

The land snail genus *Opisthoporus* Benson in L. Pfeiffer, 1851 (Gastropoda: Caenogastropoda: Cyclophoridae) from Vietnam, with description of a new species

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Abstract. Species of the genus *Opisthoporus* Benson in L. Pfeiffer, 1851 (family Cyclophoridae) occurring in Vietnam are reviewed and presented. In total, three species are included: *Opisthoporus beddomei* Dautzenberg & Fischer, 1908; *O. lubricus* Dautzenberg & Fischer, 1908; and *O. thuathienhuensis*, new species. *Opisthoporus thuathienhuensis*, new species, differs most distinctly from related congeners by its small inverted U-shaped breathing tube that has its distal end touching the last whorl. The new species is known only from limestone hills of Thua Thien Hue Province, central Vietnam, where terrestrial gastropod fauna is diverse, but relatively poorly known. This discovery represents the first record of the genus *Opisthoporus* in central Vietnam. A checklist of *Opisthoporus* taxa (mainly literature data) is presented.

Key words. systematics, limestone hill, breathing tube, Thua Thien Hue, Vietnam

INTRODUCTION

Land snails of the family Cyclophoridae are a characteristic and widespread component of the terrestrial fauna of the forested tropics of Asia, Africa and Australia, comprising more than 56 genera and subgenera (Nevill, 1878; Kobelt, 1902, 1908; Bartsch, 1932; Low & Tan, 2017). The Cyclophoridae is divided into four subfamilies, including Cyclophorinae Gray, 1847; Spirostomatinae Tielecke, 1940; Alycaeinae Blanford, 1864; and Pterocyclinae Kobelt & von Möllendorff, 1897 (Vaught, 1989). In Vietnam, all subfamilies except Spirostomatinae have been discovered (Kobelt, 1902, 1913; Dautzenberg & Fischer, 1905, 1908; Páll-Gergely et al., 2017). Around 150 species have been thus far reported (Vermeulen & Maassen, 2003; Nguyen, 2016, 2017, 2018; Páll-Gergely et al., 2017; D.S. Do & V.N. Do, 2019; Vermeulen et al., 2019).

Opisthoporus Benson in L. Pfeiffer, 1851, one of the more than 40 genera of Cyclophorinae, has a wide distribution range that covers the Southeast Asia and South China regions (von Möllendorff, 1894; Kobelt, 1902, 1908; Fischer &

Dautzenberg, 1904; Kobelt, 1913). Currently, *Opisthoporus* comprises 33 nominal species and subspecies, of which some 22 were described from Malaysia and Indonesia, and around 11 from other areas such as Thailand, Cambodia, Philippines, Laos, Vietnam, and southern China (Kobelt, 1913; Foon et al., 2017; Low & Tan, 2017; Inkhavilay et al., 2019; Sutcharit et al., 2019). The current species delimitation of *Opisthoporus* is reliant on the works of Kobelt (1902, 1908, 1913) and Egorov (2009), which are mainly based on the breathing tube structures, degree of apertural lip expansion, the calcareous operculum, and other shell characters.

Previously, only two *Opisthoporus* species were known from Vietnam, both described from Quang-Huyen (Dautzenberg & Fischer, 1908). It has been more than a century since they were described. The present paper aims to conduct a study of the *Opisthoporus* species found in Vietnam, including distribution range and sampling materials from different regions of northern and central Vietnam. Here, we describe a new species and report a new record from central Vietnam.

MATERIAL AND METHODS

This study is based on material collected during surveys by the first and second authors in north and central Vietnam in 2015–2019. Description of the new species in this paper is based on shell morphology, colouration, and patterns. Identification of *Opisthoporus beddomei* and *Opisthoporus lubricus* is based on published descriptions and figures (see literature cited herein). Type material was not located in the Institute royal des Sciences naturelles de Belgique (Brussels, Belgium) and the Muséum National d'Histoire Naturelle (Paris, France), where they could have been deposited.

