Ital. J. Zool., 68: 235-241 (2001)

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
Muséum 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: *pbzt@dts.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 Sambirano 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 albilabris* 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 *Pseudoacontias* 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.

ACKNOWLEDGEMENTS

The field work of F. Andreone and J. E. Randrianirina was carried out in collaboration with the Parc Botanique et Zoologique de Tsimbazaza (Antananarivo), the Wildlife Conservation Society (Antananarivo), and the Association Européenne pour l'Étude et la Conservation des Lémuriens (Mulhouse). M. Vences conducted his work through a co-operation agreement between the Département de Biologie Animale (Antananarivo) and the Zoologische Staatssammlung (Munich), and was supported by DAAD. The survey was possible thanks to the agreement of the Ministry of Eaux et Forêts, which issued the requested authorisations. The Authors thank L. Andriamampianina, A. Andriamanalina, F. Glaw, S. M. Goodman, A. Greer, M. Hatchwell, J.-M. Lernould, P. Lehmann, C. Rabarivola, M. Rakotondratsima, H. Randriamahazo, and Y. Rumpler, who helped with logistic assistance, bibliography, unpublished information, drawing of the map, and taxonomic identification. A. Raselimanana kindly allowed to quote his unpublished preliminary observations at Sahamalaza. Special thanks to D. Vallan and an anonymous referee for the valuable comments and suggestions on an earlier draft of this paper. Last but not least, thanks to Prof. N. E. Baldaccini for the editorial assistance and useful advice.

(Received 21 December 2000 - Accepted 2 May 2001)

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 endemicity 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.*, 1994). 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, Analalava Fivondronana, Ambolobozo Firaisana and western part of the Befotaka Firaisana), 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 *Hildegardia* 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, 220-290 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 euthanasised (with immersion or injection of chlorobuthanol 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-FAZC), the Parc Botanique et Zoologique de Tsimbazaza, Antananarivo (Madagascar, PBZT-FAZC), the Université d'Antananarivo, Departément 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 Andohahela, SE Madagascar (study period: 5-19.XI.1994; Andreone & Randriamahazo, 1997); and (ii) a Sambirano humid forest at the Réserve Naturelle Integrale de Lokobe, Nosy Be Island, NW Madagascar (study period: 4-18.II.1999; Andreone & Randrinirina, 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 been 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 tephraeomystax* (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. gimmeli*. Among the reptiles, a burrowing skink proved to be a new *Pseudoacontias* species, currently in phase of description (F. An-

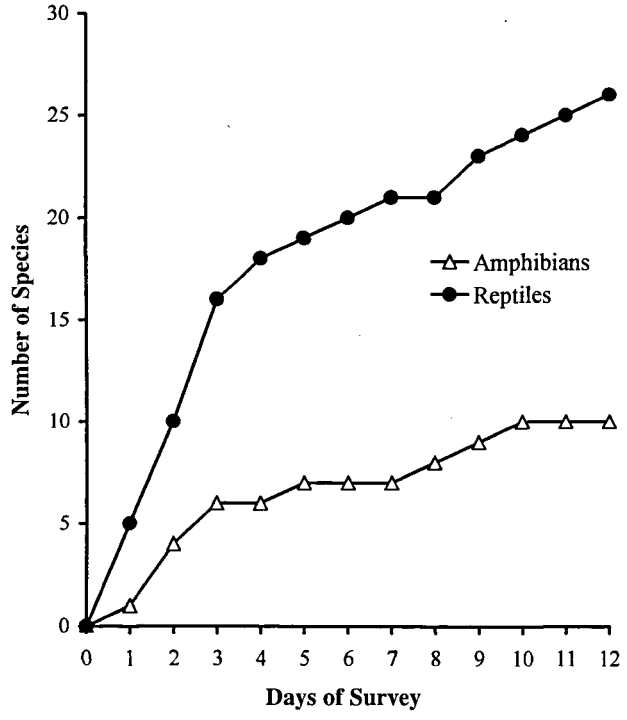

Fig. 1 - Species accumulation curves of amphibians and reptiles at Berara Forest, Sahamalaza Peninsula (all sample techniques combined).

