

**TWO NEW CHAMELEONS OF THE GENUS *CALUMMA* FROM NORTH-EAST MADAGASCAR, WITH OBSERVATIONS ON HEMIPENIAL MORPHOLOGY IN THE *CALUMMA FURCIFER* GROUP (REPTILIA, SQUAMATA, CHAMAELEONIDAE)**

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During herpetological surveys in N.E. Madagascar two new species of *Calumma* chameleons belonging to the *C. furcifer* group were found and are described here. The first species, *Calumma vencesi* n. sp., was found at three rainforest sites: Ambolokopatrika (corridor between the Anjanaharibe-Sud and Marojejy massifs), Besariaka (classified forest south of the Anjanaharibe-Sud Massif), and Tsararano (forest between Besariaka and Masoala). This species is related to *C. gastrotaenia*, *C. guillaumeti* and *C. marojezensis*. *C. vencesi* n. sp. differs in having a larger size, a dorsal crest, and – in females – a typical green coloration with a network of alternating dark and light semicircular stripes. Furthermore, it is characterized by a unique combination of hemipenis characters: a pair of sulcal rotulae anteriorly bearing a papillary field; a pair of asulcal rotulae showing a double denticulated edge; and a pair of long pointed cylindrical papillae bearing a micropapillary field on top. The second species, *Calumma vatosoa* n. sp., found in ericoid habitat on the summit of the Tsararano Chain, is conspicuous due to its bright greenish coloration, with a longitudinal midlateral whitish band, and a yellowish spot in the middle of each flank. The hemipenis ornamentation includes a feature exclusive to this species which has not been described in any other species of the genus *Calumma*: the coexistence of three pairs of rotulae. This species is perhaps related to *C. peyrierasi*. The distribution of the species belonging to the *C. furcifer* group is also discussed from the point of view of biogeographic patterns and refuge massifs.

*Key words: Calumma, Madagascar, chameleon, hemipenial morphology*

## INTRODUCTION

According to the revision of the family Chamaeleonidae proposed by Klaver & Böhme (1986, 1997) and complementary studies (Hofman *et al.*, 1991), two genera endemic to Madagascar and neighbouring islands are ascribed to the subfamily Chamaeleoninae: *Furcifer* and *Calumma*. Whereas most *Furcifer* species are typical inhabitants of deciduous habitats with a marked dry season – including degraded areas of this type – the *Calumma* species seem to be restricted to rainforests within the eastern region of Madagascar. Most of the latter exclusively occur in mid- and high-altitude rainforests, thus showing a rather narrow range of microthermal preferences: the highest elevational record belongs to *Calumma tsaratananensis*, collected at about 2500 m on the Tsaratanana Massif (Brygoo & Domergue, 1968). A phenetic classification based on external morphology proposed by Brygoo (1971) and reviewed by Glaw &

Vences (1994) identified five species groups within the genus *Furcifer* and four within the genus *Calumma*. The *Calumma furcifer* group has been recently reviewed by Böhme (1997), giving evidence for the elevation to full species status of the taxa formerly regarded as *C. gastrotaenia* subspecies: *C. guillaumeti*, *C. marojezensis* and *C. andringitraensis*. The description of *C. glawi* by Böhme (1997) made the *C. furcifer* group the richest species assemblage within the genera *Calumma* and *Furcifer*, with seven species.

During recent survey work in northern Madagascar, we had the opportunity to find several new species of amphibian and reptile and to obtain new records for others (e.g., Andreone *et al.*, 1998; Nussbaum *et al.*, 1998; Jesu *et al.*, 1998; Mattioli, 1998), thus stressing the importance of this geographic area. In particular, we collected two chameleons that did not fall into any known taxon, and therefore are regarded as new species. In this paper we describe them and summarize information on their distribution and phenetic relationships. Furthermore, we provide data on the hemipenis morphology and a preliminary key to the identification of the males of all the known species of this group.

