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A New Species of *Mantidactylus* (Anura: Mantellidae) from Andasibe in Eastern Madagascar

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ABSTRACT.—A new scansorial frog species of *Mantidactylus* (subgenus *Phylacomantis*) is described from Andasibe, a midaltitude locality in central, eastern Madagascar. The new species is similar to the sympatric *Mantidactylus cornutus* but differs by smaller size, presence of a chevron-like dorsal ridge, more distinct supraocular dermal spines, throat coloration, and advertisement call. Its discovery emphasizes the importance of midaltitude rain forests in central, eastern Madagascar as a center of anuran diversity.

Madagascar harbors a high diversity of anurans, with currently 182 described and numerous undescribed species (Glaw and Vences, 2000). The genus *Mantidactylus*, endemic to Madagascar and Mayotte Island, belongs to the familiy Mantellidae (Blommers-Schlösser and Blanc, 1991; Vences and Glaw 2001) and is divided into 12 subgenera (Dubois, 1992; Glaw and Vences, 1994). One of these subgenera, *Phylacomantis*, was erected to accommodate two groups of scansorial species; the *Mantidactylus pseudoasper* group (defined by highly specialized, territorial, and partly carnivorous tadpoles) and the *Mantidactylus granulatus* group. Species of *Phylacomantis* are similar to the direct-developing species of the *Mantidactylus asper* group in the subgenus *Gephyromantis* in external morphology but are distinguished from all *Gephyromantis* by behavior of calling along brooks (vs. calling far from water bodies). Including the most recent descriptions (Glaw and Vences, 2001) eight *Phylacomantis* species have been described. In this paper, we describe a new species of this subgenus, which differs both morphologically and bioacoustically from all other known *Mantidactylus* species.

MATERIALS AND METHODS

Frogs were primarily collected at dusk and night by localization of calling males. Voucher specimens were fixed in 96% ethanol, subsequently stored in 70% ethanol, and deposited in the herpetological collections of the Zoologisches Forschungsinstitut und Museum A. Koenig at Bonn (ZFMK) and the Zoologische Staatssammlung at München (ZSM). Additionally, we examined specimens in the Museo Regionale di Scienze Naturali, Torino (MRSN) bearing provisional field numbers of Franco Andreone (FAZC). Vocalizations were recorded with a portable Tensai tape recorder (model RCR-3222) and an external microphone (Vivanco EM 238). Tapes (TDK SA 90) were analyzed with the MEDAV sound analyzing system Spektro 3.2. The following morphological measurements were taken to the nearest 0.1 millimeter with a cali-

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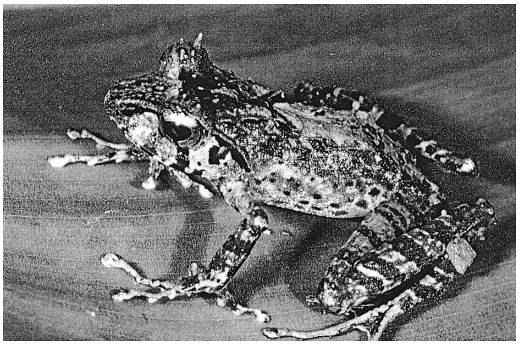

FIG. 1. Holotype of *Mantidactylus moseri* in life, dorsolateral view.

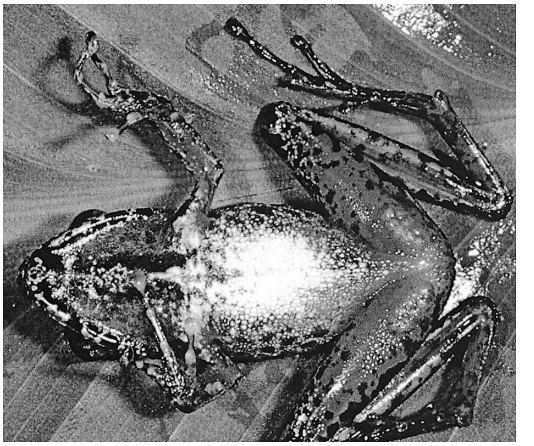

FIG. 2. Holotype of *Mantidactylus moseri* in life, ventral view.

per: 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 (tympanum diameter), HAL (hand length), FORL (forelimb length), HIL (hind-limb length), FOL (foot length), FOTL (foot length including tarsus); IMTL, IMTH (length and height of the inner metatarsal tubercle); FGL, FGW (length and width of femoral gland); TL1 (length of first toe).

