

# The subfamily Phaedusinae in Bhutan (Gastropoda, Pulmonata, Clausiliidae)

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Two genera of Clausiliidae, Phaedusinae, are reported from Bhutan. *Cylindrophaedusa* is represented with two species, viz. *Cylindrophaedusa (Montiphaedusa) parvula* Gittenberger & Leda, spec. nov. and *C. (M.) tenzini* Gittenberger & Sherub, spec. nov. *Phaedusa* is represented with at least four species, viz. *P. (P.) adrianae* Gittenberger & Leda, spec. nov., *P. (P.) bhutanensis* Nordsieck, 1974, *P. (P.) chimiae* Gittenberger & Sherub, spec. nov., and *P. (P.) sangayae* Gittenberger & Leda, spec. nov.

Key words: Gastropoda, Clausiliidae, Phaedusinae, taxonomy, new species, Bhutan.

## INTRODUCTION

With the publications of Nordsieck (1973, 1974, 2002, 2007) to start with, the identification of the clausiliid species of Bhutan is less difficult than that of most other molluscan taxa from that country.

Until now *Phaedusa bhutanensis* Nordsieck, 1974, has been the only clausiliid species that was described with certainty from the territory of modern Bhutan. Referring to Gude (1914), Nordsieck (1973: 71; 1974: 43; 2002: 94) indicated that *Cylindrophaedusa (Montiphaedusa) ioes ioes* (Benson, 1852) also occurs in that country. However, Gude

(1914: 309) mentioned for the record only “Bhutan (Blanford)”, without further details. According to Blanford & Godwin-Austen (1908: xxxi) nothing had been collected in “Bhutan east of longitude 89°”. West of that longitude there have been some changes in the political boundaries after the Anglo-Bhutan war of 1864. Localities that were once inside Bhutan, may no longer be Bhutanese territory now. Despite the suggestive epithet, species like *Alycaeus bhutanensis* Godwin-Austen, 1914, *Dalingia bhutanensis* Godwin-Austen, 1907, and *Kaliella bhutanensis* Godwin-Austen, 1907, all of which described from the frontier areas of Bhutan, might no longer belong to the modern Bhutanese molluscan fauna.

## MATERIAL AND METHODS

Within the scope of the Bhutan Evertebrata Inventory Project that was started 2012 by (1) the National Biodiversity Centre in Serbithang, Thimphu, Bhutan, (2) the Ugyen Wangchuck Institute for Conservation and Environmental Research in Bumthang, Bhutan, (3) Naturalis Biodiversity Center, in Leiden, The Netherlands, and (4) associated institutes, molluscs were collected at many places in Bhutan (Gittenberger et al., 2017). This resulted in a quickly growing reference collection in the National Biodiversity Centre in Serbithang, Thimphu, Bhutan.

Abbreviations: B = breadth; H = height; NBCB = National Biodiversity Centre, Serbithang, Thimphu, Bhutan; NMB = Naturhistorisches Museum, Basel, Switzerland; RMNH = Naturalis Biodiversity Center, Leiden, The Netherlands; SMF = Forschungsinstitut Senckenberg, Germany.

**KEY TO THE PHAEDUSINAE SPECIES FROM BHUTAN**

- 1a Inside the aperture, the final part of the columellaris is visible in oblique view as a straight lamella, which may be covered by a pseudocolumellaris in frontal view: *Cylindrophaedusa (Montiphaedusa)* ..... 2.
- 1b Inside the aperture, the columellaris is visible as a conspicuous, spirally ascending lamella: *Phaedusa (P.)* ..... 4.
- 2a With a lunella: *C. (M.) ioes* (Benson, 1852).  
Not known with certainty from modern Bhutan.
- 2b With parallel plicae palatales ..... 3.
- 3a. Shell height c. 12 mm: *C. (M.) parvula*.
- 3b Shell height c. 15 mm: *C. (M.) tenzini*.
- 4a Shell with a dense sculpture of rib-striae ..... 5.
- 4b Shell with riblets that are about as far as their own width apart ..... 6.
- 5a Apertural border protruding, shell breadth 2.9-3.3 mm: *P. (P.) chimiae*.
- 5b Apertural border not protruding: shell breadth 3.4-3.6 mm: *P. (P.) adrianae*.
- 6a Shell breadth 3.6-4.3 mm: *P. (P.) bhutanensis*.
- 6b Shell breadth 3.1-3.6 mm: *P. (P.) sangayae*.

