

## A New Species of *Philautus* (Anura: Ranidae) from the Western Ghats of India

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**ABSTRACT.**—A new frog, *Philautus griet* sp. nov., is described from Munnar in the Western Ghats of India. Molecular phylogenetic analyses of a 548 bp fragment of the mitochondrial 16S rRNA-gene confirm its placement in the genus *Philautus* (Anura, Ranidae, Rhacophorinae). In its small size, general brown coloration, and reduced webbing on toes, the new species is similar to *Philautus bombayensis* and *Philautus tinniensi*. However, relative to *P. griet*, *P. bombayensis* differs by the invariable presence of greyish-black and yellow spots in the groin and on the inside of the thighs, and *P. tinniensi* can be distinguished by the dark side of the head and the yellow inner fingers and toes. Phylogenetic analyses of Indian and Sri Lankan *Philautus* have identified *Philautus charius* as the sister taxon of *P. griet*. However, the latter can be readily distinguished by its smaller adult size (20.7–22.1 mm,  $N = 5$ , vs. 27.5–30.9 mm,  $N = 10$ , in *P. charius*) and lack of black coloration with yellow spots on the posterior surface of the thighs. The 30 km wide Palghat Gap, dividing the Western Ghats into northern and southern components, may have played a role in the vicariant isolation of these species.

Although the Western Ghats (a range of hills along the west coast of India) are considered one of the global hotspots of biodiversity (Myers et al., 2000), taxonomic knowledge of amphibians in this region remains incomplete. One of the main reasons for this is that most species were described by British zoologists during the colonial past. For example, some 80% of all southern Indian and Sri Lankan *Philautus* species currently recognized were described during the 19th century (Bossuyt and Dubois, 2001). Because of the primitive state of descriptive taxonomy at that time, this period produced brief descriptions of species whose type locality was mainly defined in terms of large geographic regions, such as "Madras Presidency," "Malabar," or "Travancore" (Dutta, 1997).

After the work of Boulenger (1890), no revisions were published on the amphibian fauna of the Western Ghats until the publications of Daniel (1963a,b, 1975), Daniel and Sekar (1989), and the biogeographic overview of Daniels (1992a). However, these publications did not cover the genus *Philautus*. In the last 50 years, only checklists (Gorham, 1974; Inger and Dutta, 1986; Dutta, 1992, 1997; Frost, 2000) have been published on Indian species of *Philautus*.

The above factors, together with enormous intraspecific variation (Bossuyt and Dubois, 2001), have led to a confused taxonomy of this group. In a review of the species-level taxonomy of the genus *Philautus* Gistel, 1848 (Ranidae, Rhacophorinae), Bossuyt and Dubois (2001) assembled information on the taxonomic status of all available names and their name-bearing types. During that work, we came across several mu-

seum specimens belonging to an undescribed species. Herein, a new species of *Philautus* is described from Munnar in the Western Ghats, India.

### MATERIALS AND METHODS

Measurements and terminology follow Bossuyt and Dubois (2001). The following measurements were taken, to the nearest 0.1 mm, using a digital slide-caliper (SVL, HL, and TL) or a binocular microscope with a micrometer ocular. SVL (snout–vent length), HW (head width, at the angle of the jaws), HL (head length, from rear of mandible to tip of snout), MN (distance from rear of mandible to nostril), MFE (distance from rear of mandible to anterior orbital border of eye), MBE (distance from rear of mandible to posterior orbital border of eye), SL (snout length, from tip of snout to anterior orbital border of eye), EL (eye length, horizontal distance between bony orbital borders of eye), IUE (inter upper eyelid width, the shortest distance between the upper eyelids), UEW (maximum upper eyelid width), IN (distance between internal border of nostrils), IFE (internal front of eyes, shortest distance between anterior orbital border of eyes), IBE (internal back of eyes, shortest distance between posterior orbital border of eyes), NS (distance from nostril to tip of snout), EN (distance from nostril to anterior orbital border of eye), TYD (largest tympanum diameter), TYE (distance from posterior orbital border of eye to tympanum), FLL (forelimb length, from elbow to base of outer palmar tubercle), HAL (hand length, from base of outer palmar tubercle to tip of third finger), TFL (third finger