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Terminology used in the description of the shell characters, including features of the peristome, breathing tube structures, body whorl, umbilicus and apertural lip expansion, follow Stoliczka (1872), Vermeulen & Junau (2007), and Egorov (2009). Shell measurements were made for adult specimens (with a developed outer lip) using digital calipers. The counting of shell whorls (to the nearest ¼ whorl) follows Kerney & Cameron (1979: 13).

These specimens were deposited in the following institutions: Vietnam National Museum of Nature (VNMN), Vietnam; Zoological Collection of Biological Museum (ZMHU), Hanoi University of Science, Vietnam; Zoological Reference Collection (ZRC) of the Lee Kong Chian Natural History Museum, National University of Singapore, Singapore; and the Laboratory of Zoology, Hue University of Education (LZ–HUE), Vietnam.

SYSTEMATICS

Superfamily Cyclophoroidea Gray, 1847

Family Cyclophoridae Gray, 1847

Subfamily Cyclophorinae Gray, 1847

***Opisthoporus* Benson in L. Pfeiffer, 1851**

Opisthoporus Benson in L. Pfeiffer, 1851: 8; Benson, 1855: 14; von Martens, 1867: 110; Stoliczka, 1872: 265; Nevill, 1878: 263; von Möllendorff, 1900: 136; Kobelt, 1902: 188, 213; 1913: 834; Gude, 1921: 130; Bartsch, 1932: 323; Egorov, 2009: 16; Low & Tan, 2017: 15.

Tubicyclotus – Habe, 1965: 119.

Siphonocyclus von Möllendorff, 1900: 136; Egorov, 2009: 17.

Type species. *Cyclostoma taylorianum* L. Pfeiffer, 1851.

Diagnosis. Shell discoidal in shape, with spire that varies from rather high conical to nearly flat, and a wide umbilicus, unicoloured or adorned with irregular axial brownish stripes, usually covered by thin hairy periostracum. Terminal part of the last whorl is separated from the penultimate whorl, or completely attached to the penultimate whorl. Body whorl with breathing tube behind apertural margin. Aperture circular, peristome double or single, with an expanded outer lip. Operculum calcareous, circular, multi-lamellar, nucleus central, with external fringe deeply grooved (H. Adams & A. Adams, 1855; Benson, 1855; Egorov, 2009).

Remarks. The *Opisthoporus* is superficially similar to the *Cyclotus* Swainson, 1840, in general shell form, colouration and pattern, and in the structure of the operculum. However, it can be distinguished from *Cyclotus* by the presence of a breathing tube, which is a curved hollow horn-like projection that opens into the last whorl behind the operculum (Kobelt, 1913; Bartsch, 1932; Egorov, 2009; Páll-Gergely et al., 2016). The genera *Opisthoporus*, *Pterocyclos* Benson, 1832, *Rhiostoma* Benson, 1860, and *Pearsonia* Kobelt, 1902, have many similar features (see Sutcharit et al., 2019). However,



Fig. 1. Approximate localities of *Opisthoporus* spp. in Vietnam. (1): *Opisthoporus beddomei*; (2): *Opisthoporus lubricus*; (3): *Opisthoporus thuatienhuensis*, new species. The numbered locality names are detailed in Table 1.

the structure of the breathing tube varies from notch-like to completely tubular in *Pterocyclos* (see Sutcharit et al., 2014), whereas it always forms a complete tube in *Opisthoporus*. *Rhiostoma* differs from *Opisthoporus* by its calcareous cup-shaped operculum, the peculiar detached and extended terminal part of last whorl. The operculum of *Opisthoporus* is calcareous, rather thin, and concave on both sides. *Pearsonia* has the breathing tube situated far away from the peristome and the outer lip forms a peristomal projection near the suture (see Tumpeesuwan & Tumpeesuwan, 2015).