Webbing formula follows Savage and Heyer (1967) as modified by Myers and Duellman (1982) and Savage and Heyer (1997). To facilitate comparisons with other species of *Mantidactylus*, we also give the formula used by Blommers-Schlösser (1979) and most subsequent authors who published accounts on Madagascan anurans.

Mantidactylus moseri sp. n.

Figures 1–2

Holotype.—ZSM 935/2000 (originally ZFMK 60024), adult male, collected by F. Glaw and N. Rabibisoa on 18 December 1994 at Andasibe (18°55′3″S, 48°25′22″E; approximately 850 m above sea level).

Paratypes.—ZFMK 60025–60026, two adult males, same locality and collecting dates as holotype.

Additional Specimens.—ZFMK 59896, adult male, collected by F. Glaw and O. Ramilison on 4 March 1995 at the Marojejy massif, Campsite 1 (14°26′S, 49°46′E; approximately 300 m above sea level); MRSN-FAZC 7040, 7010, 7011, 7370, 7009, 7349 and 6786, six adult males and one adult female, collected by F. Andreone, G. Aprea and J. E. Randrianirina in 1997 at Ambolokopatrika (14°32′S, 49°26′E); MRSN uncataloged, one adult male, collected by F. Andreone at Ambanizana. These specimens from northeastern Madagascar are larger and have shorter legs than those from the type locality. Since their conspecifity with the types is not confirmed by bioacoustic or genetic data, they are not included in the paratype series.

Diagnosis.—Assigned to the genus *Mantidactylus* based on the lack of nuptial pads and presence of femoral glands in males. Distinguished from all known species of this genus by combination of the following characters: (1) male SVL 27–39 mm; (2) horizontal tympanum diameter about 50% of eye diameter; (3) lateral metatarsalia largely separated; (4) feet distinctly but not fully webbed; (5) dorsal surface with large granules and dermal spines, including one conspicuous large spine above each eye and a chevron-like ridge on the dorsum; (6) males with a grayish, largely distensible and slightly bilobed subgular vocal sac; (7) distinct, well defined femoral glands without external median depression; and (8) temporal and spectral parameters of the advertisement call.

Description of the Holotype.—For measurements see Table 1. Body relatively slender; head longer than wide; body of same width as head in its anterior two-thirds; snout pointed in dorsal view, truncate in lateral view; nostrils directed laterally, slightly protuberant, nearer to tip of snout than to eye; canthus rostralis distinct, curved; loreal region concave; tympanum distinct, vertically elliptical, 46% of eye diameter; supratympanic fold distinct, straight; tongue ovoid, distinctly bifid posteriorly; vomerine teeth distinct, in two rounded aggregations, positioned posterolateral to choanae; choanae large, rounded. Arms slender, subarticular tubercles single; inner and two outer metacarpal tubercles distinct; fingers without webbing; comparative finger length 1<2<4<3, second finger distinctly shorter than fourth finger; fin-

TABLE 1. Measurmeents (in millimeters) of adult specimens of *Mantidactylus moseri*. See Materials and Methods section for abbreviations of characters. M, male; F, female; HT, holotype; PT, paratype. RHL (relative hind-limb length) gives the position reached by the tibiotarsal articulation when the hind limb is adpressed along the body: 1, anterior eye corner; 2, between eye and nostril; 3, nostril; 4, between nostril and snout tip; 5, snout tip; 6, beyond snout tip; 7, widely beyond snout tip.

