



A new large and colorful skink of the genus *Amphiglossus* from Madagascar revealed by morphology and multilocus molecular study

AURÉLIEN MIRALLES^{1,5}, ACHILLE P. RASELIMANANA², DOMOINA RAKOTOMALALA³, MIGUEL VENCES¹ & DAVID R. VIEITES⁴

¹Technical University of Braunschweig, Zoological Institute, Mendelssohnstr. 4, 38106 Braunschweig, Germany.

²Département de Biologie Animale, Université d'Antananarivo, B.P 906, Antananarivo (101), Madagascar, and Association Vahatra, BP 3972, Antananarivo 101, Madagascar

³WWF Madagascar and West Indian Ocean Programme Office, BP. 738, Antananarivo (101), Madagascar

⁴Department of Biodiversity and Evolutionary Biology, Museo Nacional de Ciencias Naturales–CSIC, C/ José Gutiérrez Abascal 2, 28006 Madrid, Spain

⁵Corresponding author. E-mail: miralles.skink@gmail.com

Abstract

We describe a new species of *Amphiglossus* skink from the western edge of the Central Highlands of Madagascar in the Reserve of Makira, and also found in the Réserve Spéciale of Ambohijanahary and in the Réserve Spéciale of Marotandrano. *Amphiglossus meva* n. sp. is characterized and differentiated from other species of the genus by a combination of morphological, chromatic and molecular characters: 1) a relatively large size (SVL of adults from 126 to 150 mm); 2) a characteristic pattern of coloration, *Amphiglossus meva* being the only skink in Madagascar together with *Amphiglossus crenni* with dark grey dorsum contrasting with orange flanks and ventrum; 3) the absence of a postnasal scale; 4) the pre-subocular frequently absent, 5) the presence of single elongated tertiary temporal bordering lower secondary temporal and 6) pentadactyl limbs. In addition to the morphological approach, a multi-locus genetic analysis based on eight mitochondrial and nuclear genes clearly supports the distinctiveness of *A. meva*. This new species was found in areas of rainforest, sometimes containing transitional deciduous forest elements. It was typically observed under large rotten logs associated with dense layers of decomposed wood retaining certain humidity and providing habitat for invertebrate larvae and termites.

Key words: *Amphiglossus*, conservation, Madagascar, molecular phylogeny, rainforest, Squamata: Scincomorpha: Scincidae

Résumé

Une nouvelle espèce de scinque de genre *Amphiglossus* est décrite de la bordure ouest des hauts plateaux de Madagascar, dans la Réserve de Makira, et dans les Réserves Spéciales de Marotandrano et d'Ambohijanahary. *Amphiglossus meva* sp. nov. se distingue des autres espèces du genre par la combinaison des caractères suivants: 1) une taille relativement importante (distance tête-cloaque comprise entre 126 et 150 mm chez les adultes); 2) un modèle de coloration caractéristique, puisqu'il s'agit avec *Amphiglossus crenni* des deux seuls scinques malgaches dotés d'une face dorsal gris foncée contrastant avec des flancs et une face ventrale orange; 3) l'absence d'écaille postnasale; 4) l'écaille presuboculaire qui est fréquemment absente, 5) la présence d'une unique temporale tertiaire, allongée et bordant la temporale secondaire inférieure, et 6) des membres pentadactyles. En plus de l'approche morphologique, une analyse génétique basé sur sept gènes mitochondriaux et nucléaires soutient également la validité taxinomique de *A. meva*. Cette espèce n'est actuellement connue que par quelques spécimens récoltés dans des secteurs de forêt pluviale contenant parfois des éléments de forêt décidue transitionnel. Son biotope préférentiel semble être constitué par les larges souches et troncs d'arbres en décomposition retenant l'humidité et hébergeant des larves d'invertébrés et des termites.

Introduction

Scincid lizards have radiated extensively on the island of Madagascar, with almost 80 recognized species and many more candidate species yet to be described (Glaw & Vences 2007; Crottini *et al.* 2009; Köhler *et al.* 2009, 2010; Miralles *et al.*, 2011 a, b). According to a recent molecular study, seven endemic genera of Scincinae skinks plus one genus present also at Comoros and Glorieuse islands are currently recognized in Madagascar (*Amphiglossus* Duméril & Bibron, *Androngo* Brygoo, *Madascincus* Brygoo, *Paracontias* Mocquard, *Pseudoacontias* Bocage, *Pygomeles* Grandidier, *Sirenoscincus* Sakata & Hikida and *Voeltzkowia* Boettger) although their phylogenetic relationships and taxonomy have not been completely clarified (Crottini *et al.* 2009). All phylogenetic studies published to date agree (1) on the monophyly of Malagasy scincines, (2) on the existence of two main clades (Whiting *et al.* 2004; Schmitz *et al.* 2005; Crottini *et al.* 2009) and (3) on the paraphyly of the genus *Amphiglossus* even after the exclusion of those species now included in *Madascincus*. The genus *Amphiglossus* currently includes 21 Malagasy species, with one species (*A. johannae*) endemic to the Comoro Islands and another one (*A. valhallae*) for the Glorieuses Islands (Brygoo 1983; Glaw & Vences 2007). Three main clades within *Amphiglossus* have been identified, with three other genera (*Androngo*, *Pygomeles* and *Voeltzkowia*) nested within them (Schmitz *et al.* 2005; Crottini *et al.* 2009), which suggests that further work is needed to elucidate their taxonomy.

The largest species (*A. astrolabi* and *A. reticulatus*) belong to a strongly supported monophyletic group within the *Amphiglossus* clade (Schmitz *et al.* 2005; Crottini *et al.* 2009). Their snout-vent length (SVL) in adults can exceed 200 mm, being also larger than any other known Malagasy skink (Fig. 1). Both species are mainly aquatic, being found near streams and active during day and night (pers. obs.). *Amphiglossus astrolabi* shows a continuous distribution in rainforests from north of the Masoala Peninsula towards the southeastern tip of Madagascar, while *A. reticulatus* is known to occur in transitional and dry forest environments, mostly in the north and central western portions of Madagascar (Brygoo 1980, Glaw & Vences 2007). A certain degree of variation has been observed in *A. reticulatus*, which led to the description of *A. waterloti* (Angel 1930). However, recent genetic analyses suggest that *A. waterloti* is genetically similar to *A. reticulatus* (Schmitz *et al.* 2005), therefore, until further taxonomic evidence is provided *A. waterloti* should be considered as a junior synonym of *A. reticulatus* (Glaw & Vences 2007).

Malagasy scincine lizards show a wide diversity of morphologies, with different degrees of limb or digits reduction, body elongation or body size (Andreone & Greer 2002; Raselimanana & Rakotomalala 2003; Crottini *et al.* 2009). Although most species show a relatively dull overall coloration, with different degree of patterning on the flanks, some species have a characteristic bright coloration including orange to reddish patterns on (1) the tail (e.g. frequent in *Madascincus igneocaudatus*), (2) the ventral side of the posterior part of the body (e.g. in *A. anosyensis*), (3) the flanks (e.g. *A. crenni*) or (4) the whole body (e.g. in *Pseudoacontias menamainty*). Only *A. crenni* shows a very contrasting pattern between the bright pink/reddish lateral and ventral sides of the body and tail, with a wide dark dorsal stripe that extends from the snout to the tip of the tail.

During several zoological surveys conducted within the Réserve Spéciale (RS) of Ambohijanahary (December 1999), the RS of Marotandrano (November 2004) and the recently delimited new Protected Area of Makira (June 2009), we discovered an unknown large and colorful skink. This new taxon is distinguished from the other species by several morphological characters, and it is further characterized by a remarkable contrasting coloration pattern, in particular by a large dark brown dorsal band, in contrast with an orange coloration on the flanks, and a pinkish ventral face (coloration faded after several months in preserving solution). Here, we describe this new species of the genus *Amphiglossus*, compare its morphology to the most similar species in this genus, and provide new molecular data to support its distinctiveness.

Material and methods

Molecular sampling. Fifty-two new mitochondrial and nuclear DNA sequences were determined from nine samples belonging either to the new species or to the *Amphiglossus astrolabi* / *reticulatus* group, and were deposited in GenBank (Table 1). These sequences were incorporated to the dataset published by Crottini *et al.* (2009) (with the exclusion of *Amphiglossus crenni* and *Pseudoacontias menamainty* for which only mitochondrial sequences were available), both to ensure the distinctiveness of the new species, and to infer its phylogenetic affinities within the Malagasy genera of Scincine. One lygosomine (*Tiliqua*) and one scincine (“*Eumeces*” sensu lato) were used as out-

groups. Among the non-Malagasy skinks, previous more inclusive studies (Whiting *et al.* 2004; Schmitz *et al.* 2005) suggested that species of the genus *Eumeces* sensu lato are relatively close to the Malagasy radiation. For these two outgroup taxa, concatenated "chimera" sequences of different species were compiled from GenBank (see Crottini *et al.* 2009).

Laboratory techniques. Total genomic DNA was extracted using proteinase K (10 mg/ml) digestion followed by a standard salt-extraction protocol (Bruford *et al.* 1992). From the mitochondrial DNA (mtDNA), we amplified three fragments of the 12S rRNA, 16S rRNA and ND1 genes. Additionally, fragments of five nuclear DNA genes (nuDNA) were amplified: brain-derived neurotrophic factor (BDNF); recombination activating gene 2 (Rag2); α -enolase (enol); oocyte maturation factor (C-mos) and phosphatidylinositol-3-OH kinase (PI3K). Standard polymerase chain reactions were performed in a final volume of 12.5 μ l containing 0.3 μ l each of 10 pmol primer, 0.25 μ l of total dNTP 10 mM (Promega), 0.1 μ l of 5 U/ml GoTaq, and 2.5 μ l of GoTaq Reaction Buffer (Promega). See Crottini *et al.* (2009) for primers and PCR conditions used. The successfully amplified products were purified using ExoSAP-IT purification kit according to the manufacturer's instruction. Purified PCR templates were sequenced using dye-labeled dideoxy terminator cycle sequencing on an ABI 3130 automated DNA sequencer.

Analysis of molecular data. All obtained DNA sequences were edited and checked for errors using Codon-Code Aligner (v. 2.0.6, Codon Code Corporation). No stop codons were found in protein coding genes. The data matrix included 34 samples representing 32 taxa with an aligned sequence length of 3936 base pairs (Table 1). Four additional specimens, for which not all the genes could be successfully sequenced, were included in a separate analysis based on a reduced number of markers. Maximum parsimony (MP) and partitioned Bayesian inference searches based on the full concatenated dataset, were performed to infer trees. We used PAUP* 4.0b10 (Swofford 2002) to perform MP analyses with 100 random addition sequence replicates, equal character weighting, tree bisection and reconnection (TBR) branch swapping, and gaps coded as missing data. Nodal support was obtained using bootstrap analyses, with 10000 replicates, 10 random addition sequences replicates and TBR branch swapping. Partitioned Bayesian analyses were performed using the 21 partitions and the same parameters as previously used by Crottini *et al.* (2009) with MrBayes 3.1.2 (Ronquist & Huelsenbeck 2003). We performed one run of 20 million generations (started on random trees) and four incrementally heated Markov chains (using default heating values) each, sampling the Markov chains at intervals of 1000 generations. The first 10 million generations were conservatively discarded and 10000 trees were retained post burn-in and summed to generate a majority rule consensus tree. Genetic divergences were estimated with MEGA 4.1 (Tamura *et al.* 2007) by calculating uncorrected p-distances from the 16S and ND1 genes.

