

A distinctive new species of chameleon of the genus *Furcifer* (Squamata: Chamaeleonidae) from the Montagne d'Ambre rainforest of northern Madagascar

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Abstract

We describe *Furcifer timoni* **sp. nov.**, a new colourful and morphologically highly distinct chameleon from Montagne d'Ambre National Park in northern Madagascar. Males of this rainforest species are characterized by short paired bony rostral appendages which are completely absent in females. The new species differs from all other *Furcifer* species except *F. bifidus* (Brongniart, 1800) and *F. balteatus* (Duméril & Bibron, 1851) by a light ventrolateral band that is composed of scales which are arranged in a rosette-like manner. It differs from *F. bifidus* and from *F. balteatus* by smaller size, shorter rostral appendages of the males, and colouration. We suspect that *F. timoni* may be a cryptic species of the forest canopy. Furthermore, we designate a lectotype for *Dicranosaura bifurca* var. *crassicornis* Gray, 1864 and confirm its synonymy with *Furcifer bifidus*.

Key words: Squamata, Chamaeleonidae, *Furcifer timoni* **sp. nov.**, Madagascar

Introduction

Madagascar is the hotspot of chameleon species diversity. Recent molecular studies suggest that chameleons evolved on this microcontinent and later colonized Africa and the islands in the Indian Ocean by oversea dispersal (Raxworthy *et al.* 2002; Rocha *et al.* 2005). The three Malagasy genera *Brookesia*, *Calumma*, and *Furcifer* include almost 50% of the world's chameleon species, including the biggest and the smallest. The chameleon genus *Furcifer* is currently composed of 19 species which are distributed over Madagascar and the Comoro islands (Glaw & Vences 2007). In contrast to the genera *Brookesia* and *Calumma*, many *Furcifer* species inhabit relatively arid regions in western Madagascar and only a few are exclusively found in rainforest areas. Intensive herpetological fieldwork and taxonomic revisions during the past 15 years have led to a strong increase in the number of species in the genera *Brookesia* and *Calumma* (Raxworthy & Nussbaum 1995; Schimmenti & Jesu 1996; Böhme 1997; Glaw *et al.* 1999; Andreone *et al.* 2001; Raxworthy & Nussbaum 2006). Modelling of distribution areas based on remote sensing data has further predicted the discovery of new chameleon species (Raxworthy *et al.* 2003). In *Furcifer*, some species like *F. pardalis* (Cuvier, 1829), *F. oustaleti* (Mocquard, 1894) and *F. lateralis* (Gray, 1831), show a significant geographic variation in colour and/or molecular characters, indicating the possible presence of still unrecognized taxa (e. g. Boumans *et al.* 2007). Nevertheless, only a single new species of *Furcifer* has been described subsequent to 1972 (Jesu *et al.* 1999), indicating that the species inventory of this genus might have been largely completed.

However, during recent field work we discovered a colourful and morphologically highly distinct species of *Furcifer* in the isolated rainforests of the Montagne d'Ambre massif in northern Madagascar. In this paper we describe this new, apparently secretive species that has obviously been overlooked by previous surveys in this region (see also D'Cruze *et al.* 2008).

Materials and methods

Most specimens were collected at night during the rainy season, using torches and headlamps to detect roosting chameleons in the vegetation. Voucher specimens were euthanized and fixed in 90% ethanol. Muscle tissue samples for future molecular analysis were taken from all specimens and preserved in pure ethanol. Measurements were made on preserved specimens to the nearest 0.1 mm using calipers. Definition of measurements and the description scheme of the holotype largely follow Raxworthy & Nussbaum (2006), except snout-vent length (SVL) which was measured from the tip of the snout to the vent, excluding the rostral appendage (if present). Male rostral appendage (MRA) length was measured in lateral view along the anterior surface, from the appendage base to the tip of the appendage. Male rostral appendage projection anterior to the mouth was measured in ventral view as the overhang distance from the anteriormost point of mouth to the rostral appendage tip. Terminology in description of crest and ornamentation characters and other external morphology follows previously published chameleon descriptions (Brygoo 1971, 1978), except that the canthus rostralis is here referred to as the rostral crest. Museum acronyms are: Museum National d'Histoire Naturelle, Paris (MNHN), Université d'Antananarivo, Département de Biologie Animale (UADBA); Zoologisches Forschungsmuseum Alexander Koenig, Bonn (ZFMK); Zoologische Staatssammlung München (ZSM). FGZC are field numbers of F. Glaw.

Furcifer timoni sp. nov.

Figs. 1–5

Holotype. ZSM 2103/2007 (FGZC 1095), adult male, from Montagne d'Ambre National Park (12°30' E, 49°11' S), ca. 750–800 m a.s.l., Antsiranana Province, northern Madagascar, collected on 25 February 2007, by P. Bora, H. Enting, F. Glaw, A. Knoll, J. Köhler and A. Razafimanantsoa.

