Rapid Communication

The first record of the introduced land snail *Bradybaena similaris* (Férussac, 1822) (Mollusca: Heterobranchia: Camaenidae) from Bangladesh

Takahiro Hirano[1,2,*], Takumi Saito[3], Shovon Mohammad Shariar[4], T. S. Rupamoy Tanchangya[5] and Satoshi Chiba[1,2]

[1]*Center for Northeast Asian Studies, Tohoku University, Miyagi, Japan*
[2]*Graduate school of Life Sciences, Tohoku University, Miyagi, Japan*
[3]*Department of Biology, Faculty of Science, Toho University, Funabashi, Chiba, Japan*
[4]*Department of Biochemistry and Molecular Biology, Rajshahi University, Rajshahi, Bangladesh*
[5]*Upazila Health Complex, Mohalchari, Khagrachari, Bangladesh*

**Corresponding author*
E-mail: *hirano0223t@gmail.com*

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Abstract

Bradybaena similaris (Férussac, 1822) is an invasive land snail species native to East and Southeast Asia. Here we report the first record of *B. similaris* in Bangladesh, an introduced species in this country.

Key words: terrestrial mollusc, introduced species, Gastropoda, Asian tramp snail

Introduction

Bangladesh is located in South Asia, the most densely-populated country in the world. The geography of this country is dominated by the Bengal Delta, so Bangladesh has many rivers and low elevation wetlands. There are some natural forests and mountain areas, but the terrestrial malacological fauna of Bangladesh is not well studied (Jahan 1993; Khondker 2007).

Bradybaena similaris (Férussac, 1822) (Heterobranchia: Camaenidae) is an invasive land snail. The native distribution area of this snail is probably East and Southeast Asia (De Winter et al. 2009; Serniotti et al. 2019), but currently *B. similaris* has spread to all continents except Antarctica, mainly in the tropical and subtropical areas (Brodie and Barker 2012; Serniotti et al. 2019). The species tends to inhabit disturbed habits such as urban and suburban areas, and *B. similaris* is known to cause damage to several crop species (Capinera and White 2011; Naranjo-García and Castillo-Rodríguez 2017), and feeding on a wide variety of plants (Dundee and Cancienne 1978; Pena and Waddill 1982; Chang 2002; Robinson and Hollingsworth 2009; Herbert 2010; Matamoros 2014; Serniotti et al. 2019). In addition, *B. similaris* can serve as intermediate host of some parasites (Serniotti et al. 2019). For example, *Angiostrongylus* nematodes can cause angiostrongyliasis (Kim et al. 2014). In the worst cases, angiostrongyliasis can result in death to humans (Hirano et al. 2019a).

Figure 1. Photographs of the locality of *Bradybaena similaris* in Bangladesh. A, agricultural field. B, irrigation canal. The arrows indicate individuals of *B. similaris*. Photographs by Takahiro Hirano.

In 2019, we found *B. similaris* in an agricultural field in East Bangladesh. We assessed its shell and genital morphology, to identify these snails. This is the first record of *B. similaris* in Bangladesh.

Materials and methods

We collected 11 individuals of *B. similaris* in Kayangghat, East Bangladesh (5 July 2019, N22.967704; E92.026259). They were collected along an irrigation canal adjacent to an agricultural field (Figure 1). The foot muscle from each individual was fixed in 99.5% ethanol for DNA extraction and the remaining soft bodies were stored in 70% ethanol for dissection. The remaining specimens were accessioned at Tohoku University Museum.

DNA extraction, Polymerase chain reaction (PCR), and sequencing were conducted in accordance with the study by Hirano et al. (2019b). To estimate the genetic similarity of the population we found in Bangladesh, we sequenced fragments of the nuclear ITS1 and 2 (internal transcribed spacer 1 and 2) regions from one of the specimens. PCR conditions and the primers used are shown in Hirano et al. (2019b). PCR products were purified using Exo-SAP-IT (Amersham Biosciences, UK). Sequencing was performed using PCR primers and BigDye Terminator Cycle Sequencing Ready Reaction Kit (Applied Biosystems) followed by electrophoresis using an ABI 3130xl sequencer (Applied Biosystems). The newly generated sequences were deposited in the GenBank databases (GenBank accession number LC534829).

