Short Communication

New records, distribution and conservation of *Mantella bernhardi*, an Endangered frog species from south-eastern Madagascar

Falitiana Rabemananjara, Parfait Bora, John E. Cadle, Franco Andreone, Emile Rajeriarison, Pierre Talata, Frank Glaw, Miguel Vences and David R. Vieites

Abstract We report on seven new localities for *Mantella bernhardi*, a Malagasy poison frog that was previously known only from a single site. This species has been considered threatened with extinction because of ongoing habitat destruction and collection for the pet trade (up to *c.* 3,000 specimens per year). The new localities considerably extend the known range of this species, which has now been documented from *c.* 21.00° to 24.15°S and 47.00° to 48.00°E, and over 60–629 m altitude. Two of the sites are within protected areas (Ranomafana National Park and Manombo Special Reserve). An overlap analysis of the potential distribution area of the species, based on the extent of remaining primary vegetation, indicates that the habitat of *M. bernhardi* in south-eastern Madagascar is fragmented and populations may be relatively small and isolated. We support the IUCN Red List category of Endangered for this species and highlight the need for detailed studies of its populations.

Keywords Amphibia, distribution, Madagascar, *Mantella bernhardi*, Mantellidae, status.

Among the endemic amphibian fauna of Madagascar, the Malagasy poison frogs of the genus *Mantella* are outstanding for their bright, often aposematic coloration, diurnal activity and toxicity (Vences *et al.*, 1999). These frogs, belonging to the endemic Malagasy-Comorian family Mantellidae, are highly prized in the pet trade (Behra, 1993; Andreone & Luiselli, 2003). One of the most recently described species of the genus, *Mantella bernhardi*, was known only from a single locality (Raxworthy & Nussbaum, 2000). The original description (Vences *et al.*, 1994) lacked precise locality data because the specimens upon which the description was based were obtained from commercial collectors.

M. bernhardi has been categorized as 'extremely vulnerable to extinction' because the single previously known locality is not in a protected area and is under strong pressure from small-scale logging and slash and burn agriculture (Raxworthy & Nussbaum, 2000). Here we report the results of recent intensive survey work in south-eastern Madagascar that yielded several new localities for this species, and summarize the known data on its commercial exploitation and threats. Voucher specimens were deposited in the collections of the Département de Biologie Animale, Université d'Antananarivo (UADBA), the Field Museum of Natural History, Chicago (FMNH), the Museo Regionale di Scienze Naturali, Torino (MRSN), the Museum of Comparative Zoology (Harvard), Cambridge (MCZ), Zoologisches Forschungsinstitut und Museum A. Koenig, Bonn (ZFMK), and the Zoological Museum, University of Amsterdam (ZMA). Collections were limited to the minimum number of specimens required for the integrity of this research (1–5 per site). The existence of such voucher specimens is vital because of the taxonomic uncertainty of many *Mantella* field records (Vences *et al.*, 1999).

The holotype of *M. bernhardi* (ZFMK 57164) was part of a larger series of specimens that A. Peyrieras obtained

Falitiana Rabemananjara and **Parfait Bora** Université d'Antananarivo, Département de Biologie Animale, Antananarivo, Madagascar.

John E. Cadle Department of Herpetology, Chicago Zoological Society, 3300 Golf Road, Brookfield, IL 60513, USA.

Franco Andreone Museo Regionale di Scienze Naturali, Sezione di Zoologia, Via G. Giolitti, 36, 10123 Torino, Italy.

Emile Rajeriarison and **Pierre Talata** Parc National de Ranomafana, BP 2, 312 Ranomafana, Madagascar.

Frank Glaw Zoologische Staatssammlung, Münchhausenstr. 21, 81247 München, Germany.

Miguel Vences (Corresponding author) Institute for Biodiversity and Ecosystem Dynamics, Zoological Museum, University of Amsterdam, Mauritskade 61, 1092 AD Amsterdam, The Netherlands. E-mail vences@science.uva.nl

David R. Vieites Museum of Vertebrate Zoology, 3101 Valley Life Sciences Bldg., University of California, Berkeley, CA 94720-3160, USA.

