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A new tree hole breeding *Anodonthyla* (Chordata: Anura: Microhylidae: Cophylinae) from low-altitude rainforests of the Masoala Peninsula, northeastern Madagascar

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Abstract.—We describe a new arboreal, cophyline, microhylid frog from the rainforest of northeastern Madagascar belonging to the genus *Anodonthyla*. *Anodonthyla hutchisoni*, new species, is named in honor of a lifetime of dedication to excellence in herpetology by V. H. Hutchison. *Anodonthyla hutchisoni* differs from a close relative, *A. boulengeri*, in having generally larger morphometric features and in aspects of pattern (most *A. hutchisoni* have distinct lightly colored spots on their dorsum). Furthermore, *A. hutchisoni* is genetically divergent from two close relatives, *A. boulengeri* and *A. moramora* (11–12% uncorrected pairwise sequence divergence for a fragment of the mitochondrial ribosomal 12S ribosomal RNA gene). *Anodonthyla hutchisoni* is likely an endemic species to northeastern Madagascar inhabiting and breeding within tree holes.

The complex of protected areas in Madagascar is growing, and the recent creation of several new reserves may enhance the chances for safeguarding some of the island's most natural and pristine biota and communities. Regardless of the SLOSS debate, "single large or several small" reserves (Diamond 1975, Simberloff & Abele 1976, Terborgh 1976), it is important to protect any and all nature reserves in Madagascar as a crucial and important stepping stone for the conservation of this biodiversity hotspot. In recent years we had the opportunity to visit the largest protected area in northeastern Madagascar: The Masoala National Park (2100 km^2 of land plus three marine reserves; ANGAP 2000). Without roads leading into it, this peninsula has been isolated from much of the human activities on the island and is essentially free from tourism. Masoala includes the largest portion of primary, lowland tropical forest remaining in the country (Kremen et al. 1999) and has an annual rainfall exceeding 3500 mm (Nicoll & Langrand 1989). Our recent surveys provided the opportunity to study a diverse herpetofauna, including previously unknown species (Andreone et al. 2003). The Canopy Raft Program (Radeau des Cimes) enabled us (DBF, MEW, JFS, JER) to survey the herpetofauna of this forest from the ground up through the emergent canopy layer. Moreover, FA conducted a series of field surveys at particularly biologically rich areas, at Masoala and other northeastern locali-

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ties, which yielded many new discoveries (Andreone 2004).

Frogs in the Masoala's wet forests exploit a variety of microhabitats ranging from the ground to the upper canopy (DBF & MEW pers. obs.), including plant-held waters, referred to collectively as phytotelmata (Maguire 1971). While surveying the herpetofauna at various canopy levels and studying phytotelm community structure, we found a species of *Anodonthyla* that could not be classified as a currently recognized species. Subsequently we learned that it was genetically differentiated from *A. boulengeri* and *A. moramora* (11–12% uncorrected pairwise sequence divergence for a fragment of the mitochondrial 12S ribosomal gene, Glaw & Vences 2005), taxa that are close relatives of the species described here.

Materials and Methods

We collected all specimens described here on the Masoala Peninsula of northeastern Madagascar (Fig. 1). The first specimens were collected in the years 1998 and 1999 by FA while conducting a diversity survey in some unprotected forest plots of Masoala. Subsequent specimens were collected on an expedition with the French-run canopy RAFT program (Radeau des Cimes) in 2001 along the southwestern coast of the peninsula.

We searched for frogs opportunistically during the day and night along and just off of forest trails (from ground level to emergent canopy, 0–30 m) looking in phytotelmata, leaf litter, logs, and pools of water. We also employed bioacoustic searching methods. We used canopy ascension techniques to determine the presence of frogs higher in the forest canopy. Where possible for phytotelmata, we recorded dissolved oxygen, conductivity, and temperature of water using a digital DO/conductivity/temperature probe, and we measured pH with a sepa-

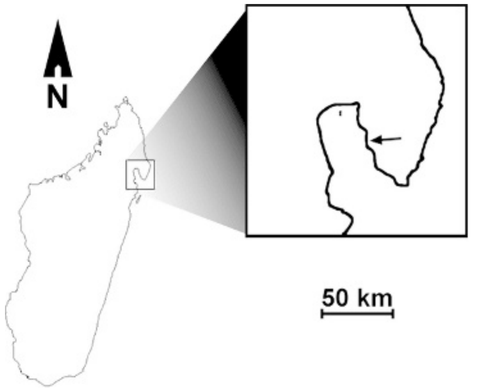

Fig. 1. Map of Madagascar, inset of the Masoala Peninsula. Arrow designates type locality of *Anodonthyla hutchisoni*.

rate digital pH probe (Cumberlidge et al. 2005).

Anuran vocalizations were recorded in 2001 with a Sony Walkman Professional WM-D6C stereo cassette recorder. We recorded a calling individual (OMNH 39030) located 40 cm from our microphone on the evening of 31 Oct 2001 and analyzed the calls using Raven (version 2.1), producing a sonogram with Canary (version 1.2.1). Air temperature near this individual was approximately 18°C, and the frog called from 3 m above the ground from a large tree trunk. Complications with the recording quality limit us to the preliminary call description below.

