# Breeding and nesting behaviour of *Rhacophorus maximus* (Anura: Rhacophoridae) in Meghalaya, North East India

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**The present study deals with the breeding and nesting behaviour of *Rhacophorus maximus* at Cherrapunjee and Mawsynram, Meghalaya, North East India. Breeding activity of *R. maximus* occurred after the first few showers of rain and an increase in air temperature. The species breeds sporadically for a short period, which lasts for about 6–8 weeks during March and April. Amplexus took place on land as well as in water and lasted for several hours. Aggregations of male frogs making advertisement call at the breeding sites have been observed. Competition among the males to mate with the female frogs and at the same time trying to dislodge the amplecting pairs have also been observed. Multiple amplecting pairs are seen in the temporary rainfed pond at Mawsynram, which appeared to be a congenial breeding habitat during the peak of the breeding period. Both male and female frogs took active part in nest construction. The species constructs foam nests on diverse substrata such as aquatic vegetation about 2–3 cm above the water surface, on bare rocks near the water bodies and on earthen banks. The water temperature recorded during oviposition ranged from 20°C to 22.5°C, air temperature from 21.5°C to 26°C and relative humidity from 65% to 99%. The eggs are large, measuring 2 mm in diameter, unpigmented, white in colour and clutch size varies between 809 and 2059 with a mean of 1351.96 ± 83.07.**

**Keywords:** Aggregation, amplecting pairs, breeding, foam nest, *Rhacophorus maximus.*

A great diversity of reproductive modes has been found in anuran amphibians. One of the most interesting modes is that of rhacophorids, where majority of them deposit their eggs in foam nests, while others exhibit direct development[1]. The foam nests are thought to protect the eggs and embryos from predation and desiccation[2,3]. Construction of foam nests by Indian rhacophorids has been reported by many workers[4–6]. Anurans have a biphasic life cycle and they breed in a variety of water bodies such as temporary rainfed ponds, ephemeral pools, cemented tanks and permanent ponds.

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The breeding activity of rhacophorids like other anurans is influenced by the abiotic factors like temperature and rainfall[7–9]. Certain reproductive behaviour of many anuran species like the timing of their calling period are linked to climate[10]. Vocalization in amphibians is a common component of breading behaviour as male anurans call to advertise their breeding status, defend territory and attract females[11]. It was observed that *Rhacophorus malabaricus* produced advertisement calls after three or four heavy showers of rain[5]. Rainfall also fills the pools and ponds and provides excellent breeding sites for a number of anuran species, as there must be some standing water for their breeding activity. In this context, the Indian bull frog, *Rana tigerina*[12] and *Ramanella variegata*[13] breed in the temporary rainwater pools; *Polypedates maculatus* construct foam nests attached to vegetation either above or near the water body[4], *Chirixalus simus* construct foam nests hanging from grass over temporary water[9], and *Rhacophorus lateralis* construct a purse-like nest over water[14].

Although it is known that like other rhacophorids, *Rhacophorus maximus* construct foam nests to protect the eggs from dessication during development, there is scanty information on the breeding biology of this treefrog. Therefore the present investigation was carried out for a better understanding of its breeding and nesting behaviour in Cherrapunjee (locally known as Sohra) and Mawsynram, Meghalaya, NE India.

The breeding and nesting behaviour of *R. maximus* was studied in Cherrapunjee (25°16′N lat. and 91°44′E long.) for a period of four consecutive years (2001–2004) in a selected temporary pond measuring 150 $m^2$ and surrounded on all sides by grasses such as *Imperata cylindrical* and *Gleichenia* sp. Medium to large trees and shrubs like *Alnus nepalensis*, *Phyllanthus glaucus*, *Myrica esculenta* are present in the adjacent forest area near the breeding ponds. A second breeding site was selected at Mawsynram (25°18′N lat. and 91°35′E long.) and breeding studies were also conducted for three years (2009–2011). This is a temporary rainfed pond measuring 200 $m^2$, surrounded by grasses, small shrubs and trees. This has been identified as a congenial breeding and nesting site of *R. maximus* in Khasi Hills, Meghalaya. These two places are well known for receiving the highest annual rainfall. Observations of the breeding activity of *R. maximus* were made from 1600 h till midnight using dim flash light during the emergence and breeding period in March and April at the two breeding sites. During field study, the breeding behaviours such as courtship, spawning and nature of nest construction were observed, recorded and photo documented. Similarly, the frog calls were identified and recorded. The depth of the pond, rainfall, relative humidity, water and air temperature were recorded. The snout-vent length (SVL) of amplecting pairs and foam size were measured and the number of eggs per clutch was counted ($n$ = 30).

