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Description of three new species of *Wormaldia* McLachlan, 1865 from Vietnam (Trichoptera: Philopotamidae)

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Abstract. Three previously unknown species of *Wormaldia* McLachlan, 1865 are herein described from the Cao Bang Province, N Nui Pia Oac Nature Reserve, located in northern Vietnam: *Wormaldia piadenensis* sp. nov., *Wormaldia nui* sp. nov., and *Wormaldia caobangensis* sp. nov. These species are considered rare and encountered either as singletons or as a pair. The specimens were collected in 2012 using Malaise traps and light traps, which were strategically positioned along stream banks. Additionally, a key for the identification of the male individuals of the 19 known species of *Wormaldia* in Vietnam is provided.

Keywords. Cao Bang Province, Nui Pia Oac Nature Reserve, biodiversity, streams.

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Introduction

The Philopotamidae Stephens, 1829 are a group of species regarded as monophyletic, a status initially proposed by Ross (1956) and later supported by several researchers (e.g., Holzenthal *et al.* 2007; Malm *et al.* 2013). Ross (1967) suggested that the Philopotamidae form the sister family to the Stenopsychidae Martynov, 1924, a hypothesis that has been corroborated by phylogenetic analyses based on various characters, including morphology and DNA (Holzenthal *et al.* 2007; Malm *et al.* 2013). Currently, the family consists of nine fossil genera and 22 extant genera (Morse 2025).

The genus *Wormaldia* McLachlan, 1865, was described and named in honor of the British 19th-century entomologist Percy C. Wormald, in recognition of his contributions to the study of Trichoptera (McLachlan 1865). At the time of its description, the genus included two known species: *Wormaldia occipitalis* (Pictet, 1834) and *Wormaldia subnigra* McLachlan, 1865. According to Morse (2025), a total of 279 species have been described within the genus, with 20 of these known only from fossils.

Approximately one-third of the described extant species (81 species) are from the Oriental Region, slightly fewer than those recorded from the Palearctic Region (90 species). The genus is not found in Australia.

The evolutionary history of *Wormaldia* was first proposed by Ross (1956), who, based on wing morphology and the shape of male genitalia, suggested that the genus originated in the Nearctic Region. The phylogenetic position of *Wormaldia* within the Philopotamidae was later analyzed by Holzenthal *et al.* (2007), who included four recent species of *Wormaldia* exclusively from the Nearctic Region. They concluded that the genus is monophyletic and forms the sister group to all other genera in the family.

Material and methods

The material consists of male specimens collected using light and Malaise traps placed at streams in or north of the Nui Pia Oac Nature Reserve in Cao Bang Province in April 2012. The specimens were preserved directly in 80% ethanol along with other insects collected during the same event. Specimens of Trichoptera were initially sorted and identified to the family and genus levels at the Swedish Museum of Natural History (SMNH), with identification primarily based on the work of Malicky (2010).

Before detailed examination and illustration, each abdomen was macerated in Proteinase K and extracted for DNA simultaneously. DNA extraction was performed using the QIAamp® DNA Micro Kit (QIAGEN). The abdomens were dehydrated in absolute alcohol and temporarily suspended in Euparal on a microscope slide. Illustrations of genitalia were prepared using a Leitz Ortholux II light microscope equipped with a drawing tube. These illustrations were then scanned and finalized using Adobe® Illustrator® ver. 28.7.1 and Photoshop® ver. 25.11.0. After examination and illustration, the abdomens were returned to 80% ethanol with the rest of the specimen.

Wing photographs were captured using a Nikon DS Ri2 digital camera mounted on a Nikon SMZ25 stereo microscope. Wing and genital measurements were obtained using NIS Elements D ver. 5.10.01 software. All drawings and photographs were edited and finalized in Adobe Photoshop.