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FIG. 1. Map of N.E. Madagascar with sites where some taxa belonging to the *Calumma furcifer* group were found during field surveys. 1-3, campsites 1-3 at Ambolokopatrika Corridor (collecting localities of *Calumma vencesi* n.sp.); 4, campsite 1 at Forêt de Besariaka (Betaolana Ridge) (collecting locality of *C. vencesi* n.sp.); 5, campsite 1 at Forêt de Tsararano (collecting locality of *C. vencesi* n.sp.); 6, campsite 2 at Forêt de Tsararano (collecting locality of *C. vatsooa* n.sp.). Area borders refer to the political boundaries of protected areas (PN de Marojejy, RS d'Anjanaharibe-Sud, PN de Masoala) and classified forests (Forêt de Besariaka, Forêt de Tsararano). Based upon FTM (Foiben-Taosarintanin'I Madagasikara/Institut Géographique et Hydrogéographique National) maps and a digital elaboration of GIS Service at WWF Madagascar.

## MATERIALS AND METHODS

### STUDY SITES AND PERIODS

The sites where the two new species were found are described below, and a map is given in Fig. 1. Latitudes and longitudes were given according to GPS prospecting, maps and IUCN/UNEP/WWF (1987). A more detailed description of these sites is given by Andreone *et al.* (2000).

(1) *Ambolokopatrika*. This forest is situated northwest of the Andapa Basin, between the Anjanaharibe-Sud and Marojejy massifs (Betaolana Ridge). The vegetation of the forest belongs to the domains of East and Central Madagascar (Humbert, 1955). Due to human activity, the Ambolokopatrika corridor is currently a mosaic of fairly intact forest, "savoka" (a degraded vegetational formation mainly constituted of herbaceous species) and secondary forest. At Ambolokopatrika three study sites were chosen, all within the Andapa Fivondronana, Antsiranana (Diégo Suarez) Faritany (Province), "Andemakatsara" (Campsite 1), 14°31.8'S, 49°26.5'E, 810-875 m (27 May - 3 June 1997); "Andranomadio" (Campsite 2),

14°32.4'S, 49°26.3'E, 860-910 m (4-12 June 1997 and 29 November-8 December 1997); "Antsinjorano" (Campsite 3), 14°32.6'S, 49°25.8'E, 950-1250 m (9-20 December 1997). The forest around Campsites 1 and 2 is a mid-altitude rainforest, while at Campsite 3 it is transitional between lowland and mid-altitude rainforest; at all sites there are patchworks of, on the one hand, fairly rather intact, and on the other, somewhat altered rainforest.

(2) *Besariaka*. This classified forest is about 60 km south of Andapa. It is delimited to the north by the RS d'Anjanaharibe-Sud, and to the south by the Tsararano Chain. The elevational range is 470-1232 m. Capture of the first newly described species occurred at "Ambinanin'ny miaka-midina" (Campsite 1), 14°50.8'S, 49°35.7'E, 940-995 m (4-15 June 1996). This campsite is within the Andapa Fivondronana, Antsiranana (Diégo Suarez) Faritany (Province). There the forest is rather degraded, especially in parcels far from streams. This is apparently due to several reasons, among which are the use of forest areas for cattle, the cutting of trees by villagers, and the use of well established path systems to search for "bilahy" bark (used to make the local alcoholic beverage named "betsabetsa"), and for hunting.

(3) *Tsararano*. This chain, formed by several hills (altitude 400-1269 m) and the forest of the same name lie south of the Andapa Basin, midway between the Anjanaharibe-Sud Massif and the Masoala Peninsula. The collections were made at two sites: "Antsarahan'ny tsararano" (Campsite 1), 14°54.4'S, 49°41.2'E, 700-850 m (29 November - 7 December 1996), and "Andatony anivo" (Campsite 2), 14°54.8'S, 49°42.6'E, 600-750 m (8-18 December 1996). Both of the campsites are included within the Antalaha Fivondronana, Antsiranana (Diégo Suarez) Faritany (Province). The forest of Tsararano appears to be quite intact, most likely due to its distance from large sized villages. As elsewhere, paths are being cut for the collection of local products and for the hunting of lemurs.

According to Goodman & Lewis (1998) the Andapa region is characterized by a humid and tropical climate. The mean temperature ranges from 18°C in July to 25°C in February. The relative humidity is about 87%, but reaches 97% in March and April. The annual precipitation is slightly more than 2000 mm. On average it rains 271 days per year. The "dry" season lasts about two months (September and October), with 41.1 mm and 52.6 mm of rain distributed throughout 14.7 and 15.1 days respectively.

