



Patterns of amphibian and reptile diversity at Berara Forest (Sahamalaza Peninsula), NW Madagascar

FRANCO ANDREONE

Museo Regionale di Scienze Naturali,
via G. Giolitti 36, I-10123 Torino (Italy)
e-mail: frand@tin.it

MIGUEL VENCES

Museum national d'Histoire naturelle, Laboratoire des Reptiles
et Amphibiens,
25 rue Cuvier, 75005 Paris (France)
e-mail: m.vences@t-online.de

JASMIN EMILE RANDRIANIRINA

Parc Botanique et Zoologique de Tsimbazaza,
BP 4096, Antananarivo (101) (Madagascar)
e-mail: ph21@ats.mg

ABSTRACT

Amphibians and reptiles were surveyed at Berara, a forest on the Sahamalaza Peninsula, NW Madagascar. Visual methods and pitfalls were used, leading to the discovery of 12 amphibian and 30 reptile species. The herpetofaunal community appeared as a mosaic of dry forest species and species from the more humid Sumbirano Domain. The comparatively low amphibian diversity may be correlated with the ecological characteristics of Berara, in particular with the scarcity of permanent water bodies and strong seasonality. The survey provided new records of *Aglyptodactylus securifer* and *Heterixalus luteostriatus*, further north than hitherto known. The encountered specimens of the treefrog *Boophis abbilabris* displayed characters typical for the subspecies *occidentalis*, resulting in a substantial range extension. *Boophis jaegeri* proved to be abundant at Berara, which is the second known locality for this treefrog. The reptile fauna included taxa of special interest, such as a new *Pseudoacantias* burrowing skink, a new *Amphiglossus*, the aquatic skink *Amphiglossus reticulatus*, and many geckos. Presence of several taxa known only from restricted western localities (e.g., *Aglyptodactylus securifer*, *Amphiglossus reticulatus*) or from a few protected areas (e.g., *B. jaegeri*), as well as of several regional endemics emphasises the importance for conservation of the Sahamalaza transitional forest, which should urgently be included in the network of protected areas in Madagascar.

KEY WORDS: Madagascar - Amphibians - Reptiles - Biodiversity - Conservation - Sahamalaza Peninsula.

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INTRODUCTION

Over the last years, the study of biodiversity has proved to be an important tool in conserving Madagascar's peculiar biota and species. With a high endemism rate, the amphibians and reptiles remain key organisms in many surveys (e.g., Raxworthy *et al.*, 1998; Andreone *et al.*, 2000b). It is worth noting that most of these surveys usually concern protected areas, whereas still little is known from remote and unprotected regions. Many of these areas are indeed of high conservation interest, and their study allows us to outline important biogeographic scenarios, indispensable for having an unbiased picture of conservation priorities. At present, considering the high deforestation rate which affects much of Madagascar, indeed one of the 'hottest' biodiversity hotspots in the World (Myers *et al.*, 2000), the protection of such 'forgotten' areas appears one of the main priorities in preserving unique ecosystems and increasing their development.

In this context, we had the possibility to carry out a survey at Sahamalaza Peninsula (NW Madagascar), where some preliminary data had already been formerly gathered (e.g., Andriamanandratra, 1996). Much of the work was done in collaboration with the "Association Européenne pour l'Étude et la Conservation des Lémuriens", with the aim of promoting its upgrading to a protected area, taking into account the existence of a large population of the 'critically endangered' lemur *Eulemur macaco flavifrons* (Mittermeier *et al.*, 1997). Amphibians and reptiles were formerly cursorily studied by Raselimanana (1996), but they were surveyed during the winter-dry season, when most of the species are inactive. Our research was done during a more suitable period, in order to obtain a sufficiently exhaustive species list. Furthermore, at the light of presence-absence and abundance of species, we put forward considerations regarding conservation.

MATERIALS AND METHODS

Site and context

The Sahamalaza Peninsula is sited in NW Madagascar (Mahajanga Province, Analava Fivondronana, Amboloboza Firasana and western part of the Befotaka Firasana), between 14°04' S and 14°37' S, and between 47°52' E and 48°04' E. The peninsula is characterised by a series of hills of about 300-350 m a.s.l., crossed

by some seasonal streams. The climate is of the hot sub-humid type, receiving a yearly mean of 1747 mm of rainfall; the temperature is more or less constant all the year (about 26°-27° C; Projet ZICOMA, 1999). Although Sahamalaza is included in the biogeographic domain of the West, the vegetational aspects (dominated by a dry forest belonging to the *Dalbergia*, *Commiphora* and *Hildebrandia* series; Humbert, 1955) and climate are transitional between those of the Sambirano Domain and those of the dry Western Domain (Projet ZICOMA, 1999).

