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

Anh D. Nguyen1,2,*; Manh-Ha Nguyen3; Thu-Anh T. Nguyen1; and Hong-Luong T. Phung1

1Institute of Ecology and Biological Resources, Vietnam Academy of Science and Technology, 18, Hoangquocviet Rd., Hanoi, Vietnam. *Correspondence: ducanh410@yahoo.com or ducanh@iebr.ac.vn
2Graduate University of Science and Technology, Vietnam Academy of Science and Technology, 18, Hoangquocviet Rd., Hanoi, Vietnam
3Vinh Phuc Gifted High School, Chu Van An Str., Vinh Yen city, Vinh Phuc, Vietnam

Received 30 January 2019 / Accepted 24 May 2019 / Published xx June 2019
Communicated by Benny K.K. Chan

The genus *Hylomus* Cook & Loomis, 1924 is reviewed from Vietnam, with 13 recorded species. Of these, three are described as new to science, *H. songoku* sp. nov. from Xuan Son National Park, *H. namek* sp. nov. from Cuc Phuong National Park, and *H. sai yans* 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 gonopod femorite being short, parallel-sided, slightly constricted at middle; tip of gonopod rounded; and lastly *H. sai yans* sp. nov. is diagnosed by 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 should 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, later 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), 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 recently allocated to the genus *Hylomus* (Srisonchai et al. 2018a). They are listed in alphabetic order in below.
Our work presents a review of this genus in the Vietnam fauna 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 as well.

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 a microscope Olympus SZX11. Gonopods were removed for morphological observation, then coated with gold for SEM (Scanning Electron Microscopy) performance using Hitachi T3030 in Vietnam National Museum of Nature (Hanoi) or the JEO system in Field Museum of Natural History (Chicago). After SEM performance, gonopods were returned to their specimen in separated vials. Line drawings were made using a camera lucida attached directly to the microscope Olympus SZX11. Digital images were taken using a camera Infinity3 Lumenera attached to a Leica M205C stereomicroscope and stacked using the software I-Solutions. Images were assembled into plates using the 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).
Fig. 1. Distribution of *Hylomus* species in the mainland of 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).
Zoological Studies 58: n (2019)

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 µl 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 initial PCR. Unfortunately, we were only successful to amplify and sequence 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. Bayesian Inference (BI) tree was created using MrBayes ver 3.1.2 (Huelsenbeck & 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 are deposited at GenBank.

RESULTS
TAXONOMY
Order Polydesmida

Family Paradoxosomatidae Daday, 1889

Tribe Orthomorphini Broleman, 1916

Genus **Hylomus** Cook & Loomis, 1924


*Type species:* **Hylomus draco** Cook & Loomis, 1924, by original designation.

*Diagnosis:* The genus can be recognised by the combination of characters: small to large size (12–35 mm long); often brightly coloured; paraterga strongly to exceedingly well developed, wing-, spine- and 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 southern China and Vietnam. Few species are found in Laos and Thailand. The distribution of the genus *Hylomus* in Vietnam is shown in Fig. 1.

**Hylomus asper** (Attems, 1937)  
(Figs. 1–2)


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

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; Attems 1938).

Distribution: Southern part of central Vietnam.

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

Hylomus cattienensis (Nguyen, Golovatch & Anichkin, 2005)


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 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.

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 (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 of this figure. Emphasis of this figure is focused on 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.

**Hylomus cervarius** *(Attems, 1953)*

(Figs. 1, 5)


**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).

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

Distribution: Only known from northern Vietnam.

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

*Hylomus enghoffii* (Nguyen, Golovatch & Anichkin, 2005)

(Figs. 1, 6–8)


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.

**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 of this figure. Emphasis of this figure is focused on 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 of this figure. Emphasis of this figure is focused on colouration, shapes of paraterga (Pa), metaterga (Me), collum (Co), epiproct (Epi) and hypoproct (Hy).

