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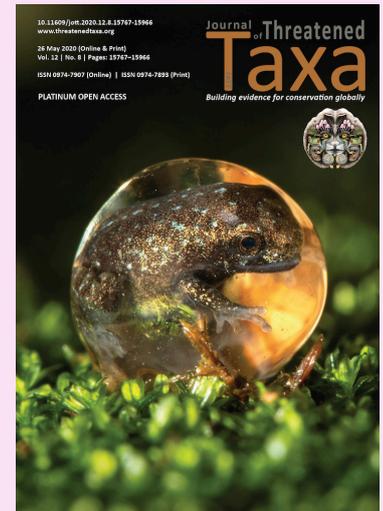
SHORT COMMUNICATION

LIFE-HISTORY TRAITS AND COURTSHIP BEHAVIOUR OF FOUR POORLY KNOWN ENDEMIC BUSH FROGS (AMPHIBIA: ANURA: RHACHOPHORIDAE) FROM THE WESTERN GHATS OF INDIA

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Life-history traits and courtship behaviour of four poorly known endemic bush frogs (Amphibia: Anura: Rhachophoridae) from the Western Ghats of India

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Abstract: The Western Ghats have a high level of anuran endemism. Although there has been an extensive focus on their taxonomy, the ecology of most species are poorly known. In this note we describe the reproductive life-history traits and breeding behavior of four species of endemic bush frogs, *Pseudophilautus wynaadensis*, *Raorchestes akroparallagi*, *Raorchestes glandulosus*, and *Raorchestes ponmudi* (Amphibia: Anura: Rhachophoridae) from Wayanad region of Western Ghats.

Keywords: Clutch-size, reproduction, metamorphosis, direct metamorphosis, coffee plantation, *Pseudophilautus wynaadensis*, *Raorchestes akroparallagi*, *Raorchestes glandulosus*, *Raorchestes ponmudi*

The Western Ghats mountain ranges is one of the global biodiversity hotspots (Myers et al. 2000). The area has a high diversity of amphibians, many of which are endemic (Das et al. 2006; Dahanukar & Molur 2020). In the past two decades, while researchers have extensively focused on amphibian taxonomy and systematics, the knowledge about their basic life-history traits (e.g., time to first reproduction, clutch size, weight at hatching) are still limited. This information can be vital for understanding both the ecology and conservation status of a species.

In this note, we describe the egg-laying behavior, and two life-history traits (clutch size, and time to metamorphosis) for four species of endemic bush frogs, *Pseudophilautus wynaadensis*, *R. akroparallagi*, *R. glandulosus*, and *R. ponmudi*, all of which have direct development (Vijayakumar et al. 2016). All these species are known to breed during the monsoon season.

Previously, one paper each has described the breeding behavior of *R. akroparallagi* (originally reported as *R. glandulosus* by Biju (2003) but species identity rectified in Biju & Bossuyt (2009)) and *R. glandulosus* (Krishnamurthy et al. 2002). However, after reviewing Krishnamurthy et al. (2002), we realized that *R. glandulosus* had been misidentified (it is likely *R. tuberothumerus* since the groin and anterior surfaces of thighs in their Figure 1 is dark brown with yellow blotches). No article, to the best of our knowledge, has reported the breeding behavior or life-history traits of the other two species (*R. ponmudi* and *P. wynaadensis*).

We report observations that were made in a coffee plantation situated next to Kalloor, Sulthan Bathery (Wayanad, Kerala), around half a kilometer away from Wayanad Wildlife Sanctuary, Kerala (11.664°N &

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76.331⁰E). For detailed observations, each amplexing pair was transferred to a terrarium (a plastic circular 20L tub – 80cm diameter and ~1m height), which was installed outdoors in a shaded area to maintain the ambient temperature and humidity. The terrarium was covered with a mesh and consisted of a layer of soil collected from the same area (7–8 cm thick), leaf litter, and vegetation (a few branches of a coffee tree with intact leaves, grass). All the adult individuals were released back to the same location from which they were captured the previous night, assuming there is no parental care (as suggested by Biju 2003). All the observations were done using a LED torch whenever necessary.