With an increase in air temperature in March after the cold winter months (November to January) and with a few consecutive showers of rain at Cherrapunjee, it was observed that the temporary rainfed ponds were waterlogged and measured about 1.5 m in depth.

Adult male frogs were always observed to be the first to emerge from their hiding places during the evening and they actively move towards the pond for breeding activity. On reaching the breeding site, males *R. maximus* select a suitable site and make advertisement calls by the side of the pond behind the grasses. The peak of the breeding activity was recorded in March–April at Cherrapunjee. The atmospheric temperature recorded during March ranged from 22.8°C to 24.4°C, relative humidity from 65% to 80% and rainfall from 27.8 to 316.8 mm.

Interestingly, during the present investigation, it was observed that near the pond multiple males aggregate and produce advertisement calls in chorus. The males exhibited a unique advertisement call while hiding in the shade of tall grasses and in some damp places near the breeding site, or while floating on the water surface. Aggregation behaviour of male frogs at the breeding site is unique, as they compete to produce loud advertisement calls to attract the females for mating. At the same time the males fight with one another during this competition (Figure 1). The calling sound was usually heard during the evening (around 1600 h) and continued till early in the morning. During the peak of the breeding period (March–April), the advertisement calls were found to be maximum and the sound of the calling males could also be heard during daytime. However, it was remarkably high in the evening after rainfall. The rainfall recorded during April ranged from 501.5 to 1294.2 mm, relative humidity from 86.5% to 96% and atmospheric temperature from 24.3°C to 25.8°C. Advertisement calls were audible to the human ear from a distance of 30–35 m; the calls were heard continuously for three days before any amplexus took place. It was also observed that during this period, males were more abundant than the females at the breeding sites.

Attracted by the calls, the female frog emerged and responded to them by swimming towards the male in the pond. On seeing the female, the male frog emerged from its hiding place and encircled the female. It then suddenly grasped the female resulting in axillary amplexus. Amplexus was observed to take place both during the day and night-time. In the present study, combating behaviour of males was observed, where one male frog tried to dislodge another amplecting pair (Figure 2). Amplexus was observed to lasts several hours before nest construction took place and the female deposited its eggs in a large creamy white foam nest. The nests were observed to be constructed on diverse substrata. Some of the foam nests were observed to be constructed attached to vegetation like *I. cylindrical* and *Gleichenia* sp. about 2–3 cm above the water level, on earthen banks attached to the grasses and stones on the side of the pond and also floating on the water surface (Figures 3 and 4). Several nests were also found to be constructed by the frogs attached to vegetation near the surface of water and the foam nests were usually found exposed. After a few minutes of egg-laying, the foam nest became sticky, the outer covering being hard and the inner part soft. The water temperature recorded during oviposition ranged from 20°C to 22.5°C, air temperature from 21.5°C to 26°C, relative humidity from 65% to 99%; 123 mm of rainfall was recorded. No nest construction was observed during heavy showers. Both male and female frogs left the nests after construction and no parental care was observed.

In the present investigation, a total of 10 amplecting pairs and their foam nests were collected from the study sites and measured. The foam nests are large in size, white in colour, irregular in shape and some varying from 15.5 to 20.5 cm in length. The eggs are unpigmented and white in colour measuring 2 mm in diameter. The clutch size varies between 809 and 2059 with a mean of $1351.96 \pm 83.07$.

An interesting observation was made at the other study site, i.e. Mawsynram in a temporary pond, which is a rainfed pool where multiple amplecting pairs of *R. maximus* were observed at the peak of the breeding activity in

**Figure 1.** Aggregating behaviour of males *Rhachophorus maximus* in the breeding site making advertisement calls.

**Figure 2.** Male frog showing combating behaviour to dislodge the amplecting pair.

April 2011. During this period, amplexus was also observed to take place during the daytime (Figure 4). Amplexus took place both on land and in water. Some of the amplecting pairs constructed foam nests on a rock at the side of the pond at about 30 cm above the water. The female produced a batch of eggs and pushed them into the froth by swimming motion of its hind limbs and the male was also observed to make the same movements. Both male and female frogs were observed to take part in nest construction. On the same rock another pair was observed in amplexus. Some of the amplecting pairs were found in the pond and a number of males were observed to dislodge the amplecting pairs and combat with other frogs in the pond.