For descriptions based on a single specimen, the species were confirmed to be distinct from all other Vietnamese species, as well as some other Oriental species, based on a combination of morphological features and DNA sequences. In the descriptions, the genital terminology follows Nielsen (1957), and wing venation terminology follows Mosely (1939).

All holotypes are deposited in the Vietnam National Museum of Nature (VNMN), Vietnam Academy of Science and Technology (VAST), Hanoi, Vietnam. The paratype of *Wormaldia nui* sp. nov. is deposited in the Swedish Museum of Natural History (NHRS).

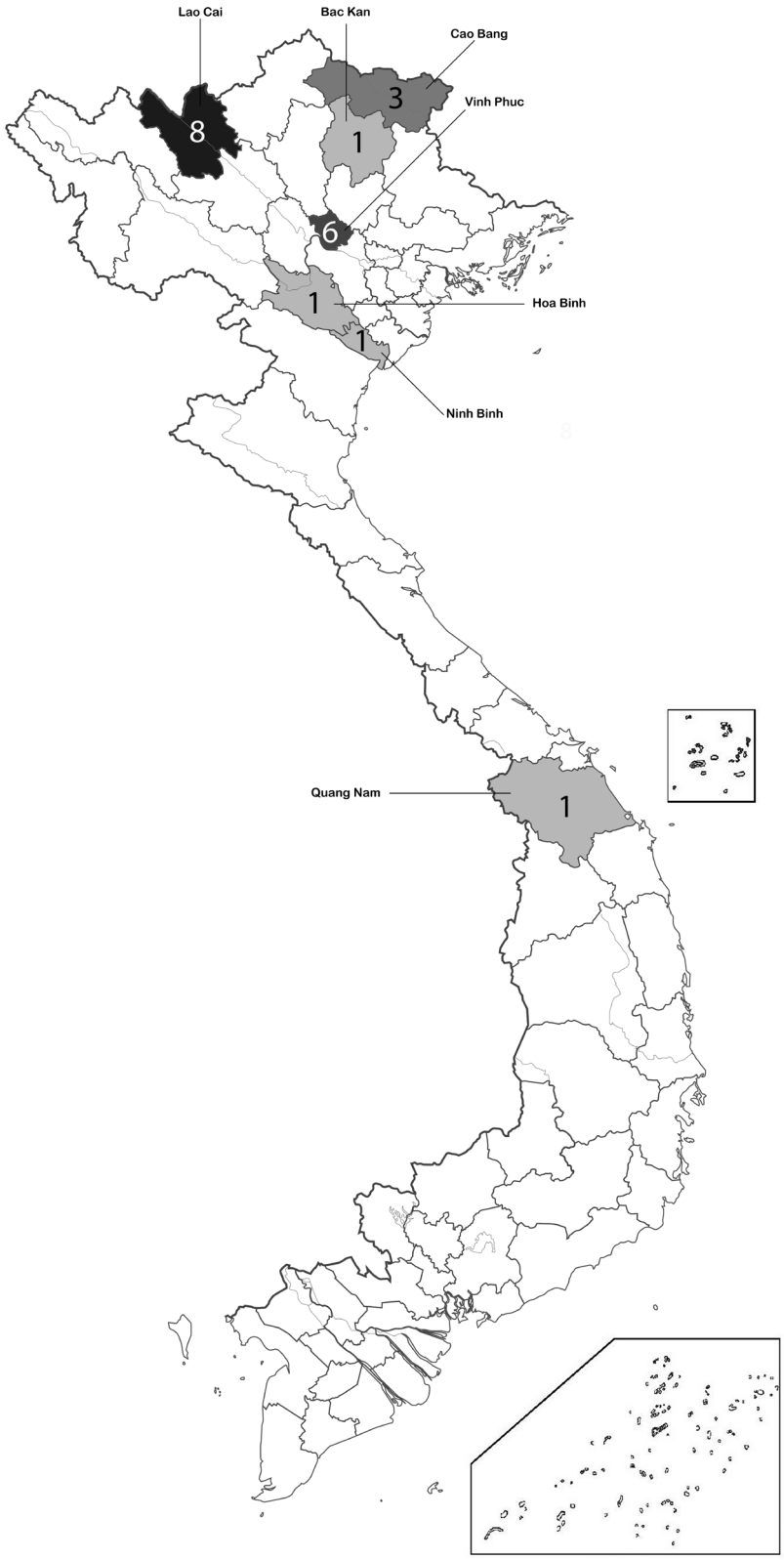


Fig. 1. A map of Vietnam with provinces; figures indicate the number of species of *Wormaldia* McLachlan, 1865 recorded in each respective province. The shading represents the species richness, with darker shading corresponding to a higher number of species recorded in that province.

Results

Taxonomy

Class Insecta Linnaeus, 1758
Order Trichoptera Kirby, 1813
Superfamily Philopotamoidea Stephens, 1829
Family Philopotamidae Stephens, 1829

Genus ***Wormaldia*** McLachlan, 1865

Key to the Vietnamese male species of *Wormaldia* McLachlan, 1865

1. Harpagones are clearly shorter than coxopodites 2
– Harpagones about as long as, or longer than coxopodites 9

2. Harpagones about straight in lateral view 3
– Harpagones curving ventrally in lateral view 6

3. Tergite X exceeding coxopodites posteriorly ..... ***Wormaldia sinocornuta*** Mey, 1996
– Tergite X not exceeding coxopodites posteriorly 4

4. Harpagones almost parallel-sided in lateral view .....***Wormaldia caobangensis*** sp. nov.
– Harpagones triangular in lateral view 5

5. Tergite X curving dorsally at apex; harpagones with rounded mesal projection in ventral view .... ***Wormaldia meosorum*** (Mey, 1996)
– Tergite X curving pointing distally at apex; harpagones with mesal margin straight in ventral view .....***Wormaldia muoinam*** (Malicky, 1995)