Pseudophilautus wynaadensis

Two amplexing pairs were found on coffee plant (about 50–100 cm from the ground), the first on 15 May 2016 and second on 15 July 2019 (Image 1a). Both the pairs were transferred to the terrarium, and by morning the pairs had finished laying eggs. The frogs

had transformed into a duller brown color over the night in both cases.

After inspecting the terrarium, in both cases the eggs (Image 1b) were found underneath a small layer of soil (1–2 cm deep). The number of eggs in the first and second clutch were 29 and 33, respectively. In the successive days, the froglets underwent direct development (Image 1c) and hatched synchronously after 22 and 25 days, respectively (Image 1d).

We weighed the eggs from the 2019 clutch throughout the developmental period. The average weight of the eggs was 0.074g (N=10; measured on 11th, 18th, 22th, and 25th day after the egg laying). A newly hatched froglet weighed 0.019g (N=3).

Raorchestes akroparallagi

An amplexing pair of *R. akroparallagi* (Image 2a) was found during late evening (20.25h) on 10 June 2019, during a slight drizzle. The pair was observed sitting on a coffee plant leaf (about 160cm above ground). After around half hour of observation, they were transferred



Image 1. *Pseudophilautus wynaadensis*: a—amplexing pair | b—eggs | c—eggs after 22 days of development | d—froglets. © Abhijith A.V.

to a terrarium. The frogs were inspected every few hours, and throughout the night the male remained attached to the female's dorsum. The greenish colored frogs had transformed into shades of brown by morning (Image 2b).

At 11.54h, we found that the female had already started laying eggs (5 eggs were visible). The pair was closely observed throughout the egg-laying period (Image 2b). After egg-laying (12.17h), the male detached himself from the female and positioned himself in a restful manner on one of the coffee leaves. Meanwhile, the female covered up the eggs with soil particles that surrounded it. During this process, the female rolled the eggs in the soil such that the whitish-cream colored egg turned into a reddish-brown color (same as the soil). An earlier study had recorded the egg-laying on a coffee leaf (Biju 2003).

On 11 June 2019, we carefully exposed all the eggs (a total of 49 eggs) from the soil. The eggs underwent direct development (Image 2c), and after 21 days of

laying the eggs, all the froglets hatched synchronously (Image 2d).

Raorchestes glandulosus

On 07 June 2019, at around 19.30h a female *R. glandulosus* was located on the leaf of a coffee plant at a height of approximately 200cm. The female approached a calling male (also situated around 2m from the ground level) on the same plant. After about 15 minutes, the male gave out a distinct call and pounced onto the female. The female reacted by jumping away from the male after which the male started calling again. The male and female responded to each other in this manner three times. On the fourth try, the male managed to successfully hold onto the female's dorsum facing the opposite direction (Image 3a). After a while, the male realigned himself facing towards the female, head following which the amplexing pair was transferred to a terrarium.

The amplexing pair laid eggs inside the soil (1–2 cm



Image 2. *Raorchestes akroparallagi*: a—amplexing pair | b—pair laying eggs, note the change in color | c—eggs after 22 days of development | d—a froglet. © Abhijith A.V.



Image 3. *Raorchestes glandulosus*: a—amplecting pair, male sitting on the female facing the opposite direction | b—eggs laid in the soil | c—eggs after 15 days of development | d—froglet. © Abhijith A.V.

in depth; Image 3b), even though they had the choice to lay their eggs on the leaf of a branch. The yellowish-green frogs transformed into shades of brown during the process of egg-laying (at 02.33h), and the female covered the eggs using soil particles that surrounded the egg clutches. A total of 55 eggs were laid and underwent direct development (Image 3c). The froglets synchronously hatched after 21 days (Image 3d).