### CAPTURE AND PRESERVATION TECHNIQUES

Chameleons were captured by hand during the night when they are paler and more visible, with the aid of battery powered torches. Some specimens were photographed to obtain information on their natural coloration. Later they were euthanased, fixed in 10% formalin or in 90% ethanol, and preserved in a final so-

lution of 75% ethanol. The voucher specimens are now housed at the Museo Regionale di Scienze Naturali (Torino), and Parc Botanique de Tsimbazaza (Antananarivo).

#### ACRONYMS, MORPHOMETRY AND HEMIPENIS TERMINOLOGY

Throughout the text the following acronyms have been used: BM(NH), Natural History Museum, London (formerly the British Museum of Natural History); MNHN, Muséum national d'Histoire naturelle, Paris; MRSN, Museo Regionale di Scienze Naturali, Torino; MZUT, Museo di Zoologia dell'Università di Torino (collection now housed at the MRSN); MSNG, Museo Civico di Storia Naturale "G. Doria", Genova; PBZT-FN, Parc Botanique et Zoologique de Tsimbazaza, Antananarivo; ZFMK, Zoologisches Forschungsinstitut und Museum "Alexander Koenig", Bonn; PN, Parc National (National Park); RNI, Réserve Naturelle Intégrale (Strict Nature Reserve); RS, Réserve Spéciale (Special Reserve). Some specimens quoted in the species description (paratypes), and marked with an asterisk (\*) currently bear the MRSN acronym, but will be later housed at PBZT. We also analysed several specimens belonging to the species of the *Calumma furcifer* group. All morphological measurements (Tables 1-2) were taken by one of us (F. Mattioli) with a dial calliper (precision at 0.1 mm): head length (HL), head depth (HD), head width (HW), socket diameter (SD), snout-vent length (SVL), tail length (TL), axilla-groin distance (AGD). For hemipenis morphology, we followed the terminology proposed by Klaver & Böhme (1986) and Böhme (1988).

The drawings of the external morphology of heads and hemipenes were made by tracing pictures obtained from slides in order to maintain the correct proportions; these were then enhanced with details gathered from direct observations using a binocular microscope.

On the basis of a few dissected specimens which all showed completely developed gonads, we assumed that all other specimens of a similar size were adults. The only exception was represented by the specimen MRSN R11682.2: in this case the dissection revealed the presence of incompletely developed ovaria, thus indicating that it had not reached maturity.

## RESULTS

### *CALUMMA VENCESI* NEW SPECIES

*Diagnosis.* A medium-sized chameleon (snout-vent length up to 73 mm), included in the *Calumma furcifer* group (*sensu* Glaw & Vences, 1994) by virtue of the absence of occipital lobes, absence of gular and ventral crest, markedly acute rostral profile and greenish coloration. This new species differs from all the others in the group in the following combination of morphological features: homogeneous scalation, divided canthi rostrales, absence of rostral appendage, evident lateral crests, evident nuchal fold, markedly oblique parietal

profile, double longitudinal ventral white line, weakly developed dorsal crest, rings made by 1-2 rows of white scales on upper surfaces of fingers [described as "bagues au niveau des doigts" by Brygoo (1978) in regard to *Calumma marojezensis*, formerly *Chamaeleo gastrotænia marojezensis*]. Concerning the hemipenis ornamentation, it differs in that (1) a pair of sulcal rotulae anteriorly bear a papillary field, and (2) a pair of asulcal rotulae showing a double denticulated edge and a pair of long pointed cylindrical papillae bear a micropapillary field on top.

*Holotype.* MRSN R1690, Forêt d'Ambolokopatrika (Campsite 2), 870 m, 14 December 1997, leg. F. Andreone, G. Aprea and J. E. Randrianirina.