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						
Heterixalus luteostriatus	(4)	Betsimipoaka	10		+	+
MANTELLIDAE[1]						
Aglyptodactylus securifer	28	Berara	170-300			+
*Boophis albilabris**	7 [180][2]	Berara	170-300		+	+
*Boophis jaegeri**	N	Berara	170	+		
*Boophis tephraeomystax**	(calls)	Marozavavy	10	+	+	+
*Mantella betsileo**	6	Berara-Betsimipoaka	170-210	+	+	+
Mantidactylus pseudoasper	1	Berara	170	+	+	
Mantidactylus ulcerosus	1	Berara	170	+	+	+
Cophyla sp.* 12	Berara	170-300				
Platypelis sp. 13	Berara	170-210				
Plethodontohyla sp.	4	Berara	170-210			
Stumpffia cf. *gimmeli**	3	Berara	170		+	
REPTILIA						
CHAMAELEONIDAE						
Brookesia stumpffi	32	Berara	170-210	+	+	
Furcifer oustaleti	(2)	Betsimipoaka	10		+	+
Furcifer pardalis	15	Berara	170-210	+	+	
OPLURIDAE						
Oplurus cuvieri	3 (17)	Berara-Betsimipoaka	290-350		+	+
GEKKONIDAE						
Geckolepis maculata	1	Berara		+	+	+
Hemidactylus cf. *frenatus*	(2)	Betsimipoaka	10	+	+	?
Lygodactylus tolampyae	N	Berara	170-350			+
Paroedura oviceps	9	Berara	170-210	+	+	
Paroedura stumpffi	5	Berara	170-210	+	+	
Phelsuma abbotti	2	Berara	170-210	+	+	+
Phelsuma madagascariensis	1 (1)	Berara-Betsimipoaka	170	+	+	
Uroplatus ebenaui	4	Berara	170-350	+	+	
Uroplatus henkeli	8	Berara	170-350	+	+	+
GERRHOSAURIDAE						
Zonosaurus laticaudatus[3]	7	Berara	170-250	?	+	+
SCINCIDAE						
Amphiglossus n.sp.	1	Berara	170			
Amphiglossus reticulatus	9	Berara	170			+
Amphiglossus stumpffi	10	Berara	170-210	+	+	
Pseudoacontias n.sp.	1	Berara	200			
Mabuya elegans	(2)	Betsimipoaka	10	+	+	+
Mabuya gravenhorstii	2	Berara	170	+	+	+
BOIDAE						
Sanzinia madagascariensis	1	Berara	300	+	+	+
COLUBRIDAE						
Alluaudina bellyi	2	Berara	170-210		+	
Dromycodryas quadrilineatus	1	Berara	170	+	+	+
Ithycyphus miniatus	1	Berara	170	+	+	+
Leioheterodon madagascariensis	2	Betsimipoaka	170	+	+	+
Liophidium torquatum	2	Berara	170-200	+		
Liopholidophis lateralis	1	Berara	200			+
Madagascarophis citrinus	2	Berara	170	+	+	
Madagascarophis colubrinus	15	Berara	170-300	+	+	
Stenophis pseudogranuliceps	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.

TABLE II - *Amphibian and reptile taxa quoted by Raselimanana (1996) for Analavory Forest and their occurrence at Berara in the present survey.*

Raselimamana (1996) Analavory Forest	2000 Survey Berara Forest
AMPHIBIA	
Ptychadena mascareniensis	-
Laliostoma labrosum	-
Boophis tephraeomystax	+
REPTILIA	
Phelsuma madagascariensis	+
Phelsuma abboti	+
Lygodactylus madagascariensis[1]	?
Uroplatus henkeli	+
Paroedura stumpffi	+
Blaesodactylus sakalava	-
Geckolepis maculata	+
Amphiglossus reticulatus	+
Paracontias hildebrandti	-
Mabuya elegans	+
Oplurus cuvieri	+
Zonosaurus laticaudatus	+
Furcifer pardalis	+
Furcifer oustaleti	+
Sanzinia madagascariensis	+
Mimophis mahfalensis	-
Liopholidophis lateralis	+
Leioheterodon madagascariensis	+
Dromicodryas quadrilineatus	+
Madascarophis colubrinus	+

