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Two new sibling species of *Mantidactylus cornutus* from Madagascar

(Amphibia, Anura, Ranidae)

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A review of the Malagasy frogs which in the past were subsumed under the name *Mantidactylus redimitus*, together with new field data, led to the confirmation of the specific validity of *M. cornutus* and to the recognition of two new species: *M. tschenki*, spec. nov. from Ranomafana is morphologically similar to *M. cornutus* but shows distinct differences in advertisement call and has a slightly bilobed (instead of a roundish) subgular vocal sac. *M. tandroka*, spec. nov. from higher elevations of the Marojezy massif is distinguished by a wide head, distinct dorsal ridges, and colouration from *M. cornutus*, *M. tschenki*, and *M. redimitus*. The discovery of close syntopy of *M. redimitus* and *M. cornutus* in central eastern Madagascar confirms that they represent valid species and that advertisement calls are good indicators for specific distinctness in Malagasy anurans.

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Introduction

During the last decades it has become evident that the analysis of advertisement calls is crucial to understand the species diversity of anurans (e.g. Passmore & Carruthers 1995). This is especially true for tropical anuran communities like those in Madagascar which are poorly studied and where numerous new amphibian species are still to be discovered and described. A significant percentage of the recently discovered new species are morphologically similar to already known species and some of those sibling species pairs are hardly distinguishable when preserved (Glaw & Vences 2000). However, in all cases in which anurans with relevant differences in their advertisement calls have been investigated genetically, relevant genetic distances – indicative of reproductive isolation at the species level – have been found (pers. obs. in more than 20 species pairs from Madagascar, South America, and Asia).

In the present paper we review a complex of species in the Malagasy genus *Mantidactylus* which previously (Guibé 1978, Blommers-Schlösser & Blanc 1991) were all subsumed under the name *Mantidactylus redimitus*. Glaw & Vences (1992b) noted the bioacoustic and morphological differences of low-altitude *M. redimitus* specimens and those of mid-altitude localities, and described the latter as new species *M. cornutus*. We here provide evidence that *M. cornutus* populations as listed in the distribution map of Glaw & Vences (1994) are still composed of various species: one new sibling species was discovered during a bioacoustic survey near the village Ranomafana in south-eastern Madagascar; its morphology is very similar to *M. cornutus* but its advertisement calls are rather different. In contrast, specimens from the Marojezy massif in north-eastern Madagascar differ by distinct morphological features and are described as second new species, although their advertisement calls are not yet known.

Materials and methods

Vocalizations were recorded using portable tape recorders with an external microphone (Vivanco EM 238) and were analyzed with the MEDAV sound analyzing system Spektro 3.2. The following morphological measurements were taken with a calliper to the nearest 0.1 millimeter: 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), HIL (hindlimb length), FOL (foot length), FOTL (foot length including tarsus), IMTL, IMTH (length and height of inner metatarsal tubercle), TIL (length of first toe). Webbing formula is given according to Blommers-Schlösser (1979). Institutional abbreviations are as follows: BM (Natural History Museum, London); MNHN (Muséum national d'Histoire naturelle, Paris); MRSN (Museo Regionale di Scienze Naturali, Torino); ZFMK (Zoologisches Forschungsinstitut und Museum Alexander Koenig, Bonn); ZSM (Zoologische Staatssammlung, München). Statistical analyses were carried out using SPSS for Windows, version 9. We performed Mann-Whitney U-tests to test significance of intersexual differences in size and morphometric ratios (relative tympanum length, ratio TD/SVL; relative size of inner metatarsal tubercle, IMTL/SVL and IMTH/SVL). Temporal and metric measurements are given as range, with mean ± standard deviation in parentheses.

Results

Mantidactylus redimitus (Boulenger, 1889)

Material examined. BM 1947.2.26.55 (holotype; original number BM 89.8.1.24; Madagascar); BM 92.3.7.39-41 (Sahembendrana); BM 1928.5.9.11-12 (Brickaville); BM 1988.593 (Ambatovaky); MNHN 1973.911 (Marojezy, 600-1300 m altitude); MNHN 1973.937 (Marojezy, 300 m altitude); MNHN 1973.938-939, 1973.941 (Marojezy, 600 m altitude); ZFMK 52704-52705 (Nosy Boraha); ZFMK 52716 (Nosy Mangabe, juv.); ZFMK 60073 (An'Ala).

