

SEASONAL VARIATIONS OF THE AMPHIBIAN COMMUNITIES IN TWO RAINFORESTS OF MADAGASCAR ¹

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ABSTRACT .- Field surveys in different seasonal periods were carried out on the amphibians of two Malagasy protected areas: Ranomafana (National Park) and Andohahela (Strict Nature Reserve, Parcel 1). These rainforests are featured by different climates, the former by rainy precipitations throughout the year, the latter by rain-dry alternance. The 24 amphibians considered at Ranomafana are more abundant during the warmest months, showing different reproductive strategies and a narrow temporal-spatial niche partitioning. At Andohahela only a few of the 16 species considered (e.g. *Mantidactylus boulengeri*, *M. betsileanus*) were found in high concentrations. Some others (e.g. *Mantidactylus lugubris*, *M. microtympanum*) were abundant along streams, or found with very few individuals (e.g. *Plethodontohyla bipunctata*, *Mantidactylus* cf. *peraccae*). As a general rule, in both the studied areas, the *K*-oriented species depend closely on the microhabitat stability, while the *r*-oriented species are more adaptable and can be found in relatively high concentrations throughout the seasons.

KEY WORDS .- Madagascar, Amphibians, Rainforests, Seasonal abundance

RESUME .- Des recherches ont été conduites sur les amphibiens dans deux aires protégées de Madagascar, le Parc National de Ranomafana et la Réserve Naturelle Intégrale d'Andohahela (Parcelle 1). Ces forêts sont caractérisées par des climats différents, la première avec de fortes précipitations pendant toute l'année, la deuxième avec une alternance sécheresse-pluie. Les 24 amphibiens de la forêt primaire de Ranomafana sont plus abondants pendant les mois les plus chauds, ont des stratégies de reproduction différenciées et une étroite niche écologique tempo-spatiale. A Andohahela sur les 16 espèces considérées seules deux d'entre elles présentent de fortes concentrations: *Mantidactylus boulengeri* et *M. betsileanus*. D'autres, comme *Mantidactylus lugubris* et *M. microtympanum*, sont abondantes près des fleuves et ruisseaux, alors que *Plethodontohyla bipunctata* et *Mantidactylus* cf. *peraccae*, ont été trouvées en petits nombres. En règle générale, les espèces à stratégie *K* sont très dépendantes de la stabilité du microhabitat, tandis que les espèces *r* ont une plus grande capacité d'adaptation et peuvent être observées en grandes concentrations pendant toute l'année.

MOTS CLES .- Madagascar, Amphibiens, Forêts pluviales, Abundance saisonale

¹ Project for the Study and Conservation of Madagascar Amphibians (*Tetik'asa ho Fianarana sy Fikajiana ny Sahona Malagasy*)

INTRODUCTION

Although the rainforests, once distributed almost continuously along the eastern coast of Madagascar, are now highly fragmented, they are still the habitats of great part of the diversified Malagasy batrachofauna. In the « Grande Ile » a large number of anurans is present, with about 200 species presently known, but with many others discovered and described each year. Anyway, as often happens in insular faunas, such a specific richness is accompanied by a substantial poorness of families: only three families (Hyperoliidae, Microhylidae and Ranidae, sensu BLOMMERS-SCHLÖSSER, 1993) can be found in this island-continent, lacking many other groups, present elsewhere (*e.g.* Gymnophiones, Bufonidae). Because amphibians are said to be declining all around the World and sensitive to habitat alterations (BLAUSTEIN & WAKE, 1990), a particular attention should be deserved to variations and fluctuations in natural populations. Rainforests are the ideal habitat to make such an analysis, since, albeit usually considered stable, they are currently suffering a decline in amphibian abundance, and sometimes also the possible extinction of some species (see CRUMP *et al.*, 1992). A preliminary work was yet carried out at Ranomafana (ANDREONE, 1994), focusing on the effects of the habitat alteration. In this paper the amphibian community of another rainforest (Andohahela) is studied and compared to that of Ranomafana.

