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Bhutan freshwater gastropods and trematodes, with a warning

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ABSTRACT The freshwater gastropod species that have been recorded in Bhutan are listed in this work. Distributional data for the country are presented and references are given to the original descriptions and to illustrations of the species that may be useful for identification. An identification key is added and shells of all gastropod species are illustrated. We emphasize that some of the freshwater gastropods occurring in Bhutan may act as hosts for trematodes, as is known to be the case in other countries in Asia. These species may cause trematodiases in livestock and humans. Introductory references to the literature on snails and their parasitic trematodes are cited.

KEY WORDS Gastropoda; Trematoda; freshwater; trematodiases; biogeography; Bhutan.

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INTRODUCTION

The present paper is based on a small collection of shells of freshwater snails from Bhutan. It is the first article ever that is devoted to freshwater snails occurring in Bhutan. All the locality data are new and nearly all species have not been reported from that country before. The few species that have been mentioned being simply from 'Bhutan' in the literature, without any further detail, may actually be from present-day Indian territory. The shells were collected within the scope of a more general inventory of the evertebrate animals of Bhutan, directed by the National Biodiversity Centre in Serbithang, Thimphu, Bhutan, in co-operation with partner institutes like the Ugyen Wangchuck Institute for Conservation and Environment, Bumthang, Bhutan, and the Naturalis Biodiversity Center, Leiden, The Netherlands.

Freshwater snails may be useful as a measure for ecological water quality, as it is implemented in nearby Nepal (Shah et al., 2011). Even more important, it is the fact that several species of aquatic snails that were recorded in Bhutan are essential for the life cycle of trematodes and, indirectly, for the infection of both humans and livestock (Lockyer et al., 2004, Mas-Coma, 2005, Chontananarth & Wongawad, 2013, and literature therein). At the 'Third Global Meeting of the Partners for Parasite Control', held in the WHO Headquarters, Geneva, in November 2004, it was concluded that trematodiases have a great impact on human health and development (World Health Organisation, 2005). Human fascioliasis or 'liver rot', as it is called, may result from drinking contaminated water or eating raw vegetables in an area where particular species of snails occur (Soli-

man, 2008, Ramachandran et al., 2012, Anupam Pati Tripathi et al., 2013). Because Ramachandran et al. (2012) have reported human fascioliasis, for example in nearby Arunachal Pradesh and W. Bengal in India, the disease might occur in Bhutan as well. The occurrence of trematodes with freshwater snails in Nepal was mentioned by Devkota et al. (2011) and Budha (2016). To judge the risk of these parasitic diseases, it is relevant to know what species of freshwater snails occur in a particular region. When that kind of data is available, the vast literature on trematodes and snails can be used.

For more detailed descriptions of the habitats of the various species, we refer to a recent monograph on the aquatic invertebrates of the Ganga river system, published by Nesemann et al. (2007). The Middle Brahmaputra ecoregion (Mitra et al., 2010: 57), extending into southern Bhutan, is closely related to the Ganga river system, so that the study by Nesemann et al. (2007) could be used as the basis for this article. Another important paper on freshwater molluscs from Nepal and North India was recently published by Glöer & Bössneck (2013). To summarize the data regarding the freshwater molluscs of the Eastern Himalaya, we refer to Budha et al. (2010). For an overview of the entire freshwater biodiversity of the Eastern Himalaya, see Allen et al. (2010).

MATERIAL AND METHODS

Shells of freshwater snails were collected by several participants of the "Bhutan Invertebrate Biodiversity Survey Project", in or near water, and occasionally among leaves or plants in very humid places. Many areas have not been explored yet and species with shells that are less than 1 cm in height or width, are underrepresented because sieving aquatic bottom samples has only rarely been done, thus relatively small shells may have been overlooked.

A recent monograph on the aquatic invertebrates of the Ganga river system (Nesemann et al., 2007) and articles on freshwater molluscs from Nepal and North India (Glöer & Bössneck, 2013; Budha, 2016) were used to identify the shells collected in Bhutan.

Under the heading "Parasitology", data regarding trematodes are mentioned. This is always based on data in the literature for regions outside Bhutan.

A *Thiara* (*Tarebia*) species that is reported from "Bhutan" in the IUCN Red List (Budha, 2010, 2016), without further details, is included in the identification key, and is only dealt with in short. The common Asian planorbid *Indoplanorbis exustus* (Deshayes, 1834) is also in the identification key, although no records for Bhutan are known to us.

The number of shells is indicated after the locality number. All specimens are in the collection of the National Biodiversity Centre, Serbithang, Thimphu, Bhutan.

References to citations in the literature are restricted to the original descriptions and to illustrations that may be helpful for species recognition.

