Herpetology Notes, volume 1: 39-48 (published online on 22 September 2008)

Geographical distribution of three species of Malagasy poison frogs of high conservation priority: *Mantella aurantiaca, M. crocea* and *M. milotympanum*

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Abstract. The genus *Mantella* comprises 16 described species of Malagasy poison frogs, several of which are threatened. Despite their importance as flagship species for conservation, remarkably little was known until recently about their geographical distribution. We here provide a revision of the distribution of a complex of three closely related *Mantella* species from central eastern Madagascar: *Mantella aurantiaca* (Critically Endangered) *M. crocea* (Endangered) and *M. milotympanum* (Critically Endangered). These taxa were thus far known from only a very limited number of sites. Based on own surveys, we could identify 21 new sites to complement the 13 sites known for these frogs. We also provide corrected geographical coordinates for some published sites. Altogether 16 localities are known for *M. aurantiaca*, nine for *M. crocea*, five for *M.* cf *milotympanum* and four for *M. milotympanum*. One site of *M. crocea* is in a Special Reserve (Ambohitantely), a second possibly in the Zahamena National Park, one site of *M. aurantiaca* (Torotorofotsy) is protected as Ramsar site, and a second site of *M. aurantiaca* is at the boundary of, and possibly inside, Mantadia National Park, but all other localities do not receive legal protection. All newly recorded sites are along the western edge of the eastern forest band, except Ambohitantely which is a relict forest in central Madagascar. Among the sites reported for *M. aurantiaca*, only one (Ambakoana) is situated on the western bank of the Mangoro River, indicating that this river is no insurmountable barrier for this species, at least in its upper course.

Keywords: *Mantella*, Anura, Mantellidae, geographical distribution, Madagascar

Introduction

Malagasy poison frogs of the genus *Mantella* are known for their bright colouration and the presence of alkaloid skin toxins (Daly et al., 1996). Currently there are 16 described species in the genus, and at least one undescribed species has been identified (Glaw and Vences 2007; Rabemananjara et al., 2007). Due to their attractive coloration and diurnal behaviour, *Mantella* are prominent representatives of the Malagasy herpetofauna, and they are also exported in large numbers for the pet trade (Rabemananjara et al., in press). Nevertheless, for many species, basic data on distribution and natural history were missing (Vences et al., 1999) and this has hindered the creation of appropriate conservation measures. This is particularly true for three closely related species, *Mantella aurantiaca*, *M. crocea* and *M. milotympanum,* to which we will here refer to as the *Mantella aurantiaca* complex. These taxa have been included in a *Mantella aurantiaca* group (Vences et al., 1999), but more recent molecular studies have shown that they should be included in the *M. madagascariensis* group which in addition contains *M. madagascariensis* and *M. pulchra*. Up until 1999, there was no precise locality information available for *Mantella crocea* and *M. milotympanum,* and only one locality, the Torotorofotsy marsh, had been identified as containing sites with *M. aurantiaca*.

Considering the announcement of Madagascar's president Ravalomanana, at the Durban Parks Conference in 2003, to triple the surface of protected areas, it is now important to identify unprotected forest fragments that harbour significant populations of restricted range species which merit future protection. All three species in the *M. aurantiaca* complex are

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threatened with extinction, with *M. aurantiaca* and *M. milotympanum* listed as Critically Endangered and *M. crocea* as Endangered on the IUCN Red List (Andreone et al., 2005). This database of threatened species relies on precise information on the extent of occurrence and area of occupancy, and periodic reviews when new information becomes available are required.

The three species in the *Mantella aurantiaca* complex are characterized by a similar morphology. They can be distinguished by color patterns, but the distinction between *M. crocea* and *M. milotympanum* is unclear since many intermediate color morphs exist. Genetically, these two taxa are not differentiated in mitochondrial genes, and their species status is doubtful; *M. aurantiaca* appears to be differentiated on the mitochondrial level but some populations show haplotype sharing with *M. crocea.*

In the last decade, much information on the distribution of these species has become available from new field surveys. Some of these data, however, are only available from unpublished reports, while some other locality information has been published in molecular phylogenetic studies (Vences et al., 2004; Chiari et al., 2004) and is not easily available to conservationists. Furthermore, various locality names have partly been used for the same sites, and some of the published coordinates appear to be erroneous. Therefore in this study our goal is to summarize all available information on the distribution of these species, to enable its use by conservation authorities for establishing management plans for these species.

Methods

Field surveys were carried out in Madagascar between 2001 and 2007. Preliminary locality information was in many cases obtained from commercial collectors. Geographical coordinates and elevation were assessed using various GPS devices. All available literature and unpublished reports, as well as several major museum collections, were checked for precise locality data referring to the three *Mantella* species discussed here. Coordinates were transformed into decimal format and entered into Google Earth to check for possible mistakes.