Morphological characters and coloration. Specimens were collected using opportunistic searches and pitfall traps (see Raxworthy & Nussbaum, 1994). The specimens captured were euthanized with a 4% chloro-butanol solution, tissue samples were collected and conserved in pure ethanol for molecular studies, and specimens were subsequently preserved in 70% ethanol (with exception of the UADBA specimens that have been fixed in a 12% formalin solution before the final conservation in alcohol). Specimens examined for the present study are deposited in the Göteborg Natural History Museum, Göteborg, Sweden (GNM); Museo Nacional de Ciencias Naturales, Madrid, Spain (MNCN); Muséum National d'Histoire Naturelle, Paris, France (MNHN); Département de Biologie Animale, Université d'Antananarivo, Madagascar (UADBA); Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany (ZFMK) and Zoologische Staatssammlung München, Germany (ZSM). All additional specimens used for comparisons with the new species are listed in the Appendix 1.

Measurements of specimens were recorded to the nearest 0.1 mm using a dial caliper (except the tail length which was measured with a string). Meristic, mensural and qualitative characters examined here are routinely used in the taxonomy of Scincidae, such as scale counts, presence or absence of homologous scale fusions or the variability in color patterns. Scale nomenclature, scale counts, and measurements used in the morphological analyses essentially follow Andreone & Greer (2002). Nuchal scales are defined as enlarged scales of the nape, occupying transversally the place of two or more rows of dorsal cycloid scale (see Miralles 2006). The ventral scales are counted in a single row from the postmentals to the preanal scales (both included in the count), with mental scale excluded. The frontal scale is considered *hourglass-shaped* when constricted by first supraocular, *bell-shaped* when this is not the case (Greer & Shea 2000).

For several voucher specimens, color pictures were taken to record alive natural coloration. Drawings were made using Adobe Illustrator CS2 and a WACOM graphic tablet CTE-640, after photographs were taken through a ZEISS stereomicroscope SteREO Discovery V12.

TABLE 1. List of taxa included in the present study, with their respective localities, voucher field numbers, institutional catalogue number (where available) and GenBank accession numbers (12S, 16S, NDI, BDNF, C-mos, Rag2, a-Enolase, and PDC). Newly determined sequences are in bold. Abbreviations: FG/MV, FGZC and ZCMV refer to Frank Glaw and Miguél Vences field numbers; MVTIS refers to the tissue collection of M. Vences; DRV refers to David R. Vieites field numbers; MRSN, Museo Regionale di Scienze Naturali, Torino; UADBA, Università d'Antananarivo, Département de Biologie Animale (not yet catalogued); ZMA, Zoologisch Museum Amsterdam; ZSM, Zoologische Staatssammlung München.

Taxon	Locality	Voucher number	field	Institutional catalogue	Accession No. (12S, 16S, NDI, BDNF, C-mos, Rag2, a-Enolase, PDC)
<i>Amphiglossus</i>					
<i>anosyensis</i>	Ambatolahy	ZCMV 591		ZMA 20342	FJ667609 FJ667621 FJ744569 FJ667634 FJ667663 FJ667721 FJ744555 FJ667692
<i>astrolabi</i> A3	Ranomafana	FG/MV 2002-312	312	ZSM 201/2003	JF424670 AY315523 FJ744570 FJ667635 FJ667664 FJ667722 AY391213 FJ667693
— A4	Andasibe	ZCMV 2224	2224	UADBA	JF424672 JF424683 JF424708 — — — — — — —
— A5	Andasibe	ZCMV 2225	2225	uncatalogued	JF424671 JF424684 JF424709 — — — — JF424722 — —
— A6	Marotondrano	APR 09466	09466	ZSM 397/2005	— JF424682 JF424707 JF424685 JF424697 JF424721 — JF424715
<i>frontoparietalis</i>	Ambohitsara	ZCMV 153	153	ZMA 20341	FJ667610 FJ667622 FJ744571 FJ667636 FJ667665 FJ667723 FJ744560 FJ667694
<i>macrocerus</i>	Ankaratra	FG/MV 2002-2142	2142	ZSM 1016/2003	AY315484 AY315533 FJ744572 FJ667637 FJ667666 FJ667724 AY391216 FJ667695
<i>mandokava</i>	Montagne d'Ambre	FGZC 1240	1240	ZSM 2167/2007	FJ667611 FJ667623 FJ744573 FJ667638 FJ667667 FJ667725 AY391217 FJ667696
<i>melanurus</i>	Maroantsetra	MVTIS 2002-A6	A6	—	AY315502 AY315551 FJ744574 FJ667639 FJ667668 FJ667726 AY391218 FJ667697
<i>meva</i> M1	RS of Marotondrano	APR 05959	05959	UADBA 294404*	— JF424677 JF424702 JF424686 JF424691 JF424716 — JF424710
— M2	Makira	DRV 5885	5885	MNCN_44649*	JF424673 JF424678 JF424703 JF424687 JF424692 JF424717 JF424698 JF424711
— M3	Makira	DRV 5947	5947	MNCN_44650*	JF424674 JF424679 JF424704 JF424688 JF424693 JF424718 JF424699 JF424712
<i>punctatus</i>	Ambatolahy	ZCMV 519	519	ZMA 20230	AY315489 FJ667624 FJ744575 FJ667640 FJ667669 FJ667727 AY391221 FJ667698
<i>reticulatus</i> R1	Berara	MVTIS 2000-E44	E44	MRSN/PBZT**	AY315490 AY315539 FJ744576 FJ667641 JF424694 FJ667728 AY391224 FJ667699
— R2	Ankarafantsika	MVTIS 2001-B54	B54	ZSM 528/2001	JF424675 JF424680 JF424705 JF424689 JF424695 JF424719 JF424700 JF424713
— R3	Ankarafantsika	MVTIS 2001-C2	C2	ZSM 527/2001	JF424676 JF424681 JF424706 JF424690 JF424696 JF424720 JF424701 JF424714
<i>tarysoma</i>	Berara	MVTIS 2000-D58	D58	MRSN-FAZC 10698	AY315498 AY315547 FJ744577 FJ667642 FJ667671 FJ667729 FJ744556 FJ667700
sp. "robustus"	Andasibe	ZCMV 373	373	ZMA 20228	FJ667612 FJ667625 FJ744562 FJ667643 FJ667672 FJ667730 FJ744546 FJ667701
sp. "phaeureus"	Andasibe.	ZCMV 3062	3062	UADBA uncat	FJ667613 FJ667626 FJ744563 FJ667644 FJ667673 FJ667731 FJ744547 FJ667702
sp. "variegatus"	Montagne des Français	FGZC 482	482	ZSM 246/2004	FJ667614 FJ667627 FJ744564 FJ667645 FJ667674 FJ667732 FJ744548 FJ667703
<i>Androngo</i>					
<i>trivittatus</i>	Tolagnaro	FGZC 2306	2306	ZSM 389/2005	FJ667615 AY151444 FJ744565 FJ667646 FJ667675 FJ667733 FJ744549 FJ667704

continued next page

TABLE 1. (continued)

Taxon	Locality	Voucher number	field	Institutional catalogue	Accession No. (12S, 16S, ND1, BIDNF, C-mos, Rag2, a-Enolase, PDC)
<i>Madascincus</i>					
<i>igneocaudatus</i>	Ibity	MVTIS 2001-D14	—	—	AY315476 FJ667629 FJ744567 FJ667648 FJ667677 FJ667735 AY391214 FJ667706
<i>intermedius</i>	Ampijoroa	MVTIS 2001-B55	—	—	AY315479 AY315528 FJ744568 FJ667649 FJ667678 FJ667736 AY391215 FJ667707
<i>mouroundavae</i>	Antsahamanara	MVTIS 2001-F17	—	—	AY315487 AY315536 FJ744578 FJ667650 FJ667679 FJ667737 AY391219 FJ667708
<i>polleni</i>	Berara	MVTIS 2000-E18	—	—	AY315497 AY315546 FJ744579 FJ667651 FJ667680 FJ667738 AY391222 FJ667709
sp. "baeus"	Andasibe	ZCMV 2283	—	UADBA uncat.	FJ667617 AY315542 FJ744580 FJ667652 FJ667681 FJ667739 FJ744552 FJ667710
<i>Paraconitias</i>					
<i>brocchii</i>	Montagne d'Ambre	FGZC 476	—	ZSM 244/2004	AY315507 AY391155 FJ744583 FJ667655 FJ667684 FJ667742 AY391225 FJ667713
<i>fasika</i> *	Baie de Sakalava	FGZC 1347	—	ZSM 2256/2007*	FJ667619 FJ667632 FJ744589 FJ667661 FJ667690 FJ667748 FJ744558 FJ667719
<i>hildebrandti</i>	Montagne des Français	FGZC 1946	—	ZSM 1578/2008	FJ667620 FJ667633 FJ744590 FJ667662 FJ667691 FJ667749 FJ744559 FJ667720
<i>kankana</i> *	Mahasoia forest	DRV 5711	—	ZSM 1810/2008*	AY315509 FJ667631 FJ744582 FJ667654 FJ667683 FJ667741 AY391227 FJ667712
<i>manify</i> *	Antsahamanara	MVTIS 2001-F58	—	MRSN R1887*	AY315510 AY315559 FJ744584 FJ667656 FJ667685 FJ667743 FJ744554 FJ667714
<i>minimus</i>	Baie de Sakalava	FGZC 1027	—	ZSM 2251/2007	FJ667616 FJ667628 FJ744566 FJ667647 FJ667676 FJ667734 FJ744550 FJ667705
<i>rothschildi</i>	Baie de Sakalava	FGZC 1020	—	ZSM 2246/2007	FJ667618 FJ667630 FJ744558 FJ667653 FJ667682 FJ667740 FJ744553 FJ667711
<i>Pygomeles braconnieri</i>					
	Ifaty	FG/MV 2002-2048	—	—	AY315514 AF215235 FJ744585 FJ667657 FJ667686 FJ667744 FJ744555 FJ667715
<i>Voeltzkowia</i>					
<i>ferinensis</i>	Arboretum Tulear	FG/MV 2000-569	—	UADBA uncat.	AY315516 AY315563 FJ744586 FJ667658 FJ667687 FJ667745 FJ744556 FJ667716
<i>lineata</i>	Anakao	FGZC 2683	—	ZSM 384/2005	AY315518 AF215238 FJ744587 FJ667659 FJ667688 FJ667746 AY391228 FJ667717
sp. "pallida"	Anakao	FG/MV 2002-1536	—	UADBA uncat.	AY315589 AY315565 FJ744588 FJ667660 FJ667689 FJ667747 FJ744557 FJ667718
Out group					
" <i>Eumeces</i> "	—	—	—	—	EU27802 EU278085 AY315600 EF646320 EF646320 DQ119628 AY2180 -
sensu lato	—	—	—	—	—
spp.	—	—	—	—	—
<i>Tiliqua</i> sp.	—	—	—	—	AB057376 AY217965 - - EF534983 AY218053 EF534856

* Holotype and paratype specimens. ** The sample R1 of *A. reticulatus* refers to a specimen from a series of specimens that are deposited in the Museo Regionale di Scienze Naturali di Torino, Italy, and in the Parc Botanique et Zoologique de Tsimbazaza in Antananarivo, Madagascar. Exact allocation of the sample to a voucher specimen is not possible.

