

## *Plethodontohyla guentheri*, a new montane microhylid frog species from northeastern Madagascar

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### Abstract

We describe a new microhylid frog (subfamily Cophylinae) from a high elevational habitat of the Marojejy National Park in northeastern Madagascar, based on a single specimen. *Plethodontohyla guentheri* sp. n. has enlarged terminal discs on fingers and toes, greenish dorsal coloration, a distinct border between its dorsal and lateral colours, and a pointed snout. The new species has obvious relationships to the other *Plethodontohyla* species with enlarged fingertips (*P. inguinalis*, *P. notosticta*, *P. mihanika*) but differs from these by hand morphology, body size, coloration, and genetic traits. We discuss the unusual greenish dorsal colours of *P. guentheri* and its diurnal activity as possible adaptations to montane habitats and consider the conservation status of this poorly known new species as “data deficient”. Furthermore, a lectotype of *Mantipus pulcher* Ahl, 1929, a junior synonym of *P. notosticta* (Günther, 1877), is designated.

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### Introduction

Intensive studies over the past 15 years have resulted in a remarkably improved knowledge on the herpetofauna of Madagascar. Among the amphibians a large number of new species has been named and new classifications have been proposed. Most of these studies referred to the frog family Mantellidae (e.g. Glaw & Vences 2006; Glaw et al. 2006). Comparatively few of the numerous newly discovered species of microhylids have been formally described so far (Vallan 2000; Vences & Glaw 2003; Vences et al. 2003a, 2003b; Glaw & Vences 2005; Glos et al. 2005; Andreone et al. 2003, 2006).

The family Microhylidae is represented in Madagascar by three subfamilies, all of which are endemic to Madagascar according to recent studies. The subfamily Dyscophinae comprises only one genus, *Dyscophus*, with currently three recognized species (Chiari et al. 2006) whereas the Oriental genus *Cal-*

*luella*, previously considered to belong to the Dyscophinae is phylogenetically related to other Asian genera (Frost et al. 2006). The subfamily Scaphiophryinae (currently about 10 species) contains two genera (*Scaphiophryne* and *Paradoxophyla*) with different larval morphologies (Haas 2003), although the position of the latter genus was considered as “incerta sedis” by Frost et al. (2006). By far the largest radiation of microhylids in Madagascar is represented by the subfamily Cophylinae which currently contains seven genera and 42 species.

A recent phylogenetic study based on DNA sequences has shown that the current definition of the cophyline genus *Plethodontohyla* actually comprises two clades which are not closely related to each other, indicating the need to divide *Plethodontohyla* into two genera, *Plethodontohyla* and *Rhombophryne* (Andreone et al. 2005b). Unfortunately, no characters have been identified so far to diagnose these two clades by external morphology or osteology. Thus a reliable attribution of all for-

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mer *Plethodontohyla* species to one of the two genera was impossible, and Andreone et al. (2005b) consequently proposed to postpone taxonomic rearrangements. Frost et al. (2006), based on the data of Andreone et al. (2005b), transferred several *Plethodontohyla* species to *Rhombophryne*. In the meantime DNA sequences of almost all remaining *Plethodontohyla* have become available to us through collaborative work with D. C. Cannatella (University of Austin/Texas), though still unpublished. These data which will be published elsewhere show that the new species described in this paper belongs to the genus *Plethodontohyla*.

Almost all cophylines occur in humid rainforest of eastern Madagascar or – with less species – in humid montane habitats above the tree line. Cophylines include terrestrial as well as arboreal species (Blommers-Schlösser & Blanc 1991) and are characterized by derived reproductive modes including development of non-feeding tadpoles in water-filled tree-holes, terrestrial jelly, or foam nests, as well as parental guarding of eggs and tadpoles (Guibé 1952; Blommers-Schlösser 1975; Glaw & Vences 1994; Köhler et al. 1997; Vences et al. 2003a).

