

Research Article

Antipredator Behaviour of *Limnonectes blythii* (Boulenger, 1920) (Anura: Dicroglossidae) from Kedah, Peninsular Malaysia

Shahriza Shahrudin

School of Pharmaceutical Sciences, Universiti Sains Malaysia, 11800 Penang, Malaysia

Correspondence should be addressed to Shahriza Shahrudin; shahriza20@yahoo.com

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The frog *Limnonectes blythii* was collected at different locations in Kedah, Peninsular Malaysia, three from Sungai Sedim Recreational Forest, two from Bukit Hijau Recreational Forest, and two from Ulu Paip Recreational Forest. Nine antipredator mechanisms were displayed by this species, including fleeing, hiding among leaf litter, diving into water, bladder discharge, defensive call, feigning death, crouching, inflating the body, and body-raising. The two latter actions were accompanied by a defensive call. These observations document for the first time antipredator behaviour in *L. blythii*.

1. Introduction

Limnonectes blythii, or Blyth's Giant Frog, is a large species with the snout-vent length of the females and males ranging between 90–260 mm and 85–125 mm, respectively [1]. This riparian species is recognised by its stout body, broad head, rounded to pointed snout, moderate eyes, distinct tympanum, thick and stocky limbs, slightly swollen tips of the digits, and a conspicuous supratympanic fold [1]. It is widely distributed in Southeast Asia, from Vietnam and Laos, to Thailand and Peninsular Malaysia, Singapore and Sumatra, Anambas and the Natuna Islands, and commonly found from sea level to 1,200 m asl [2]. In Peninsular Malaysia, this species is often found along rivers and streams in primary and secondary forests [3, 4] and encountered on the forest floor away from sources of water [1].

Anurans are consumed by various types of predators due to their high abundance, small to moderate size, and soft skin [5]. For protection and survival purposes, they have developed diverse antipredator mechanisms, including fleeing, feigning death, crouching, contracting, unken reflex, toxic secretions, and many more actions [5–7]. Amphibians utilise different synergistic tactics to enhance their chances of survival, and different defensive strategies act in different phases of predation [7, 8]. Most descriptions

of antipredator behaviour were on neotropical frogs, for example *Proceratophrys boiei* [9], *Physalaemus kroyeri* [10], *Rhinella granulosa* [11], *Agalychnis aspera* [12], *Phyllomedusa azurea*, *P. iheringii*, and *P. tetraploidea* [13].

Although Peninsular Malaysia has a rich variety of amphibians (currently 107 species), information on the behaviour, especially the antipredator strategies, is lacking. A few reports on defensive behaviour have been documented: *Microhyla berdmorei* [14], *Leptobrachium hendriksoni* [15], and *Hylarana nigrovittata* [16]. To provide more information and understanding of anuran behaviour, we recorded defensive strategies exhibited by *L. blythii*.

2. Materials and Methods

Seven *Limnonectes blythii* (Figure 1) were collected at different locations in Kedah, Peninsular Malaysia: three from Sungai Sedim Recreational Forest (SSRF) (5°25'N, 100°46'E; <150 m asl; December 2013), two from Bukit Hijau Recreational Forest (BHRF) (5°30'N, 100°46'E; <150 m asl; June 2014), and two from Ulu Paip Recreational Forest (UPRF) (5°23'N, 100°39'E; <150 m asl; November 2014). Specimens were collected at night, between 2030 and 2330 hours, along riverbanks, forest streams, forest trails, swampy areas, and



FIGURE 1: An adult *Limnonectes blythii* from Kedah, Peninsular Malaysia.



FIGURE 2: Feigning death behaviour demonstrated by *L. blythii*.

forest pools of the sampling sites. The frogs were captured by hand or fish nets, aided by head lamps and flashlights by groups of 3 to 4 persons. Air temperature and relative humidity of the sampling sites were measured with a Thermo-Hygrometer (Fisher Scientific).