Diagnosis of the new species is focused on distinguishing it from all other large-size species (SVL more than 130 mm, see fig. 1) of *Amphiglossus* that may be morphologically similar, and/or that share the same coloration pattern, namely *Amphiglossus astrolabi* (Duméril & Bibron), *A. ardouini* (Mocquard), *A. crenni* (Mocquard), *A. reticulatus* (Kaudern) and *A. mandokava* Raxworthy & Nussbaum.

Additionally, we took the opportunity of the present contribution to publicize photographs of the holotype of *Amphiglossus crenni* (MNHN 1906.60) that were taken by E. R. Brygoo in 1976, and that we have recently rediscovered in the archives of the Laboratoire des Reptiles et Amphibiens at the MNHN. These unpublished documents constitute a precious testimony given that they represent the only available pictures for this type specimen that has been lost between 1977 and 1982 (see Brygoo 1987). A set of six photographs of *A. crenni* have been deposited in Morphobank (available at www.morphobank.org) under the accession numbers M53279 to M53284, two of them being published in the present paper.

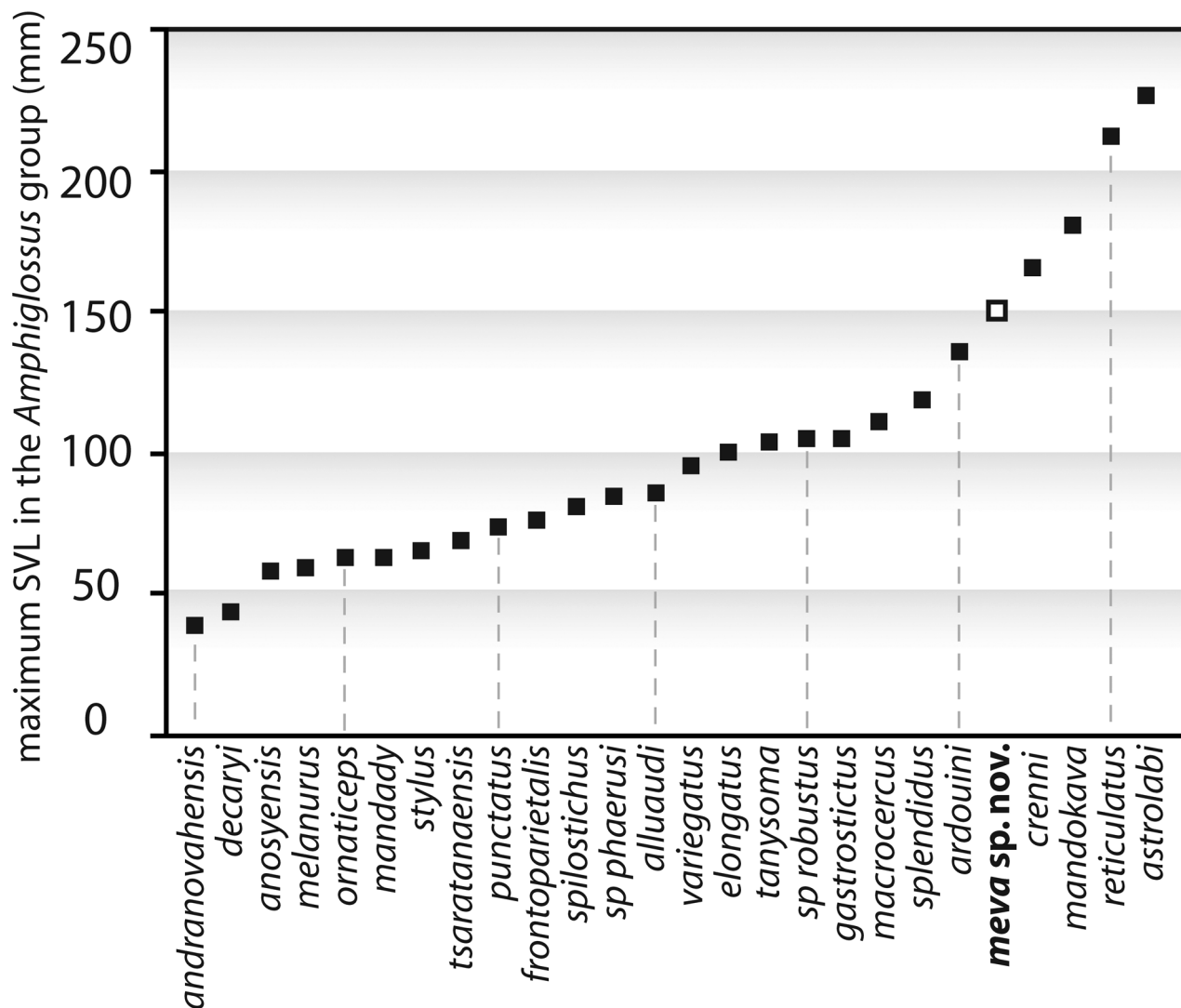


FIGURE 1. Maximum snout vent-length (mm) recorded in Malagasy species of *Amphiglossus*. Data essentially from Glaw & Vences (2007), excepted for *A. crenni* (based on Andreone & Greer 2002) and for *A. meva* and *A. mandokava* (present study).

Results

Taxonomy and description of new species

The new species described herein has been recognized using an integrative taxonomic approach. The concept of integrative taxonomy (sensu Dayrat 2005) is based on the General lineage species concept (de Queiroz 1998, 2007), rejects the superiority of any particular set of characters (morphological, behavioural, molecular) over oth-

ers, and advocates the combined and integrated use of various such methods (Padial *et al.* 2010). In the present case, both morphological data (qualitative and quantitative scalation characteristics, coloration pattern) and molecular data (phylogenetic position, genetic distances) congruently support the distinctiveness of this new species:

***Amphiglossus meva* sp. nov.**

(figs. 2, 3)

Holotype. MNCN 44648 (field no. ZCMV 11324), collected in the western portion of the Makira plateau, close to a campsite locally named Angozongahy, at 15°26'13.3"S 49°07'07.0"E, 1009 m above sea level, district of Mandritsara, region of Sofia, province of Mahajanga, northeastern Madagascar, by D.R. Vieites, M. Vences, F. Ratsoavina and R.-D. Randrianiaina on 28 June 2009. The holotype is in a good state of preservation; it was fixed and preserved in alcohol. At the time of preservation the specimen was shedding, which explains the somewhat faded coloration.

Paratypes (n=10). One adult specimen, MNCN 44650 (field no. DRV 5947), a subadult, MNCN 44649 (field no. DRV 5885), and a juvenile, ZSM 0487/2009 (field no. ZCMV 11323), collected by the same collectors and at the same locality as the holotype; a juvenile, UADBA 29402 (field no. APR 05957), collected on 24 November 2004 in the transitional rainforest at Riamalandy, 16°17.1'S 48°48.9'E, 850 m elevation within the RS of Marotandrano, Region of Sofia, Madagascar, by A. P. Raselimanana; a juvenile, UADBA 29403 (field no. APR 05958) and an adult male, UADBA 29404 (field no. APR 05959), collected at the same date and in the same area as above, but both were found together in a different rotten log, by A. P. Raselimanana; an adult male, UADBA 29405 (field no. APR 06021) captured on 26th November 2004 in the transitional rainforest at Riamalandy, same conditions as above, by A. P. Raselimanana; an adult female, UADBA 29406 (field no. APR 06039) and two juveniles, UADBA 29407 and UADBA 29408 (field no. APR 06040 and APR 06041), collected in the same rotten logs on 27th November 2004 in transitional forest at Riamalandy, 16°16.9'S 48°49.1'E, 800 m elevation within the RS of Marotandrano, Region of Sofia, Madagascar, by A. P. Raselimanana.

Additional specimens (n=2). Two additional specimens were collected in the RS of Ambohijanahary. We refrain to include these specimens in the type series given that (1) this locality is far away from both the Makira reserve and the RS of Marotandrano, (2) these specimens have a narrower brown dorsal stripe than those from Makira and from the RS of Marotandrano (6 scales rows vs. 10) and (3) no tissue sample from this locality was available for molecular analysis. These specimens are: an adult male, UADBA 12209 (field no. RD 1225) and an adult female, UADBA 12210 (field no. RD 1269) in excellent condition of preservation, collected on 18 and 19 December 1999, in the “forêt d' Ankazotsihatafototra”, 18°15.7'S 45°25.2'E, 1150 m elevation within the RS of Ambohijanahary, Region of Bongolava, Madagascar, by D. Rakotomalala and S. M. Goodman.

Diagnosis. A member of the phenetic *Amphiglossus/Madascincus* group which differs (1) from the Malagasy genera in the subfamily Lygosominae (*Cryptoblepharus* and *Trachylepis*) by the presence of entirely movable and scaly eyelids (versus fused immovable eyelids forming spectacles over the eyes in *Cryptoblepharus*; or movable eyelids with a translucent disk or window in the lower eyelid in *Trachylepis*), absence of prefrontals (present in both *Cryptoblepharus* and *Trachylepis*), and lack of frontoparietal scales (present in *Trachylepis*); (2) from all the other Malagasy scincine genera by the presence of four legs.

Within the *Amphiglossus/Madascincus* group, it is placed in the lineage called *Amphiglossus* (sensu Crottini *et al.* 2009) by molecular data. Within *Amphiglossus*, it is distinguished from all the other species by a combination of (1) a relatively large size (SVL of adults from 126 to 150 mm); (2) a characteristic pattern of coloration with dark/grey dorsum contrasting with bright orange to yellowish flanks and ventrum, including the ventral side of the tail; (3) absence of a postnasal scale; (4) presubocular frequently absent, (5) presence of a single elongated tertiary temporal bordering lower secondary temporal.

Among large-sized *Amphiglossus* (*A. astrolabi*, *A. reticulatus*, *A. ardouini*, *A. mandokava*, *A. crenni*), the new species can be distinguished from the superficially similar *Amphiglossus astrolabi* (see fig. 4A, 5A–D) by showing significantly shorter fingers and toes with lower numbers of lamellae under fourth finger (6–8 versus 10–13) and fourth toe (11–13 versus 15–21); a smaller size (SVL max = 150 mm versus 226 mm); more compact head; a lower number of ventrals (91–96 versus 99–113); absence of postnasal; presubocular frequently absent (versus always present, most often two on each sides). From *A. reticulatus* (see fig. 5E–H) it can be distinguished by showing sig-

nificantly shorter limbs in proportion to body size; smaller size (SVL max = 150 mm versus 212 mm); a less prominent parietal area and more compact head; a lower number of ventral scales (91–96 versus 95–108) and of scale rows around midbody (32–36 versus 39–41); absence of postnasal; by the uniform dark dorsal and light ventral coloration (versus complex patterns). From *A. ardouini* it differs by the absence of postnasals (versus presence), a higher number of scale rows around midbody (32–36 versus 31–33), shorter fingers with a lower number of lamellae under fourth finger (6–8 versus 7–10) and toe (9–13 versus 17–21), a uniform dark dorsal and light ventral coloration (versus complex patterns, including dark transversal dark stripes in the anterior part of body). From *A. mandokava* it differs by the absence of postnasals (versus present), a lower number of ventrals (91–96 versus 103–120) and paravertebrals (95–101 versus 129–141), by the uniform dark dorsal and light ventral coloration (versus complex patterns, including dark transversal dark stripes in the anterior part of body). From *A. crenni* (see fig. 4B, 6), it differs by the absence of postnasals (versus presence); a more compact body with 32–36 scales around midbody (versus a slender elongated body with 26–28 scales around mid-body), and pentadactyl limbs (versus extremely reduced limbs, usually with two toes and two fingers, but sometimes with up to four). See also table 2 for a summary of morphological characteristics of the new species. Furthermore, the new species differs from all *Amphiglossus* and *Madascincus* species for which DNA sequences were available, by high sequence divergences in mitochondrial and nuclear genes (see below).