Received 6 April 2004. Revision requested 25 August 2004. Accepted 9 November 2004.

alive from local collectors in 1994. According to the information available at the time, the specimens originated from a site near Tolongoina in south-eastern Madagascar. Raxworthy & Nussbaum (2000) reported that the species had been discovered by R.A. Nussbaum in a single patch of relict forest near Tolongoina, located at 21°28.557′S, 47°33.759′E (C. J. Raxworthy, pers. comm., 2003).

The same area, presumably the same spot, was visited by F. Andreone on 18–21 July 1995 and by P. Bora on 22–24 August 2003. This small rainforest parcel (21°28′42.5″S, 47°33′37.4″E, 577 m altitude) is located next to Ambohimanana village, Tolongoina Fivondronana, Fianarantsoa Province. According to information from local guides this site was the same locality in which the collectors of A. Peyrieras had been working.

The forest near Ambohimanana was clearly suffering repeated slash and burn clearance in 1995. Also, traces of intensive amphibian and reptile collecting activity were recognizable: the ground was disturbed and many *Pandanus* screw palms were cut. Local people from a small settlement next to the site reported that slash and burn agriculture (*tavy*) had increased considerably in recent years, although until a few years earlier (*c.* 1992) the forest had still been intact and not yet converted to rice fields. In 1995 a single specimen of *M. bernhardi* was found by searching under dead trunks (MRSN A1964, leg. F. Andreone, 20 July 1995). This apparent low density is explained by the fact that the search was done during the cold dry season, when these frogs are inactive.

New localities of *M. bernhardi* were identified during the survey work conducted by ourselves and the staff of the Association Nationale pour la Gestion des Aires Protégées (ANGAP) of Ranomafana National Park. To avoid looting of these new sites by commercial collectors, we here give coordinates only with a precision of 0.1°. The first site is located within the Park boundaries at 21.4°S, 47.5°E and 605 m elevation. Several individuals were found in a forest with semi-open canopy next to a river within an area of *c.* 50 m^2. This site had previously been cleared to form a research expedition campsite, but had been recolonized by native plants common to the eastern forests of Madagascar, such as small bamboos *Nastus* sp., the longoze *Aframomum angustifolium*, and a large tree *Croton mongue*. The surface was flat, allowing the formation of a small puddle of stagnant water. Among other amphibians and reptiles found sympatrically with *M. bernhardi* at this site was a second species of Malagasy poison frog *Mantella baroni.* Voucher specimens were deposited under the catalogue numbers UADBA 20747-20752 and ZMA 19799-19780 (*M. bernhardi*) and UADBA 20753-20754 and ZMA 19803-19804 (*M. baroni*). In the same area, just outside the boundaries of the Park, a second locality with the species was found at 629 m altitude, in a degraded area close to a swamp that had largely been transformed into a ricefield (21.6°S, 47.5°E). The vegetation at this site was made up by longoze *Rubis mollucanus* and *Cledemia hirta*. The area is flat, and probably permanently wet.

Five other localities are located south of the Ranomafana National Park. These populations are all in small isolated patches of forest at: (1) 23.7°S, 47.5°E, 90 m; (2–3) 22.8°S, 47.0°E, 550 m; (4) 22.8°S, 47.2°E, 550 m; (5) 23.0°S, 47.7°E, 60 m. The last site is within Manombo Special Reserve, although it was previously reported that the species does not occur there (Raxworthy & Nussbaum, 2000). At all of these five localities *M. bernhardi* was found in primary lowland rainforest or swamp forest on the floodplain of streams. They were generally associated with areas having much leaf litter on the ground. At locality (4) the forest was a small fragment and *M. bernhardi* was found in more open situations and not as abundantly as in the other localities.

Considering all these records, the species is known from *c.* 21.00° to 24.15° S and 47.00° to 48.00° E, and at altitudes of 60–629 m. We drew a minimum convex polygon around the available records to obtain an estimate of the area in which *M. bernhardi* occurs with high probability, using the *Animal Movement Analysis Extension for ArcView* (Hooge *et al.*, 1999). In this area we identified within a 15′ square grid map of Madagascar those grid squares that overlapped with the area of potential occurrence, by overlap analysis using *ArcView 2.0* (ESRI, Redlands, USA) and using precise coordinates of all records, hypsometry (NASA-US Geological Survey, 2005), geology and natural vegetation (Royal Botanic Gardens, Kew (2005), and bioclimatology (Missouri Botanical Garden, 2004). The results of this analysis (Fig. 1) indicate a relatively fragmented distribution. Within the potential distribution area of *M. bernhardi* several grid squares appear not to be covered by suitable habitat. *M. bernhardi* populations appear to be localized and often occupy small, isolated and degraded patches of forest that are likely to be destroyed by slash and burn agriculture in the near future. Such fragmentation is known to negatively affect many species of Malagasy amphibians (Vallan, 2000). The high rates of deforestation (Achard *et al.*, 2002) suggest that the remaining suitable habitat may be even more reduced than the potential range estimated here.