[1] Taxonomic attribution as given in Raselimanana's report. See the text for further considerations.

dreone & A. Greer, in prep.). Other findings enlarged the formerly known species distribution. The specimens of *Boophis albilabris* found at Berara match the subspecies *occidentalis* (until now known from Isalo and the Tsingy de Bemaraha; Glaw & Vences, 1994). The green *Boophis* observed at Berara are attributed to *B. jaegeri*, a species formerly recorded only at Nosy Be (Glaw & Vences, 1994). The semi-aquatic skink *Amphiglossus reticulatus* was known from only a few specimens, and *Lygodactylus tolampyae* had a mostly southern distribution. Among the snakes, the *Stenophis* (= *Lycodryas*) specimen found appears to belong to *S. pseudogranuliceps*, a species known from Ampijoroa and other western and northwestern localities (Domergue, 1994). Finally, the list of the taxa found by Raselimanana (1996) (three species of amphibians and 20 of reptiles) is provided in Table II.

Accumulation curves and species diversity

The species accumulation curves for amphibians and reptiles (Fig. 1) point to the relevant differences between amphibian and reptile discovery rates already outlined by Andreone & Randrianirina (2000). A total of 363 pitfall trap-days yielded 23 captures, corresponding to four species of amphibians, and four of reptiles (Table III). Overall mean daily pitfall capture rate of small vertebrates was 9.6% (1.9% for amphibians, and 4.4% for reptiles). The 6.3% daily trap success for amphibians and reptiles doubles the values found at eastern rainforest sites: 3.0%, 3.5%, and 2.1%, respectively, at Andohahela, Andringitra, and Anjanaharibe-Sud (Nussbaum *et al.*, 1999; Raxworthy & Nussbaum, 1996; Raxworthy *et al.*, 1998).

Margalef's diversity index was 1.76 for amphibians, 3.19 for lizards and 2.70 for snakes (Table IV). The Berara amphibian value is not considerably lower than the 1.86 value observed at Lokobe, while there is a conspicuous difference between the amphibian diversity of both these sites and the 2.57 value found at Andohahela during the warm season. Among these three sites, the highest diversity index for lizards was at Lokobe (D_{Mg} = 4.66), while for snakes D_{Mg} was more or less similar for both Berara and Lokobe (2.70 and 2.79 respectively).

DISCUSSION

Sampling methods

Pitfall trapping did not yield any amphibian species not found with other methods, thus indicating that pitfalls are not very useful for obtaining information on the presence of frogs in the habitat we studied. In con-

TABLE III - *Characteristics and captures (Amphibia, Reptilia) for all pitfall lines during February 2000 at Berara Forest (Sahamalaza Peninsula).*

	Pitfall lines			Total
	a	b	c	
Altitude range (m)	170	170-190	190-205	
Trap position	Valley	Slope	Ridge	
No. of nights	11	11	11	33
Pitfall number	11	11	11	33
Trap-nights	121	121	121	363
No. of captured specimens				
AMPHIBIA				
Aglyptodactylus securifer		2		2
Cophyla sp.		1		1
Platypelis sp.		2	1	3
Plethodontohyla sp.		1		1
Total		6	1	7
REPTILIA				
Amphiglossus stumpffi	2	3	8	13
Amphiglossus n.sp.	1			1
Pseudoacontias n.sp.		1		1
Liophidium torquatum			1	1
Total	3	4	9	16
Overall total	3	10	10	23

TABLE IV - *Margalef's index* (D_{Mg}) *for the amphibians, lizards and snakes at Berara Forest (Sahamalaza Peninsula, NW Madagascar), Lokobe (Nosy Be Island, NW Madagascar) and Andohahela (SE Madagascar).*