TABLE 2. Comparison of some characteristics distinguishing the new species from other “large-sized” (SVL 130 mm) and/or superficially similar species of *Amphiglossus*. For each character, range, mean \pm standard deviation (SD) and sample size (n; inside parentheses) are given. For some bilateral characters, the sample size has been noted as the number of sides rather than specimens.

		<i>A. ardouini</i> ¹	<i>A. astrolabi</i>	<i>A. crenni</i> ²	<i>A. mandokava</i> ³	<i>A. reticulatus</i>	<i>A. meva</i>
SVL max (mm)		137	226	164	171	212	150
Color pattern ⁴		variegated	bicolor	bicolor	variegated	bicolor or variegated	bicolor
Postnasals	Present	100%	100%	X	100%	100%	–
	Absent	–	–	–	–	–	100%
	N sides	(8)	(24)	(1)	(10)	(12)	(26)
Presubocular	N=0	–	–	–	–	–	42,3%
	N=1	100 %	25%	X	100 %	100 %	57,7%
	N=2	–	75%	–	–	–	–
	n sides:	(4)	(24)	(1)	(10)	(12)	(26)
N lamellae under 4th finger	min–max:	7–10	10–13	–	5–6	7–10	6–8
	mean \pm SD: n sides:	– (7)	11.59 \pm 0.81 (31)	–	5.38 \pm 0.92 (8)	8.36 \pm 0.84 (14)	6.85 \pm 0.67 (26)
N lamellae under 4th toe	min–max:	17–21	15–21	6–7	9–12	12–16	9–13
	mean \pm SD: n sides:	– (8)	18.16 \pm 1.27 (32)	6.7 (6)	10.20 \pm 0.92 (10)	14.19 \pm 1.22 (16)	11.23 \pm 1.11 (26)
N ventral scale rows	min–max:	94–104	99–113	–	103–120	95–108	91–96
	mean \pm SD:	–	105.41 \pm 4.40	–	116.20 \pm 7.40	102.13 \pm 4.7	93.23 \pm 1.48
	n:	(10)	(17)	–	(5)	(8)	(13)
N paravertebral scale rows	min–max:	100	98–109	116–132	129–141	96–108	95–101
	mean \pm SD:	–	103.12 \pm 2.82	152.66	136.75 \pm 5.44	103.13 \pm 4.45	98.30 \pm 2.13
	n:	(2)	(17)	(6)	(4)	(8)	(13)
N longitudinal scale rows at mid–body	min–max:	31–33	34–38	26–28	36–38	39–41	32–36
	mean \pm SD:	–	35.53 \pm 1.06	27.3	36.80 \pm 1.10	40.00 \pm 0.53	34.38 \pm 1.12
	n:	(10)	(17)	(6)	(5)	(8)	(13)

¹Partly based on Angel (1942) and Brygoo (1983). ²Based on Andreone & Greer (2002) and on the photographs of the lost holotype taken by Brygoo in 1976 (see fig. 6). ³Partly based on Raxworthy & Nussbaum (1993). ⁴Two types of color patterns are presently distinguished: (1) the “bicolor pattern” with a dorsal side uniformly dark contrasting with a ventral side uniformly light, and (2) the “variegated patterns” that may be composed by dark transversal or longitudinal stripes, dash lines, or reticulations on a lighter background.

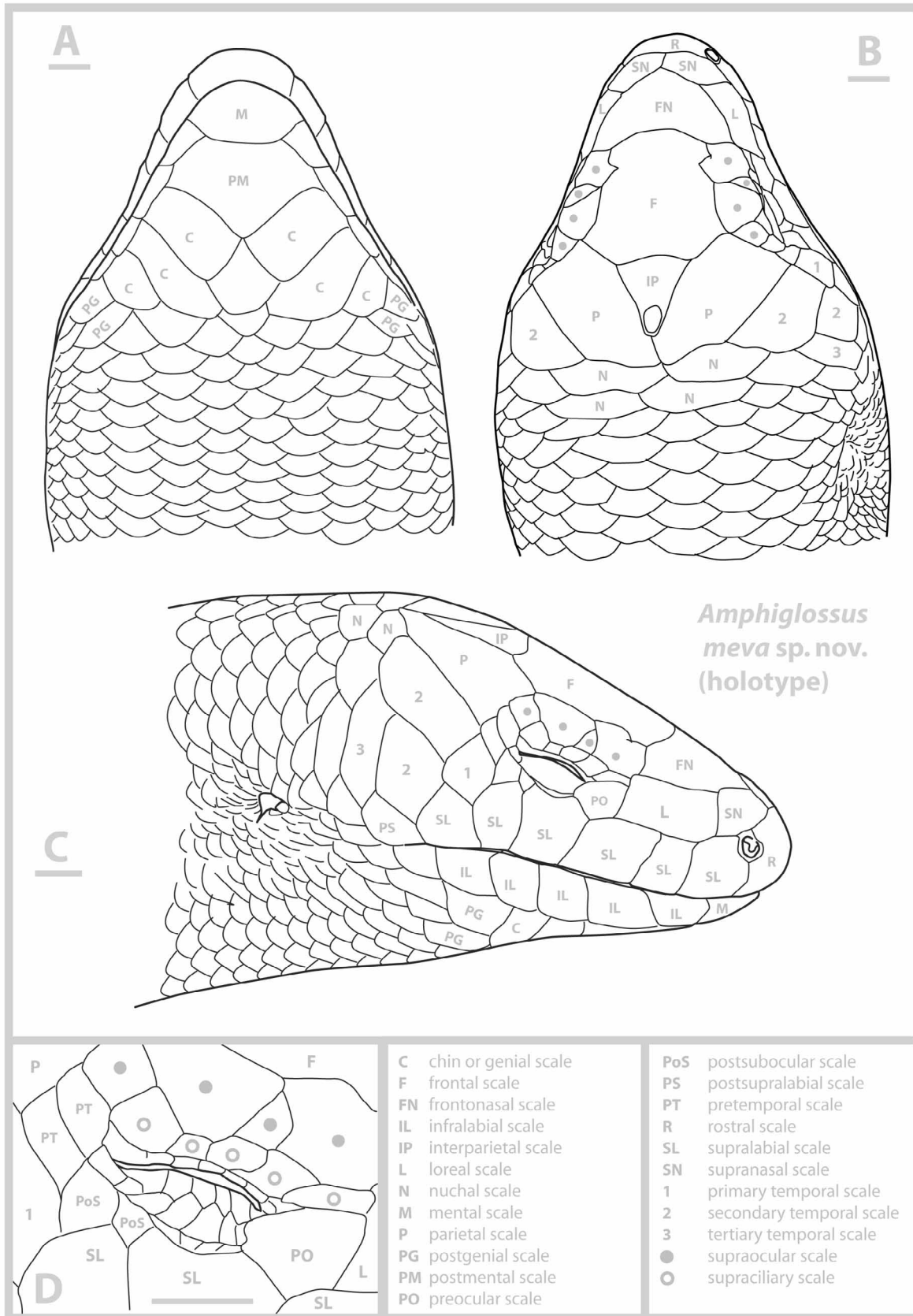


FIGURE 2. Drawings of the head of the holotype of *Amphiglossus meva* sp. n. (MNCN 44648): (A) dorsal view, (B) ventral view, (C) lateral view, (D) close up of the ocular region. Scale bar = 2 mm.



FIGURE 3. Photographs of *Amphiglossus meva* sp. n.: (A) picture of the holotype specimen in life (MNCN 44648) and (B) four freshly euthanased specimens including juveniles and an adult, all from the Makira reserve ; (C) living picture of an adult specimen from Ambohijanahary (UADBA 12209). Photographs by M. Vences and D.R. Vieites (A-B) and Harald Schütz (C), respectively.



FIGURE 4. Photographs of two species of *Amphiglossus* sharing with *A. meva* a bicolor pattern and a relatively large size: (A) *A. astrolabi*, from Ranomafana and (B) *A. crenni*, from Analabe. Photographs taken by F. Glaw and Franco Andreone, respectively.

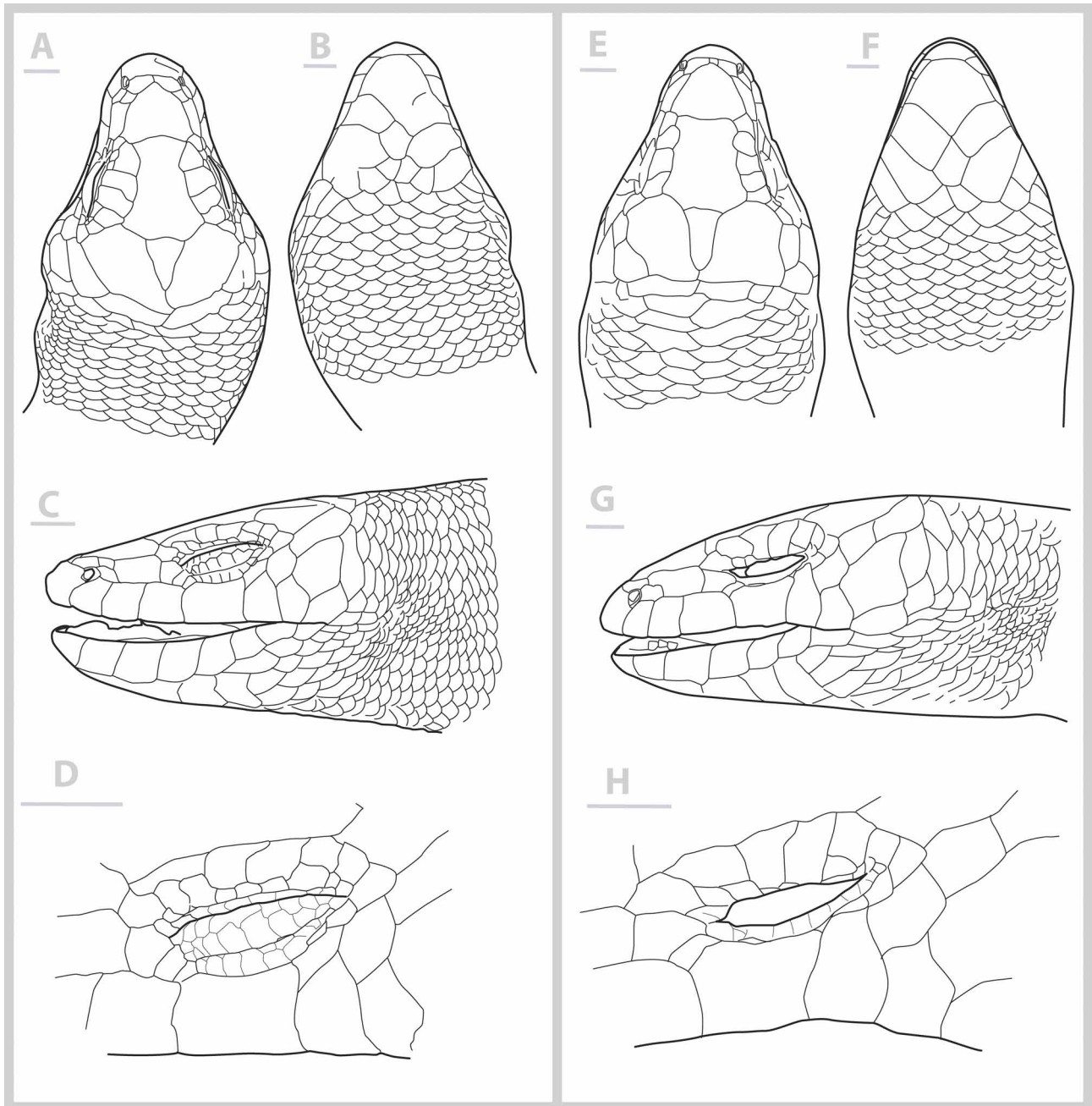


FIGURE 5. Drawings of the head of (A-D) the lectotype of *Amphiglossus atrolabi* (MNHN 5256) and of (E-H) a specimen of *A. reticulatus* (MNHN 1931.77, holotype of *Scelotes waterloti* Angel, 1930). Scale bar = 4 mm.