**SYSTEMATIC PART**

**Family Clausiliidae Gray, 1855**

**Subfamily Phaedusinae A.J. Wagner, 1922**

**Genus *Cylindrophaedusa* O. Boettger, 1877**

Type species (by monotypy): *Clausilia cylindrica* L. Pfeiffer, 1846

**Subgenus *Montiphaedusa* H. Nordsieck, 2002**

Type species (by original designation): *Clausilia ioes* Benson, 1852

***Cylindrophaedusa (Montiphaedusa) parvula***

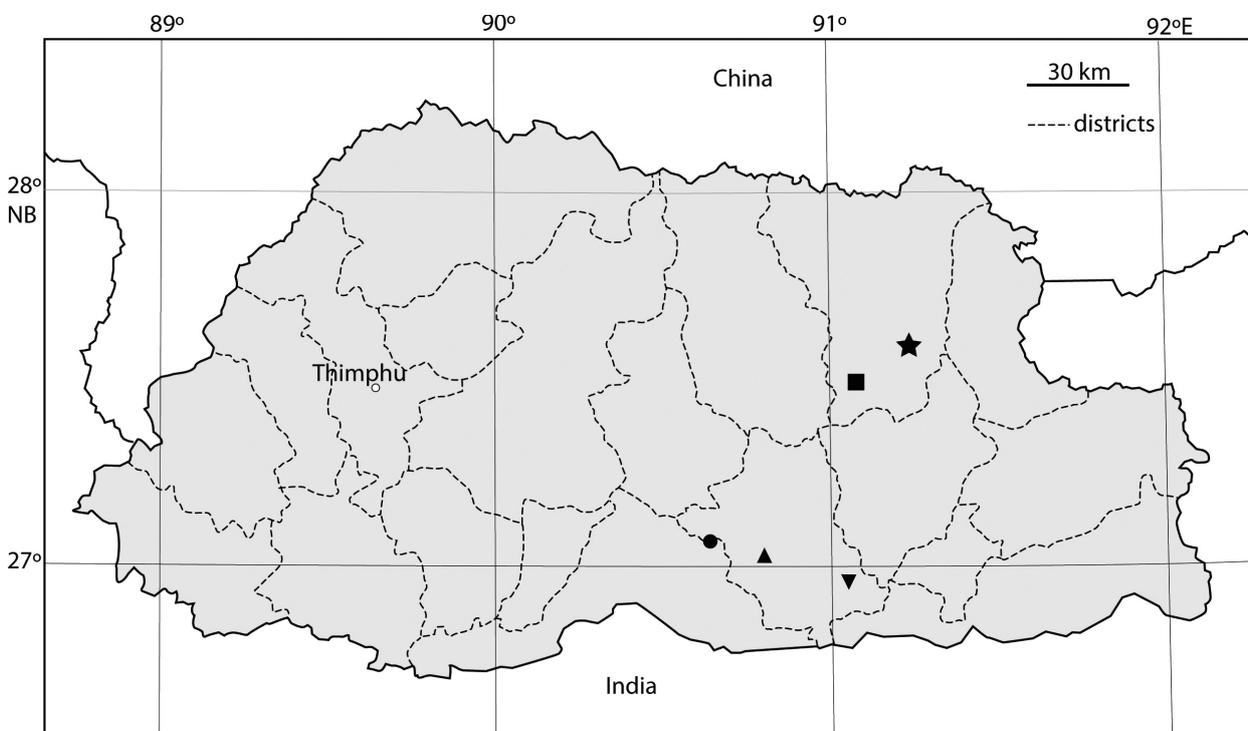
**E. Gittenberger & Leda, spec. nov.**

(Figs 1, 2, 4)

*Phaedusa* spec. 3 — Gittenberger et al., 2017: 63, fig. 48.

Type series. — Holotype (NBCB 1028): Bhutan, district Sarpang, 17 km s of Zhemgang, 1850 m a.s.l., 27°04'N 90°38'E; E. Gittenberger & Pema Leda leg. 25.iii.2016.

Diagnosis. — Shell little more than 1 cm high; visible part of the columellaris ascending straight; with 3 palatal plicae, no lunella; parietalis and spiralis connected; apertural border not protruding.



**Fig. 1.** Records of Phaedusinae species in the eastern part of Bhutan. ● = *Cylindrophaedusa (Montiphaedusa) parvula* Gittenberger & Leda, spec. nov.; ▲ = *Phaedusa (P.) chimiae* Gittenberger & Sherub, spec. nov.; ▼ = *Phaedusa (P.) chimiae* subspec.; ■ = *Cylindrophaedusa (Montiphaedusa) tenzini* Gittenberger & Sherub, spec. nov.; ★ = *Phaedusa (P.) adrianae* Gittenberger & Leda, spec. nov.



**Figs 2-3.** *Cylindrophaedusa* (*Montiphaedusa*) species. 2. *C. (M.) parvula* Gittenberger & Leda, spec. nov., holotype (NBCB 1028); district Sarpang, 17 km s of Zhemgang; H = 11.6 mm. 3. *C. (M.) tenzini* Gittenberger & Sherub, spec. nov., holotype (NBCB 1029); district Lhuentse, Garbrag (Phag Sang), 11 km w of Gorgon; H = 15.3 mm.

**Description.** — The shell is white (maybe secondarily bleached) and very slender; it has  $10\frac{1}{8}$  whorls, the final three of which are equally broad. The protoconch is rounded conical. The entire teleoconch is densely ribbed, with 10 ribs per mm above the aperture. The aperture is broadly rounded basally, with parallel columellar and palatal sides; the apertural border is continuous but not protruding, and strongly thickened and reflected. The cervix is regularly rounded.

The parietalis is very prominent and after a lower part connected with the prominent spiralis. The columellaris is hardly visible in frontal view; it ascends inside as a straight lamella. The subcolumellaris is short and not even discernible in oblique view. The clausilium is missing in the damaged holotype. The principalis ends inside above the aperture and close to the apertural border at its other end. The lunellar is situated laterally, with three parallel plicae palatales of which the upper one has about twice the length of the others.

Measurements: H 11.6 mm, B 2.5 mm.

**Habitat.** — The shell was found amidst a dense vegetation.

**Differentiation.** — In size, shape and sculpture this species recalls *C. (M.) ioes ioes* (Benson, 1852) as described and figured by Nordsieck (1973: pl. 3 fig. 6; 2007: pl. 3 fig. 1). It differs most clearly from that species by the presence of three palatal plicae instead of a lunella (Nordsieck, 1973: fig. 7) and the apertural border, which does not protrude. Shells of

the other species that are classified in *Montiphaedusa* differ by the presence of a lunella and/or by larger dimensions.

**Notes.** — Despite intensive searching, only a single, damaged specimen was found.

**Derivatio nominis.** — The epithet *parvula* refers to the small size of the shell.



**Figs 4-5.** Body whorls of *Cylindrophaedusa* (*Montiphaedusa*) species. 4. *C. (M.) parvula* with prominent parietalis and ascending, low, straight columellaris in oblique view (NBCB 1028). 5. *C. (M.) tenzini* with (5a) ascending, low, straight columellaris, hidden behind a small 'pseudocolumellaris' in frontal view and (5b) dorsolateral lunellar with the principalis and 5 palatal plicae, gradually shortening abapically (NBCB 1029).