Specimens were anaesthetized by immersion in chlorobutanol. We fixed captured frogs in 10% formalin after writing a description of color in life and photographing most individuals. Subsequently, we transferred specimens to 70% ethanol for permanent storage at the Oklahoma Museum of Natural History or at the Museo Regionale di Scienze Naturali di Torino. Comparative materials were examined from the Naturhistorisches Museum Basel.

With digital calipers or a dissecting microscope micrometer, we took the following measurements of specimens: snout-vent length from the tip of the snout to the venter (SVL); head width at the point of the widest dorsal view of the cranium (HW); head length from angel of jaw to tip of snout (HL); horizontal eye diameter from anterior to posterior edge of eye (ED); interocular distance from the edge of the ocular swelling of one eye to the edge of the opposing eye (IOD); eye to nostril distance measuring from the anterior edge of the eye to the center of the nostril (END); distance from the center of the nostril to the tip of the snout (NSD); internarial distance from the center of one nostril opening to the center of the other (NND); horizontal tympanum diameter from anterior to posterior edge of tympanic ring (TD); hand length from proximal edge of palmer tubercle to tip of the longest digit (HAL); forelimb length from axilla to tip of longest digit (FORL); foot length from proximal articulation of metatarsal tubercle to tip of the longest digit (FOL); tibia length measuring from tip of knee to base of tarsus on bent leg (TIBL); and maximum toe pad width on each forelimb digit (TPI–TPIV). All specimens were surgically sexed. We used analysis of variance, implemented in R, for all statistical comparisons of morphometrics (R Core Development Team 2005). We considered differences statistically significant at $p \leq 0.05$.

Abbreviations for museum specimens are as follows: OMNH = Sam Noble Oklahoma Museum of Natural History; MRSN = Museo Regionale di Scienze Naturali di Torino; NHMB = Naturhistorisches Museum Basel; NMBE = Naturhistorisches Museum der Burgergemeinde, Bern; ZFMK = Zoologisches Forschungsmuseum Alexander Koenig, Bonn; ZMA = Universiteit van Amsterdam, Zoologisch Museum; ZSM = Zoologisches Staatssammlung, München.

In their phylogeny of *Anodonthyla* and several other cophyline frogs, Glaw & Vences (2005) reported *A. boulengeri* from "Ilampy," Madagascar as genetically distinct from *A. boulengeri* from Foulpointe, Madagascar. These specimens were reported as having a 12% uncorrected pairwise sequence divergence for a fragment of the mitochondrial 12S ribosomal gene. Glaw & Vences (2005) comment that, "The strong genetic differentiation among the two individuals of *A. boulengeri* further demonstrates that this species may be composed of several cryptic, yet unrecognized species." One of these specimens is mistakenly reported as, "Ilampy; Field number of F. Andreone, No. 10243; AY684182," but is actually from field site Menamalona, Masoala Peninsula (Masoala camp 5) described in this paper and collected by FA. This specimen received the final museum number MRSN A4435 and has been included in our paper as a paratype of the new species of *Anodonthyla* described herein. Therefore, genetic differences referred to in Glaw & Vences (2005) between the Ilampy and Foulpointe *A. boulengeri* specimens actually refer to differences between the new species of *Anodonthyla* described herein (MRSN A4435 from Masoala 5) and their *A. boulengeri* specimen from Foulpointe.

Systematics

Anodonthyla hutchisoni, new species
Figs. 1, 2

Type material.—Holotype: OMNH 39029, adult male from the southern versant of the Masoala Peninsula, Andranobe campsite, Maroantsetra fivondronana (district), Toamasina faritany (province), Madagascar (Fig. 1, arrow), 15°40.820′S, 49°57.750′E, 200 m, leg. DBF, MEW, JER, 31 Oct 2001.

Paratypes: OMNH 39026, adult male, same province, locality, and collectors as for the holotype, 28 Oct 2001; OMNH 39027, 39030, adult males, same province, locality, and collectors as for the holotype, collected on 31 Oct 2001; OMNH 39028, adult female collected with holotype; OMNH 39031, 39032 adult female