Voucher specimens for some localities are deposited at the Museum of the Département de Biologie Animale de l'Université d'Antananarivo, Madagascar (UADBA), the Zoologische Staatssammlung München, Germany (ZSM), and the Zoological Museum Amsterdam, The Netherlands (ZMA).

Results and discussion

The following accounts list all known localities separately for *M. aurantiaca*, *M. crocea*, *M. milotympanum*, and some populations assigned to *M. milotympanum* in a preliminary way (as *M*. cf. *milotympanum*). For each species, localities are listed alphabetically. In addition we give brief accounts of historical records in the literature that either are considered to be in error or could not be confirmed by recent surveys.

Localities of *Mantella aurantiaca* Mocquard, 1900

Historical localities: *Mantella aurantiaca* has initially been described from a "forest between Beforona and Moramanga". Later, specimens were often reported from "Perinet" or "Perinet district" (e.g., Blommers-Schlösser and Blanc 1991) which refers to a village called Andasibe, east of Moramanga. Although Zimmermann and Hetz (1992) mapped the species in grid squares close to Andasibe, it is almost certain that the species does not occur here, and that historical records refer to sites at some distance from Andasibe whereas more recent records may refer to specimens locally introduced by commercial collectors (see Vences et al., 1999 for a more detailed discussion). Most historical records refer to the marsh of Torotorofotsy (Zimmermann and Hetz 1992; Zimmermann 1996), including the record of Blommers-Schlösser (1979) who reported the species from Antaniditra, a village directly bordering the Torotorofotsy marsh. One additional locality in the Andasibe area is Ambatodradama (Ambatoharanana) (Methuen and Hewitt 1913) which we could not trace on recent maps and which has not been confirmed since. Behra et al. (1995) further discuss the occurrence of this species in forests near the Ankaratra massif but give no precise locality. No sites in this area have been confirmed since.

Ambakoana: This previously unknown site was reported by members of a local NGO (ACCE) and was verified by us in January 2007. Specimens of yellow-orange and reddish color were observed in a pine forest bordering a fragment of natural rainforest (where no specimens were found). Two males (SVL = 19.6 mm, UADBA 30073 (RBJ 1051), and UADBA 30102 / RBJ 1049) and one female (SVL = 26.3 mm; UADBA 30103 / RBJ 1045) were collected as vouchers. No individuals were heard calling.

Ambatovy: This site was surveyed by J. Rafanomezantsoa in 1997, very close to the border of Mantadia National

Table 1. List of available locality records of *Mantella aurantiaca, M. crocea* and *M. milotympanum*. Sites in italics are not considered as separate sites (either because of erroneous coordinates, or because they are identical to another site). Sources of information are coded as follows: 0, New locality; 1, Chiari et al. (2004); 2, Vences et al. (2004); 3, FADES report (F. Rabemananjara); 4 Randrianirina (2005); 5 Behra et al. (1995); 6 Zimmermann & Hetz (1992) and Zimmermann (1996).