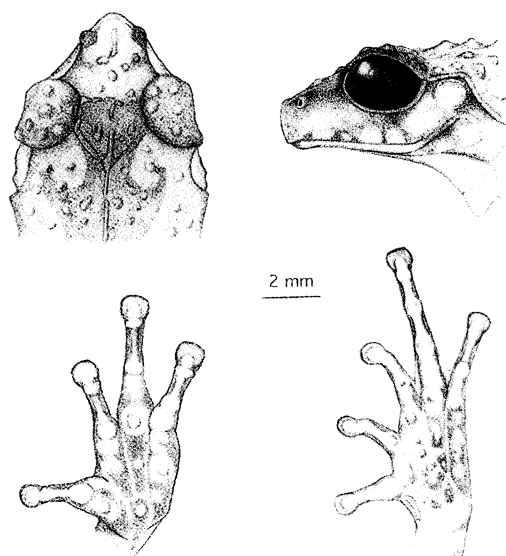


FIG. 1. Holotype of *Philautus griet* sp. nov.: Dorsal (above left) and lateral (above right) view of head; ventral view of hand (below left) and foot (below right).

length, from base of first subarticular tubercle),  $FD_{I-IV}$  (disk width on finger I-IV),  $FW_{I-IV}$  (width of finger I-IV, at base of disk),  $TD_{I-V}$  (disk width on toe I-V),  $TW_{I-V}$  (width of toe I-V, at base of disk), TL (tibia length), TW (maximum tibia width), FL (femur length), FOL (foot length, from base of inner metatarsal tubercle to tip of fourth toe), FTL (fourth toe length, from base of first subarticular tubercle to tip of fourth toe), TFOL (distance from heel to tip of fourth toe), MTTF (distance from distal edge of metatarsal tubercle to maximum incurvation of web between third and fourth toe), MTFF (distance from distal edge of metatarsal tubercle to maximum incurvation of web between fourth and fifth toe), TFTF (distance from maximum incurvation of web between third and fourth toe to tip of fourth toe), FFTF (distance from maximum incurvation of web between fourth and fifth toe to tip of fourth toe), IMT (inner metatarsal tubercle length), and ITL (inner toe length).

Because the genus *Philautus* has been confused with many other ranid genera (e.g., *Indirana* and *Micrixalus*) throughout the history of anuran taxonomy (Bossuyt and Dubois, 2001), a molecular phylogenetic analysis was performed to justify the generic allocation of the new species. I followed procedures outlined elsewhere (Bossuyt and Milinkovitch, 2000) for DNA-extraction, PCR-amplification, and sequencing of both strands of a 548 bp DNA-sequence of the 16S rRNA-gene of one of the paratypes (KBIN

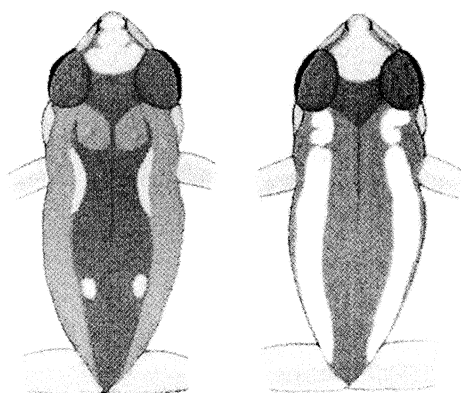


FIG. 2. Color-pattern variation of *Philautus griet* in dorsal view (left: holotype KBIN 1918; right paratype KBIN 1926).

