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## A new species of frog (Ranidae, Rhacophorinae, *Philautus*) from the rainforest canopy in the Western Ghats, India

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**A new frog of the genus *Philautus* is described from Wayanad district in the Western Ghats of India. It differs from all its congeners by the combination of webbed fingers, nearly fully webbed toes and a distinct dermal fringe along the outer margin of the fore- and hind limbs. *Philautus nerostagona* sp. nov. exhibits several characteristics suggesting that it is strongly adapted to life in the upper layers of the rainforest.**

THE discovery of quite a number of undescribed frog and caecilian species in India<sup>1-4</sup> during the past decade illustrates that our knowledge on the amphibian diversity of this region is still far from complete. While the ground- and shrub level of rainforests in the subcontinent is now being explored intensively, it remains difficult to investigate the lowest (subterranean) and highest layers (canopy) of these habitats. During our exploration of the anurans in the Western Ghats of India, we located an undescribed frog inhabiting the canopy layer (between ca. 10–20 m) of the forests in Kalpatta, Wayanad district. The glandular belly, the large unpigmented eggs and the fully endotrophic development identify this taxon as a member of the genus *Philautus*.

*Philautus nerostagona* sp. nov. (The species epithet is the combination of two Greek words – *nero*, water and *stagona*, drop – and refers to the call resembling drops falling down in water.) Holotype: Bombay Natural History Society (BNHS), Mumbai, Maharashtra, India, BNHS 4244, an adult male collected by S.D.B. on 20 July 2000 at an altitude of 1000 m asl, from Kalpatta, 11°38'N, 76°08'E, North of the Palghat Gap, Wayanad district, Kerala, India; Paratypes: BNHS 4245 (adult male), collected by Anil Zachariah on 4 June 1999, and BNHS 4246 (adult male), collected by S.D.B. on 1 August 2000 from the same locality as the holotype.

Diagnosis: *Philautus nerostagona* is easily distinguished from all species in the genus by a combination of the presence of webbing between the fingers, nearly fully webbed toes, a distinct dermal fringe along the outside of the fore- and hind limbs, and a tongue with a pointed papilla.

The description (all measurements in mm) of the holotype (Figures 1a and 2) follows terminology used elsewhere<sup>5</sup>: Small size (SVL 34.0); head (Figure 2b) broader than long (HW 13.7; HL 12.6; MN 10.6; MFE 9.1; MBE 4.8); outline of snout in dorsal view rounded, in profile rounded, its length (SL 5.3) longer than the horizontal diameter of the eye (EL 4.4); canthus rostralis sharp, loreal region obtusely concave; interorbital area slightly concave, equal (IUE 3.2) to upper eyelid (UEW 3.2) and internasal distance (IN 3.2); distance between anterior margins of eyes (IFE 6.8) 1.7 times in distance between posterior margins of eye (IBE 11.7); nostrils oval, closer to tip of snout (NS 1.6) than to front of eyes (EN 3.5); pupils oval, horizontal; tympanum distinct, rounded, its diameter (TYD 2.0) less than half the diameter of the eye, larger than distance from tympanum to eye (TYE 1.0); vomerine teeth absent; tongue large (9.8 × 5.7), emarginate, with a pointed papilla; supratympanic fold distinct, from posterior corner of upper eyelid to base of forelimb; no co-ossified skin on skull.

Forelimbs (FLL 7.4) shorter than hand (HAL 10.6; TFL 6.3; Figure 3a); dermal fringe along the outside of the fore limbs; relative length of fingers: I < II < IV < III; tips of fingers with disks, oval, with distinct circummarginal grooves; fingers, with lateral dermal fringe moderately webbed; subarticular tubercles prominent, rounded, single, III2 and IV2 absent; prepollex rather distinct and oval; supernumerary tubercles distinct, prominent on palm and second and third fingers.