Study area: localities

1a. Dzongkhag Bumthang, NE of Yotong La, 10 km ENE of Trongsa, 3250 meters a.s.l.; 27°31'N 90°36'E; E. Gittenberger & P. Leda legit 20.IV.2015.

1b. Dzongkhag Bumthang, Wangdicholing School Campus, 2610 meters; 27°33'N 90°44'E; Chimi Yuden legit, 2016

2. Dzongkhag Gasa, Khame, Kabena, 1782 meters a.s.l.; 27°47'N 89°43'E; Rinchen Singye legit, I.2015.

3. Dzongkhag Haa, 15 km WSW of Paro, 2985 meters a.s.l.; 27°23'N 89°16'E; E. Gittenberger & P. Leda legit, 30.III.2016.

4. Dzongkhag Punakha, Toeb, Lamperi lake, 2694 meters a.s.l.; 27°30'N 89°45'E; Sherub Sherub legit, 21.III.2014.

5a. Dzongkhag Samdrup Jongkhar, Samdrupjongkhar, 299 meters a.s.l.; 26°49'N 91°28'E; legit ?, 11.VI.2015.

5b. Dzongkhag Samdrup Jongkhar, Bhayter, 309 meters a.s.l.; 26°53'N 91°44'E; Karma & Tsethup legit, 13.IV.2015.

6. Dzongkhag Sarpang, Chuzagang, Gelephu, Kalikhola, 235 meters a.s.l.; 26°53'N 90°31'E; Sonam Penjor & Sherub Sherub legit, 2013.

7. Dzongkhag Thimphu, 4.5 km E of Chhuzom, W of Genekha, 2750 meters a.s.l.; 27°19'N 89°36'E; E. Gittenberger legit, 21.VI.2012.

8. Dzongkhag Trashigang, Kanglung, campus Sherubtse College, 1850 meters a.s.l.; 27°17'N 91°31'E; donated, III.2016.

9. Dzongkhag Trongsa, Chendebji, 2479 meters a.s.l.; 27°29'N 90°20'E. Dzongkhag Trongsa, Jigme Wangchuk & Sherub Sherubleg, 7.IX.2016.

10. Dzongkhag Wangdue Phodrang, Gangchhu, Phobjikha valley, 2883 meters a.s.l.; 27°26'N 90°11'E; Jigme Wangchuk legit, 21.III.2015

11. Dzongkhag Wangdue Phodrang, Gangchhu, Phobjikha valley, 2915 meters a.s.l.; 27°27'N 90°10'E; Jigme Wangchuk legit, 21.III.2015

12. Dzongkhag Zhemgang, Ngangla Trong; Sangay Dorji & Tsethup Tshering legit [no additional data].

RESULTS

KEY TO THE SPECIES

1a. Shell broader than high: Planorbidae.....2
1b. Shell higher than broad.....4

2a. Much less than 1 cm broad: *Gyraulus* spec.....3
2b. More than 1 cm broad....*Indoplanorbis* spec. (not known from Bhutan)

3a. Less than 3 mm broad, body whorl evenly rounded, protoconch in line with the teleoconch whorls.....*Gyraulus rotula*
3b. More than 4 mm broad, body whorl obliquely rounded, only protoconch conspicuously deepened .....*Gyraulus sivalensis*

4a. Less than 3 mm high: *Erhaia* spec.....5
4b. Much larger.....6

5a. Umbilicus very narrow; aperture touching the penultimate whorl.....*Erhaia* sp. 1
5b. Umbilicus widely open; aperture not touching the penultimate whorl.....*Erhaia wangchuki*

6a. Shell fragile, brownish to yellowish, without any colour pattern or sculpture; without operculum: Lymnaeidae.....7
6b. Shell not fragile, with a prominent sculpture or a colour pattern; with an operculum.....9

7a. Shell height less than 1.5 cm.....8
7b. Shell height over 1.5 cm, aperture large, measuring ca ¾ of the total shell height.....
.....*Lymnaea acuminata*

8a. Height usually much less than 1 cm, spire as high as the aperture or higher.....*Galba truncatula*
8b. Height much more than 8 mm, aperture higher than the spire.....*Radix andersoniana*

9a. Obliquely ovoid.....*Paludomus conica*
9b. Slender or very slender conical.....10

10a. Yellowish green with darker spiral bands.....
.....*Bellamya* (*Filopaludina*) *bengalensis*
10b. Without spiral colour bands.....11

11a. Shell large, up to nearly 5 cm high, whorls flattened and nearly smooth (shells from Bhutan)....
.....*Brotia costula*
11b. Shell smaller, whorls with a spiral and a radial sculpture.....12