*Cylindrophaedusa (Montiphaedusa) tenzini*

E. Gittenberger &amp; Sherub, spec. nov.

(Figs 1, 3, 5)

Type series. — Holotype (NBCB 1029) & paratype (NBCB 1030): Bhutan, district Lhuentse, Garbrag (Phag Sang), 11 km W of Gorgon, 1800 m a.s.l., 27°30'N 91°04'E; Ugyen Tenzin, Dawa Yoezer & Sherub Sherub leg. 22.ii.2017.

Diagnosis. — Shell c. 15 mm high; columellaris ascending as a straight lamella; with a row of 5-7 palatal plicae, no lunella; parietalis and spiralis not connected.

Description. — The shell is light yellowish brown; it has 10¾ whorls. The protoconch is about cylindrical. The teleoconch has c. 8 blunt ribs per mm above the aperture; the ribs are broader than the interspaces, which do not increase in breadth on the final quarter of the body whorl. The aperture is pear-shaped, with a broadly rounded basal half; the apertural border is continuous, strongly thickened and reflected and protruding 0.3 mm. The parietalis is prominent but short, ending far away from the spiralis. The columellaris is concealed by an elevated part of the columellar wall of the aperture, and not visible in strict frontal view; it ascends as a straight lamella. The subcolumellaris is short and even in oblique view not visible. The clausilium is missing in the two shells that are available.

The lunellar is lateral; the principalis is very long, reaching into the penultimate whorl. There are 7 palatal plicae, viz., starting adapically, a very narrow and short plica, a prominent plica, 4 plicae that slightly decrease in length, the uppermost of which is half as long as the most prominent plica, and a hardly discernible lowest plica. The inside of the shell could not be investigated.

Measurements: the only undamaged shell (holotype) measures H 15.3 mm, B 3.3 mm; a specimen in poor condition, without apical part, measures H c. 15.3, B c. 3.3 mm.

Differentiation. — In *C. (M.) annandalei* (Preston, 1915) from the Abor Hills in NE India, c. 350 km ENE of Bhutan, there is a series of palatal plicae as in *C. (M.) tenzini* (see Nordsieck, 1973: 65 fig. 9, pl. 3 figs 7-9), but the shells are larger, i.e. nearly 2 cm high, and the parietalis is connected to the spiralis. In *C. (M.) martensiana* (Nordsieck, 1973) and *C. (M.) kathmandica* (Nordsieck, 1973) from Nepal, and *C. (M.) bacillum* (Hanley & Theobald, 1870) from the Khasi Hills in NE India, there are no parallel palatal plicae but there is a lunella instead (Nordsieck, 1973: 65 figs 3, 4, 11). For additional data about the *Cylindrophaedusa (Montiphaedusa)* species of the eastern Himalaya we refer to Nordsieck (1973).

Habitat. — Unknown.

Derivatio nominis. — The epithet *tenzini* refers to Ugyen Tenzin, who collected many interesting gastropod shells in Bhutan.

Genus *Phaedusa* H. & A. Adams, 1855Subgenus *Phaedusa* H. & A. Adams, 1855

Type species (by subsequent designation of E. von Martens, 1860: 275): *Clausilia corticina* L. Pfeiffer, 1842

*Phaedusa (Phaedusa) adrianae* E. Gittenberger & Leda, spec. nov.

(Figs 1, 6, 7, 9)

*Phaedusa* spec. 2 — Gittenberger et al., 2017: 62, fig. 47.

Type series. — Holotype (NBCB 1031), paratypes (NBCB 1032/4): Bhutan, district Lhuentse, 33 km N of Mongar; 1310 m a.s.l.; 27°35'N 91°13'E; E. Gittenberger & Pema Leda leg. 17.iv.2015.

Diagnosis. — Shell densely sculptured with radial ribstriae; aperture not protruding; columellaris spirally ascending; with a curved upper plica below the principalis.

Description. — The shell is yellowish brown; it has 10¾ whorls. The protoconch is cylindrical; the teleoconch is slender spindle-shaped apart from the tapering upper whorls. There are c. 13 riblets per mm above the aperture and 9 riblets per mm on the final quarter of the body whorl. The aperture is broadly rounded basally and gradually narrows towards the parietal sinus; the apertural lip is whitish, broadly reflected and thickened, but not protruding. The cervix is regularly rounded.