Morphology. Summarizing measurements of the specimens in Table 1 (only adults considered; type not included due to bad state of preservation) results in a male SVL of 43.4-52.8 mm (47.6 ± 3.7 mm, n = 6) and a female SVL of 48.1-48.3 mm (n = 2). Mean male SVL was 99 % of mean female SVL. Sexual size dimorphism was not significant (U-test, P = 1). All specimens corresponded to the description in Glaw & Vences (1994) in having short legs (tibiotarsal articulation reaching at least to the anterior eye corner, at most between nostril and snout tip), and a rather smooth dorsal skin, without large dermal spines on the eyes, and with a pair of only faintly expressed tubercles between the eyes. Mean relative tympanum size did not differ significantly between sexes (U-test, P > 0.6), while intersexual differences in relative length and height of inner metatarsal tubercle (means of both values larger in males) were close to significance (U-test, P = 0.07). In contrast to the following species, the femoral glands in male *M. redimitus* were prominent and always well visible. Their size was 9.7 × 2.9 mm in MNHN 1973.911, 8.6 × 2.9 mm in MNHN 1973.937, 7.8 × 3.0 mm in ZFMK 52704, 8.4 × 3.3 mm in ZFMK 52705, and 9.2 × 3.1 mm in ZFMK 60073.

Habitat and habits. Calling activity generally started at dusk, but sometimes single calls were also heard since the early afternoon (14.30 h). Calling males were found in February and March sitting horizontally in the vegetation (1-2 m above the bottom) along larger brooks (broader than 1 m). At An'Ala, where *M. redimitus* was observed calling syntopically with *M. cornutus*, the former was only found at the edge of a broad brook (> 3 m) whereas the latter was sitting along a small afflux (not broader than 0.5 m) only several metres apart. W. Herwig (pers. comm.) photographed a specimen of *M. redimitus* at Vohidrazana on 16 July 2000 at 19.30 h. It was sitting on a leaf of a bush about 160 cm above the bottom. This record indicates that *M. redimitus* is also active in the comparatively cold and dry winter season.

Advertisement calls. Calls were recorded at An'Ala (on 11 February 1995, 17.30 h, at 22 °C air temperature) and Marojezy (on 22 February 1995, ca. 21.00 h, at 25 °C air temperature). They consisted either of single notes or note series. Each note (Fig. 1) corresponded to one expiration. At An'Ala, note duration was 274-352 ms (309 ± 22 ms, n = 9), duration of intervals between notes was 484-717 ms (584 ± 75 ms, n = 8). Each note was composed of 4-6 pulse groups, each of which contained 2-7 pulses. The longest note series recorded consisted of 12 notes and had a note repetition rate of 1.1 / s. Frequency was 900-1400 Hz. At Marojezy, note duration was 315-350 ms (329 ± 10 ms, n = 9), duration of intervals between notes 493-737 ms (597 ± 106 ms, n = 6). Each note consisted of 7-10 pulse groups, each of which

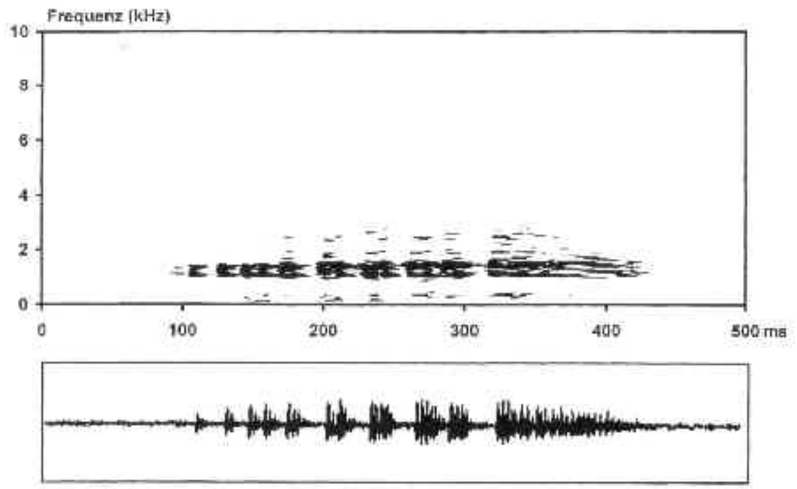

Fig. 1. Sonagram and oscillogram of one note of *Mantidactylus redimitus* from Marojezy.

