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FIRST RECORD OF MALAYAN HORNED FROG, *MEGOPHRYS NASUTA* (AMPHIBIA: ANURA: MEGOPHRYIDAE) EGG CLUTCH IN SINGAPORE WITH OBSERVATION OF AMPLEXUS

Prarthini M. Selveindran
Department of Biological Sciences, National University of Singapore
14 Science Drive 4, Singapore 117576, Republic of Singapore
(Email: prar.selv@gmail.com)

ABSTRACT. — The first field observations of mating and breeding in the Malayan horned frog, *Megophrys nasuta* in Singapore are recorded at the Bukit Timah Nature Reserve. This species exhibits inguinal amplexus during mating, while oviposition results in large white gelatinous eggs (approximately 2 mm in diameter) that are laid attached to one another.

KEY WORDS. — *Megophrys nasuta*, egg clutch, amplexus, breeding

INTRODUCTION

Megophrys is a genus of frogs that occurs in the Malay Peninsula and Archipelago (including Borneo, Mindanao, East Timor, and the Sunda Islands of Indonesia). Kuhl & van Hasselt (1822) based the genus on the type species *Megophrys montana*, characterised by extended dermal projections over the eyelids (van Kampen, 1923).

The Malayan Horned frog, *Megophrys nasuta* (Schlegel, 1858), was first recorded in Singapore in 1881 (Blanford, 1881 as *Megalophrys nasuta*). Globally, the species is distributed from Yala, in southern Thailand, throughout the Malay Peninsula, Singapore, Sumatra, Borneo, to the Natuna Islands archipelago (van Dijk et al., 2004). The International Union for Conservation of Nature (IUCN) lists *Megophrys nasuta* as a taxon of 'Least Concern' owing to its presumed wide distribution range and population size (van Dijk et al., 2004). In Singapore however, it is currently listed as nationally endangered and its distribution is confined to the Bukit Timah and Central Catchment nature reserves (Lim & Yang, 1991; Leong & Chou, 1999; Ng et al., 2008).

Megophrys nasuta exhibits sexual dimorphism, with females being substantially larger than males (Inger, 1966). This species is known to display inguinal amplexus where the female is grasped in the lumbar region by the male (Boulenger, 1912; Wildenhues et al., 2012). This usually leads to oviposition, with eggs being "white, glutinous, and attached to each other" (Wildenhues et al., 2012). Here, I report the first Singapore observation of amplexus of *Megophrys nasuta* and subsequent discovery of an egg clutch in the Bukit Timah Nature Reserve.

OBSERVATIONS

On 16 Sep.2013, at 1732 hours, a pair of *Megophrys nasuta* was encountered in amplexus in one of the streams of Bukit Timah Nature Reserve. The weather was cloudy and overcast, with light rain. The female (112 mm snout-to-vent, SVL) was larger than the male (74 mm SVL). The pair was observed submerged in the stream (Fig. 1), and they did not move when approached and photographed. However, once both frogs were measured, they swam to the side of the stream near the bank, remaining in amplexus. Two hours later, both individuals were still in amplexus, although they had moved onto a large rock on the side of the bank (Fig. 2). Throughout this two-hour period, males were calling frequently along that stretch of the stream.

Two days later the stream was systematically searched for eggs. An egg clutch was discovered on the stream edge about 3 m upstream from the location where the pair was observed in amplexus (Fig. 3). I estimated the clutch size (about 6 cm wide and 2.5 cm deep) to be around 500 eggs, each approximately 2 mm in diameter and covered by a gelatinous layer. Eggs were deposited as a cluster inside and on the underside of a hollow dead piece of bark that was partially submerged in the stream. As these observations correspond with descriptions of *Megophrys nasuta* eggs in the literature, I was confident that these were almost certainly the eggs of the amplexing pair (Schidmt, 1976; Wildenhues et al., 2012).

Fig. 1. Amplexing pair of *Megophrys nasuta* (male, 74 mm SVL and female, 112 mm SVL) in stream. (Photograph by: Prarthini M. Selveindran).

Fig. 2. Amplexing pair (male, 74 mm SVL and female, 112 mm SVL) on rock. The pair was discovered to have moved from the stream to a large rock on the bank after two hours. Scale bar = 2 cm. (Photograph by: Prarthini M. Selveindran).

The site was revisited every 2–4 days over a period of two weeks. No discernible change was observed in the egg clutch on the first and second visits (20 and 23 Sep.2013)—eggs were still on the underside of the bark. However, on the next visit (26 Sep.2013), most of the eggs had detached from the bark and possibly had been swept down the stream. Only a small number of eggs were observed in the stream at the area of egg deposition (Fig. 4). Detachment from the bark was possibly the result of heavy rains the previous day (25 Sep.2013), which had the highest rainfall recorded for the month at 52.6 mm (NEA, 2013). On the final visit to the site (30 Sep.2013), no more eggs were observed at the site.

