

## Two new treefrogs of the *Boophis rappiodes* group from eastern Madagascar (Amphibia Mantellidae)

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Two new sibling species of *Boophis* Tschudi 1838 are described from Andasibe in central-eastern Madagascar. Both are small greenish treefrogs with a translucent ventral skin and without lateral fringes along lower arm and tarsus, and are thereby assignable to the phenetic *B. rappiodes* group. *Boophis bottae* n. sp. is morphologically similar to *B. rappiodes* (Ahl 1928) and occurs syntopically with this species. It strongly differs from its sibling by advertisement calls (long trill notes instead of two-pulse notes), and by a reddish-brown dorsal pattern which does not fade soon in ethanol, often covering the entire back (vs a red pattern that largely fades in ethanol in *B. rappiodes*). *Boophis tasymena* n. sp. is similar to *B. erythroductylus* (Guibé 1953) but differs in advertisement calls (notes composed of two instead of four-seven pulses) and lack of red colour on tips of fingers and toes. A lectotype is designated for *B. erythroductylus*. The discovery of the two new species in addition to the revised distributional information for *B. rappiodes*, *B. erythroductylus* and *B. viridis* Blommers-Schlösser 1979 confirms that mid-elevational central-eastern Madagascar is the centre of diversity for many Malagasy amphibian groups but has a relatively low degree of endemism. DNA sequence divergence was high within each pair of sibling species (6-7% in a fragment of the mitochondrial 16S rRNA gene), suggesting that their reproductive isolation was not a recent event and probably predates the Pleistocene.

KEY WORDS: Amphibia, Anura, Mantellidae, *Boophis viridis*, *Boophis rappiodes*, *Boophis erythroductylus*, *Boophis bottae* n. sp., *Boophis tasymena* n. sp., Madagascar, advertisement calls, distribution.

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## INTRODUCTION

With currently more than 45 species, the treefrog genus *Boophis* is one of the most speciose groups of Malagasy anurans. It is part of an endemic frog radiation (RICHARDS et al. 2000) which has recently been defined as the family Mantellidae (VENCES & GLAW 2001). *Boophis* was first recognized as a natural unit and divided into seven species groups by BLOMMERS-SCHLÖSSER (1979). Later, BLOMMERS-SCHLÖSSER & BLAKE (1991) assigned all known species in the genus to these groups, while GLAW & VENCES (1994) proposed some modifications to the grouping. According to the molecular data of RICHARDS et al. (2000), who studied representatives of five of the seven species groups (sensu GLAW & VENCES 1994), *Boophis* is a monophyletic assemblage.

One characteristic pattern in *Boophis* is the high proportion of sibling species which are well defined by advertisement calls and partly by colouration, but virtually indistinguishable by external morphology. This pattern has received particular attention by BLOMMERS-SCHLÖSSER (1979) in her treatment of the *Boophis rappiodes* group. She assigned two described species (*B. rappiodes* and *B. erythroductylus*) to this group and described two new taxa (*B. mandraka* and *B. viridis*). She found all these species in central-eastern Madagascar, at her collecting localities Mandraka and Andasibe, and demonstrated close syntopy of two species (*B. erythroductylus*, *B. mandraka* Blommers-Schlösser 1979) at one site (Mandraka). All species of the *B. rappiodes* group are small, basically greenish-coloured treefrogs with a translucent venter in life, reminiscent of the Neotropical Glass frogs of the family Centrolenidae. When preserved, the often diagnostic colour pattern is lost: the greenish colour changes first to pale yellow and then to whitish. If present, the red pattern often becomes brownish or fades to white. Although a few morphological characters are known to distinguish some of the species as defined by BLOMMERS-SCHLÖSSER (1979) (e.g., the position of the nostrils, which are closer to the eye in *B. mandraka* but closer to the snout tip in the other species), in general the *B. rappiodes* group exemplifies the difficulties in distinguishing sibling Malagasy frog species better than most other species assemblages (paralleled, however, by the *B. luteus* group; e.g., ANDREONE 1993, ANDREONE et al. 1995).

The recent intensive survey work carried out in several parts of eastern Madagascar revealed that the species inventory of Madagascar's herpetofauna is far from being complete (GLAW & VENCES 2000). Several of the newly discovered forms are assignable to the *B. rappiodes* group. In the present paper, we describe two of these as new species, partly revise the two species *B. rappiodes* and *B. erythroductylus*, and provide new information about the distribution and advertisement calls of *B. viridis*. A revision of the remaining representative of the group, *B. mandraka*, and two new sibling species will be published elsewhere.

## MATERIALS AND METHODS

Specimens were collected at night, mainly by locating calling males with the aid of electric torches. They were euthanised using chlorobutanol, fixed in 90% ethanol and preserved in 70% ethanol. Samples of femur muscle were preserved in pure 90% ethanol; DNA was extracted from these tissue samples, and a fragment of the mitochondrial 16S rRNA gene (560 nucleotides) was amplified and sequenced using protocols given in VENCES et al. (2000).

Morphological measurements of the preserved specimens were taken by the senior author with callipers to the nearest 0.1 mm: SVL (snout-vent length), HW (head width), HL (head length), ED (horizontal eye diameter), END (eye-nostril distance), NSD (nostril-snout tip distance), NND (nostril-nostril distance), TD (horizontal tympanum diameter), HAL (hand length), FORL (forelimb length), HLL (hindlimb length), FOI (foot length), FOIL (foot length including tarsus). The webbing formula is given according to BLOMMERS-SCHLÖSSER (1979).

Vocalizations were recorded using portable tape recorders with an external microphone (Vivanco EM 238) and were analyzed with the MEDAV sound analyzing system Spekro 3.2. Temporal measurements are given as range, with mean  $\pm$  standard deviation, and number of temporal units measured, in parentheses.

Institutional abbreviations used are as follows: MNHN (Muséum National d'Histoire Naturelle, Paris); UADBA (Université d'Antananarivo, Département de Biologie Animale) (numbers given refer to the fieldnumbers of different collectors; UADBA-MICE1, collection of the MICE1 team; UADBA-RD, collection of D. Rakotomalala; UADBA-MV, collection of M. Vences; UADBA-FG/MV, collection of F. Glaw and M. Vences); ZFMK (Zoologisches Forschungsinstitut und Museum Alexander Koenig, Bonn); ZMA (Zoologisch Museum Amsterdam); ZMB (Zoologisches Museum der Universität, Berlin); ZSM (Zoologische Staatssammlung München). Coordinates and altitudes of localities are given according to GLAW et al. (2001) or given at first mention.

DNA sequences were submitted to public databases; EMBL/Genbank accession numbers are the following (voucher specimens in parentheses): *Boophis bottae* n. sp. (ZSM 344/2000, AJ314817); *Boophis erythroductylus* (ZSM 324/2000, AJ314814); *Boophis rappiodes* (ZSM 347/2000 and UADBA-FG/MV 2000.59), AJ314815 and AJ314816; *Boophis tasymena* n. sp. (ZFMK 62888), AF215339; *Boophis viridis* (ZSM 338/2000), AJ314818.