contained 1-10 rather indistinct pulses. Frequency was 900-1500 Hz.

Further recordings from Nosy Boraha were analyzed by Glaw & Vences (1992a,b). The high note repetition rate (up to 2.5 / s) in those recordings differ from the An'Ala and Marojezy data, and may be due to an exceptional motivation of the corresponding specimen (several specimens were calling rather close to each other). The low note duration (ca. 100 ms) as given by Glaw & Vences (1992b), however, is an artefact of analysis (probably originated by measuring note duration on the sonagram), the actual note duration in the Nosy Boraha recordings was similar to that in An'Ala and Marojezy as we ascertained by re-analysis.

Distribution. Data presented here confirm that *M. redimitus* is primarily a low-altitude species. At Marojezy, it has mainly been found at 300-600 m above sea level, only one specimen comes from an imprecise higher altitude (600-1300 m). The collecting localities at Nosy Boraha and Nosy Mangabe were close to sea level (< 100 m altitude), whereas that of An'Ala was at 840 m above sea level. Sahembendrana is also at mid-altitude, while Ambatovaky and Brickaville can be considered as low-altitude sites. Beside these localities, Glaw & Vences (1994) list one additional locality, Maroantsetra-Antalaha (that means the path between both cities), which is based on personal observations in 1987 (only photographic voucher available). A further photographic record was made by W. Herwig at Vohidrazana some 700 m above sea level.

Raxworthy & Nussbaum (1996) reported *M. redimitus* [*M. redimitis* (sic!)] from altitudes of 650-1700 m in the Andringitra massif but did not list *M. cornutus*. Since *cornutus*-like specimens are known from Andringitra (see below), it is possible that this record is based on a misidentification. The same regards their record of *M. redimitus* from Ranomafana (900-1050 m altitude) which possibly refers to the new species *M. tschenki* described below. Two additional records of *M. redimitus* exists for the "Réserve Spéciale du Pic d'Ivohibe" (1200 m altitude) and the corridor to the "Parc National d'Andringitra", 900 m altitude (Raselimanana 1999). Since *M. cornutus* is not mentioned in this paper and MNHN material from Pic d'Ivohibe is *cornutus*-like these records are also likely to refer to *M. cornutus* or *M. tschenki*.

Mantidactylus cornutus Glaw & Vences, 1992

Material examined. ZFMK 52702-52703 (paratypes, Andasibe); ZFMK 53691 (holotype, Andasibe); ZFMK 59867 (Andasibe); ZSM 573/1999 (paratype, Andasibe, originally ZFMK 53690); ZSM 308/2000 (Vohidrazana, 18°57' 57" S, 48°30' 37" E, 730 m above sea level).

Notes on the type material. In the original description of *M. cornutus* (Glaw & Vences 1992b: 272) the paratypes were defined as follows: "Three adult males (ZFMK 53690, 52702, 52702) from Andasibe ...". The latter number was a typing error and must be corrected to 52703.

Tab. 1. Morphometric measurements (all in mm) of specimens of *Mantidactylus redimitus*, *M. cornutus*, *M. tschenki*, and *M. tandroka*. For abbreviations of measured variables, see Materials and Methods; further abbreviations used: M, male; F, female; SA, subadult; HT, holotype; PT, paratype; TT, point reached by tibiotarsal articulation when adpressed along the body: 0, anterior eye margin; 1, between eye and nostril; 2, nostril; 3, between nostril and snout tip; 4, snout tip; 5, beyond snout tip; 6, widely beyond snout tip.