The genus *Plethodontohyla* contains mainly terrestrial species with non-expanded digital tips. Only three described species, *P. inguinalis*, *P. notosticta*, and *P. mihanika* have distinctly enlarged finger discs. *Plethodontohyla notosticta* is semi-arboreal and breeds in tree holes (Blommers-Schlösser

1975). In this paper we describe a new high-altitude species of *Plethodontohyla* which is morphologically similar to the low and mid-altitude species *P. notosticta* and *P. mihanika* but differs from these species by hand morphology, by its greenish coloration, and a strong genetic differentiation.

## Materials and Methods

The description of *Plethodontohyla guentheri* largely follows the format used by Vences et al. (2003a) to allow for a better comparison with *P. mihanika*. The following museum acronyms are used in this paper: BMNH (The Natural History Museum, London – formerly British Museum of Natural History); ZMB (Museum für Naturkunde, Berlin); ZSM (Zoologische Staatssammlung, München). SVL is used for snout-vent length.

## Results

### *Plethodontohyla guentheri* sp. n.

Figs. 1–3

**Holotype.** – ZSM 61/2005 (field number FGZC 2814), adult female (with large eggs in the body cavity), collected by R. D. Randrianiaina, F. Glaw and M. Vences on 16 February 2005, above a campsite locally known as Camp Simpona (ca. 14°26' S,



Fig. 1. *Plethodontohyla guentheri*, dorsolateral view of holotype in life.



Fig. 2. Holotype of *Plethodontohyla guentheri* (ZSM 61/2005), preserved, dorsal view.



Fig. 3. Holotype of *Plethodontohyla guentheri* (ZSM 61/2005), preserved, ventral view.

49°44' E, >1326 m above sea level), Marojejy National Park, northeastern Madagascar.

**Diagnosis.** – A medium-sized species of *Plethodontohyla* (snout-vent length 33 mm) with pointed tip of snout, distinctly expanded finger discs, and a sharp dorsolateral colour border along supratympanic and dorsolateral folds.

*Plethodontohyla guentheri* is distinguished from all other described *Plethodontohyla* and *Rhombophryne* species except *P. notosticta*, *P. mihanika* and *P. inguinalis* by enlarged finger discs. It differs from *P. inguinalis* by smaller size (33 vs. 55–100 mm SVL) and pointed snout (vs. rounded); from *P. mihanika* by shorter hind limbs (tibiotarsal articulation reaching to posterior edge of eye vs. reaching beyond eye), less developed finger discs, greenish coloration and larger size (33 vs. 26.4–31.1 mm). *P. guentheri* differs from *P. notosticta* (based on data taken on the lectotype and other ZSM east coast specimens from Nosy Mangabe) and from the type specimens of its junior synonym *Mantipus pulcher* by having a different hand morphology with a distinctly shorter first finger (i.e. length of first finger shorter than inner metacarpal tubercle vs. length of first finger longer than inner metacarpal tubercle), less enlarged and less triangular fingertips, by having the second finger only slightly shorter than the fourth finger (vs. distinctly shorter), by a darkly mottled throat coloration, by the green

dorsal coloration (vs. brownish), by the absence of two distinct light spots surrounded by dark colour on the lower back which are visible in the studied *P. notosticta* and *Mantipus pulcher* specimens. Furthermore, there is a strong genetic differentiation of *P. guentheri* from the similar species (*P. notosticta*, *P. mihanika*) (unpublished data).

**Description of the holotype.** – Specimen in good state of preservation, fixed in 90% ethanol and preserved in 70% ethanol. Tissue samples from the right shank have been preserved separately in 99% ethanol. Body moderately slender; head wider than long, not wider than body; snout pointed in dorsal and lateral views; nostrils directed laterally, very slightly protuberant, nearer to tip of snout than to eye; canthus rostralis distinct, slightly concave; loreal region slightly concave; tympanum distinct, rounded, 68% of eye diameter; supratympanic fold distinct and straight; tongue ovoid, broad, posteriorly free and not notched; maxillary teeth present; vomerine teeth distinct, forming transverse rows posterior to choanae; choanae ovoid. Arms slender, subarticular tubercles not well recognizable; a single, indistinct outer metacarpal tubercle; large inner metacarpal tubercle (forming distinct protuberance at first finger); fingers without webbing; relative length of fingers  $1 < 2 \leq 4 < 3$ , fourth finger only slightly longer than second; finger discs moderately enlarged, only slightly triangular. First