Sites	Berara (Sahamalaza)	Lokobe	Andohahela
Coordinates	14°18' S 47°54' E	13°25' S 48°20' E	24°45' S 46°51' E
Forest type	transitional dry deciduous / Sambirano humid forest	Sambirano humid forest	low altitude rainforest
Study periods	13-23.II.2000	4-18.II.1999	5-19.XI.1994
Margalef's index (D_{Mg})			
Amphibia	1.76	1.86	2.57
Sauria	3.19	4.66	1.91
Ophidia	2.70	2.79	1.56
Mean ± SD	2.55 ± 0.73	3.10 ± 1.43	2.01 ± 0.51

trast, they were much more relevant for reptiles. At Berara we captured *Amphiglossus stumpffi, A.* n. sp. and *Pseudoacontias* n. sp. by pitfall trapping alone.

Both amphibian and reptile species accumulation curves show a steep increase during the first days, as the most common species were found at this time. Amphibians did not prove to be very diverse: only two species were discovered from the fifth day onwards. Conversely, the reptile curve shows an almost continuous growth from the third day onwards, with a discovery of about one additional species per day. Twenty-six species were finally observed in the forest alone, but we consider this number far from being complete. The apparently low abundance of many reptiles makes them difficult to find in a short time, and it is therefore likely that only a longer survey period will yield a realistic picture of reptile diversity (Andreone & Randrianirina, 2000).

Biogeographical aspects

The only other herpetological survey carried out within the Sahamalaza Peninsula was made by Raselimanana (1996), who visited the Analavory Forest (14°23.30' S, 47°56.15' E) during the dry season (July 1996). Most of taxa found by this Author (see Table II) were also found during our survey (if we consider the *Lygodactylus* quoted by Raselimanana as conspecific to *L. tolampyae* and we include the taxa found at Betsimipoaka and Marozavavy villages). Among the amphibians, we missed *Ptychadena mascareniensis* and *Laliostoma labrosum*, which are two species likely to be present in open areas and close to the Betsimipoaka and Marozavavy villages, where we found *Heterixalus luteostriatus* and *Boophis tephraeomystax*. For the reptiles, it is worth noting the apparent absence at Berara of *Mimophis mahfalensis* and *Liopholidophis lateralis*, which may also prefer open areas. The absence of *Blaesodactylus sakalava* and *Paracontias hildebrandtii* is perhaps only apparent, and most probably it is due to their secretiveness and low abundance. In conclusion, pooling the species found during this survey and those quoted by Raselimanana (1996), we have a total of 14 species of amphibians and 33 species of reptiles: we are confident that a great part of the Sahamalaza herpetofauna has been detected.

For a general point of view, the observed herpetofauna appears to be composed of two kinds of biogeographic elements: (i) taxa shared between Nosy Be, mainland Sambirano, and - partly - other northeastern sites (e.g., *Boophis jaegeri, Mantidactylus pseudoasper, Brookesia stumpffi, Furcifer pardalis, Paroedura oviceps, P. stumpffi, Phelsuma madagascariensis grandis, Uroplatus ebenaui, Amphiglossus stumpffi, Alluaudina bellyi*); (ii) taxa more or less widely distributed along the western and northwestern coasts (e.g., *Heterixalus luteostriatus, Aglyptodactylus securifer, Amphiglossus reticulatus, Ithycyphus miniatus, Stenophis pseudogranuliceps*). This composition may be explained taking into account the fact that Sahamalaza is located in northwestern Madagascar, close to the assumed boundary between the biogeographic domains of West Madagascar and Sambirano (NW Madagascar). Among the amphibians, eight out of the 12 species recorded at Sahamalaza, including *Heterixalus luteostriatus* which was found at Betsimipoaka (Andreone *et al.*, 2000a) (corresponding to 66.7%) are also present in Sambirano (mainland and Nosy Be together), and six (50%) at sites in the West (Table I). These numbers are not significantly different from the expected values ($\chi^2 = 0.417$, $P > 0.05$). Moreover, all the amphibians found in the West (excluding *Aglyptodactylus securifer* and *Boophis albilabris occidentalis*) were found in Sambirano, too, thus suggesting that the amphibians are more or less homogeneously distributed in these areas. The situation appears different for reptiles since 25 out of the 30 analysed species (corresponding to 83.3%) were shared with Sambirano, while only 16 (53.3%) were found in the West. These values differ significantly from the ex-