Name of the site	Source	Observers	Remark
Mantella aurantiaca			
Ambakoana 1	0	D. Andriafidison, R. Randrianavelona and P. Bora	
Ambakoana 2	0	D. Andriafidison, R. Randrianavelona and P. Bora	Very close to Ambakoana 1
Ambatovy	0	J. Rafanomezantsoa	
Analabe	0	R. Jenkins, R. Randrianavelona and P. Bora	
Analamay 1	0	J. Rafanomezantsoa	
Analamay 2	0	J. Rafanomezantsoa	
Analamay 3	0	J. Rafanomezantsoa and A. F. Ranjanaharisoa	
Andranomandry 1	1	M. Vences, E. Edwards, D. R. Vieites, F. Rabemananjara, P. Bora	
Andranomandry 2	0	F. Rabemananjara	Same site as Andranomandry 1
Andranomandry 3	0	F. Rabemananjara	Same site as Andranomandry 1
Andranomandry 4	0	J. Randrianirina	Same site as Andranomandry 1
Andranomena	1	M. Vences, I. Somorjai, L. Raharivololoniaina, E. Edwards	
Andranonakoho	0	J. Randrianirina	
Besariaka forest	0	J. Randrianirina	
Sahasarotra forest	0	J. Randrianirina	
Torotorofotsy 1	*1,2*	*M. Vences, L. Raharivololoniaina*	*Published coordinates in error; same locality as Torotorofotsy 3*
Torotorofotsy 2	*1,2*	*M. Vences, L. Raharivololoniaina*	*Published coordinates in error; same locality as Torotorofotsy 5*
Torotorofotsy 3	-	O. Jovanovic	Same locality as Torotorofotsy 1
Torotorofotsy 4	0	J. Rafanomezantsoa	
Torotorofotsy 5	6	Not confirmed	Several populations north of Antaniditra; corresponds to Torotorofotsy 2
Torotorofotsy 6	6	Not confirmed	Several populations west of Antaniditra
Mantella crocea			
Ambodivoasary	0	F. C. Rabemananjara	
Ambohimanarivo	1	M. Vences, I. Somorjai, L. Raharivololoniaina, E. Edwards	
Ambohitantely	0	M. Vences, O. Jovanovic and G. Safarek	
Ampangadimbolana	0	M. Vences, D. R. Vieites, C. Woodhead and E. Edwards	
Ankosy	0	F. C. Rabemananjara	
Bakozetra	5 (6)	Not confirmed	Coordinates estimated from published map
Ihofa	1,2	Local collectors instructed by M. Vences and L. Raharivololoniaina	
Marisiaka	3	F. C. Rabemananjara	
Zahamena	0	C. J Raxworthy, A. Raselimanana, J. B. Ramanamanjato, A. Ravoninjatovo, J. Rafanomezantsoa, F. Rabemananjara	No precise coordinates and locality information available
Mantella milotympanum			
Antanifotsy forest	4	J. Randrianirina	
Bemandotra forest	4	J. Randrianirina	
Sahalava forest	4	J. Randrianirina	
Sahamarolambo 1	*1*	*P. Bora, F. Rabemananjara, B. Razafimahatratra, D. R. Vieites, M. Vences*	
Sahamarolambo 2	3	F. C. Rabemananjara	Same site as Sahamarolambo 1
Mantella cf. ***milotympanum***			
Ambatombolana	0	O. Jovanovic, R. Dolch and H. Kurrer	
Andriambe	1	P. Bora, B. Razafimahatratra	Published as "Andriabe"
Andaingo	1	D. R. Vieites, P. Bora	Published as "North of Fierenana"
Mandrevo Amboa	0	O. Jovanovic, R. Dolch and H. Kurrer	
Savakoanina	1	P. Bora, B. Razafimahatratra	