## SPECIES ACCOUNTS

### *Boophis viridis* Blommers-Schlösser 1979

*Boophis viridis* BLOMMERS-SCHLÖSSER 1979. *Name-bearing type*: holotype ZMA 7100A, adult male, collected by R. Blommers-Schlösser on 14 November 1972. *Type locality*: "near Perinet (high-road R.N. 2 at km 142)" according to original description (Perinet being the old French name of Andasibe). *Other types*: paratypes ZMA 7100B, two adult males.

*Identity and diagnosis*. See Table 1 for morphometric measurements. A member of the *Boophis rappiodes* group as recognizable by relatively small size (SVL 29–31 mm in males, 32–35 mm in females; Table 1 and BLOMMERS-SCHLÖSSER 1979), greenish and slightly translucent dorsal colouration (during the day; at night more reddish), translucent venter (inner organs can be clearly seen through the skin in live specimens) and absence of lateral fringes along lower arm and tarsus (Fig. 1). Distinguishable from all other species of the group by the larger size of males (below 27 mm in all other species), characteristic iris colouration (inner iris area

Table 1.

Morphometric measurements (all in mm) of samples of species of the *Boophis rufipoides* group. For abbreviations of variables, see Materials and methods. Other abbreviations: HT, holotype; PT, paratype; LT, lectotype; PLI, paralectotype; M, male; F, female; SA, subadult. Relative hindlimb length (RHL) is the position reached by the tibiotarsal articulation when the hindlimb is adpressed along the body.

Catalogue number	Status	Sex	Locality	SVL	HW	HL	TD	ED	END	NSD	NND	FORL	HAL	HIL	FOPL	FOI	RHL
<i>Boophis variabilis</i>																	
ZFMK 60012	—	M	Andasibe	29.5	11.5	10.9	1.7	4.0	2.6	1.9	2.7	18.8	8.7	50.0	20.6	12.0	beyond snout tip
ZFMK 60013	—	M	Andasibe	29.1	11.6	11.1	1.9	3.3	2.4	2.2	2.6	18.1	8.9	49.2	21.2	12.2	snout tip
ZFMK 53620	—	F	Andasibe	34.1	13.4	13.3	1.6	4.1	3.2	2.3	3.4	22.3	10.2	60.1	25.4	15.9	slightly beyond snout tip
ZFMK 60014	—	F	Andasibe	32.0	11.7	11.8	1.8	3.8	2.7	1.9	2.7	20.1	9.7	54.9	23.3	13.7	nostril
ZFMK 62211	—	F	Andasibe	35.1	12.9	12.7	2.1	3.6	2.9	2.2	3.1	22.1	10.7	62.0	25.8	15.1	beyond snout tip
<i>Boophis mandraka</i>																	
ZFMK 59815	—	M	Mandraka	22.1	8.8	8.0	1.3	3.1	1.8	1.9	2.8	12.7	7.7	39.9	17.0	10.3	snout tip
ZFMK 59816	—	M	Mandraka	23.2	9.3	8.3	1.4	3.3	1.5	2.1	2.9	13.8	7.7	40.0	17.4	10.7	snout tip
<i>Boophis rufipoides</i>																	
ZMB 30540	HT	M	Ankoraka	25.1	9.0	9.0	1.6	3.2	2.2	1.7	2.8	14.9	7.3	43.6	17.8	10.5	beyond snout tip
ZFMK 53621	—	M	Nahampoana	24.0	9.6	8.8	1.4	3.3	2.0	1.7	3.0	13.9	6.6	41.9	17.7	10.3	beyond snout tip
ZFMK 53622	—	M	Nahampoana	25.1	10.0	9.5	1.7	3.6	2.3	2.0	3.0	16.3	7.7	43.8	18.3	11.1	beyond snout tip
ZFMK 53624	—	M	Andasibe	20.4	7.7	7.4	1.4	3.1	1.5	1.3	2.3	13.9	6.9	38.3	15.8	9.2	clearly beyond snout tip
ZFMK 53625	—	M	Andasibe	21.4	8.0	8.0	1.2	3.0	1.6	1.4	2.2	13.2	6.4	36.5	14.5	8.4	snout tip
ZSM 347/2000	—	M	Andasibe	24.2	9.0	8.8	1.3	3.1	2.1	1.4	2.7	15.0	7.0	42.7	17.8	10.0	beyond snout tip
ZSM 676/2001	—	M	Andasibe	22.7	8.8	8.0	1.1	3.2	2.0	1.5	2.0	13.5	6.7	40.2	16.5	9.3	beyond snout tip
ZFMK 53623	—	F	Andasibe	33.6	11.7	12.6	1.8	4.2	2.4	2.1	3.2	21.2	10.0	60.2	26.0	15.8	beyond snout tip
ZFMK 59869	—	F	Andasibe	32.7	11.2	10.9	1.6	3.6	2.2	2.3	3.4	19.0	9.1	53.7	22.4	14.8	anterior eye corner
ZFMK 62278	—	F	Vohiparara	30.0	10.8	10.6	1.7	3.0	2.4	2.1	3.2	18.6	8.6	50.2	21.4	13.0	snout tip
<i>Boophis borae</i> n. sp.																	
ZSM 678/2001	HT	M	Andasibe	24.2	9.0	8.7	1.4	3.4	2.0	1.5	2.2	15.5	6.9	43.0	17.3	10.4	beyond snout tip
ZSM 679/2001	PT	M	Andasibe	23.5	8.6	8.6	1.4	3.3	2.1	1.3	2.3	15.6	7.4	41.6	17.5	10.7	beyond snout tip
ZSM 344/2000	PT	M	Andasibe	21.9	8.1	8.2	1.4	3.3	1.6	1.4	2.4	15.0	6.9	37.7	16.3	9.6	beyond snout tip

(continued)

Table 1 (continued)