**Fig. 8.** *Hylomus enghoffi* (Nguyen, Golovatch & Anichkin, 2005) from Phong Nha – Ke Bang National Park. Right gonopod, lateral view (A), mesal view (B).
**Hylomus grandis** (Golovatch, VandenSpiegel & Semenyuk, 2016)


*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 solenophore.

*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)


*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 & Enghoff 1994).

*Distribution:* Only known from northern Vietnam.
Fig. 9. *Hylomus hostilis* (Golovatch & Enghoff, 1994) from Tam Dao National Park.
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 of this figure. Emphasis of this figure is focused on colouration, shapes of collum (Co), paraterga, metaterga (Me), pleura (Ple), sterna (Ste), epiproct (Epi) and hypoproct (Hy).

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

*Hylomus pilosus* (Attems, 1937)

(Figs. 1, 11–12)


Diagnosis: The species can be recognised by the 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 & Enghoff 1994; Nguyen et al. 2005).

Distribution: Only known from Vietnam. The species is widely distributed in southern Vietnam.
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 of this figure. Emphasis of this figure is focused on colouration, shapes of head (He), collum (Co), paraterga (Pa), metaterga (Me), sterna (Ste), epiproct (Epi) and hypoproct (Hy).
Fig. 12. *Hylomus pilosus* (Attems, 1937) from Cat Tien National Park. Right gonopod, lateral view (A), mesal view (B).

*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) 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.

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

*Hylomus specialis* (Nguyen, Golovatch & Anichkin, 2005)

(Figs. 1, 14)


*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 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 Vietnam.

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

**Hylomus spectabilis** *(Attems, 1937)*

(Figs. 1, 15)

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


Zoological Studies 58: n (2019)


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.

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

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).

**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 (Fig. 16A–B) somewhat narrower than segment 2 in width; surface shining, densely micro-granulated 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 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 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 (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.

**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.

**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.
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 bar = 1mm for A-B, = 0.1 mm for C. (Note: solenophore in Fig. 16C is 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.

*Hylomus saiyans* sp. nov.

(Figs. 1, 21–25)

urn:lsid:zoobank.org:act:949D8441-0F5F-421E-84B1-7B3688AA04DD


*Etymology:* The name refers to naturally aggressive warriors in the Japanese manga “Dragon balls” 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 & 7 with a ventral hump, sometimes femur 5 inflated. Gonopod femorite slightly curved 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 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 four spinnerets. Hypropt (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 & 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.
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.
Fig. 24. *Hylomus saiyans* sp. nov. from Cuc Phuong National Park. Holotype. Right gonopod, lateral view (A), mesal view (B). Scale bar = 1mm.

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

*Hylomus namek* sp. nov.

(Figs. 1, 26–30)

urn:lsid:zoobank.org:act:AEDAF341-76F4-4D37-BB94-3F564724CDCB
Material examined: Holotype: male (IEBR-Myr 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 dragon balls, in the Japanese manga “Dragon balls” 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 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 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 & 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.
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.

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.
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 bar = 1 mm for A–B, = 0.5 mm for C–D.

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 = 1mm.

**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
2. Paraterga antler-shaped (Figs 3, 7, 11) ................................................................. 3
   - Paraterga spine-shaped (Fig. 9) ......................................................................................... 11
3. Epiproct unmodified, without conspicuous setiferous knobs near tip (Fig. 18A−B) ............ 4
   - Epiproct modified, with several evident setiferous knobs near tip (Figs 7F, 28B) ................. 7
4. Metaterga smooth, more or less shining. Male femora unmodified ......................... *H. asper*
   - Metaterga rough, dull, granular. Male femora modified, inflated ................................. 5
5. Metaterga with more than 4 + 4 posterior setiferous spines on midbody segments (Fig. 17A).
   Body pale or weakly pigmented. Lamina lateralis of gonopod solenophore with densely setose
   region (Figs 19−20) ........................................................................................................ *H. songoku*
   - Metaterga with less than 4 + 4 posterior setiferous spines on midbody segments. Body
   pigmented. Lamina lateralis of gonopos solenophore without densely setose region ..................... 9
6. Metaterga with \(3 + 3\) posterior setiferous spines. Male femora 6, 7 and 9 humped ventrally. Fifth sternum with a pair of tubercles between coxae 4 ................................. \textit{H. cervarius}