Paratypes. ZSM 255/2004 (FGZC 495), ZSM 256/2004 (FGZC 496), ZFMK 87585 (originally ZSM 257/2004 [FGZC 499]), UADBA uncatalogued (FGZC 497), UADBA uncatalogued (FGZC 498), five adult and gravid females, from Montagne d'Ambre National Park (same general area as holotype locality), Antsiranana Province, northern Madagascar, collected 20–23 February 2004, by F. Glaw, M. Puente, R. Randrianiaina & A. Razafimanantsoa; ZSM uncatalogued (FGZC 1884) [still in UADBA], adult and gravid female, Montagne d'Ambre National Park, 850 m a.s.l. (similar geographical coordinates as holotype), Antsiranana Province, northern Madagascar, collected 26 February 2008, by N. D'Cruze, F. Glaw, Z. Nagy & A. Razafimanantsoa.

Diagnosis. The new species differs from all other *Furcifer* species except *F. bifidus* and *F. balteatus* by a whitish lateroventral band that is composed of scales which are arranged in a rosette-like manner. It differs from *F. balteatus* by smaller size (male SVL 88 mm, female SVL 95–96 mm versus male SVL up to 175 mm, female SVL up to 145 mm), shorter rostral appendages of the males (6 mm versus up to 10 mm), general colouration, and the position and extension of an oblique light band on the flanks that runs from the dorsal crest (or slightly below) posteroventrally without reaching the lateroventral band (versus running from the upper flanks to the whitish lateroventral band). It differs from *F. bifidus* by distinctly smaller size (SVL of adult male 88 mm versus up to 200 mm), much shorter rostral appendages of the males (6 mm versus up to 24 mm, Fig. 5), a lower number of scales (4 vs. 6–8) between nostril and tip of rostral appendage, and by colouration. In addition, males of *Furcifer timoni* differ from all other *Furcifer* species except those of the

Furcifer bifidus group - *F. bifidus*, *F. balteatus*, *F. minor* (Günther, 1879), *F. willsii* (Günther, 1890) and *F. petteri* (Brygoo & Domergue, 1966) - by the presence of two bony rostral appendages and from adult males of all five species within the *F. bifidus* group by a shorter length of the rostral appendages (6 mm vs. 5–24 mm).