Catalogue number	Status	Sex	Locality	SVL	HW	HIL	TD	ED	END	NSD	NND	FORL	HAL	HIL	FOPL	FOI	RHL
ZFMK 60015	PT	M	Andasibe	23.8	8.9	8.4	1.5	3.4	1.6	1.3	2.4	14.4	7.4	40.3	17.6	10.5	nostril
ZFMK 60016	PT	M	Andasibe	24.1	9.1	8.3	1.5	3.4	1.9	1.4	2.3	14.6	7.3	42.1	18.1	10.6	beyond snout tip
ZFMK 62220	PT	M	Andasibe	21.2	8.0	7.8	1.3	3.3	1.9	1.6	2.5	14.0	6.4	39.5	16.8	9.7	clearly beyond snout tip
ZFMK 62221	PT	F	Andasibe	35.1	12.7	12.5	1.8	4.0	2.4	2.2	3.4	20.7	9.8	56.7	24.2	15.0	nostril
<i>Boophis erythrodractylus</i>																	
MNHN 1994.1469	LT	M	Mahaibe	25.7	9.3	8.9	1.7	3.0	1.7	1.7	2.4	13.8	7.4	42.1	17.7	10.5	snout tip
MNHN 1953.171	PLI	M	Mahaibe	23.8	9.5	9.2	1.7	3.3	1.8	1.7	2.8	14.3	7.2	39.9	16.8	10.2	between eye and nostril
MNHN 1994.1470	PLI	SA	Mahaibe	21.3	7.8	7.6	1.2	2.8	1.6	1.6	2.5	12.4	6.3	37.7	15.4	9.3	snout tip
MNHN 1994.1471	PLI	SA	Mahaibe	21.2	8.2	7.6	1.4	2.8	1.7	1.2	2.2	14.8	6.1	36.9	15.6	9.4	snout tip
ZFMK 59813	—	M	Mandraka	24.6	9.6	9.1	1.7	2.7	2.0	1.5	2.6	16.4	8.0	44.0	18.8	11.4	beyond snout tip
ZSM 677/2001	—	M	Mandraka	24.2	9.2	8.5	1.7	3.3	2.0	2.0	2.8	15.9	7.4	43.2	18.0	10.5	snout tip
ZFMK 59814	—	F	Mandraka	33.0	11.9	11.1	2.2	3.1	2.5	1.7	2.9	20.4	10.0	53.7	23.8	14.2	nostril
<i>Boophis tasymena</i> n. sp.																	
ZSM 1085/2001	HI	M	Andasibe	22.7	8.7	8.0	1.7	3.0	1.9	1.6	2.4	13.8	7.0	39.6	17.2	10.2	snout tip
ZFMK 62225	PI	M	Andasibe	22.2	8.4	8.0	1.5	3.1	1.7	1.5	2.6	14.6	7.2	40.3	17.0	10.2	beyond snout tip
ZFMK 62243	PT	M	Mantady	21.0	8.2	7.5	1.4	2.7	1.6	1.4	2.0	13.6	6.4	38.7	16.1	9.6	clearly beyond snout tip
ZFMK 62244	PT	M	Mantady	21.9	8.3	7.5	1.5	3.0	2.0	1.5	2.3	15.2	7.0	38.9	16.3	9.8	snout tip
ZFMK 62262	PT	M	An'Ala	21.8	8.6	7.7	1.6	2.8	1.7	1.6	2.5	13.5	6.3	38.1	15.9	9.5	slightly beyond snout tip
ZFMK 62267	PT	M	An'Ala	21.8	8.5	7.8	1.5	3.0	1.7	1.2	2.3	14.9	6.6	38.0	16.2	9.6	beyond snout tip
ZFMK 62888	PT	F	Andasibe	32.3	11.1	11.0	2.2	3.0	2.4	1.7	3.1	19.0	8.7	53.3	23.1	13.5	nostril
Uncertain attribution																	
MNHN 1930.432	—	M	Vondrozo	24.5	9.3	8.7	1.5	3.1	2.3	1.8	2.6	15.6	7.7	40.8	17.5	10.3	nostril

brown, outer iris area blue), and by advertisement calls (unharmonious pulsed notes instead of pulsed click or trill notes of more harmonious structure).

*Material examined.* UADBA-MICET 331, 335, 344, 347 (Marotreh forest, 6 km S Ranomafana, 21°18.14'S, 47°27.4'E, 910 m elevation); UADBA-MICET 260-262, 304 (Ankopakopaka forest, 12 km NW Ikongo, 21°49.39'S, 47°20.20'E, 645 m elevation); UADBA-MV 2001.186, 2001.188-189 (Andasibe); ZFMK 53620, 60012-60014 and 62211 (Andasibe); ZSM 338/2000 and 675/2001 (Andasibe).

*Natural history and advertisement calls.* A few observations were reported by BLOMMERS-SCHLÖSSER (1979) and GLAW & VENCES (1994). According to published data and observations made in 1994-1996 and 2000-2001 at Andasibe, males generally call at night from leaves at 1-2 m above the ground, along (or up to 10 m away from) slow-moving brooks and streams, at forest edges. However, on 28 December 1994, during dry weather conditions, calling males were sitting on trees up to 5 m above the ground. Calling activity was recognized in the months October, November, December, and March. One pair in axillary amplexus (the female being ZFMK 62211) was observed on 31 January 1996 and laid 154 eggs in captivity. In contrast to the pale-yellowish eggs of *B. rappiodes*, *B. erythrodactylus*, and *B. bottae*, the eggs of *B. viridis* were dark brown. Another pair in amplexus was observed on 10 March 1996.

Advertisement calls were briefly described by GLAW & VENCES (1994); we here provide a more detailed description. Calls (recorded on 28 December 1994, in the evening around 19:00 hr) consisted of two note types. Notes of type 1 (Fig. 2) consisted of up to 40 pulses (pulse repetition rate about 135/sec) and had a duration of 131-295 msec ( $213 \pm 41$  msec,  $n = 15$ ). They were sometimes arranged in series, with intervals of 347-755 msec ( $546 \pm 129$  msec,  $n = 10$ ) between notes. The frequency ranged between 2150 and 3300 Hz. Each note was emitted as one expiration. Note type 2 generally consisted of three pulses (less frequently up to five pulses) and had a duration of 42-74 msec ( $53 \pm 11$  msec,  $n = 9$ ). The intensity of the first pulse was usually lower than that of the following pulses. This note type was often emitted in short series of 2-3 notes; inter-note interval duration was 347-484 msec ( $420 \pm 59$  msec,  $n = 6$ ). When both note types were combined (e.g., a note of type 1 followed by a series of notes of type 2), the note of type 1 was usually more intense.

*Distribution.* The species was originally known only from the type locality, Andasibe in central-eastern Madagascar, but was recorded from the Andringitra massif at 700-720 m altitude by RAXWORTHY & NUSSBAUM (1996). Recent collections by teams of the University of Antananarivo in the Ranomafana and Ikongo areas yielded one specimen (UADBA-MICET 331) which clearly can be assigned to *B. viridis* (as well as several additional specimens probably belonging to the species: UADBA-MICET 260-262, 304, 335, 344, 347).

#### *Boophis rappiodes* (Ahl 1928)

*Rhacophorus rappiodes* Ahl 1928: *Name-bearing type*: holotype ZMB 30540, collected by Braun. *Type locality*: "Ankoraka, Sahambendrana (Zentral-Madagaskar)" according to the original description; corresponding to Akkoraka near Sahambendrana according to BLOMMERS-SCHLÖSSER & BLASC (1991). *Other types*: none.