- Metaterga with \(2 + 2\) posterior setiferous spines. Male femora 6 & 7, sometime femur 5 modified, each with a large hump on ventral side. Fifth sternum with either rectangular process or bifid trapeziform lamina between coxae 4 ................................. \textit{H. cervarius}

7. Body light or darkish brown. Fifth sternum with a bifid trapeziform lamina between coxae 4 .... 8

- Body reddish or pinkish. Fifth sternum with four round tubercles on a prominent, elevated, rectangular lamina between male coxae 4 ................................. \textit{H. enghoffi}

8. Male femora 6, 7 humped ventrally (Fig. 28D). Tip of solenophore broadly rounded lobuliform (Fig. 29–30) ................................................................. \textit{H. namek}

- Male femora 6, 7, sometimes 5, humped ventrally (Fig. 23B). Tip of solenophore acute (Figs 24–25) ................................................................. \textit{H. saiyans}

9. At least \(3 + 3\) posterior metatertgal spines on metaterga ................................. 10

- Only \(1 + 1\) posterior poor setae on metaterga (Figs. 3B, D) .............................. \textit{H. cattienensis}

10. Colour pink to red. Metaterga with numerous microsetae, and \(4 + 4\) posterior spines (Figs. 4A, B, D, E) ................................................................. \textit{H. pilosus}

- Colour dark to castaneous brown. Metaterga with microgranulation, and \(3 + 3\) posterior spines ................................................................. \textit{H. proximus}

11. A row of \(1 + 1\) posterior spines on metaterga. Gonopod subfalcate, femorite slightly curved; solenomere long ................................................................. \textit{H. specialis}

- A row of \(2 + 2\) posterior tubercles/spines on metaterga. Gonopod falcate; solenophore short, pointed terminally ................................................................. 12

12. Fifth sternum with two independent setiferous tubercles between coxae 4. Antenna long and slender ................................................................. \textit{H. grandis}
Fifth sternum with a bifid 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 from 20 species including two outgroup species (Table 1), *Tylopus 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 are variable and relatively high from 0.142 to 0.282 (Table 2). The p-distance between the genus *Hylomus* and other genera is also very high, from 0.181 to 0.305. The mean p-distance among all species is 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