Currently, the genus *Opisthoporus* is considered a genus (e.g., Stoliczka, 1872; von Möllendorff, 1900; Bartsch, 1932; van Benthem Jutting, 1960; Bragado et al., 2000; Low & Tan, 2017) or subgenus of *Cyclotus* (e.g., Nevill, 1878; Kobelt, 1912; Gude, 1921; Egorov, 2009; Inkhavilay et al., 2019; Sutcharit et al., 2019). In this paper, we treat *Opisthoporus* as a full genus. For other details on the systematics and nomenclature of the *Opisthoporus* and related genera, see Egorov (2009). Nevertheless, the reliability of currently accepted conchology-based systematics has not been thoroughly examined along other lines of evidence, and further research based on anatomical and radula characteristics or molecular analyses will no doubt be needed to answer questions regarding the systematic positions and affinities of the above genera.

***Opisthoporus beddomei* Dautzenberg & Fischer, 1908**

(Figs. 1, 2A–D, 3A, D, G; Table 1, 2)

Opisthoporus beddomei Dautzenberg & Fischer, 1908: 200, pl. 7 figs. 1–4 (type locality: Quang-Huyen, Vietnam).

Cyclotus (Opisthoporus) beddomei – Kobelt, 1913: 836, pl. 124 figs. 1–4.

Table 1. Shell size variation in *Opisthoporus* spp. specimen collections.

Species and locality	No. of specimens	Range, mean \pm S.D. (mm) of shell			
		Shell height (SH)	Shell width (SW)	SH/SW ratio	Aperture diameter
<i>Opisthoporus beddomei</i>					
1. Nam Dong, Thua Thien Hue, Vietnam	15	8.1–10.3 8.9 \pm 0.65	15.3–20.0 16.8 \pm 1.02	0.49–0.57 0.52 \pm 0.03	6.1–7.0 6.3 \pm 18
<i>Opisthoporus lubricus</i>					
2. Trang Dinh, Lang Son, Vietnam	9	9.2–16.3 12.6 \pm 0.66	16.1–25.8 20.5 \pm 0.92	0.58–0.63 0.61 \pm 0.02	7.5–8.9 8.4 \pm 0.37
3. Bac Son, Lang Son, Vietnam	27	11.2–14.9 12.9 \pm 0.74	17.8–24.5 21.7 \pm 1.12	0.55–0.62 0.59 \pm 0.03	7.4–8.8 8.2 \pm 0.26
4. Huu Lung, Lang Son, Vietnam	6	11.2–13.8 12.3 \pm 0.66	15.4–18.6 19.1 \pm 0.95	0.57–0.62 0.60 \pm 0.02	7.3–8.6 8.0 \pm 0.23
5. Vo Nhai, Thai Nguyen, Vietnam	5	9.8–11.3 10.4 \pm 0.58	15.7–18.0 17.4 \pm 0.83	0.58–0.62 0.60 \pm 0.02	7.3–8.6 8.1 \pm 0.29
<i>Opisthoporus thuathienhuensis</i> , new species					
6. Nam Dong, Thua Thien Hue, Vietnam	9	8.7–12.3 10.0 \pm 0.91	14.0–19.5 15.7 \pm 1.10	0.60–0.65 0.63 \pm 0.03	5.9–6.8 6.5 \pm 0.22

Table 2. Comparison of shell morphology between *Opisthoporus thuathienhuensis*, new species, and its Vietnamese congeners based on Dautzenberg & Fischer (1908) and this study.

Species	Breathing tube	Shell colour	Zig-zag pattern	Peristome	Number of whorls
<i>O. beddomei</i>	Oblique	Pale yellow	Dorsal side	Double	4–4 $\frac{1}{4}$
<i>O. lubricus</i>	Forward or upright	Yellowish brown	Dorsal side	Double	4 $\frac{1}{2}$ –5
<i>O. thuathienhuensis</i>	Backward	Brown	Absent	Single	3 $\frac{3}{4}$ –4

Material examined. 7 shells (LZ–HUE 1021), 5 shells (ZMHU), 2 figured shells (figs. 2A, B, 3A, D, G), Vietnam, Thua Thien Hue Province, Nam Dong District, Thuong Quang Commune, Limestone hill, 215 m a.s.l., 16°06'51"N, 107°38'27"E, coll. T.C. Bui, 16 September 2017; 3 shells (LZ–HUE 1022), Vietnam, Thua Thien Hue Province, Nam Dong District, Thuong Quang Commune, Limestone hill, 111 m a.s.l., 16°07'08"N, 107°37'20"E, coll. T.C. Bui, 10 July 2018.