6. In lateral view, harpagones as high at mid-length as at base 7
– In lateral view, harpagones clearly lower at mid-length than at base 8

7. In lateral view, coxopodites with straight ventral margin; dorsal margin with triangular projection oriented dorsally .....***Wormaldia piadenensis*** sp. nov.
– In lateral view, coxopodites with convex ventral margin; dorsal margin smoothly convex, without triangular projection ..... ***Wormaldia muoihai*** Malicky, 1995

8. In lateral view, harpagones uniformly curving venrally along their length .... ***Wormaldia nyctimon*** (Schmid, 1991)
– In lateral view, harpagones sharply bending ventrally before apex .... ***Wormaldia sonlama*** Oláh & Malicky, 2010

9. Harpagones curving ventrally in lateral view 10
– Harpagones about straight in lateral view 11

10. Each posterodorsal corner of segment strongly prolonged into slender, ventrally curving posterior projection ..... ***Wormaldia muoisan*** (Malicky, 1995)
– Each posterodorsal corner of segment not prolonged posteriorly ***Wormaldia muoiba*** (Malicky, 1995)

11. Tergite VIII produced posteriorly above segment IX 12
– Tergite VIII not produced posteriorly above segment IX 16

12. In lateral view, harpagones narrowing dorsally and ventrally at mid-length 13
– In lateral view, harpagones as high at mid-length as distally of mid-length 14

13. In lateral view, segment IX longer than coxopodites .....***Wormaldia muoimot*** Malicky, 1995
– In lateral view, segment IX as long as coxopodites .....***Wormaldia relicta*** (Martynov, 1935)

14. In lateral view, harpagones narrowing along their length .....
.....***Wormaldia hephoa*** Oláh & Malicky, 2010
– In lateral view, harpagones equally high along their length ..... 15.

15. In ventral view, harpagones narrowing along their length .....***Wormaldia muoibon*** (Malicky, 1995)
– In ventral view, harpagones parallel-sided along their length ..... ***Wormaldia nui*** sp. nov.