<table>
<thead>
<tr>
<th>No.</th>
<th>Species</th>
<th>Voucher code</th>
<th>Locality</th>
<th>Accession number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Antheromorpha festiva</em></td>
<td>IEBR-Myr 519</td>
<td>Yok Don NP, Dak Lak Prov., Vietnam</td>
<td>KX755577</td>
</tr>
<tr>
<td>2</td>
<td><em>Antheromorpha pumatensis</em></td>
<td>IEBR-Myr IPE3</td>
<td>Pu Mat NP, Nghe An Prov., Vietnam</td>
<td>MG669559</td>
</tr>
<tr>
<td>3</td>
<td><em>Hylomus cervarius</em></td>
<td>IEBR-32</td>
<td>Sa Pa, Lao Cai Prov., Vietnam</td>
<td>MG564329</td>
</tr>
<tr>
<td>4</td>
<td><em>Hylomus enghoffi</em></td>
<td>IEBR-Myr IPE5</td>
<td>Phong Nha – Ke Bang NP, Quang Binh Prov., Vietnam</td>
<td>MG564330</td>
</tr>
<tr>
<td>5</td>
<td><em>Hylomus namek</em></td>
<td>IEBR-Myr 514</td>
<td>Duc Xuan commune, Ha Giang Prov., Vietnam</td>
<td>MK457227</td>
</tr>
<tr>
<td>6</td>
<td><em>Hylomus pilosus</em></td>
<td>IEBR-65</td>
<td>Cat Tien NP, Dong Nai Prov., Vietnam</td>
<td>MK457226</td>
</tr>
<tr>
<td>7</td>
<td><em>Hylomus proximus</em></td>
<td>IEBR-Myr 243</td>
<td>Van Ban Distr., Lao Cai Prov., Vietnam</td>
<td>MG564331</td>
</tr>
<tr>
<td>8</td>
<td><em>Hylomus sayans</em></td>
<td>IEBR-Myr 219</td>
<td>Xuan Son NP, Phu Tho Prov., Vietnam</td>
<td>MK457228</td>
</tr>
<tr>
<td>9</td>
<td><em>Hylomus songoku</em></td>
<td>IEBR-Myr 164</td>
<td>Cu Phuong NP, Ninh Binh Prov., Vietnam</td>
<td>MK457229</td>
</tr>
<tr>
<td>10</td>
<td><em>Hylomus specialis</em></td>
<td>IEBR-67</td>
<td>Ngoc Linh Mt., Kon Tum Prov., Vietnam</td>
<td>MK457225</td>
</tr>
<tr>
<td>11</td>
<td><em>Nesorthomorpha montana</em></td>
<td>IEBR-Myr 453</td>
<td>Ngoc Linh Mt., Kon Tum Prov., Vietnam</td>
<td>MG564338</td>
</tr>
<tr>
<td>12</td>
<td><em>Nesorthomorpha montana</em></td>
<td>IEBR-Myr 561</td>
<td>Chu Mon Ray NP, Dak Lak Prov., Vietnam</td>
<td>MG564337</td>
</tr>
<tr>
<td>13</td>
<td><em>Nesorthomorpha montana</em></td>
<td>IEBR-Myr 596</td>
<td>Chu Mon Ray NP, Dak Lak Prov., Vietnam</td>
<td>MG564339</td>
</tr>
<tr>
<td>14</td>
<td><em>Orthomorpha arboricola</em></td>
<td>IEBR-Myr 455</td>
<td>Ngoc Linh Mts., Kon Tum Prov., Vietnam</td>
<td>MG564332</td>
</tr>
<tr>
<td>15</td>
<td><em>Orthonomorpha grandulosa</em></td>
<td>IEBR-Myr 237</td>
<td>Phuoc My, Quang Nam Prov., Vietnam</td>
<td>MG564333</td>
</tr>
<tr>
<td>16</td>
<td><em>Orthonomorpha scabra</em></td>
<td>IEBR-Myr 432</td>
<td>Bi Doup – Nui Ba NP, Lam Dong Prov., Vietnam</td>
<td>MG564334</td>
</tr>
<tr>
<td>17</td>
<td><em>Orthonomorpha setosus</em></td>
<td>IEBR-Myr 523</td>
<td>Bi Doup – Nui Ba NP, Lam Dong Prov., Vietnam</td>
<td>MG564335</td>
</tr>
<tr>
<td>18</td>
<td><em>Piccola odontopyga</em></td>
<td>IEBR-Myr 463</td>
<td>Bi Doup – Nui Ba NP, Lam Dong Prov., Vietnam</td>
<td>MG564336</td>
</tr>
<tr>
<td>19</td>
<td><em>Tylopus hilaroides</em></td>
<td>IEBR-Myr 198</td>
<td>Cu Phuong NP, Ninh Binh Prov., Vietnam</td>
<td>KX755588</td>
</tr>
<tr>
<td>20</td>
<td><em>Tylopus roseiparaterga</em></td>
<td>IEBR-Myr 185A</td>
<td>Tam Dao NP, Vinh Phuc Prov., Vietnam</td>
<td>KX755590</td>
</tr>
</tbody>
</table>
**Table 2.** Uncorrected distance of the 16S rRNA gene calculated by MEGA 7.0. The genetic distances among *Hylomus* species are highlighted in bold.