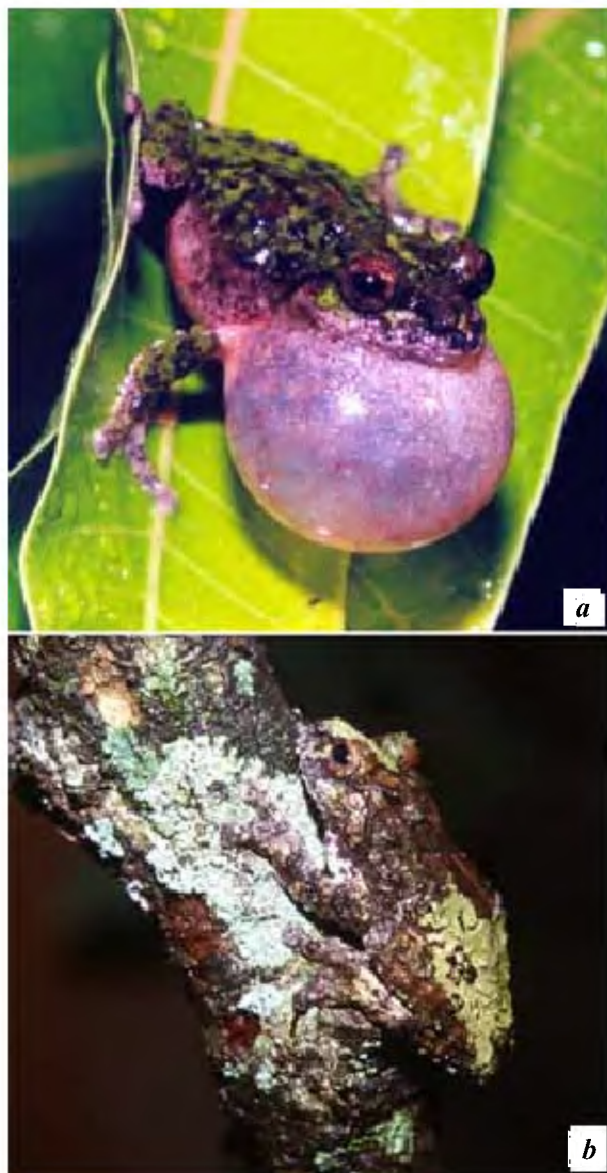
Hind limbs moderately long, heels touch with limbs folded at right angles to the body; shank nearly five times longer (TL 17.1) than wide (TW 3.6), as long as the thigh (FL 17.1), and longer than distance from base of internal metatarsal tubercle to tip of toe IV (FOL 14.3); length of toe IV (FTL 8.8) 2.6 times in distance from heel to tip of toe IV (TFOL 23.1); relative length of toes: I < II < III < V < IV; tips of toes with discs, rather wide compared to the toe width, with a distinct circummarginal groove; toes nearly fully webbed (Figure 3b); a distinct dermal fringe along the outside of the hind limbs, ending with a well-developed spinular projection on the heel; subarticular tubercles distinct,

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rounded, simple, V2 absent, and IV3 weakly developed; inner metatarsal tubercle distinct, oval, and its length (IMT 1.7) two times in length of toe I (ITL 3.4); supernumerary tubercles present on all fingers and toes.

Skin shagreened to granular on snout, and glandular with short spinular projections on side of head and between eyes, on upper eyelids, and on dorsum and flanks; dorsal parts of fore- and hind limbs shagreened with some scattered granules; throat, chest, belly and posterior ventral part of thighs glandular.

Secondary sexual characters: Nuptial pads not evident; vocal sac median subgular, with a pair of openings at the base of the throat.



**Figure 1.** *Philautus nerostagona* in life. *a*, Holotype (BNHS 4244) and *b*, Paratype (BNHS 4245).

Colour of holotype in alcohol: Dorsally light brown with tan and dark brown patches, laterally light brown; loreal and tympanic region grey with irregular white, tan and dark grey patches; dorsal surface of fore- and hind limbs light grey with light brown cross-bands; disks of fingers and toes grey; ventrally grey with various amounts of irregular patches and spots; tibia with light brown to black markings.

Colour of holotype in life (Figure 1*a*): Dorsum and dorsal side of fore- and hind limbs light brown with dark green and reddish-brown irregular patches of varying size, laterally bluish-black vermiculated with brown patches; loreal and tympanic region light brown with irregular light green patches; iris reddish-grey with a dark brown ring; hands and feet grey; posterior margins of femur and tibia chocolate brown; ventrally off-white with various amounts of brown, light grey and light yellow spots forming a vermiculated pattern; throat grey; lips white with dark bands.

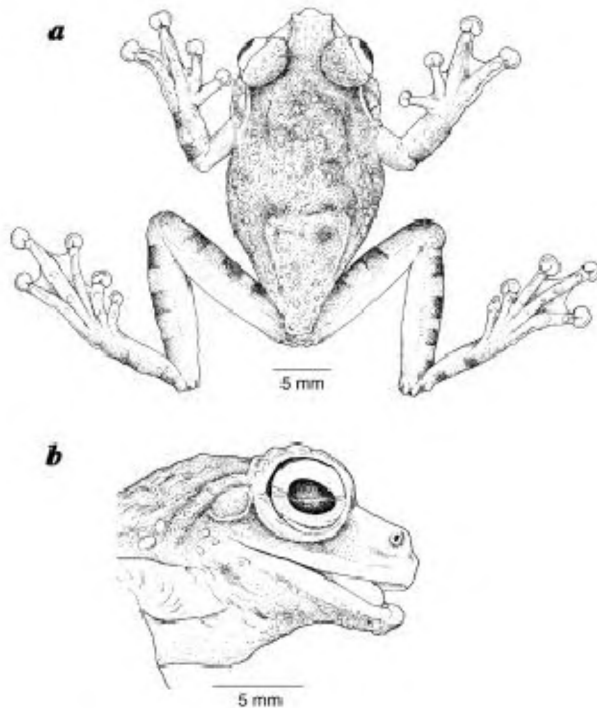
Variation: Measurements (in mm) reflecting the morphological variation of the type series are given in Table 1. This species has the ability to adapt its colour to the surroundings, and is thus highly variable. For example, the colour pattern of the paratype (BNHS 4245) in Figure 1*b*, closely resembles the lichen-covered tree bark on which it is perched.