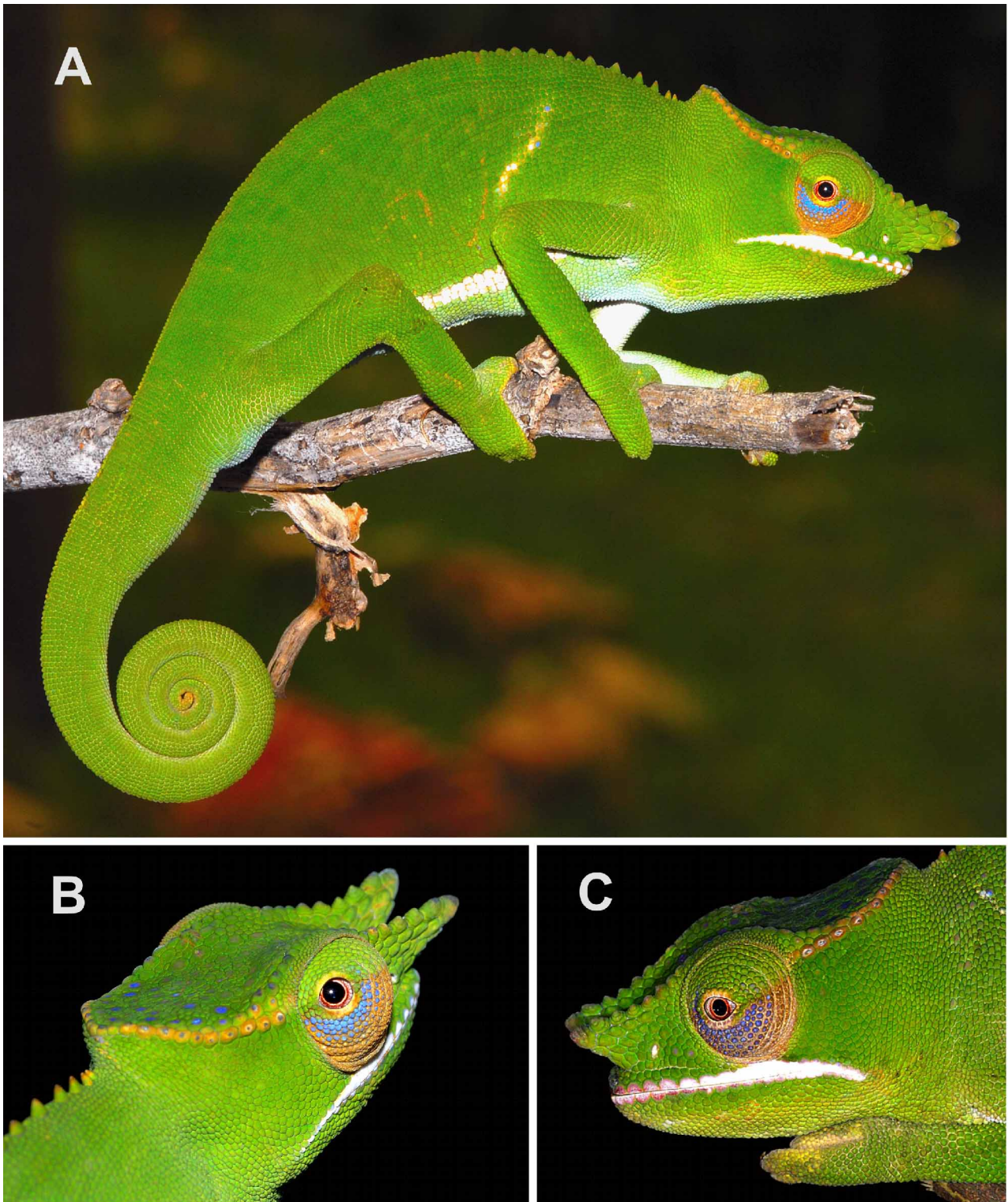


FIGURE 1. Male holotype of *Furcifer timoni* sp. nov., ZSM 2103/2007 in life, (A) lateral view, (B) dorsolateral view of head; and (C) additional male of the same species photographed near the type locality by P. Schönecker (not collected).

Description of the holotype. Adult male, in good condition, both hemipenes completely everted; SVL 88.0 mm (length from tip of rostral appendage to vent 93.0 mm); tail 121 mm; axilla-groin distance 48.8 mm;

eye horizontal diameter 8.7 mm. Head with two ossified, scaled rostral appendages, length 5.9 mm, projecting beyond the upper lip by 4.7 mm, rostral appendages laterally compressed, almost parallel, but slightly diverging, distance between anterior tips 9.2 mm; rostral crest well developed; supra-orbital crest rounded in lateral view and formed by single, rather smooth row of tubercles; lateral crest moderately distinct, smooth in lateral view; temporal crest recognizable behind eye, almost parallel with lateral crest, both crests fusing posteriorly; parietal crest absent; no traces of occipital lobes; no traces of gular crest. Dorsal crest present, consisting of a single row of 12 pointed tubercles 1 mm or less in height on the anterior dorsum; body laterally compressed with homogeneous scalation; no distinct ventral crest; axillary pits not obvious; limbs and tail with homogeneous scalation, tail without dorsal crest of pointed tubercles, feet without tarsal spines.

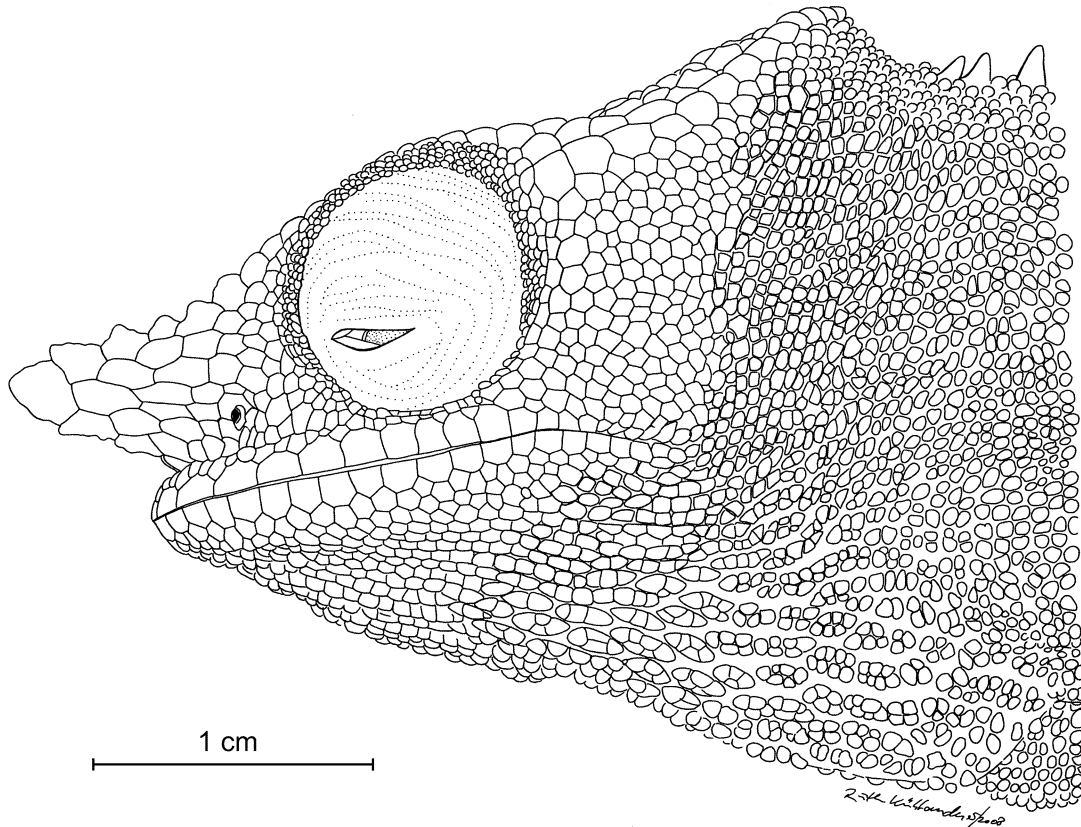


FIGURE 2. Drawing of the head of the male holotype of *Furcifer timoni* sp. nov., ZSM 2103/2007 (by Ruth Kühbandner).

