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Observations on heterospecific amplexus in Asiatic toads (Anura: Bufonidae: *Bufo gargarizans*) in the Republic of Korea

Yucheol Shin[1,2], Johanna Ambu[1,3], and Amaël Borzée[1,*]

Anurans exhibit diverse and complex mating behaviours (Duellman and Trueb, 1994). The breeding strategy of bufonids is qualified as explosive (Santos et al., 2010; Sodré et al., 2014) as opposed to prolonged (Wells, 2010). While prolonged breeders have multiple mating opportunities (Arak, 1983), males from explosive breeding species actively search for females (Arak, 1983) to counter the limited number of breeding opportunities (Cheong et al., 2008; Santos et al., 2010). Thus, males of explosive breeding species aggregate in large numbers around breeding sites and undergo intense competition for mating opportunities, during which males attempt amplexus with females or other moving objects (Arak, 1983).

Males' encounters with conspecific females are followed by amplexus, in which males clasp females with their forelimbs until oviposition and fertilization (Duellman and Trueb, 1994). Deviations from this usual mating pattern are sometimes observed, including multiple-male amplexus, amplexus from ventral side, male-male amplexus, necrophilia, and heterospecific amplexus (Mollov et al., 2010; Groffen et al., 2019a,b). Of these types of abnormal amplexus, heterospecific amplexus is notable as it has implications for interspecies interactions and mate recognition. Heterospecific amplexus have been documented for various anuran species around the world (Mollov et al., 2010; Sodré et al., 2014; Vivek et al., 2014; Shahrudin, 2016; Groffen et al., 2019a) but the mechanisms and associated costs behind this peculiar behaviour are poorly known.

Regarding anurans in the Republic of Korea, heterospecific amplexus have been observed in *Bombina orientalis* (with *Bufo stejnegeri*), *B. stejnegeri* (with eggs of *Hynobius leechii*), *Dryophytes japonicus* (with *H. leechii*), *Rana huanrenensis* (with a fish *Rhynchocypris oxycephalus*), and in *Rana uenoi* (with *Lithobates catesbeianus* and *D. japonicus*; Lee et al., 2012; Lee and Park, 2016). For *Bufo gargarizans*, only heterospecific amplexus with *L. catesbeianus* have been reported (Cheong et al., 2008; Lee et al., 2012; Yu et al., 2014; Lee and Park, 2016).

Herein, we report additional observations on heterospecific amplexus in *B. gargarizans* collected on 20 February 2020, at a *B. gargarizans* breeding site in Moam Reservoir, Changwon, South Gyeongsang Province, Republic of Korea (35.291370°N, 128.673047°E; 105 x 52 m at the largest points, elevation 60 m a.s.l.; measures at the site: air temperature 19.39 °C; relative humidity 30.51 %). We found 393 *B. gargarizans* individuals within a single funnel fish trap illegally set in the water body, roughly 6 m in length and 70 cm in diameter, with each "funneling section" about seven metre long. In the trap, we found a male *B. gargarizans* in amplexus with a turtle *Mauremys reevesii*, with its forelimbs clasped around the carapace of the latter (Fig. 1B). We also recorded 11 mating balls of *B. gargarizans* with seven to 11 males in amplexus with a single female (Fig. 1D). In the vicinity of the trap, we also observed four male *B. gargarizans* in amplexus with a male *L. catesbeianus.* Two males were in inguinal amplexus, one male was in amplexus with the head, and the other male attempted amplexus with the right hindlimb of *L. catesbeianus* (Fig. 1C). Another male attempted amplexus with one of the author's hand while the author was photographing an amplectant pair (Fig. 1A). In addition, observations at other sites showed a male *B. gargarizans* amplexed with a female *B. gargarizans* estimated to have been dead for over a week.

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[1] Laboratory of Animal Behaviour and Conservation, College of Biology and the Environment, Nanjing Forestry University, Nanjing 210037, People's Republic of China.

[2] Department of Biological Sciences, School of Natural Science, Kangwon National University, Chuncheon 24341, Republic of Korea.

[3] Aix-Marseille Université, Observatoire des Sciences de l'Univers Institut Pythéas, 13003 Marseille, France.