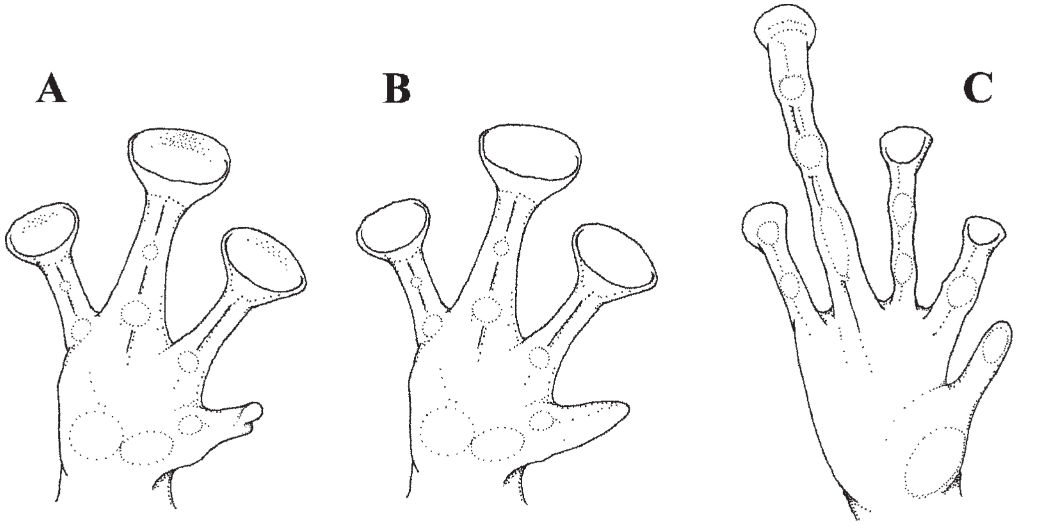

Fig. 2. *Anodonthyla hutchisoni*. A. Illustration of hand of male holotype, OMNH 39029, demonstrating sexual dimorphism in presence of prepollex in males. B. Illustration of hand of female paratype, OMNH 39033. C. Illustration of foot of holotype, OMNH 39029. Illustrations by Mark Mandica.

and male respectively, same province, locality, and collectors as for the holotype, 1 Nov 2001; OMNH 39033, adult female, same province, collected south of Andranobe, 10 m above sea level, same collectors as for the holotype, 4 Nov 2001; MRSN A4435 [genbank accession number AY684182 for the 12S fragment], A4439, adult males, MRSN A4438, adult female, Masoala Peninsula, Menamalona (Masoala camp 5), Antalaha fivondronana (district), Antsiranana faritany (province), 15°22.87′S, 49°59.27′E, 780 m, leg. FA and JER, 17 Dec 1999; MRSN A4441, adult male, Masoala Peninsula, Antsarahan'Ambararato (Masoala camp 4), Antalaha fivondronana (district), Antsiranana faritany (province), 15°23.52′S, 50°02.82′E, 550 m, leg. FA and JER, 1 Dec 1999; MRSN A4442, adult female, Masoala Peninsula, Andasin'i Governera (Masoala camp 3), Antalaha fivondronana (district), Antsiranana faritany (province), 15°18′S, 50°01′E, 650 m, leg. FA and JER, 7 Dec 1998.

Additional material.—We tentatively leave the specimen MRSN A201, from Nosy Mangabe Island, Maroantsetra fivondronana (district), Toamasina faritany (province), leg. FA 23 Apr 1990 as unassigned to either *A. hutchisoni* or *A. boulengeri* until further genetic analysis can be done.

Diagnosis.—Assigned to the genus *Anodonthyla* based on the presence of a distinct prepollex visible in male specimens (Figs. 2, 3), and on molecular phylogenetic relationships (Glaw & Vences 2005). *Anodonthyla hutchisoni* is characterized by: 1) head as wide as long; 2) snout rounded and blunt in profile; 3) canthus rostralis barely distinct; 4) tympanum roughly one-half diameter of eye; 5) eyelid diameter usually greater than or equal to interocular distance; 6) light copper or gold iris; 7) fingers without webbing; 8) first finger shorter than second, third finger longer than others; 9) toe pads on hands truncate and large; 10) pads on feet more ovoid than circular in shape and smaller than pads on hands; 11) prepollex on digit I in males, absent in females; 12) feet without webbing; 13) first digit on hand shorter than second, third longer than all others; 14) first digit on foot shorter than second, third longer than fifth, fourth longer than all others; 15) inner metatarsal tubercle vague if