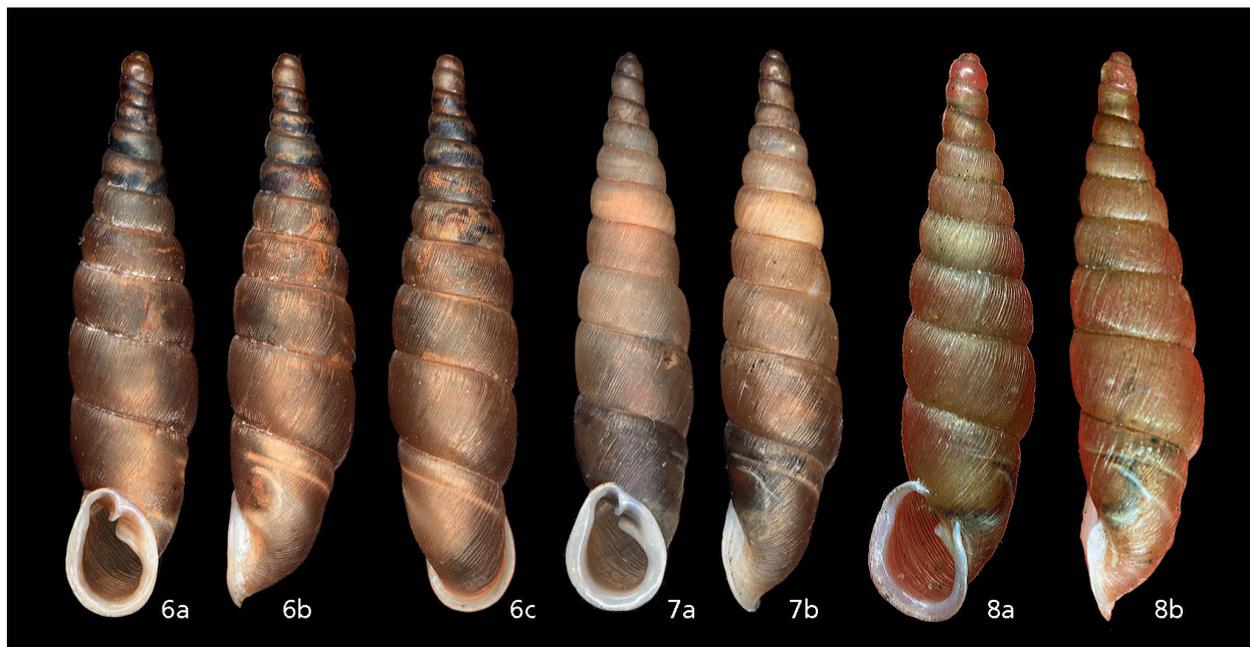
The parietalis and the spiralis are not in line, but far apart or vaguely connected by a long, low ridge that looks like an additional faint lamella in the specimen that was opened (Fig. 9b). The columellaris is prominent in frontal view, and spirally ascending adapically about as far as the spiralis and the subcolumellaris (n = 1). The subcolumellaris is visible in oblique view. The clausilial blade is not visible from the outside; it is broad and irregularly curved, with an obtuse tip. The border of the clausilial blade may be partly seen through the shell wall, misleadingly suggesting the presence of a palatal plica or a lunella. The lunellar is situated little deeper than lateral. The principalis runs from close to frontal to little less than ¼ whorl from the apertural border; at the lunellar it is accompanied by a curved (n = 4) or straight (n = 1) upper palatal plica of ½-¾ its length and a much shorter lower plica.

Measurements (n = 5): H 15.2-15.6 mm, B 3.4-3.6 mm.

Habitat. — The specimens were found on a rocky wall amidst mosses and other plants.

Differentiation. — *Phaedusa (P.) adrianae* differs from *P. (P.) chimiae* most clearly by its more pyriform aperture, which does not protrude and by being less slender in general shape.

Notes. — At the type locality of *P. (P.) adrianae* two shells were found that are similar to that species in sculpture and the structure of the clausilial plicae while differing in other characters (Fig. 8). They are smaller, i.e. H 12.8 mm and H



**Figs 6-8.** *Phaedusa* (*P.*) species; district Lhuentse, 33 km N of Mongar. 6-7. *P. (P.) adrianae* Gittenberger & Leda, spec. nov. 6. Holotype (NBCB 1031); H = 15.5 mm. 7. Paratype (NBCB 1032); H = 15.7 mm. 8. Malformed shell of *P. (P.) adrianae* (?); H = 12.8 mm.

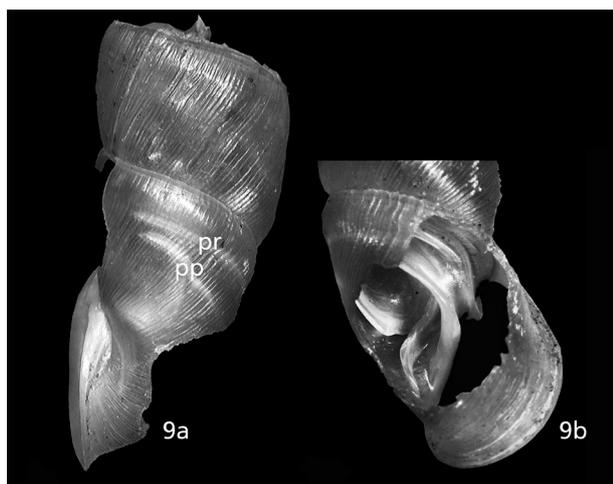
13.1 mm, the parietal part of the apertural lip is missing, the parietalis is obsolete, and the apertural lip is flattened. These specimens are considered malformations.

Derivatio nominis. — The epithet *adrianae* refers to Ms Prof. Dr Adriana C. Gittenberger-de Groot, companion of the first author not only during the fieldwork in Bhutan.

