UIE level indicates current iodine status in a population. In the present study TGR was 12.6%, which indicates the prevalence of mild iodine deficiency, while median UIE was 12.4 mcg/dl indicating no biochemical iodine deficiency in the age group. Hence, the findings of the present study suggest that Birbhum district is in a transition phase from iodine-deficient to iodine-sufficient. Similar findings have been reported in earlier studies in India[8–11]. However, sustained monitoring and intensified information, education and communication (IEC) activities are needed for elimination of IDD in the district.

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Breeding ecology of a rare microhylid, *Ramanella montana*, in the forests of Western Ghats, India

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We studied the breeding seasonality, habitat characterization, and survival of the species from egg until tadpole by counting the total eggs, tadpoles and froglets that finally emerged from a hole of the *Dipterocarpus indica* tree in a cardamom estate in the hill ranges of Western Ghats. Egg-laying coincides with the early monsoon period. The eggs of *Ramanella montana* were predated by snails, caddisfly larvae and millipedes. The hatching success ranged between 11.81 and 20.37% (mean = 17.72; SD = 5.13; *n* = 4) and all the tadpoles that survived in the hole metamorphosed to froglets.

ANURANS having a biphasic life cycle, breed in a variety of water bodies ranging from highly ephemeral to permanent ponds. Different communities of predators and competitors in turn inhabit these diverse water bodies[1]. Many species that breed in temporary water bodies are explosive breeders, and metamorphosis and development is completed within a short hydroperiod[2]. In the tropical rain-forests, frogs also breed in unusual microhabitats. Small phytotelmata, pools of water formed in various plant structures such as bromeliad tanks, modified leaves, open fruits, and nut capsules are frequently used for egg and tadpole deposition by tropical frogs during the wet season[3].

The evergreen forests along the slopes of the Western Ghats in South India support a wide variety of amphibian species. Of the 121 species of anurans known to occur here, 92 are endemic[4,5]. Out of the eight known species of the genus *Ramanella*, six are confined to India[6]. *Ramanella montana* is a rare and secretive microhylid, endemic to the Western Ghats[7] and is a near-threatened species[4]. Data on the species are sparse; little is recorded of its aestivation habits[8] and breeding habitats[9]. This is a report on the breeding ecology of *R. montana*.

The study area, Hosagadde, is a cardamom estate (12°15′N and 75°33′E) located in the higher elevations, adjoining Bisale Reserve Forest, a crest of the western slopes of the Western Ghats at an elevation of 910 m asl. The area receives an annual mean rainfall of 5500 mm, resulting in numerous hill streams. This makes it an ideal habitat for diverse anuran species. The vegetation is semi-evergreen[9] and classified as *Dipterocarpus indicus–Kingidendron pennatum–Humboldtia brunonis* forest type[10].

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Although adults are reported to aestivate in stem holes and tree crevices during the non-breeding season[11], we observed *R. montana* among the fronds of tree ferns and the leaf sheaths of palms and wild banana plants during the non-breeding season (March–April). They began their activity only after the area started receiving few consecutive monsoon showers. A total of 32 night call surveys along a 4 km transect were conducted from the third week of May to the end of September, within the 40-ha plot of the study area. Single breeding aggregation with four calling males and five females of *R. montana* was located in rainwater collection within the tree hole of *Dipterocarpus indica* in May 2002 (Figure 1). The tree hollow was an upwardly facing 10-cm deep hole, between the parallel buttresses of ca.15-m tall live tree. We made observations until the post-monsoon season (November 2002) on calling time, breeding behaviour, and predation every hour until the eggs were deposited and thereafter between 1700 and 2200 h and also 0500 and 0800 h each day. The number of eggs per clutch was counted (n = 4). The height of the water-filled hole from the ground, hole diameter, hole volume (measured by filling the dried hole with a known quantity of water after the breeding season ended), and water temperature were recorded. Hatching success was calculated as the percentage of eggs that ultimately hatched to tadpoles. The percentage of froglets that emerged from tadpoles was also calculated from the total tadpole count data.

Breeding coincided with the early monsoon rains from May (Figure 2). The breeding pool on the tree hole was 1.5 m above the ground. The water was dark brown in colour with 3–4 layers of decaying leaves and sticks at the bottom (8–13 cm). The water hole measured 30 cm in diameter and 10 cm in depth. The total volume of the hole was 9.5 l. Rainwater filled the hole and dense vegetation covered it from above. Fallen and dead leaves in the pool provided areas for egg deposition and a refuge for the tadpoles.

Figure 1. *Ramanella montana* in a tree hole water collection in the forests of the Western Ghats.

At the start of the breeding season, male *R. montana* locate suitable breeding sites and start calling. Single males emitted calls which were audible from a distance of 20 m. Four calling males eventually occupied the same tree hole. The individual calls of the four males did not overlap temporally with each other. Five days after the males began calling, females arrived at the breeding site. There was no territorial behaviour among the males.

Males positioned in the water and called throughout the night beginning at 1830 h and lasting until 0800 h (sunset, 1815 h and sunrise, 1800 h). Each call was of 20–30 s duration and had 6–8 notes. Calling males measured 27.8–29.5 mm SVL (mean = 28.67; SD = 0.89; n = 4), and females 30.2–31.1 mm SVL (mean = 30.5; SD = 0.4; n = 5). Water temperature during oviposition ranged between 21.5 and 22°C and the air temperature was 24°C. The relative humidity varied from 55 to 68%.