Diagnosis. Shell brownish grey with numerous, rather regularly spaced growth lines that form distinct axial lines. Breathing tube curved towards the antepenultimate whorl.

Distribution. *Opisthoporus beddomei* is known from northern and central Vietnam (Cao Bang and Thua Thien Hue Provinces) (Dautzenberg & Fischer, 1908; this study).

Remarks. *Opisthoporus beddomei* is characterised by a medium-sized thin shell, with corneous and translucent periostracum, and a surface that has a brownish grey colour pattern. Like its congeners, the last part of its last whorl is usually slightly detached from the penultimate whorl. This species is most similar to *O. lubricus*, although they differ

slightly in terms of shell colouration. Both species have similar aperture morphology with the double peristome and white lip, although *O. beddomei* has a less prominent expansion on the upper part of its lip. The most distinctive difference between the two is the breathing tube, which is curved towards the antepenultimate whorl in *O. beddomei* and upright or curved forward towards the aperture in *O. lubricus*.

Its type locality Quang-Huyen most probably refers to Quang Uyen District in Cao Bang Province, although this species was not present in samples collected from surveys conducted in north Vietnam. Our discovery of this species from Thua Thien Hue, shell width of up to 20.0 mm, represents a range extension and the first record of *Opisthoporus beddomei* in central Vietnam.

***Opisthoporus lubricus* Dautzenberg & Fischer, 1908**
(Figs. 1, 2E–G, 3B, E, H; Table 1, 2)

Opisthoporus lubricus Dautzenberg & Fischer, 1908: 201, pl. 7 figs. 5–8 (type locality: Quang-Huyen, Vietnam).

Cyclotus (Opisthoporus) lubricus – Kobelt, 1913: 836, pl. 124 figs. 5–8.