1923). This sequence (deposited in the GenBank database, accession number AF536203) was aligned with sequences of two outgroup species and 10 representatives of southern Indian and Sri Lankan ranid genera having toe disks. Apart from the new species, *Philautus* in this dataset include *Philautus microtympanum*, *Philautus wy-naadensis*, and *Philautus charius*. The software SOAP (Löytynoja and Milinkovitch, 2001) was used to produce and compare 20 CLUSTAL W (Thompson et al., 1994) multiple alignments characterized by different gap/extension penalties (11.0–19.0/3.0–9.0, with steps of 2). Positions at which the alignments differed were identified and excluded in the subsequent analyses (Gatesy et al., 1993). Gaps resulting from the alignment were treated as missing data. The complete dataset of 13 species was submitted to a phylogenetic analysis in PAUP\* 4.0b7 (D. L. Swofford, Sinauer Associates, Sunderland, MA, 2001, unpubl.), using maximum parsimony (MP) with all characters weighted equally. The stability of relevant clades was estimated by computing bootstrap values (Felsenstein, 1985) and by calculating decay indices ("branch support"; Bremer, 1994). Additionally, a maximum likelihood (ML) analysis was performed with the following settings: empirical nucleotide frequencies, Ti:Tv ratio and proportion of invariable sites estimated by means of ML, Hasegawa-Kishino-Yano (HKY) model (Hasegawa et al., 1985) with rate heterogeneity, rates for variable sites assumed to follow a  $\gamma$  distribution with shape parameter estimated by ML, and tree bisection-reconnection (TBR) branch-swapping.

*Philautus griet* sp. nov.  
Figs. 1–3

*Holotype*.—KBIN (Koninklijk Belgisch Instituut voor Natuurwetenschappen, Brussel) 1919,



FIG. 3. A calling male of *Philautus griet* at Munnar, the type locality (specimen not collected).

an adult male, SVL 21.3 mm, from Munnar (10°05'N, 77°03'E), altitude approximately 1500 m, Kerala, Western Ghats, India, collected in July 1979 (collector unknown).

*Paratypes*.—KBIN 1920–1922 and KBIN 1926, four adult males, SVL 20.7–22.1 mm, same locality and collection date as the holotype.

*Diagnosis*.—*Philautus griet* was compared with the 84 valid species names currently recognized in the genus *Philautus* (Bossuyt and Dubois, 2001), including the name-bearing types of all southern Indian and Sri Lankan species (see Appendix 1). The combination of small size at sexual maturity, relatively large spines on head and back of adult males, reduced webbing on toes, and the distinctive color pattern, make this species clearly distinguishable from all its congeners. In its small size, general brown coloration, and reduced webbing on toes, the new species is similar to two other *Philautus*-species of the Western Ghats, *Philautus bombayensis* and *Philautus tinniensi*. However, *Philautus bombayensis* can be recognized by the invariable presence of greyish-black and yellow spots in the groin and on the inside of the thighs (pers. obs.), and *P. tinniensi* can be distinguished by the dark side of the head and the yellow inner fingers and toes (Bossuyt and Dubois, 2001). Molecular phylogenetic analyses of Indian and Sri Lankan *Philautus* (unpubl. data) have identified *P. charius* as the sister taxon of *P. griet*. However, the latter

can be readily distinguished by its smaller adult size (20.7–22.1 mm,  $N = 5$ , vs. 27.5–30.9 mm,  $N = 10$ , in *P. charius*). Additionally, the new species lacks the black coloration with yellow spots on the posterior surface of the thighs, which is characteristic for *P. charius* (pers. obs.).

*Description of the Holotype*.—Small size (SVL = 21.3); head (Fig. 1) broader than long (HW = 7.6, HL = 7.0, MN = 6.3, MFE = 5.1, MBE = 2.8), flat above; outline of snout in dorsal view rounded, in profile rounded, slightly protruding; snout (SL = 2.7) about as long as horizontal diameter of eye (EL = 2.6); canthus rostralis rounded, loreal region slightly concave; interorbital space flat, wider (IUE = 2.5) than upper eyelid (UEW = 2.0), wider than internasal distance (IN = 2.1); distance between posterior margin of eyes (IBE = 6.8) 1.7 times distance between anterior margin of eyes (IFE = 4.1); nostrils oval, without lateral flap of skin, closer to tip of snout (NS = 0.9) than to eye (EN = 1.3); pupil rounded, horizontal; tympanum indistinct, rounded, small (TYD = 1.0), 38% of horizontal diameter of eye; tympanum-eye distance (TYE = 0.4) 15% of largest tympanum diameter; tongue emarginate, without papilla, with shallow depression anteriorly; toothlike projections on maxilla absent; supratympanic fold prominent, from back of eye to shoulder; no co-ossified skin on head; vocal sacs present,

distinct on throat as a pair of slitlike openings at rear of jaws.