Specimens were placed in plastic bags and brought to the laboratory, where snout-vent length (SVL), maximum head width (HW), and mass (*W*) were measured using a digital caliper (Fisher Scientific) and electronic balance (Ohaus). SVL was measured from the tip of the snout to the cloacal area. Identification of *L. blythii* followed Berry [3], based on their morphological characteristics, while taxonomic nomenclature followed Frost [17]. Live specimens and defensive behaviour exhibited were photographed using an Olympus digital camera, model SP800 (30x optical zoom). All the specimens were released in their natural environments after measurements were taken and observations made.

3. Results

Individual 1 (adult; SVL = 95 mm; HW = 35 mm; *W* = 23 g) was collected along a small forest stream at SSRF in December 2013. The stream was approximately 0.5–1.5 m wide, 5–40 cm deep, composed of granite rocks, possessing a sandy-gravel bed, and slow to moderate flow of current. The air temperature and relative humidity of the sampling site were 24°C and 72%, respectively. When approached, the frog executed a series of leaps before it was successfully captured. The collected specimen was placed in a plastic bag and brought to the laboratory. During photography, the specimen leaped in various directions for approximately 8 minutes before stopping. Later, the frog was recaptured and placed on leaves to be photographed. Unexpectedly, the frog gradually inverted its body and feigned death (Figure 2). Several characteristics were also recorded: exposure of the whitish ventral surface, lifting of the forelimbs in an upward manner, exposure of the palmar surface, holding the hind limbs close to the body, exposing the webbing and plantar surface, and both eyes either fully or partially open. After staying in a motionless posture for about 2 minutes, the specimen returned to a normal position and leaped away.



FIGURE 3: Crouching behaviour exhibited by *L. blythii*.

Individual 2 (adult; SVL = 106 mm; HW = 36 mm; *W* = 24 g) was also collected along a small forest stream at SSRF in December 2013. The specimen was sitting on the wet, sandy bank of a stream, approximately 3 m from the first specimen. When handled, the specimen leaped away in a very erratic manner for nearly 7 minutes, before it was overcome with fatigue and feigned death. The characteristic of feigning death exhibited by this specimen is similar to individual 1. After staying immobilised for nearly 1.5 minutes, the frog resumed its ordinary posture. Besides feigning death, this specimen also crouched (Figure 3). The behaviour was displayed after the frog leaped continuously and hid beneath dead leaves. After hiding for about 3 minutes, we carefully removed the leaves and found it in a crouching posture. Several features were also recorded: chin and belly flattened and touching the substrates, mid-dorsal body slightly arched, snout facing down, both eyes being open, and forelimbs and hind limbs brought close to the body. The frog maintained this stationary posture for approximately 1.5 minutes before resuming its regular posture.

Individual 3 (adult; SVL = 114 mm; HW = 38 mm; *W* = 24 g) was captured while perching on a rotten log, near a main river, at SSRF in December 2013. When approached, the frog attempted to flee by leaping away, and hiding among leaf litter near a tree buttress. The dorsal pattern and colour of the frog (brownish red) is very similar to dead leaves and twigs, making it very difficult to detect. The frog remained in its hiding spot among the leaf litter for nearly 3 minutes, before it was found and captured. During hiding, the frog

FIGURE 4: Inflation behaviour displayed by *L. blythii*.FIGURE 5: Elevating behaviour exhibited by *L. blythii*.

also demonstrated a crouching behaviour. The observation was done and recorded at the sampling site.

Individual 4 (adult; SVL = 127 mm; HW = 37 mm; W = 28 g) was captured on a wet forest trail, approximately 2 m from the main river, at BHRF in June 2014. The air temperature and relative humidity of the sampling site was 23°C and 75%, respectively. When transferring the specimen from the vivarium to substrate, it leaped away for nearly 4 minutes. Shortly after, the frog stopped leaping and crawled underneath leaves. When the frog was uncovered, it stayed in a motionless posture and crouched. After a while, the frog was approached by touching its body with a stick several times. The specimen did not leap away but emitted a sound and elevated its body to demonstrate inflating behaviour (Figure 4). Several characteristics were deduced: inflated and elevated body, exposure of the whitish ventral surface, snout facing up, both eyes largely open, forelimbs erected in a straight position, and the hind limbs and inguinal parts slightly raised. The frog stayed in this stationary position for nearly 2 minutes, before returning to its ordinary posture.