finger shorter than inner metacarpal tubercle. Hindlimbs slender; tibiotarsal articulation reaching posterior edge of eye when hindlimb is adpressed along body; tibia length 49% of SVL; lateral metatarsalia connected; inner and outer metatarsal tubercles rather indistinct; only traces of webbing between toes; relative length of toes  $1 < 2 < 5 < 3 < 4$ ; third toe distinctly longer than fifth. Toe discs slightly enlarged. Skin on dorsum almost smooth (although less smooth than in the studied specimens of *P. notosticta*) with clearly visible dorsolateral folds continuous with supratympanic folds. Ventral skin almost smooth.

**Measurements** (taken by FG with a calliper to the nearest 0.1 mm). – Snout-vent length 33.1 mm, maximum head width 12.8 mm, head length (from the rictus to the snout tip) 10.4 mm, horizontal eye diameter 3.1 mm, eye-nostril distance 3.0 mm, nostril-snout tip distance 2.1 mm, internarial distance 3.4 mm, horizontal tympanum diameter 2.1 mm, hand length (from the carpal-metacarpal articulations to the tip of the longest finger) 9.6 mm, forelimb length (from the axilla to the tip of the longest finger) 20.5 mm, hind limb length (from the cloaca to the tip of the longest toe) 49.1 mm, foot length (from the tarsal-metatarsal articulation to the tip of the longest toe) 14.3 mm, foot length including tarsus (from the tibiotarsal articulation to the tip of the longest toe) 21.6 mm, tibia length 16.3 mm, maximum length of inner metacarpal tubercle 2.1 mm, length of first finger 1.4 mm.

**Coloration.** – After 18 months in preservative, head and dorsum light grey with two distinct brown converging lines of ca. 6 mm length on anterior dorsum and two parallel lines running from posterior dorsum to inguinal region (also ca. 6 mm long). In addition, an irregular and less distinct pattern of shorter light brown lines and spots on the back. Upper surfaces of arms grey with a broad brown band on the lower arm, upper surfaces of hands and fingers brown with fine white dots. Upper surfaces of legs and feet grey with two narrow brown lines on tibia and two narrow lines on femur, upper surfaces of toes brown with fine white dots. A very distinct dorsolateral colour border, running from snout tip to inguinal region (passing just above nostrils, eyes and tympanum). Above this colour border a very thin white line from eye to inguinal region. Sides of head, tympanic region, and anterior flanks dark brown, becoming lighter posteriorly by fine whitish mottling. Ventrally, throat and anterior part of chest with distinct brown and white mottling, venter greyish with fine and less distinct pattern. Ventral surfaces of legs yellowish with brown spots on femur, more greyish on tibia and tarsus. Dorsolateral part of tarsus dark brown and in sharp contrast to the dorsal colour which has a somewhat violet shade in this area. Ventral surface of feet and toes dark brown.

The general colour pattern in life was similar to that in preservative, but with the dorsal ground colour greenish instead of grey. The iris was brownish.

**Etymology.** – We dedicate this species to Dr. Rainer Günther in recognition of his important contributions to herpetology and as acknowledgement of his continuous support of our research on Madagascan amphibians over the past 15 years.

**Distribution, natural history and conservation status.** – *Plethodontohyla guentheri* is reliably known only by the holotype. Future studies should clarify if some of the previous records of *P. notosticta* from the Marojejy National Park, 700–1300 m elevation (Raselimanana et al. 2000), and the Anjanaharibe-Sud Special Reserve, 1000–1700 m elevation (Raxworthy et al. 1998), refer to *P. guentheri*, *P. notosticta* or even another species. In any case it appears remarkable that no low-altitude records of *Plethodontohyla notosticta* are known from the two mentioned reserves in northeastern Madagascar, although this species is common in coastal localities of the east between Nosy Mangabe in the north and Ste. Luce in the south.