16. In lateral view, harpagones clearly longer than coxopodites 17
– In lateral view, harpagones about as long as coxopodites 18

17. In lateral view, harpagones almost equally high along their length .....
.....***Wormaldia montuosa*** Arefina-Armitage & Armitage, 2015
– In lateral view, harpagones shallower at mid-length than subapically .....
.....***Wormaldia clavella*** Mey, 1995

18. Phallus with three spines shorter than high of posterior part of phallus .....
.....***Wormaldia daona*** Oláh & Malicky, 2010
– Phallus with one spine almost as long as phallus .....***Wormaldia longicornuta*** Mey, 1996

Wormaldia piadenensis sp. nov.
urn:lsid:zoobank.org:act:A47E096C-BDC2-4038-97C3-82309676D9E3
Figs 1–2, 5–8

Diagnosis

The male genitalia of *Wormaldia piadenensis* sp. nov. exhibit a notable similarity to those of *Wormaldia muoihai*, particularly in the presence of downwardly curving harpagones, which are of equal height at mid-length and at the base, and are each shorter than the coxopodites. However, *W. piadenensis* can be distinguished from *W. muoihai* by several key characteristics in the male genitalia: segment IX is shorter, segment IX possesses a distinct posteroventral process, the dorsal margin of the coxopodites is more sharply produced dorsally, and the phallus features a single posterior curved sclerite and a long, needle-shaped anterior sclerite, in contrast to the two short, straight sclerites present in *W. muoihai*.

Etymology

Wormaldia piadenensis sp. nov. was named after Phia Dén Village, near the type locality of the species.

Type material

Holotype

VIETNAM • ♂ (in alcohol); Cao Bang Province, N Nui Pia Oac Nature Reserve, about 9.5 km (rd) N of Phia Dén Village, 100 m upstream of bridge; 10 Apr. 2012; Johanson and Pham leg.; light trap at stream with mixed stream bottom; loc#VN028; VNMN.

Figs 2–4. Right forewing and hind wing of species of *Wormaldia*. **2**. *Wormaldia piadenensis* sp. nov., holotype, ♂ (VNMN). **3**. *Wormaldia nui* sp. nov., holotype, ♂ (VNMN). **4**. *Wormaldia caobangensis* sp. nov., holotype, ♂ (VNMN).

Description (holotype)

Forewing (Fig. 2) 5.5 mm (N = 1), membrane light brown, veins dark brown. Forks 1–5 present; fork 1 originates at distal corner of Dc; basis of M1+2 and Ms hyaline; arc located opposite to base of fork 5. Abdominal segments VII and VIII with long posteroventral lobes (Figs 5, 7). In lateral view (Fig. 5), segment IX anteriorly triangular and posteroventral part produced posteriorly; coxopodites with almost straight ventral margin, dorsal margin slightly produced into triangular; harpagones almost uniformly curving ventrad along their length, about ½× as long as coxopodites, each with rounded apex. In dorsal view (Fig. 6), segment IX with wide U-shaped anterior margin; tergum X triangular, with few setae. In ventral view (Fig. 7), with sternum IX produced into small, narrow triangle; basal half of coxopodites fused, distal half with irregularly shaped mesal margin bearing stout setae at posteromesal corner; harpagones almost straight, with small mesal process at mid-length. Phallus (Fig. 8) with one pair of very short sclerites running along its length, and one sickle-shaped sclerite near apex.