Catalogue Nr.	Sex	SVL	HW	HL	TD	ED	END	NSD	NND	FORL	IIAL	IIIL	FOTL	FOL	IMTL	IMTH	TLI	TT
M. redimitus																		
BM 1947.2.26.55 (HT)	M	47.4	15.6	18.0	2.6	4.9	5.5	2.9	4.4	28.5	13.7	73.1	33.1	22.4	2.2	1.6	3.7	0
MNHN 1973.911	M	50.5	17.0	19.3	3.1	5.4	6.1	2.6	4.0	29.8	15.2	80.6	39.4	26.4	2.9	2.3	5.5	0
MNHN 1973.967	M	52.8	17.7	20.3	3.3	5.7	6.1	2.7	4.3	32.7	15.7	83.8	39.7	27.3	2.8	2.1	5.3	0
MNHN 1973.938	F	48.3	15.8	18.7	2.8	5.8	5.5	2.5	4.0	29.6	15.1	88.4	39.2	25.0	2.0	1.1	4.8	2
MNHN 1973.939	M	48.4	15.6	18.0	2.7	5.3	5.2	3.2	4.4	30.4	14.9	81.4	37.9	26.0	2.7	2.0	5.2	1
MNHN 1973.941	F	48.1	15.8	18.8	2.6	6.0	5.6	2.7	3.7	29.0	14.7	86.8	38.2	25.5	2.2	1.3	5.6	1
ZFMK 52704	M	44.0	15.7	17.6	2.6	4.5	5.4	3.0	4.4	26.5	12.2	67.0	31.0	24.7	2.2	1.6	3.2	1
ZFMK 52705	M	43.4	15.0	19.0	2.5	5.5	5.2	2.2	4.1	27.7	13.3	70.9	32.1	22.0	2.0	1.7	3.5	1
ZFMK 60073	M	46.6	15.7	18.0	2.5	5.5	6.0	3.0	4.1	29.2	14.2	78.2	34.2	24.0	2.8	1.9	4.3	3
M. cornutus																		
ZFMK 52702 (PT)	M	37.5	12.8	14.5	2.1	4.6	4.1	2.2	3.2	23.9	11.8	70.2	30.2	20.1	1.7	1.6	3.7	5
ZFMK 52703 (PT)	M	39.4	12.7	15.0	2.0	4.5	5.0	1.9	3.5	21.7	12.0	67.7	29.8	19.4	1.6	1.4	3.6	3
ZFMK 53691 (HT)	M	39.7	12.4	14.7	2.0	4.7	4.1	2.2	3.7	23.7	11.2	67.7	29.3	20.0	1.9	1.7	3.7	5
ZFMK 59867	F	38.9	12.3	14.7	2.3	4.7	4.0	2.2	3.6	24.9	11.6	73.2	31.2	20.3	1.4	0.9	3.8	6
ZSM 573/1999 (PT)	M	40.1	13.2	15.7	2.3	4.2	4.8	2.2	3.5	24.6	12.6	69.5	30.8	21.0	1.6	1.5	3.4	5
ZSM 308/2000	F	33.3	11.0	13.4	2.3	4.1	4.0	2.1	2.8	23.2	10.3	72	32.2	20.3	1.3	0.5	3.3	6
M. tschenki																		
MRSN A379 (PT)	M	34.7	11.0	13.0	2.1	4.0	3.7	1.7	2.9	21.6	10.4	58.1	26.1	18	2.2	1.1		1
ZFMK 62296 (PT)	M	36.2	12.6	14.0	2.1	4.3	3.9	2.0	3.2	26.0	12.0	67.0	29.0	20.0	2.0	1.4	3.3	6
ZFMK 62297 (PT)	M	34.8	12.2	14.0	2.2	4.5	4.2	2.0	2.8	23.7	10.7	63.5	29.2	19.4	2.0	1.5	3.2	6