MATERIALS AND METHODS

Study sites

The Ranomafana National Park (21°16'S, 47°28'E) is situated at 800-1200 m a.s.l. and have a temperature range from 3.0° to 35.1° C (NICOLL & LANGRAND, 1989). The rainfall is distributed with about 200 days a year, the maximum in January and the minimum in October. Field surveys were made in December 1991 and August 1992. The survey site within the Andohahela Strict Nature Reserve, Parcel 1 (24°42'S, 46°11'E), is located from 380 to 600 m a.s.l. Compared to Ranomafana it shows a quite marked seasonality, with « rainy » warmest months (October- February) and « dry » coldest months (March-September). Field surveys were made in April and November 1994.

Survey methods

The searching consisted mainly of localization of specimens after examination of refuges. Field work occupied about 50 hours each month, the time being divided almost equally between day and by night. Species identification was based upon the keys provided by GLAW and VENCES (1994). Voucher specimens are conserved in the herpetological collections of the Museo Regionale di Scienze Naturali (Torino) and the Parc Botanique et Zoologique de Tsimbazaza (Antananarivo).

Habitat and species categorisation

The comparisons were made only in relatively undisturbed habitats, thus excluding part of the results formerly reported by ANDREONE (1994). As far as habitat preferences are concerned, the following categories were recognized throughout day and nighttime (see table I): T, « terrestrial species » (non-arboreal and aquatic amphibians, living along and within forest streams or in still water), and A, « arboreal species » (low-arboreal frogs, climbing up the forest layers to 1-2 m of elevation; high-arboreal species, which live usually on higher trees). When a species exhibited a « mixed » habitat preference it has been reported the most frequently observed habitat choice (e.g. *Mantidactylus boulengeri*, that is terrestrial for most of the time, but may climb on shrubs and small trees during nighttime to intonate its reproductive call, is defined as terrestrial). Abundance indices (AI) (referring to the survey in the whole area) were coded for each species in each habitat: 0, apparently absent; 1, $n < 5$; 2, $n = 5-10$; 3, $n = 10-20$; 4, $n > 20$. The average abundance index (AAI) was obtained dividing the sum of the AIs for all the species in a given period by the relative total number of species. Species utilised for the abundance estimation are reported in Tab. I. In this operation the highly cryptic and arboreal species, which can be located mainly by call haring and hardly to be found only by sight, were excluded. In fact, their AI would be underestimate if they do not call, and overestimate in the case of active calling. This is true especially for treefrogs of the *Boophis luteus* group (e.g. *B. albipunctatus*, *B. andohahela*, *B. elenae*, *B. luteus* and *B. sibilans*), for *Boophis difficilis* (at Andohahela) and for arboreal *Mantidactylus* species, such as *M. aglavei* (at Ranomafana). On the other hand, some species (e.g. *Mantidactylus betsileanus*) considered as « disturbed forest - oriented » in a former work on Ranomafana (ANDREONE, 1994) are here included, since they were found in the almost unaltered area at Andohahela. *Mantidactylus femoralis*, quoted by ANDREONE (1994) was not considered in the abundance index of Ranomafana, due to the taxonomic uncertainty of this population.

RESULTS

At Ranomafana 40 species were preliminarily found (see ANDREONE, 1994), while at Andohahela 24 species (ANDREONE & RANDRIAMAHAZO, in prep.). Of these 24 (Ranomafana) and 16 species (Andohahela) were considered for the ecological analyses and comparisons. The community composition of Ranomafana amphibians varied throughout the periods, since 24 species (100%) were found in December and only 16 (66.6%) in August; all the species found in August were also found in December. The faunal composition and abundance index change significantly between December and August (Wilcoxon test, $p = 0.009$). The AAI is significantly higher in December (2.50) than in August (1.66) if estimated on all the species (Mann-Whitney test, $U = 193$, $p = 0.042$), but identical (2.50) if calculated only on the species found in that period ($n = 24$ and 16; $U = 193$, $p = 0.976$).