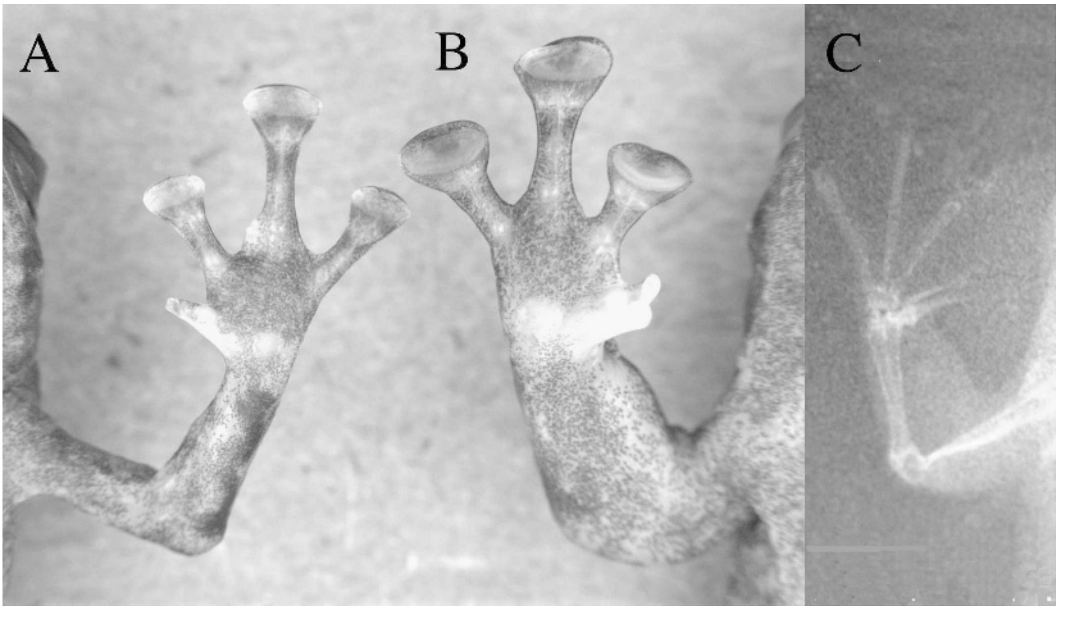

Fig. 3. *Anodonthyla hutchisoni*. A. Digital image of hand of female paratype, OMNH 39033. B. Digital image of hand of male holotype, OMNH 39029, showing sexual dimorphism in presence of prepollex in males. C. Enhanced x-ray image of hand of holotype, OMNH 39029, demonstrating prepollex attached to first digit of males.

present; 16) tarso-metatarsal articulation reaches eye or beyond; 17) dorsal surface smooth with small, dorsal, semi-prominent tubercles, brown in color, sometimes white tipped; 18) dorsal color ranges from brown, tan, or gray with vague darker pattern; 19) lower flank marked by irregular cream and brown markings, upper flank with fewer brown markings; 20) dorsal surface of thighs and legs with tan or brown bands sometimes outlined by think cream lines; 21) ventral surface cream with numerous and minute brown dots, frequently aggregated to form large brown spots; 22) adult males 19.6–23.1 mm; females 19.0–24.4 mm SVL.

Description of Holotype.—Body robust; head slightly wider than long, HW 35% of SVL, HL 31% of SVL; snout short, not protruding beyond margin of lip; rounded and blunt in dorsal view and in profile; END 67% of ED; END 25% of HL; eye large in size relative to head but comparable to other *Anodonthyla* (i.e., *A. boulengeri*); ED 38% of HL; upper eyelid with moderate tubercles, IOD 89% of ED. Pupil horizontal. Vocal sac moderate in size, single, and gular. Supratympanic fold absent, tympanum round and moderately distinct, TD 68% of ED. Top of head flat; cranial crests absent; canthus rostralis barely distinct; internarial area not depressed; nostril ovoid, protruding laterally at point above margin of lower jaw; choanae small, round, separated, partially obscured by palatal shelf of maxillary arch. Vomerine teeth absent. Tongue pear-shaped, widest at the free margin, no groove or notch, free behind for about four-fifths of its length.

Skin on dorsum of head, body, and limbs smooth but with numerous distinct tubercles. Ventral surfaces smooth. Cloacal opening elliptical, unmodified. Forearm broad in males, fingers moderate in length bearing truncate, broad, large discs; disc on digit I smaller than others: III $>$ II $>$ IV $>$ I; subarticular tubercles semi-distinct, circular, slightly elevated; supernumerary tubercles absent; palmar

Fig. 4. Photograph of live *Anodonthyla hutchisoni* at the type locality, male holotype, OMNH 39029.

tubercle semi-distinct; prepollex attached to digit I in males (Figs. 2, 3). No webbing between digits on hands. Digits on hands and feet have slight flanges. Longest hand digit to shortest: III > IV > II > I. Feet without distinct tubercles. Small pads on digits of feet, ovoid in shape and smaller than those on hands (Fig. 2). No webbing between digits of feet. Longest foot digit to shortest: IV > III > V > II > I.

Color of holotype in preservative.—(ethanol) Adult male (OMNH 39029), dorsum of head, body, and limbs brown or tan with vague darker markings, legs with tan bands outlined in thin cream lines. Two of four (in life) dorsal white spots apparent. Flanks gray, lower flanks with brown and cream irregular markings. Ventral surface gray to cream with numerous brown flecks sometimes conglomerating to form dark spots.

Color of holotype in life.—Adult male (OMNH 39029) (Fig. 4), dorsum a combination of several shades of tan and brown, creating a vague background pattern of irregular dorsolateral stripes. Scapular region with two distinct white spots, two spots mid-dorsum, ovular or circular in shape. Dorsal spots may fade or intensify through time (in as little as five minutes). Inguinal region lighter in color with dark chevrons. Posterior parts of thighs cream with dark vermiculations. Gular region gray with heavy brown spotting. Small, brown, dorsal tubercles, sometimes white tipped. Ventral surface cream with brown flecks sometimes conglomerating to form dark spots. Venter cream. Iris gold with fine black striations.