*Identity.* During fieldwork in Andasibe, central-eastern Madagascar, we noted that *B. rappiodes* as defined by BLOMMERS-SCHLÖSSER (1979), BLOMMERS-SCHLÖSSER

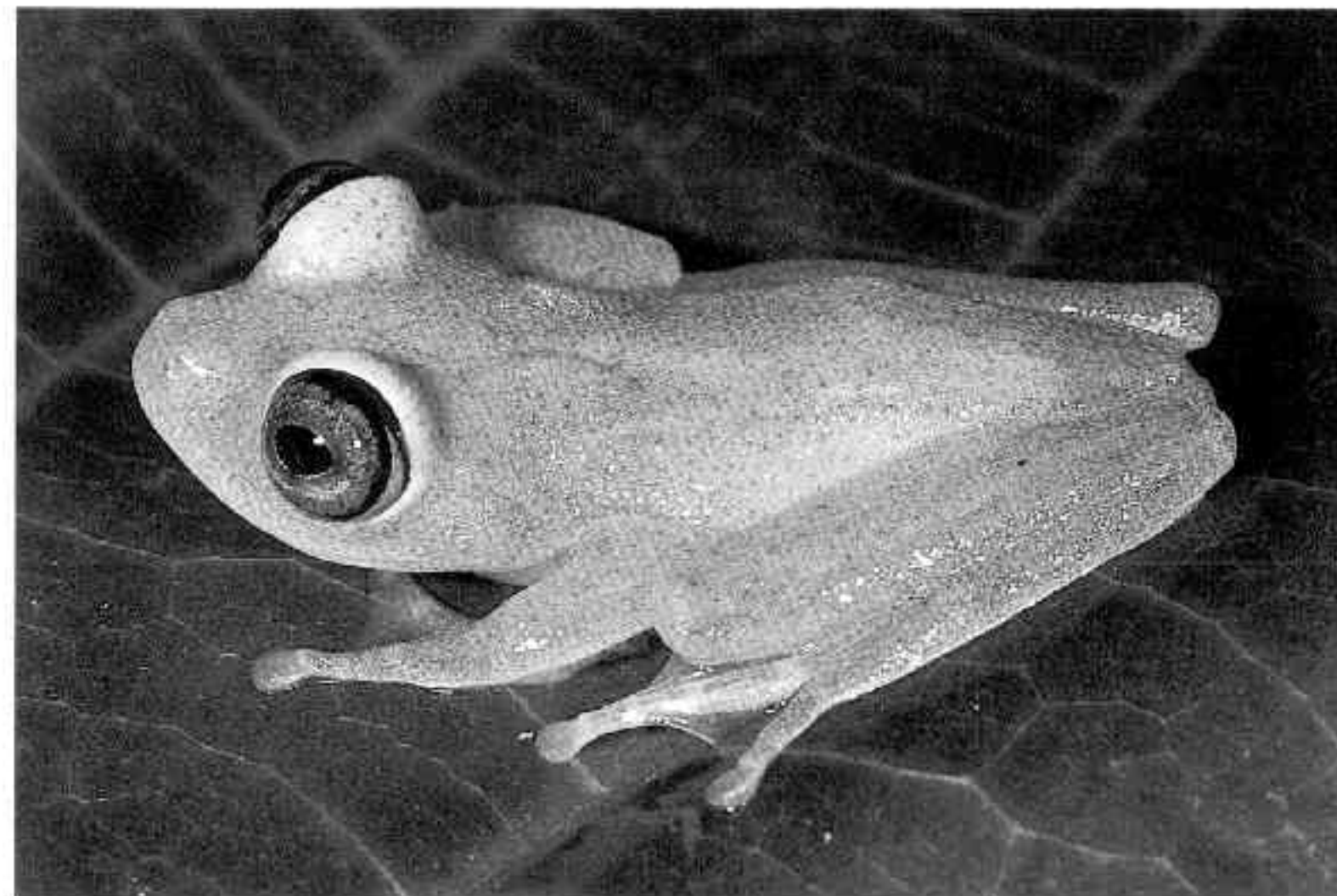


Fig. 1. — *Boophis viridis*, adult specimen from Andasibe.

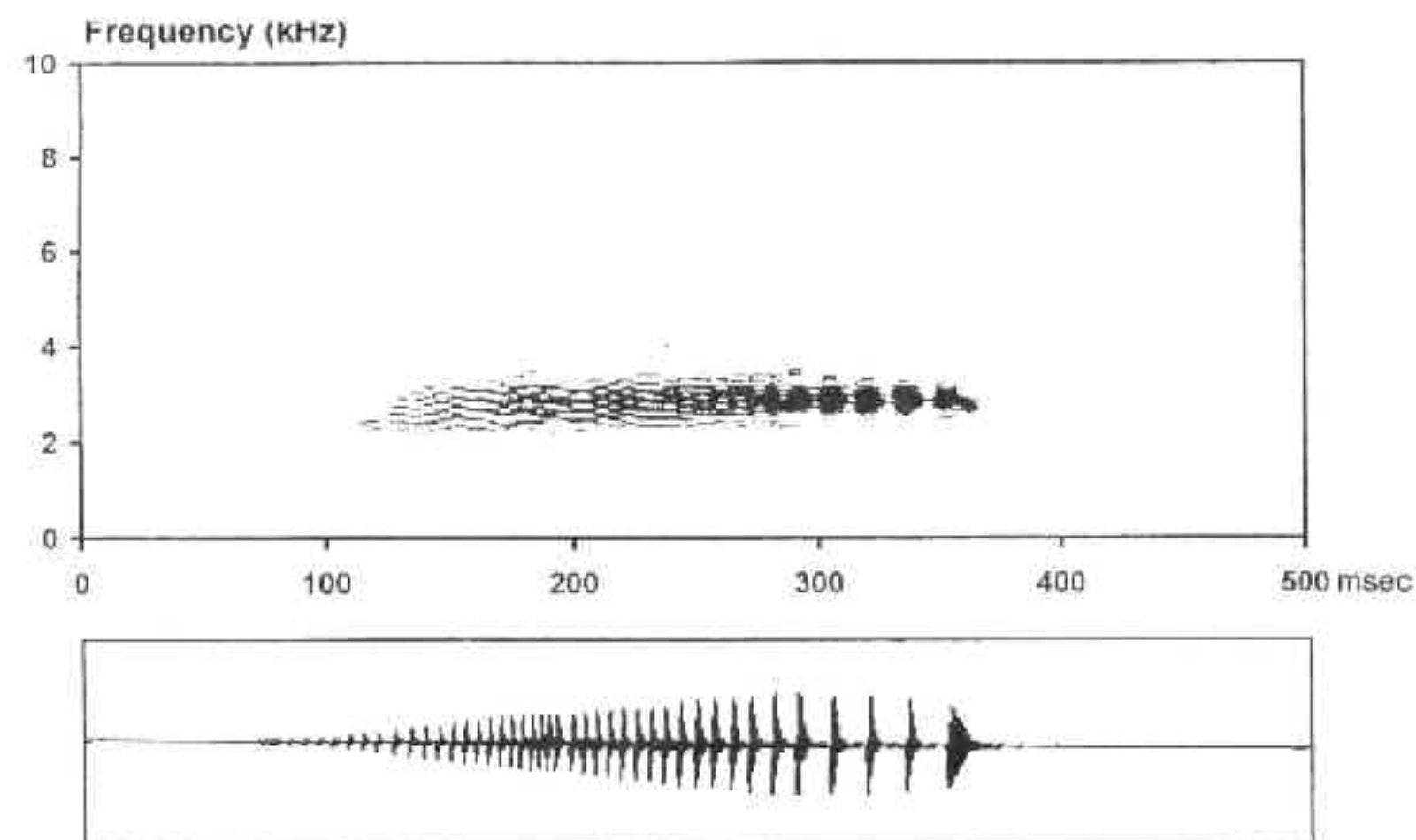


Fig. 2. — Sonagram and oscillogram of a note of type 1 of *Boophis viridis*, recorded at Andasibe.