Forelimb (FLL = 5.6) shorter than hand (HAL = 6.3, TFL = 4.5; Fig. 1). Relative length of fingers: I < II < IV < III; tips of all fingers with well-developed disks (FD<sub>I</sub> = 0.6, FW<sub>I</sub> = 0.5, FD<sub>II</sub> = 0.8, FW<sub>II</sub> = 0.6, FD<sub>III</sub> = 0.8, FW<sub>III</sub> = 0.6, FD<sub>IV</sub> = 0.7, FW<sub>IV</sub> = 0.5) with distinct circummarginal grooves; all fingers with dermal fringe on both edges; webbing on fingers absent; subarticular tubercles prominent, rounded and single; prepollex oval, distinct; two distinct, oval palmar tubercles; supernumary tubercles present on all fingers.

Hind limbs moderately long, heels touch with limbs folded at right angles to the body; tibia four times longer (TL = 9.3) than wide (TW = 2.3), about as long as thigh (FL = 9.2), longer than distance from base of internal metatarsal tubercle to tip of Toe IV (FOL = 8.9); distance from heel to tip of Toe IV (TFOL = 13.4) 2.5 times length of Toe IV (FTL = 5.4); relative length of toes when opposed: I < II < III < V < IV; tips of toes with disks (Fig. 1), rather wide compared to toe width (TD<sub>I</sub> = 0.7, TW<sub>I</sub> = 0.6, TD<sub>II</sub> = 0.7, TW<sub>II</sub> = 0.6, TD<sub>III</sub> = 0.7, TW<sub>III</sub> = 0.6, TD<sub>IV</sub> = 0.9, TW<sub>IV</sub> = 0.6, TD<sub>V</sub> = 0.8, TW<sub>V</sub> = 0.6), with a distinct circummarginal groove; webbing on toes rudimentary, reaching to between penultimate and antepenultimate subarticular tubercle on inside of Toe IV, reaching penultimate subarticular tubercle on outside of Toe IV (MTTF = 3.7, MTFF = 4.7, TFTF = 4.5, FFTF = 4.0); small dermal fringe along Toe V, from tip of toe to second subarticular tubercle; all subarticular tubercles distinct and rounded; inner metatarsal tubercle short (IMT = 0.8), oval, indistinct, 2.5 times in length of Toe I (ITL = 2.0); tarsal fold and outer metatarsal tubercle absent; supernumary tubercles present on all toes; tarsal tubercle absent.

Skin of snout with small horny spines; horny ridges between eyes, arranged in triangle (Fig. 1) directed posteriorly; side of head (Fig. 1) smooth, entire dorsum and upper part of flanks (above line from insertion of arm to groin) with small horny spines, lower part of flanks granular; dorsolateral folds absent; dorsal part of forelimbs, thighs, and calves smooth; throat, chest, belly, and ventral side of thighs granular.

In preservative, overall coloration of dorsal parts brown; dorsal part of head with off-white stripe between eyes; triangular ridge on head dark brown; dorsal part of trunk with dark brown mark on back, edged by off-white spot on both sides (Fig. 2); flanks light brown; loreal region, tympanic region, and tympanum dark brown; upper lip with faint bands of dark and light brown; forelimbs with off-white spots at base, remaining forelimbs light brown, with

TABLE 1. Measurements (range, mean and standard deviation) for the type specimens (N = 5) of *Philautus griet*.

	Males (N = 5)		
	Range	Mean	SD
SVL	20.7–22.1	21.3	0.5
HW	6.9–7.8	7.5	0.4
HL	6.6–7.2	6.9	0.2
IFE	4.1–4.2	4.2	0.1
IBE	6.5–7.2	6.9	0.3
IUE	2.5–2.8	2.6	0.1
UEW	1.7–2.0	1.8	0.1
IN	2.1–2.2	2.1	0.0
EN	1.4–1.5	1.4	0.0
EL	2.5–3.1	2.8	0.3
TYD	0.8–1.0	0.9	0.1
FLL	5.6–5.9	5.7	0.1
HAL	5.9–6.3	6.1	0.2
TFL	4.1–4.5	4.3	0.2
FLL	8.9–9.8	9.3	0.5
TL	9.1–9.4	9.3	0.1
FOL	8.9–9.5	9.2	0.2
FTL	4.7–5.4	5.2	0.3
IMT	0.9–1.2	1.1	0.1
ITL	1.8–2.0	1.9	0.1

some darker brown spots; dorsal part of thighs and calves with two dark brown transverse bars, which merge when legs are folded; dorsal part of feet light brown, posterior surface of thighs dark brown with some lighter brown spots; throat and margin of throat light gray; vocal sac light gray; chest, belly and thighs off-white; webbing transparent, with small black spots.