***Phaedusa (Phaedusa) bhutanensis* H. Nordsieck, 1974**  
(Figs 10-15, 27-29)

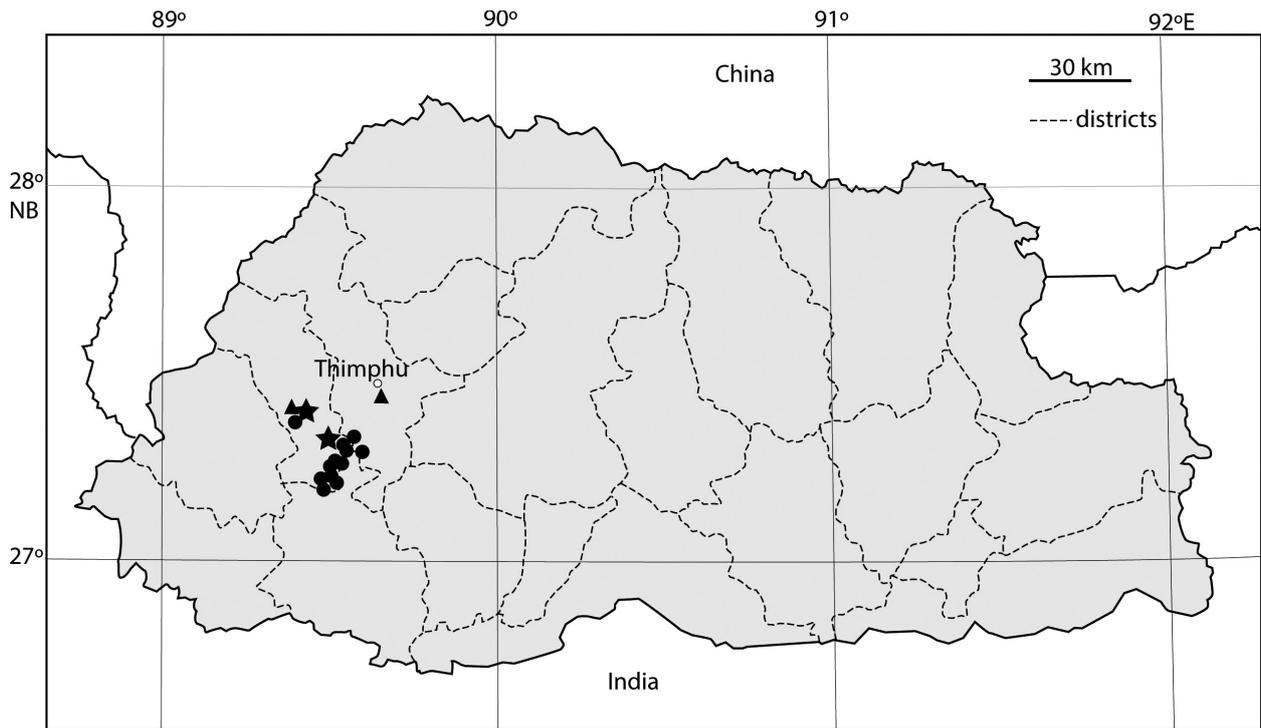
*Phaedusa bhutanensis* H. Nordsieck, 1974: 42 partly ('Bhutan: Paro [2300 m]'), fig. 1, pl. 2 fig. 5 (not figs 2-3).

*Phaedusa bhutanensis* — Gittenberger et al., 2017: 60, fig. 45.



**Fig. 9.** *Phaedusa (P.) adrianae* Gittenberger & Leda, spec. nov., paratype (NBCB 1032). District Lhuentse, 33 km N of Mongar. Details of the body whorl, with (a) principalis (pr) and characteristic, curved upper palatal plica (pp), and (b) inside of the body whorl with clausilial blade (partly), with subcolumellaris, columellaris and separate spiralis and parietalis with an inconspicuous obliquely running lamella in between.

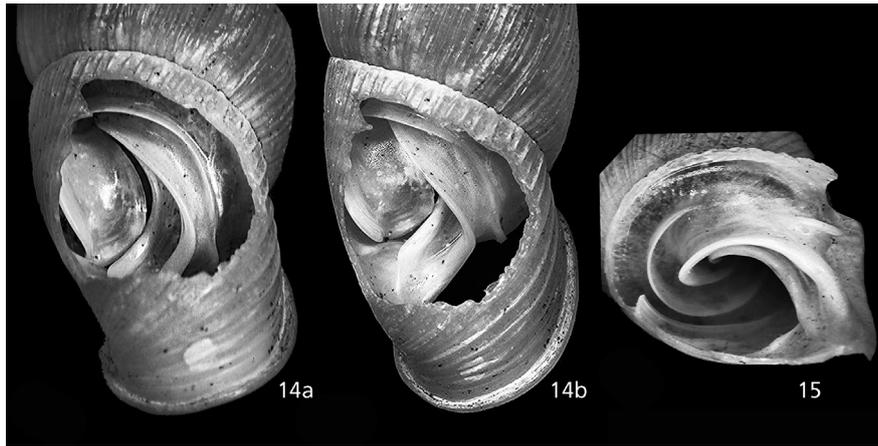
**Material.** — Bhutan. District Thimphu: w of Goneykha (2.5 km E of Chhuzom), 2825 m a.s.l., 27°18'43"N 89°36'10"E, E. Gittenberger leg. 16.vi.2012 (NBCB 1053/1); 16 km ssw of Thimphu, 3 km N of bridge; 2100 m a.s.l.; 27°20'N 89°34'E; E. Gittenberger & Pema Leda leg. 6.iv.2013 (NBCB 1052/2). **District Paro:** 14 km SE of Paro, N-side river, near monastery Tachugang Lhakhang, 2150 m a.s.l., among rocks, near small rockface, 27°20'N 89°30'E, E. Gittenberger & Pema Leda leg. 6.iv.2013 (NBCB 1043/18); s-slope E of limestone quarry NW of Dobji Dzong, 2300 m a.s.l., 27°17'N 89°31'E, E. Gittenberger & Pema Leda leg. 7.iv.2013 (NBCB 1044/64); rocky s-slope 9 km ssw of Chhuzom, 2450 m a.s.l., 27°14'N 89°30'E, E. Gittenberger & Pema Leda leg. 7.iv.2013 (NBCB 1055/2); rocky s-slope 12 km ssw of Chhuzom, 2650 m a.s.l., 27°13'N 89°29'E, E. Gittenberger & Pema Leda leg. 7.iv.2013 (NBCB 1054/3); 10 km sw Chhuzom, 2500 m a.s.l., 27°14'N 89°30'E, E. Gittenberger & Pema Leda leg. 7.iv.2013 (NBCB 1048/3); small gully with high rockface at N-side, 2150 m a.s.l., 27°18'N 89°33'E, E. Gittenberger & Pema Leda leg. 7.iv.2013 (NBCB 1051/25); 8 km sw Paro near Dzongdrakha, 2530 m a.s.l., 27°23'N 89°24'E, E. Gittenberger & Pema Leda leg., 11.iv.2013 (NBCB 1049/1); – of Paro (= Rinpung) Dzong, E-side river, 2250 m a.s.l., 27°25'N



**Fig. 10.** Records of Phaedusinae species in the western part of Bhutan. ● = *Phaedusa (P.) bhutanensis* Nordsieck, 1974; ▲ = *Phaedusa (P.) sangayae* Gittenberger & Leda, spec. nov.; ★ = both species in sympatry.