M. bernhardi was originally described based on specimens destined for the pet trade, and it has been repeatedly exported in small to moderate numbers. Since 2000 this and all other species of *Mantella* have been on Appendix II of CITES, and more precise numbers of legally exported specimens are therefore available. According to reports of the Malagasy CITES authorities, in 2000 a total of 390 specimens of *M. bernhardi* were exported to the USA and Canada, and in 2001 a total of

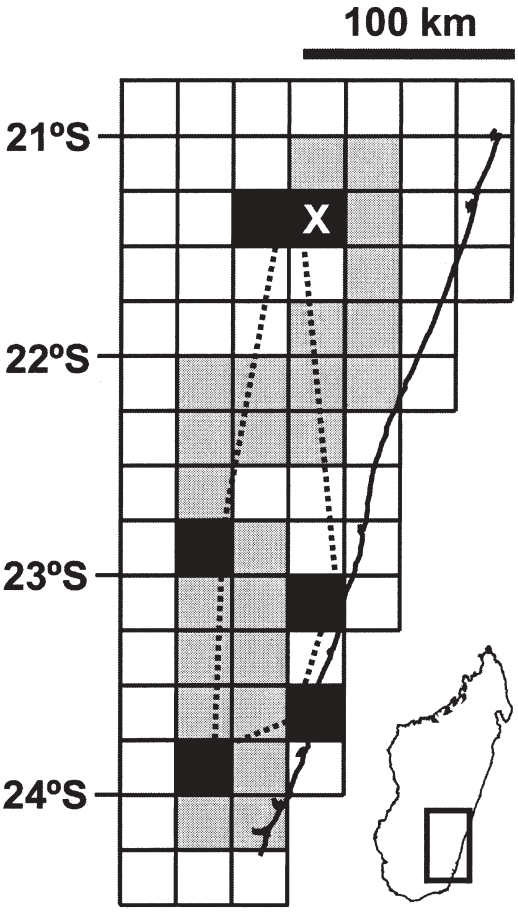

Fig. 1 Grid map with known distribution records of *M. bernhardi*. Grid squares with ascertained distribution are black (an 'X' marking the presumed type locality), squares including areas of potential distribution are grey. The dotted line is the minimum convex polygon around known localities. The rectangle on the inset indicates the location of the main map in Madagascar.

955 to the USA and 50 to Japan. Rakotomavo (2000) gave numbers for earliers years, *viz*: 1995, 290 specimens; 1996, 10 specimens; 1997, 400 specimens; 1998, 2,709 specimens.

Based on our data we support the Red List category of Endangered for *M. bernhardi* based on criteria B2ab(iii,v) (IUCN, 2004) mainly because of its small area of occupancy, which is probably <500 km^2, its severely fragmented distribution, and the decline of its forest habitat in east-central Madagascar, in agreement with the opinion of the Global Amphibian Assessment (Andreone *et al.*, in press). Future research should focus on understanding densities, habitat requirements, and extent of genetic differentiation of and among populations of this species. Our data highlight the importance of low-altitude rainforests in south-eastern Madagascar, which may harbour a larger species diversity than is currently known, including regional endemics such as *Mantella bernhardi*. Lower altitude areas within Ranomafana National Park and forested areas within Manombo Special Reserve should be priorities in regional conservation efforts. In addition, other forest blocks at low- to mid-elevations in south-eastern Madagascar, such as Vevembe forest near Vondrozo, should be considered for inclusion in Madagascar's network of protected areas.