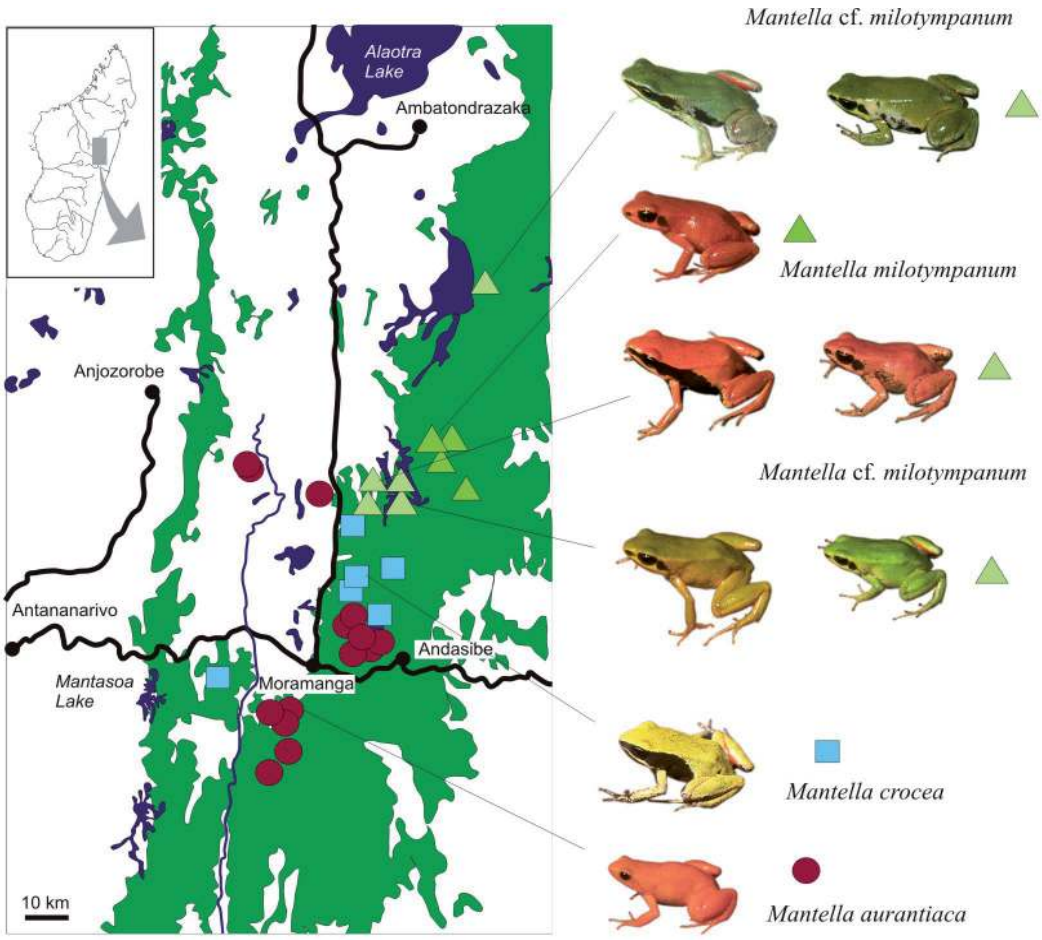

Figure 1. Map showing the distribution of *Mantella aurantiaca*, *M. crocea*, *M.* cf. *milotympanum* and *M. milotympanum* in the East region in Madagascar. *M. aurantiaca* sites are marked with circles. *M. crocea* sites are marked with squares. *M.* cf. *milotympanum* and *M. milotympanum* are marked with triangles. Placement of locality symbols is schematic and adjusted to be able to show all localities. Two sites of *M. crocea* (Zahamena and Ambohitantely) are outside the range of the map (northeast of Ambatondrazaka and west of Anjozorobe, respectively).

Park, probably located inside the reserve boundaries according to available coordinates. *Mantella aurantiaca* was found in rainforest next to a small marsh. Ongoing degradation and disturbance of the habitat was noted during the survey.

Analabe: This new site was also discovered first by a local NGO (ACCE) and verified by us in January 2007. It is a forest fragment of about 400 ha surrounded by a pine plantation and agriculture. The species was found only in a narrow valley alongside small streams. Calling males were hidden among dead leaves of *Pandanus* plants and in the base of the living plants. Observed individuals were of red color. In total five individuals were captured of which one male with SVL = 21.0 mm; UADBA 30071 (RBJ 1048) and one female with SVL = 24.5 mm; UADBA 30072 (RBJ 1047) were collected as vouchers. An additional voucher specimen was collected in a different part of the forest during March 2007.

Analamay: A first site in Anamalay was visited by J. Rafanomezantsoa. The habitat is a temporary marsh 3 meters from a stream inside primary forest beside a small fragment of secondary forest. A second site is located close to the previous site and was visited by J. Rafanomezantsoa in 1997. The habitat was primary forest close to a temporary marsh.

Analamay 3: This site was surveyed by J. Rafanomezantsoa and A. F. Ranjanaharisoa at the end of November 2004. *Mantella aurantiaca* was found in degraded primary forest close to a temporary marsh. Many males were heard calling around the marsh inside of the forest during daytime.

Andranomandry: This site was visited by M. Vences, D. R. Vieites, E. Edwards, P. Bora and F. C. Rabemananjara in 2003. Coordinates were published by Chiari et al. (2004) and Vences et al. (2004). It consists of a valley and a hill with a slope of 20° to 30 ° horizontally. Forest is primary but degraded by heavy exploitation of timber. As well, a marsh is used as a meadow for zebus. This is also a well-known area for collecting individuals of this species for pet trade. This locality has also been visited by other researchers subsequently who all confirmed the existence of *M. aurantiaca* at the site with slightly differing GPS readings (see Table 2).

Andranomena: This site is sometimes also called Beparasy by local collectors because it is close to a local road leading to this village. In fact, it refers to the same forest fragment as Andranomandry (see above). This site was visited by M. Vences, I. Somorjai, L. Raharivololoniaina and J. Edwards in 2002. The site is a fragmented and disturbed forest with some hills and some marsh areas in the forest. At the time, we observed no calling specimens, but a large number of specimens were found in the degraded forest. The coordinates were taken at the bank of the Samarirana River, at some distance from the actual *M. aurantiaca* site. Coordinates of this site were published by Vences et al. (2004) and Chiari et al. (2004).

Andranonakoho: This site was visited by J. Randrianirina in November-December 2005. A population consisting of red-orange colored individuals was found in a patch of little disturbed rainforest.

Besariaka forest: Another site surveyed by J. Randrianirina in November-December 2005.

Sahasarotra: A rainforest site surveyed by J. Randrianirina in the same period like Andranonakoho, but located further south than that locality.