pected ones (χ^2 = 6.03, P < 0.05), thus indicating that the reptile fauna at Sahamalaza is much more similar to that from the Sambirano Domain.

Ecology

Excluding *Boophis jaegeri* and *B. albilabris* (for the formerly reported reasons), the most abundant amphibian species at Berara was *Aglyptodactylus securifer,* with 28 adult specimens observed (and many newly metamorphosed ones). The rarest amphibians were *Mantidactylus pseudoasper* and *M. ulcerosus,* both with one specimen. The rarity of these species, quite abundant elsewhere (e.g., Lokobe Forest, pers. obs.), is most likely only apparent, but may be also explained taking into account the seasonal climatic shifts in combination with sudden and extreme changes in stream size and water speed. These factors may have fatal effects on many terrestrial clutches laid close to water, the typical egg-laying mode in most mantellids. Furthermore, the apparent lack of stagnant or slow-flowing water bodies at Berara (at least in the studied area) excludes several *Mantidactylus* species from the batrachological community.

General ecological patterns were different in lizards and snakes; while lizards were sometimes quite abundant, with five species exceeding a number of ten specimens each, snakes were only rarely observed. The overall scarcity of snake species is in accord with the observations of Andreone & Luiselli (2000), and to the fact that snakes are in general elusive and difficult to contact in the field. Only *Madagascarophis colubrinus* was frequently encountered (15 specimens), while the other taxa did not exceed a maximum of two specimens each. A single specimen of *M. colubrinus* vomited four *Boophis albilabris*, while another vomited a freshly predated *Eliurus* rodent (most likely *E. myoxinus*), thus showing to be in general an opportunistic species.

Finally, the comparison of Margalef's diversity indices in Table IV shows that the transitionary forest of Berara and the Sambirano humid forest of Lokobe are more 'reptile-biased' (especially characterised by a low number of mantelline amphibians: three and four, respectively), while the south-eastern rainforest of Andohahela is more 'amphibian-biased' (harbouring 11 mantellines, despite its rather high seasonality as compared to other eastern rainforest sites; Andreone & Randriamahazo, 1997).

Conclusion regarding conservation

The Sahamalaza Peninsula is not yet covered by any concrete legal protection, although it is a proposed protected area (ANGAP, 2000), since it is one of the few areas where *Eulemur macaco flavifrons* occurs, and it is featured by a large variety of habitats and ecosystems. Anyhow, the whole surface of Sahamalaza is subject to repeated *tavy* practice (slush and burn agriculture), which has resulted in a patchwork of fragmented forest remains. Since the restoration of forest corridors in Madagascar is still in an experimental phase, it is clear that the conservation of the remaining forest blocks is now a high priority at Sahamalaza. The forest where we carried out our research is included in the Ambolobozo Forest, which is apparently the largest patch of forest. Concerning amphibians and reptiles, the diminution of forest area will probably be accompanied by reduced habitat variety, and consequently by a lower specific diversity (Ganzhorn *et al.,* 2000; Vallan, 2000).

When evaluating the conservation importance of the Sahamalaza for herpetofauna, it is worth noting the presence of a peculiar and rich community, some of which, in the light of current knowledge, are potential endemics. These are the *Pseudoacontias* n. sp., and most of the microhylids. Other taxa are known from only a few other localities, and therefore the upgrading of Sahamalaza to a protected area would guarantee the conservation of these animals. So far, *Amphiglossus reticulatus* has not been recorded from any protected area, and this may depend on sufficiently large water bodies in relatively undisturbed habitats. *Aglyptodactylus securifer* is only known from the Kirindy Forest (next to Morondava, western Madagascar), while *Boophis jaegeri* was formerly recorded from only Nosy Be, and this is the first sighting on the mainland.