Catalogue number	Sex	Status	SVL	HW	HL	TD	ED	END	NSD	NND	HAI	FORI	HII	FOTL	FOL	IMTL	IMTW	FGL	FGW	RHL
Andasibe																				
ZSM 935/2000	M	HT	28.6	9.5	11.4	1.7	3.7	2.9	1.6	2.5	20.8	9.5	54.0	23.9	16.3	1.7	1.1	4.1	1.7	6
ZFMK 60025	M	PT	30.1	9.9	11.9	1.9	3.5	3.3	1.6	2.4	21.4	10.3	57.4	25.2	16.7	1.5	1.1	4.5	1.8	6
ZFMK 60026	M	PT	26.9	9.5	10.7	1.8	3.5	2.9	1.7	2.4	19.0	9.0	53.3	22.5	14.5	1.4	0.8	4.6	2.0	7
Marojejy																				
ZFMK 59896	M	—	31.5	11.3	12.6	1.8	4.1	3.3	1.4	2.5	22.4	10.7	60.1	26.3	18.4	1.4	0.9	3.5	1.2	7
Ambanizana																				
MRSN-FAZC uncat.	M	—	39.1	13.6	14.8	2.8	5.1	4.4	2.1	3.1	11.0	23.3	59.3	26.0	17.6	1.9	1.4	4.6	1.8	2
Ambolokopatrika																				
MRSN-FAZC 7040	M	—	35.1	11.4	13.3	2.0	4.4	3.7	2.1	2.8	10.0	21.3	57.1	24.5	16.6	1.5	1.1	4.7	2.4	3
MRSN-FAZC 7010	M	—	34.9	12.2	13.5	2.4	4.6	3.7	1.7	2.8	10.1	21.8	59.3	25.6	17.0	1.7	1.2	4.3	1.5	4
MRSN-FAZC 7011	M	—	34.3	11.0	12.8	2.0	4.2	3.6	1.9	2.8	10.0	21.4	59.6	26.0	17.2	1.7	1.2	5.0	1.9	5
MRSN-FAZC 7370	M	—	30.9	10.5	12.1	1.9	4.4	3.0	1.9	2.8	9.2	19.2	51.8	22.7	14.9	1.6	1.0	4.6	2.1	3
MRSN-FAZC 7009	M	—	35.5	11.8	13.7	2.1	4.5	4.0	2.0	2.8	10.1	21.3	58.8	26.2	17.1	1.5	0.9	5.0	1.9	5
MRSN-FAZC 7349	M	—	30.7	10.2	11.3	2.0	3.9	3.2	1.7	2.7	9.9	20.0	52.5	24.2	16.3	1.8	0.9	3.9	2.0	1
MRSN-FAZC 6786	F	—	36.7	11.4	13.9	2.1	4.1	3.9	1.9	2.9	10.9	23.5	65.9	28.6	18.6	1.2	0.6	—	—	6

ger disks distinctly enlarged; nuptial pads absent. Hind limbs slender; tibiotarsal articulation reaches distinctly beyond snout tip; lateral metatarsalia largely separated; comparative toe length 1<2<3<5<4; third toe distinctly shorter than fifth toe; inner metatarsal tubercle large, outer metatarsal tubercle small but recognizable; webbing formula between toes I 2–3 II 2–3 II 2–3^+ IV 3^+ - 2 V; webbing formula according to the notation of Blommers-Schlösser (1979) 1(1), 2i(2), 2e (1), 3i (2), 3e (1), 4i (2.25), 4e (2.25), 5 (1). Skin on the upper surface granular; central dorsum with symmetrical dermal ridges that form a chevron-like pattern pointing anteriorly, flanked by several large granules. Interorbital area with two small blackish tubercles; 3–6 dermal spines, one much larger than the others, above the eyes; ventral skin smooth, slightly granular on belly. Femoral glands distinct (4.1 × 1.7 mm), of Type 2 (sensu Glaw et al., 2000). Throat skin distensible, caused by presence of vocal sac (slightly bilobate when fully inflated in life).

Color in preservative (after six years): dorsally grayish brown with irregular and indistinct pattern, dark brown in the head region, lighter on the posterior dorsum. Femur dorsally yellowish brown with five dark brown crossbands; tibia light brown with six dark brown crossbands. Posterodorsal part of the femur irregularly marbled with yellowish brown and dark brown. Forelimbs light brown with four dark brown crossbands. Head laterally light brown; tympanum, a streak immediately below supratympanic fold and canthus rostralis dark brown; a dark brown patch positioned below the eye, including the lower lip. Throat with brownish, irregular pattern and an indistinct light central stripe bordered by darker brown. Belly whitish; limbs yellowish with brown spots and markings.