Torotorofotsy: This site (sometimes also named Antorotorofotsy) was historically the only certain locality of *Mantella aurantiaca* (see Vences et al., 1999). Torotorofotsy is a large marsh that currently is protected as Ramsar Site. At some places around the marsh there is gallery forest which gets partly flooded during the rainy season and which is used by *M. aurantiaca* for reproduction. Zimmermann and Hetz (1992) and Zimmermann (1996) provided a detailed map of *M. aurantiaca* populations in this area, but their work also indicated populations in Reserve Speciale d'Analamazoatra near Andasibe which almost certainly were due to individuals introduced by locals at the time, and these populations have never been confirmed since despite intensive research activity in this area. Although these works contained no coordinates, they confirmed the presence of the species at many sites in the Torotorofotsy area, with three main nuclei. The best studied of these is located at the place where the (abandoned) railroad from Andasibe village arrives at the marsh. This site has been named Torotorofotsy 1 by Vences et al. (2004) and Chiari et al. (2004), but their geographical coordinates were slightly mistaken, probably due to a GPS reading error during the visit in January 2001 (by M. Vences and L. Raharivololoniaina). The site has further been visited by M. Vences, C. Woodhead and E. Randriamitso in February 2004, and by O. Jovanovic in January 2007, and is here thus named Torotorofotsy 3. A further locality at Torotorofotsy was visited by J. Rafanomezantsoa. The different GPS readings obtained from sites around Torotorofotsy are reproduced in Table 2.

Localities of *Mantella crocea* Pintak and Böhme, 1990

Historical localities: Type locality of *Mantella crocea* is Andasibe, but the species is not found in or near the village of Andasibe. Instead, the closest populations of *Mantella crocea* are north of the Torotorofotsy marsh (Hetz and Zimmermann, 1992; Zimmermann, 1996), in an area called Bakozetra (Behra et al., 1992; see below).

Ambodivoasary: This site was surveyed by F. Rabemananjara in 2003 and 2004. It is located in the district of Marovoay Gara. The site consists of a marsh in a clearing with decomposing dead trunks covered with ferns and surrounding by a forest with dense understorey.

Ambohimanarivo: This site was surveyed by M. Vences, I. Somorjai and E. Edwards in 2002 and is quite close to

Ambodivoasary and Marisiaka. The name of the site was given after a village along the road from Moramanga to Ambatondranzaka which however is at some distance from the actual locality. Samples collected at this site have been used in the molecular works of Vences et al. (2004) and Chiari et al. (2004). The locality is a medium-sized open marsh with rainforest at its edges. Specimens were found in the forest and likely reproduce in flooded areas where the forest borders the marsh.

Ambohitantely: The Reserve Speciale d'Ambohitantely consists of fragmented parcels of humid forest in the central highlands of Madagascar. This site is isolated from the nest nearest known population of *M. crocea* by over 100 km. Here, the first records of *M. crocea* were made by A. Raselimanana who observed the species several years ago. New searches in 2005 and 2006 were unsuccessful, but in 2007, both A. Raselimanana and a team consisting of P. Bora, F. Rabemananjara, T. Razafindrabe, M. Vences, O. Jovanovic and G. Safarek confirmed the existence of the species in the largest forest block remaining at this site. A large number of individuals were found in February 2007 on a slope, far from water between a major cascade and the Jardin Botanique. The forest here was relatively dry and open, and characterized by a number of large *Pandanus* plants. Specimens had a characteristic bright green-black coloration.

Ampangadimbolana: This site was identified by M. Vences, D. R. Vieites, C. Woodhead and E. Edwards in 2004. Different from most localities for the species (but in agreement with Ambohitantely which is located much further west), this site is situated on the west bank of the river Mangoro. It is the only known site south of Moramanga. The pace of habitat destruction in this area is extreme, and it is possible that the population has in the meantime disappeared. We observed a few calling males from an exposed marsh bordered by remains of rainforest. Calling individuals were all relatively close to the forest border but were calling in the unforested marsh area where fallen logs and some large grass tufts were providing shelter. Local collectors later in 2004 secured a larger series of individuals from a site said to be very closely nearby (no coordinates taken), indicating that in 2004, some larger populations were still existing in this area. Specimens were of greenish colour with black pigment laterally.

Ankosy: This site was visited by F. Rabemananjara in 2003 and 2004. It comprises parts of rather intact as well as disturbed forest surrounding a large marsh, and the population consists of yellow-brown coloured individuals with black lateral band reaching to the flanks, with SVL between 18-22 mm.

Bakozetra: This locality immediately north of Torotorofotsy marsh has not been confirmed in recent surveys, and no precise GPS reading is available. We here provide approximate coordinates based on the maps of Zimmermann and Hetz (1992) and Behra et al. (1995) (Table 2).