**Figs 11-13.** *Phaedusa (P.) bhutanensis* Nordsieck, 1974; district Paro. **11.** 14 km SE of Paro, N-side river, near monastery Tachugang Lhakhang (NBCB 1043); H = 19.3 mm. **12.** s-slope E of limestone quarry NW of Dobji Dzong (NBCB 1044); H = 19.8 mm. **13.** 26 km SW of Paro (NBCB 1047); H = 17.3 mm.



**Figs 14-15.** Body whorls of *Phaedusa* (*P.*) *bhutanensis* Nordsieck, 1974. **14.** 14 km SE of Paro, N-side river, near monastery Tachugang Lhakhang (NBCB 1043); **15.** s-slope E of limestone quarry NW of Dobji Dzong (NBCB 1044).

89°25'E, E. Gittenberger & Pema Leda leg. 11.iv.2013 (NBCB 1056/2); 26 km SW of Paro, 2485 m a.s.l., 27°12'N 89°29'E, E. Gittenberger & Pema Leda leg. 31.iii.2016 (NBCB 1047/25); 20 km SSE of Paro, 2325 m a.s.l., 27°16'N 89°31'E, E. Gittenberger & Pema Leda leg. 31.iii.2016 (NBCB 1050/2); 21 km SE of Paro; 2160 m a.s.l., 27°18'N 89°32'E, E. Gittenberger & Pema Leda leg. 31.iii.2016 (NBCB 1045/25); 6.5 km S of Chhuzom, 2043 m a.s.l., dry w-exposed slope, 27°15'24"N 89°31'42"E, E. Gittenberger, Choki Gyeltshen & Pema Leda leg. 20.x.2018 (NBCB 1046/2).

**Diagnosis.** — Shell brown, relatively large, with 11 or more whorls, over 3.6 mm broad.

**Description.** — The shell is dark brown to yellowish brown; it has 10 $\frac{3}{4}$ -14 whorls. The protoconch is cylindrical or subcylindrical; the teleoconch varies between slender spindle-shaped and gradually tapering over nearly its entire length. Above the aperture there are 5-9 sharp to rather obtuse riblets per mm; the riblets are more widely spaced, i.e. 3-5 per mm, on the final quarter of the last whorl. The aperture is obliquely piriform, broadly rounded basally and gradually narrowing towards the parietal sinus; the apertural lip is whitish, broadly reflected and thickened, and protruding for c. 0.3 mm. The cervix is regularly rounded.

The parietalis and the spiralis are not in line; these lamellae are more or less vaguely connected by a long low ridge (Fig. 14a,b) or are entirely separate (Fig. 15). The columellaris is more or less prominent in frontal view; it is spirally ascending adapically about as far as the spiralis and equally far or little further than the subcolumellaris ( $n = 2$ ). The subcolumellaris is discernible or hardly so in oblique view. The clausilial blade is partly visible from the outside; it is broad and irregularly curved, with an obtuse tip. The lunellar is situated dorsolateral to lateral. The principalis runs from lateral to little less than  $\frac{1}{4}$  whorl from the apertural border; it is accompanied by an upper palatal plica of  $\frac{1}{4}$ - $\frac{1}{3}$  its length, a lower palatal plica, which is usually shorter, occasionally a short, more or less prominent to obsolete upper middle plica, and very rarely more middle plicae. The

holotype is exceptional by having three short palatal plicae in between the upper and the lower palatal plica.

Measurements ( $n = 164$ ): H 15.4-21.9 mm, B 3.6-4.3 mm.

**Genital tract** ( $n = 3$ ). — The description is based on specimens from two localities. In the two specimens from 26 km SW of Paro both the penis proximalis and the epiphallus are cylindrical and two or three times broader than the penis distalis. In the specimen from 12 km SSW of Chhuzom the penis distalis is narrowed in the middle to less than half its maximal breadth. The penis distalis and the epiphallus are about equally long, measuring half the length of the penis proximalis or less. The penial retractor muscle inserts in the middle of the epiphallus.

The epiphallus could not be subdivided into two parts (the structure of the lumen was not studied). The part of the vas deferens between the epiphallus and the genital atrium is about as short as the vagina, measuring  $\frac{1}{4}$ - $\frac{1}{3}$  of the oviductus. The extremely fragile uterus of the snails was broken during dissection in all specimens; it contained 3 or 4 embryonic snails, showing that the species is ovoviparous. The bursa copulatrix is large, with a diverticulum that is c.  $\frac{4}{5}$  as long as the entire pedunculus; the pedunculus proximalis is two to nearly three times longer than the pedunculus distalis, which is much longer than the diameter of the bursa. The bursa is characteristically turned off from the pedunculus.

In the specimen of *P. (P.) sangayae* that was described by Nordsieck (1974: 43) the bursa of the bursa copulatrix is much larger than in the 3 specimens of *P. (P.) bhutanensis* that we could study. The penis proximalis and the oviductus are relatively shorter, and the diverticulum of the bursa copulatrix is longer. It remains unclear to what extent these differences are species specific.

**Habitat.** — *Phaedusa (P.) bhutanensis* is found in rocky, open habitats, sometimes together with *P. (P.) sangayae*.

**Notes.** — *Phaedusa (P.) bhutanensis* was described after three shells (Nordsieck, 1974: 42). According to the measurements, i.e. H 18.1 mm, B 3.9 mm, the holotype of *P. (P.)*



*bhutanensis* is specifically distinct from the two paratypes for that species, measuring H 15.8 mm, B 3.5 mm and H 14.9 mm, B 3.4 mm. These paratypes are classified here with *P. (P.) sangayae* spec. nov. (see also the notes for that species). As a consequence, the genital tract of paratype 1 of *P. (P.) bhutanensis* (see Nordsieck, 1974: 44, fig. 3) belongs to *P. (P.) sangayae*.