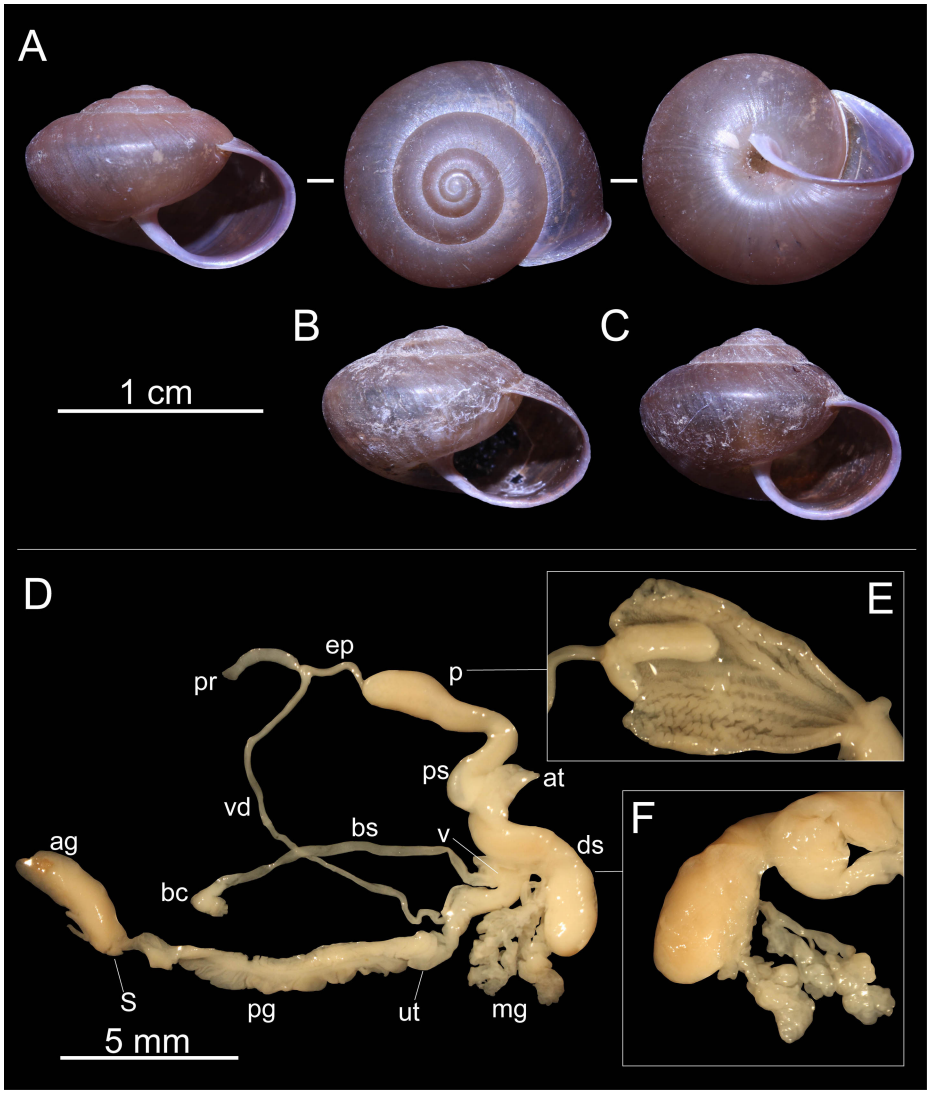

Figure 2. Shell and genital morphologies of *Bradybaena similaris* from Bangladesh. A, Shell views, shown from left to right: apertural, apical, and umbilical. B and C, Shells variations of the species. D, external genital morphology: ag, albumen gland; at, atrium; bc, bursa copulatrix; bs, bursa stalk; ds, dart sac; ep, epiphallus; fl, flagellum; mg, mucous gland; ov, oviduct; p, penis; pg, prostate gland; ps, penial sheath; rm, penial retractor muscle; s, spermoviduct; ut, uterus; v, vagina; vd, vas deferens. E, internal penial ornamentation. F, the reverse side of dart sac. Photographs by Takahiro Hirano.

Results

We confirmed that nuclear ITS regions of an individual we collected has more than 99% similarity to that of *B. similaris* by BLAST.

All specimens appear to be the unbanded brownish morphotype of *B. similaris* (Figure 2A–C). Shell measurements are indicated in Table 1. The individuals we collected exhibit the colors of the internal organs through the nearly transparent shell with some white portions at the apex. The color of the integument of the soft body when extended outside the shell is darker brown. The color of the periostracum is also brownish. This species exhibits polymorphisms in shell color (yellow or brown) and a band (present or absent), which are maintained by supergenes controlling color and a band (Komai and Emura 1955). Shell width of *B. similaris* shows

Table 1. Shell measurements of *Bradybaena similaris*.

Individual no. (this study) /Reference	Shell width (mm)	Shell height (mm)
1	12.12	9.61
2	12.39	8.71
3	13.16	9.27
4	13.69	9.27
5	13.47	9.61
6	12.98	8.93
7	12.9	9.2
8	12.13	9.57
9	13.76	9.82
10	12.62	8.63
11	12.73	9.51
Emura (1932)	11.9-17.0	5.4–10.1
De Winter et al. (2009)	up to 15	–
Brodie and Barker (2012)	~ 14	~ 11

We compared the ranges of morphological feature variation from our samples with those of confirmed and published populations of *B. similaris*. The specimens of *Bradybaena similaris*, *Lissachatina fulica* and *Macrochlamys* sp. are preserved in the Tohoku University Museum.

relatively wide range (Table 1), overlapping the shell measurements of our specimens. The shape of the peristome of the shell indicated in a prior study seems to be different from the shell of the species of Bangladesh (e.g. De Winter et al. 2009). This is distinctly rounded in the shell in De Winter et al. (2009), but the columellar to basal part of the peristome of some specimens of Bangladesh is rather straight (Figure 2). However, there is some variations of pattern of peristome (e.g. Japan; Emura 1940).