Ihofa: This *M. crocea* site has been sampled in 2001 and coordinates were published in Vences et al. (2004) and Chiari et al. (2004). The locality is to the north of Torotorofotsy marsh and was surveyed by local collectors who also took GPS readings themselves and reported these to M. Vences, I. Somorjai and L. Raharivololoniaina in 2001. No data are therefore available on the habitat at this site.

Marisiaka: This site was surveyed by F. Rabemananjara in 2003. This site is comprised of a humid valley of a width of approximately 2-3 m, covered with 1 to 10 cm leaf litter, in forest with some underwood and without a dense canopy. Ground vegetation is formed by tree ferns, *Pandanus* and *Cephalostachyum viguieri*. The forest was overexploited for wood but this activity is currently reduced by forest managers elected by the local community.

Zahamena: Specimens assigned to *M. crocea* have been observed by C. J. Raxworthy, A. Raselimanana, J.-B. Ramanamanjato, A. Ravoninjatovo, J. Rafanomezantsoa and F. Rabemananjara in early February 1994. Specimens were not encountered in the dense rainforest of Zahamena reserve but at a site outside the major forest block, and possibly outside of the protected area. The individuals were found along the trail crossing a block of humid rainforest (Ampangadinatrandraka forest), NW of Manakambahiny Est village. The forest was disturbed by cattle grazing and timber exploitation for local needs. Specimens were collected in open canopy and disturbed slope forest at around 10:30 am. Geographic coordinates of this locality are not available to us at the time of writing the present paper, but the elevation was about 1250 m. The locality has also been used to estimate the

Table 2. Geographical coordinates and altitude above sea level of localities of *Mantella aurantiaca, M. crocea* and *M. milotympanum*. Original coordinates refer to the precise format of published data or fieldbook entries. Corrected coordinates refer to coordinates transferred into decimal degrees, and partly replaced by more precise or correct readings (in italics) if a locality was visited more than once. Localities in italics do not represent separate sites but different visits to the same site.

Name of the site	Altitude a.s.l.	Original latitude	Original longitude	Corrected decimal latitude	Corrected decimal longitude
Mantella aurantiaca					
Ambakoana 1	955	18°31'17''	48°10'09''	18.5214°	48.1692°
Ambakoana 2	893	18°31'24''	48°10'16''	18.5233°	48.1711
Ambatovy	unknown	18°51.3	48°21.3	18.855°	48.355°
Analabe	940	18°35'36''	48°15'06''	18.5933°	48.2517°
Analamay 1	1006	18°47.957'	48°20.541	18.79928°	48.34235°
Analamay 2	unknown	18°49.7	48°20.0	18.82833°	48.33333°
Analamay 3	1039	18°48.736'	48°20.213'	18.81227°	48.33688°
Andranomandry 1	917	19°02'22''	48°10'34''	19.0394°	48.1761°
Andranomandry 2	918	19°02.373'	48°10.576'	19.03955°	48.17627°
Andranomandry 3	898	19°02.259'	48°10.408'	19.03765°	48.17347°
Andranomandry 4	915	19°02'03''	48°10'05''	19.0342°	48.1681°
Andranomena	921	19°01'30''	48°10'0''	19.025°	48.1761°
Andranonakoho	1000	19°08'32''	48°09'58''	19.1422°	48.1661°
Besariaka forest	950	19°02'06''	48°09'09''	19.035°	48.1525°
Sahasarotra forest	1065	19°10'34''	48°08'12''	19.1761°	48.4403°
Torotorofotsy 1	960	18°52'29''	48°22'21''	*18.87622*°	*48.37072*°
Torotorofotsy 2	950	18°51'19''	48°21'36''	*18.8454*°	*48.3741*°
Torotorofotsy 3	941	18°52.573'	48°22.243'	18.87622°	48.37072°
Torotorofotsy 4	956	18°52.575'	48°22.265'	18.87625°	48.37108°
Torotorofotsy 5	---	---	---	18.8454°	48.3741°
Torotorofotsy 6	---	---	---	18.854°	48.3505°
Mantella crocea					
Ambodivoasary	952	18°47.586'	48°17.492'	18.7931°	48.29153°
Ambohimanarivo	1057	18°48'34''	48°16'52''	18.8094°	48.2811°
Ambohitantely	1572	18°10.695'	47°17.426'	18.17825°	47.29043°
Ampangadimbolana	890	18°58.425'	48°04.838'	18.97375°	48.08063°
Ankosy	1025	18°38.559'	48°16.857'	18.64265°	48.28095°
Bakozetra	---	---	---	18.8223°	48.3701°
Ihofa	1017	18°46'06''	48°22'12''	18.7683°	48.3717°
Marisiaka	1041	18°48.167'	48°17.330'	18.80278°	48.28883°
Zahamena	---	---	---	ca. 17.637	ca. 48.768
Mantella milotympanum					
Antanifotsy forest	925	18°34.36	48°26.38	18.57267°	48.43967°
Bemandotra forest	915	18°36.56	48°27.74	18.60933°	48.46233°
Sahalava forest	964	18°33.44	48°27.56	18.55733°	48.45933°
Sahamarolambo 1	948	18°32'36''	48°26'56''	*18.53963*°	*48.44547*°
Sahamarolambo 2	889	18°32.378'	48°26.728'	18.53963°	48.44547°
Mantella cf. ***milotympanum***					
Ambatombolana	938	18°36.422'	48°22.383'	18.60703°	48.37305°
Andriambe	1047	18°36'46''	48°19'34''	18.6128°	48.3261°
Andaingo	1060	18°16'10''	48°29'03''	18.2694°	48.4842°
Mandrevo Amboa	945	18°35.396'	48°20.816'	18.58993°	48.34693°
Savakoanina	959	18°34'44''	48°24'30''	18.6122°	48.4083°