***Phaedusa (Phaedusa) chimiae* E. Gittenberger & Sherub, spec. nov.**

(Figs 1, 16-17)

Type series. — Holotype (NBCB 1034) & paratypes (NBCB 1035/41): Bhutan, district Zhemgang, between Duenmang Tshachu and Gomphu Zero Point, 24 km SE of Zhemgang, 335 m a.s.l., 27°02'N 90°48'E; Sherub & Ugyen Tenzin leg. 08.i.2017.

Diagnosis. — Teleoconch with dense rib-striae, body whorl with sutural papillae, clausilial blade not visible from outside.

Description. — The shell is greyish brown; it has 10-11¼ whorls. The protoconch is cylindrical. The teleoconch has c. 18 very thin riblets per mm above the aperture, where the sculpture may be blurred. On the final quarter of the body whorl there is a slight indentation corresponding with the presence of the principalis inside the shell; several rib-striae end at this indentation and do not reach the suture. The body whorl has small, sutural papillae. The aperture is slightly compressed laterally, with roughly parallel sides and a broadly rounded basal half. The apertural border is continuous and protruding 0.2-0.3 mm; it is strongly thickened and very broadly reflected.

The columellaris is prominent in frontal view, and spirally ascending adapically as far as the spiralis and little further than the subcolumellaris (n = 4). The subcolumellaris

is clearly visible in oblique view. The clausilial blade is not visible from the outside; it is broad and irregularly curved, with a lateral widening and an obtuse tip. The parietalis is prominent but short, ending far away from the spiralis, or more rarely more or less clearly connected with it by a long low ridge. The lunellar is situated laterally. The principalis runs from nearly frontal or more lateral to little less than ¼ whorl from the apertural border; it is accompanied by a straight or twisted upper palatal plica which measures c. ½ of the length of the spiralis, a shorter or much shorter lower palatal plica, and rarely an upper middle plica.

Measurements (n = 42): H = 12.9-15.9 mm, B = 2.9-3.3 mm.

Habitat. — Among debris from a slope in a warm broadleaf forest.

Notes. — In the relatively large sample of the type series the character states are not very variable. Therefore, some shells from another locality in the district of Zhemgang are dealt with separately below.

Derivatio nominis. — The epithet *chimiae* refers to Ms Chimi Yuden, the youngest Bhutanese collector and student of gastropod shells.

***Phaedusa (Phaedusa) chimiae* subspec.?**

(Figs 1, 18)

Material. — Bhutan, district Zhemgang, Ngangla - Trong, 2 km N of Ngangla, c. 17 km NE of Panbang; 1085 m a.s.l.; 26°58'20"N 91°03'17"E; Choki Gyeltshen & Nima Gyeltshen leg. 11.ii.2018 (NBCB 1036/3).

Notes. — Three shells that are most similar to *P. (P.) chimiae* as that species is described here differ slightly by a more oblique columellar side of the aperture and by rib-striae that are more widely spaced, i.e. c. 10 per mm above the aperture and 6-7 per mm on the final quarter of the body whorl.

These shells could be considered representative of a subspecies of *P. (P.) chimiae* if not a separate species. In view of the limited material a conclusion would be too premature here.

***Phaedusa (Phaedusa) sangayae* E. Gittenberger & Leda, spec. nov.**

(Figs 10, 19-22, 24-26)

*Phaedusa bhutanensis* — H. Nordsieck, 1974: 42 partly ('Bhutan: Paro [2300 m]'), figs 2-3 (not fig. 1, not pl. 2 fig. 5). *Phaedusa* spec. 1 — Gittenberger et al., 2017: 61, fig. 46.

Type series. — Holotype (NBCB 1037): Bhutan, district Paro, 14 km SE of Paro, N-side river, near monastery Tachugang Lhakhang, 2150 m a.s.l., near small rockface, 27°20'N 89°30'E,

< Figs 16-23. *Phaedusa (P.)* species. 16-17. *P. (P.) chimiae* Gittenberger & Sherub, spec. nov.; district Zhemgang, between Duenmang Tshachu (hotspring) and Gomphu Zero Point, 24 km SE of Zhemgang. 16. Holotype (NBCB 1034); H = 14.9 mm. 17. Paratype (NBCB 1035); H = 15.7 mm. 18. *P. (P.) chimiae* subspec.; district Zhemgang, Ngangla - Trong, 2 km N of Ngangla, c. 17 km NE of Panbang (NBCB 1036); H = 14.7 mm. 19-22. *P. (P.) sangayae* Gittenberger & Leda, spec. nov.; district Paro. 19. Holotype; 14 km SE of Paro, N-side river, near monastery Tachugang Lhakhang (NBCB 1037); H = 15.7 mm. 20. Paratype; S of Paro (= Rinpung) Dzong, E-side river (NBCB 1038); H = 13.9 mm. 21. Paratype; Khangkhu, 4.5 km SW of Paro (NBCB 1039); H = 15.8 mm. 22. Paratype (2) of *P. (P.) bhutanensis* Nordsieck, 1974 (SMF 229507) from 'Bhutan: Paro [2300 m]'; H = 14.9 mm (Photo: Ms Sigrid Hof). 23. *P. (P.)* cf. *sangayae* Gittenberger & Leda, spec. nov.; district Thimphu, Lungtenphu (RMNH 83774/1); H = 14.0 mm.



**Figs 24-26.** *Phaedusa (P.) sangayae* Gittenberger & Leda, spec. nov., details of the body whorl. **24-25.** Khangkhu, 4.5 km sw of Paro. **24.** Lateral lunellar with the inner end of the principalis, a moderately long upper and a very short lower palatal plica. **25.** Inside of the body whorl, with clausilial blade, lower palatal plica, subcolumellaris, columellaris, and separate parietalis and spiralis. **26.** 14 km SE of Paro, N-side river, near monastery Tachugang Lhakhang; like **25** but parietalis and spiralis connected.