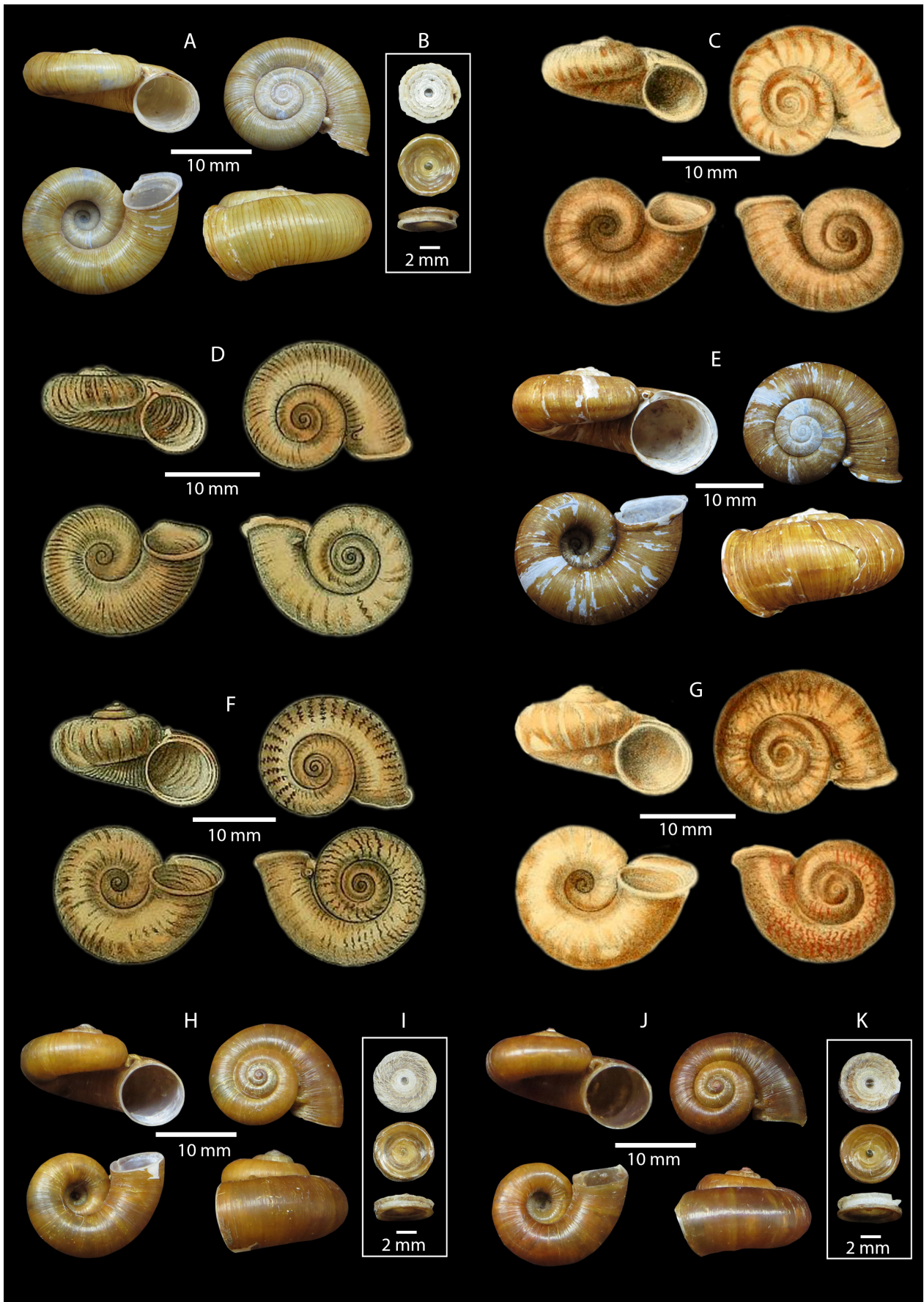


Fig. 2. Shell (apertural view, dorsal view, ventral view, and side view) and operculum (outer surface, inner surface, and side view) of *Opisthoporus* spp. in Vietnam. A–D, *Opisthoporus beddomei* Dautzenberg & Fischer, 1908; A, B, ZMHU/5; C, from Dautzenberg & Fischer, 1908; D, from Kobelt, 1913. E–G, *Opisthoporus lubricus* Dautzenberg & Fischer, 1908; E, ZMHU/4; F, from Kobelt, 1913; G, from Dautzenberg & Fischer, 1908. H–K, *Opisthoporus thuathienhuensis*, new species; H, I, holotype VNMN_IZ 000.000.176; J, K, paratypes ZRC.MOL. 15631. Photographs by D.S. Do and T.S. Nguyen.