Hemipenis (Fig. 3) large, total length 17.4 mm, morphology strongly differing from that of the closely related species *F. bifidus*, *F. minor*, *F. willsi* and *F. petteri* (see drawings and descriptions in Ramanantsoa 1978 and Brygoo & Domergue 1969). Truncus covered with calyces, especially in asulcal view, calyces absent around the sulcus spermaticus. Sulcus spermaticus poorly recognizable. Apex bilobed, formed by two big lobes each covered with two rotulae and one field of short papillae; a further field of long papillae on each side at the base of the apex in sulcal view.

Colour after almost two years in preservative generally blackish brown, especially on flanks, dorsal surfaces of upper arms and legs and lateral parts of the proximal tail. Throat, sides of head, lower arms, lower legs, distal parts of tail and dorsalmost 5–6 mm of flanks grey to purple. A white band starting at the angle of the mouth runs along the upper lip and fades below the eye. The ventrolateral light band between fore- and hindlimb is faded to brownish but still recognizable. An indistinct whitish midventral line is recognizable. Several blue scales on the dorsal plate of the head are the only colourful remnants of the life colouration. Hemipenis uniformly whitish.

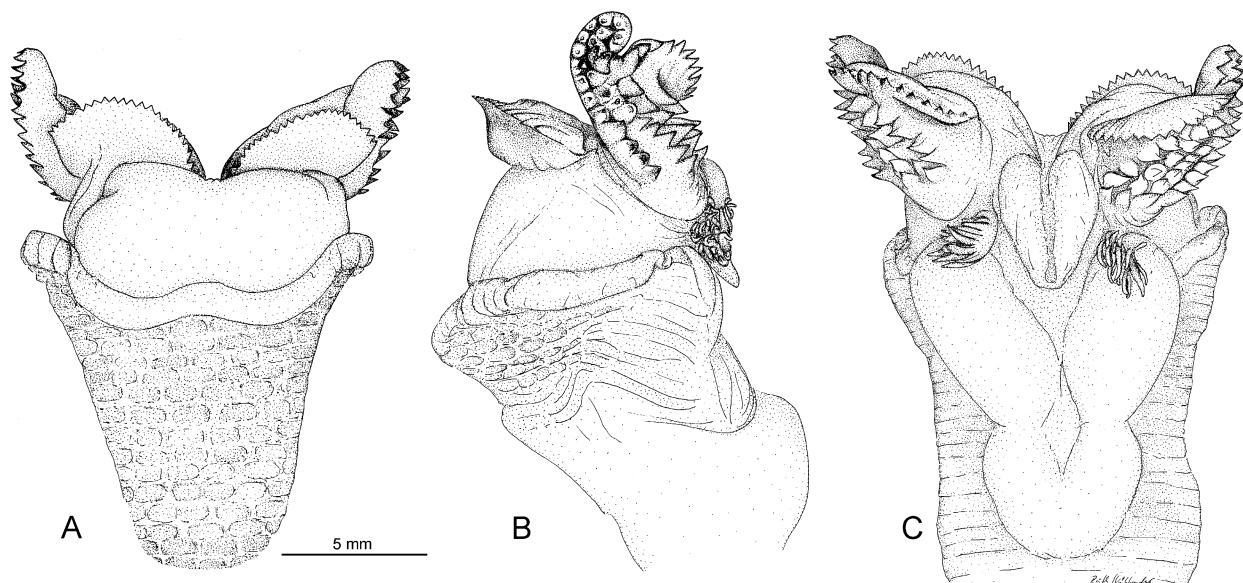


FIGURE 3. Drawings of hemipenis of the male holotype of *Furcifer timoni* **sp. nov.**, ZSM 2103/2007 (by Ruth Kühbandner): (A) asulcal view, (B) lateral view; (C) sulcal view.

In life when unstressed (Fig. 1), dorsal and lateral colouration of head, body, limbs, and tail uniformly lime green, with a whitish-beige oblique stripe on the anterior flanks, starting several millimeters below the seventh dorsal tubercle and ending several millimeters above a whitish lateroventral band of rosette-like scales that runs along the flanks between the insertion of fore- and hindlimbs. A white band along the whole upper lip starting at mouth angle. Eye ball with a characteristic colouration: upper half green, lower half with a light brown outer ring and a blue inner ring, eye opening encircled by a complete, narrow yellowish-orange ring. Lateral crest light brown. Head dorsally with numerous blue scales. Ventral surfaces of head yellowish-green, body ventrally greyish-green, inner surface of limbs light grey.

Variation of the paratypes. For measurements and character conditions of the type specimens see Table 1. Females of *F. timoni* lack the rostral appendages of the male and have a distinctly less swollen tail base. Furthermore, the relative tail length of the male holotype is longer than in the females (Table 1) which were all gravid with fully developed, yellowish eggs. The colouration of the female paratypes in preservative is almost uniformly blackish. The light ventrolateral bands and the whitish midventral line are more distinct than in the holotype. Bluish spots are recognizable on the heads.