12a. Whorls flattened; with 5 or 6 rather coarse spiral ridges below the periphery of the last whorl.....14
12b. Whorls moderately convex; with more than 6 spiral ridges below the periphery of the last whorl..13

13a. With fine spiral lines and prominent, oblique, radial elevations which may form spines.....
.....*Thiara* (*T.*) *scabra*
13b. Spiral and radial sculpture about equally prominent, without spines.....*Melanoides tuberculata*

14a. Short radially elongated tubercles above the periphery.....*Thiara* (*Tarebia*) *lineata* (not seen)
14b. Some spiral rows of prominent roundish tubercles above the periphery...*Thiara* (*Tarebia*) *granifera*

SYSTEMATICS

Subclassis CAENOGASTROPODA Cox, 1960
Superfamilia VIVIPAROIDEA Gray, 1847
Familia VIVIPARIDAE Gray, 1847
Subfamilia BELLAMYINAE Rohrbach, 1937
Genus *Bellamya* Jousseaume, 1886
Type species: *Bellamya duponti* (De Rochebrune, 1882) (? = *Bellamya unicolor* (Olivier, 1804). See Brown (1994)
Subgenus *Filopaludina* Habe, 1964
Type species: *Vivipara bengalensis* Lamarck, 1822

Bellamya* (*Filopaludina*) *bengalensis (Lamarck, 1822) (Fig. 1)

Paludina bengalensis - Lamarck, 1822: 174.
Bellamya (*Filopaludina*) *bengalensis* - Nesemann et al., 2007: 73, pl. 19 figs 2, 3, pl. 20 fig. 1.
Bellamya bengalensis - Devkota et al., 2015: 862. Budha, 2016: 34, fig.

EXAMINED MATERIAL. Loc. 5a, 5 ex.

DESCRIPTION. Shell conical with convex whorls, yellowish green with more than five brown, spiral, colour bands, that alternate in width. The largest shell from Bhutan measures 26.5×18.0 mm. Much larger specimens have been reported from elsewhere; Nesemann et al. (2007: 83, fig. 1) have figured a shell of 39.5 mm height.

NOTES. Species of the family Viviparidae, which are eaten in certain regions of Asia, like Nepal (Budha et al., 2010: 51, 52), "*serve as important intermediate hosts for human trematode infections*" (Brandt, 1974: 19). Nesemann et al. (2007: 73) and Budha (2016: 35) report this Oriental species from many types of lowland water bodies. The locality in Bhutan is situated at 299 meters a.s.l.

Vivipara bengalensis nepalensis Kobelt, 1909, the holotype of which was figured by Zilch (1955: pl. 5, fig. 39), differs by more slender shells with only four, or occasionally five, spiral bands. That nominal taxon was considered a junior synonym of *Filopaludina filosa* (Reeve, 1863) by Brandt (1974: 24). We refrain from using subspecies in *Filopaludina* Habe, 1964.

PARASITOLOGY. See the note on the family.

Superfamilia CERITHIOIDEA Fleming, 1822
Familia PACHYCHILIDAE P. Fischer et Crosse, 1892
Genus *Brotia* H. Adams, 1866
Type species: *Melania pagodula* Gould, 1847

Brotia costula (Rafinesque, 1833) (Figs. 2, 3)

Melania costula - Rafinesque, 1833: 166.
Brotia costula - Köhler & Glaubrecht, 2001: 284, fig. D, 295, 297, fig. 10A - H. Budha, 2016: 41, fig.
Brotia costula costula - Brandt, 1974: 181, pl. 13 figs. 37, 38. Nesemann et al., 2007: 72, 81, pl. 18 fig. 1.

EXAMINED MATERIAL. Loc. 5a, 5 ex.

DESCRIPTION. Shell very slender conical, with flattened whorls, dark greenish brown. Aperture greyish white, slightly pointed instead of broadly rounded basally. Except for irregular growthlines, the shells from Bhutan have an inconspicuous sculpture. There may be about six, vague spiral ribs on the shell base and equally inconspicuous, oblique, radial ribs above the periphery. Apical whorls are missing in all shells. The largest shell measures 48.2×19.4 mm.

NOTES. This conspicuous Oriental species, occurring at ca. 300 meters a.s.l. in Bhutan, is reported from Nepal by Budha (2016: 41, fig). The shell that is illustrated for this species differs from the Bhutanese specimens by the presence of prominent radial riblets. The shells of *B. costula* are quite variable in sculpture (Brandt, 1974: 181). According to Nesemann et al. (2007: 72), its habitat are "*moderately fast running streams and rivers of lowlands*", whereas Budha (2016: 41) mentions "*Clear creeks with sandy bottoms, large rivers, even ponds*". Köhler & Glaubrecht (2001) report this species (p. 296) from both Sikkim and (p. 298) "*Dooars, West Bhutan*" after a sample in The Natural History Museum (London), overlooking the fact that the British annexed the Dooars in 1865, after the Anglo-Bhutan war, so that the Dooars eventually became a part of India.