Variation.—Thirteen adults from mainland Masoala. All standard measurements reported in Table 1. Males with a SVL ranging from 19.6–23.1 mm; females ranging from 19.0–24.4 mm. Head roughly as wide as long; HW 32–38% of SVL (ratio range of 1:2.7–3.1); HL 30–38% of SVL (ratio range of 1:2.6–3.3); snout short, not protruding beyond margin of lip; rounded and blunt in dorsal

Table 1.—Morphometric values (mm) for the type series of *Anodonthyla hutchisoni* and for a published series of morphometrics for *A. boulengeri* (Glaw & Vences, 2005). See text for description of field sites. Holotypes are denoted by a superscript "H" while all others are paratypes. SVL = snout-vent length, HW = head width, HL = head length, ED = eye diameter, IOD = interocular distance, END = eye to nostril distance, NSD = nostril-snout distance, NND = internarial distance, TD = tympanum diameter, HAL = hand length, FORL = forelimb length, FOL = foot length, TIBL = tibia length.

A. hutchisoni															
Locality	Museum/#	Sex	SVL	HW	HL	ED	IOD	END	NSD	NND	TD	HAL	FORL	FOL	TIBL
Masoala 5	MRSN A4435	M	21.8	7.6	6.6	2.9	2.2	1.9	1.7	2.0	1.5	6.5	9.6	10.0	10.6
Masoala 5	MRSN A4439	M	20.5	6.6	6.3	2.9	2.5	1.5	1.6	2.7	1.7	6.4	8.9	9.3	10.5
Masoala 4	MRSN A4441	M	21.7	7.3	6.5	3.2	2.5	2.2	1.8	2.2	1.7	6.8	8.9	10.7	10.7
Andranobe	OMNH 39026	M	21.9	7.1	7.0	2.6	2.5	1.4	1.1	2.1	1.1	5.2	10.7	8.5	10.3
Andranobe	OMNH 39027	M	19.6	7.2	6.8	2.6	2.2	1.7	1.1	2.1	1.1	4.4	10.0	7.6	10.2
Andranobe	OMNH 39029[H]	M	22.9	8.1	7.2	2.7	2.4	1.8	1.4	2.3	1.3	5.7	11.4	8.9	11.1
Andranobe	OMNH 39030	M	21.5	7.3	7.2	2.3	2.4	1.6	1.2	2.2	1.1	5.1	10.7	8.7	10.5
Andranobe	OMNH 39032	M	23.1	7.7	7.6	2.5	2.3	2.0	1.2	2.2	1.2	5.0	10.9	8.4	10.7
Masoala 5	MRSN A4438	F	19.0	7.2	7.3	3.0	2.6	2.3	1.5	2.5	1.7	6.4	9.6	9.8	10.5
Masoala 3	MRSN A4442	F	21.0	7.4	7.4	2.8	2.1	2.2	2.0	1.8	1.9	6.5	9.7	9.7	11.8
Andranobe	OMNH 39028	F	24.4	8.1	7.9	2.8	2.8	1.6	1.6	2.4	1.9	5.8	11.2	9.6	11.3
Andranobe	OMNH 39031	F	22.2	7.9	7.6	2.6	2.7	1.6	1.2	2.1	1.4	5.0	10.7	8.4	11.2
Andranobe	OMNH 39033	F	21.6	7.3	7.1	2.5	2.2	1.9	1.4	2.1	1.4	5.3	11.3	8.6	10.4

A. boulengeri															
Locality	Museum/#	Sex	SVL	HW	HL	ED	IOD	END	NSD	NND	TD	HAL	FORL	FOL	TIBL
Andasibe	ZFMK2222	M	16.2	5.3	5.4	1.6	-	1.0	0.7	1.6	1.0	4.7	11.1	-	8.3
Nosy Mangabe	ZFMK52775	M	22.0	7.5	6.4	2.7	-	1.5	1.1	2.0	1.3	6.8	14.6	-	10.0
Nosy Mangabe	ZFMK52781	M	21.9	7.0	6.3	2.4	-	1.6	1.0	2.3	1.5	6.8	14.0	-	9.8
Nosy Mangabe	ZFMK52782	M	22.3	7.0	6.5	2.1	-	1.5	1.0	2.2	1.5	6.4	12.0	-	9.7
Nosy Mangabe	ZFMK52783	M	18.0	5.7	5.7	2.0	-	1.3	0.9	1.6	-	5.6	12.0	-	8.6
Nosy Boraha	ZFMK52784	M	15.7	5.1	5.2	1.6	-	1.3	1.0	1.7	1.0	4.1	9.4	-	6.9
Nosy Boraha	ZFMK52786	M	17.3	5.5	5.5	1.9	-	1.3	1.0	1.9	0.9	5.3	11.2	-	7.5
Andasibe	ZFMK53742	M	19.0	5.9	5.6	1.7	-	1.3	1.0	1.7	1.4	5.4	10.5	-	8.3
Andasibe	ZFMK62215	M	17.8	5.8	5.5	2.0	-	1.6	1.0	1.8	1.2	5.1	10.6	-	8.5

Table 1.—Continued.

