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Short Communication

Death-feigning behavior in *Microhyla berdmorei, M. butleri,* and *M. heymonsi* (Anura: Microhylidae) from Peninsular Malaysia

Shahrudin Shahriza
School of Pharmaceutical Sciences, Universiti Sains Malaysia. 11800, Penang, Malaysia
E-mail: shahriza20@yahoo.com.

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Anurans live in various types of environments and are exposed to different predators, such as snakes, fishes, birds, small mammals, and larger invertebrates such as spiders (Duellman and Trueb 1986, Wells 2007). Anurans have evolved a wide array of defensive mechanisms to survive; these include immobility, escape, death feigning (thanatosis), leg stiffening, legs interweaving, skin secretions, body contraction, and the unken reflex (Duellman and Trueb 1986, Toledo *et al.* 2011). Death feigning—a state of immobility that many species of anurans employ in response to external stimuli—has been considered to be a defensive mechanism (Miyatake *et al*. 2004). In death feigning, the animal "pretends" to be dead when it is threatened or attacked by a potential predator (McFarland 1982, Toledo *et al*. 2010). According to Humphreys and Ruxton (2018), death feigning or tonic immobility (TI) is the innate adoption of a motionless posture by a prey individual that is triggered by physical contact or the close proximity of a predator. This has been observed in various animal taxa, including amphibians such as *Dendrophryniscus brevipollicatus* and *D. leucomystax* (Bertoluci *et al.* 2007), *Physalaemus kroyeri* (Gally *et al*. 2012), *Osornophryne percrassa* (Escobar-Lasso and Gonzalez-Duran 2012), *Odontophrynus carvalhoi,* and *O. cultripes* (Borges-Nojosa *et al.* 2016). In Peninsular Malaysia, this defensive strategy has been documented in several frog species, including *Occidozyga laevis, Pulchrana picturata, P. laterimaculata,* and *Polypedates leucomystax* (Shahriza 2016). To supplement knowledge of anuran defensive mechanisms, I report here the incidence of death feigning in three species of microhylids—*Microhyla berdmorei, M. butleri,* and *M. heymonsi.*

Microhyla berdmorei is a forest frog with snout–vent lengths of 25–45 mm (Berry 1975). The widespread species ranges across southern Yunnan Province, northeast India, Bangladesh, through Myanmar, Thailand, Laos, Cambodia, Vietnam, south to peninsular Malaysia, Sumatra,

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and Borneo, but does not occur in Singapore (Van Dijk *et al*. 2004c). In peninsular Malaysia, *M. berdmorei* lives on the forest floor of primary rainforests and along logging tracts (Berry 1975). The two smaller microhylids, *M. butleri* and *M. heymonsi,* have total lengths of 22.5–26.0 and 20.0–21.5 mm, respectively. Both occur in central and southern China, including Taiwan and Hong Kong, throughout Myanmar, Thailand, Laos, Cambodia, Vietnam, peninsular Malaysia, and Singapore (Van Dijk *et al.* 2004a, b). The range of *M. heymonsi* extends to Sumatra, Siberut, Phuket Island, and Great Nicobar Island (Van Dijk *et al*. 2004b). In peninsular Malaysia, both species are found in cleared and disturbed areas, such as gardens, roadsides, low bushes, among grasses and shrubs (Berry 1975).