The research was focused at Berara, within the larger Anabohazo Forest, at an altitude of about 170 m a.s.l. (14°18.55' S and 47°54.92' E). Complementary observations were also made around the villages of Betsimipoaka (14°19.79' S, 47°57.76' E), and Marozavavy (14°19.82' S, 47°58.33' E). Fieldwork was carried out from 13 to 23 February 2000, a period which corresponds to the warm and rainy season, when most amphibians and reptiles are at the peak of their activity.

Survey techniques

Searching included opportunistic observations and pitfall trapping. Two people were active about 6 a day (night and day). Different paths and streams were followed, thus avoiding contact several times with the same individuals. Pitfalls were plastic buckets (280 mm deep, 230-290 mm internal diameter), sunk into the ground at 10-m intervals along a plastic drift fence (0.5 m high and 100 m long). Small holes were punched in the bottom, to allow water to drain. The fence was stapled to wooden stakes, its lower part being buried 50 mm deep into the ground and positioned so as to run across each pitfall trap. Pitfalls were checked each morning and evening. Three fence lines were placed in different forest types: ridge (along the crest of a ridge), slope (on a gradient), and valley (within 20 m of a stream in a valley bottom).

Representative individuals of several taxa were photographed to document their life coloration. As a further aid to taxonomic identification, advertisement calls of frogs were recorded when possible, and compared to an existing vocalisation database. Voucher specimens were euthanised (with immersion or injection of chlorbutanol solution), fixed in 10% buffered formalin or 90% ethanol, and transferred to 65-75% ethanol. Collected material is deposited at the Museo Regionale di Scienze Naturali, Torino (Italy, MRSN and MRSN-EAZC), the Parc Botanique et Zoologique de Tsimbazaza, Antananarivo (Madagascar, PBZT-EAZC), the Université d'Antananarivo, Département de Biologie Animale (Madagascar, UADBA), and the Zoologische Staatssammlung München (Germany, ZSM). The list of collected specimens is provided in the Appendix I.

Diversity estimation

Since even rough information on species abundance may allow the identification of general patterns of biodiversity (Andreone & Luiselli, 2000), we calculated Margalef's diversity index (Magurran, 1988), $D_{Mg} = (S - 1) / \ln N$, where S is the total number of species and N is the total number of individuals. The values obtained for Berara were then compared with those of two other forest sites (among the few for which quantitative data are available), which are respectively: (i) a low altitude rainforest within the Parc National de Andohahelo, SE Madagascar (study period: 5-19.XI.1994; Andreone & Randriamahazo, 1997); and (ii) a Sambirano humid forest at the Réserve Naturelle Intégrale de Lokobe, Nosy Be Island, NW Madagascar (study period: 4-18.II.1999; Andreone & Randriamirina, unpubl. data).

Some taxa found at Berara were not included in the diversity index estimation, limiting the analysis to the species detected by sight. The arboreal frogs belonging to the species *Boophis jaegeri*, which are difficult to locate and count when silent, were excluded from the estimation. Their inclusion would have resulted in a biased number not located by sight. Another *Boophis* species, *B. albilabris*, aggregated at some spots of the streams over a few nights. During these nights their total number was very high (about 180), due to the aggregation in mating choruses. In this case we did not consider this number (which was the result of a non-random distribution),

but only that of non calling specimens found at a certain distance from the chorus points. We also excluded from this analysis newly metamorphosed amphibians and the specimens captured with pitfalls, since the results obtained with these trapping methods are not comparable with those obtained with direct observations.

RESULTS

Species numbers, taxonomy and distribution

A total of 10 species of amphibians and 26 reptiles were recorded at Berara Forest (Table I, Fig. 1). We also observed some other taxa in the degraded habitats around Betsimipoaka and Marozavavy villages: *Boophis tepbraeomystax* (call record only), *Heterixalus luteostriatus*, *Furcifer oustaleti*, *Hemidactylus cf. frenatus*, *Mabuya elegans*, and *Leioheterodon madagascariensis*.