Wormaldia nui sp. nov.
urn:lsid:zoobank.org:act:CB2E57C6-4B85-4619-8D95-F40DC1A02ECB
Figs 1, 3, 9–12

Diagnosis

The male genitalia of *Wormaldia nui* sp. nov. closely resemble those of *Wormaldia muoibon*, particularly in lateral view, where the harpagones are almost straight and parallel-sided, and of equal length as the coxopodites. Additionally, tergite VIII is produced above segment IX. However, *W. nui* is distinguishable from *W. muoibon* based on several male genital features: in *W. nui*, the harpagones are parallel-sided in ventral view, whereas they slightly taper in *W. muoibon*; further, the phallus of *W. nui* has two short, straight sclerites at the posterior end, in contrast to the three longer, straight sclerites found in *W. muoibon*.

Etymology

Wormaldia nui sp. nov. was named after the Nui Pia Oac Nature Reserve, the type locality of the species.

Type material

Holotype

VIETNAM • ♂ (in alcohol); Cao Bang Province, N Nui Pia Oac Nature Reserve, about 9.5 km (rd) N of Phia Dén Village, 100 m upstream of bridge; 10 Apr. 2012; Johanson and Pham leg.; light trap at stream with mixed stream bottom; loc#VN028; VNMN.

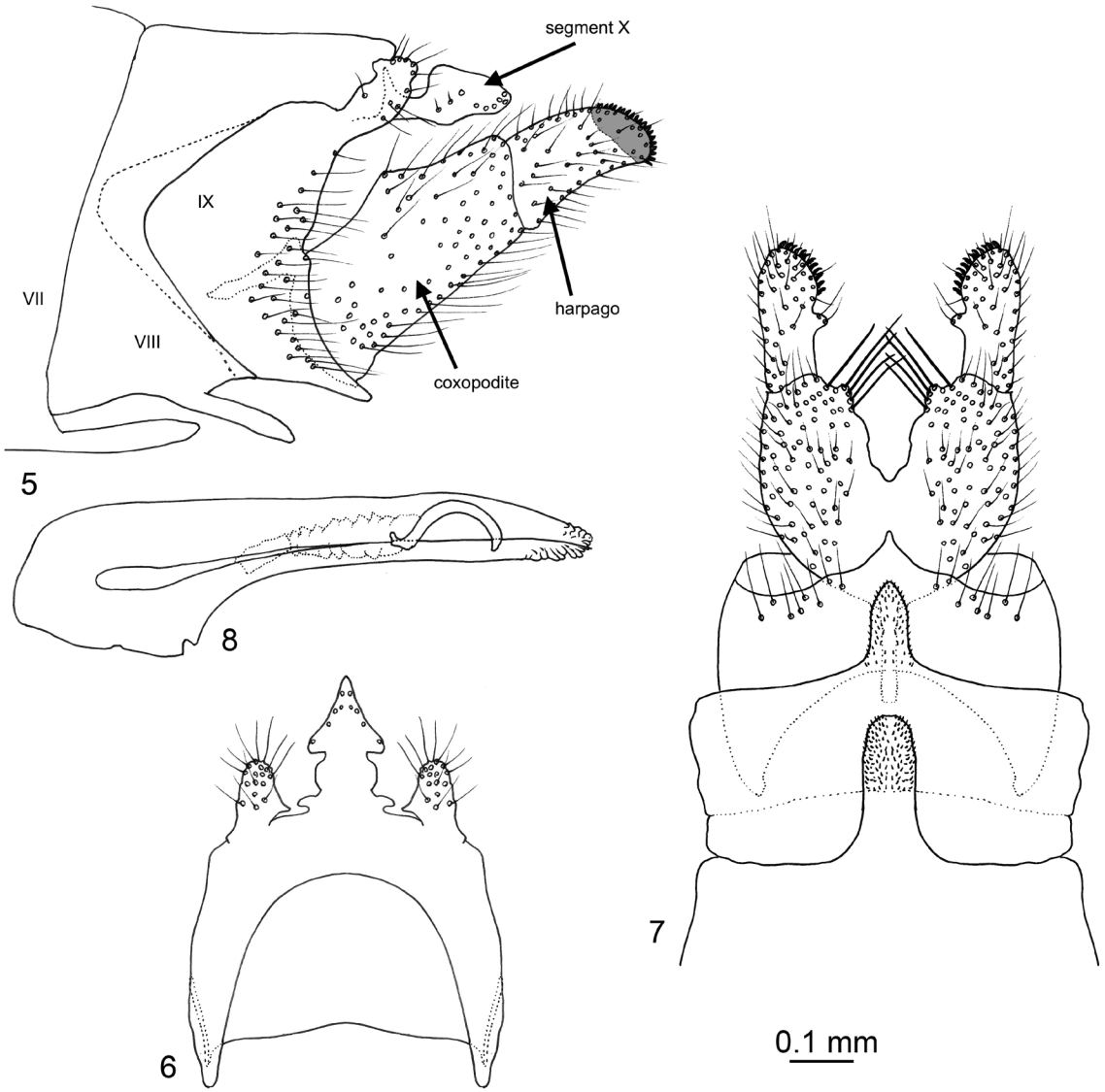
Paratype

VIETNAM • 1 ♂ (in alcohol); Cao Bang Province, Nui Pia Oac Nature Reserve, about 200 m downstream on rd to radio tower; 10 Apr. 2012; Johanson and Pham leg.; light trap at village center; loc#VN030; NHRS.

Description (holotype)

Forewing (Fig. 3) 4.5 mm (N = 1), membrane light brown, veins dark brown. Forks 1–5 present; fork 1 originates shortly before distal corner of Dc; basis of M1+2 and Ms hyaline; arc located slightly distally of base of fork 5. Abdominal segments VII and VIII with long posteroventral