In November 2017, two *Microhyla berdmorei* were collected from Sungai Sedim Recreational Forest, Kedah (SSRF) (5°25' N, 100°46' E; elevation < 150 m a.s.l.). Both specimens were caught while actively calling under leaf litter, near an intermediate-sized rock pool. The clear water rock pool had a sandy-gravel bed and the bottom was covered by leaf litter and twigs. A single *M. butleri* and four individuals of *M. heymonsi* were captured from Ulu Paip Recreational Forest, Kedah (UPRF) (5°23' N, 100°39' E; elevation < 150 m a.s.l.). The single *M. butleri* was collected while hiding under a rotten tree buttress, near a small ditch, which consists of shallow water. The four specimens of *M. heymonsi* were captured among the grasses, near an oil palm plantation, along the way to Ulu Paip. Both species were caught in December 2017, after heavy downpour. All the specimens were collected at night, between 20:00 and 22:00 h, via active searching and chance encounters. Frogs were captured by hand, aided with head lamps or flash lights. They were placed in the plastic aquaria (30 × 20 × 20 cm) according to the species, and transported back to the laboratory by car. The distance between the laboratory and sampling location is 54 km and took about 50 min to arrive. Wet leaf-litter and twigs were added into the aquaria as hiding places for the frogs. In the laboratory (Universiti Sains Malaysia), snout–vent length (SVL), head width (HW) and mass (W) of each frog were measured by using digital calliper and electronic balance. The live specimens and defensive postures of the frogs were photographed using an Olympus digital camera, model SP800UZ with 30× optical zoom. The frogs were kept for approximately 24 hours before being stimulated. After being stimulated and photographed, all the frogs were euthanized using tricane, fixed with 10% formalin, stored in 70% ethanol and deposited at the School of Pharmaceutical Sciences, Universiti Sains Malaysia for future reference (17USM-SS-MBe-05; 17USM-UP-MBu-01; 17USM-UP-MH-01,02). Frogs with no sign of death feigning were also preserved (17USM-SS-MBe-06; 17USM-UP-MH-03,04). The experiments were conducted in the laboratory with temperature between 25–30°C. The sample sizes were small because the frogs are very difficult to locate and capture.

During this study, a single specimen of *M. berdmorei* (adult, SVL = 35 mm, HW = 10 mm, W = 8 g) and *M. butleri* (adult, SVL = 25 mm, HW = 6 mm, W = 2 g), and two specimens of *M. heymonsi* (SVL = 24 and 22 mm, HW = 7 and 6 mm, W = 2 and 1 g) demonstrated death feigning (Figure 1). This behavior was performed by the frogs in the laboratory, after being approached or handled. When handled, the frogs leaped in an erratic pattern, at various angles for approximately 4–5 min, before displaying a death feigning posture. While in this position, several characteristics were recorded; venter region turned upwards, dorsal region turned downwards, exposing throat and belly surfaces; body inflated, forelimbs raised upward, exposing palmar surfaces**;** hindlimbs held close to body, exposing plantar surfaces and exposing thigh surfaces**;** eyes partially closed, mouth closed and whole frog staying motionless. All the frogs retained an immobilized position between 1–2 min, before turning to normal position, and leaping away. Additionally, one of the *M. heymonsi* specimens displayed a crouching down posture (Figure 1G).

