hypoproct (Fig. 28B) triangular, with two well separated, distolateral, setiferous knobs.

Sterna densely setose, longitudinal sulcus thin



Fig. 26. *Hylomus namek* sp. nov. from Ha Giang Province. Holotype. Anterior part, dorsal view (A), ventral view (B). Collum, subdorsal view (C). Segments 7–9, dorsal view (D). Scale bar = 1 mm.

(A)

whereas transverse sulcus broader, deep and distinct, without modifications except a setiferous bifid trapeziform process between coxae 4 (Fig. 28C).

Leg (Fig. 27C–D) slender and extremely long, ca. 3–3.5 times as long as midbody height. Prefemora not swollen. Femora 5 and 6 with a ventral hump (Fig. 28D). Tarsal brushes absent.

Gonopods (Figs. 29–30) simple. Coxite cylindrical, subequal to femorite in length; ventrodistal part sparsely setose. Prefemorite densely setose, laterally separated from femorite by oblique sulcus. Femorite and postfemoral region subequal in length, weakly constricted at middle, without modifications. No demarcation between femorite and postfemoral region. Solenomere flagelliform, partly sheathed by well-developed solenophore. Seminal groove running entirely mesally, directed distodorsad before entering the solenophore. Tip of solenophore broadly rounded lobuliform.

Key to species of the genus *Hylomus* species in Vietnam

- 1. Paraterga wing-shaped H. spectabilis
- Paraterga antler- or spine-shaped (Figs. 3, 7, 9, 11) 2

- 4. Metaterga smooth, more or less shining. Male femora unmodified *H. asper*
- Metaterga rough, dull, granular. Male femora modified, inflated .
- 5. Metaterga with more than 4 + 4 posterior setiferous spines on

Image: provide the provide

Fig. 27. *Hylomus namek* sp. nov. from Ha Giang Province. Holotype. Segment 9, dorsal view (A). Segment 13, dorsal view (B). Posterior part, lateral view (E), ventral view (F). Scale bar = 1 mm.

- Metaterga with 2 + 2 posterior setiferous spines. Male femora 6 and 7, sometime femur 5 modified, each with a large hump on ventral side. Fifth sternum with either rectangular process or bifd trapeziform lamina between coxae 4

- Male femora 6, 7 humped ventrally (Fig. 28D). Tip of solenophore broadly rounded lobuliform (Figs. 29–30) *H. namek*
- 9. At least 3 + 3 posterior metatergal spines on metaterga 10

- A row of 1 + 1 posterior spines on metaterga. Gonopod subfalcate, femorite slightly curved; solenomere long
- *H. specialis* A row of 2 + 2 posterior tubercles/spines on metaterga. Gonopod
- filter fi
- Fifth sternum with a bifd setiferous trapeziform lamina between coxae 4. Antenna short and stout (Fig. 9B) *H. holstii*

Phylogenetic analysis

Molecular variations and genetic distance

The 16S rRNA dataset revealed that 20 species, including two outgroup species (Table 1), *Tylopus*



Fig. 28. *Hylomus namek* sp. nov. from Ha Giang Province. Holotype. Epiproct, lateral view (A). Epiproct and hypoproct, ventral view (B). Sternal process between coxae 4 (C). Legs 5-6 (D). Scale bars: A-B = 1 mm; C-D = 0.5 mm.



Fig. 29. Hylomus namek sp. nov. from Ha Giang Province. Left gonopod, mesal view (A), lateral view (B). Scale bar = 1 mm.



Fig. 30. Hylomus namek sp. nov. from Ha Giang Province. Left gonopod, mesal view (A), lateral view (B). Scale bar = 1 mm.

hilaroides and *T. roseiparaterga*, consists of 393 bp excluding gaps, and has nucleotide frequencies of 34.0, 32.5, 10.2 and 23.3 for A, T, G and C, respectively. The GC content accounts for 33.5% of total nucleotides. The 16S rRNA dataset contains 173 (44.2%) parsimony informative and 211 (53.7%) variable sites.