lobes (Figs 9, 11). In lateral view (Fig. 8), segment IX forming triangular anteriorly, posteroventral corner not produced posteriorly; coxopodites with slightly convex ventral margin, dorsal margin strongly convex; harpagones straight, with almost parallel-sided dorsal and ventral margins, about as long as coxopodites, each with rounded apex. In dorsal view (Fig. 10), segment IX with wide U-shaped anterior margin; tergum X with basal three-quarters with parallel-sided lateral margins, with two pairs of short setae before narrowing apex.

In ventral view (Fig. 11), with sternum IX with small central incision at posterior margin; basal two-thirds of coxopodites fused, each with distal half of mesal margin straight, bearing few stout setae near posteromesal corner; harpagones almost straight, without mesal process. Phallus (Fig. 12) with thin sclerites in group before mid-length and one pair of short, triangular sclerites situated close to each other near apex.



Figs 5–8. *Wormaldia piadenensis* sp. nov., ♂, holotype (VNMN). **5**. Lateral view. **6**. Dorsal view. **7**. Ventral view. **8**. Phallus, lateral view. Roman numbers relate to abdominal segment numbers.

Wormaldia caobangensis sp. nov.
urn:lsid:zoobank.org:act:412B7D98-4ED4-4DAB-BA79-3F7F50EAED53
Figs 1, 4, 13–16

Diagnosis

The male genitalia of *Wormaldia caobangensis* sp. nov. exhibit similarities to those of *Wormaldia muoihai*, particularly in the presence of the downwardly curving harpagones that are of equal height at mid-length and at the base, and are shorter than the coxopodites. However, in lateral view, *W. caobangensis* is distinguishable from *W. muoihai* by the more prominently produced anterior segment IX.