Color in life: similar to preserved specimen; light brown patch on the posterior dorsum well delimited and of similar color as flanks; light vertical bands laterally on head more beige. Iris beige, reddish-brown laterally.

Variation.—The paratypes are very similar morphologically to the holotype. The pair of interocular granules is not visible in ZFMK 60026 but is rather distinct in 60025. The latter has an overall darker coloration, with a light brown patch anterior to the eye, running from the canthus rostralis to the lower lip. In life, the head coloration of this specimen was more contrasting than in the other types, with a beige anterior head. The central white stripe on the throat is more distinct in both paratypes; except for this stripe, their dark brown throat pattern is more uniform. The single female in the Ambolokopatrika sample (MRSN-FAZC 6786) has a SVL of 36.7 mm, whereas mean male SVL at this locality is 33.5 mm (range 30.7–35.5 mm) and corresponds to 91% of female size.

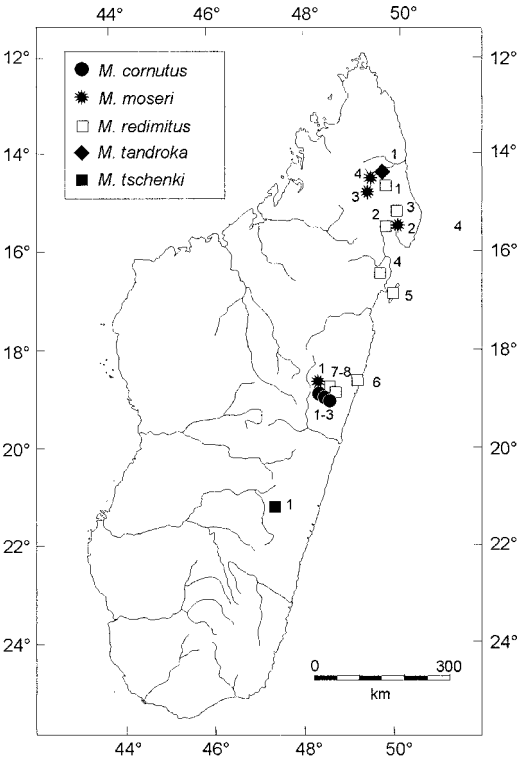

FIG. 3. Distribution of species of the *Mantidactylus granulatus* species group in the subgenus *Phylacomantis*. Locality numbers of *Mantidactylus moseri* correspond to those given in the text; those of the other species are from Glaw and Vences (2001). *Mantidactylus cornutus*: (1) Andasibe, (2) An'Ala, (3) Vohidrazana. *Mantidactylus tschenki*: (1) Ranomafana. *Mantidactylus tandroka*: (1) Marojejy. *Mantidactylus redimitus*: (1) Marojejy, (2) Nosy Mangabe, (3) Maroantsetra-Antalaha, (4) Ambatovaky, (5) Nosy Boraha, (6) Brickaville, (7) An'Ala, (8) Vohidrazana.

Etymology.—Dedicated to Felix Moser (Hamburg), in recognition of his financial support to biodiversity research and nature conservation through the BIOPAT programme.

Natural History.—Specimens were found at Andasibe 0.5–1.5 m high in the vegetation along a small brook in primary rain forest. Highest calling activity was observed immediately after dusk, no calling activity was heard at 2100 h or later. ZFMK 59896 was captured during the day in forest.

Distribution.—The species is only known reliably from (1) the type locality Andasibe. Other localities are located in northeastern Madagascar: (2) Ambanizana, (3) Ambolokopatrika, and (4) Marojejy (Fig. 3). Considering the high number of cryptic species among Malagasy anurans,

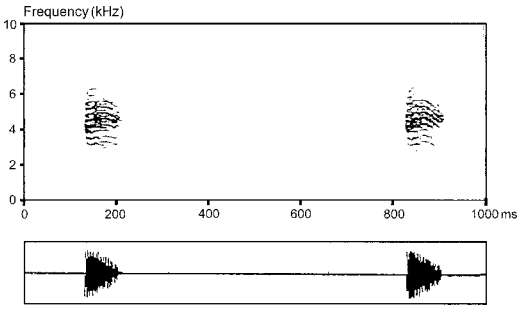

FIG. 4. Sonagram (upper) and oscillogram (lower) of two notes from an advertisement call of *Mantidactylus moseri*, recorded on 18 December 1994 at the type locality Andasibe (20°C air temperature).

assignment of these specimens to *M. moseri* remains tentative.