The present study indicates that *R. maximus* is an early breeder, as breeding activity and movements of frogs to the temporary rainfed pools and ponds for spawning are initiated with an increase in temperature and the arrival of rainfall in March. In this context, *R. maximus* exhibits sporadic rain-linked breeding. Also, the species breeds after rainfall as there must be some standing water for the deposition of spawn. Rainfall influences the reproductive phenology of many amphibian species, particularly in tropical forests with seasonal precipitation. Therefore, dependency upon an aquatic environment for reproduction results in breeding migrations before and after spawning[15], covering distances of up to several kilometres[1]. This was also observed in *R. maximus*, where movement of the arboreal frogs to the aquatic environment for spawning was initiated with the increase in temperature and the first few showers of rain. The availability of these sites which are mostly temporary rainfed ponds restricts their breeding period to a short interval (6–8 weeks).

**Figure 3.** Foam nest attached to grasses and stones by the side of the pond.

**Figure 4.** Multiple amplecting pairs at the breeding site in Mawsynram, Meghalaya, NE India.

As indicated from the present study, *R. maximus* is an explosive breeder and breeds mostly in temporary pools and ponds. It has been reported that in explosive breeders, when male density is high, intense scramble competition occurs, and male mating success depends greatly on the ability to locate females and stay paired with them until the eggs are laid[16]. This has been recorded in the present study by the aggregating behaviour, combat among the males to compete with the others by producing loud chorusing advertisement calls to attract the females at the breeding site. It has been reported in *Polypedates leucomystax* that once reproductive activity is initiated at the onset of rainfall, an overcast sky with high humidity plays a greater role than temperature or heavy rainfall during the breeding season[8], which is also evident in case of *R. maximus* in the present study. The same preference for water availability in the breeding site was also reported in *Physalaemus* (Leptodactylidae)[17].

The loud and clear croaking sounds of male *R. maximus* heard mostly during the evening after rainfall and those heard in the daytime during the peak of the breeding period are relevant to its breeding behaviour, which is species-specific and serves to attract gravid females to the breeding sites. The presence of an abundant number of males and their aggregating behaviour at the breeding sites in the present study, lead to vocal competition or the defence of individual territories[18]. These calls are distinctive and of widespread interest in the studies of behaviour and sexual selection. The advertisement calls of the males contain information for species recognition[19]. Similar observation was also made in the present study, where it was found that the advertisement calls of *R. maximus* are species-specific, which serves to attract gravid females of the same species only to the breeding site. In this context, our observations on severe mating competition, appears to be in line with the aforementioned findings.

Various studies have reported that majority of Indian rhacophorids construct their foam nests attached to vegetation above the water bodies[4–6]. Interestingly, the foam nest of *R. maximus* constructed on diverse substrata is unique from that of other tree frogs reported so far, e.g. some of the foam nests were observed to be constructed attached to vegetation above the surface of water, on earthen banks attached to the grasses and stones on the side of the pond, and the foam nests were usually found exposed. No foam nest was seen on leaves as in some other rhacophorids[5,14]. This may be due to the short duration of breeding activity so the frog takes the opportunity to spawn in any substrata where water is available to avoid desiccation.

Rhacophorids avail the opportunity of transitional aquatic habit during monsoon, and desiccation is a major factor for reduction of populations in tropical climate[4]. Therefore, foam nests are thought to be related to egg or tadpole protection against desiccation[1] and predators[20]. Thus, construction of foam nest in *R. maximus* appears to have evolved mainly for protection against desiccation, predation on eggs or embryos in the aquatic media and thermal damage. A similar logic was put forward for foam nests in leptodactylids[3,20]. Further research on rhacophorids of NE India is needed so that more information about their evolution, ecology and reproductive strategies could be obtained.


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# A novel ant species of the genus *Anochetus* (Hymenoptera: Formicidae) from India with a remarkable nest entrance architecture

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**A novel ant species, *Anochetus daedalus*, is described based on worker caste collected from a nest in secondary tropical semi-evergreen forest from Sirsi, Karnataka, India, part of the Western Ghats biodiversity hotspot. It is very similar to *Anochetus nietneri* Roger, but is distinctly different in shape of the petiole. The species is notable for constructing elaborate nest entrance which resembles 'fort nests' constructed by some *Pheidole* spp.**

**Keywords:** *Anochetus daedalus*, labyrinthine fortification, nest entrance, worker caste.

THE ant genus *Anochetus* Mayr (sub-family Ponerinae) has 119 extant and eight fossil species[1], predominantly distributed within the tropics and warm temperate regions[2]. So far 11 species have been reported from India[3], out of which nine are found in the Western Ghats biodiversity hotspot. In this communication we describe *Anochetus daedalus* sp. nov. collected from the tropical evergreen forests of Sirsi, Karnataka, India in the central Western Ghats. This species is notable for conspicuous labyrinthine fortification at the nest entrance constructed using excavated mud or clay (Figure 1 *a*).

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