On the basis of some shells only, it is not possible to classify the sample at the subspecific level.

PARASITOLOGY. For a subspecies of *B. costula*, Davis (1971) reported that it may act as a host species for the oriental lung fluke *Paragonimus westermani* Kerbert, 1878. Wilke et al. (2000: 457) also refer to this association. Singh et al. (2012) reported the connection between *Brotia* and *Paragonimus* Braun, 1899, and indicated (p. 196, fig. 2) that human paragonimiasis has been diagnosed in Arunachal Pradesh.

Familia PALUDOMIDAE Stoliczka, 1868
Subfamilia PALUDOMINAE Stoliczka, 1868
Genus *Paludomus* Swainson, 1840
Type species: *Melania conica* Gray, 1834

Paludomus conica (Gray, 1833) (Figs. 4, 5)

Melania conica - Gray, in Griffith & Pidgeon, 1833: pl. 14 fig 5 [legend]. See Petit & Coan (2008) for bibliographical data.

Paludomus conica - Nesemann et al., 2007: 72, 81, pl. 18 fig 3.

Examined material. Loc. 6, 5 ex.

Description. Shell obliquely ovoid, solid, dark brown with one or two very dark spiral bands; with a very large last whorl, determining nearly the total shell height.The largest of 5 shells measures 23.5×16.1 mm.

Notes. An Oriental species that has been reported from Nepal and Bhutan by Nesemann et al. (2007: 72), who describe its habitat as "*small lowland rivers and streams with pebbly, gravel or sand substrate*". It remains unclear, however, whether "Bhutan" refers to present-day Bhutan (see the notes with *Brotia costula*). Budha & Daniel (2010) also mentioned the species for "Bhutan" without further details.

Petit & Coan (2008) pointed at the fact that *Melania conica* Say, 1821, is a senior homonym of *Melania conica* Gray, 1833.

Parasitology. No data.

Familia THIARIDAE Gill, 1871
Genus *Thiara* Röding, 1798
Type species: *Helix amarula* Linnaeus, 1758

Thiara* (*Thiara*) *scabra (Müller, 1774) (Fig. 6)

Buccinum scabrum - Müller, 1774: 136.
Thiara (*Thiara*) *scabra* - Nesemann et al., 2007: 69, 80, pl. 17 fig. 8.
Thiara scabra - Brandt, 1974: 163, pl. 12 fig. 8. Budha, 2016: 39, fig.

Examined material. Loc. 5a, 1 ex.; 6, 1 ex.

Description. Shell slender conical, dark yellowish brown, with moderately convex whorls; with prominent, oblique, slightly undulating radial ribs that may form a spiral row of spines above the periphery, and additionally fine spiral ridges that become somewhat coarser towards the lower parts of the whorls, crossed by fine growth-lines. Apical whorls missing in both shells. The largest specimen (loc. 5) measures 25.9[+ ?] × 10.6 mm.

Notes. An Oriental species, occurring up to 450 meters a.s.l. in Nepal according to Nesemann et al. (2007: 70), who summarized the habitat as "*rivers and streams .. and stony to muddy substrate*". The two localities known for Bhutan are below 300 meters a.s.l.

Parasitology. Chontananarth (2015) reported a low infection rate by *Philophthalmus* sp. in *Thiara scabra*. Commonly known as oriental avian eye fluke, it has mainly been found in eyes of several bird species, but infections of humans are also known.

Subgenus *Tarebia* H. et A. Adams, 1854
Type species: *Melania granifera* Lamarck, 1822

Notes. Two species of *Thiara* (*Tarebia*) are mentioned for Bhutan (Budha, 2010, 2016; Madhyastha & Dutta, 2012), viz. *Thiara* (*Tarebia*) *lineata* (Gray, 1828) and *Thiara* (*Tarebia*) *granifera* (Lamarck, 1822). These species are recognized by both Nesemann (2007) and Budha (2016), but their descriptions and the accompanying figures are not entirely congruent. In contrast to this, Brandt (1974: 167, pl. 12 figs 14–18) regarded *Helix lineata* Gray, 1828, and *Melania granifera* Lamarck, 1822, as synonyms.

Thiara* (*Tarebia*) *lineata (Gray, 1828)

Helix lineata - Gray, in Wood, 1828: 24, fig. 68.
Thiara (*Tarebia*) *lineata* - Nesemann et al., 2007: 69, 80, fig. 6.
Tarebia lineata - Budha, 2016: 40, fig.