*Paratypes.* MRSN R1703.1-2, Forêt de Besariaka (Campsite 1), 950 m, 7 May 1996, leg. J. E. Randrianirina; MRSN R1681, Forêt de Besariaka (Campsite 1), 945 m, 9 June 1996, leg. F. Andreone and J. E. Randrianirina; MRSN R1682.1-2\*, Forêt de Besariaka (Campsite 1), 970 m, 12 June 1996, leg. F. Andreone and J. E. Randrianirina; MRSN R1683.1-2, Forêt de Tsararano (Campsite 1), 700 m, 20 October 1996, leg. J. E. Randrianirina; MRSN R1684, Forêt de Tsararano (Campsite 1), 730 m, 28 November 1996, leg. F. Andreone and J. E. Randrianirina; MRSN R1685\*, Forêt de Tsararano (Campsite 1), 730 m, 2 December 1996, leg. F. Andreone and J. E. Randrianirina; MRSN R1686.1 and R1686.2\*, Forêt d'Ambolokopatrika (Campsite 2), 875 m, leg. F. Andreone, G. Aprea and J. E. Randrianirina 30 November 1997; MRSN R1687.1-2, Forêt d'Ambolokopatrika (Campsite 2), 860 m, 4 December 1997, leg. F. Andreone, G. Aprea and J. E. Randrianirina; MRSN R1688, Forêt d'Ambolokopatrika (Campsite 2), 865 m, 12 December 1997, leg. F. Andreone, G. Aprea and J. E. Randrianirina; MRSN R1689.1-3, Forêt d'Ambolokopatrika (Campsite 3), 960 m, 11 December 1997, leg. F. Andreone, G. Aprea and J. E. Randrianirina; PBZT-FN 6661 [specimen not measured], Forêt d'Ambolokopatrika (Campsite 1), 850 m, 29 May 1997, leg. F. Andreone and J. E. Randrianirina; PBZT-FN 6662 [specimen not measured], Forêt d'Ambolokopatrika (Campsite 1), 850 m, 29 May 1997, leg. F. Andreone and J. E. Randrianirina; PBZT-FN 6690 [specimen not measured], Forêt d'Ambolokopatrika (Campsite 1), 850 m, 2 June 1997, leg. F. Andreone and J. E. Randrianirina.

### DESCRIPTION OF THE HOLOTYPE

*External morphology.* Adult male in a good state of preservation with fully everted hemipenes. Scales homogeneous, except on vicinity of cranial crests and parietal region (upper side of the cranium), in which they are a little bit larger. Head (Fig. 2) shows slightly developed orbital and parasagittal crests and rather developed lateral crest. The parasagittal crests joined at occiput apex. Absence of occipital lobes and gular crest. Canthi rostrales divided and rostral appendage

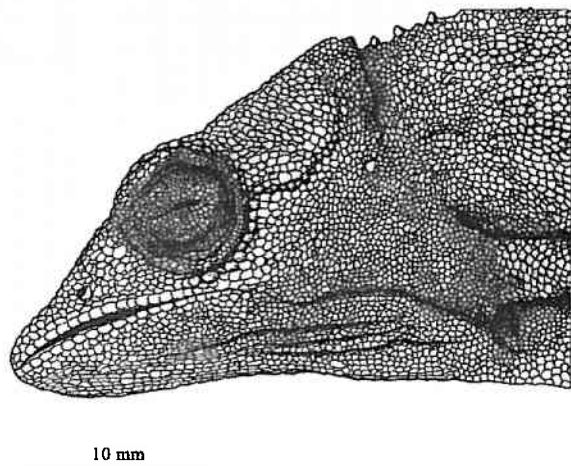


FIG. 2. Lateral view of the head of *Calumma vencesi* n. sp. (MRSN R1690, male, holotype).