On the contrary the community composition of Andohahela amphibians does not vary significantly throughout the analysed periods. Thirteen species (81.25% of the total) were found in April, 15 (93.75%) in November and 12 (75%) in both the field surveys. The faunal composition and abundance index do not change significantly between April and November (Wilcoxon test, $p = 0.735$). The AAI of species found at Andohahela is

quite similar in both the periods, although a slightly higher (difference not significant) in April (2.19) than in November (2.13) if calculated on all the species ($U = 131$, $p = 0.907$), and similar too (2.69 and 2.27) if calculated only on the species found in that period ($n = 13$ and 15 ; $U = 117$, $p = 0.362$). One aspect of microhabitat partitioning, namely arboreality/terrestriality, coincided with the basic dichotomy of diel activity period between night and day. None of the arboreal species is diurnal. Finer distinctions can be made among the arboreal species, since different frogs utilise various habitats (e.g. canopy, trunks, leaf axills). Some arboreal microhylids (e.g. *Platypelis*, *Anodonthyla*) live in bamboo internodes, holes in tree trunks and in leaf axills. Fourteen (Ranomafana) and ten (Andohahela) species are terrestrial or aquatic, 71.4% and 70% of which are mantellines. Most arboreal and semi-arboreal species (all the rhacophorines except *Aglyptodactylus* and many microhylids) move from their diurnal retreats to nocturnal breeding sites, usually temporary or permanent ponds. Most of the species which do not exhibit changes in AI are included in the terrestrial-aquatic category, 57.14% at Ranomafana and 75% at Andohahela.

DISCUSSION

Of course it is necessary to stress that the almost instantaneous surveys do not give an overall indication about seasonal fluctuations: many species were certainly missed and most likely the total amphibian composition at Ranomafana and at Andohahela is much more varied. The amphibian communities of Ranomafana and Andohahela low altitude forest show diversity in habitat preference and in annual and diel cycles of activity. Although, as pointed out by NICOLL and LANGRAND (1989), there is not a real dry season at Ranomafana, the temperature excursion and the higher rainfall rate during the warmest months do not allow an equal repartition and activity of all the species throughout the year. In the years after the first survey many other species were found and it is likely that Ranomafana is, similarly to another central-eastern protected area of Madagascar (Périnet-Analamazaotra), one of the « hot spots » of Malagasy amphibian biodiversity. Conditions of high humidity and precipitations all around the year allow a narrow niche segregation, not only in the diel activity, but also throughout the seasons. In fact, a considerable part of the species has been observed in only one of the considered period. Fourteen species out of 24 (Ranomafana) and ten of 16 (Andohahela) were utilised for the community analysis. At Ranomafana most of them were found in different abundances in the months under study. Most likely, since most of the terrestrial species are « *K*-oriented » mantellines or microhylids, they rely on a general environmental stability. In fact, many of the terrestrial species strictly confined to the leaf litter (e.g. *Mantidactylus opiparis*, *Plethodontohyla inguinalis*) are more specialised in their habitat requirements. Other species (e.g. *Mantella madagascariensis*, *Mantidactylus lugubris* and *Aglyptodactylus madagascariensis*) occurs originally in the unaltered or primary rainforest, but may now be found in some degraded parcels as well. The situation is much different at Andohahela. In this area the seasonality is much higher and the rain precipitations are low in some periods. As yet stressed by NICOLL and LANGRAND (1989), the faunal and botanical composition of Andohahela is transitional in several aspects between the eastern and southern domains. Although all the amphibians reflect an overall eastern composition, many species (e.g. *Mantidactylus bertini*, the « southern variety » of *Boophis difficilis*, *B. miniatus*, possibly *B. albipunctatus* and *B. andohahela*) reflect a considerable degree of endemism, most likely due to the function of refuge

made by the Anosyenne chain. Only a few species are present in high concentrations, they are: *Mantidactylus bouleengeri*, which most likely has a direct egg development, and possibly needs only a high air humidity (as noticed at Andohahela), some species closely related to the stream habitat (*M. lugubris*, *M. microtympalum*), or species which usually aggregate around lentic water bodies (e.g. *M. betsileanus*, *Boophis madagascariensis*). *Boophis luteus*, *B. difficilis* and *B. andohahela* - not considered in the community analysis - are equally present in high number in both the surveys and are, like many arboreal rhacophorines, highly adaptable and possibly breed in several seasonal periods. It should anyway be stressed that the two study periods at Andohahela (April and November) were not characterised by high rainfalls. Perhaps, for this reason the amphibian community and abundance indices did not vary significantly. Possibly the species of this rainforest area (among the southernmost of Madagascar) have an « explosive » breeding activity in the true rainy season, which is likely in January-February. In this sense they would behave like the species of the western dry forests. Further analyses should be therefore deserved to the knowledge of the faunal composition of forests of Madagascar, taking into account that species inhabiting these extraordinary ecosystems constitute a world heritage to be strongly protected.