Individual 5 (adult; SVL = 131 mm; HW = 40 mm; W = 30 g) was collected in a rock pool, at BHRF in June 2014. The moderate-sized pool was approximately 1 m wide, 1.5 m length, and less than 30 cm deep. It was also filled with leaf litter and twigs and had a sandy-gravel bed. While trying to capture it, the frog fled by diving into the pool and concealed itself among the leaf litter and twigs. At the bottom of the pool, the specimen retained a motionless position for nearly 7 minutes before diving back onto the surface. While submerged in the water, the ventral surface of the frog was lowered towards the substrate, and both limbs were extended. The fleeing, diving, and camouflage behaviours were observed at the sampling site.

Individual 6 (adult; SVL = 98 mm; HW = 36 mm; W = 25 g) was collected along a small ditch, at UPRF in November 2014. The ditch was about 1–1.5 m wide and less than 30 cm deep and possessed a sandy and silt bottom. It was drained by slow currents and located approximately 4–6 m from the main river. The air temperature and relative humidity were 24°C and 68%, respectively. When manipulated for photography, the frog attempted to flee by leaping in various directions for nearly 5 minutes. Later, it crawled and concealed itself beneath leaves. After 4 minutes, the leaves were removed

and the frog was found in a crouching posture. The frog was then stimulated by pinching its body with blunt forceps. Unexpectedly, the specimen raised its body and exhibited a body-raising posture (Figure 5). Several other features were also observed: inflated body, body and head lifted upwards, ventral surface not meeting substrates, forelimbs and hind limbs widely stretched, inguinal part raised, and both eyes fully open. The frog maintained this position for about 2 minutes, before it resumed a normal posture. The specimen also emitted a sound when touched or pinched with blunt forceps.

Individual 7 (adult; SVL = 118 mm; HW = 37 mm; W = 26 g) was also collected along a small ditch, at UPRF in November 2014. Three types of defensive behaviour, including fleeing, feigning death, and bladder discharge, were displayed by this specimen. The characteristic of feigning death exhibited by this specimen is similar to individuals 1 and 2, except for the position of their legs. The hind limbs of this specimen were not held close to the body, but extended. The frog remained in this immobilised position for approximately 1.5 minutes before resuming a normal position. Furthermore, bladder discharge was released by the frog, when its body was grasped tightly. The summary of the antipredator strategies displayed by *L. blythii* was shown in Table 1.

4. Discussion

Based on the observation, nine antipredator strategies were exhibited by *L. blythii*: fleeing, feigning death, crouching, hiding among leaf litter, diving underwater, inflating the body, body-raising, defensive call, and bladder discharge. The act of fleeing away, by leaping in various directions, was the main defensive strategy displayed by this species, and all the observed specimens displayed such behaviour. According to Toledo et al. [7], fleeing is a widespread behaviour utilised by all kinds of anuran species and accompanied with bladder discharge, defensive calls, and exposure of colours.

Specimens 4 and 6 emitted defensive calls when touched or pinched using blunt forceps. Toledo et al. [7] classified defensive calls into three types: distress calls, warning calls, and alarm calls, synergistically with fleeing, body-raising, inflating the body, and fighting. In this case, defensive calls

TABLE 1: Antipredator strategies displayed by *Limnonectes blythii* from Kedah, Peninsular Malaysia.