Notes. The species is mentioned for Bhutan without further details (Budha, 2010, 2016). Its habitat are "*rivers and streams*" (Budha, 2016: 40).

Thiara* (*Tarebia*) *granifera (Lamarck, 1822)

Melania granifera - Lamarck, 1822: 167.
Tarebia granifera - Brandt, 1974: 167, pl. 12 figs 14–18.
Thiara (*Tarebia*) *granifera* - Nesemann et al., 2007: 69, 80, fig 5.

Examined material. Loc. 12, 1 ex.

Description. Shell slender conical, brownish, with flat whorls with some spirally arranged rows

of prominent roundish tubercles above the periphery and spiral lines on the body whorl below the periphery. Height 22–42 mm; width 7–14 mm (after Brandt, 1974: 166).

NOTES. This species, occurring in "*rivers*" (Budha, 2016: 40), is mentioned for Bhutan without further details (Madhyastha & Dutta, 2012). Only a seriously damaged shell of an inaccurate locality is available.

Genus *Melanoides* Olivier, 1804
Type species: *Melanoides fasciolata* Olivier, 1804 (= *Nerita tuberculata* Müller, 1774)

Melanoides tuberculata (Müller, 1774) (Fig. 7)

Nerita tuberculata - Müller, 1774: 191.
Melanoides tuberculatus - Nesemann et al., 2007: 70, 81, pl. 18 figs 4–5, 83, pl. 20 fig 5.
Melanoides tuberculata - Brandt, 1974: 164, pl. 12 figs 9–12. Budha, 2016: 39, fig.

EXAMINED MATERIAL. Loc. 5b, 5 ex.; 6, 1 ex.

DESCRIPTION. Shell very slender and conical, brownish, sometimes with blotches and bands, with more than 10 moderately convex to flattened whorls; with spiral ridges that are crossed by radial riblets. Height 22–42 mm; width 7–14 mm (after Brandt, 1974: 166). The largest shell from Bhutan measures 28.3×8.5 mm.

NOTES. This well-known invasive species is very widely distributed, from the tropics to aquaria worldwide. According to Budha (2016: 40) the snails are "*abundant in streams, rivers*" and less common in stagnant water.

PARASITOLOGY. Krailas et al. (2014) investigated whether this species may act as a vector of human trematode infections in Thailand, and concluded (p. 84) more generally "*that this species can doubtlessly be considered as of considerable medical significance*". For additional data we refer to that paper and articles cited therein.

Superfamilia RISSOOIDEA Gray, 1847
Familia AMNICOLIDAE Tryon, 1863
Genus *Erhaia* Davis et Kuo, 1985
Type species: *Erhaia daliensis* Davis et Kuo, in Davis, Kuo, Hoagland, Chen, Yang & Chen, 1985.

NOTES. *Erhaia* belongs to the Holarctic family Amnicolidae (Wilke et al., 2001; Liu et al., 2014). Two *Erhaia* species are reported here from Bhutan on the basis of few data. For *E. wangchuki* there are molecular data that confirm its classification.

PARASITOLOGY. According to Wilke et al. (2000) *Erhaia* species may host *Paragonimus*.

Erhaia sp. 1 (Fig. 8)

Erhaia spec. - Gittenberger, Sherub & Stelbrink, 2017: 23, fig 3.

EXAMINED MATERIAL. Loc. 7, 1 ex.

DESCRIPTION. Shell ovoid, greyish, with a last whorl measuring more than ¾ of the total shell height; aperture attached to the penultimate whorl for less than ⅓ of the parietal-columellar side, somewhat pointed above and broadly rounded below; umbilicus very narrow; measurements ca. 2.0×1.3 mm.

NOTES. A single very small shell that was collected in an isolated cold spring got lost after being photographed. It is rather similar in size and shape to the two "*Erhaia*" species figured by Nesemann (2007: 78, figs 4–5). Additional data are required to determine its classification in a more reliable way.

Erhaia wangchuki Gittenberger, Sherub et Stelbrink, 2017 (Figs. 9, 10)

Erhaia wangchuki - Gittenberger, Sherub & Stelbrink, 2017: 23, figs 1–2.

EXAMINED MATERIAL. Loc. 10, 3 ex.

DESCRIPTION. Shell conical with a flat apex because the initial ¾-1 whorl is planispiral; 3¼ whorls in total. Growthlines moderately strong, with a more prominent periostracal ridge at more or less regular distances. Teleoconch whorls broadly shouldered and separated by a deeply incised suture. Aperture obliquely ovoid, smooth inside; apertural edge not touching the penultimate whorl. Umbilicus widely open. The holotype is the largest shell and measures 2.2×1.9 mm.