Fig. 3. Egg clutch. Eggs were deposited under a partially submerged dead log in the stream. The clutch was covered by dead leaves and shaded by overhanging fern vegetation. Scale bar = 10 mm. (Photograph by: Prarthini M. Selveindran)

Fig. 4. Remains of egg clutch eight days later. Most of the eggs had been dislodged and washed away down the stream, likely due to the heavy rain the day before. Scale bar = 10 mm. (Photograph by: Prarthini M. Selveindran)

Weather and microhabitat. — Daily temperatures for the month of Sep. ranged from 21.9°C (min) to 30.9°C (max) with a monthly mean temperature of 27.5°C (NEA, 2013). Sep. (one of the months within the Southwest Monsoon period) had a total rainfall of 257 mm with records of rain almost daily (NEA, 2013). Furthermore, prior to the discovery of the amplexing pair, there was heavy rainfall on 15 Sep.2013 and light rain for the preceding days of the week—possibly a stimulus for breeding. Point measurements of certain habitat parameters were taken at the area of egg

deposition on the day of discovery. Stream water, as measured when the eggs were observed, was 25.6°C and clear, and the stream substrate was sandy. Ambient air temperature was 26.8 °C; relative humidity was 87%. The bark was covered by a layer of dead leaves and shaded by overhanging ferns. Canopy coverage, measured by a spherical densiometer, was 88.4%. The bark was situated in a position such that there was swifter-flowing water at the deposited egg clutch area as compared to other parts of the stream (0.371 m s^{-1} as compared to 0.166 m s^{-1}). Furthermore, dissolved oxygen levels in the stream, as measured across a period of three months (Sep. to Nov.), were generally high, ranging from 84–90%.

DISCUSSION

Little information is available regarding the reproductive behaviour and ecology of *Megophrys nasuta* in the wild. Despite the distinct call of *Megophrys nasuta*—a loud "honk"—the frog is difficult to locate owing to its highly cryptic appearance that closely resembles leaf litter of the forest floor. This cryptic appearance has also been noted by several authors (Boulenger, 1912, 1914; Inger, 1966; Mattison, 1992), making observations of its reproductive behaviour difficult. Males appear to increase calling frequency during the later hours of the evening, between 1800–1945 hours (pers. obs.) so this further corresponds with the period of greatest anuran vocalisation (Bickford et al., 2010). This species exhibits inguinal amplexus, where a male embraces the female's waist for hours (van Kampen, 1923; Wildenhues et al., 2012) as was observed.

Boulenger (1914) noted that several species of *Megophrys* (then reported as *Megalophrys*)—*Megophrys parva*, *Megophrys montana*, and *Megophrys nasuta*—lay eggs in swift-flowing water. This has also been reported by Inger & Voris (2001), observing that *Megophrys nasuta* 'breed(s) in streams of moderate or strong current'. The gelatinous egg clusters are adhered and partially submerged in water to surfaces that form natural 'caves', such as dead logs and rocks (Mattison, 1993; Walls, 1995; Burger, 2000). Tadpoles are adapted to survive in fast-flowing water and once hatched, larvae are noted to swim against the current almost immediately (Leong & Chou, 1999). The tadpoles are equipped with enlarged labia that are possibly utilised in holding onto fixed objects such as root mats of stream vegetation or rocks, even in the face of fast flowing water (Boulenger, 1914; Fig. 5). This funnel-mouth structure also aids in the tadpole's feeding strategy (Fig. 6). The funnel channels in water, which carries fine particles that are subsequently filtered in the tadpoles' gill chamber (Inger, 1966; Mattison, 1992; Leong & Chou, 1999; Burger, 2000).

Fig. 5. Top view of *Megophrys nasuta* tadpole on the vertical surface of a partially submerged rock in the water. The tadpole, which was fully submerged, was facing against the direction of water flow. Note the enlarged labia (circled) that appear to aid the tadpole in holding onto the rock. The blue arrow indicates the direction of water flow. Scale bar = 2 cm. (Photograph by: Prarthini M. Selveindran).

Fig. 6. Dorsolateral view of *Megophrys nasuta* tadpole over submerged roots. Note the funnel-shaped labia (circled)—this structure aids in the surface feeding strategy of the tadpole. The blue arrow indicates the direction of water flow. Scale bar = 1 cm. (Photograph by: Prarthini M. Selveindran).

Captive management records of the *Megophrys nasuta* document the development from eggs to adults and indicate that larvae take approximately one week to hatch following egg deposition (Wildenhues et al., 2012). In captive breeding, eggs are also laid partially submerged in water and adhered to surfaces such as cork or the sides of the aquarium (Burger, 2000). Initially, larvae depend upon their yolk reservoir for food with the funnel mouth necessary for surface feeding develops only about one week after hatching (Burger, 2000; Wildenhues et al., 2012). The tadpoles, which develop their brown pigmentation about 10 days after hatching, begin to develop hind limbs after 60 days (Wildenhues et al., 2012). Although most captive-bred larvae begin to metamorphose about two and a half months from hatching (commencing metamorphosis a month later), some individuals were observed to take more than seven months to reach the metamorphosis stage (Wildenhues et al., 2012).

A preliminary study of *Megophrys nasuta* conservation status in Singapore recorded evidence of a decline in population size (Selveindran, 2013). This was based on data suggesting that populations were confined to only three (including this stream) of nine surveyed sites where the species had been historically recorded in the central nature reserves. Absence from historical sites and an overall population size estimated at fewer than 250 mature individuals—both criteria for classification of threat categories according to Singapore's Red Data book—suggested that the species' conservation status in Singapore was in need of review. Knowledge of the species' breeding within this stream demonstrates the importance of this site in Singapore. In addition, such knowledge may aid in suggesting modifications of existing streams from which populations have been extirpated so as to allow for future reintroduction. In order to better understand this frog's distribution and ecology, more resurveys of historical locations and robust habitat studies should be conducted. This information will add to our knowledge of the conservation status and habitat requirements of *Megophrys nasuta* in Singapore, as well as aid conservation measures of Singapore's nature reserves.

CONCLUSIONS

These observations represent the first records of the mating and breeding of *Megophrys nasuta* in Singapore. *Megophrys nasuta* is a species that exhibits inguinal amplexus during mating while oviposition results in large white gelatinous eggs (approximately 2 mm in diameter) that are laid attached to one another. The egg clutch observed here was deposited under a dead log partially submerged in a flowing stream.

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