& BLANC (1991) and GLAW & VENCES (1994) was actually a mix of two different forms. One form had extensive reddish-brown markings on its greenish back, which in preservative changed into a persistent brownish pattern, and a call that included long trills, sometimes preceded and followed by click notes. Specimens of the second form often had less extensive and usually bright red markings on the greenish back (Fig. 3), which in ethanol faded after a few days or weeks, and had calls consisting of short click series only. The two forms were observed syntopically at Andasibe, while at Nahampoana in south-eastern Madagascar only the second form was found and trill calls were not heard. DNA sequences (560 nucleotides of the 16S rRNA gene) differed in the two forms; 38 substitutions and 3 indels were found, corresponding to a total pairwise sequence divergence of 7.3%. Altogether, the evidence is overwhelming that the two forms are reproductively isolated and constitute two separate species. The holotype of *Boophis rappiodes* is in rather good state of preservation (despite the contrary statement of GUIBÉ 1978) and clearly shows remains of a light dorsolateral band on each side (presumably yellow in life) running from the nostril over the eye along the supratympanic fold, fading in the shoulder region. Except for a fine dark spotting all over the dorsum, no other pattern is recognizable. This agrees exactly with specimens from Nahampoana (ZFMK 53621-53622) which are clearly attributable to the form with little dark pigment on the back. We therefore conclude that this form must be considered as *Boophis rappiodes* (Ah! 1928), while the species with more dark pigment on the back will be described below.

**Diagnosis.** See Table 1 for morphometric measurements. A member of the *Boophis rappiodes* group as recognizable by small size (males 20-25 mm, females 30-34 mm), greenish and slightly translucent dorsal colouration, translucent venter (inner organs can be clearly seen through the skin in live specimens) and absence of lateral fringes along lower arm and tarsus (Fig. 3). Distinguished from *Boophis mandraka* by nostril position (closer to snout tip vs slightly closer to eye), iris colour (absence of distinct reticulations on a light beige iris), usual presence of red markings on the back (vs generally absent) and continuation of dorsolateral stripes from eye to supratympanic fold (vs restricted to snout tip-eye). Distinguished from *B. viridis* by smaller size and presence (vs absence) of yellowish dorsolateral stripes. For distinction from *B. erythrodictylus* and the two new species described herein, see below.

**Material examined.** UADBA-FC/MV 2000.59 (Andasibe); ZFMK 53621-53622 (Nahampoana); ZFMK 53623-53625 and 59869 (Andasibe); ZFMK 62278 (Vohiparara); ZMB 30450 (holotype; Ankoraka); ZSM 347/2000 and 676/2001 (Andasibe).

**Natural history and advertisement call.** Calling males were observed at night 2-3 m high in the vegetation along a large, slow-moving stream at Andasibe (sometimes more than 10 m from the water), and about 1 m high in the vegetation along a rather large and noisy brook at Nahampoana, at forest edges or outside primary forest. At Nahampoana, advertisement calls were recorded on 4 January 1992 at 18:30 hr (air temperature about 25 °C). Each note consisted of two pulses; duration of inter-note intervals was 2800-5400 msec. Duration of single pulses was 13-21 msec ( $n = 6$ ), duration of inter-pulse intervals was 40-45 msec ( $n = 3$ ). The frequency was between 2500 and 3500 Hz. Similar calls were recorded at Andasibe (from specimen ZSM 347/2000; Fig. 4). The second pulse had generally a higher intensity and longer duration than the first pulse. Duration of the first pulse of a note was



Fig. 3. — *Boophis rappiodes* (ZFMK 59869), adult female from Andasibe.