Comparison: *Philautus nerostagona* was compared with the description and available material of all valid species currently recognized in the genus *Philautus*<sup>5-8</sup>. In general morphology, it most closely resembles '*Theloderma*' *schmarda*, which was shown to be a member of the *Philautus* radiation in Sri Lanka<sup>9</sup>. However, *P. nerostagona* is easily distinguished by the presence of webbing between the fingers and more extensive webbing between the toes.

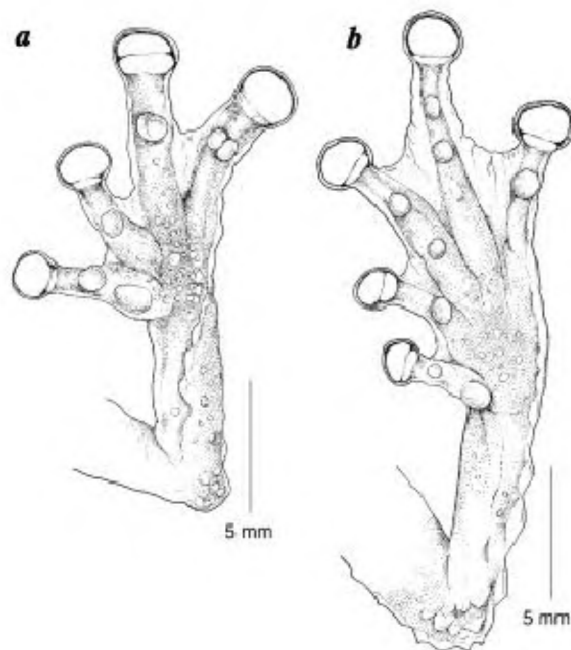
This frog cannot easily be located because it lives almost exclusively in the highest canopy layers; the holotype was

**Table 1.** Measurements (mm) of three adult males (holotype\* and two paratypes) of *Philautus nerostagona* sp. nov

	BNHS 4244*	BNHS 4245	BNHS 4246
Snout-vent length (SVL)	34.0	30.1	32.4
Head width (HW)	13.7	12.4	13.1
Head length (HL)	12.6	11.1	11.9
Internal front of eye (IFE)	6.8	6.0	6.2
Internal back of eye (IBE)	11.7	10.7	11.7
Inter upper eyelid width (IUE)	3.2	3.5	3.3
Maximum upper eyelid width (UEW)	3.2	2.9	3.0
Snout length (SL)	5.3	5.0	5.8
Eye length (EL)	4.4	3.8	3.8
Tympanum diameter (TYD)	2.0	1.9	1.9
Forelimb length (FLL)	7.4	6.5	7.1
Hand length (HAL)	10.6	9.1	9.4
Third finger length (TFL)	6.3	5.6	6.4
Tibia length (TL)	17.1	16.0	17.2
Foot length (FOL)	14.3	12.6	14.0
Fourth toe length (FTL)	8.8	7.2	7.8
Inner metatarsal tubercle length (IMT)	1.7	1.8	1.6
Inner toe length (ITL)	3.4	3.0	3.2



**Figure 2.** *Philautus nerostagona* holotype. Dorsal view (a) and profile of head (b).



**Figure 3.** *Philautus nerostagona* holotype. Ventral view of hand (a) and foot (b).

tree near the forest fringe, and paratype BNHS 4246 was collected from a height of about 20 m in the forest canopy. However, the nearly ubiquitous presence of *P. nerostagona* in the Sultanbathery–Kalpatta–Mananthavady triangle in Wayanad district can be easily established during the monsoon season by means of its distinctive call, resembling the sound of a drop falling into water, at intervals of 3–4 s.

The genus *Philautus* is characterized by direct development, a specialized reproductive mode without a free-living larval phase, but the number of species for which this has actually been observed remains limited. Most species seem to have their oviposition site either on the ground, or on leaves in vegetation up to 2 m above the ground<sup>5,10–12</sup>. In contrast, we located at Kalpatta a clutch of *P. nerostagona* eggs in a ca. 10 cm deep tree hole at about 10 m height. The eggs were non-pigmented white and protected by a dense jelly layer, measuring  $4.5 \pm 0.3$  mm ( $N = 41$ ) in diameter. Hatched froglets (20 days after discovery) were morphologically similar to the adults – confirming accurate identification. The oviposition and male calling-site preference, together with the relatively extensive webbing on fingers and toes, suggest that *P. nerostagona* is strongly adapted to life in the upper layers of the rainforest.