Specimens	Sampling locations	Date of capture	Antipredator strategies
Individual 1	Small forest stream, Sungai Sedim	Dec 13	Fleeing, feigning death (laboratory observation)
Individual 2	Small forest stream, Sungai Sedim	Dec 13	Fleeing, feigning death, crouching (laboratory observation)
Individual 3	River bank, Sungai Sedim	Dec 13	Fleeing, hiding among leaf litter, crouching (field observation)
Individual 4	Forest trail, Bukit Hijau	June 14	Fleeing, crouching, inflating the body, defensive call (laboratory observation)
Individual 5	Rock pool, Bukit Hijau	June 14	Fleeing, diving under water, (field observation)
Individual 6	Small ditch, Ulu Paip	Nov 14	Fleeing, crouching, body-raising, defensive call (laboratory observation)
Individual 7	Small ditch, Ulu Paip	Nov 14	Fleeing, feigning death, bladder discharge (laboratory observation)

emitted by specimens 4 and 6 were more likely to be a distress call, but further study is needed to identify it. Furthermore, defensive calls emitted by specimens 4 and 6 were accompanied by inflating and body-raising behaviour, respectively, which was also noted by Toledo et al. [7]. Specimen 7 displayed bladder discharge. It released clear liquid when its body was grasped tightly. According to Toledo et al. [7], bladder discharge is the commonest behaviour in many anuran species and occurs during fleeing or fighting with another predator.

Feigning death, or otherwise known as thanatosis behaviour, was demonstrated by specimens 1, 2, and 7. After continuously leaping in erratic directions for approximately 7-8 minutes, the frogs were overcome with exhaustion. When this happened and they were unable to escape, they thus displayed such behaviour. We consider this behaviour as a secondary defensive mechanism, as it was displayed after the primary strategy (fleeing) was not successful. The results were similar to the observations of Toledo [18, 19], who recorded death feigning behaviour in the frog after a series of jumps. Feigning death was recorded among various types of animals, including amphibians. While displaying such behaviour, the animal acted in a manner that resembled dead frogs, which may prevent assault by a potential predator [6]. Three frog species from Peninsular Malaysia, including *M. berdmorei*, *L. hendricksoni* [14, 15], and *H. nigrovittata* [16], exhibited this type of behaviour. Other frog species, such as *Dendrophryniscus brevipollicatus*, *Rhinella abei* [6], *Physalaemus kroyeri* [10], *Odontophrynus carvalhoi*, and *O. cultripes* [20], were also displayed this type of defensive strategies.

Crouching behaviour was exhibited by specimens 2, 3, 4, and 6. In all four, the behaviour was demonstrated by the frogs when they hid beneath leaves. To conceal themselves, the frogs flattened their bodies resulting in a crouching posture. From our observations, this behaviour is synergistic with the camouflage tactic. Because of the dorsal pattern and colour of the frog is very similar to their environment (leaf litter, twigs, branches, and the ground in general), hiding beneath leaves can confuse potential predators. This behaviour was also exhibited by *M. berdmorei* from Peninsular Malaysia [14]. It also has been recorded in *Centrolene savagei* from Colombia [21].

Inflating the body was performed by specimen 4 and accompanied by a defensive call. For this behaviour, the frog inflated and elevated its body, thus enlarging its size [22]. The act of increasing its body size intimidates potential predators and prevents attacks. According to Toledo et al. [7], this behaviour is accompanied by defensive calls, crouching, chin-tucking, and thanatosis.

Body-raising behaviour was displayed by specimen 6 and also accompanied by a defensive call. In this situation, the frog inflated its body, raised its body and head, but did not elevate it. This behaviour also enlarged the size of the frog. Usually, in this posture, the frog exposes its aposematic colouration and eyespot-like glands [7], but this condition was not demonstrated by specimen 6.

Hiding by utilising camouflage was displayed by specimens 3 and 5 at the sampling sites. Specimen 3 hid among leaf litter on the forest floor, whereas specimen 5 dove into the water and hid among dead leaves accumulated at the bottom of the pool. The dorsal pattern and colour of the frogs resemble dead leaves and twigs, making it difficult to be detected by potential predators. According to Duellman and Trueb [5], the colours, patterns, and structural features of many amphibians can reduce visual recognition or even create optical illusions that confuse the predators.

Competing Interests

The author declares no competing interests.

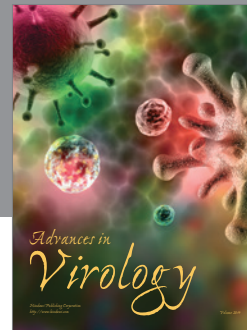
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