ACKNOWLEDGEMENTS

I thank F. Glaw (Cologne), H. Randriamahazo (Antananarivo), D. Vallan (Berne) and M. Vences (Cologne) for the help in the field and for the scientific support. The staff of the PBZT (Antananarivo) was as usually friendly and helpful: special thanks to its Director, A. Randrianjafy and to Mrs. C. Ravoarimanga of DEF (Antananarivo) for the necessary permits to visit the protected areas and to capture the amphibians. Part of the work was financially supported by Zoo-Project s.r.l. and by C. Guidi (Perugia).

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TABLE I. Amphibians found in the Ranomafana N.P.(left column) and at Andohahela S.N.R. (right column) and considered for the abundance indices. Hab = Habitat (T = terrestrial and aquatic species; A = arboreal species). Seasonal abundance: 0, none observed; 1, n < 5 observed; 2, n = 5-10; 3, n = 10-20; 4, n > 20. AUG = August, DEC = December, APR = April, NOV = November.

Hab	Family, subfamily and species	Ranomafana		Andohahela		
		AUG	DEC	APR	NOV	
Ranidae						
Mantellinae						
T	<i>Mantella madagascariensis</i>	0	2			
T	<i>Mantidactylus betsileanus</i>	4	4	3	3	<i>Mantidactylus betsileanus</i>
T	<i>Mantidactylus biporus</i>	0	2			
T	<i>Mantidactylus blommersae</i>	1	2			
T				4	4	<i>Mantidactylus boulengeri</i>
A	<i>Mantidactylus cornutus</i>	2	2			
T	<i>Mantidactylus curtus</i>	0	2			
T				2	1	<i>Mantidactylus femoralis</i>
T	<i>Mantidactylus grandidieri</i>	3	3			
A	<i>Mantidactylus liber</i>	3	3			
T	<i>Mantidactylus lugubris</i>	3	3	4	4	<i>Mantidactylus lugubris</i>
A	<i>Mantidactylus luteus</i>	2	3	1	1	<i>Mantidactylus luteus</i>
T	<i>Mantidactylus majori</i>	3	3			
T				4	4	<i>Mantidactylus microtypanum</i>
T	<i>Mantidactylus mocquardi</i>	2	2			
T				0	1	<i>Mantidactylus cf. peraccae</i>
T	<i>Mantidactylus opiparis</i>	2	3	4	4	<i>Mantidactylus opiparis</i>
A	<i>Mantidactylus pulcher</i>	1	3			
A				1	1	<i>Mantidactylus tornieri</i>
Rhacophorinae						
T	<i>Aglyptodactylus madagascariensis</i>	0	4	2	2	<i>Aglyptodactylus madagascariensis</i>
A				0	1	<i>Boophis boehmei</i>
A	<i>Boophis madagascariensis</i>	4	3	4	3	<i>Boophis madagascariensis</i>
A	<i>Boophis reticulatus</i>	4	2			
Microhylidae						
A	<i>Anodonthyla boulengeri</i>	2	2			
A				2	2	<i>Anodonthyla nigrigularis</i>
T				0	1	<i>Plethodontohyla bipunctata</i>
T	<i>Plethodontohyla inguinalis</i>	0	1	1	0	<i>Plethodontohyla inguinalis</i>
T	<i>Plethodontohyla notosticta</i>	0	2			
A	<i>Platypelis grandis</i>	0	2	3	2	<i>Platypelis grandis</i>
A	<i>Platypelis cf. pollicaris</i>	3	3			
A	<i>Platypelis tuberifera</i>	1	2			
T	<i>Scaphiophryne marmorata</i>	0	2			