[*] Corresponding author. E-mail: amaelborzee@gmail.com

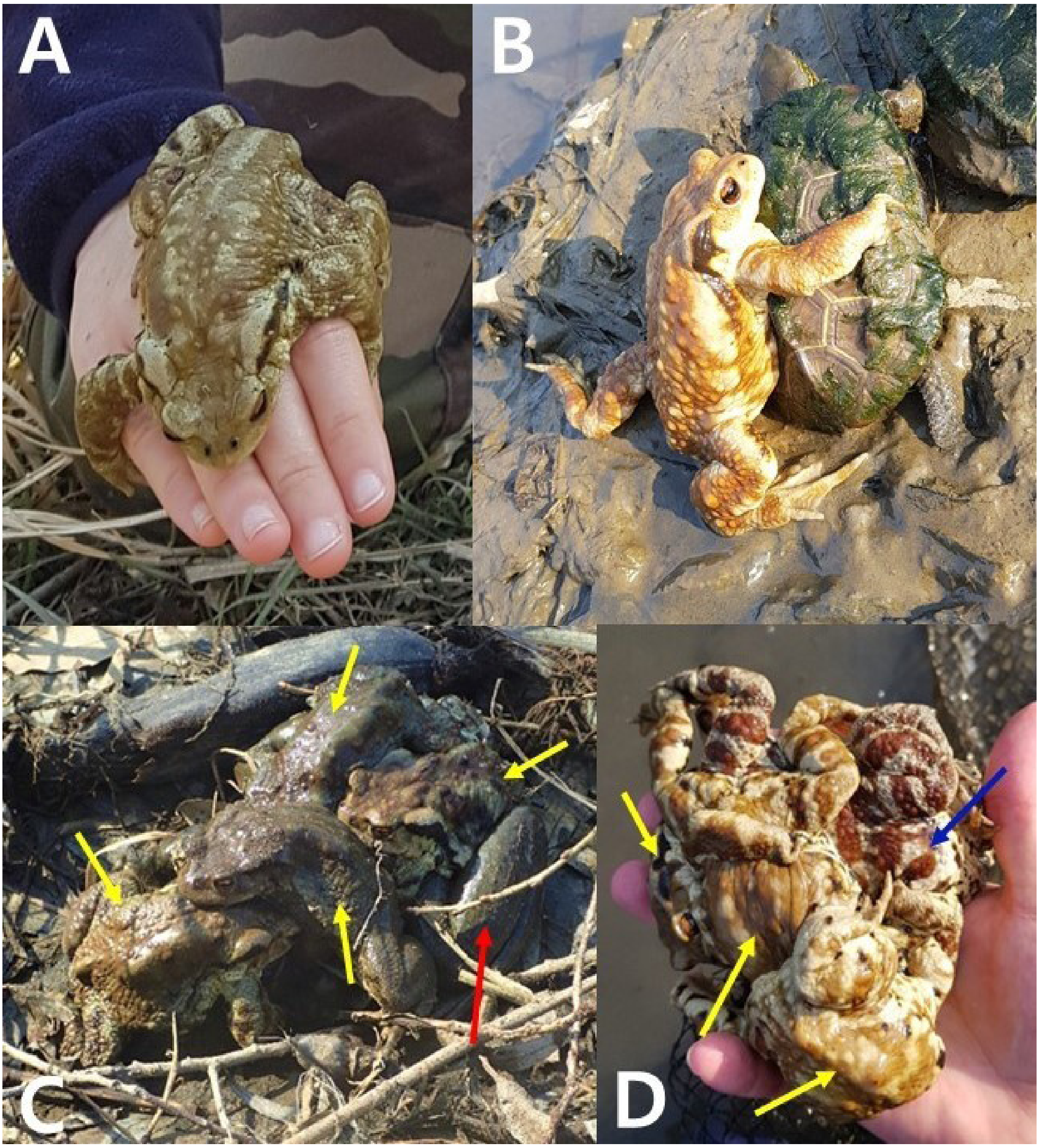

Figure 1. Observations of heterospecific amplexus in *Bufo gargarizans* in the Republic of Korea. (A) A male *B. gargarizans* attempting amplexus with human hand. (B) A male *B. gargarizans* in amplexus with a turtle *Mauremys reevesii*, post-removal from a trap and displacement of the toad by the researcher during the rescue. (C) Four male *B. gargarizans* (yellow arrows) in amplexus with an American bullfrog (*Lithobates catesbeianus*; red arrow). (D) Three male *B. gargarizans* (yellow arrows) in amplexus with one female (blue arrow). Photographs by AB and JA.

Bufo gargarizans is qualified as an explosive breeder (Cheong et al., 2008) and previous studies have demonstrated a general lack of preferential mate choice in males of the species. It includes males not distinguishing between the reproductive condition of females (but see Yu and Lu, 2013), sex of conspecifics, species (Cheong et al., 2008; Yu and Sharma, 2012), and selecting larger mate when available regardless of sex (Cheong et al., 2008; Yu and Sharma, 2012). However, these results do not indicate the complete lack of mate choice ability in *B. gargarizans*, but may suggest a lower cost associated with making wrong mate choices (Yu and Lu, 2013). Therefore, the reproductive strategy and associated costs may explain the occurrence of heterospecific amplexus in *B. gargarizans*. In addition, the fact that the males we observed were trapped with many individuals crowded within a small space may have facilitated intense multiple-male amplexus and heterospecific amplexus with *M. reevesii* and *L. catesbeianus*. Our observations add additional cases of heterospecific amplexus in *B. gargarizans,* and show that this species may also attempt amplexus with a completely different kind of animal (a turtle) and a totally different type of object (human hand).

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