TABLE 1. Morphological variation in *Furcifer timoni* **sp. nov.** All measurements in mm.

| | ZSM 2103/2007 | ZSM 255/2004 | ZSM 256/2004 | ZFMK 87585 |
|----------------------------|---------------|-----------------|-----------------|-----------------|
| Status | holotype | paratype | paratype | paratype |
| Sex | male (adult) | female (gravid) | female (gravid) | female (gravid) |
| SVL | 88.0 | 96.0 | 94.5 | 95.5 |
| Total length | 214 | 194 | 195 | 198 |
| head length | 28.7 | 27.3 | 26.7 | 27.5 |
| snout length | 20.8 | 19.6 | 18.9 | 19.3 |
| eye diameter | 8.7 | 7.8 | 7.0 | 7.6 |
| number of dorsal tubercles | ca. 12 | ca. 10 | ca. 12 | ca. 9 |
| egg number in body cavity | --- | 14 | 10 | 13 |

During the day the ground colouration of apparently unstressed gravid females in life is green with a pattern of green or brown, mainly transversal bands (Fig. 4) on the flanks and sides of the head. Thinner, regularly shaped and regularly spaced transversal bands are also present on tail and legs. A red band starting from middorsum or slightly below runs posteroventrally until the middle of the flanks. The ventrolateral band between fore- and hindlimbs is reddish (Fig. 4). The posterior part of the head is covered by a large more or less triangular red spot which is strongly bordered posteriorly but fades less distinct anteriorly. The head (including the red spot) is covered with many blue scales and similar blue scales, which are partly arranged in longitudinal rows, are scattered along the flanks, decreasing in density posteriorly. There is no distinct white band along the lip, but a whitish spot on the upper lip is recognizable below the eye. The eye ball is similar but less distinctly coloured than in males, usually without distinct blue colour. At night when roosting the body is uniformly green with only indistinct transversal banding pattern, but with distinct diagonal red band on the flanks and triangular red spot on the head. Only few bluish scales are recognizable on the head and no distinctly blue scales on the flanks. The eye ball is brown in the lower half, but without blue colour. When the throat is inflated a reddish reticulated pattern is visible.