*Variation*.—Measurements (range, mean and standard deviation) for the five specimens are given in Table 1. A single specimen (KBIN 1926) has a distinctly different color pattern, where the spots on the back are enlarged to form two broad dorsolateral bands (Fig. 2).

*Phylogenetic Analyses and Generic Allocation*.—Alignment of the 13 DNA-sequences resulted in a data matrix of 468 unambiguously aligned characters, of which 168 were variable and 101 parsimony informative. MP analyses yielded a single best tree (length = 366, not shown), demonstrating a *P. griet* + *P. charius* clade with a bootstrap value of 100% and decay index of 10. This clade clusters with a *P. wynaadensis* + *P. microtympanum* clade, which has a bootstrap value of 95% and a decay index of 6. Together, these two clades constitute a monophyletic *Philautus*-group (bootstrap 60%, decay index 2). ML analyses yielded a single best tree (−Ln L = 2296.00506, not shown), which agreed in all aspects of relationships in *Philautus*. The MP majority rule bootstrap consensus tree in Figure 4 was compatible with both the MP and ML trees.

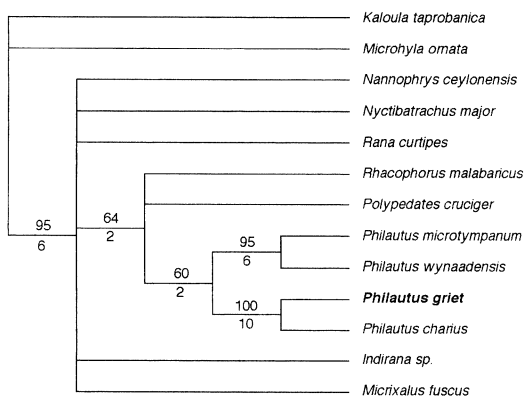


FIG. 4. The MP majority rule bootstrap consensus tree for the analysis of 468 unambiguously aligned nucleotides for 13 species of Indian and Sri Lankan Ranoidea. The values given above and below the branches indicate bootstrap values and decay indices, respectively. *Philautus griet* (indicated in bold) is nested within species currently assigned to the genus *Philautus*, corroborating its generic allocation.

These analyses demonstrate that *P. griet* is nested within an assemblage of species currently classified in the genus *Philautus* (Bossuyt and Dubois, 2001).

**Etymology.**—This species is named after my wife Griet Decock, as a token of appreciation for her active involvement in fieldwork and many other aspects of my herpetological research. The specific name is therefore a noun in the nominative singular standing in apposition to the generic name.

#### DISCUSSION

The 30 km wide Palghat Gap (approximately between 10°35'N and 10°50'N; Fig. 5) dividing the Western Ghats into northern and southern components is regarded as an ancient river valley (Krishnan, 1982). As several *Philautus* species are confined to high altitudes (Inger et al., 1987), the influence of such a geographical barrier is expected to be strong in this taxon.

The new species is currently known only from its type locality, Munnar (Fig. 5), at an altitude of approximately 1500 m, south of the Palghat Gap. During field research in August 1999, we established that *P. griet* is still present, and is (together with *P. beddomii*) a common *Philautus* species in this region. Its sister species, *P. charius* (unpubl. data), is common north of Palghat, from the hills around Chikmalagur (13°20'N, 75°46'E) down to Talakaveri and Madikeri (12°25'N, 75°45'E; pers. obs.). It was also described from two localities south of Palghat. First, Inger et al. (1984) mentioned this species from Ponmudi (8°45'N, 77°08'E; Fig. 5), about 600 km south of the type locality. However, the