Sahamalaza appears a relevant and interesting area for amphibian and reptile conservation, with western and northwestern elements which so far have been only insufficiently protected due to the overall critical situation of Malagasy western forests. Protection should therefore be assured, most likely sustaining the upgrading of the Peninsula to a protected area with the direct participation of local populations.

REFERENCES

Andreone F., Luiselli L., 2000 - Are there shared patterns of specific diversity, abundance, and guild structure in snake communities of tropical forests of Madagascar and continental Africa? Terre Vie, 55: 215-239.

Andreone F., Randriamahazo H., 1997 - Ecological and taxonomic observations on the amphibians and reptiles of Andohahela low altitude rainforest, S. Madagascar. Rev. Fr. Aquariologie., 3/4: 95-128.

Andreone F., Randrianirina J. E., 2000 - Biodiversity, rainforests and herpetological communities in Madagascar: what about differences between amphibians and reptiles? *In*: W. R. Lourenço & S. M. Goodman (eds), Diversity and endemism in Madagascar. Mém. Soc. Biogéographie, pp. 217-228.

Andreone F., Vences M., Randrianirina J. E., 2000a - Geographic distribution. *Heterixalus luteostriatus* (Yellow-striped Reed Frog). Herpetol. Rev., 31: 20.

Andreone F., Randrianirina J. E., Jenkins P. D., Aprea G., 2000b - Species diversity of Amphibia, Reptilia and Lipotyphla at Ambolokopatrika, a rainforest between Anjanaharibe-Sud and Marojejy massifs, NE Madagascar. Biodiver. Conserv., 9: 1587-1622

Andriamanandratra A., 1996 - Proposition pour un nouveau parc national dans la région Nord-Ouest de Madagascar: Un commencement intégratif. Unpubl. rep. to Wildlife Conservation Society and Association Européenne pour l'Etude et la Conservation des Lémuriens, Antananarivo, 68 pp.

ANGAP, 2000. - Plan de gestion du réseau national des aires protégées de Madagascar. Ministère de l'Environnement and ANGAP, Antananarivo, 108 pp.

Domergue C., 1994 - Serpents de Madagascar: note liminaire sur

des espèces nouvelles du genre *Stenophis* Boulenger, 1896 (Colubridae, Boiginae). Arch. Inst. Pasteur Madag, 61: 121-122.

Ganzhorn J. U., Goodman S. M., Ramanamanjato J.-B., Rakotondravony D., Rakotosamimanana B., Vallan D., 2000 - Vertebrate species in fragmented littoral forests of Madagascar. *In*: W. R. Lourenço & S. M. Goodman (eds), Diversity and endemism in Madagascar. Mém. Soc. Biogéographie, pp. 155-164.

Glaw F., Vences M., 1994 - A field guide to the amphibians and reptiles of Madagascar. Second edition, including freshwater fish and mammals. Vences und Glaw Verlag, Cologne, pp. 1-480.

Goodman S. M., Jenkins P. D., 1998. - The insectivores of the Réserve Spéciale d'Anjanaharibe-Sud. *In*: S. M. Goodman (ed.), A floral and faunal inventory of the Réserve Spéciale d'Anjanaharibe-Sud, Madagascar: with reference to elevational variation. Fieldiana Zool., 90: 139-161.

Humbert H., 1955 - Les territoires phytogéographiques de Madagascar. Leur cartographie. Ann. biol., 31: 195-204.

Magurran A. E., 1988 - *Ecological diversity and its measurement*. Princeton University Press, Princeton, 323 pp.

Mittermeier R. A., Tattersall I., Konstant W. R., Meyers D. M., Mast R. B., 1994 - Lemurs of Madagascar. Conservation International, Washington, 356 pp.