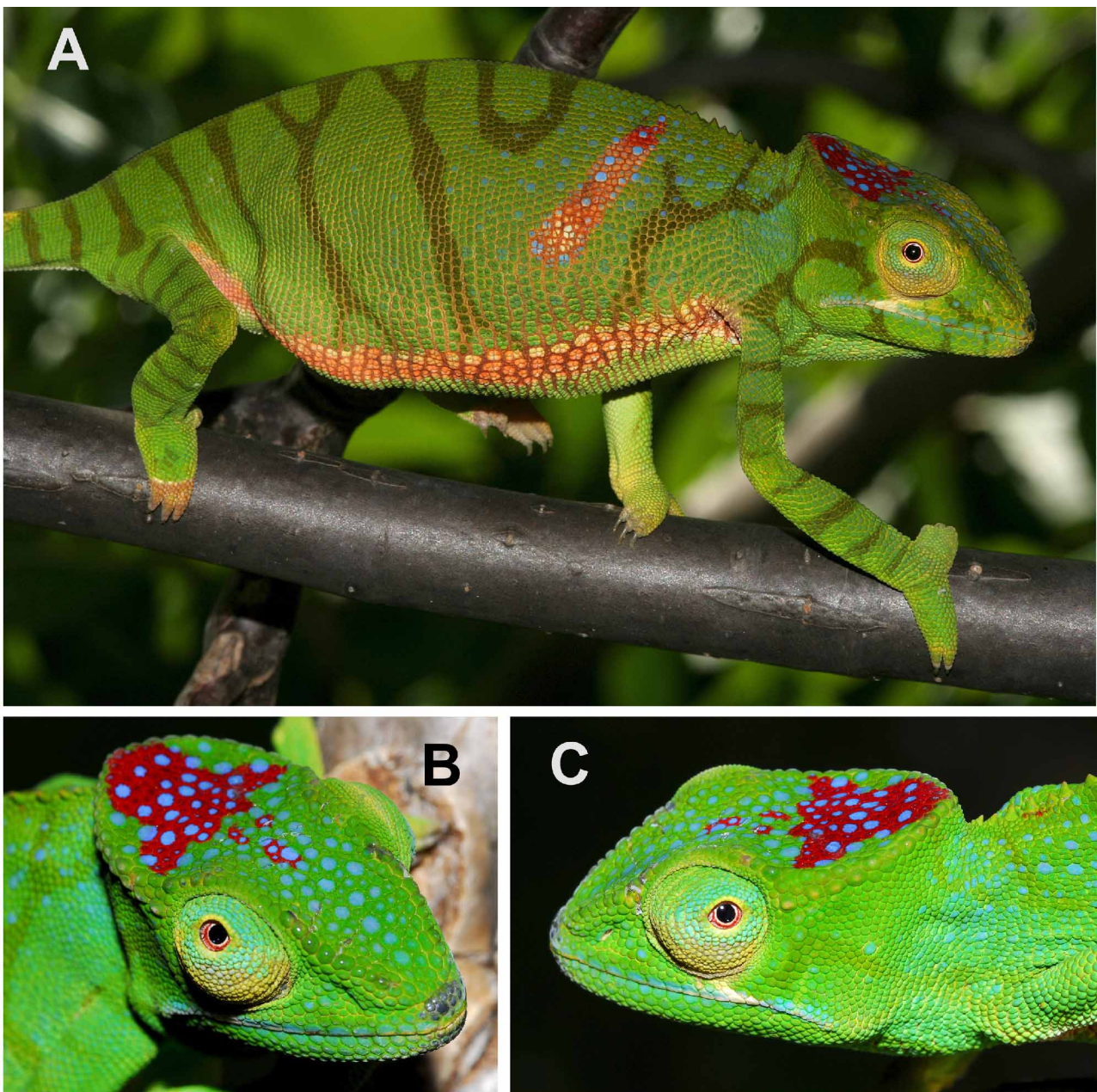


FIGURE 4. Gravid female paratype of *Furcifer timoni* **sp. nov.**, ZSM uncatalogued (FGZC 1884) in life.

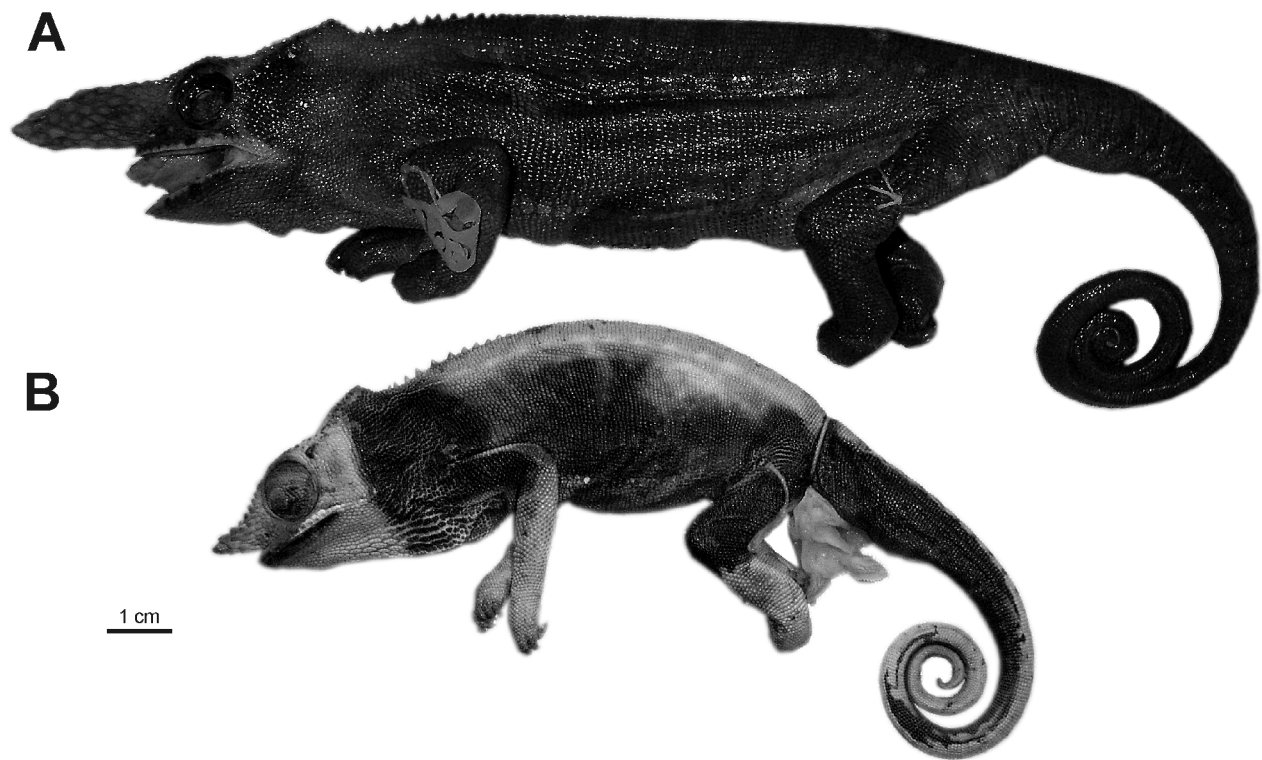


FIGURE 5. (A) Preserved male holotype of *Furcifer bifidus* (MNHN 6660) in comparison to (B) preserved male holotype of *Furcifer timoni* **sp. nov.** (ZSM 2103/2007).



FIGURE 6. Female *Furcifer* cf. *timoni* from Marojejy National Park (Photograph by G. Gomboc).

Additional photographic records. Photographs of one or two males of unknown origin were published in a Japanese chameleon book (Kimura 2003: 114) and might refer to *F. timoni*. Two additional males from Montagne d'Ambre were photographed by H.-P. Berghof and P. Schönecker (e.g., Fig. 1c), respectively. All these photographs strongly resemble the holotype of *Furcifer timoni* in morphology and principal colouration and strongly confirm that it represents a distinctive new species and not a subadult or aberrant specimen of the green colour morph of *Furcifer bifidus* as shown in Martin & Wolfe (1992: 139). Similarly, the photographs of females taken from the pet trade (Kimura 2003 and own photographs of a specimen taken in the 1990s) resemble those from Montagne d'Ambre. Unstressed gravid females appear to be largely green, with a network pattern of brown bands which are principally arranged similarly among different females.