The holotype was caught on the ground during the day by R. D. Randrianiaina, crossing the trail that runs from Camp Simpona to the top of the Marojejy massif. The large eggs in the holotype suggest that reproduction occurs during the rainy season.

Due to the extremely limited knowledge on *P. guentheri*, we have to consider its conservation status as “data deficient”, in accordance with the criteria used for the classification of other Madagascan amphibian species by Andreone et al. (2005a).

**Status of *Mantipus pulcher* Ahl, 1929 and designation of a lectotype.** – Due to the similarities of *P. guentheri* to *P. notosticta* and its junior synonym *Mantipus pulcher* (synonymy by Guibé 1978) it is important to have an unambiguous definition of the latter name. *Mantipus pulcher* is based on five syntypes (Ahl 1929; Parker 1934) from “Akkoroka, Central-Madagascar”, collected by “Braun” (Ahl 1929). All specimens are in a condition that gives the impression of rather “soft”, not strongly fixed, body. In their type catalogue, Bauer et al. (1996) located only four of the five syntypes, but in the meantime the fifth one has apparently been rediscovered as all five syntypes were available to us. Three of these are obviously juveniles: ZMB 66738 (formerly 31623B), 24.7 mm SVL; ZMB 66739 (formerly 31623C), 22.5 mm SVL; ZMB 66740 (formerly 31623D), 23.8 mm SVL. ZMB 66737 (formerly 31623A) has 31.7 mm SVL; although there is a ventral opening, a reliable sex determination was not possible without further damage, but the specimen might be adult. ZMB 31623 has a SVL of 34.4 mm and is an adult

female with large oocytes in the body cavity. This specimen was the only one explicitly mentioned in the original description of Ahl (1929) and assumed to show indications of an unusual reproduction: “Das größte Exemplar, ein Weibchen, mit sehr wenigen, etwa 20, sehr großen Eiern mit einem Durchmesser von etwa 3,5 mm und sehr starkem Dottergehalt, die Spuren von embryonaler Entwicklung erkennen lassen; diese interessante Art ist augenscheinlich lebendgebärend oder anderweitig Brutpflege treibend”. In order to avoid further damage of this specimen, we had only a superficial look at the eggs which were visible around the ventral opening, but were unable to detect any traces of embryonic development as suggested by Ahl. ZMB 31623 is the only specimen of the syntype series that is undoubtedly an adult and well sexed. Its preservation status does not differ from the other specimens examined. For these reasons, we designate the female ZMB 31623 (Figs 4, 5) as the lectotype of *Mantipus pulcher* Ahl, 1929. All five type specimens of *Mantipus pulcher* have enlarged fingertips which are distinctly triangular in the two largest specimens, the lectotype and ZMB 66737. The lectotype has distinct metatarsal and subarticular tubercles, the first finger (2.0 mm) is longer than the inner metacarpal tubercle (1.4 mm), and the second finger is distinctly shorter than the fourth finger. The tibiotarsal articulation



Fig. 4. Lectotype of *Mantipus pulcher* Ahl, 1929 (ZMB 31623), dorsal view.



Fig. 5. Lectotype of *Mantipus pulcher* Ahl, 1929 (ZMB 31623), ventral view.

does not reach the eye in all five specimens when the hindlimbs are adpressed along the body (which is a distinct difference to *P. mihanika*). All four paralectotypes have one light, darkly surrounded spot on each side of the lower back, as is typical for *P. notosticta*. In the lectotype this spot is only recognizable on the left side. The throat is uniformly light in all five specimens which is also in accordance with *P. notosticta* but different from the darkly marbled throat of *P. guentheri*. In conclusion, we confirm the synonymy of *Mantipus pulcher* with *Plethodontohyla notosticta* (Figs 6, 7) although morphological observations (Vences et al. 2003a) indicate that *P. notosticta* is still composite and thus a future resurrection of the taxon *pulcher* cannot be excluded.