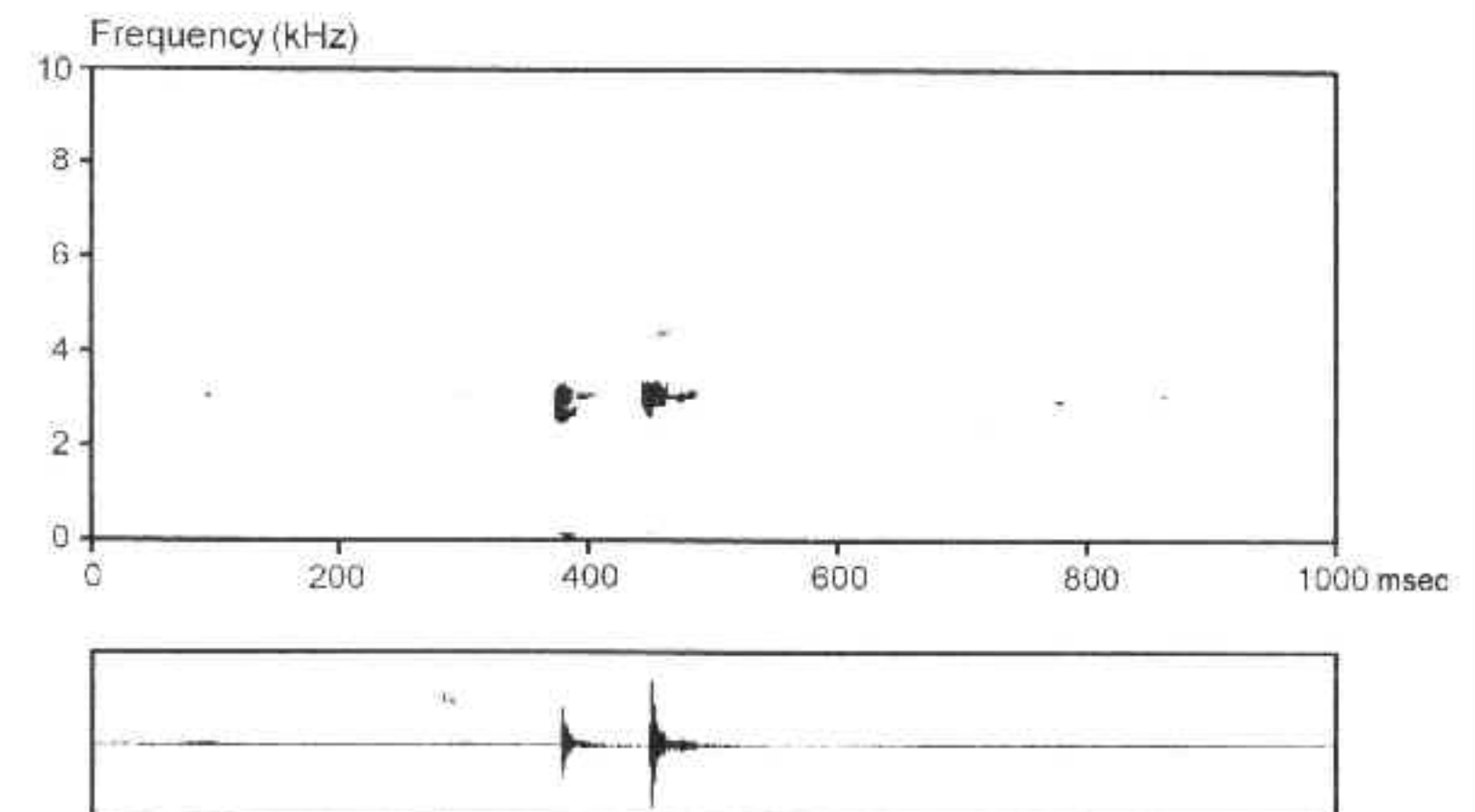


Fig. 4. — Sonogram and oscillogram of a call of *Boophis rappiodes*, recorded from specimen ZSM347/2000 at Andasibe.

9.29 msec ( $14 \pm 7$  msec,  $n = 9$ ); duration of inter-pulse intervals was 42-62 msec ( $55 \pm 6$  msec,  $n = 9$ ); duration of the second pulse was 11-27 msec ( $20 \pm 7$  msec,  $n = 9$ ). The frequency ranged between 2500 and 3400 Hz.

**Distribution.** Besides the holotype from (1) Ankoraka and specimens collected by us at (2) Andasibe, (3) Nahampoana, and (4) Vohiparara, BLOMMERS-SCHLÖSSER & BLANC (1991) recorded *B. rappiodes* from three additional localities, Mandraka, Moramanga and Anosibe. These records are probably based on ZMA 7161 and 7168, tadpoles and young from Mandraka, and ZMA 7166, tadpoles "collected along the road from Moramanga to Anosibe at km 27" (BLOMMERS-SCHLÖSSER 1979). As it is not known at present how the tadpoles and young of *B. rappiodes* can be distinguished from those of *B. bottae* n. sp. (see below), we consider these sites as in need of confirmation. Also the identity of *B. rappiodes* records from Marojejy, Anjanaharibe-Sud and Tsararano in north-eastern Madagascar (RAXWORTHY et al. 1998, ANDREONE et al. 2000, RASULIMANANA et al. 2000) remains to be revised.

### *Boophis bottae* n. sp.

**Identity.** This is the *B. rappiodes*-like species with distinct dark pigment on the back and trill calls (see above). Calls of this species were attributed to *B. rappiodes* by GLAW & VENCES (1994).

**Diagnosis.** A member of the *Boophis rappiodes* group as recognizable by small size (males 21-24 mm, one female 35 mm), greenish and slightly translucent dorsal colouration, translucent venter (inner organs can be clearly seen through the skin in live specimens) and absence of lateral fringes along lower arm and tarsus. Distinguished from *B. mandraka* by nostril position (closer to snout tip than to eye vs slightly closer to eye), and iris colour (absence of distinct reticulations on a light beige iris). Distinguished from *B. viridis* by smaller size, iris colouration, and presence (vs absence) of yellowish dorsolateral stripes. Distinguished from *B. erythro-dactylus* by lack of reddish colour of fingertips, and from *B. erythro-dactylus* and *B. tasymana* n. sp. (see below) by lack of regular pattern of red dorsal spots. By morphology and colouration, *B. bottae* n. sp. is most similar to *B. rappiodes*. It is distinguished, however, by a more extensive dark pattern on the dorsum. This difference is most distinct in living or freshly preserved specimens; while the dorsal pattern in *B. rappiodes* is intensely red, and remains red in preservative before it eventually fades, the pattern in *B. bottae* is reddish-brown in life and becomes persistently dark brown in preservative, often covering almost the entire dorsum (Fig. 5). Additionally, *B. bottae* is easily distinguished by its advertisement calls as no other species of the *B. rappiodes* group emits long trill calls composed of double click notes (Fig. 6).

**Holotype.** ZSM 678/2001, adult male, collected by M. Vences and D. Vieites on 16 February 2001 close to Andasibe (at a bridge on the road between the National Road 2 and the Andasibe village), central-eastern Madagascar  $18^{\circ}56'S$ ,  $48^{\circ}25'E$ , ca 900 m elevation.

**Paratypes.** UADBA-MV 2000.194 and 2000.196, ZSM 679/2001, three adult males, same collection data as holotype; UADBA-FG/MV 2000.60 and ZSM 344/2000, two adult males, collected by F. Glaw and M. Vences on 9 February 2000 at the type locality; ZFMK 60015-60016, two adult males, collected by F. Glaw on 28 December 1994 at Andasibe; ZFMK 62220-62221, one adult male and one adult female, collected by F. Glaw on 9 February 1996 at Andasibe.