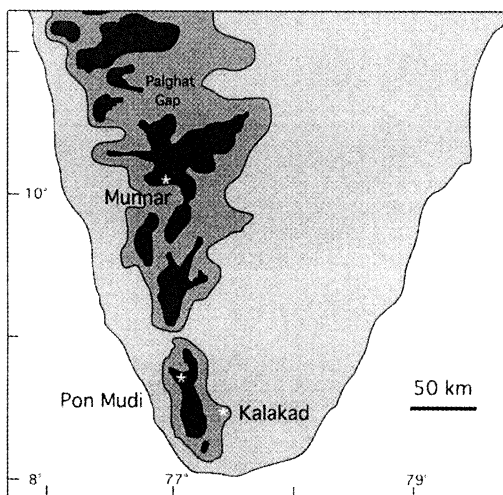


FIG. 5. Map of southern India, showing Munnar (the type locality of *Philautus griet*) and other localities mentioned in the text. The Western Ghats are in dark gray, with hill ranges over 1000 m in black.

adult males from Ponmudi are significantly smaller (16.5–18.8 mm,  $N = 6$ ; Inger et al., 1984) than those of *P. charius* (27.5–30.9 mm,  $N = 10$ ) and lack the characteristic black coloration with yellow spots on the posterior surface of the thighs. These specimens likely represent yet another species. Second, Daniels (1992b) described *P. charius* from Kalakad (8°31'N, 77°33'E; Fig. 5) but provided no information on specific morphological characters. During seven fieldtrips between 1991 and 1999, we found no evidence for the occurrence of *P. charius* in this region. Given the difficulties in identifying species in this genus, it is probable that the specimens referred to as *P. charius* by Daniels (1992b) belong to another *Philautus* species. Pending additional surveys in the Western Ghats, the known distribution of *P. charius* is considered limited to localities north of the Palghat Gap.

It has been suggested that the isolated hill ranges of the Western Ghats act as ecological islands, and “provide a potential arena for allopatric isolation” (Inger et al., 1987). Because both *Philautus griet* and *P. charius* are particularly found at high altitudes (> 1000 m) on different sides of the Palghat Gap, this valley may have played a role in the divergence of these species.

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## APPENDIX 1

## Specimens Examined

*Philautus glandulosus* (BMNH 1947.2.27.22, ZMB 10140), *P. tinniensis* (MNHN 1985.0515-0579, BMNH 1947.2.6.14), *P. wynnaadensis* (MNHN 1999.5596), *P. leucorhinus* (ZMB 3057, BMNH 1947.2.6.39-40, BMNH 1947.2.6.16), *P. variabilis* (BMNH 1947.2.7.87), *P. microtympaum* (BMNH 1947.2.8.48), *P. temporalis* (BMNH 1947.2.6.8-11), *P. femoralis* (BMNH 1947.2.26.89, BMNH 1947.2.26.90, BMNH 1947.2.26.91), *P. nanus* (BMNH 1947.2.7.78, BMNH 1864.7.11.24), *P. nasutus* (BMNH 1947.2.6.21), *P. cavirostris* (BMNH 1947.2.7.83, BMNH 1947.2.31.29), *P. adspersus* (BMNH 1947.2.6.23), *P. jerdonii* (BMNH 1947.2.7.84), *P. chalazodes* (BMNH 1947.2.6.35), *P. dubius* (BMNH 1947.2.7.86), *P. beddomii* (BMNH 1947.2.26.59-66, BMNH 1947.2.26.70-78, BMNH 1947.2.26.80-84), *P. stictomerus* (BMNH 1947.2.8.54), *P. hypomelas* (BMNH 1947.2.7.47-57, BMNH 1947.2.27.8-10), *P. flaviventris* (BMNH 1947.2.26.98), *P. signatus* (BMNH 1947.2.27.36, BMNH 1920.11.4.1-2, MNHN 1985.481-486), *P. travancoricus* (BMNH 1947.2.6.20), *P. pleurotaenia* (BMNH 1947.2.7.64), *P. annandalii* (BMNH 1947.2.26.58), *Rhacophorus variabilis* (KBIN 1918, ZMB 10142), *P. fergusonianus* (BMNH 1947.2.27.61), *P. charius* (MNHN 1999.5597), *P. bombayensis* (BMNH 1956.1.9.92-99).