Remarks. – In a previous study (Vences et al. 2003a, table 1) the measurements of *Plethodontohyla notosticta* (lectotype) and *P. mihanika* (holotype) were exchanged. The data in the first (left) column of table 1 actually refers to the holotype of *mihanika* and the data in the second column to the lectotype of *notosticta*. In addition, the 1 cm scale presented in Figure 1 is incorrect, suggesting that the *mihanika* holotype is much bigger (ca. 45 mm) as it is (29.7 mm). The size range of *mihanika* (26–31 mm SVL) as given in Vences et al. (2003a) is correct.



Fig. 6. Lectotype of *Calulla notosticta* Günther, 1877 (BMNH 1947.2.10.40), dorsal view.



Fig. 7. Lectotype of *Calulla notosticta* Günther, 1877 (BMNH 1947.2.10.40), ventral view.

## Discussion

Although most microhylids throughout the world have a predominantly brownish colour, several Madagascan microhylids are rather unusual concerning their splendid coloration. The famous tomato frog (*Dyscophus antongili*), as well as *Scaphiophryne gottlebei* and *S. spinosa* are obvious examples of colourful microhylids. In contrast to these, most of the 42 described and numerous undescribed cophylinae species are brownish and only very few have any greenish dorsal colour: juveniles of *Platypelis grandis* are known to have an olive-greenish colour whereas the adults are dark brown (Blommers-Schlösser 1975; Glaw & Vences 1994). The Madagascan microhylid *Anodonthyla moramora* lives on mossy trees and also displays an olive-green dorsal colour (Glaw & Vences 2005). Lastly, juvenile *P. notosticta* can also show yellowish or slightly greenish tones which, however, are unusual in adults (see Blommers-Schlösser 1975).

The green dorsal coloration with darker vermiculation of *P. guentheri* therefore appears as exceptional among cophylines and – on the other hand – reminds to unrelated, but also montane frogs which live above or near the tree line, especially *Boophis microtympanum* (family Mantellidae). In contrast to most other *Boophis* species which are arboreal and nocturnal and live in forests, *B. microtympanum* leads a rather terrestrial life in more open habitats (often grassland, low herbs, moss, or heathland) and occasionally shows some diurnal activity (Vences et al. 2002). This change in circadian activity may be understood as an adaptation to relatively low temperatures at higher altitudes. Apart from this, it obviously leads to novel selection pressures regarding colour and pattern. Although the splendid green coloration with darker vermiculation appears conspicuous to humans, it might actually serve as an efficient camouflage in its natural habitat to escape diurnal predators like birds.

Other montane species like *Scaphiophryne madagascariensis* and *Spinomantis guibei* show comparable adaptations, including a greenish dorsal colour pattern and at least partial diurnal activity. The dorsal coloration of *P. guentheri* and its diurnal activity could indicate that it is a high altitude specialist as well. This assumption is further supported by the hand morphology which shows less distinct adaptations for arboreal activity. Future studies are needed to test this hypothesis.

The description of *Plethodontohyla guentheri* increases the number of described *Plethodontohyla* with enlarged finger discs to four, three medium-sized species (*P. notosticta*, *P. mihanika*, *P. guentheri*), and one large-sized (*P. inguinalis*). They all share an inverted V-shaped dorsal marking, and a distinct dorso-lateral colour border (see Fig. 1 and figures in Glaw & Vences 1994; Vences et al. 2003a) which implies they may belong to a monophyletic group. In contrast

to all *Plethodontohyla* species without enlarged terminal discs of fingers *P. notosticta*, *P. mihanika* and *P. inguinalis* are known to climb in the vegetation at least occasionally (Vences et al. 2003a; Vallan et al. 2005). Furthermore, *P. notosticta* and *P. inguinalis* are known to breed in treeholes. Thus, we expect that *P. guentheri* is also able to climb and breed in tree holes, an assumption that has to be proven by further field studies.

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