E. Gittenberger & Pema Leda leg. 6.iv.2013. Paratypes, Bhutan, district Paro: type locality (1038/13); Khangkhu, 4.5 km sw of Paro, 2339 m a.s.l., 27°24'N 89°24'E, Sherub leg. 10-v-2015 (NBCB 1040/21); s of Paro (= Rinpung) Dzong, E-side river, 2250 m a.s.l., 27°25'N 89°25'E, E. Gittenberger & Pema Leda leg. 11.iv.2013 (NBCB 1039/8); Paro, 2300 m a.s.l., 28.iv.1972 (NMB/1; SMF 229507/1).

Additional material (see notes). — District Thimphu: Lungtenphu, 27°27'N 89°40'E, H.R. Feijen leg. 1-i-2000 (RMNH 83774/1).

Diagnosis. — Shell pale yellowish brown, moderately large, with less than 11 whorls, less than 3.6 mm broad.

Description. — The shell is pale brown to light yellowish; it has 10¼-10¾ whorls. The protoconch is subcylindrical; the teleoconch is gradually tapering, apart from the c. 3 lowest whorls that are about equally broad. Above the aperture there are 7-10 sharp riblets per mm; the riblets are more widely spaced, i.e. 3-5 per mm, on the final quarter of the last whorl. The aperture is obliquely piriform, broadly rounded basally and gradually narrowing towards the parietal sinus. The apertural lip is whitish, broadly reflected and thickened; it protrudes c. 0.2 mm. The cervix is regularly rounded.

The parietalis and the spiralis are more or less vaguely connected by a long low ridge (Fig. 26) or entirely separate (Fig. 25). The columellaris is more or less prominent in frontal view, and spirally ascending adapically nearly as far as the spiralis and the subcolumellaris ( $n = 2$ ). The subcolumellaris is discernible or hardly so in oblique view. The clausilial blade is partly visible from the outside; it is broad and irregularly curved, with an obtuse tip. The lunellar is situated laterally. The principalis runs from lateral to little less than ¼ whorl from the apertural border; it is accompanied by an upper palatal plica of ¼-½ its length, a lower palatal plica, which is usually shorter, and occasionally a short, more or less prominent to obsolete upper middle plica.

Measurements ( $n = 38$ ): H 13.0-15.7 mm, B 3.1-3.6 mm.

Genital tract. — For a description and figures of the genital tract of this species, we rely on Nordsieck (1974: 44, fig. 3), who suggested that this is probably an ovoviviparous species ( $n = 1$ ). — The penis proximalis and the epiphallus are cylindrical and as broad as the penis distalis at its two ends; the penis distalis is narrowed in the middle to half the width of the adjoining ducts. The penis distalis and the epiphallus are about equally long, measuring ¾ of the length of the penis proximalis. The epiphallus is supposed to have a proximal and a distal part that cannot be distinguished from the outside, however. The part of the vas deferens between the epiphallus and the genital atrium is very short. The vagina is short, measuring ¼ of the oviductus. The bursa copulatrix is large and provided with a diverticulum that is somewhat longer than the entire pedunculus; the pedunculus proximalis is little more than double the length of the pedunculus distalis, which is somewhat longer than the diameter of the large bursa.

In *P. (P.) bhutanensis* the bursa of the bursa copulatrix is much smaller, i.e. its diameter is only ⅓ of the length of the pedunculus distalis, whereas the penis proximalis and the oviductus are relatively longer. The diverticulum of the bursa copulatrix is longer in *P. (P.) sangayae*. It remains unclear to what extent these differences are specific or individual.

Notes. — At two locations in the district of Paro, the *Phaedusa* populations show a bimodal distribution in shell measurements. s of Paro Dzong, E of the river: H 13.4-15.5 mm, B 3.1-3.6 mm ( $n = 8$ ) and H 17.5-18.2 mm, B 4.0-4.1 mm ( $n = 2$ ). 14 km SE of Paro, N of the river near monastery Tachugang Lhakhang: H 13.9-16.4 mm, B 3.1-3.6 mm ( $n = 14$ ) and H 17.2-19.2 mm, B 3.6-4.3 mm ( $n = 18$ ). At Khangkhu, a third location in the district of Paro, all shells are relatively small: H 14.8-15.7 mm, B 3.1-3.4 mm ( $n = 21$ ). At 12 additional locations in the districts of Paro and Thimphu all shells are relatively large. The two size categories that differ only slightly in additional characters are considered



**Figs 27-29.** *Phaedusa (P.) bhutanensis* Nordsieck, 1974. Parts of the genital tract. **27a.** Specimen freed from the uterus of **27b** during dissection (H = 2.5 mm). District Paro. **27-28.** 26 km sw of Paro. **29.** 12 km ssw Chhuzom. Abbreviations (**Fig. 27b**): b = bursa of the bursa copulatrix; d = diverticulum; dh = ductus hermaphroditicus; e = epiphallus; g = glandula albuminifera; o = oviductus; pd = penis distalis; pp = penis proximalis; r = retractor muscle; u = uterus with embryonic snails; ud = pedunculus distalis; up = pedunculus proximalis; v = vagina; vd = vas deferens.

representative of closely related species here. As a consequence, the two paratypes of *P. (P.) bhutanensis* belong to *P. (P.) sangayae* according to the measurements of the shell, viz. H 15.8 mm, B 3.5 mm (paratype 1, NMB) and H 14.9 mm, B 3.4 mm (paratype 2, SMF 229507 [Fig. 22]). These shells are designated as paratypes of *P. (P.) sangayae*.

A single shell from Lungtenphu (Fig. 23) is provisionally classified with *P. (P.) sangayae*. It differs by clearly more convex whorls.

**Habitat.** — *Phaedusa (P.) sangayae* was found as a bottom dweller in rocky, open habitats, sometimes together with *P. (P.) bhutanensis*.

**Derivatio nominis.** — The epithet *sangayae* is given in honour of Ms Sangay Dema MSc, Principal Biodiversity Officer at the National Biodiversity Centre, Serbithang, Thimphu, who supported the molluscan inventory of Bhutan from the initial stage on.

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