NOTES. This species occurs in a spring with pure water that is used in the nearby village of Gangchhu.

PARASITOLOGY. See previous species.

Infraclassis PULMONATA Cuvier in Blainville, 1814
Ordo BASOMMATOPHORA Keferstein in Bronn, 1864
Superfamilia Lymnaeoidea Rafinesque, 1815
Familia Lymnaeidae Rafinesque, 1815;
subfamilia Lymnaeinae Rafinesque, 1815
Genus *Radix* Montfort, 1810
Type species: *Radix auriculatus* Montfort, 1810 (= *auricularia* Linnaeus, 1758).

Radix acuminata (Lamarck, 1822) (Fig. 11)

Lymnaea acuminata - Lamarck, 1822: 160. Nesemann et al., 2007: 88, 98, figs 2–5.
Radix acuminata - Glöer & Bössneck, 2013: 152, 154 figs 52–54, 58–60.

EXAMINED MATERIAL. Loc. 6, 3 ex.

DESCRIPTION. Shell fragile, with a very large aperture, measuring 70-80% of the entire shell height. Aperture with a prominent columellar fold. Apical whorls somewhat flattened, forming an acute spire, separated by a very oblique suture. Our largest shell is 18.7 mm high, whereas Nesemann et al. (2007: 98, figs 2–3) figure a shell that measures 27.4 mm.

In *Radix luteola* (Lamarck, 1822) the sides of the body whorl are running parallel more clearly, and the apical whorls are more convex and separated by a less oblique suture.

NOTES. This is a common Oriental species, which occurs in "*slowly running rivers, streams, ponds, lakes and wetlands*" (Nesemann et al. (2007: 88).

While incorrectly assuming that *Lymnaea acuminata* Lamarck, 1822, is not available because of *Limneus acuminatus* Brongniart, 1810, Hubendick (1951: 157, 158 fig. 344a–g, 179) used the name *Lymnaea auricularia rufescens* Gray, 1822, for this species. *Radix auricularia* (Linnaeus, 1758) is not listed for the Ganga river system by Nesemann et al. (2007). The shell figured by Budha (2016: 43, fig) for "*Lymnaea acuminata*" differs from the Bhutanese specimens by a less acute spire.

PARASITOLOGY. *Radix acuminata* may transmit the trematodes (= flukes) *Fasciola hepatica* Linnaeus, 1758 and *F. gigantica* Cobbold, 1855. Chontananarth & Wongawad (2013: 238), in an article on trematodes in freshwater snails in northern Thailand, probably refer to this species as *Lymnaea auricularia rubiginosa* (Michelin, 1831).

Radix andersoniana (Nevill, 1881) (Fig. 12)

Limnaea andersoniana - Nevill, 1881: 142, pl. 5 fig. 9.
? *Lymnaea* (*Radix*) *viridis* Quoyet et Gaimard, 1832; Brandt, 1974: 231, pl. 16 fig 97.
"*Lymnaea andersoniana simulans*" - Nesemann et al., 2007: 87, 97, pl. 21 figs 6, 7.
Radix andersoniana - Glöer & Bössneck, 2013:153, 154 figs 64, 65.

EXAMINED MATERIAL. Loc. 1b, 1 ex.

DESCRIPTION. Shell ovoid with a conical spire, with 4¾ narrowly shouldered whorls, corneous brown. Aperture with a conspicuous, broadly reflected, columellar callus, which forms no clear fold. The specimen from Bhutan measures 10.3×6.4 mm.

NOTES. Nesemann et al. (2007: 87) report "*Lymnaea*" *andersoniana simulans* (Preston, 1908) from "*small streams of the Nepalese middle-mountains*", while indicating, opposite Brandt (1974: 231), that *Lymnaea viridis* Quoy et Gaimard, 1832, is a separate, closely related species.

PARASITOLOGY. According to Brandt (1974: 232), this species is host to the same trematodes as *Radix auricularia.* That implies that it may be "*an important intermediate host of several trematode species in Thailand and other parts of SE Asia*", including both *Fasciola* species. See also the notes for *Radix acuminata*.

Genus *Galba* Schrank, 1803
Type species: *Galba pusilla* Schrank, 1803 (= *Buccinum truncatulum* Müller, 1774).
Galba truncatula (Müller, 1774) (Fig. 13)

Buccinum truncatulum - Müller, 1774: 130.
Galba truncatula - Nesemann et al., 2007: 86, 97, pl. 21 fig 2.

EXAMINED MATERIAL. Loc. 2, 2 ex.; 3, 2 ex.; 7, 4 ex.; 8, 2 ex.; 9, 1 ex.