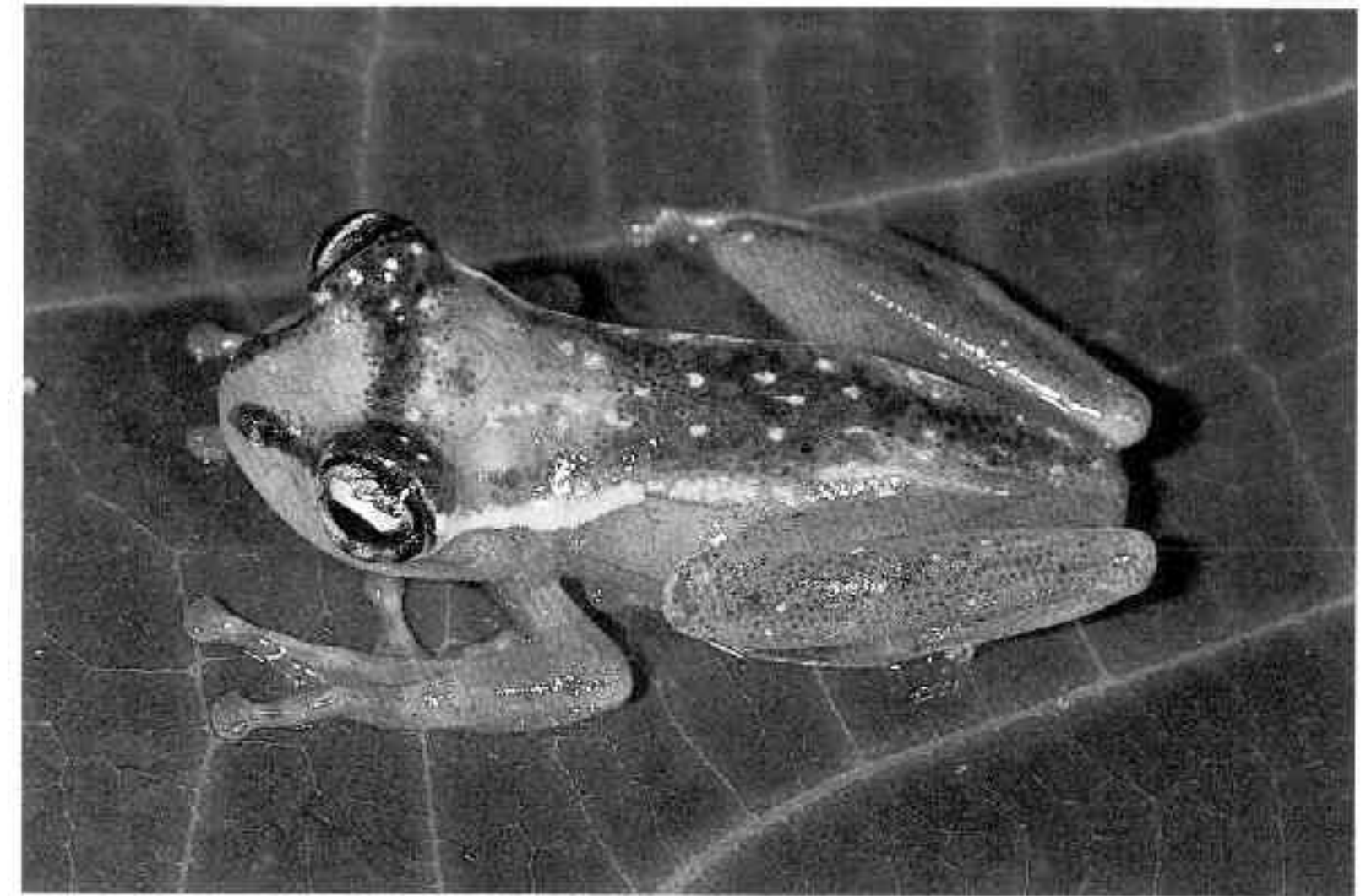


Fig. 5. — *Boophis bottae* n. sp. (paratype ZFMK 60016), adult male from Andasibe.

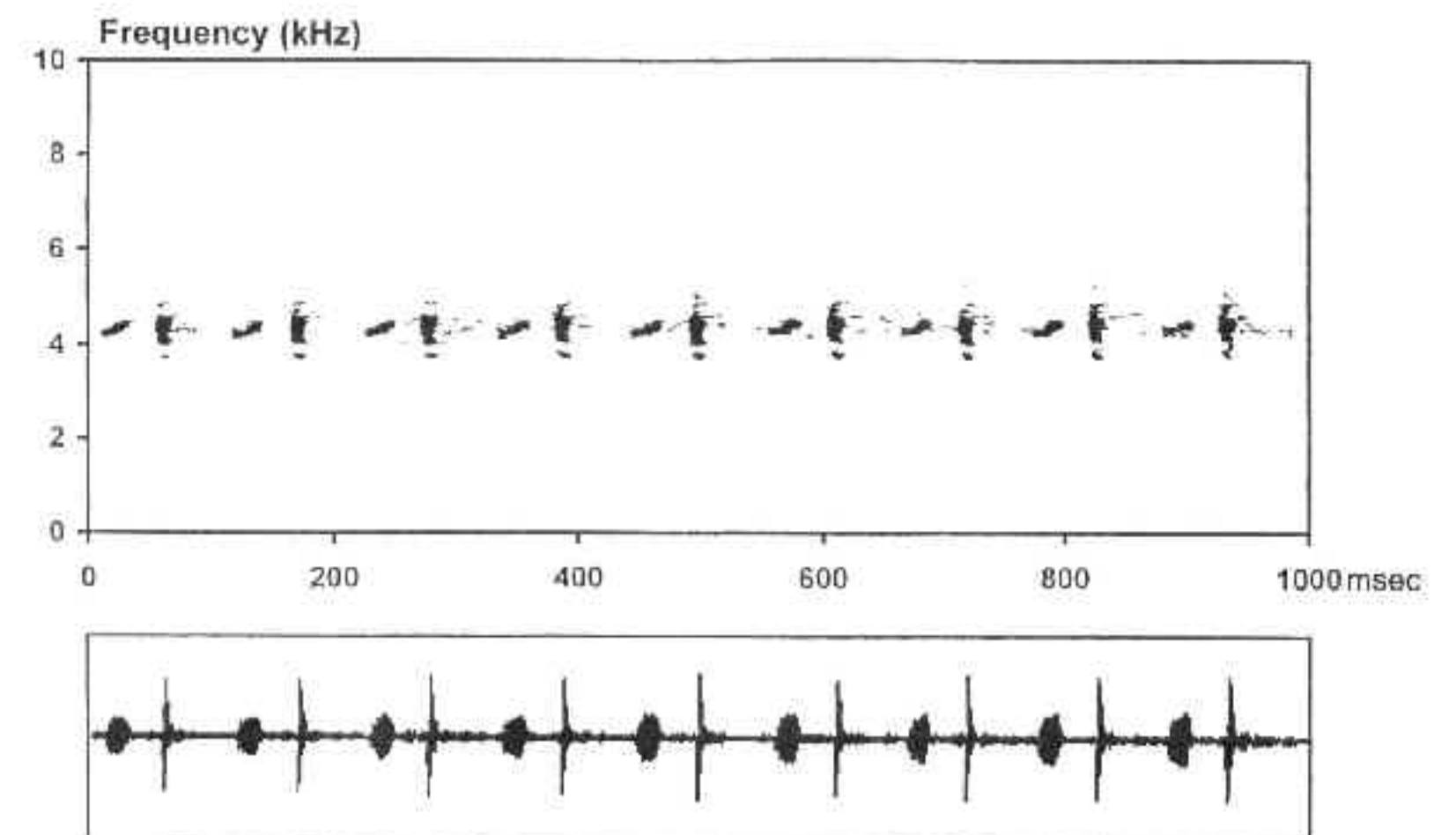


Fig. 6. — Sonogram and oscillogram of a section of a call of *Boophis bottae* n. sp. (series of notes of type I), recorded at Andasibe.