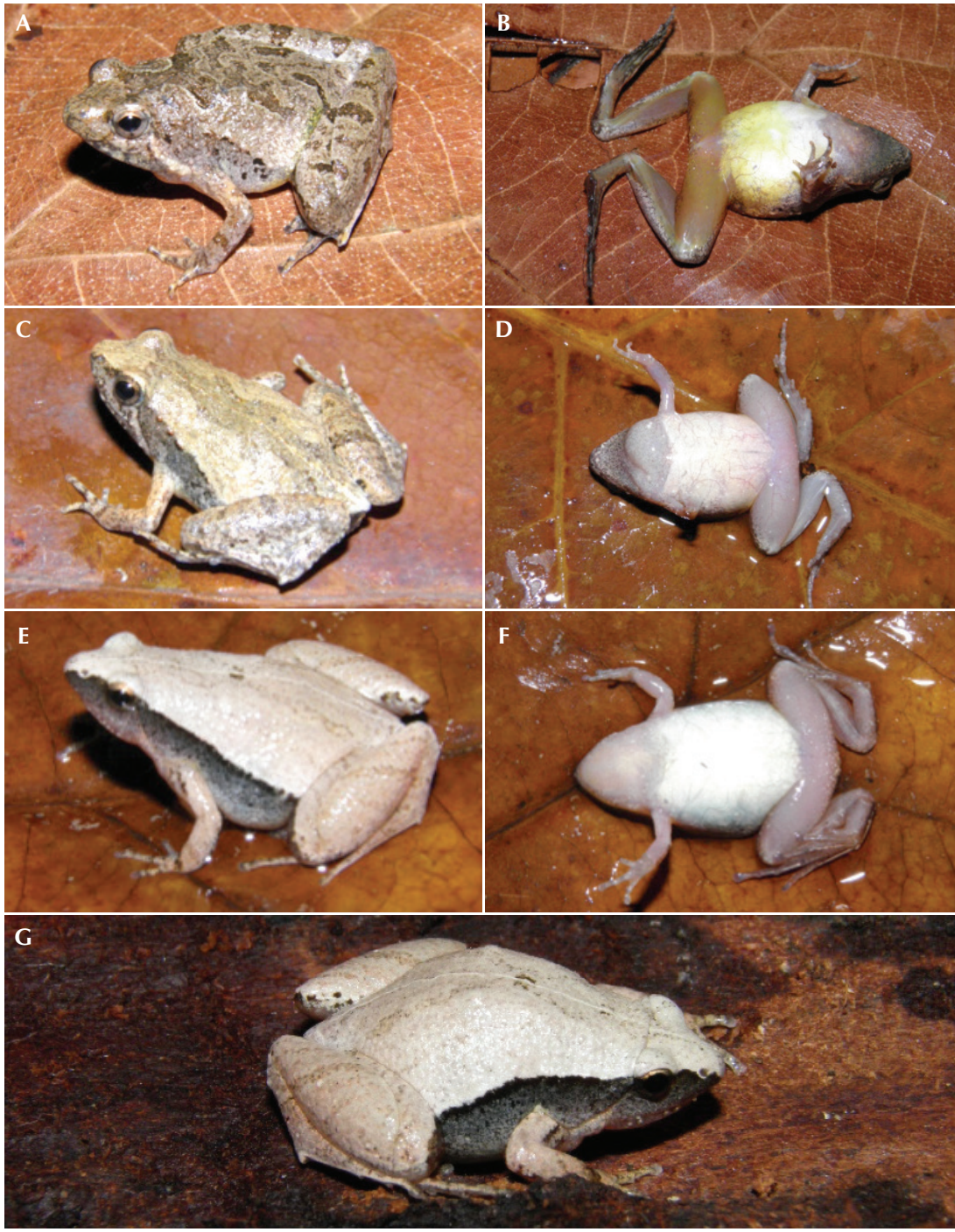

Figure 1. Death feigning behavior in microhylids from Kedah, Peninsular Malaysia. (**A-B**) *Microhyla berdmorei,* (**C-D**) *M. butleri,* (**E-F**) *M. heymonsi*. Crouching down behavior displayed by *M. heymonsi* (**G**).

After performing death feigning, the frog leaped and crawled under dead leaves to hide. Shortly, the leaves were removed, and the frog was found in a crouched posture. Several features were noted; the ventral region was adpressed to the substrate, the dorsal region slightly arched up, head and hindlimbs were flexed onto body, forelimbs were held close to body, the head facing down and both eyes opened. The frog remained immobilized for approximately 1 min, before leaping away.

In the present study, all the observed specimens were fleeing away in attempt to escape. As noted by Toledo *et al.* (2011), this behavior may be used by all anuran species, and can be either quick and erratic, or slower but directed. In our case, the frogs leaped and fled in quick and erratic patterns. Only a single individual of *M. berdmorei* and *M. butleri,* and two individuals of *M. heymonsi* demonstrated death feigning mechanisms. This was displayed by the frogs, after they leaped in various irregular directions for approximately 4 to 5 min. After being fatigued and failed to escape, they performed this action. Thus, I propose this as a secondary defensive mechanism. Several frog species from different families, including *Pulchrana laterimaculata, P. picturata* (Ranidae)*, Polypedates leucomystax* (Rhacophoridae) and *Occidozyga laevis* (Dicroglossidae), show the same leaping pattern before displaying a death feigning posture (Shahriza 2016). Toledo *et al.* (2010) reported that this behavior was shown by anurans after a short series of jumps.

While displaying death feigning, the frogs inverted their bodies and remained motionless, like a dead animal. Since many predators do not consume dead organisms, this type of behavior might prevent the frogs from being attacked (Toledo *et al*. 2011). This also can reduce the motivation of predators, which specialize in capturing live prey (Rovee *et al.* 1976). Additionally, death feigning can enhance escape opportunities from predators, which handle prey gently or momentarily release them prior to feeding (Ratner and Thompson 1960). However, the success or failure of this depends on the foraging mode of the predator (Honma *et al.* 2006). Death feigning may be associated with other features, including aposematic coloration (Toledo *et al*. 2010) and stiff-legged posture (Bertoluci *et al*. 2007). However, these were not displayed by the observed individuals.

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