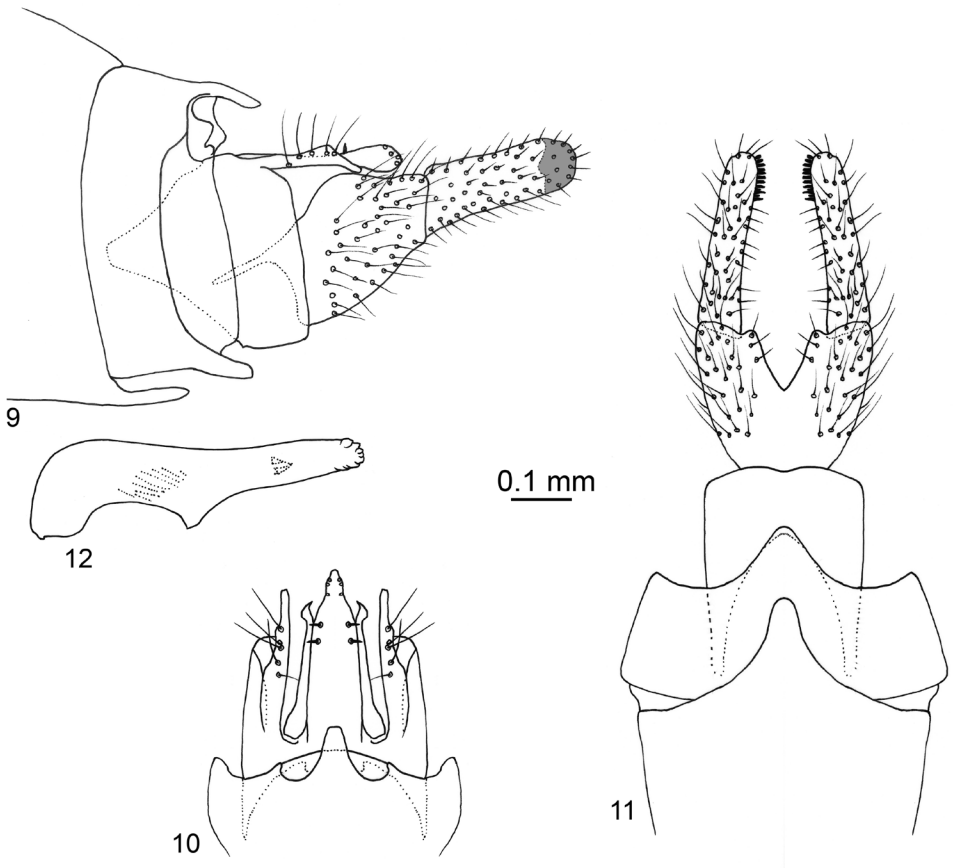
Etymology

Wormaldia caobangensis sp. nov. was named after the Vietnamese Cao Bang Province, the type locality of the species.

Type material

Holotype

VIETNAM • ♂ (in alcohol); Cao Bang Province, Nui Pia Oac Nature Reserve, N Phia Dén Village, upstream road to the radio tower; 8–10 Apr. 2012; Johanson and Pham leg.; Malaise trap across stream with large stones; loc#VN024; VNMN.