*Further material.* UADBA-RD 1724 and 1732 (Vinanitelo, 15.5 km SE Vohitrafeno, 21°46.5'S, 47°20.8'E, 1100 m elevation); UADBA-MICET 19-21 (Mandriandry forest, 4.4 km SW Tolongoina, 21°35.3'S, 47°29.1'E, 750 m elevation); UADBA-MICET 144 and 147 (Ambahaka forest, 9 km NW Ambatofotsy, 21°44.2'S, 47°24.5'E, 750 m elevation). As no bioacoustic data of these specimens are known, we do not include them in the type series; they agree, however, with the type material in morphology and colouration.

*Description of the holotype.* SVL 24.2 mm. For measurements, see Table 1. Body slender; head wider than long, much wider than body; snout rounded in dorsal and lateral views, nostrils directed dorsolaterally, slightly protuberant, nearer to tip of snout than to eye; canthus rostralis moderately distinct, curved; loreal region concave; tympanum distinct, rounded, 41% of eye diameter; supratympanic fold rather indistinct and straight; tongue ovoid, distinctly bifid posteriorly; vomerine teeth distinct, in two elongate aggregations, positioned posterolateral to choanae; choanae rounded. Arms slender, subarticular tubercles single; metacarpal tubercles not recognizable; fingers webbed; webbing formula 1 (1), 2i (1.5), 2e (1), 3i (2.25), 3e (1), 4 (1); relative length of fingers 1 < 2 < 4 < 3, finger 2 distinctly shorter than finger 4; finger disks distinctly enlarged; unpigmented nuptial pads recognizable on the inner side of first finger. Hindlimbs slender; tibiotarsal articulation reaches beyond snout tip when hindlimb is adpressed along the body; lateral metatarsalia separated by the webbing; inner metatarsal tubercle recognizable, no outer metatarsal tubercle; webbing formula between toes 1 (0), 2i (0.5), 2e (0), 3i (0.5), 3e (0), 4i (1.5), 4e (1), 5 (0.25). Skin on the upper surface smooth; ventral skin smooth on throat where the presence of a vocal sac is clearly recognizable, slightly granular on belly; no distinct enlarged tubercles in the cloacal region.

After 5 months in preservative, the basic colour is beige-whitish. No further pigments are present on the flanks, while the whole dorsal side is irregularly covered with more or less intense dark pigment. This dark colour is interrupted by a pattern of small pigmentless spots. The area above the eyes is beige to reddish. The dorsal side of the legs is covered by few small dark pigment cells. The venter is unpigmented, the inner organs are visible through the translucent belly skin.

*Variation.* The paratypes agree largely in morphology and colouration with the holotype. The dark dorsal pattern is strongly expressed in the single female specimen (ZFMK 62221) and some males (ZFMK 62220), while in some other males (ZFMK 60016; Fig. 5) it is less distinct and sometimes relatively faint (ZFMK 60015). A dark inter-ocular stripe or band is always visible, and the dark pattern is always more intense on the posterior back. Two light dorsolateral bands are visible in most preserved specimens.

*Colour in life.* Based on colour slides of several paratype specimens (Fig. 5). The ground dorsal colour, including limbs, webbing and finger and toe disks is light greenish, more yellowish towards the flanks. Thin yellow dorsolateral stripes run from behind the eye to at least the forelimb insertion, sometimes along the whole body. Additionally, the dorsal surface has a pattern consisting of four general pigment types, but presence and extent of all of them is very variable. First, a red-brownish pattern is generally present above the eyes and as an inter-ocular band, and often as spots and larger markings on the posterior back. Second, a black pattern is often seen as very fine regular spotting on the back (probably consisting of single melanophores); often, the blackish pigment forms larger and more intense spots (probably dense layers of melanophores) at the center of the red-brownish

markings, i.e. above and between the eyes. Third, a pattern of bright red dorsal spots is often present; although sometimes intermediate states between these spots and the red-brown markings are observed, generally the red colour appears similar to that observed in *B. rappiodes*. Fourth, small dorsal yellow spots are often also observed. Few markings are present on fore- and hindlimbs. The venter is translucent. The iris is beige with a turquoise outer iris area and a brownish central marking in its lower part; the iris periphery is blue.

*Etymology.* Dedicated to Ursula Boti, ZFMK, in recognition of her invaluable help during the past 10 years.

*Natural history and advertisement calls.* Calling males were regularly observed during the night at Andasibe, 1-3 m high in the vegetation along a slow-moving stream, in part syntopically with *B. rappiodes*. Advertisement calls recorded from ZFMK 62220 at Andasibe on 9 February 1996 (20:30 hr) at 23 °C air temperature had a complex structure. Note type 1 was a double click which corresponded to one expiration and was emitted in long trill series of up to 2800 msec (note repetition rate 8-9/sec). Each note consisted of one longer and one shorter click pulse (Fig. 6). Duration of the first, longer pulse was 21-27 msec ( $22 \pm 2$  msec,  $n = 15$ ), duration of the second pulse was 7-11 msec ( $9 \pm 1$  msec,  $n = 15$ ), inter-pulse interval duration was 26-29 msec ( $27 \pm 1$  msec,  $n = 15$ ). Inter-note intervals in trill calls had a duration of 48-70 msec ( $54 \pm 5$  msec,  $n = 13$ ). The frequency of the long pulses was 4050-4450 Hz with a dominant frequency of 4150-4350 Hz, the frequency of the short pulses was 3600-4900 Hz with a dominant frequency of 4200-4500 Hz. Notes of type 2 generally consisted of three pulses (the first pulse having a lower intensity) and were usually emitted at the end of one trill call with a note repetition rate of about 2/sec. Pulse duration was 7-28 msec ( $17 \pm 9$  msec,  $n = 5$ ) for the first pulse, 21-26 msec ( $24 \pm 2$  msec,  $n = 5$ ) for the second pulse, and 20-27 msec ( $24 \pm 3$  msec,  $n = 5$ ) for the third pulse. Inter-pulse interval duration was 28-40 msec ( $33 \pm 6$  msec,  $n = 5$ ) between first and second pulse and 14-25 msec ( $20 \pm 4$  msec,  $n = 5$ ) between second and third pulse. Calls recorded on 27 February 1996 at Vohiparara had an almost identical structure; the duration differences between the two pulses of note type 1 were less distinct. The vocal sac was single subgular and remained partly inflated between calls.

*Distribution.* The species is known from (1) the type locality Andasibe, and from (2) the Ranomafana area. The latter locality is corroborated by our own call recordings and photographs from Vohiparara, and by UADBA specimens.

### *Boophis erythroductylus* (Guibé 1953)

*Hyperolius erythroductylus* Guibé, 1953. *Name-bearing type:* lectotype by present designation, MNHN 1994.1469 (originally numbered 1953.171A), adult male, collected in September 1952 by R. Paulian. *Type locality:* "forêt de Mahajebby, près de Morafenobe, Ouest de Madagascar" according to the original description. *Other types:* paralectotypes, 1953.171, adult male, and 1994.1470-1471 (originally numbered 1953.171B-C), two subadult specimens, with same collecting data as lectotype.