Locality	Museum/#	Sex	SVL	HW	HL	ED	IOD	END	NSD	NND	TD	HAL	FORL	FOL	TIBL
A. boulengeri															
Ranomafana	ZFMK62313	M	18.7	5.6	5.4	2.0	-	1.3	0.9	1.7	1.0	5.2	11.2	-	8.8
Ranomafana	ZMA 19430	M	17.3	5.0	4.6	2.0	-	1.2	1.0	1.8	0.9	5.0	11.3	-	8.2
Foulpointe	ZSM 264/2002	M	18.0	5.4	5.2	2.1	-	1.2	1.0	1.9	1.1	4.9	11.6	-	7.8
Ranomafana	ZSM 642/2003	M	17.4	5.0	5.3	2.0	-	1.3	0.8	1.8	1.1	5.0	11.4	-	9.2
"Madagascar"	NHMB 1448[H]	F	19.0	6.3	6.4	2.4	2.1	1.9	1.9	2.1	1.1	5.0	6.8	-	9.2
Andasibe	ZFMK52780	F	19.4	5.7	5.8	1.9	-	1.5	1.1	1.6	1.4	5.4	11.6	-	8.5
Nosy Boraha	ZFMK52785	F	19.2	5.7	5.7	2.2	-	1.3	0.9	1.8	1.1	4.4	10.6	-	7.7
Anevoka	ZMF 4299	F	21.2	6.2	6.1	2.3	-	1.3	1.0	2.2	1.5	5.3	12.6	-	9.5
Ranomafana	ZSM 643/2003	F	18.2	5.1	5.4	1.9	-	1.2	1.1	1.5	1.3	5.4	13.2	-	8.9

view and in profile; END 54–79% of ED (ratio range of 1:1.1–1.9); END 20–34% of HL (ratio range of 1:3.0–5.0); eye large in size relative to head but comparable to *A. boulengeri*; ED 32–48% of HL (ratio range of 1:2.1–3.1); upper eyelid with moderate tubercles, IOD 76–104% of ED (ratio range of 1:1–1.3). Tympanum round and moderately distinct with TD 41–68% of ED (ratio range of 1:1.5–2.4). Forearm broad in males and thinner in females (Figs. 2, 3A, B).

Variation of color in preservative.—(ethanol) Two to four dorsal white spots often apparent, with posterior two spots faded to one light patch in one individual. Ventral surface gray to cream with numerous brown flecks sometimes conglomerating to form dark spots.

Variation of color in life.—Dorsum a combination of several shades of tan and brown, creating a vague background pattern of irregular dorsolateral stripes. Dorsal spots may fade or intensify through time (in as little as five minutes). In one individual at different times, we observed four spots, then only two spots, and infrequently, none of the spots were obvious. Gular region gray or cream with heavy brown spotting. Ventral surface cream with brown flecks sometimes conglomerating to form dark spots. Iris light copper to gold with fine black striations.

Sexual dimorphism.—Females with a more robust body than males. Males with a prepollex fused to thumb (Figs. 2, 3), absent in females. Males with broad forearms, females with relatively thin forearms (Fig. 3A, B).

Vocalization.—We provide only a preliminary call description here due to our low recording quality. Males call from both exposed positions and from tree holes. The call is a repetitive single note produced for durations of 10–45 sec. The note repetition rate is approximately 1.0–1.3 notes/sec recorded at 18°C. From a spectrographic point of view, each single note shows two peaks at 3100–

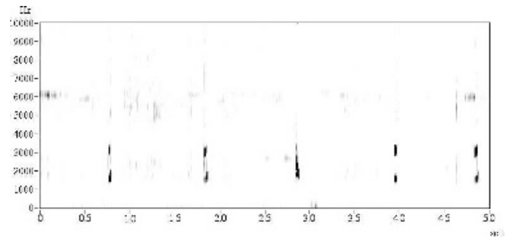

Fig. 5. Advertisment call of *Anodonthyla hutchisoni* (OMNH 39030), recorded on 31 Oct 2001 at 18°C.

3200 Hz and 4600 Hz with a fundamental frequency of 1600–1700 Hz (Fig. 5).

Justification of the new species.—The phylogenetic tree provided by Glaw & Vences (2005) indicates that *A. hutchisoni* is closely related to *A. boulengeri* but genetically distinct. A paratype of *A. hutchisoni* (MRSN A4435 — see note in the Materials and Methods regarding this specimen) shows a strong genetic differentiation of 12% uncorrected pairwise sequence divergence for a fragment of mitochondrial 12S ribosomal gene, compared to a specimen assigned to *A. boulengeri* from Foulpointe. This indicates that at least two *Anodonthyla* species inhabit the north-central and northeastern portions of Madagascar. Smaller individuals from this range have been attributed to *A. boulengeri*. The female holotype of *A. boulengeri* (NHMB 1448) is only recorded as coming from "Madagascar." Even with the ambiguous range designation for the holotype of *A. boulengeri*, we assume it was collected from central-eastern Madagascar based on the current recognized range of *A. boulengeri* and the specimen's small size. The color of this specimen is faded and cannot provide any useful chromatic data.