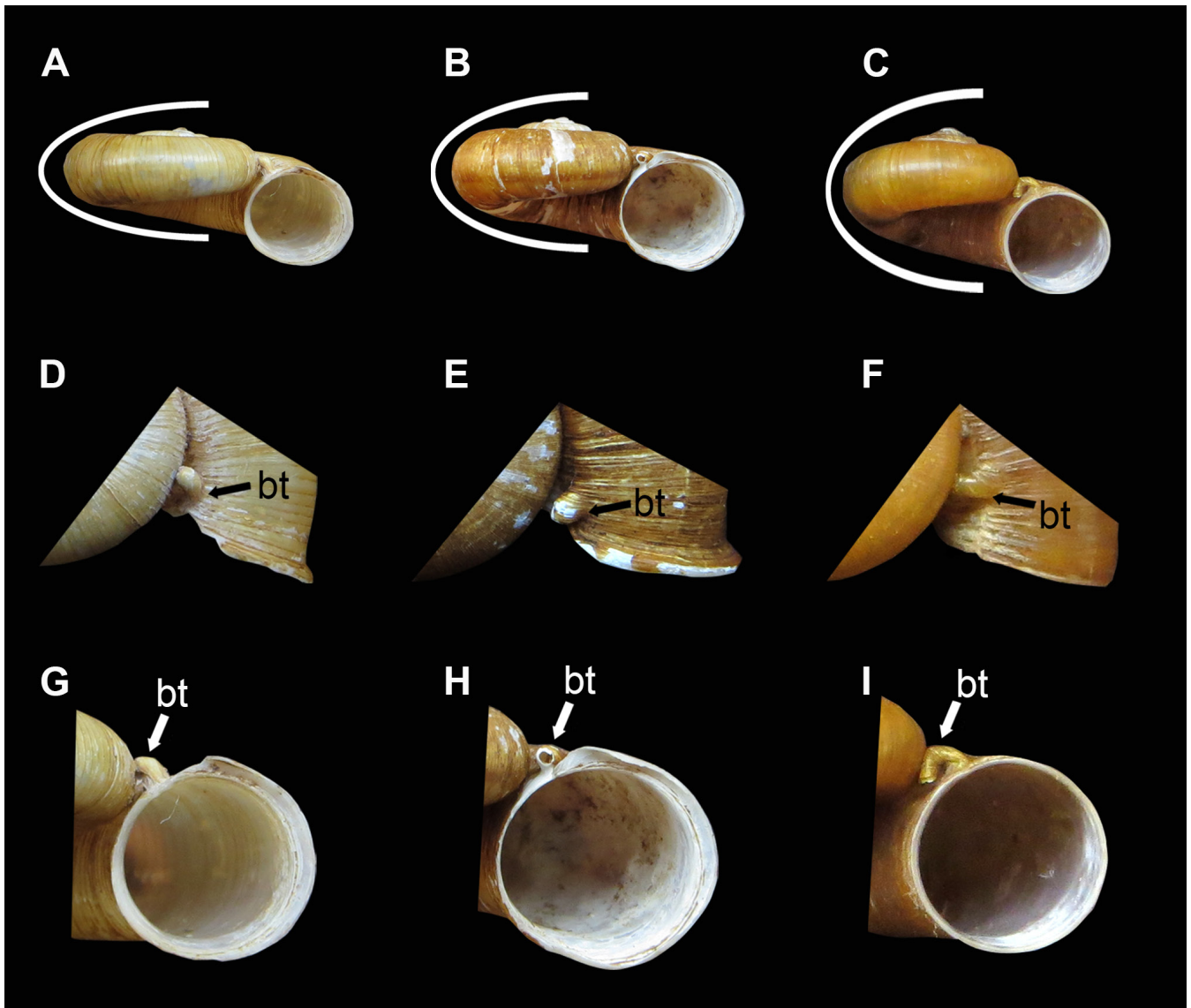


Fig. 3. Comparison of shell profile, breathing tube, and peristome of *Opisthporus* spp. in Vietnam. A, D, G, *Opisthporus beddomei* (ZMHU/5), with oblique breathing tube and double peristome; B, E, H, *Opisthporus lubricus* (ZMHU/4), with forward pointing breathing tube and double peristome; C, F, I, *Opisthporus thuathienhuensis*, new species (holotype VNMN_IZ 000.000.176), with inverted U-shaped breathing tube and single peristome. Photographs by D.S. Do and T.S. Nguyen.

Material examined. 5 shells (ZMHU), 2 figured shells (figs. 2E, 3B, E, H), Vietnam, Lang Son Province, Trang Dinh District, Tri Phuong Commune, Bo Village, Limestone karst forest, 429 m a.s.l., 22°19'28"N, 106°29'15"E, coll. D.S. Do, 10 July 2018; 4 shells (ZMHU), Vietnam, Lang Son Province, Trang Dinh District, Chi Minh Commune, Lung Phay Village, Limestone karst forest, 482 m a.s.l., 22°20'09"N, 106°27'02"E, coll. D.S. Do, 10 July 2018; 27 shells (ZMHU), Vietnam, Lang Son Province, Bac Son District, Nga Hai Village, Limestone mountain with depleted primary forest, 397 m a.s.l., 21°47'41"N, 106°09'13"E, coll. D.S. Do, 9 July 2018; 6 shells (ZMHU), Vietnam, Lang Son Province, Huu Lung District, Quyet Thang Commune, Bong Village, Limestone karst forest, 627 m a.s.l., 21°38'40"N, 106°14'06"E, coll. C.N. Duong, 20 December 2018; 5 shells (ZMHU), Vietnam, Thai Nguyen Province, Vo Nhai District, Than Sa-Phuong Hoang Nature Reserve, Densely vegetated limestone hill, 260 m a.s.l., 21°50'51"N, 105°53'19"E, coll. D.S. Do & T.B. Nguyen, 14 May 2017.