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collected from a height of 10 m on a tree near a coffee plantation, paratype BNHS 4245 was found at 14 m height in a

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## Embryonic development in alligator pipefish, *Syngnathoides biaculeatus* (Bloch, 1785)

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**The alligator pipefish, *Syngnathoides biaculeatus* (Bloch, 1785) is a common inhabitant of seagrass beds along Palk Bay, southeast coast of India. This primitive pipefish broods the embryos along the undersurface of its trunk. Eleven embryonic stages were sequenced based on morphological differences. The newborn resembles adults in form except for a slightly cylindrical body, shorter snout and brown colour. The gestation period was  $25 \pm 5$  days at a temperature range of  $28\text{--}32^\circ\text{C}$ .**

PIPEFISHES are amongst the most unusual and derive the name from their long and slender angular body. They belong to the family Syngnathidae, consisting of about 215 species in 52 genera. Pipefishes are cosmopolitan in distribution<sup>1</sup> between the north-south limits of latitudes  $71^\circ\text{N}$  and  $56^\circ\text{S}$ . They are commonly represented in fabrics and artwork and are sold dried or embedded in plastic as curios. Pipefishes are primarily sold for use in Traditional Chinese Medicine (TCM) and are credited with curing ailments ranging from asthma and arteriosclerosis to impotence and incontinence. They also provide remedies for skin ailments, high cholesterol levels, excess throat phlegm, goitre and lymph node disorders. They are reputed to facilitate parturition and also as powerful general tonic for the kidneys<sup>2</sup>. Apart from the inclusion in TCM, pipefishes are also exploited for aquarium-keeping for their peculiar and interesting habits<sup>3</sup>. Though as many as thirteen genera are reported to occur in Indian waters, not much is known about their reproduction. The present study has been undertaken for sequencing the embryonic development stages of the pipefish *Syng-*

*nathoides biaculeatus* for which no information is available so far.

The sampling was carried out in Thondi (lat  $9^\circ 45'\text{N}$ ; long  $79^\circ 13'\text{E}$ ) along Palk Bay, Southeast coast of India. Live adult male and female fishes, caught as bycatches, were collected from country trawls and shore seines. They were transported and maintained in the laboratory. Males brood the embryos along the undersurface of their trunk. Embryos at different stages of development were randomly removed from the brooder using a canula and preserved in 5% neutral formalin or glycerol. The developmental stages were then observed under a binocular microscope and sequenced based on morphological features.

Three stages can be distinguished in the development of a bony fish: embryonic, larval and fry. The embryonic stage is divided into nine substages: activation of egg, cleavage, blastulation, gastrulation, neurulation, organogenesis, separation of tail region from the yolk sac, development of the embryonic circulatory system and development of gill and jaw apparatus. In the larval stages there are four substages: mixed feeding, complete external feeding and differentiation of the unpaired fin fold, development of rays in unpaired fins and development of rays in paired fins. The fry period is characterized by the development of scale cover<sup>4</sup>.

Eleven advanced stages of development were identified and sequenced in the present study (Table 1). In the first stage (Figure 1a), the fertilized egg is translucent and nearly round in shape, measuring  $1600\text{--}1635\ \mu\text{m}$  in diameter. Yolk contains many lipid granules. Small projections can also be seen all over the egg surface. The second stage is the organogenesis stage (Figure 1b). The egg becomes more pear-shaped and the embryo is just formed. The head region and the tail remain attached to the yolk. The yolk is still larger with many granules. During the third stage (Figure 1c), the head and the tail regions are separated from the yolk mass. The head is directed to the base of the egg attachment. Yolk is prominent and the space between the embryo and egg membrane contains large vacuoles. Slight elongation occurs and the egg measures 4 mm in length and 2 mm in width. The embryo during the fourth stage (Figure 1d) remains concentrated at one end of the egg. The other

**Table 1.** Stages of embryonic development of alligator pipefish

Number	Developmental stage
1	Activation – fertilized egg $1600\text{--}1635\ \mu\text{m}$ in diameter
2	Organogenesis – embryo just formed
3	Separation of tail from yolk sac
4	Development of embryonic circulatory system
5	Development of jaws
6	Differentiation of unpaired fins, embryo 10 mm
7	Development of rays in unpaired fins, dorsal fin – 13 to 15 rays
8	Development of snout, rays in paired fins, pectoral fin – 12 to 14 rays
9, 10	Development of bony plates, yolk in small quantities
11	Hatchling, yolk fully absorbed

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