The uncorrected genetic distances among Hylomus

species were variable and relatively high, from 0.142 to 0.282 (Table 2). The *p*-distance between the genus *Hylomus* and other genera was also very high, from 0.181 to 0.305. The mean *p*-distance among all species was 0.219. The high distance suggests that the DNA region used for the phylogenetic analysis is variable, not conservative.

 Table 1. Species vouchers and accession numbers deposited in GenBank

No.	Species	Voucher code	Locality	Accession number
1	Antheromorpha festiva	IEBR-Myr 519	Yok Don NP, Dak Lak Prov., Vietnam	KX755577
2	Antheromorpha pumatensis	IEBR-Myr IPE3	Pu Mat NP, Nghe An Prov., Vietnam	MG669559
3	Hylomus cervarius	IEBR-32	Sa Pa, Lao Cai Prov., Vietnam	MG564329
4	Hylomus enghoffi	IEBR-Myr IPE5	Phong Nha – Ke Bang NP, Quang Binh Prov., Vietnam	MG564330
5	Hylomus namek	IEBR-Myr 514	Duc Xuan commune, Ha Giang Prov., Vietnam	MK457227
6	Hylomus pilosus	IEBR-65	Cat Tien NP, Dong Nai Prov., Vietnam	MK457226
7	Hylomus proximus	IEBR-Myr 243	Van Ban Distr., Lao Cai Prov., Vietnam	MG564331
8	Hylomus saiyans	IEBR-Myr 219	Xuan Son NP, Phu Tho Prov., Vietnam	MK457228
9	Hylomus songoku	IEBR-Myr 164	Cuc Phuong NP, Ninh Binh Prov., Vietnam	MK457229
10	Hylomus specialis	IEBR-67	Ngoc Linh Mt., Kon Tum Prov., Vietnam	MK457225
11	Nesorthomorpha montana	IEBR-Myr 453	Ngoc Linh Mt., Kon Tum Prov., Vietnam	MG564338
12	Nesorthomorpha montana	IEBR-Myr 561	Chu Mon Ray NP, Dak Lak Prov., Vietnam	MG564337
13	Nesorthomorpha montana	IEBR-Myr 596	Chu Mon Ray NP, Dak Lak Prov., Vietnam	MG564339
14	Orthomorpha arboricola	IEBR-Myr 455	Ngoc Linh Mts., Kon Tum Prov., Vietnam	MG564332
15	Orthomorpha grandulosa	IEBR-Myr 237	Phuoc My, Quang Nam Prov., Vietnam	MG564333
16	Orthomorpha scabra	IEBR-Myr 432	Bi Doup – Nui Ba NP. Lam Dong Prov., Vietnam	MG564334
17	Orthomorpha setosus	IEBR-Myr 523	Bi Doup – Nui Ba NP. Lam Dong Prov., Vietnam	MG564335
18	Piccola odontopyga	IEBR-Myr 463	Bi Doup – Nui Ba NP. Lam Dong Prov., Vietnam	MG564336
19	Tylopus hilaroides	IEBR-Myr 198	Cuc Phuong NP, Ninh Binh Prov., Vietnam	KX755588
20	Tylopus roseiparaterga	IEBR-Myr 185A	Tam Dao NP. Vinh Phuc Prov., Vietnam	KX755590

 Table 2. Uncorrected distance of the 16S rRNA gene calculated by MEGA 7.0. The genetic distances among *Hylomus* species are in boldface