Description of the holotype. MNCN 44648 (field number ZCMV 11324) (Fig 2, 3A). In general appearance, a medium to large-sized *Amphiglossus* skink, assigned to this (paraphyletic) genus on the basis of molecular phylogenetic relationships and presence of pentadactyl limbs; snout–vent length (143.0 mm), 6.5 times head length (21.9 mm), almost as long as tail length (136 mm, tip regenerated). Both pairs of limbs short, pentadactyl, with very short fingers; as a proportion of SVL, front limb 14% (20–19.5 mm) and rear limb 17% (24.5–26.2 mm).

Snout bluntly rounded in both lateral and medial aspect; rostral wider than high contacting first supralabials, nasals and supranasals. Paired supranasals in median contact, contacting loreal. Frontonasal triangular, wider than long, posterior side concave, contacting loreals and first suproculars. Prefrontals absent. Frontal quadrilateral, as long as wide becoming wider at the posterior part. Supraoculars four, the second one is significantly reduced, the first and third are barely in contact medially, the fourth supraocular is also reduced; first supraocular constricting frontal (frontal hourglass-shaped sensu Andreone & Greer 2002), the first and the third supraoculars contacting frontal. Frontoparietals absent. Interparietal present, well separated from supraoculars and of triangular shape, lon-

ger than wide; parietal eye evident. Parietals contact posterior to interparietal. Two pairs of enlarged nuchals. Nasal an anteriorly open ellipsis, just slightly larger than nostril, in contact with rostral, first supralabials and supranasals. Postnasal absent, probably fused with first supralabials. Loreal single, longer than higher. Preocular single; presubocular absent. Supraciliaries five, in continuous row, first and last pairs significantly larger and longer than the intermediate ones; last pair projecting medially into supraocular series (thereby greatly reducing fourth supraocular in size); upper palpebrals small except for last which projects dorsomedially slightly. Pretemporals two, both contacted by parietal; postsuboculars two, the first reduced, upper contacting lower pretemporal, both contacting penultimate supralabial. Lower eyelid moveable, scaly; lower palpebrals small, longer than high, interdigitating with large columnar scales of central eyelid; contact between upper palpebrals and supraciliaries direct but flexible, i.e. palpebral cleft narrow. Primary temporal single. Secondary temporals two, upper long, contacting lower pretemporal anteriorly and the first pair of nuchal posteriorly and overlapping lower secondary temporal ventrally; tertiary temporal single, bordering lower secondary temporal, dorsoventrally elongated, and posteriorly followed by a scale slightly smaller and similar in shape. Supralabials six, the fourth being the subocular which contacts scales of lower eyelid. Postsupralabial single, external ear opening approximately half size of eye opening, circular to horizontally suboval, with short, narrow, blunt lobules anteriorly (at least three evident, the first one being the biggest). Mental twice wider than long; postmental diamond shaped, wider than long, contacting two infralabials. Infralabials five. Three pairs of large chin scales, members of first pair nearly in contact medially, members of second pair separated by one scale row, and members of third pair separated by five scale rows. Two asymmetrical postgenials posterolaterally in contact with the third pair of chin scales. Gulars similar in size and outline to ventrals. All scales, except head shields and scales on palms, soles, and digits, cycloid, smooth, and imbricate; longitudinal scale rows at mid-body 35; paravertebrals 98–99, including nuchals, similar in size to adjacent scales; ventrals 92, including the preanals and postmentals; larger inner preanals overlap outer smaller; scales of midventral caudal series similar in size to more adjacent scales. Both pairs of limbs pentadactyl; fingers and toes very short, clawed. Subdigital lamellae smooth, single, with 7/8 subdigital lamellae beneath fourth digit of hands, 11/11 subdigital lamellae beneath fourth digit of feet.

Color in life. The color in life is similar to the color in preservative as described below, except the scales of the flanks that showed a faded orange coloration which was lost when preserved in ethanol. The orange was present in the central portion of the scales, with the posterior border creamy-whitish.

Color in preservative. Background color of the upper side of the head, neck, back, limbs, and tail light grey/brownish. Venter, lower side of head, throat, lower side of limbs, tail and flanks are creamish, with the flanks slightly darker than venter. The limit between the dorsal coloration and the flanks shows a little contrast, which was more evident in life. Dorsal scales show lighter posterior edges, and the grey/brownish coloration comprises ten dorsal scales in wide. On the head, the area between the ear opening and the eye, including the two posteriormost supralabial, post-supralabial and the lower temporals, are whitish (the same coloration as the throat), contrasting with the rest of the dorsal side of the head. On all limbs, the dark coloration of the upper part does not connect with the dorsum, having an area in the proximal part of the limb with light-cream coloration. The coloration of the palms and feet is slightly darker than the ventral coloration. The rostral, first supralabials and the supranasals scales show a contrasting milky or semi-translucid coloration, with a clearer whitish dot on the central part of the rostral.

Intraspecific variation. The following summary of the variation in meristic and mensural characters gives the range for each of them, followed by the mean, \pm the standard deviation, and sample size in parentheses. For some bilateral characters, the sample size has been noted as the number of sides rather than specimens, and this is then indicated after the sample size. Ventrals scales rows: 91–96 (93.23 ± 1.48 , $n=13$); paravertebral scales rows: 95–101 (98.30 ± 2.13 , $n=13$); longitudinal scale rows at mid-body: 32–36 (34.38 ± 1.12 , $n=13$); lamellae under 4th finger: 6–8 (6.85 ± 0.67 , n sides=26); lamellae under 4th toe: 9–13 (11.23 ± 1.11 , n sides=26); SVL adults: 126–150mm (140 ± 8.0 , $n=7$), with a minimal SVL of 68 mm recorded on a juvenile; supralabials (n sides=26): most often six supralabial (88.46%), sometimes five (11.53%); postsupralabials (n sides=23): always single (100%); infralabials (n sides=18): most often five (72.2%), sometimes four (16.7%) or six (11.1%); supraoculars (n sides=26): most often four (84.6%), sometimes three (7.7%) or five (7.7%), number of supraoculars in contact with the frontal (n sides=26): most often three (73.1%), sometimes two (19.2%) or four (7.7%); supraciliaries (n sides=24): most often five (50%), sometimes six (29.2%) or seven (20.8%); loreals (n sides=26): always single (100%); postnasals (n sides=26): always absent (100%).

Most of the specimens show the contrasting milky coloration on rostral, first supralabials and the supranasals scales as in the holotype. Juveniles frequently show a whitish patch on the anterior supraciliary area. Specimens

from the western population (Ambohijanahary) have a narrower dark dorsal stripe (always six scale rows on the neck, $n=2$) than those from Makira and Marotandrano (always ten scale rows on the neck, $n=11$). The life coloration of juveniles is similar to the adults, with a bright contrasting orange / pink on the flanks, venter, lower side of head, throat, lower side of limbs, and tail. Nevertheless, in Makira, the pattern shown by the available series of specimens suggests that the orange coloration fades in parallel with the age of the specimen, what does not seem to be the case in the populations of Marotandrano and Ambohijanahary. In all specimens, the orange coloration disappeared after fixation, becoming cream or peach colored. See also table 2.

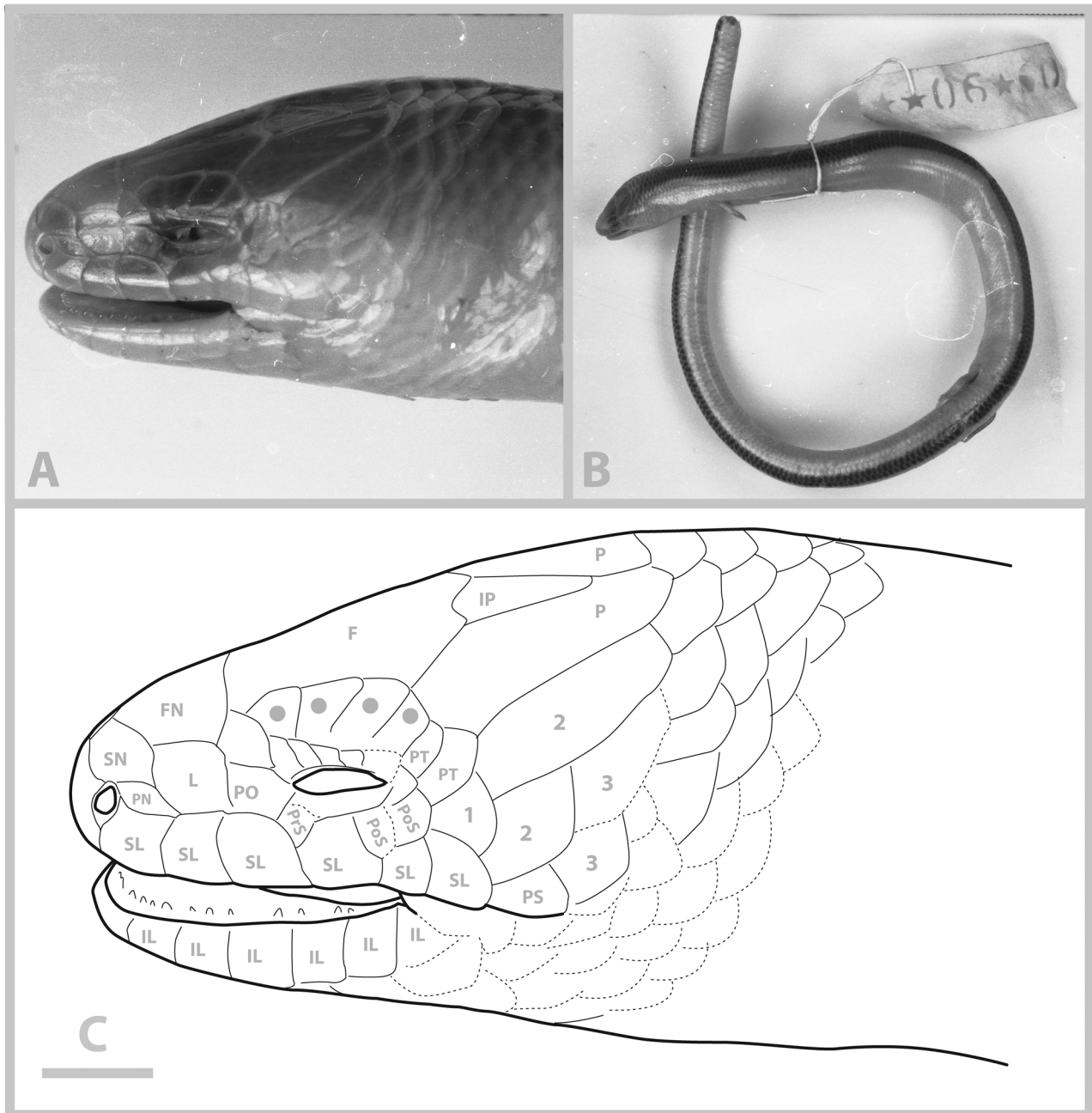


FIGURE 6. Photographs (A, B) of the lost holotype of *Amphiglossus crenni* (MNHN 1906.60; unpublished pictures taken by E. R. Brygoo in 1976, archives of the Laboratoire des Reptiles et Amphibiens at the MNHN), and (C) a drawing made after the photograph A. Scale borders hardly distinguishable and doubtful have been represented by dashlines. Scale bar = 2 mm.