<table>
<thead>
<tr>
<th></th>
<th>IPE5</th>
<th>67</th>
<th>65</th>
<th>243</th>
<th>514</th>
<th>32</th>
<th>219</th>
<th>164</th>
<th>455</th>
<th>432</th>
<th>237</th>
<th>596</th>
<th>561</th>
<th>453</th>
<th>519</th>
<th>IPE3</th>
<th>463</th>
<th>523</th>
<th>198</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>H. enghoffi</em></td>
<td>IPE5</td>
<td>0.294</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>(IPE5)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>H. specialis</em></td>
<td>67</td>
<td>0.282</td>
<td>0.176</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>H. pilosus</em></td>
<td>65</td>
<td>0.244</td>
<td>0.280</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(243)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>H. namek</em></td>
<td>514</td>
<td>0.219</td>
<td>0.262</td>
<td>0.216</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(243)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>H. cervarius</em></td>
<td>32</td>
<td>0.196</td>
<td>0.267</td>
<td>0.186</td>
<td>0.170</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(243)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>H. namek</em></td>
<td>514</td>
<td>0.224</td>
<td>0.272</td>
<td>0.198</td>
<td>0.214</td>
<td>0.186</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(243)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>H. specialis</em></td>
<td>67</td>
<td>0.191</td>
<td>0.232</td>
<td>0.257</td>
<td>0.163</td>
<td>0.193</td>
<td>0.142</td>
<td>0.181</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(243)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>O. arboricola</em></td>
<td>455</td>
<td>0.247</td>
<td>0.262</td>
<td>0.303</td>
<td>0.232</td>
<td>0.229</td>
<td>0.221</td>
<td>0.221</td>
<td>0.221</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(455)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>O. scabra</em></td>
<td>432</td>
<td>0.247</td>
<td>0.247</td>
<td>0.305</td>
<td>0.234</td>
<td>0.239</td>
<td>0.206</td>
<td>0.221</td>
<td>0.221</td>
<td>0.204</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(432)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>O. grandulosa</em></td>
<td>237</td>
<td>0.257</td>
<td>0.252</td>
<td>0.285</td>
<td>0.226</td>
<td>0.234</td>
<td>0.219</td>
<td>0.216</td>
<td>0.209</td>
<td>0.064</td>
<td>0.097</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(237)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>N. montana</em></td>
<td>596</td>
<td>0.244</td>
<td>0.244</td>
<td>0.290</td>
<td>0.216</td>
<td>0.234</td>
<td>0.218</td>
<td>0.214</td>
<td>0.216</td>
<td>0.122</td>
<td>0.125</td>
<td>0.127</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(596)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>N. montana</em></td>
<td>561</td>
<td>0.244</td>
<td>0.244</td>
<td>0.290</td>
<td>0.216</td>
<td>0.234</td>
<td>0.218</td>
<td>0.214</td>
<td>0.216</td>
<td>0.122</td>
<td>0.125</td>
<td>0.127</td>
<td>0.003</td>
<td>0.003</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(561)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>N. montana</em></td>
<td>453</td>
<td>0.244</td>
<td>0.247</td>
<td>0.288</td>
<td>0.219</td>
<td>0.234</td>
<td>0.216</td>
<td>0.216</td>
<td>0.216</td>
<td>0.125</td>
<td>0.127</td>
<td>0.127</td>
<td>0.003</td>
<td>0.003</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(453)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>A. festiva</em></td>
<td>519</td>
<td>0.257</td>
<td>0.272</td>
<td>0.303</td>
<td>0.252</td>
<td>0.260</td>
<td>0.234</td>
<td>0.221</td>
<td>0.216</td>
<td>0.216</td>
<td>0.198</td>
<td>0.216</td>
<td>0.214</td>
<td>0.214</td>
<td>0.214</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(519)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>A. pumatensis</em></td>
<td>453</td>
<td>0.244</td>
<td>0.272</td>
<td>0.298</td>
<td>0.244</td>
<td>0.242</td>
<td>0.219</td>
<td>0.219</td>
<td>0.239</td>
<td>0.226</td>
<td>0.221</td>
<td>0.234</td>
<td>0.234</td>
<td>0.234</td>
<td>0.186</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(453)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>P. odontogyga</em></td>
<td>463</td>
<td>0.237</td>
<td>0.247</td>
<td>0.275</td>
<td>0.224</td>
<td>0.242</td>
<td>0.260</td>
<td>0.239</td>
<td>0.221</td>
<td>0.234</td>
<td>0.229</td>
<td>0.242</td>
<td>0.234</td>
<td>0.234</td>
<td>0.234</td>
<td>0.234</td>
<td>0.234</td>
<td>0.239</td>
<td></td>
</tr>
<tr>
<td><em>(463)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>O. setosus</em></td>
<td>523</td>
<td>0.247</td>
<td>0.265</td>
<td>0.293</td>
<td>0.232</td>
<td>0.244</td>
<td>0.247</td>
<td>0.239</td>
<td>0.234</td>
<td>0.224</td>
<td>0.226</td>
<td>0.226</td>
<td>0.221</td>
<td>0.221</td>
<td>0.254</td>
<td>0.216</td>
<td>0.196</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(523)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>T. hilaroides</em></td>
<td>198</td>
<td>0.229</td>
<td>0.242</td>
<td>0.288</td>
<td>0.229</td>
<td>0.242</td>
<td>0.226</td>
<td>0.226</td>
<td>0.209</td>
<td>0.206</td>
<td>0.193</td>
<td>0.209</td>
<td>0.201</td>
<td>0.201</td>
<td>0.201</td>
<td>0.237</td>
<td>0.211</td>
<td>0.191</td>
<td>0.206</td>
</tr>
<tr>
<td><em>(198)</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>T. roseiparaterga</em></td>
<td>185A</td>
<td>0.262</td>
<td>0.247</td>
<td>0.288</td>
<td>0.237</td>
<td>0.252</td>
<td>0.219</td>
<td>0.229</td>
<td>0.221</td>
<td>0.237</td>
<td>0.209</td>
<td>0.224</td>
<td>0.214</td>
<td>0.214</td>
<td>0.224</td>
<td>0.216</td>
<td>0.214</td>
<td>0.214</td>
<td>0.204</td>
</tr>
</tbody>
</table>
Phylogenetic relationship