Diagnosis. Shell yellow to yellowish brown with a short and stout breathing tube directed toward aperture.

Distribution. *Opisthporus lubricus* is known from its type locality in northeastern Vietnam (Cao Bang, Lang Son and Thai Nguyen Provinces) (Dautzenberg & Fischer, 1908; this study).

Remarks. *Opisthporus lubricus* has a thick shell, with thin corneous periostracum. The shell colour is usually rather uniform yellow to yellowish brown, with a darker brown spiral band below the periphery. This species differs mainly from *Opisthporus beddomei* by its larger shell with darker colouration, somewhat higher spire, slightly different aperture morphology, and breathing tube structure (see also Remarks for that species).

Table 3. Known species and subspecies of *Opisthoporus* and their respective type localities.

S/N	Species	Type locality
1.	<i>O. beddomei</i> Dautzenberg & Fischer, 1908	Quang-Huyen (Quang Uyen, Cao Bang) Vietnam
2.	<i>O. bernardii</i> (Pfeiffer, 1862)	Siam (Thailand)
3.	<i>O. bialatus</i> von Möllendorff, 1902	Kelantan, Malaysia
4.	<i>O. biciliatus</i> (Mousson, 1849)	Borneo
5.	<i>O. birostris</i> (Pfeiffer, 1854)	Sarawak, Borneo
6.	<i>O. cavernae</i> (Godwin-Austen, 1889)	“Sarawak proper”
7.	<i>O. celebicus</i> (P. Sarasin & S. Sarasin, 1899)	“Dongala an der Palos-Bai”, Celebes
8.	<i>O. corniculus</i> (Mousson, 1849)	“Aus den Kaffeepflanzungen von Pardana”, Java, Indonesia
9.	<i>O. dautzenbergi</i> Sykes, 1902	Kelantan, Malaysia
10.	<i>O. deflexus</i> von Möllendorff, 1897	“in regione Badung”, Hubei, China
11.	<i>O. euryomphalus</i> (Pfeiffer, 1856)	Borneo
12.	<i>O. gwendolena</i> (Godwin-Austen, 1889)	Niah Hills, Sarawak, Malaysia
13.	<i>O. hungerfordi</i> (Godwin-Austen, 1889)	Molu Hills, Borneo, Malaysia
14.	<i>O. iris</i> (Godwin-Austen, 1889)	Borneo
15.	<i>O. lahatensis</i> (de Morgan, 1885)	Gunung Lano, Perak, Peninsular Malaysia
16.	<i>O. latistrigus</i> von Martens, 1865	Borneo, Malaysia
17.	<i>O. lubricus</i> Dautzenberg & Fischer, 1908	Quang-Huyen (Quang Uyen, Cao Bang), Vietnam
18.	<i>O. penangensis</i> (Stoliczka, 1872)	Penang, Malaysia
19.	<i>O. pertusus</i> (Morelet, 1861)	Borneo, Malaysia
20.	<i>O. pterocycloides</i> (Pfeiffer, 1855)	Borneo, Malaysia
21.	<i>O. quadrasi busuangensis</i> Bartsch, 1932	Busuanga, Philippines
22.	<i>O. quadrasi palawanensis</i> Bartsch, 1932	Iwahig, Palawan, Philippines
23.	<i>O. quadrasi quadrasi</i> Hidalgo, 1888	Ile de Balabae, Philippines
24.	<i>O. quadrasi turturinganus</i> Bartsch, 1932	Turturingan, Palawan, Philippines
25.	<i>O. rhiostrima</i> Gredler, 1902	Borneo, Malaysia
26.	<i>O. serena</i> Vermeulen & Junau, 2007	Sarawak, Malaysia
27.	<i>O. setosus</i> von Möllendorff, 1894	Samui, Thailand
28.	<i>O. siamensis</i> von Martens, 1860	Siam (Thailand)
29.	<i>O. singaporeanus</i> Low & Tan, 2017	Singapore
30.	<i>O. solutus</i> (Stoliczka, 1872)	Penang, Malaysia
31.	<i>O. spiniferus</i> (Morelet, 1861)	Borneo, Malaysia
32.	<i>O. sumatranus</i> von Martens, 1864	Sumatra, Indonesia
33.	<i>O. thuathienhuensis</i> , new species	Thua Thien Hue, Vietnam
34.	<i>O. tubuliferus</i> (Pfeiffer, 1854)	Unknown