Etymology. Meva, pronounced “mæva or mœva”, is a Malagasy word used to express beauty and refers to the splendid bicolouration of this skink. It is used as a noun in apposition.

Phylogenetic position and genetic differentiation. The results of the phylogenetic analyses are summarized in Figure 7. Unsurprisingly, the phylogenetic tree obtained is highly congruent with the one published by Crottini *et*

al. (2009). Although many of the most basal nodes of the genus *Amphiglossus* are insufficiently supported to reliably infer the exact position of the new species within this taxon, some significant results may be formulated : (1) both MP and Bayesian analyses gave results congruently supporting the placement of *A. meva* within the genus “*Amphiglossus*” sensu Crottini *et al.* (2009), with a bootstrap support value of 79% and a posterior probability of 1.00; and (2) the results show that *Amphiglossus astrolabi* is more closely related to *Amphiglossus reticulatus* (88%; 1.00) than to *Amphiglossus meva*.

The uncorrected p-distances (Table 3) estimated between *Amphiglossus meva* and *Amphiglossus astrolabi* (p-distances ranging between 7.4% and 8.3% for the 16S gene, and between 14.4% and 15.3% for the ND1 gene) or between *Amphiglossus meva* and *Amphiglossus reticulatus* (5.5% to 5.8%, and 11.3% to 12.0%, respectively) are of the same order of magnitude as those observed between *Amphiglossus astrolabi* and *Amphiglossus reticulatus* (6.00% to 7.10%, and 12.90% to 14.20%, respectively).

TABLE 3. Summary of genetic divergence (uncorrected p-distances) within the “*Amphiglossus astrolabi / meva / reticulatus*” clade, estimated from 16S and ND1 sequences. Range, followed by mean \pm standard deviation and sample size (inside parentheses) are given for both intra- and interspecific comparisons.

	16S	ND1
Intraspecific distances within :		
<i>Amphiglossus astrolabi</i>	0.2 – 2.1 (1.37 \pm 1.02 ; 3)	2.0 – 2.1 (2.00 \pm 2.04 ; 6)
<i>Amphiglossus meva</i>	0.0 (0.0 ; 3)	0.0 – 0.2 (0.13 \pm 0.11 ; 3)
<i>Amphiglossus reticulatus</i>	0.0 – 0.7 (0.47 \pm 0.40 ; 3)	0.0 – 2.7 (1.80 \pm 1.55 ; 3)
Interspecific distances between:		
<i>A. astrolabi</i> / <i>A. meva</i>	7.4 – 8.3 (7.70 \pm 0.45 ; 9)	14.4 – 15.3 (14.94 \pm 0.31 ; 12)
<i>A. astrolabi</i> / <i>A. reticulatus</i>	6.0 – 7.1 (6.52 \pm 0.41 ; 9)	12.9 – 14.2 (13.62 \pm 0.65 ; 12)
<i>A. meva</i> / <i>A. reticulatus</i>	5.5 – 5.8 (5.60 \pm 0.15 ; 9)	11.3 – 12.0 (11.60 \pm 0.27 ; 9)

Habitat and distribution. In the Makira reserve, despite the use of pitfall lines, no specimen of *A. meva* was collected in pitfall traps. Instead, all individuals were caught in a flat valley area not too far from a stream, at sites that during the rainy season are probably flooded, but that during our visit (in the dry period) did not have any water or wet soil. All specimens were found within or under large logs, which typically were largely rotten and which maintained a certain degree of humidity without being soaked with water. The collecting site was on the main plateau of Makira, which is made up by a vast rainforest area at an altitude between 900-1200 m above sea level. The collecting site was characterized by a herpetofaunal composition typical for the mid-altitude eastern rainforests of Madagascar, whereas within a few kilometers, on the western slopes of the plateau, a drastic ecotone towards the drier areas of western Madagascar occurs, characterized by numerous herpetofaunal elements typical for western and northern Madagascar, such as the frogs *Mantidactylus ambreensis* and *M. ulcerosus* and the gecko *Paroedura oviceps* (a comprehensive account of the results of our survey at Makira will be published elsewhere). In the RS of Ambohijanahary, the specimens UADBA 12209 and 12210 (not included in the type series) were captured in the same pitfall bucket, which was part of a line within the bottom of a forested valley, 5 m away from a small stream, and 50 m away from the forest edge. In this area, the vegetation is the typical mid-elevation (1150 m) primary rainforest, within the category western humid forest (Moat & Smith 2007). The RS of Ambohijanahary is located along the extreme western portion of the Central Highlands, within the Bongolava chain, approximately 80 km NW of the town Tsiroanomandidy. This forest shows some transitional vegetation elements between two phyto-geographic subdivisions of the Western and Central Domains (Nicoll & Langrand 1989), and can be attributed to the humid vegetation (Moat & Smith 2007). The specimens were collected from the RS of Marotandrano at Riama-landy, located in the northern region of Madagascar, about 12.5 km SSW of the Commune rurale de Marotandrano. The habitat is a closed canopy midelevation (800–850m) transitional rainforest with humid vegetation (Moat & Smith 2007) associated with taller trees and forest floor rich in organic material with thick leaf litters and diverse detritus. All specimens were found in large and humid rotten logs, in valley closed canopy rainforest during refuge examination. Three pitfall lines with drift fence were used during the survey, but no individuals of this species were caught.

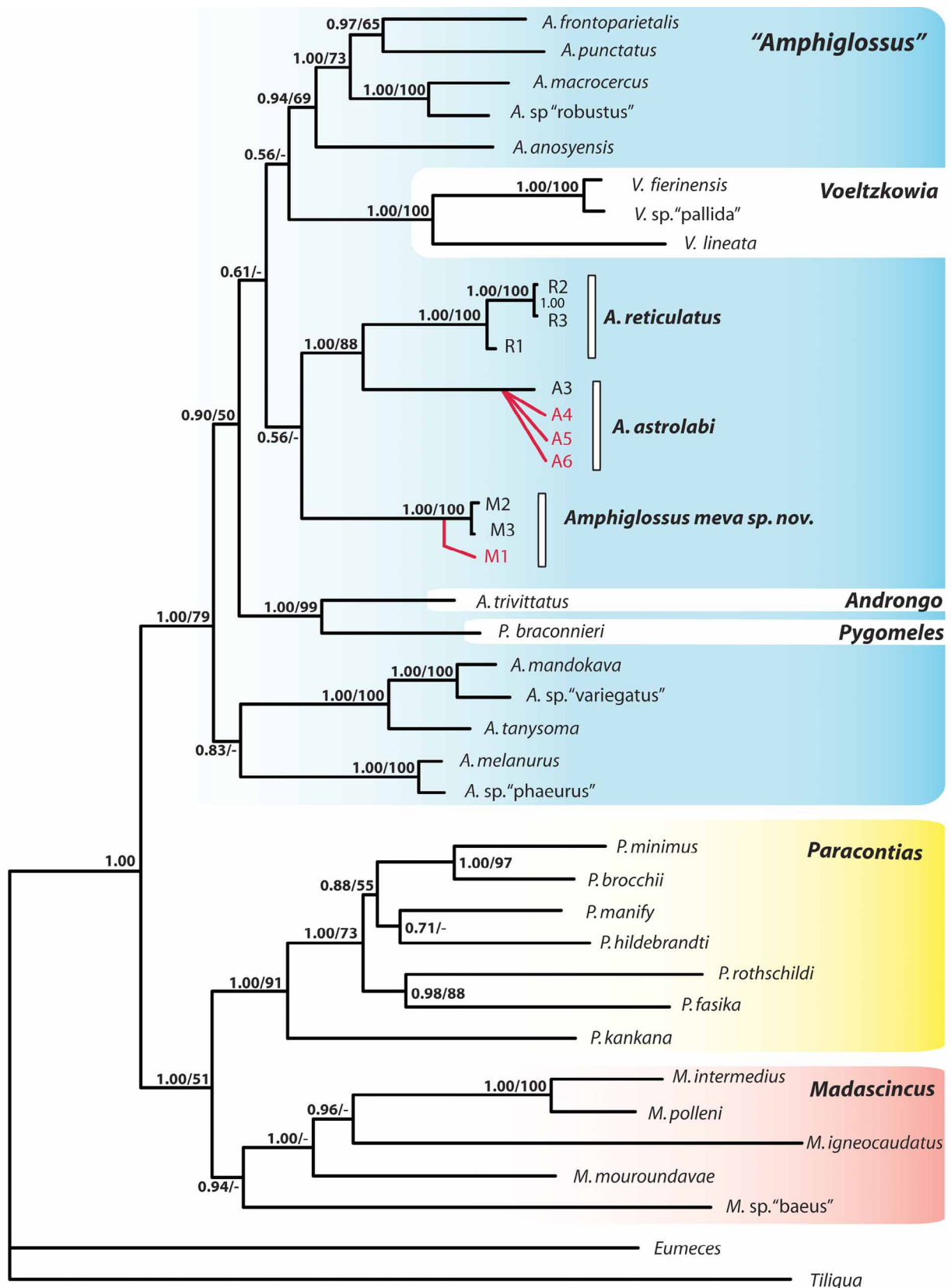


FIGURE 7. Phylogenetic position of *Amphiglossus meva* sp. nov. within the Malagasy scincine. The present tree has been inferred from a Bayesian analysis combining five nuclear (BDNF, Rag2, enol, C-mos, PDC) and three mitochondrial (12S, 16S rRNA, ND1) genes, with posterior probabilities followed by the bootstrap support values >50% from Maximum Parsimony analysis. Red lines indicate the positions of four specimens as resulted from a separate analysis including a reduced number of markers (see table 1).