Figure 31 shows the phylogenetic tree inferring from the dataset of 590 bp including gaps of 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. sai yans*, *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 of three other orthomorphinine genera (*Antheromorpha*, *Orthomorpha* and *Nesorthomorpha*) whereas both *Orthomorphoides* and *Piccola* are outgroup of this clade supported with 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 revalidated by Srisonchai et al. (2018a). The genus can be divided into three groups based on morphology of paraterga: wing-shaped, antler-shaped and spiniform. Although all three groups have been recorded in Vietnam: *Hylomus spectabilis* representing for the wing-shaped group; *H. hostilis* for the spiniform group; all other species belonging to the antler-shaped group, our phylogenetic analysis only uses 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, *Hylomus* is a monophyletic group. Therefore, more *Hylomus* species should be used to analyse for better reconstructing the phylogenetic relationship of the genus.
CONCLUSIONS

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

Acknowledgments: This work and the three new species names have been registered with ZooBank under urn:lsid:zoobank.org:pub:C94632C2-5500-4241-861F-33314C80D4FA. We would like to thank all National Parks and Nature Reserves mentioned above for their kind permissions to our field surveys. The work was supported by Vietnam Academy of Science and Technology under the project VAST04.10/19-20, and NAGAO Environmental...
Foundation (Japan). Two anonymous reviewers are acknowledged for their invaluable comments to improve the manuscript before publication. Dr. Nguyen Quoc Binh (Vietnam National Museum of Nature) are thanked for his kindly assisting the SEM performance.

**Author’s contribution:** All authors contributed equally to this work.

**Competing interests:** All authors do not have any conflicts of interests.

**Availability of data and materials:** All materials and data are available in Institute of Ecology and Biological Resources, Hanoi, Vietnam, and upon on the requests.

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

**Ethics approval consent to participate:** Not applicable.

**REFERENCES**