The larger, differently patterned, and morphometrically distinct frogs from northeastern Madagascar's Masoala Peninsula are here attributed to *A. hutchisoni*. Important morphological differences between *A. hutchisoni* and *A. boulengeri* exist: Male *A. hutchisoni* were significantly larger in the characters SVL, HW, HL, END, ED, and TIBL compared to male *A. boulengeri*, while male *A. hutchisoni* were significantly smaller than *A. boulengeri* in FORL ($F = 7.01$, $p = 0.01$; Table 2). Female *A. hutchisoni* were significantly larger than female *A. boulengeri* in the comparisons of HW, HL, END, ED, TD, and TIBL, with SVL showing a marginally significant difference ($F = 4.97$, $p = 0.056$; Table 2).

In addition to size differences, the dorsal pattern of *A. hutchisoni* typically has large, distinct cream spots not described in *A. boulengeri*. Finally, the vocalizations of *A. hutchisoni* appear to be distinct from *A. boulengeri*. *Anodonthyla hutchisoni* vocalizes at 1.0–

Table 2.—Morphometric comparisons between *Anodonthyla hutchisoni* and *A. boulengeri*. Mean values (mm) for the *A. hutchisoni* type series (Table 1) and an *A. boulengeri* series (Glaw & Vences 2005) are listed, followed by analysis of variations results (implemented in R). Significance is considered at $p \leq 0.05$. SVL = snout-vent length, HW = head width, HL = head length, END = eye to nostril distance, ED = eye diameter, TD = tympanum diameter, TIBL = tibia length.

	Males				Females			
	A. hutchisoni	*A. boulengeri*	*F* value	*P* value	*A. hutchisoni*	*A. boulengeri*	*F* value	*P* value
SVL	21.6	18.6	13.19	=0.002	21.6	19.4	4.97	=0.056
HW	7.4	5.8	23.27	<0.001	7.6	5.8	40.94	<0.001
HL	6.9	5.6	34.22	<0.001	7.5	5.9	52.01	<0.001
END	1.8	1.3	19.90	<0.001	1.9	1.4	6.23	=0.037
ED	2.7	2.0	28.54	<0.001	2.7	2.1	19.78	=0.002
TD	1.3	1.2	2.75	=0.115	1.7	1.3	7.60	=0.024
TIBL	10.6	8.6	35.06	<0.001	11.0	8.8	21.14	=0.001
FORL	10.1	11.6	7.01	=0.010	10.5	11.0	0.15	=0.708

1.3 calls/sec with frequency peaks of 3100–3200 Hz and 4600 Hz. In contrast, *A. boulengeri* has a call repetition rate of 1.8–3.1 calls/sec and a fundamental frequency of 3500–4500 Hz, while *A. moramora* has a call repetition rate of 0.6–0.9 calls/sec and a fundamental frequency of 2700–3150 Hz (Glaw & Vences 2005).

Anodonthyla hutchisoni differs from a population of *A. boulengeri* formerly recognized as "*Mantella pollicaris*." These frogs are from a locality, Anevoka, approximately 400 km SSW of the range of *A. hutchisoni*. The type specimen of what was *M. pollicaris* (SMF 4299) has relatively smooth skin on its dorsal surface and little indication of a pattern. *Anodonthyla hutchisoni* has tuberculate skin on its dorsal surface and preserved animals retain clear indications of their dorsal pattern.

A. hutchisoni is distinguished from *A. nigrigularis*, which has a blackish throat and is found in the southeast region of the island. The recently described species, *A. moramora*, is smaller than *A. hutchisoni*, and has a variegated dorsal pattern including a green color in its pattern (Glaw & Vences 2005).

Anodonthyla hutchisoni is also morphologically similar to some small microhylids of the closely related cophyline genus *Platypelis*. While males can be quickly differentiated in the presence (*Anodonthyla*) or absence (*Platypelis*) of a prepollex, females may not be as easily differentiated. *Platypelis tetra* is morphologically similar to *A. hutchisoni* (Andreone et al. 2003). However, *A. hutchisoni* is larger in size, (19.0–24.4 mm SVL vs. 15.7–19.4 mm SVL), with larger toe pads, bifurcate toe pads, second greatest toe pad diameter on digit four, presence of dorsal tubercles, increased brown spotting on the ventral surface, absence of a dorsolateral brown stripe bordered by cream bars on the flanks, and distinct white dorsal spots that, when present, do not interconnect.

Of the other *Platypelis* species that may be sympatric and similarly sized, *A. hutchisoni* differs from *P. barbouri* in lacking webbing between the toes and fingers, in lacking the red or green markings on the dorsal surface of the groin and thighs, in the possession of white dorsal spots, usually, and in a tympanum diameter half the diameter of the eye. *Anodonthyla hutchisoni* differs from *P. cowani* in lacking webbing between the toes, in lacking a uniformly white ventral surface, in the absence of a beige triangular marking on the dorsal surface, in the possession of dorsal tubercles, and in the possession of white dorsal spots, usually. *Anodonthyla hutchisoni* differs from *P. occultans* in lacking vestiges of webbing between the toes, in lacking a triangular marking on the dorsal surface, in a tibio-tarsal articulation that extends at least to the eye, in the possession of dorsal tubercles, and in the possession of white dorsal spots, usually. In addition to morphological differentiation of the new species from frogs in the genus *Platypelis*, Glaw & Vences (2005) demonstrate that *A. hutchisoni* is phylogenetically nested amongst other species of *Anodonthyla*; a monophyletic group that has diverged from *Platypelis* (Andreone et al. 2005).

