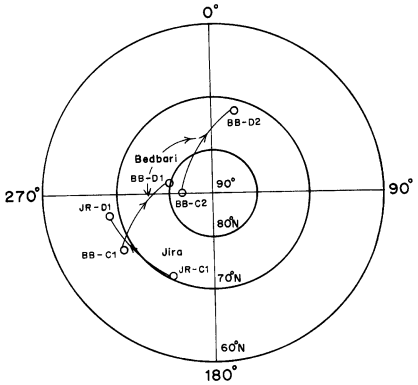

Figure 4. Virtual Geomagnetic Pole (VGP) position of samples investigated for palaeoseismology from Shillong Plateau. Arrows denote changes in VGP positions of the host strata (C) and sand dykes (D) for liquefaction sites at Bedabari (BB) and Jira (JR).

from Figure 4 that there is a considerable difference in the VGP positions of the dyke of seismic origin *vis-à-vis* host strata which can be attributed to differences in emplacement timings of the dykes and host strata. Figure 4 shows cases of Bedabari D1 and D2, and Jira D1, wherein the VGP positions have moved clockwise in comparison to those of the host strata (Bedabari C1 and C2, and Jira C1). However, neither the emplacement time of the sand dyke nor that of the host strata can be assigned at present due to lack of secular variation curve of geomagnetic field of the study area for this period. However, the potential of remanent magnetic studies is demonstrated here to obtain the timing of emplacement of the palaeoliquefaction features as a result of earthquake occurrences belonging to historical or pre-historical past.

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Reproductive mode in the shrub frog *Philautus glandulosus* (Jerdon, 1853) (Anura: Rhacophoridae)

The diversity of reproductive modes is much greater in amphibians than in other groups of vertebrates, especially the amniotes[1]. Mode of reproduction is a combination of oviposition site and type of egg development[2].

Among the 33 genera of anurans reported from India[3,4], *Philautus* is the only genus having direct development (all development occurs within the egg membranes, and there is no free-swimming tadpole stage). The Asian genus *Philautus* consists of 84 nominal species belonging to the family/subfamily Rhacophoridae/nae[4]. The highest diversity in this genus is found in the Western Ghats of India and in Sri Lanka; many of these species are awaiting scientific description[5,6]. But taxonomy and systematics of this group are, however, in a preliminary stage[4]. Courtship and mode of reproduction of this group in India have virtually not been studied, except in *P. 'variabilis'*[7], *P. tinniens*[4] and *P. bombayensis*[8]. This communication reports the mode of reproduction of a fourth species – *Philautus glandulosus* (Jerdon, 1853) from Kalpatta in the Western Ghats. This species has direct development.

This small-sized (SVL 20.4–22.9 mm male; 24.5–26.0 mm female) shrub frogs usually have a light leaf-green dorsum without marking. During the breeding season, however, the leaf-green colour of the female turns light yellowish-green with small brownish specks, and males turn uniform brownish-green.

The study was conducted in a coffee plantation near the moist secondary forests in Kalpatta, Wayanad (11°38′N, 76° 08′E). During the late evening (18.00 h) of 28 June 1997, a pair of *P. glandulosus* in amplexus was observed sitting on a coffee leaf about 1 m above the ground. Many calling males were observed on the same plant (Figure 1), but no other female was located nearby. By night, two sources of light were used to take

Figure 1. Male *Philautus glandulosus* with single subgular external vocal sac (SVL 21.3 mm).

observations: a dim light and a red flashlight. The 'focal animal' method[9] was employed. Due to significant variation in the breeding behaviour between wild and caged individuals of some Rhacophorid species of the Western Ghats (Biju, unpublished), the following observations were made under natural conditions.

The pair in amplexus was seen at 20.00 h just after a drizzle. The frogs continually moved from one plant to another and had not laid eggs by 21.00 h. By 22.30 h the pair stopped moving, settled on a leaf, and started laying eggs along with a fluid. No movement by the male was observed; he remained firmly positioned on the female's dorsum. The female moved forward during the process of egg-laying to avoid clumping of the eggs on top of each other (Figure 2). The eggs were non-pigmented, white in colour, and they were protected by a dense jelly layer. They were large and measured 4.4 ± 0.2 mm ($N = 48$) in diameter. Forty-one eggs were laid by 3.00 h. The male dismounted the female after completion of egg-laying, and both male and female moved away from the egg mass. The egg mass was repeatedly observed at different intervals, day and night, but no parental attendance was noticed. The eggs underwent direct development, and hatching of froglets occurred after 28 days. A detailed description of this development will be published elsewhere.

Figure 2. Axillary amplexus in a pair of *P. glandulosus* in the process of egg-laying.

There are 29 types of reproductive mode reported in amphibians, and this species belongs to 'type 20' (ref. 1). Among the four species of *Philautus* so far reported with direct development of eggs, *P. tinniens* deposits eggs on the ground under a log or stone (mode 17)[4], and *P. 'variabilis'* and *P. bombayens* deposit eggs on vegetation above the ground (type 20)[7,8].

The present study documents direct development in the wild in this group of frogs. Previous reports were either in captivity[7] or by indirect observation[4,8].

Additional observations were conducted in the habitat during daytime. Two more clutches, containing 20 and 28 eggs, were located. These clutches were also attached to the upper side of leaves. All the eggs were dry with fungal infestation, probably due to dry weather. Although egg masses that develop directly on vegetation do not directly depend on rainwater, atmospheric moisture plays an important role in the successful completion of development.

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