ZSM 936/2000 (HT)	M	36.1	12.0	13.6	2.0	4.6	3.9	2.2	3.2	24.8	11.6	67.0	29.4	20	2.0	1.3	3.4	6
M. tandroka																		
MNHN 1973.913 (PT)	F	43.2	14.9	16.4	2.9	5.1	4.1	2.5	4.6	29.2	13.9	81.8	36.2	24.2	1.3	0.9	4.4	6
MNHN 1973.922 (PT)	M	38.9	13.1	14.5	2.2	4.8	3.4	2.2	3.7	26.6	13.0	74.4	32.8	21.8	1.8	1.3	4.6	5
MNHN 1973.924 (HT)	M	38.7	13.2	14.6	2.4	4.8	3.5	1.9	3.9	26.0	12.7	70.2	32.9	21.9	1.8	1.5	4.4	5
MNHN 1973.926 (PT)	F	44.7	15.3	16.7	2.8	5.4	4.4	2.5	4.2	28.8	14.5	84.1	37.6	24.3	1.5	0.8	4.8	5
MNHN 1973.927 (PT)	M	38.8	14.0	15.6	2.4	5.1	3.8	2.3	3.5	26.3	12.7	73.3	32.8	21.9	1.9	1.4	4.5	5
MNHN 1973.928 (PT)	F	39.8	13.3	14.8	2.2	5.1	3.8	2.3	3.8	25.8	12.6	78.4	34.3	22.4	1.2	1.1	5.1	6
MNHN 1973.929 (PT)	M	38.8	13.1	15.0	2.4	5.2	3.8	2.4	4.1	23.3	12.5	73.5	31.7	22.1	1.8	1.7	4.5	5
MNHN 1973.930 (PT)	SA	33.9	11.6	13.0	2.4	4.3	3.4	1.9	3.6	23.8	11.1	72.3	32.3	20.0	1.2	0.6	4.6	6
ZFMK 59894 (PT)	F	39.6	15.0	16.5	2.3	5.4	4.3	2.7	4.7	27.0	13.6	80.1	36.0	23.1	1.2	0.2	4.6	6
ZSM 937/2000 (PT)	F	41.5	15.3	16.6	2.3	5.6	4.3	2.6	4.3	28.3	14.0	85.0	38.1	24.5	1.8	0.9	4.1	6
Determination uncertain																		
MNHN 1953.74	F	37.9	11.8	14.0	2.4	4.7	4.0	2.7	3.4	25.9	13.3	76.1	33.6	21.3	1.3	0.6	3.7	5
MNHN 1991.2940	F	42.6	13.5	16.0	2.4	5.3	4.7	2.3	3.2	24.8	12.8	74.4	33.4	20.5	1.3	0.6	4.0	4
MNHN 1991.2941	M	38.8	12.3	13.9	2.1	4.7	4.1	2.2	3.6	25.5	13.0	66.3	28.6	19.4	2.2	1.6	3.2	3
MNHN 1972.571	F	39.4	12.3	14.8	1.8	4.1	4.1	2.2	3.4	–	12.9	71.3	31.6	21.8	1.3	0.6	4.0	3
MNHN 1972.572	F	35.9	12.0	14.6	2.0	3.3	4.4	2.3	3.2	–	11.6	68.2	30.9	21.0	0.9	0.4	4.3	5
MNHN 1972.1471	M	39.5	12.4	15.2	2.6	4.5	3.9	2.1	3.1	25.4	12.0	68.1	29.2	20.0	2.1	1.6	3.6	5
MNHN 1972.1472	M	41.4	13.2	16.2	2.2	4.9	4.5	2.1	3.2	24.0	11.9	68.8	29.9	20.7	1.7	1.6	4.3	2
ZFMK 50593 (PT *cornutus*)	F	40.7	13.0	14.9	2.5	4.4	4.4	2.0	3.3	24.7	12.9	74.7	33.9	22.0	1.5	0.8	3.3	6