IPE5	67	65	243	514	32	219	164	455	432	237	596	561	453	519	IPE3	463	523	198
0.249																		
0.282	0.176																	
0.224	0.244	0.280																
0.219	0.239	0.262	0.216															
0.196	0.257	0.267	0.186	0.170														
0.224	0.226	0.272	0.198	0.214	0.186													
0.191	0.232	0.257	0.163	0.193	0.142	0.181												
0.247	0.262	0.303	0.232	0.229	0.221	0.221	0.224											
0.247	0.247	0.305	0.234	0.239	0.206	0.221	0.204	0.087										
0.257	0.252	0.285	0.226	0.234	0.219	0.216	0.209	0.064	0.097									
0.244	0.244	0.290	0.216	0.234	0.198	0.214	0.216	0.122	0.109	0.125								
0.244	0.244	0.290	0.216	0.234	0.198	0.214	0.216	0.122	0.109	0.125	0.000							
0.244	0.247	0.288	0.219	0.234	0.196	0.216	0.216	0.125	0.112	0.127	0.003	0.003						
0.257	0.272	0.303	0.252	0.260	0.234	0.221	0.216	0.216	0.198	0.216	0.214	0.214	0.214					
0.244	0.272	0.298	0.244	0.242	0.219	0.181	0.219	0.239	0.226	0.221	0.234	0.234	0.234	0.186				
0.237	0.247	0.275	0.224	0.242	0.260	0.239	0.221	0.234	0.229	0.242	0.234	0.234	0.234	0.234	0.239			
0.247	0.265	0.293	0.232	0.244	0.247	0.239	0.234	0.224	0.226	0.226	0.221	0.221	0.221	0.254	0.216	0.196		
0.229	0.242	0.288	0.229	0.242	0.226	0.226	0.209	0.206	0.193	0.209	0.201	0.201	0.201	0.237	0.211	0.191	0.206	
0.262	0.247	0.288	0.237	0.252	0.219	0.229	0.221	0.237	0.209	0.224	0.214	0.214	0.214	0.224	0.216	0.214	0.204	0.158
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Phylogenetic relationship

Figure 31 shows the phylogenetic tree inferring from the dataset of 590 bp, including gaps in the 16S rRNA. The bootstrap and BI values were evaluated following Nguyen et al. (2017). The genus Hylomus forms a single clade containing 8 species, but is divided into two groups. The first group consists of two species, H. specialis and H. pilosus, both from southern Vietnam. The second group contains the other six species (H. saiyans, H. proximus, H. namek, H. songoku, H. enghoffi and H. cervarius, all from northern and central Vietnam). The relationship among Hylomus species is relatively weakly supported, with bootstrap and BI values of less than 70% and 0.7, respectively, except the value between H. specialis and H. pilosus (100% and 1.00 BBP). Hylomus is considered to be a sister group to three other orthomorphinine genera (Antheromorpha, Orthomorpha and Nesorthomorpha) whereas both Orthomorphoides and Piccola are outgroups of this clade, supported by medium bootstrap and BI values (82% and 0.69 BBP).

The genus Hylomus Cook & Loomis, 1924 was synonymized with the genus Desmoxytes Chamberlin, 1923 by Golovatch and Enghoff (1994), but was recently re-validated by Srisonchai et al. (2018a). The genus can be divided into three groups based on the morphology of the paraterga: wing-shaped, antlershaped and spiniform. Although all three groups have been recorded in Vietnam, Hylomus spectabilis belong to the wing-shaped group; H. hostilis belong to the spiniform group; all other species belong to the antler-shaped group; our phylogenetic analysis only used antler-shaped species. In addition, Srisonchai et al. (2018a) recalled the non-monophyly of the genus Hylomus, but this result has not yet published. Their analysis does not agree with our current result, arguing that Hylomus is a monophyletic group. Therefore, more Hylomus species should be analysed to better reconstruct the phylogenetic relationships of the genus.



Fig. 31. Phylogenetic tree inferring from a 590 bp fragment of 16S rRNA using Maximum Likelihood and Bayesian Inference analyses. Bootstrap and BI values are shown at the node.

CONCLUSIONS

A total of 13 *Hylomus* species were recorded in Vietnam, including three new ones, *H. songoku* sp. nov., *H. saiyans* sp. nov., and *H. namek* sp. nov. Phylogenetically, the monophyly of the genus *Hylomus* is supported by the analysis of a small fragment of the 16S rRNA mitochondrical gene. However, it is suggested that more *Hylomus* species and more genetic data should be used for better phylogenetic analysis.

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Consent for publication: All authors agree to submit the manuscript to *Zoological Studies*, and agree to publish if accepted.

Ethics approval consent to participate: Not applicable.

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