distribution range of *M. crocea* in the Global Amphibian Assessment based on an information of C. J. Raxworthy in 2003 (see map under www.globalamphibians.org). It considerably extends the distribution area of this complex of frogs into the north, and more studies on the identity of this population are necessary. According to informations of a Peace Corps volunteer in 2008 to MV, specimens probably attributable to the species have also more recently been sighted inside Zahamena reserve, close to its north-western edge, which may correspond to the same site reported here.

Localities of *Mantella milotympanum* Staniszewski, 1996

Historical localities: Type locality is the "Fiherenanana valley in central east Madagascar" which corresponds to the surroundings of Fierenana village. No further information is available from early publications.

Antanifotsy forest: This site was surveyed by J. Randrianirina in 2004 and published by Randrianirina (2005). Encountered specimens were assigned to *M. milotympanum* and were red colored. The forest at the time of survey was more or less intact without visible consequences of human activities.

Bemandotra: This site was visited and surveyed by J. Randrianirina in 2004 and published by Randrianirina (2005). The forest is similar to that in Antanifotsy.

Sahalava forest: Surveyed by J. Randrianirina in 2004 and published by Randrianirina (2005). The forest is similar to that in Antanifotsy.

Sahamarolambo: This site is located south of the village of Fierenana and has been visited by numerous researchers. *Mantella milotympanum* also occurs at other sites between Fierenana and Sahamarolambo as we could verify in January 2002 based on calls heard from small forest fragments, but no individuals were captured from these intermediate sites. Sahamarolambo was visited by M. Vences and E. Edwards in January 2002, by F. Rabemananjara, D. R. Vieites and M. Vences in February 2003, by F. Rabemananjara later in 2003, and by J. Randrianirina in 2004. The GPS coordinates used here are those taken by F. Rabemananjara in 2003 which best fit with available satellite pictures. The locality has been reported, partly just as "Fierenana", by Vences et al. (2004), Chiari et al. (2004), Randrianirina (2005) and Vieites et al. (2005). The site is a small forest fragment in-between several large marshes that partly have been converted into rice fields. The forest canopy is not very dense. A small stream of 1.5 m width and 10-50 cm water depth flows through the fragment which at some parts gets flooded. The forest is characterized by tree ferns and several large *Pandanus* plants at the swampy parts.
Sahamarolambo is the best known site with specimens that show the typical color of *M. milotympanum*, i.e. a uniformly red-orange body with a black tympanum and some black pigment around the nostril. According to Randrianirina (2005), the same coloration was also observed in the three populations listed above. The further sites listed below as *Mantella* cf. *milotympanum* have partly an intermediate color or pattern between *M. milotympanum* and *M. crocea*.

Localities of *Mantella* cf. *milotympanum*:

Ambatombolana: This site was identified by O. Jovanovic, H. Kurrer and R. Dolch in February 2007. One population of *M. crocea* consisting of uniformly yellow-blue coloured individuals was located. The site comprises of an open swampy valley between hills covered with forest. This population is not far from the one from Savakoanina which also harbours green-colored individuals.

Andriambe: This site was visited and surveyed by B. Razafimahatratra and P. Bora in February 2003 and published as sampling site for molecular analysis by Chiari et al. (2004). It is close to a village named Andriambe, and the correct spelling (Andriambe or Andriabe) is uncertain. At this locality, about 80% of the forest was burned during our visit in 2003, and *Mantella* specimens were found in remains of the forest areas devastated by fire were it used holes in fallen logs as refuges. They were of bright orange-red ground color and with a variable pattern, some individuals of largely uniform colour reminding *M. milotympanum,* others with black flanks, reminding *M. crocea.* A further species occurring at this site is *Mantella baroni* which was here massively collected for the pet trade at the time of our survey (and was erroneously known among collectors as *Mantella cowani*).