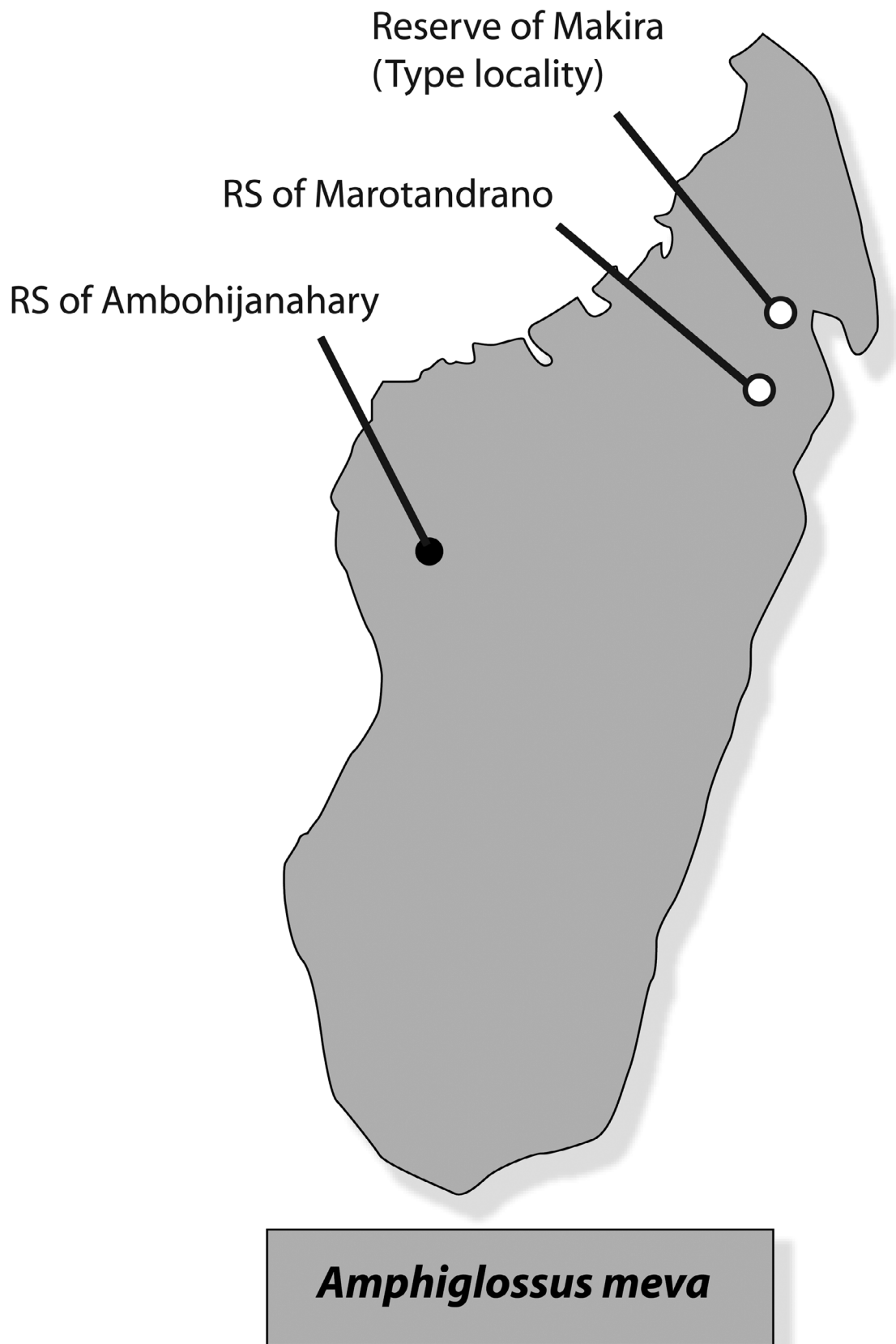


FIGURE 8. Distribution map of *Amphiglossus meva*. White circles represent localities sampled for the phylogenetic analyses.

Previous herpetological surveys using pitfall traps in the same reserve (Raxworthy, unpublished; Biodev, unpublished), the Central Highland sites of the RS d'Ambositantely (C.J. Raxworthy and collaborators and S.M. Goodman and collaborators, unpublished), Ankazomivady forest (Goodman *et al.*, 1998), Parc National d'Andringitra (Raxworthy *et al.*, 1996), and Andranomay forest (Raselimanana 1998), the west part of Parc National du Tsingy de Bemaraha (Bora *et al.* 2010), Kirindy forest (Raselimanana 2008, Raxworthy *et al.*, unpublished), the southwestern PK 32 forest (Raxworthy *et al.*, unpublished), Parc National de Zombitse (Raxworthy *et al.* 1994), and Vohibasia (Goodman *et al.* 1997), and the northwestern RS d'Ankarafantsika (Ramanamanjato & Rabibisoa, 2002; Raselimanana, 2008) did not provide any evidence for the occurrence of *A. meva* **n. sp.** although numerous other burrowing species (skinks and frogs) were collected in these surveys. The species appears to show a preference for large rotten logs retaining a certain degree of humidity but in general in parts of the rainforest with relatively dry soils. Based on our finding in Marotandrano and Makira, this new species is not rare but probably has a quite strict ecological specificity with respect to its microhabitat (Fig. 8).

Ecological notes. In Ambohijanahary, two specimens were captured on two consecutive days, both in the same pitfall trap, 5 m away from a 2 m wide stream. They may have been a breeding pair. No other individuals were found in the RS d'Ambohijanahary despite an additional 165 trap days with pitfall devices. The specimens from Marotandrano were all captured during refuge examination including rotten logs excavation and removal of barks and leaf litter accumulated under taller and big dead trees. In Makira, a group of three individuals was found together under a big log. Several larvae of coleopterans, other insects and termites were found in the same microhabitat, suggesting that this new skink may feed on these preys. In contrast to the other large species within the same genus, *A. meva* was never found in water.

Threats and Conservation status. Habitat loss due to slash and burn agriculture, bush fires, and wood extraction are the main pressures on the Ambohijanahary and Marotandrano reserve. Forests at these reserves, especially Ambohijanahary, are extensively fragmented. Although this forest is classified as a Réserve Spéciale, no management plan has been proposed. The reserve and surrounding areas are known to be the domain of zebu cattle thieves (*dahalo*). The forested areas within the reserve are often used by local people as a site to shelter stolen zebu. The importance of this form of refuge has provided some protection to the remaining forest. Moreover, MNP has an office and agents in Marotandrano Village and a coordination office is operational in Mandritsara. On the contrary, Makira reserve currently appears to be relatively well preserved at its western edge, where the type locality of the new species is located. Despite the common use of the forest for cattle grazing, in 2009 we could not detect major forest destruction nor human settlements directly in the forested area. Efforts need to be undertaken to maintain this apparently stable situation and to reduce forest destruction at the eastern lowland borders of Makira, which appears to be relatively intense in some areas.

Discussion

Madagascar is one of the richest and more biologically diverse places on Earth, and its diversity is still largely unknown with many new species being described every year and many more yet to be discovered (Köhler *et al.* 2005; Vieites *et al.* 2009). There are several reptile species in Madagascar with bright coloration; some of them have been considered aposematic. For example, several snakes such as *Stenophis citrinus* Domergue and *Liophidium pattoni* Vieites, Fanomezana, Ratsoavina, Randrianiaina, Nagy & Vences present unique color patterns consisting of alternation of yellow and black cross bands or red, yellow and blue in contrast with black respectively. None of these species are poisonous, and the factors triggering the evolution of their aposematic coloration is unclear. In skinks there are several examples of bright coloration that may be related to escaping or warning predators. Skinks such as *Madascincus igneocaudatus* have a contrasting bright red tail, which can be autotomized if a predator bites it, while other species show an overall bright coloration like *A. crenni* or *Pseudoacantias menamainty* that could be considered as aposematic. However, these species are highly fossorial and as far as it is known they are not poisonous. It is unclear if the bright coloration evolved as a warning signal to predators, but also other burrowing taxa are known to have aposematic coloration (Wollenberg & Measey 2009).

Both morphological and coloration characters distinguish *A. meva* **sp. nov.** from any other skink species from Madagascar. It is remarkable that such a large and conspicuous species of vertebrate has not been detected until now, despite this new species being relatively widespread on the island. This suggests that many more species of

vertebrates can still be expected from Madagascar and encourages more field and taxonomic work on its fauna. Despite the species is only known from three sites, we have found many specimens in a short period. Until more data is gathered, we suggest to consider this species as Data Deficient for conservation purposes following IUCN criteria.

Acknowledgements

We are grateful to Theo Rajoafiarison, Jim and Carol Patton, Emile Rajeriarison, Fanomezana Mihaja. Ratsoavina and Roger-Daniel Randrianiaina who helped collecting specimens at Makira, to Florent and François Randrianasolo from the WCS for their help and companionship in the field at Makira, and to our drivers Claude and Samy for safely carrying us to the basis of the Makira slopes. Steven M. Goodman helped in the capture of several specimens and made valuable comments on earlier versions of this manuscript. Harald Schütz took the photograph of the living specimen from Ambohijanahary. Franco Andreone, Edouard R. Brygoo and Frank Glaw contributed photographs of *Amphiglossus crenni* and *A. astrolabi*. We also thank the Département de Biologie Animale, Université d'Antananarivo, Madagascar National Park team in Mandritsara, the brigade of Gendarmerie in Marotandrano that ensuring our security during the field survey, the Ministères des Eaux et Forêts, Antananarivo, and the Technical University of Braunschweig. Many thanks to Annemarie Ohler and Ivan Ineich (MNHN), Frank Glaw (ZSM) and Göran Nilson (GNM) for providing us access to collection specimens. We are grateful to the Malagasy authorities for research and export permits, and to the Wildlife Conservation Society for supporting our research activities at Makira. The field inventory in Ambohijanahary was funded by a grant from the National Geographic Society to S.M. Goodman and D. Rakotondravony, and the mission to Marotandrano was generously supported by the MacArthur Foundation in the context of the RAP-Gasy project. We are indebted to the Ecology Training Program and the World Wide Fund for Nature, Antananarivo, for logistical support. Funding was provided by a postdoctoral research fellowship of the Alexander von Humboldt Foundation and by a SYNTHESYS grant (FR-TAF-842) to AM, by the Volkswagen Foundation to MV, and by a Spanish Ministry of Science and Innovation grant (CGL2009-10198) to DRV.

References

- Andreone, F. & Greer, A.E. (2002) Malagasy scincid lizards: descriptions of nine new species, with notes on the morphology, reproduction and taxonomy of some previously described species (Reptilia, Squamata: Scincidae). *Journal of Zoology (London)*, 258, 139–181.
- Angel, M.F. (1930) Diagnoses d'espèces nouvelles de lézards, de Madagascar, appartenant au genre *Scelotes*. *Bulletin du Muséum National d'Histoire Naturelle, Paris*, 2, 506–509.
- Bora, P., Randrianantoandro, J.C., Randrianelona, R., Hantalalaina, E.F., Andriantsimanarilafy, R.R., Rakotondravony, D., Ramilijaona, O.R., Vences, M., Jenkins, R.K.B., Glaw, F. & Köhler, J. (2010) Amphibians and reptiles of the Tsingy de Bemaraha Plateau, western Madagascar: Checklist, biogeography and conservation *Herpetological Conservation and Biology*, 5(1), 111–125.
- Brygoo, E.R. (1980) Systématique des lézards scincidés de la région malgache. II. *Amphiglossus astrolabi* Duméril et Bibron, 1839; *Gongylus polleni* Grandidier, 1869; *Gongylus stumpffi* Boettger, 1882, et *Scelotes waterloti*, Angel, 1930. *Bulletin du Muséum national d'Histoire naturelle. Section A*, 2(2), 525–539.
- Brygoo, E.R. (1983) Systématique des lézards scincidés de la région malgache. X. Rapports de *Gongylus johannae* Günther, 1880, des Comores, et de *Sepsina valhallae* Boulenger, 1909, des Glorieuses, avec les espèces malgaches. *Bulletin du Muséum National d'Histoire Naturelle, Paris, 4ème série*, 5, A, n°2, 651–660.
- Brygoo, E.R. (1987) Les types de Scincidés (Reptilia, Sauriens) du Muséum national d'Histoire naturelle. Catalogue critique. *Bulletin du Muséum national d'Histoire naturelle, Paris, Section A*, (3), 1–126.
- Crottini, A., Dordel, J., Köhler, J., Glaw, F., Schmitz, A. & Vences, M. (2009) A multilocus phylogeny of Malagasy scincid lizards elucidates the relationships of the fossorial genera *Androngo* and *Cryptoscincus*. *Molecular Phylogenetics and Evolution*, 53, 345–350.
- Dayrat, B. (2005) Toward integrative taxonomy. *Biological Journal of the Linnean Society*, 85, 407–415.
- de Queiroz, K. (2007) Species concepts and species delimitation. *Systematic Biology*, 56, 879–886.
- Glaw, F. & Vences, M. (2007) *A field guide to the amphibians and reptiles of Madagascar. Third edition*. Cologne, Vences & Glaw Verlag, 496 pp.
- Goodman, S.M., Ramanamanjato, J.-B. & Raselimanana, A.P. (1997) Les amphibiens et les reptiles. In: Langrand, O and S. M.