Distribution.—A. hutchisoni is currently known from the following localities of northeastern Madagascar: Ambanizana, Andasin'I Governora, Andranobe, Antsarahan'Ambararato, Menamalona. The localities fall within the mainland Masoala Peninsula, western coast and slope. The localities of Ambanizana, and Andranobe are on/near the coast, while the others are farther inland.

According to Glaw & Vences (2005) the similar species, *A. boulengeri*, is known from the following localities: Andasibe (ZFMK 53742, 52780, 62215, 62222), Nosy Boraha (ZFMK 52784–52786), Ranomafana (ZFMK 62313, ZMA 19430; ZSM 642/2003, 643/2003), and

Foulpointe (ZSM 264/2002). Furthermore, we also attribute to *A. boulengeri* a specimen recently collected at Antara (MRSN-RJS 0804; Toamasina faritany, Mananara fivondronana; leg. JER, 15 Jan 2005). We suspect that the distribution of *A. boulengeri* extends from central-eastern Madagascar up to the Antongil Bay (as is supported by the finding of a specimen at Antara, which is south of Maroantsetra, and identified by FA as *A. boulengeri*), while *A. hutchisoni* is a potential endemic of the mainland Masoala Peninsula. As far as is known, *A. boulengeri* and *A. hutchisoni* do not live in syntopy.

A population of *Anodonthyla* from Nosy Mangabe is difficult to unequivocally ascribe to one species. A single analyzed female housed in Turin (MRSN A201) has a light dorsal coloration and has whitish spots at the level of the groin. The SVL is 21.6 mm, similar in size to *A. hutchisoni*. So, we wait for further information before we assign the Nosy Mangabe population to a species.

Ecology.—*A. hutchisoni* was found during the day and night from 0–3 m above the ground but was only found calling or out of refuges at night. Six of eight specimens found in 2001 were found in phytotelmata (tree holes), while the other two (ONMH 39030, 39027) were found moving freely on a tree trunk and vine respectively. A male-female pair (OMNH 39011, 39012) providing useful ecological data was only recently identified as *A. hutchisoni* and are therefore not included in the type series. These were collected 4 Nov 2001 near the locality of the holotype. They were located, by following the male's call to a tree hole 1.0 m above the forest floor in a 10 cm deep hole, and they were found with 23 eggs, which appeared viable (clear gel capsule and white, unpigmented embryos). The eggs were completely submersed in water (approx. 13 ml). A different male-female pair of adults (OMNH 39031, 39032) was also found in a tree hole 0.8 m above the forest floor with 29 eggs. The eggs were colored as above, contained embryos approximately 3.3 mm long, and appeared to be in Gosner stage 15 or 16 (Gosner 1960). They were completely submersed in the water (approx. 26 ml, pH = 5.4).

One specimen (OMNH 39026) was found syntopically with *Plethodontohyla notosticta* and an unidentified microhylid (juv.). Microhylids found in sympatry during this study were: *Anodonthyla* sp. (a juvenile specimen which we were unable to assign to a species), *Platypelis grandis*, *P. tetra*, *P. barbouri*, *P. tuberifera*, *P.* sp., *Plethodontohyla notosticta*, *P. ocellata*, *Stumpffia tetradactyla*, *S. grandis*, and *S. roseifemoralis*.

Etymology.—The epithet "*hutchisoni*" is designated as a patronym in honor of Victor H. Hutchison to recognize his distinguished career and significant contribution to our understanding of herpetological biology, ecology, and physiology.

Discussion

The new species of *Anodonthyla* is an arboreal member of the genus likely allied with *A. boulengeri*, with which it shares several morphological and chromatic characteristics. It is distinct from that species through differing genetic, morphological, and likely vocalization characteristics. Further field and genetic studies are required to understand the relationships of species in this genus, but the recent phylogenetic analysis carried out by Andreone et al. (2005) clarifies what is known to date.

The new species appears to be distributed only in northeastern Madagascar, although further data are needed to confirm this hypothesis. However, our intensive work in much of the pertinent Malagasy forests allows us to be rather confident of our reported distribution. In this context, *A. hutchisoni* is the only currently described species of this genus present in Masoala proper, where it seems to be restricted only to low altitude rainforests. This description adds to the already important data for Malagasy herpetodiversity (Andreone 2004). Further inventories should be conducted to determine whether the new species is also present in the low altitude rainforests of the eastern slope of the Masoala Peninsula.

Serious threats challenge the anuran fauna of this region of Madagascar (Andreone & Luiselli 2003, Andreone 2004, Andreone et al. 2005). In terms of conservation, it is difficult to categorize the new *Anodonthyla* herein described. The few localities where it is present do not lend well to the determination of specific threats. For this reason, this species should be included in the "data deficient" species that already comprises a great number of Malagasy species (Andreone et al. 2005). Undoubtedly, deforestation represents a key threat for the Masoala Peninsula. Andranobe is currently protected, while the other known localities for *A. hutchisoni* are outside the Masoala National Park.

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