Several amphibians were of difficult determination, and might represent new species. The arboreal microhylids could not be reliably determined, which stresses once more the urgent need for a revision of this family. One species resembled *Cophyla phyllodactyla* in external morphology, but differed by the comparatively longer notes and lower note repetition rate of its advertisement call. Another small *Platypelis*, which was not heard calling, could not be assigned to any known species by morphology, while the *Stumpffia* specimens found at Berara are here only tentatively attributed to *S. gimmelii*. Among the reptiles, a burrowing skink proved to be a new *Pseudocantias* species, currently in phase of description (F. An-

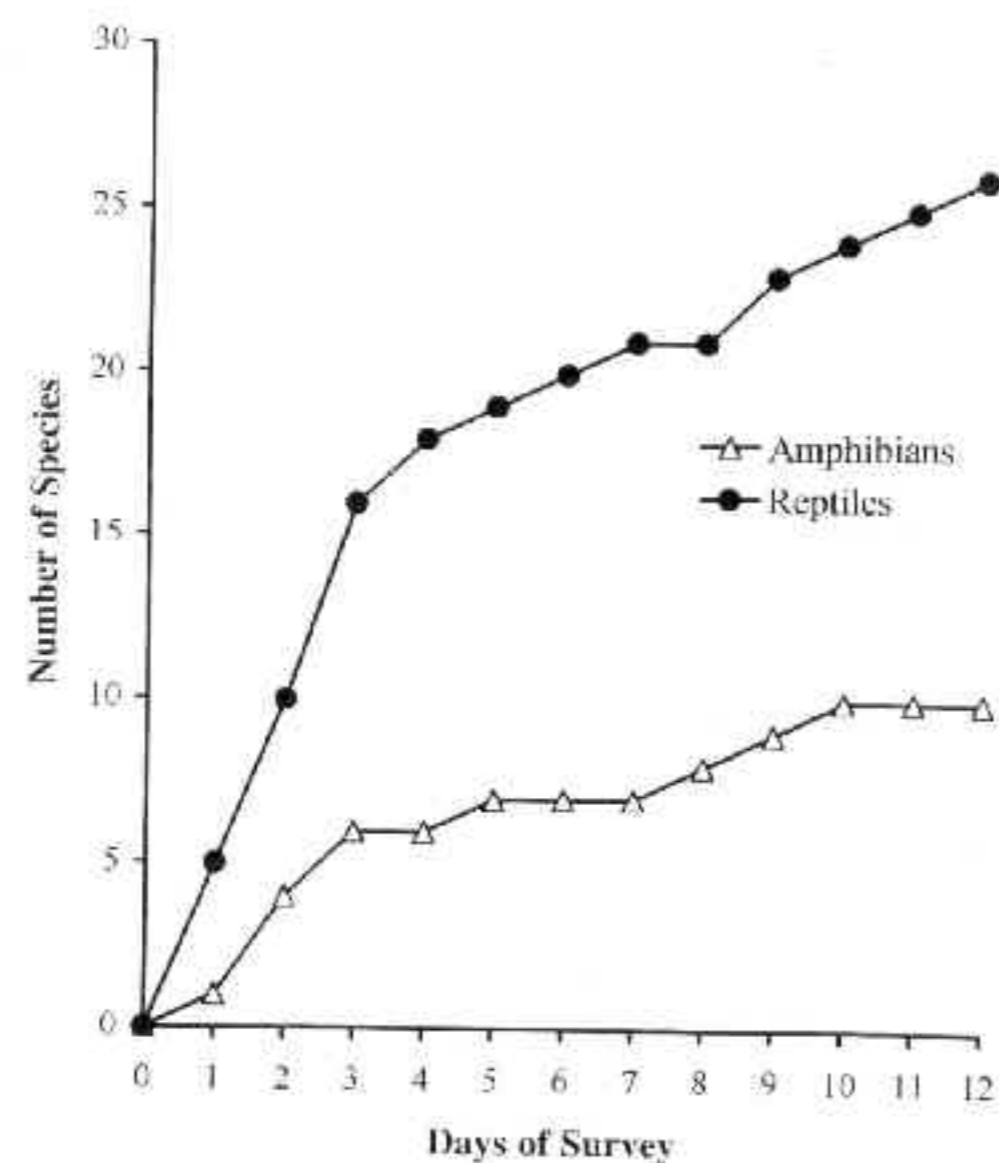


Fig. 1 - Species accumulation curves of amphibians and reptiles at Berara Forest, Sahamalaza Peninsula (all sample techniques combined).

TABLE I - List of amphibians and reptiles found at Berara (Sahamalaza Peninsula), and relative occurrence at other sites (based upon personal observations and data published in Glaw & Vences, 1994). Asterisks mark amphibian species which were recorded as calling during the study period. 'Berara-Betsimipoaka' refers to different cleared and degraded areas between the Berara forest and the village of Betsimipoaka. Numbers between parentheses indicate the number of specimens found outside the forest. 'N' refers to unnumbered specimens, no. > 50.