DESCRIPTION. Shell elongated, slender, conical and nearly twice as high as broad, light brownish, yellowish or greenish, more or less transparent, with very convex whorls that are separated by a deep suture. The largest shell from Bhutan is 7.0 mm high, but from elsewhere in the very large range of the species specimens up to 9 mm high or even larger are known; shell width (much) less than 5 mm.

NOTES. *Galba truncatula* is a Holarctic, amphibious species that may survive periods of dryness. It is known from stagnant waters that may temporarily dry up, shallow borders of lakes, pools, muddy or mossy places, among humid leaves, etc. (E.G., personal observations). There are five records in Bhutan from 1782–2985 meters altitude.

PARASITOLOGY. This species, widespread in the Holarctic region, including parts of Bhutan, is the best known host snail for the trematode *Fasciola hepatica*. Several additional trematodes and nematodes that may be associated are mentioned in the literature. The transmission potential of fascioliasis to humans and to animals is high. For an introduction to the literature on subjects related to this snail species and *Fasciola* Linnaeus, 1758 in humans and animals, we refer to Bargues et al. (2013) and the Internet.

Superfamilia PLANORBOIDEA Rafinesque, 1815
Familia PLANORBIDAE Rafinesque, 1815
Genus *Gyraulus* Charpentier, 1837
Type species: *Planorbis albus* Müller, 1776.

NOTES. Our material of *Gyraulus* specimens is much too limited for a satisfying analysis, but Glöer & Bössneck (2013) made it possible to identify at least two species with reasonable certainty.

PARASITOLOGY. No data for the *Gyraulus* species that were found in Bhutan are known. Brandt (1974: 239–240) mentions *Gyraulus convexiusculus* (Hutton, 1849) as "*first intermediate host of Echinostoma ilocanum and other species of Echinostoma*", known from birds and mammals, while also recording the presence of cercariae of *Paramphistoma* sp. *Echinostoma ilocanum* (Garrison, 1908) is also known from the gastrointestinal tract in humans. For additional data on the occurrence in Asia, see also Toledo et al. (1995) and Woon-Mok et al. (2011).

Gyraulus rotula (Benson, 1850) (Fig. 14)

Planorbis rotula - Benson, 1850: 351. Glöer et Bössneck, 2013: 148, figs 33, 34.

EXAMINED MATERIAL. Loc. 6, 10 ex.

DESCRIPTION. Shell discoid, very small, periphery rounded; final whorl rapidly increasing in width, when viewed from both above and below. Width 2.9-3.5 mm (shells from Bhutan).

Gyraulus sivalensis (Clessin, 1884) (Figs. 15, 16)

Planorbis sivalensis - Clessin, in Küster et al., 1884: 194, pl. 28 fig 9.

EXAMINED MATERIAL. Loc. 1a, 2 ex.; 4, 12 ex.

DESCRIPTION. Shell discoid, larger than the previous species, periphery rounded; only the protoconch deeply immersed at both sides; final whorl little increasing in width at the apical side (shell considered sinistral). The largest shell from Bhutan is 5.0 mm broad.

DISCUSSION

Nesemann et al. (2007) deal with 34 species of Caenogastropoda and 20 species of Pulmonata for the Ganga river system, whereas Budha et al. (2010: 45, Table 4.3) mention 78 species of Caenogastropoda and 33 species of Pulmonata for the Eastern Himalaya. We can report with certainty only 9 species of Caenogastropoda and 5 species of Pulmonata for Bhutan. Not all the species listed by Nesemann et al. (2007) will occur in Bhutan, but we may assume that there will be more than those that are reported here. Also, because of the small number of localities where shells have been collected, without sieving the substrate, we predict that the real number of gastropod species occurring in Bhutan will prove to be considerably higher.

Several gastropod species are known as hosts for trematodes that are important for lifestock and