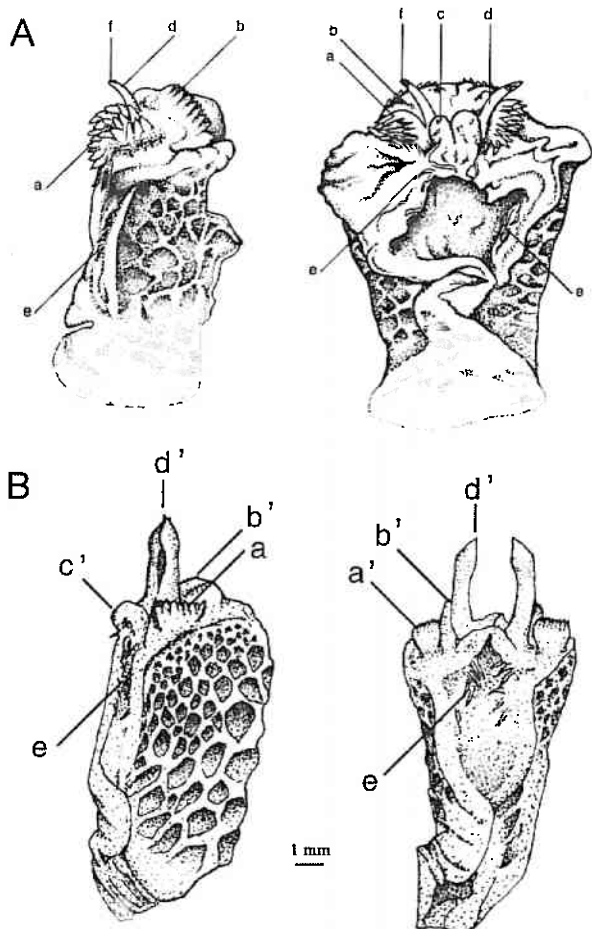


FIG. 3. Hemipenis morphology (lateral and sulcal view) of *Calumma vencesi* n. sp. (MRSN R1690, male, holotype) (A), compared with *Calumma marojezensis* (MRSN R1701) (B). Main ornamentations: sulcal rotulae bearing papillary field (a); asulcal rotulae bearing a double denticulated edge (b); pair of hypertrophic papillae (c); pair of long pointed cylindrical papillae (d); double row of pointed papillae on sulcal lips (e); micropapillary field (f); sulcal rotulae (a'); asulcal rotulae (b'); two hypertrophic papillae joined together (c'); pair of long pointed cylindrical papillae enlarged on top (d'). Same letters mark presumably homologous structures.

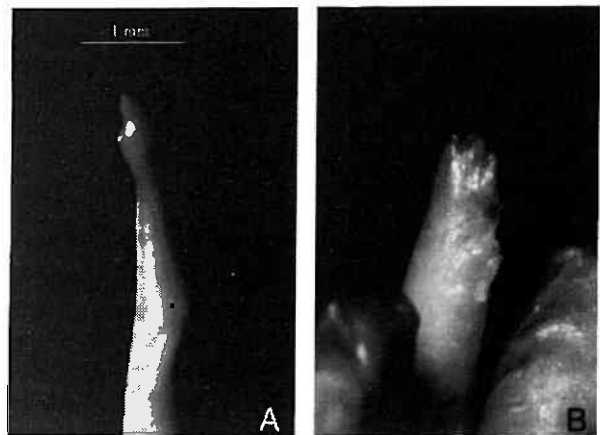


FIG. 4. Comparison between the tips of the cylindrical papillae of *C. marojezensis* (A) and the tips of the cylindrical papillae of *C. vencesi* n. sp. bearing a micropapillary field (B).

absent. Scales enlarged around nostrils. Markedly acute rostral profile and oblique parietal profile. At nape level a dermal fold extends on back for 2 mm. Occiput apex slightly raised forming a pointed helmet. Dorsal crest consisting of ten spines with different degrees of development distributed along the whole body length, but absent on tail. Deep axillary pockets. Number of scales at widest point of flanks: 58. Absence of ventral crest. Evident rings – often joined to each other – consisting of 1-2 rows of white scales on upper surfaces of fingers.

**Hemipenial morphology.** Hemipenis (Fig. 3) clavate, calcified, capitate, slightly flattened on sulcal plane. Sulcal lips markedly divergent. Sulcus with ridges and distally limited by a fleshy outgrowth sited at the point at which the sulcal lips join each other. Caput ornamentation consists of: (1) a pair of large sulcal rotulae bearing a papillary field on sulcal side; (2) a pair of smaller asulcal rotulae showing a double denticulated edge; (3) a pair of rounded hypertrophic papillae in sulcal central position; (4) a pair of long pointed cylindrical papillae – longer than any other ornamentation structures – bearing a micropapillary field on top (Fig. 4), sited between the pair of sulcal rotulae and the pair of central papillae; (5) a double row of twelve pointed thin papillae of various sizes respectively starting on left and right of the pair of central papillae and descending along the sulcal lips. Hemipenis length around 10 mm, i.e. 13.7% of snout-vent length.

**Coloration in life.** The male holotype (Fig. 5, photographed during the night) is characterised by a rather light green coloration on the back. Small scattered darker spots are also evident. A thin, pale line runs midlaterally from the head (at the level of the occiput indentation) to the hindlegs. Two light spots surrounded by a darker border are also visible along this line. Belly light green-whitish, with a double whitish longitudinal stripe bordered by reddish lines (like in most *C. gastrotaenia*). This light and reddish coloration