Species	No.	Sites	Altitude	Nosy Be	Mainland Sambirano	Western territories
AMPHIBIA						
HYPEROLIIDAE						
<i>Heterixalus luteostriatus</i>	(4)	Betsimipoaka	10		+	+
MANTELLIDAE¹						
<i>Aglyptodactylus securifer</i>	28	Berara	170-300			+
<i>Boophis albilabris</i> *	7 [180] ²	Berara	170-300		+	+
<i>Boophis jaegeri</i> *	N	Berara	170	+		
<i>Boophis tepbraeomystax</i> *	(calls)	Marozavavy	10	+	+	+
<i>Mantella betsileo</i> *	6	Berara-Betsimipoaka	170-210	+	+	+
<i>Mantidactylus pseudoasper</i>	1	Berara	170	+	+	+
<i>Mantidactylus ulcerosus</i>	1	Berara	170	+	+	+
<i>Cophyla</i> sp.*	12	Berara	170-300			
<i>Platypelis</i> sp.	13	Berara	170-210			
<i>Plethodontohyla</i> sp.	4	Berara	170-210			
<i>Stumpffia cf. gimmelii</i> *	3	Berara	170		+	
REPTILIA						
CHAMAELONIDAE						
<i>Brookestia stumpffi</i>	32	Berara	170-210	+	+	+
<i>Furcifer oustaleti</i>	(2)	Betsimipoaka	10		+	+
<i>Furcifer pardalis</i>	15	Berara	170-210	+	+	+
OPIURIDAE						
<i>Ophureta curieri</i>	3 (17)	Berara-Betsimipoaka	290-350		+	+
GECKONIDAE						
<i>Geholepis maculata</i>	1	Berara		+	+	+
<i>Hemidactylus cf. frenatus</i>	(2)	Betsimipoaka	10	+	+	+
<i>Lygodactylus tolanopyae</i>	N	Berara	170-350			+
<i>Paroedura oviceps</i>	9	Berara	170-210	+	+	
<i>Paroedura stumpffi</i>	5	Berara	170-210	+	+	
<i>Pseudisama abbotti</i>	2	Berara	170-210	+	+	+
<i>Pseudisama madagascariensis</i>	1 (1)	Berara-Betsimipoaka	170	+	+	+
<i>Uroplatus obenavi</i>	4	Berara	170-350	+	+	
<i>Uroplatus benkei</i>	8	Berara	170-350	+	+	+
GERRHOSAURIDAE						
<i>Zonosaurus laticaudatus</i> ³	7	Berara	170-250	?	+	+
SCINCIDAE						
<i>Ampbiglossus</i> n.sp.	1	Berara	170			
<i>Ampbiglossus reticulatus</i>	9	Berara	170			+
<i>Ampbiglossus stumpffi</i>	10	Berara	170-210	+	+	
<i>Pseudocantias</i> n.sp.	1	Berara	200			
<i>Mabuya elegans</i>	(2)	Betsimipoaka	10		+	+
<i>Mabuya gravenhorstii</i>	2	Berara	170	+	+	+
BODIDAE						
<i>Sanzinia madagascariensis</i>	1	Berara	300	+	+	+
COLEBRIDAE						
<i>Alluaudina bellyi</i>	2	Berara	170-210		+	
<i>Dromocodryas quadrilineatus</i>	1	Berara	170	+	+	+
<i>Ihyocyphus mimiatus</i>	1	Berara	170	+	+	+
<i>Leioheterodon madagascariensis</i>	2	Betsimipoaka	170	+	+	+
<i>Liopoldidophis torquatum</i>	2	Berara	170-200	+		
<i>Liopoldidophis lateralis</i>	1	Berara	200			+
<i>Madagascarobis citrinus</i>	2	Berara	170	+	+	
<i>Madagascarobis colubrinus</i>	15	Berara	170-300	+	+	
<i>Stenophis pseudogramuliceps</i>	1	Berara	170		+	+

¹ For the classification of Malagasy ranids we here follow a recent proposal by Vences & Glaw (2001).

² The number of *Boophis albilabris* specimens between square brackets refers to the number of individuals forming the observed choruses, and was not utilised for the calculation of the diversity index. See the text for further explanations.

³ The presence of *Zonosaurus laticaudatus* at Nosy Be has not yet been confirmed by reliable voucher specimens and should be considered as doubtful.