- Goodman (Eds.). *Inventaire biologique Forêts de Vohibasia et Isoky-Vohimena. Recherches pour le Développement, série Sciences Biologiques, n°12*, pp.110–129.
- Goodman, S.M., Duplantier, J.-M., Rakotomalaza, P.J., Raselimanana, A.P., Rasoloarison, R., Ravokatra, M., Soarimalala, V. & Wilme, L. (1998) Inventaire biologique de la forêt d'Ankazomivady, Ambositra. *Akon'ny Ala*, 24, 19–32.
- Greer, A.E. & Shea, G. (2000) A major new head scale character in non-lygosomine scincid lizards. *Journal of Herpetology*, 34, 631–636.
- Köhler, J., Vieites, D.R., Bonett, R. M., García, F.H., Glaw, F., Steinke, D. & Vences, M. (2005) New amphibians and global conservation: A boost in species discoveries in a highly endangered vertebrate group. *BioScience*, 55(8), 693–696.
- Köhler, J., Vences, M., Erbacher, M. & Glaw, F. (2010) Systematics of limbless scincid lizards from northern Madagascar: morphology, phylogenetic relationships and implications for classification (Squamata: Scincidae). *Organisms Diversity and Evolution*, 10, 147–159.
- Köhler, J., Vieites, D.R., Glaw, F., Kaffenberger, N. & Vences, M. (2009) A further new species of limbless skink, genus *Paracontias*, from eastern Madagascar. *African Journal of Herpetology*, 58, 98–105.
- Miralles, A. (2006) A New Species of *Mabuya* (Reptilia, Squamata, Scincidae) from the Isolated Caribbean Island of San Andrés, with a new interpretation of nuchal scales, character of systematic importance. *The Herpetological Journal*, 16, 1–7.
- Miralles, A., Köhler, J., Glaw, F. & Vences, M. (2011a) A molecular phylogeny of the “*Madascincus polleti* species complex”, with description of a new species of scincid lizard from the coastal dune area of northern Madagascar. *Zootaxa*, 2876, 1–16.
- Miralles, A., Köhler, J., Vieites, D.R., Glaw, F. & Vences, M. (2011b) Hypotheses on rostral shield evolution in fossorial lizards derived from the phylogenetic position of a new species of *Paracontias* (Squamata, Scincidae). *Organisms Diversity and Evolution*, 11, 135–150.
- Moat, J. & Smith, P. (2007) *Atlas de la végétation de Madagascar*. Kew: Royal Botanic Gardens, Kew, 124pp.
- Nicoll, M.E. & Langrand, O. (1989) *Madagascar: Revue de la conservation et des aires protégées*. World Wildlife Fund, Gland, 374pp.
- Padial, J.M., Miralles, A., De la Riva, I. & Vences, M. (2010) The integrative future of taxonomy. *Frontiers in Zoology*, 7, 16. doi:10.1186/1742-9994-7-16.
- Ramanamanjato, J.-B. & Rabibisoa, N. (2002) Evaluation rapide de la diversité biologique des reptiles et amphibiens de la Réserve Naturelle Intégrale d'Ankarafantsika, In: Alonso, L. E., Schulenberg, T. S., Radilofe, S. & Missa O. (Eds): *Une évaluation biologique de la Réserve Naturelle Intégrale d'Ankarafantsika, Madagascar*. – Bulletin RAP d'évaluation rapide 23, Conservation International, Washington, DC, pp 98–103 + 135–138.
- Raselimanana, A.P. (1998) La diversité de la faune de reptiles et d'amphibiens. In: Rakotondravony D., Goodman S. M. (Eds.). *Inventaire biologique de la forêt d'Andranomay, Anjozorobe*. Recherches pour le Développement, série Sciences Biologiques, 13, pp 43–59.
- Raselimanana, A.P. (2008) Herpétofaune des forêts sèches malgaches. Dans Les forêts sèches de Madagascar. In: Goodman S. M. & Wilme L. (eds.). *Malagasy Nature*, 1, 46–75.
- Raselimanana, A.P. & Rakotomalala, D. (2003) Scinicidae, skinks. In: Goodman, S. M., Benstead, J. P. (Eds.) *The natural history of Madagascar*. The University of Chicago Press, Chicago, pp. 986–993.
- Raxworthy, C.J., Ramanamanjato, J.-B. & Raselimanana, A.P. (1994) Les reptiles et les amphibiens. In: Goodman S. M., Langrand O. (Eds.) *Inventaire Biologique de Forêt de Zombitse*. Recherches pour le Développement, série Sciences Biologiques, numéro spécial, pp. 41–57.
- Raxworthy, C.J. & Nussbaum, R.A. (1993) Four new species of *Amphiglossus* from Madagascar (Squamata: Scincidae). *Herpetologica*, 49, 326–341.
- Raxworthy, C.J. & Nussbaum, R.A. (1994) A rainforest survey of amphibians, reptiles and small mammals at Montagne d'Ambre, Madagascar. *Biological Conservation*, 69, 65–74.
- Raxworthy, C.J. & Nussbaum, R.A. (1996) Amphibians and reptiles of the réserve naturelle intégrale d'Andringitra, Madagascar: a study of elevational distribution and local endemism. In: Goodman, S. M. (ed.): A floral and faunal inventory of the eastern slopes of the réserve naturelle intégrale d'Andringitra, Madagascar: with reference to elevational variation. *Fiel-diana Zoology (new series)*, 85, 158–170.
- Ronquist, F. & Huelsenbeck, J.P. (2003) MRBAYES 3: Bayesian phylogenetic inference under mixed models. *Bioinformatics*, 19, 1572–1574.
- Schmitz, A., Brandley, M.C., Mausfeld, P., Vences, M., Glaw, F., Nussbaum, R.A. & Reeder, T.W. (2005) Opening the black box: phylogenetics and morphological evolution of the Malagasy fossorial lizards of the subfamily “Scincinae”. *Molecular Phylogenetics and Evolution*, 34, 118–133.
- Swofford, D.L. (2002) *PAUP*. Phylogenetic Analysis Using Parsimony (*and other Methods)*. Version 4.0.b10. Sunderland, MA: Sinauer Associates.
- Tamura, K., Dudley, J., Nei, M. & Kumar, S. (2007) MEGA4: Molecular Evolutionary Genetics Analysis (MEGA) software version 4.0. *Molecular Biology and Evolution*. doi: 10.1093/molbev/msm092
- Vieites, D.R., Wollenberg, K.C., Andreone, F., Köhler, J., Glaw, F. & Vences, M. (2009) Vast underestimation of Madagascar's biodiversity evidenced by an integrative amphibian inventory. *Proceedings of the National Academy of Sciences of the United States of America*, 106, 8267–8272.

- Whiting, A.S., Sites J.W. Jr. & Bauer, A.M. (2004) Molecular phylogenetics of Malagasy skinks (Squamata: Scincidae). *African Journal of Herpetology*, 53(2), 135–146.
- Wollenberg, K.C. & Measey, G.J. (2009) Why colour in subterranean vertebrates? Exploring the evolution of colour patterns in caecilian amphibians. *Journal of Evolutionary Biology*, 22, 1046–1056.

APPENDIX 1. List of additional specimens examined.

Amphiglossus ardouini (4)

Antsiranana Province : MNHN 1896.417, MNHN 1897.32 (respectively paralectotype and lectotype of *Sepsina ardouini* Mocquard, 1897), “Diego Suarez” (=Antsiranana) ; ZSM 1554-2008, Montagne des Francais, ca. 2.3 km WNW Andavakoera ("trapsite 3"), 250m (12°19,575'S 49°20,495'E), coll. by E. Randriamalala on 02.04.2006 ; ZSM 1555-5008, Ambombofofo-Region (Frontier base camp), 28m (12°05,528'S 49°19,485'E) coll. by S. Megson on 11.11.2006.

Amphiglossus astrolabi (16).

Fianarantsoa province: MNHN 1930.341, Ikongo massif, coll. by R. Decary; MNHN 1965.284, .285, .286, .287, probably all collected at Pic Ivohibé near Andringitra Massif, according to the catalogue of the Paris museum with the notion "Vivarium at the IRSM (?)" thus probably kept in captivity for some time before preservation. ZSM 201/2003, Ranomafana, near Hotel Manja, 19.1.2003, coll. by F. Glaw, M. Puente, L. Raharivololoniaina, M. Thomas and D.R. Vieites. **Toamasina province**: MNHN 1906.59, Fanovana. MNHN 1983.518, region of the Alaotra lake, coll. by Therefieu, 24 mai 1961. ZSM 1557/2008, near Andasibe, 02/03. 2008, coll. by M. Vences. **Unknown exact localities**: MNHN 5256, coll. by Quoy & Gimard; MNHN 1937.84, coll. by Lavanden; MNHN 1991.4274. MNHN 8880, 8880A, 8880B, Mandraka? Institut de Recherche Scientifique de Madagascar (IRSM) (?) – this specimen might originate in fact from Mandraka (located between Antananarivo and Moramanga) but could also originate from other parts of Madagascar and been collected by A. Peyrieras and subsequently maintained in captivity at his farm in Mandraka. MNHN 8389, with the untraceable locality information "Mosbaie", coll. by L. Rousseaux

Amphiglossus crenni (2).

Toamasina province: MNHN 1906.60, Fanovana (holotype specimen of *Scelotes crenni* Mocquard, 1906); this specimen is considered to be lost since 1982, according to E.R. Brygoo, in the collection catalogue at the MNHN; MNHN 1980.1190, region of the Alaotra lake.

Amphiglossus mandokava (4).

Antsiranana province: ZSM 208-2003, Montagne d'Ambre, 800-900m, coll. By F. Glaw, R.D. Randrianiaina & A. Razafimanantsoa on 19.02.2003 ; ZSM 312-2004, Montagne d'Ambre, 900m (12°30'S 49°10'E), coll by F. Glaw, M. Puente, R. Randrianiaina & A. Razafimanantsoa on 27.02.2004 ; ZSM 2167-2007, Montagne d'Ambre, Cascade Antakarana, coll. P. Bora on 13.03.2007 ; ZSM 2232-2007, Montagne d'Ambre, coll. by P. Bora & I. Knoll on 03./04.2007.

Amphiglossus reticulatus (8).

Antsiranana province: MNHN 1956.57, Ambilobé, coll. by J. Guibé; MNHN 1931.77 Ambilobé, coll. by Waterlot (holotype of *Scelotes waterloti* Angel, 1930). **Mahajanga Province**: MNHN 1978.2703, 1978.2704, Forêt de Boza, Antsohihy, coll. by Anthony Randriamihanta, in march 1977 ; ZSM 527-2001, 528-2001 529-2001, Ankara-fantsika (Ampijoroa) coll. by M. Vences, D.R. Vieites, G. Garcia, Raheisoa, Rasoamamonjirina from 25 to 28.2.2001. GNM 1520, St Marie de Marovoay (holotype of *Sepsina reticulata* Kaudern, 1922, only examined from high resolution photographs).