While in axillary amplexus, the male clasped the female and pressed her abdomen against the tree trunk, which apparently facilitated egg deposition. Oviposition occurred on the ninth day of calling and four days after the females entered the pool. Eggs were deposited during the early morning hours between 0340 and 0430 h and were attached to the surface of the tree trunk just above the water and on the floating, dried leaves within the water collection. Clutch size varied between 108 and 130 (mean = 117; SD = 10.13; n = 4). Eggs were positioned in batches of four or five, spread throughout the pool. They hatched in eight days. Metamorphosis was completed in 160 days.

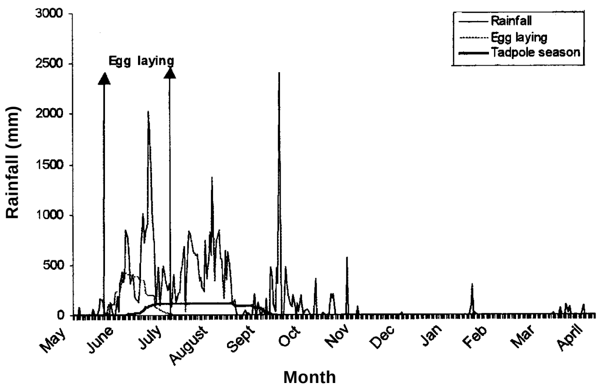

Figure 2. Rainfall and breeding seasonality of *R. montana* in Hosagadde, Western Ghats from May 2001 to April 2002.

Table 1. Hatching success of eggs of *R. montana* in tropical rainforests of Western Ghats

Clutch no.	No. of eggs per clutch	No. hatched into tadpoles	Survival rate from egg to tadpole (%)
1	108	22	20.37
2	130	20	15.38
3	110	13	11.81
4	120	28	23.33
Total	468	83	17.72 (± 5.2)

The froglets measured 4–6 mm (mean = 4.65; SD = 0.65; $n = 35$) when they emerged. The froglets were observed to live within the water collection until September. Later they dispersed and entered the dark and moist crevices of the same tree. Rains frequently replenished the pool under observation. We found that the pool was also used by few invertebrate species (e.g. *Culex* mosquitoes and caddisflies) for larval development. The eggs of *R. montana* were eaten by snails, caddisfly larvae and millipedes. Percentage survival from egg-to-tadpole stage ranged between 11.81 and 20.37% (mean = 17.72%; SD = 5.13; $n = 4$; Table 1). All the tadpoles metamorphosed into froglets and were found to leave the water body. Hence, the survival from tadpoles to froglets was 100%.

Breeding by *R. montana* coincided with the monsoon, which is typical for many other South Indian anurans[5,6]. However, unlike microhylid *R. variegata* that breeds during the mid or late monsoon, *R. montana* breeds soon after the onset of the monsoon rains[9]. This may be because *R. variegata* breeds in temporary rainwater pools, which form usually by mid monsoon after repeated rains. Late breeding by *R. variegata* may be also due to its burrowing habit and late arrival at the water source after several rains. Unlike the solitary breeding of *R. variegata*[6], *R. montanna* breeds communally, where three or more males and more than four females occupy a corner of a single waterbody within a tree hole.

Egg masses of other Indian microhylids float on the water surface[6], whereas *R. montana* clutches are always found adhered to a tree trunk just above the water level or they are placed on the surface of a floating leaf. Hence, the egg-laying habit of *R. montana* differs from other microhylids. The clutch size in *R. variegata* is reported[6] to be 575–1417, while that of *R. obscura* in Sri Lanka[6] is 557. This differs from *R. montana*, which has a clutch size of 117 ± 10.13 eggs. Tadpoles of *R. variegata* complete metamorphosis in 32 days, whereas *R. montana* completes metamorphosis in 160 days. Although 100% hatching success has been reported in the laboratory-hatched eggs of *R. variegata*[6], data in the natural habitat are not available. A low survival success of mean 17.72% in *R. montana* in the wild may either be due to predation or desiccation of eggs attached to the tree trunk that are not replenished by rain[9].

Tadpole survival depends on many physical, chemical and biological factors. Mortality during the early developmental stages is high in amphibians, mainly due to predation by invertebrates and vertebrates[12]. Survivorship from egg stage to metamorphosis in Mississippi frogs[13], *Rana capito* is 4.91%, *R. pretiosa* 4.3%, and *R. aurora* 5%. In general, survivorship of ranid larvae has been estimated[13] to be around 5%. In microhabitats such as tree holes or leaf axils, food is limited and cannibalistic behaviour has also developed as a secondary means for survival[3]. Although the cannibalistic nature was not observed among the tadpoles of *R. montana*, the low reproductive success in *R. montana* can be attributed to the breeding microhabitat where it is exposed to a high degree of predation and non-availability of tree holes. Removal of larger trees from the plantations may have an adverse effect on *R. montana* populations as it reduces the availability of breeding sites.

The survival of *R. montana* is dependent on various factors such as tree holes, hydroperiod and predation. Embryonic mortality appears to be the primary cause for the low recruitment rate in *R. montana* populations as observed in the case of *R. capito* and *Rana sphenocephala*[13]. Detailed studies of reproductive ecology and use of phytotelms as developmental sites by the tropical anurans are needed to shed light on the conservation requirements of the species and for the presence of large trees and canopy-covered forests.

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