We also dissected and evaluated the genital morphology of the snails (Figure 2D–F). Spermoviduct consisting of uterus and prostate gland; length of prostate similar to that of uterus. Penis cylindrical, long, curved. Penial sheath short, thickened, at distal end of penis. Major portion of penial internal surface covered by branched and largely crenulated longitudinal pilasters, anastomosing into a few major pilasters near the atrium (Figure 2E). Epiphallus shorter than penis. Penial retractor muscle ribbon-shaped, inserting at proximal end of epiphallus. Vas deferens thin, long. Bursa copulatrix sacculiform. Bursa stalk long. Vagina short, cylindrical. Dart sac well developed, elongated oval. No accessory dart sac present. Two long mucous glands inserting laterally on dart sac (Figure 2F). Penis, vagina and dart sac inserting directly in the genital atrium. Compared with length of such genital traits of *B. similaris* shown in the prior studies (Seki et al. 2008; Serniotti et al. 2019), there are some slight differences. However, the distinctive characters such as no accessory dart sac and the morphological pattern of the penial internal surface coincide with the results of Seki et al. (2008), Hirano et al. (2014), and Serniotti et al. (2019).

Discussion

The genus *Bradybaena* diversified in East and part of Southeast Asia (e.g. Central and East China, and Japan (Chiba and Cowie 2016; Hirano et al.

2014, 2019b), so Bangladesh is not close to the center of the diversity. In fact, there was no record of *Bradybaena* in Bangladesh (Jahan 1993; Khondker 2007; Rahman *pers. comm.*). Considering some records of the genus in another countries near Bangladesh, *B. radicicola* is distributed in Nepal, Bhutan, and China (Tibet), having a conical shell, is clearly different from shell morphology of *B. similaris* (Raheem et al. 2010; Budha et al. 2015). *Bradybaena jourdyi* (Morlet, 1886) is distributed in Vietnam, having similar shell shape to that of *B. similaris*, but *B. jourdyi* has thick shell with remarkable growth lines (Inkhavilay et al. 2019). *Bradybaena bocageana* (Crosse, 1864) is distributed in China and Russia, having a spherical shape with relatively remarkable growth lines but not thick shell (Inkhavilay et al. 2019). The most closely related species to *B. similaris* is *B. pellucida* Kuroda and Habe, 1953, which is endemic to Japan (Hirano et al. 2014, 2019b). The shell of *B. pellucida* is thought to differ slightly from *B. similaris* in having a taller shell with wider whorls, a thinner ostracum, and a shiny pale-yellowish periostracum, through which the dorsal mantle appears bright yellow near the apex (Habe 1953; Seki et al. 2008). In addition, compared with *B. similaris*, *B. pellucida* has different microsculpture patterns on penial internal surface: *B. pellucida* has that pilasters of on penial internal surface are not branched nor fused to each other (Seki et al. 2008; Hirano et al. 2014). The morphological characters of the snails we collected in Bangladesh were consistent with the morphological characters of *B. similaris* indicated in Seki et al. (2008), Hirano et al. (2014), and Serniotti et al. (2019). In fact, the outcome of the ITS analyses provide additional strong evidence for our diagnosis of the collected specimens being *B. similaris*.

There are records of *B. similaris* in several additional countries near Bangladesh: China (De Winter et al. 2009; Hirano et al. *pers. obs.*), India (Mavinkurve et al. 2004), Laos (Inkhavilay et al. 2019), Myanmar (Worldwide Mollusc Species Data Base 2019), and Sri Lanka (Naggs et al. 2003). We also investigated terrestrial malacological fauna in other areas of Bangladesh, but did not find *B. similaris* (Hirano et al. *pers. obs.*). Prior study showed that *B. similaris* can be introduced through shipments of nursery plants (De Winter et al. 2009), although this population in Bangladesh was found in an agricultural field. In the locality of *B. similaris* in Bangladesh, we also found two other species of land snails: *Lissachatina fulica* (Férussac, 1821) and *Macrochlamys* sp. These species tend to inhabit relatively disturbed environments such as cultivated lowlands. In particular, *L. fulica* is among the world's most damaging 100 invasive alien species (Lowe et al. 2000). The present findings suggest that further study is needed to determine whether these introduced snails represent a reproductive invasion in this region.

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