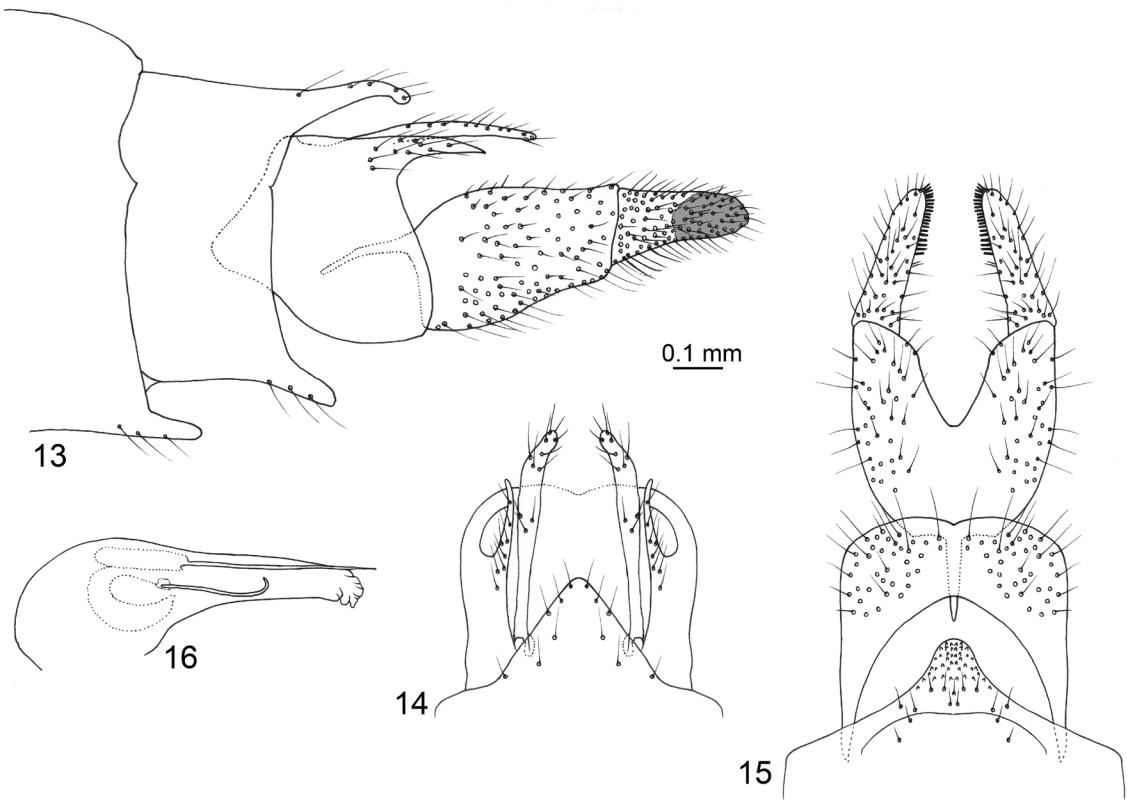
Figs 9–12. *Wormaldia nui* sp. nov., ♂, holotype (VNMN). **9**. Lateral view. **10**. Dorsal view. **11**. Ventral view. **12**. Phallus, lateral view.

Description (holotype)

Forewing (Fig. 4) 5.5 mm (N = 1), membrane light brown, veins dark brown. Forks 1–5 present; fork 1 originates shortly before distal corner of Dc; basis of M1+2 and Ms hyaline; arc located slightly distally of base of fork 5. Abdominal segments VII and VIII with long posteroventral lobes (Figs 13, 15). In lateral view (Fig. 13), segment IX anteriorly triangular, posteroventral corner not produced posteriorly; coxopodites with slightly undulating ventral margin, dorsal margin strongly convex; harpagones with weakly convex dorsal margin and weakly concave margins, about $^{3}/_{5}$ as long as coxopodites, each with rounded apex. In dorsal view (Fig. 14), segment IX with wide U-shaped anterior margin; tergum X hidden below triangular tergite VIII. In ventral view (Fig. 15), with sternum IX with small central incision at posterior margin; basal half of coxopodites fused, each with distal half of mesal margin almost straight, bearing scattered setae; harpagones almost straight, without mesal process. Phallus (Fig. 16) with one long, straight sclerite and one distally hook-shaped, slender sclerite, both originating approximately at mid-length of phallus.

Discussion

The diversity of *Wormaldia* in Vietnam covers 19 species, including the three described above (Johanson *et al.* 2023). The majority of Vietnamese species are restricted to lotic environments in the northern provinces, with only one species, *Wormaldia montuosa*, reported from Quang Nam Province in the central part of the country. Notably, 95% of the species, with the exception of *Wormaldia relicta*, were described after 1990, suggesting that the diversity of *Wormaldia* in Vietnam has not been thoroughly investigated before the late 20th century. It is likely that the actual diversity of the species is higher than currently recognized.



Figs 13–16. *Wormaldia caobangensis* sp. nov., ♂, holotype (VNMN). **13**. Lateral view. **14**. Dorsal view. **15**. Ventral view. **16**. Phallus, lateral view.

Acknowledgements

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