Although the above mentioned observations were recorded from a terrarium, similar observations have been reported from a natural setting near Madikeri, Karnataka (Abhishek Jain pers. comm. June 2019). A pair of amplexing individuals was located on 12 June 2019. The female laid 39 eggs in a cluster about 3cm below the leaf litter mixed with soil. The frogs changed their colours to dull brown within 15 minutes of heading down to the leaf litter. Even in this case, all the eggs underwent direct development and hatched synchronously.

Raorchestes ponmudi

We observed two different clutches of this species. The first pair of *R. ponmudi* was found during late evening (19.55h) on 18 May 2019, after a short rain (5.8mm). The temperature that night was 22.6°C and a humidity of 86%. The pair was observed in an amplexus, on a horizontal coffee branch about 150cm above ground. Two other males were calling from the same plant, frequently giving out a territorial call and showing a tendency for fighting. The amplexing pair (Image 4a) was observed for around an hour.

Following this, the pair was transferred to a terrarium. The frogs were inspected every few hours for around 15min, and their activities were recorded. The female carried the male from leaf to leaf and finally settled down on a small patch of bare soil at around 02.30h. The male remained firmly attached to the female's dorsum. When the frogs were inspected the following morning (~ 06.00h), the male had detached himself from the female and was resting on a coffee leaf. Since the previous



Image 4. *Raorchestes ponmudi*: a—amplecting pair | b—eggs laid in the soil | c—eggs after 18 days of development | d—froglet. © Abhijith A.V.

observation was taken at 03.30h, the egg laying must have happened sometime between 03.30h and 06.00h.

At 06.00h, the female looked lean (when compared to the previous night), and was seen covering up the eggs using soil particles that surrounded the egg clutch. This activity went on for another one and a half hours, after which the individual settled down and rested on the soil.

After a day (12 June 2019), a total of 81 eggs were carefully collected from the soil (1–2 cm). Each egg was unpigmented, whitish-cream colored, and covered by a thick jelly coat (Image 4b). Water was sprayed once in two days to prevent the eggs from drying. The egg clutch was observed every day and photographs of its developmental phases were taken. The eggs underwent direct development (Image 4c), and after 19 days, the froglets hatched (Image 4d).

The second amplexing pair of *R. ponmudi* was found at 21.31h (same coffee plantation as above), on 25 May 2019. The average rain that night was 8mm, and the

pair was located around 1m from the ground level. Interestingly, the male was sitting on the female facing the opposite direction. Only after a few hours did the male align himself properly on the female. In both the amplexing pairs, the frogs changed their color to dark brown during the egg-laying process.

This pair was also transferred to a terrarium (similar dimension as the previous pair), where the female laid the eggs in the soil at a depth of around 1–2 cm. Egg-laying started at approximately 05.00h. After the male detached himself, the female covered the eggs with soil. The female laid a total of 78 eggs. This time, the eggs were not disturbed, and the soil was sprayed with water to prevent it from drying up, however, after a few days we observed fungal growth on the soil, and the development of the froglets ceased. Later the eggs dried up.

CONCLUSIONS

To summarize, all the four species of bush frogs laid their eggs in moist soil, under a layer of leaf litter, where they underwent direct metamorphosis. The clutch size for the three *Raorchestes* species ranged from 49 (*R. akroparallagi*), 55 (*R. glandulosus*) to an average of 83 eggs (for *R. ponmudi*). Their time to hatching ranged from 19 (for *R. ponmudi*) to 21 days (*R. akroparallagi*; *R. glandulosus*). *Pseudophilatus wynaadensis*, on the other hand, had an average clutch size of 31 eggs and hatched between 22 and 25 days. To the best of our knowledge, there is only one record of the breeding biology of *R. akroparallagi* (Biju & Bossuyt 2009). Apart from this, these are the only known records of some of the reproductive life-history traits of the other three species of bush frogs.

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