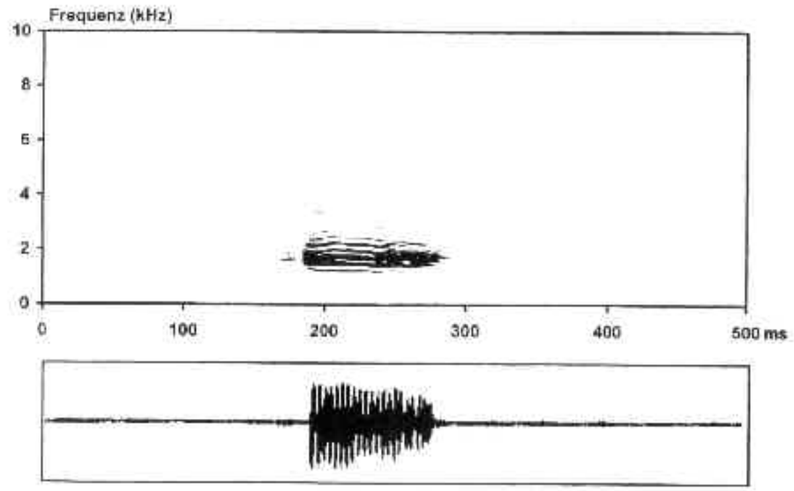

Fig. 2. Sonagram and oscillogram of one note of *Mantidactylus cornutus* from An'Ala.

Morphology. In the studied sample (see Table 1 for measurements), SVL was 37.5-40.1 mm (39.2 ± 1.2 mm, n = 4) in males and 33.3-48.9 mm (36.1 ± 4.0 mm, n = 2) in females. Mean male size was 109 % of mean female size, no significant sexual size dimorphism was found (U-test, P > 0.2). All specimens largely corresponded to the descriptions of Glaw & Vences (1992b, 1994) in having rather long legs (tibiotarsal articulation reaching at least nostril, mostly beyond snout tip) and a distinct pair of blackish tubercles between the eyes. Neither relative tympanum size (mean value smaller in males) nor relative length and height of inner metatarsal tubercle (means of both values larger in males) were significantly different between sexes (U-test, P > 0.05), but the latter may be due to small sample size.

Habitat and habits. Calling males were found in all months from December to March, indicating a prolonged mating activity during the rainy season. They were sitting horizontally in the vegetation (1.5-2.5 m above the bottom) along very small (mostly smaller than 0.5 m in diameter) and slowly running brooks, in pristine or degraded forest.

Advertisement calls. Calls were recorded at An'Ala (on 21 March 1995 at 22 °C air temperature) and Andasibe (on 16 January 1995, 19.00 h). They were long-lasting regular note series (up to several minutes). Notes (Fig. 2) were unharmonious. At An'Ala, note duration was 90-113 ms (99 ± 7 ms, n = 32), duration of intervals between notes was 616-1280 ms (825 ± 140 ms, n = 31), note repetition rate was ca. 1/s. One analyzed note consisted of 20 pulses and had a pulse repetition rate of 227/s. Frequency was 1150-2500 Hz, dominant frequency 1400-1950 Hz. At Andasibe, note duration was 93-111 ms (102 ± 6 ms, n = 10), duration of intervals between notes was 536-903 ms (720 ± 131 ms, n = 9), note repetition rate was ca. 1.3/s. One note was composed of ca. 23 pulses. Frequency was 1000-5100 Hz, dominant frequency 1300-2100 Hz.

Distribution. The species is reliably known from Andasibe (type locality, ca. 900 m altitude), An'Ala (personal observations and call recordings, ca. 840 m altitude), and most probably from Vohidrazana (only one female specimen; no calls heard, 730 m altitude). The locality Marojezy mountains, above 1300 m altitude (Glaw & Vences 1994), refers to *M. tandroka*, which is described below. All additional records of this species (Andreone 1994, Glaw & Vences 1994, Raselimanana 1998, Raxworthy et al. 1998) are in need of confirmation (see also discussion).

Mantidactylus tschenki, spec. nov.

Figs 3-4

Types. Holotype: ZSM 936/2000 (formerly ZFMK 62298), adult male, collected along the road between Ambatolahy and Ranomafana, south-eastern Madagascar, on 28 February 1996 by F. Glaw, D. Rakotomalala and F. Ranaivojaona. – Paratypes: ZFMK 62296 and 62297, adult males, collected close to the village Ranomafana