Acknowledgements

The survey work that was the basis of this paper benefited from the help and assistance of many friends and colleagues, in particular G. Aprea, M. Puente, L. Raharivololoniaina and M. Thomas. C. Raxworthy provided information on the geographical coordinates of the presumed type locality. E. Edwards supplied information on the trade in Malagasy amphibians. FA wishes to thanks Emilien 'Fidi' Rafidison, who accompanied him to Ambohimanana in 1995, and E. Rakotomavo and H. Randriamahazo for the useful exchange of information. For funding he thanks the National Amphibian Conservation Center, the Wildlife Conservation Society, the Madagascar Fauna Group, J.E. Behler and A. Katz. Financial assistance to MV and FG was provided by the Volkswagen Foundation, to MV by BIOPAT, and to FR and MV by the Netherlands Organization for Scientific Research (WOTRO/NWO). Fieldwork of JEC in Madagascar has been supported over the years by the Douroucouli Foundation, the Chicago Zoological Society (SEACON and Chicago Board of Trade funds), and the Milton Fund of Harvard University; considerable logistic support has been provided by the Madagascar Institut pour la Conservation des Environnements Tropicaux. DRV was supported by a grant from the University of Vigo for research in foreign institutions. We are grateful to the ANGAP team of Ranomafana National Park for continuous support, and to the Malagasy authorities for research and collection permits.

References

Achard, F., Eva, H.D., Stibig, H.J., Mayaux, P., Gallego, J., Richards, T. & Malingeau, J.P. (2002) Determination of deforestation rates of the world's humid tropical forests. *Science*, **297**, 999–1002.

Andreone, F., Cadle, J.E., Cox, N., Glaw, F., Nussbaum, R.A., Raxworthy, C.J., Stuart, S.N., Vallan, D. & Vences, M. (in press) A species review of amphibian extinction risks in Madagascar: results from the Global Amphibian Assessment. *Conservation Biology*.

Andreone, F. & Luiselli, L.M. (2003) Conservation priorities and potential threats influencing the hyper-diverse amphibians of Madagascar. *Italian Journal of Zoology*, **70**, 53–63.

Behra, O. (1993) The export of reptiles and amphibians from Madagascar. *Traffic Bulletin*, **13**, 115–116.

Hooge, P.N., Eichenlaub W. & Solomon, E. (1999) *The Animal Movement Program*. USGS, Alaska Biological Science Center, Gustavus, USA.

IUCN (2004) *IUCN Red List of Threatened Species*. IUCN, Gland, Switzerland [http://www.redlist.org, accessed 3 March 2005].

Missouri Botanical Garden (2004) Http://www.mobot.org [accessed 3 March 2005].

NASA-US Geological Survey (2005) *Land Processes Distributed Active Archive Center*. Http://www.edcdaac.usgs.gov [accessed 3 March 2005].

Rakotomavo, E. (2000) *Etude de la filière* Mantella *de Madagascar*. Report for the Ministère des Eaux et Forets, Service Valorisation Economique and the Office National pour l'Environnement, Cellule Biodiversité, Antananarivo, Madagascar.

Raxworthy, C.J. & Nussbaum, R.A. (2000) Extinction and extinction vulnerability of amphibians and reptiles in Madagascar. *Amphibian and Reptile Conservation*, **2**, 15–23.

Royal Botanic Gardens, Kew (2005) Http://www.rbgkew.org.uk [accessed 3 March 2005].

Vallan, D. (2000) Influence of forest fragmentation on amphibian diversity in the nature reserve of Ambohitantely, highland Madagascar. *Biological Conservation*, **96**, 31–43.

Vences, M., Glaw, F. & Böhme, W. (1999) A review of the genus *Mantella* (Anura, Ranidae, Mantellinae): taxonomy, distribution and conservation of Malagasy poison frogs. *Alytes*, **17**, 3–72.

Vences, M., Glaw, F., Peyrieras, A., Böhme, W. & Busse, K. (1994) Der *Mantella madagascariensis*-Komplex: Wiederentdeckung von *Mantella cowani* und Beschreibung von *Mantella bernhardi* n. sp. *Die Aquarien-und Terrarien-Zeitschrift*, **47**, 390–393.

Biographical sketches

F. Rabemananjara and P. Bora are students of the University of Antananarivo, studying the biology of Malagasy poison frogs. E. Rajeriarison and P. Talata are scientific guides at Ranomafana National Park and have carried out extensive zoological surveys in south-eastern Madagascar. F. Andreone, J.E. Cadle, F. Glaw and M. Vences have been involved for over 10 years in intensive work on the systematics, ecology and evolution of the herpetofauna of Madagascar. D.R. Vieites specializes in biogeographical analyses.