Calls.—Recorded at Andasibe on 18 December 1994, 1920 h at 20°C air temperature. The specimens emitted regular series of unharmonious notes (Fig. 4). Each note corresponded to one expiration. Temporal parameters of the calls of one specimen (range with mean ± SD; and number of analyzed units in parentheses): note duration 74–88 ms (83 ± 3 ms; $N = 20$), duration of intervals between notes 571–2492 ms (1104 ± 505 ms; $N = 19$). Each note consisted of 23–25 pulses. Pulse rate was 315–333 (323 ± 9; $N = 4$) pulses per second. Frequency was 2700–6200 Hz, dominant frequency 4000–4650 Hz.

Comparisons.—*Mantidactylus moseri* is assigned to the subgenus *Phylacomantis* based on vocal sac shape, behavior of calling along brooks, and general phenetic resemblance to other species of the subgenus. *Mantidactylus moseri* is distinguished from other *Phylacomantis* species as follows: from *M. pseudoasper* and *Mantidactylus corvus* by the presence of enlarged dermal spines on eyes (vs. absence of such spines), vocal sac morphology in males (single subgular or slightly bilobed and grayish vs. paired subgular with blackish folds along the lower jaw), and advertisement calls; from *Mantidactylus granulatus* and *Mantidactylus leucomaculatus* by smaller SVL (adult males 27–39 mm vs. 40–47 mm, respectively, 32–41 mm), dermal folds and tubercles on dorsum and dermal spines above the eyes (vs. absence of these structures), vocal sac morphology (single subgular or slightly bilobed and grayish vs. paired subgular with blackish folds along the lower jaw), and advertisement calls. On the basis of general appearance, *M. moseri* is similar to *Mantidactylus redimitus, Mantidactylus tandroka* and especially to *Mantidactylus cornutus* and *Mantidactylus tschenki*. All these species lack the dorsal chevron ridge and generally have no distinct median white stripe on the throat. *Mantidactylus redimitus* is much larger (males 42–50 mm SVL), has generally shorter hind limbs (tibiotarsal articulation never reaching beyond snout tip), and a much smoother dorsal surface without large dermal spines. *Mantidactylus cornutus*, which occurs sympatrically with *M. moseri* at Andasibe, has smaller spines above the eyes and generally a more distinct pair of blackish tubercles between the eyes. The same applies to *M. tschenki*, whereas *M. tandroka* is easily distinguished by the presence of dorsolateral ridges (absent in *M. moseri*). Furthermore, the new species differs from *M. redimitus, M. cornutus* and *M. tschenki* by the chevron-shaped ridge on the anterior dorsum, shorter note duration of advertisement calls (74–88 ms vs. 274–352 ms in *M. redimitus*, 90–113 in *M. cornutus*, and 274–335 im *M. tschenki*) and a much higher dominant frequency (4000–4650 Hz vs. 900–1500 Hz in *M. redimitus* and 1300–2100 Hz in *M. cornutus*). *M. moseri* of is also superficially similar to *M. asper* and *M. spinifer* (subgenus *Gephyromantis*). It differs from these species, however, by shape (slightly bilobed vs. distinctly paired) and color (grayish vs. black) of the vocal sac in males. *Mantidactylus asper* furthermore has a totally different advertisement call (Blommers-Schlösser, 1979).