Andaingo: This site was visited by D. R. Vieites, F. Rabemananjara, B. Razafimahatratra and P. Bora in February 2004, and was published as "North of Fierenana" by Chiari et al. (2004). We here assign the name Andaingo to this site based on a nearby village, located about 12 km west of the site. The site is located near a stream flowing through the forest. Forest at this locality is dense but some fragments are cut for cultivation.

Mandrevo Amboa: This site was identified by O. Jovanovic, H. Kurrer and R. Dolch in February 2007. It is inhabited by red coloured individuals similar to *M. milotympanum*. This site is located near a forest fragment, in a marshy valley near rice fields.

Savakoanina: This site was visited by B. Razafimahatratra and P. Bora in February 2003 and published by Chiari et al. (2004). It consists of primary forest that is significantly degraded, with a clear stream about 50 cm deep and 2 to 3 m wide. Specimens here are uniformly colored with black tympanum, and with some specimens tending towards light orange-yellow and others towards greenish ground color. They were numerous during the survey. This site is also used for commercial collecting by inhabitants of Fierenana village.

Discussion

Not considering duplicate entries, our list contains a total of 34 localities which all have been identified after 1990, most of them after 2000. Of these, 16 localities refer to *Mantella aurantiaca,* nine to *M. crocea,* four to *M. milotympanum* and five to *M.* cf. *milotympanum*. However, this apparent large number of *Mantella aurantiaca* populations is somewhat biased; in fact, seven of the 16 localities are in close proximity to other sites and therefore may not be counted as separate populations (Ambakoana 2, Andranomena which is close to Andranomandry, Analamay 2 and 3, and Torotorofotsy 4, 5 and 6).

Of the total of 34 localities, only 13 had been previously reported in publications and 21 new sites are listed herein. We are convinced that more unrecorded localities for these species exist. Especially populations assignable to *Mantella crocea* may occur in the large area between Andaingo and Zahamena, and possibly even north of Zahamena. However, considering the high rate of forest destruction along the borders of the main eastern rainforest blocks, many of these populations are to be expected in small fragments threatened by logging and slash-and-burn agriculture.

For *M. aurantiaca* almost all sites inventoried are found in the south part of the river Mangoro. Only the site Ambakoana is situated on the western bank of this river, indicating that the river in this area (its upper course) does not represent a barrier that small frogs could not cross. For *M. crocea*, the majority of the surveyed sites are found on the band of the east forest with the exception of Ambohitantely which is situated along the central highland (Ankazobe) in the Antananarivo province and also the only protected by laws in force (Réserve Spéciale d'Ambohitantely). *M. milotympanum* (including specimens preliminarily assigned to this species), occurs in a rather restricted area north of the distribution area of typical *M. crocea* populations. The identity of populations further north (at Zahamena), here assigned to *M. crocea,* cannot be verified at present.

All localities of *M. aurantiaca* are in partly degraded habitat and many of them are in small forest fragments that suffer from strong anthropogenic pressure. The Torotorofotsy populations are legally protected because this marsh area is a Ramsar site, and one locality may occur just within the boundaries of Mantadia National Park, but all other populations live outside of protected areas. *Mantella crocea* is found within the Special Reserve of Ambohitantely, and may also occur within the boundaries of Zahamena reserve. All localities of *M. milotympanum* are unprotected.

New conservation efforts should assess how the small forest parcels containing the populations of these restricted-range species could be protected.

Acknowledgements. For assistance during our surveys we thank the Director and all the members of the «Association Culturelle Communication et Education » (ACCE) of Moramanga (Association Arongam-panihy), the Head of the Department for Forest Resources in the Moramanga region, the Head of the District, and the Mayors of Morarano and Amboasary Gara, as well as other institutions that insure the security in these areas, local guides and the local population, and all that have contributed to obtain the data summarized here. For field companionship we thank Rainer Dolch, Hellmut Kurrer, Liliane Raharivololoniaina, Edouard Randriamitso, Tokihery Razafindrabe, Goran Safarek, Ildiko Somorjai, David R. Vieites and Cindy Woodhead. Special thanks go to Euan Edwards for his continued support and his help to obtain informations from local *Mantella* collectors. The Malagasy authorities are acknowledged for issuing research permits. We are grateful to Pierre Berner and the environmental department of the Ambatovy Project for logistic support and the permit to use coordinates from their site.

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