Etymology. The senior author wishes to dedicate this new chameleon species to his son Timon Robert Glaw.

Distribution, habitat and habits. *Furcifer timoni* is only known from the Montagne d'Ambre National Park, between 750 and 900 m altitude. The discovery of this distinctive new *Furcifer* species in Montagne d'Ambre was very surprising since this area has been repeatedly and intensively surveyed for reptiles over many years (Mocquard 1895; Ramanantsoa 1974; Andreone 1991; Kauffmann 1994; Raxworthy & Nussbaum 1994; Glaw & Vences 1994; D'Cruze *et al.* 2008). Apart from the type locality the species possibly occurs in the Marojejy National Park (Fig. 6) as well, since photographs of a female taken by G. Gomboc at Marojejy (between Camp 1 and Camp 2) resemble females of *F. timoni* and might represent this or a very closely related species. It differs from the studied type specimens (see Table 1) by a dorsal crest composed of more (ca. 20) tubercles (see Fig. 6). Similar to the situation at Montagne d'Ambre, all previous herpetological surveys in the Marojejy National Park since 1968 (see summary in Raselimanana *et al.* 2000) did not reveal any record of a chameleon resembling *F. timoni*, indicating that both the Montagne d'Ambre and the Marojejy populations had been overlooked, possibly due to them occupying a cryptic niche hidden high up in the tree canopy.

At Montagne d'Ambre, *Furcifer timoni* was exclusively found in mid-altitude primary rainforest during the rainy season, in close syntopy with *Furcifer petteri*. All specimens we captured in the years 2004–2008 were found in the period 20–26 February, roosting at night in the vegetation. The only male seen and captured during the same period was captured from a position more than 3 m above the ground. In contrast, gravid females were relatively common in late February, usually sitting on branches ca. 1.5–3 m above the ground. We suspect that they were just descending from the trees to bury their eggs into the ground. Data on egg numbers of preserved females are given in Table 1.

Available names. Among the Malagasy chameleons with paired bony rostral appendages in males, there is only one taxon, *Dicranosaura bifurca* var. *crassicornis* Gray, 1864 that needs to be discussed as a possible earlier name for *Furcifer timoni* (the other synonyms of *Furcifer bifidus* are replacement names due to errors and therefore not available). Brygoo (1971) considered the possibility that *crassicornis* could be a synonym of *F. balteatus* rather than *F. bifidus*, but the type specimens were apparently never identified or studied. Unfortunately, the original description of this taxon is very short, imprecise and difficult to interpret and we here repeat the whole description (Gray 1864: 479):

"Var. *crassicornis* B. M.

One of the males, with the horns only partly developed, has them very thick and trigonal at the base, so as nearly to reach across the nose. In another young male, about the same size, they are compressed and far apart at the base, as in the type specimens."

Colin McCarthy (in litt., 22 July and 24 Aug. 2009) kindly provided us the following information:

"The situation regarding the types of *Dicranosaura bifurca* var. *crassicornis* Gray, 1864 is unclear. We do not appear to have distinguished the types of this variety in our collection. What we have are the four specimens of '*Chamaeleo bifurcus*' mentioned in Gray's (1845) lizard catalogue to which I assume could be added BMNH 1863.4.16.1 which appears to have been the only other specimen of this taxon added to the collections before Gray's paper of 1864. So the relevant specimens for consideration are:

BMNH xxv.12a Madagascar [SVL: 170 mm, tail length: 233 mm, rostral appendage (length, ventral edge):

26.2 mm, rostral appendage length (projection): 23.4 mm]

BMNH xxv.12b Madagascar / Pres: J.E. Gray [SVL: 97 mm, tail length: 119 mm, rostral appendage (length, ventral edge): 5.7 mm, rostral appendage length (projection): 5.4 mm]

BMNH xxv.12c Madagascar / Pres: J.E. Gray [SVL: 105 mm, tail length: 128 mm, rostral appendage (length, ventral edge): 6.6 mm, rostral appendage length (projection): 6.1 mm]

BMNH RR1935.12.8.1 (formerly xxv.12d) Madagascar / Pres: J.E. Gray [SVL: 125 mm, tail length: 174 mm, rostral appendage (length, ventral edge): n/a, rostral appendage length (projection): n/a]

BMNH 1863.4.16.1 Madagascar / Purch: Mr Stevens [SVL: 147 mm, tail length: 212 mm, rostral appendage (length, ventral edge): n/a?, rostral appendage length (projection): n/a]

Just looking at the specimens, at least one of the possible candidates for *crassicornis* appears to be BMNH 1863.4.16.1. This has very short horns and I think that a very faded label on the jar may say '*crassicornis*' - though it is difficult to be sure. However this specimen is rather larger than BMNH xxv.12b and BMNH xxv.12c (which are relatively close in size to each other).

