

## A note on underground egg sacs of the Tsushima salamander, *Hynobius tsuensis* (Caudata: Hynobiidae)

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The Tsushima salamander, *Hynobius tsuensis* Abe, 1922, is a lotic-breeding species that usually spawn under rocks in mountain streams. It is endemic to the Tsushima Island (located between the Japanese Archipelago and Korean Peninsula, from 34.05° to 34.42° N latitude, and 129.10° to 129.29° E longitude), Japan. The species is phylogenetically closest to the lentic breeders *H. nebulosus* (Temminck & Schlegel, 1838) (Matsui et al., 2019; Niwa et al., 2021), thus its lotic-breeding behaviour is considered an adaptation to mountainous habitat of Tsushima Island (Kim et al., 2007).

Here, we report a pair of egg sacs and larvae of *H. tsuensis* found inside wet debris near a stream (on 21 May 2022, depth ca. 10 cm, underground water seeps (but no water current), about 5 m from the mainstream. The developmental stage of the eggs was around 11a-11c referring to Iwasawa and Yamashita (1991) (Fig. 1A, B). Tsushima Island is home to another salamander, *H. nebulosus* (Niwa et al., 2021), but *H. tsuensis* is the only species occurring at the observation site (Niwa et al., 2022; Niwa's personal observation). Hence, the egg sacs are considered to be *H. tsuensis*. We also found a larva remaining in the egg sac at another debris. The egg sacs were not attached to underwater rocks, but likely remained here given the absence of rain and flooding the week prior to our observation. Therefore, this species is likely to spawn underground intentionally. Normally *H. tsuensis* spawns egg sacs

under rocks in the stream (Matsui et al., 2021) like most of the lotic-breeding congeners: *H. amakusaensis* Nishikawa & Matsui, 2014, *H. boulengeri* (Thompson, 1912), *H. fossigenus* Okamiya et al., 2018, *H. ikioi* Matsui et al., 2017, *H. kimurae* Dunn, 1923, *H. naevius* (Temminck & Schlegel, 1838), *H. oyamai* Tominaga et al., 2019, *H. sematonotos* Tominaga et al., 2019, and *H. shinichisatoi* Nishikawa & Matsui, 2014 (Matsui et al., 2021: hereafter, "mainstream breeding type"). Our observation of underground spawning habit is the first report for *H. tsuensis*. The present observation is similar to other lotic-breeding including *H. stejnegeri* Dunn, 1923, *H. kuishiensis* Tominaga et al., 2019, *H. guttatus* Tominaga et al., 2019, *H. tsurugiensis* Tominaga et al., 2019 (Matsui et al., 2021: hereafter, "undercurrent breeding type"), and Taiwanese species that spawn undercurrent (*H. sonani* [Maki, 1922]; Kakegawa et al., 1989, *H. arisanensis* Maki, 1922; Hou et al., 2010, *H. formosanus* Maki, 1922; Kakegawa et al., 1989).

Spawning sites of *Hynobius* salamanders are species specific (Matsui et al. 2021), and one species rarely spawns in multiple sites of "mainstream" and "undercurrent" environments. As we also found egg sacs of *H. tsuensis* in a stream near (about 5 m) the debris, this species appears to be a rare exception that spawns in multiple environments. This wide-ranging spawning habit might enable the species to occur widely in the whole of Tsushima Island.

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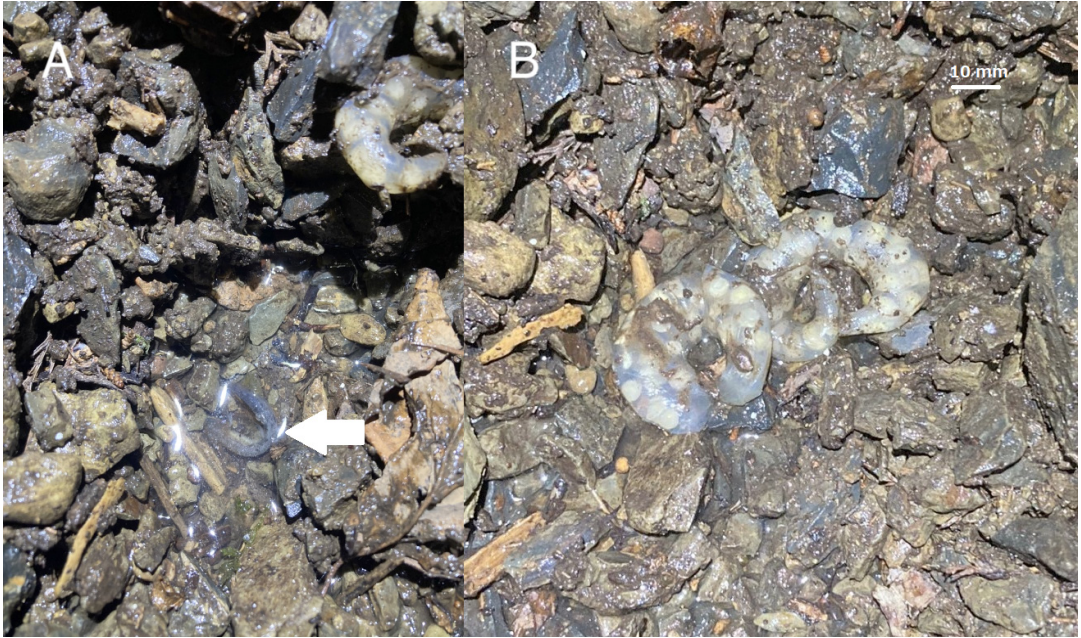
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**Figure 1.** One of the pair of egg sacs and a larva (white arrow) (A) and a pair of egg sacs taken out from the debris (B) of *Hynobius tsuensis* from Kashi, Tsushima Island, Nagasaki Prefecture, Japan. GPS coordinate information is not shown because of conservational reasons. Scale = 10 mm. Photographs by Jumpei Ito.

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