KEY TO ADULT MALES OF *Mantidactylus* SPECIES IN THE SUBGENUS *Phylacomantis*

1a. Blackish paired subgular vocal sacs (easily recognizable as dark fold along the lower jaw); supraocular tubercles absent or indistinct 2

1b. Grayish single or bilobed vocal sacs (not easily recognizable as dark fold along the lower jaw); supraocular tubercles distinct, often elevated to spines 6

2a. Tympanum large, about two-thirds of eye diameter; tibiotarsal articulation reaches between eye and nostril; lateral metatarsalia partly separated; no distinct border between lighter dorsal color and darker lateral color 3

2b. Tympanum medium-sized, about one-half of eye diameter; tibiotarsal articulation reaches beyond snout tip; lateral metatarsalia largely or completely separated; color border between lighter dorsal color and darker lateral color more or less distinct 4

3a. SVL 31–34 mm; advertisement call is a rapid series of three melodious notes; northern, northeastern and northwestern Madagascar ..... *Mantidactylus pseudoasper*

3b. SVL 37–38 mm; advertisement call is a series of at least 13 slowly repeated unharmonious notes; only known from southwestern Madagascar (Isalo) ..... *Mantidactylus corvus*

4a. Prominent interocular tubercles present; longitudinal dorsolateral folds on the back present ..... *Mantidactylus tandroka*

4b. Prominent interocular tubercles absent (blackish spots can be present); longitudinal dorsolateral folds on the back absent 5

5a. Upper lip often with a white streak (if dark, always without yellow or beige patches); femoral glands indistinct, of less than 2 mm width; inner metatarsal tubercle large and prominent ..... *Mantidactylus granulatus*
5b Upper lip usually dark (sometimes with yellow or beige patches); femoral glands distinct, of at least 2 mm width; inner metatarsal tubercle small ..... *Mantidactylus leucomaculatus*
6a. SVL large, 43–53 mm; hind limbs short (tibiotarsal articulation reaches at most between nostril and snout tip but usually between eye and nostril when hind limbs are adpressed along the body) supraocular tubercles moderately developed ..... *Mantidactylus redimitus*
6b. SVL smaller, 27–40 mm; hind limbs long (tibiotarsal articulation reaches at least between eye and nostril but often beyond the snout tip when hind limbs are adpressed along the body); supraocular tubercles well developed and partly elevated to spines 7
7a. SVL 27–39 mm; a chevron-shaped ridge on the anterior dorsum ..... *Mantidactylus moseri*
7b. SVL 35–40 mm; no chevron-shaped ridge on the anterior dorsum 8
8a. Vocal sac single subgular; note duration of advertisement calls 90–113 ms; central, eastern Madagascar ..... *Mantidactylus cornutus*
8b. Vocal sac bilobate subgular; note duration of advertisement calls 274–335 ms; southeastern Madagascar ..... *Mantidactylus tschenki*

Discussion

The discovery of *M. moseri* adds another species to the herpetofauna of Andasibe, a midaltitude site in central, eastern Madagascar with a surprisingly high anuran species diversity (Blommers-Schlösser and Blanc, 1991; Glaw and Vences, 1994). Despite of the fact that the forests around Andasibe have been rather intensively studied, we did not find any further specimens of *M. moseri* in the important collections of Paris (MNHN) and Amsterdam (ZMA). Around Andasibe, we heard and found *M. moseri* only once within many years of fieldwork along a single small brook. This may indicate that its occurrence in the speciose Malagasy anuran community is very localized and that its mating activity is restricted to a short period or to special weather conditions.

The ongoing discovery of additional anuran species in the forests around Andasibe (e.g., Glaw and Vences, 1999) reinforces the conclusion that the central, eastern midaltitude rain forests are a biodiversity hotspot within Madagascar (Lees, 1996). Midaltitudes (700–800 m) were also found to harbour the highest herpetological species diversity in the Marojejy massif in northeastern Madagascar (Raselimanana et al., 2000).

Specimens attributed to *Mantidactylus moseri* are known from four localities with a maximum distance of about 500 km from each other and within an altitudinal range of approximately 300–850 m above sea level. Therefore, we can expect that its distribution covers a significant part of the Malagasy rain forests. In addition, two localities are located within protected areas (Analamazaotra Special Reserve and Marojejy National Parc, respectively). Therefore, no immediate threats for its survival are discernible as long as an effective protection of the reserve network of Madagascar is assured.

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