***Opisthoporus thuathienhuensis* D. S. Do, T. C. Bui & V. N. Do, new species**

(Figs. 1, 2H–K, 3C, F, I; Table 1, 2)

Material examined. Holotype (1 shell, shell height 10.1 mm, shell width 16.0 mm; Figs. 2H, I, 3C, F, I) (VNMN_IZ 000.000.176), Vietnam, Thua Thien Hue Province, Nam Dong District, Thuong Quang Commune, Limestone mountain, 217 m a.s.l., 16°06'56"N, 107°38'32"E, coll. T.C. Bui, 16 September 2017; Paratypes: 6 paratypes (ZMHU.MOL 001), 2 paratypes (ZRC.MOL. 15631), same data as holotype.

Etymology. The specific epithet “thuathienhuensis” is derived from its type locality Thua Thien Hue Province in central Vietnam, with the Latin suffix “-ensis” added to form an adjective.

Diagnosis. Shell devoid of patterns on both dorsal and ventral sides of shell. Small breathing tube in the form of

an inverted U-shape, distal end touching the last whorl. Peristome single, slightly thickened, not expanded.

Description. Shell slightly thick, medium sized (shell height 8.7–12.3 mm, shell width 14.0–19.5 mm), sub-discoidal with wide umbilicus. Spire low, obtuse. Whorls 3³/₄–4, well-rounded. The last whorl is partially detached from the penultimate whorl. Sutures deeply impressed. Umbilicus wide, about 1/3 of shell diameter. Periostracum brown, translucent, shiny, without spiral sculpture. Protoconch smooth and glossy, two whorls. Teleoconch sculptured with irregularly spaced, inconspicuous growth lines, spiral sculpture virtually absent. Breathing tube present near the suture, situated a little distance (ca. 1.4–2.2 mm) from the peristome. Breathing tube curved, forming a reversed U-shape, the distal end pointing back towards the last whorl. Aperture circular, with pale yellow, slightly thickened, and non-expanded peristome.

Operculum solid, round, bi-layered, the outer calcified layer thicker than the inner corneous layer. Outer surface slightly concave, covered with fine growth lines, nucleus usually deeply sunken. Inner surface smooth, glossy, and concave.

Distribution. The new species is thus far known only from the limestone mountain in Thuong Quang Commune, Nam Dong District, Thua Thien Hue Province, central Vietnam.

Remarks. The new species differs distinctly from *O. beddomei* and *O. lubricus* by its single peristome without an expanded lip and small breathing tube, which forms an inverted U-shape with distal end touching the last whorl.

DISCUSSION

The discovery of *Opisthoporus* from central Vietnam shows an expanded distribution range for the genus, especially to the mainland of Southeast Asia. In Vietnam, the distribution of the known *Opisthoporus* is discontinuous. Present knowledge remains patchy. Three species are now known from northern and central Vietnam (this study), but no *Opisthoporus* are known from large areas of Vietnam including the northwest, northeastern coast, highlands and southern areas. Recent surveys have concentrated on the rich terrestrial operculate snail fauna of limestone karst forests, small isolated limestone hills and rocks, natural forest, and coastal island, where many new species have been found and doubtless many remain to be discovered (Nguyen, 2016, 2017, 2018; Páll-Gergely et al., 2017; Vermeulen et al., 2019). Against this background, we suggest that additional *Opisthoporus* species may be found in the abovementioned areas of Vietnam upon further surveys.

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