Myers N., Mittermeier R. A, Mittermeier C. G., da Fonseca G. A. B., Kent J., 2000 - Biodiversity hotspots for conservation priorities. Nature (Lond.), 403: 853-858.

Nussbaum R. A., Raxworthy C. J., Raselimanana A. P., Ramanamanjato J.-B., 1999 - Amphibians and reptiles of the Réserve Naturelle Intégrale d'Andohahela, Madagascar. *In*: S. M. Goodman (ed.), A floral and faunal inventory of the Réserve Naturelle Intégrale d'Andohahela, Madagascar: with reference to elevational variation. Fieldiana Zool., 90: 155-173

Projet ZICOMA, 1999 - Les zones d'importance pour la conservation des oiseaux à Madagascar. Projet ZICOMA, Antananarivo, 266 pp.

Raselimanana A., 1996 - Étude préliminaire de l'herpetofaune de la forêt près de la Baie de Sahamalaza dans le Nord-Ouest de Madagascar. Unpubl. rep. to Wildlife Conservation Society and Association Européenne pour l'Etude et la Conservation des Lémuriens, Antananarivo, 7 pp.

Raxworthy C. J., Nussbaum R. A., 1996 - Amphibians and reptiles of Andringitra Massif: a study of elevational distribution and local endemicity. *In*: S. M. Goodman (ed.), A floral and faunal inventory of the eastern side of the Réserve Naturelle Intégrale d'Andringitra, Madagascar: with reference to elevational variation. Fieldiana Zool., 85: 158-170.

Raxworthy C. J., Andreone F., Nussbaum R. A., Rabibisoa N., Randriamahazo H., 1998 - Amphibians and reptiles of the Anjanaharibe Massif: elevational distributions and regional endemicity. *In*: S. M. Goodman (ed.), A floral and faunal inventory of the Réserve Spéciale d'Anjanaharibe-Sud, Madagascar: with reference to elevational variation. Fieldiana Zool., 90: 79-92.

Vallan D., 2000 - Influence of forest fragmentation on amphibian diversity in the nature reserve of Ambohitantely, highland Madagascar. Biol. Conserv., 96: 31-43.

Vences M., Glaw F., 2001 - When molecules claim for taxonomic change: New proposals on the classification of Old World treefrogs (Amphibia, Anura, Ranoidea). Spixiana, 24: 85-92.

APPENDIX I - *List of voucher specimens conserved at the Museo Regionale di Scienze Naturali (Torino, Italy; MRSN-FAZC), Parc Botanique et Zoologique de Tsimbazaza (Antananarivo, Madagascar; PBZT-FAZC), Zoologische Staatssammlung München (München, Germany; ZSM), Université d'Antananarivo, Departement de Biologie Animale (Antananarivo, Madagascar; UADBA)*

AMPHIBIA

HYPEROLIIDAE	*Heterixalus luteostriatus* - MRSN-FAZC 10479, 10482, 10508; PBZT-FAZC 10507
MANTELLIDAE	*Aglyptodactylus securifer* - MRSN-FAZC 10478, 10481, 10543, 10545, 10567, 10570, 10571, 10599, 10657, 10662; PBZT-FAZC 10525, 10526, 10544, 10565, 10566, 10568, 10569, 10598, ZSM 415/2000-418/2000; UADBA 2000.153, 2000.163, 2000.169; *Boophis albilabris* - MRSN A1996-2009; PBZT-FAZC 10686, 10649, 10650, 10651, 10652, 10668, 10669, 10670; *Boophis jaegeri* - MRSN-FAZC 10480, 10527, 10528, 10574, 10575, 10658; PBZT-FAZC 10483, 10529, 10530, 10532, 10572, 10573, ZSM 413/2000, 414/2000; UADBA 2000.161; *Mantella betsileo* - MRSN-FAZC 10516, 10603, 10654; PBZT-FAZC 10558, 10604, 10620, 10655; UADBA 2000.154; *Mantidactylus pseudoasper* - MRSN-FAZC 10696; *Mantidactylus ulcerosus* - MRSN-FAZC 10672
MICROHYLIDAE	*Cophyla* sp. - MRSN-FAZC 10546 M; PBZT FAZC 10539, 10547, 10550; ZSM 410/2000, UADBA 2000.162, 2000.165; *Platypelis* sp. - MRSN-FAZC 10642, 10643, 10644, 10645, 10673, 10681; PBZT-FAZC 10556, 10637; *Plethodontohyla* sp. - MRSN-FAZC 10505, 10557; *Stumpffia* cf. *gimmeli* - MRSN-FAZC 10597 M; ZSM 412/2000