I think we can rule out BMNH xxv.12a since, as Gray 1845 states, it has 'elongated nose horns' and BMNH RR1935.12.8.1 (formerly xxv.12d) is Gray's 'female without horns'."

We fully agree with this interpretation and after examination of these specimens in the Natural History Museum on 30 September 2009 we consider only the three specimens (BMNH xxv.12b [subadult male], BMNH xxv.12c [subadult male], and BMNH 1863.4.16.1. (formerly xxv.12d) [probably adult male] as syntypes. To remedy the uncertainty in the usage of this name, we hereby designate BMNH 1863.4.16.1 as lectotype of *Dicranosaura bifurca* var. *crassicornis* Gray, 1864. This probably adult male (total length 359 mm, tail base moderately swollen), apparently labelled as "*crassicornis*" has very short and probably malformed rostral appendages, but otherwise agrees with males of *Furcifer bifidus*. It differs from the male holotype of *Furcifer timoni* by much larger size (147 mm vs. 88 mm SVL, total length 359 mm vs. 214 mm), more tubercles of the dorsal crest (ca. 25 vs. ca. 12) and a broader ventrolateral band of rosette-like scales (maximum width 4.8 mm vs. 2.2 mm). The remaining two paralectotypes are smaller than the lectotype. They superficially resemble the holotype of *F. timoni* in size and general morphology, but differ by a broader ventrolateral band of rosette-like scales (maximum width 3.7-3.8 mm vs. 2.2 mm) and the scalation of the rostral appendage which consists of more scales than in *F. timoni* (7 vs. 4 scales between nostril and tip of rostral appendage). A higher number (6-8) of scales between nostril and tip of rostral appendage is also typical for adult (BMNH xxv.12a, drawings in Brygoo 1971; 1978) and subadult (ZMB 7551) males of *F. bifidus* and we therefore consider the two paralectotypes as subadult males of *F. bifidus*.

Discussion

The description of *Furcifer timoni* adds a distinctive new species to the *Furcifer bifidus* group. From a morphological point of view this group can be divided into two subgroups: *F. bifidus* and *F. balteatus* are large species with males reaching up to 175–200 mm SVL sharing a light ventrolateral band that is composed of scales arranged in a rosette-like manner, and a diagonal light band on the anterior flanks. On the other hand, *F. minor*, *F. willsii*, and *F. petteri* are distinctly smaller species reaching maximum SVL of 75–100 mm and are characterized by the absence of the rosette-like ventrolateral band and the absence of an oblique light band on the anterior flanks. Instead, they usually show (especially in the female) two distinct spots in the middle of the anterior flanks, or (especially in the male) a light band at midflanks. With a SVL of 88–96 mm, *F. timoni* is intermediate between the two subgroups in size, and shares with *F. balteatus* and *F. bifidus* the diagonal light band on the anterior flanks and the rosette-like ventrolateral band which both are unique among Malagasy chameleons and therefore are likely to represent synapomorphies of these three species. *F. timoni* is unique among the *F. bifidus* group by its short rostral male appendage. Furthermore it is remarkable that the single known male has a smaller SVL than the three females whereas in all other species of the group both SVL and total length are significantly larger in males than in females (see Brygoo 1971 and Glaw & Vences 2007 for

size data). Thus, we cannot exclude that the holotype of *F. timoni* is not yet full-grown although the hemipenes appear to be fully developed.

From a phylogenetic point of view this group of rain forest dwelling species of *Furcifer* (*F. bifidus*, *F. balteatus*, *F. minor*, *F. willsi*, *F. petteri* and *F. timoni*) appears rather basal compared to other *Furcifer* species. Raxworthy *et al.* (2002) found *F. bifidus*, *F. petteri* and *F. minor* the most basal species, and Townsend & Larson (2002), using different species, found *F. balteatus* being most basal. These data may suggest that *Furcifer* originated in rain forest habitats of eastern Madagascar and invaded later into arid western Madagascar. It furthermore suggests that advanced understanding of chamaeleonid relationships could result in a future splitting of *Furcifer* (available names include *Apola*, *Cyneosaura* and *Sauroceras*). Since the type species of *Furcifer* (*F. bifidus*) is apparently closely related to *F. timoni*, its attribution to *Furcifer* might be stable even after a future revision of the genus.

Acknowledgements

We are grateful to numerous colleagues, friends and organizations: Parfait Bora, Neil D’Cruze, Hildegard Enting, Michael Franzen, Angelika Knoll, Zoltan Nagy, Marta Puente, Roger-Daniel Randrianiana, Angelun and Angeluc Razafimanantsoa helped in the field. Ruth Kühbandner prepared the drawings. Hans-Peter Berghof, Gasper Gomboc and Patrick Schönecker shared with us unpublished photographs of the new species. Mark-Oliver Rödel (ZMB) allowed the loan of a crucial specimen. Colin McCarthy (BM) kindly provided data, measurements and interpretations of potential type specimens. Malagasy authorities kindly issued permits. Research was carried out in the framework of established collaboration with the UADBA. Part of this research was funded by Volkswagenstiftung, European Association of Zoos and Aquaria (EAZA), and Act for Nature.

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