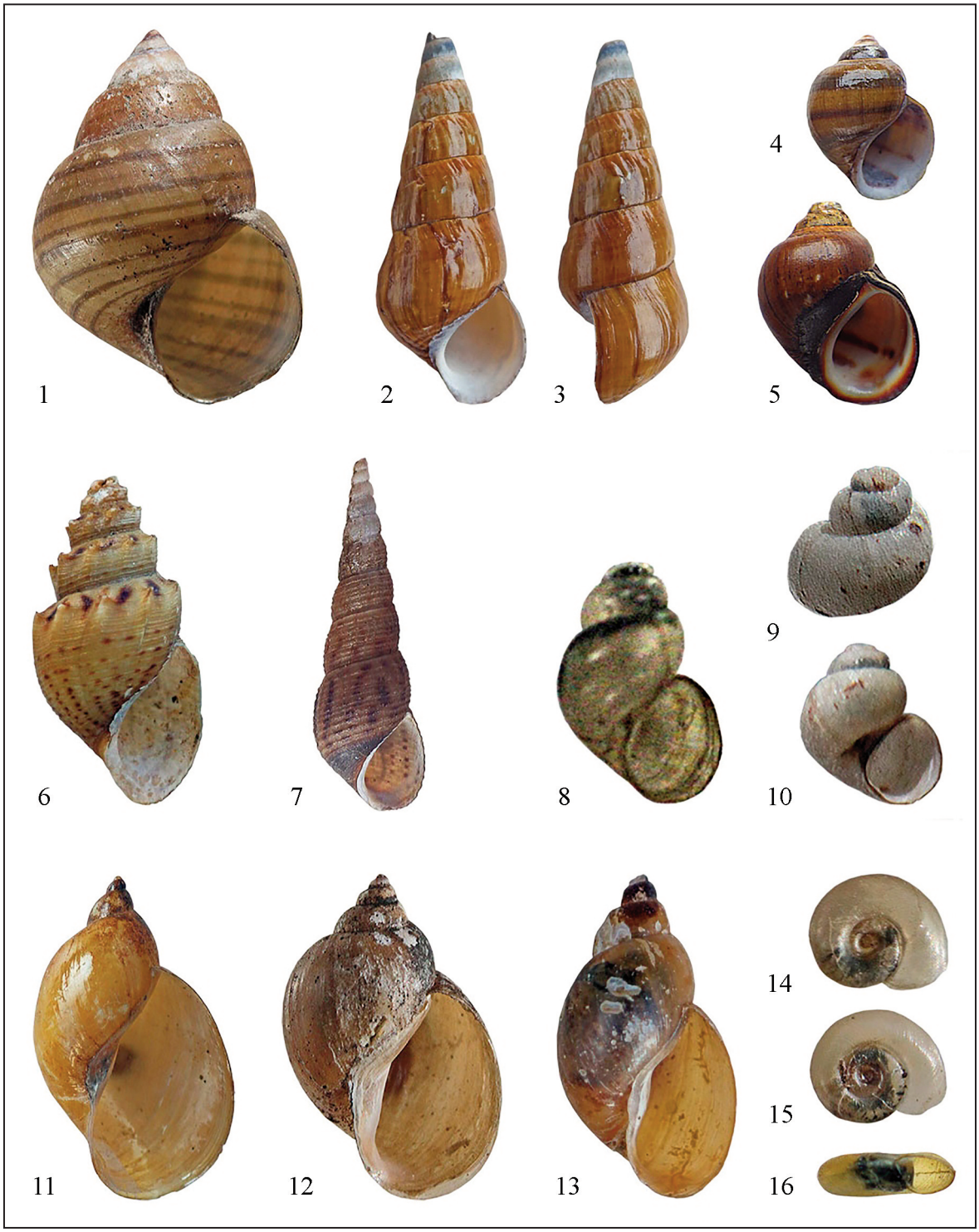

Figure 1. *Bellamya* (*Filopaludina*) *bengalensis*. Loc. 5a, height 25.6 mm. Figures 2, 3. *Brotia costula*. Loc. 5a, height 47.2 mm. Figures 4, 5. *Paludomus conica*. Loc. 6, heights 23.5 and 19.5 mm. Figure 6. *Thiara scabra*. Loc. 6, height 17.0 mm. Figure 7. *Melanoides tuberculata*. Loc. 5b, height 28.3 mm. Figure 8. *Erhaia* sp. 1. Loc. 7, height c. 2.0 mm. Figures 9, 10. *Erhaia wangchuki*. Loc. 10, height 2.2 mm. Figure 11. *Radix acuminata*. Loc. 6, height 18.7 mm. Figure 12. *Radix andersoniana*. Loc. 1b, height 10.0 mm. Figure 13. *Galba truncatula*. Loc. 2, height 7.0 mm. Figure 14. *Gyraulus rotula*. Loc. 6, maximal diameter 3.0 mm. Figures 15, 16. *Gyraulus sivalensis*. Loc. 4, maximal diameter 4.0 mm.

human well-being. At present, this fact is not sufficiently well known in Bhutan. Eating raw vegetables washed in unboiled water, where snails occur nearby, or drinking water directly from a brooklet or pond, is not advisable. A detailed survey of the aquatic gastropods of Bhutan, their distribution and the percentages of contamination with trematodes, is necessary to underpin this statement.

CONCLUSIONS

The freshwater gastropod fauna of Bhutan belongs to the Ganga & Brahmaputra river system with endemism observed only in *Erhaia*. That genus is represented in isolated spring areas, triggering allopatric speciation. Several species of snails that occur in the country are well-known hosts for trematodes. Therefore, both humans using unboiled water and livestock are at risk of trematodiases.

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