REPTILIA

CHAMAELEONIDAE	*Brookesia stumpffi* - MRSN-FAZC 10488, 10490, 10492, 10553, 10674; PBZT-FAZC 10489, 10491, 10552, 10554, 10605; *Furcifer oustaleti* - MRSN-FAZC 10514; PBZT-FAZC 10511; *Furcifer pardalis* - MRSN-FAZC 10512, 10513, 10524, 10579, 10617; PBZT-FAZC 10542, 10584, 10612
OPLURIDAE	*Oplurus cuvieri* - MRSN-FAZC 10493, 10691; PBZT-FAZC 10494
GEKKONIDAE	*Geckolepis maculata* - MRSN-FAZC 10564, 10690; PBZT-FAZC 10523; *Hemidactylus* cf. *frenatus* - MRSN-FAZC 10520, 10521, 10522; PBZT-FAZC 10487, 10519; *Lygodactylus tolampyae* - ZSM 419/2000; UADBA 2000.156; MRSN-FAZC 10495, 10496, 10498, 10499, 10501, 10503, 10504; PBZT-FAZC 10497, 10500, 10502, 10506; *Paroedura oviceps* - MRSN-FAZC 10537, 10610, 10685; PBZT-FAZC 10611, 10656, 10684; *Paroedura stumpffi* - MRSN-FAZC 10608, 10682, 10683; PBZT-FAZC 10538, 10609; *Phelsuma abbotti* - MRSN-FAZC 10559; PBZT-FAZC 10560; *Phelsuma madagascariensis* - MRSN-FAZC 10707, 10706; PBZT-FAZC 10509; *Uroplatus ebenaui* - MRSN-FAZC 10632, 10633, 10634; PBZT-FAZC 10631; *Uroplatus henkeli* - MRSN-FAZC 10515, 10541, 10561; PBZT-FAZC 10510, 10578, 10606, 10607
GERRHOSAURIDAE	*Zonosaurus laticaudatus* - MRSN-FAZC 10485, 10486, 10555
SCINCIDAE	*Androngo elongatus* - MRSN-FAZC 10698; *Amphiglossus reticulatus* - MRSN-FAZC 10592, 10593, 10635, 10697; PBZT-FAZC 10484, 10678, 10688, 10692; *Amphiglossus stumpffi* - MRSN-FAZC 10534, 10577, 10600, 10636; PBZT-FAZC 10533, 10535, 10536, 10576; *Pseudoacontias* n.sp. - MRSN-FAZC 10630; *Mabuya elegans* - MRSN-FAZC 10709; UAD BA 2000.171, 2000.172; *Mabuya gravenhorstii* - MRSN-FAZC 10689
BOIDAE	*Sanzinia madagascariensis* - PBZT-FAZC 10693
COLUBRIDAE	*Alluaudina bellyi* - MRSN-FAZC 10622, 10705; *Dromycodryas quadrilineatus* - MRSN-FAZC 10639; *Ithycyphus minia tus* - MRSN-FAZC 10680; *Liophidium torquatus* - MRSN-FAZC 10595, PBZT-FAZC 10708; *Liopholidophis lateralis* - MRSN-FAZC 10594; *Madagascarophis citrinus* - MRSN-FAZC 10679; *Madagascarophis colubrinus* - MRSN-FAZC 10615, 10616; PBZT-FAZC 10582, 10585, 10596, 10614, 10641; *Stenophis pseudogranuliceps* - MRSN-FAZC 10562