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## Malagasy poison frogs in the pet trade: a survey of levels of exploitation of species in the genus *Mantella*<sup>#</sup>

### ABSTRACT

Malagasy poison frogs of the genus *Mantella* are small, colourful amphibians that are in high demand for the pet trade. *Mantella aurantiaca* was included in CITES Appendix II in February 1995 and the whole genus in 2000. CITES annual report data indicate reported exports of about 230,000 specimens from 1994 to 2003. The reported trade in the most prominent species, *M. aurantiaca*, increased sharply from 1996 to 1998, with more than 30,000 specimens exported in 1998, but dropped after the implementation of an unofficial quota system in Madagascar. Limited information exists on their distribution, habitat preferences and impacts from potential threats, such as harvesting for commerce, and several species are currently listed as Critically Endangered. Based on field surveys of the trade network, the benefits obtained by local collectors were low (equivalent to 0.05-0.2 US\$ per specimen), with usually 100-300 frogs collected per day. Intermediaries sell the frogs to the exporters, who in turn obtain international prices of 2-4 US\$ per specimen, with wholesale prices in the USA and Europe of 5-20 US\$ (current retail in 2005, up to 40 US\$). Due to their probably high population densities and presumably high reproductive potential, it might be possible to exploit some, but probably not all, of these *Mantella* species in a sustainable way. To reach this goal, it should be a priority to transfer the focus of the regulation system more to the local collectors and ensure that substantial benefits remain with local

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communities that should gain partial control of the actual habitat of these frogs. A system of export quotas has a further potential to avoid overexploitation of single species.

Keywords: Amphibia, CITES, *Mantella*, Madagascar, pet trade.

## INTRODUCTION

Madagascar is a biodiversity hotspot (Myers et al., 2000) that receives much conservation effort, yet concerns remain for its future due mainly to habitat destruction (Ganzhorn et al., 1997; Green & Sussman, 1990). Deforestation proceeds largely due to subsistence slash-and-burn agriculture and results in increasing habitat fragmentation and threats for populations of many organisms, including amphibians (Vallan, 2000, 2003; Andreone & Luiselli, 2003; Andreone et al., 2005). However, for some animal and plant groups there is also a particular concern regarding the wildlife trade (Joint Nature Conservation Committee, JNCC, 1993). Trade in wildlife can potentially offer conservation benefits through direct use values to local people (Norman, 1987; Bodmer & Lozano, 2001). However, if the trade is conducted without reference to sustainable exploitation, then the resource may potentially be endangered (Laurance & Yensen, 1991; Wolf and Konings, 2001; Schlaepfer et al., 2005).

Madagascar ratified the Convention on the International Trade in Endangered Species (CITES) in 1975 (Carpenter, 2002). All parties to the Convention are required to submit annual reports including data on transactions under the remit of the Convention. The data are compiled in the CITES Trade Database managed by the United Nations Environment Programme World Conservation Monitoring Center (UNEP-WCMC). These trade data can be used to help understand the dynamics of the global animal trade and the conservation and economic consequences of governance changes. However, detailed studies exist for only a limited number of Malagasy flora and fauna, such as chameleons (JNCC, 1993; Brady & Griffiths, 1999; Carpenter, 2002; Carpenter et al., 2004, 2005; Carpenter & Robson, 2005), geckos (Affre et al., 2005), tortoises (Walker et al., 2004), aquaculture (EarthTrends, 2003), and medicinal plants (Randimbivololona, 1996).

Almost all the Malagasy poison frog species included in the genus *Mantella* (Fig. 1) have apparently been recorded in high numbers in the trade, as stressed by a certain amount of “gray literature” (e.g., BIODIV, 1992, 1993, 1996; Ferraro & Ramandimbison, 1994; Ramanamanjato et al., 1994, Jenkins & Rakotomanampison, 1994; Jenkins, 1994; Louys & Rajaona, 1994; Ramilison et al., 1996; Rakotomavo, 2000).

However, these unpublished reports have suffered from a lack of taxonomic consistency, reflected in various names being used for the same species and incomplete trade data. Recent morphological and genetic studies have clarified *Mantella* systematics (Vences et al., 1999, 2004; Schaefer et al., 2002; Chiari et al., 2004), while the inclusion of *Mantella aurantiaca*, in 1995, and of all *Mantella* spp., in 2000, on CITES Appendix II, now permits more consistent monitoring



Fig. 1. Currently recognized species in the genus *Mantella* (except for *M. aurantiaca*, shown in Fig. 6). (a) *M. betsileo*, Kirindy. (b) *M. ebenau* (previously considered as *M. betsileo*) from Nosy Faly. (c) *M. expectata*, specimen without precise locality information. (d) *M. viridis*, Montagne des Français. (e) *M. manery*, Marojejy. (f) *M. laevigata*, Marojejy. (g) *M. bernhardi*, Mangevo, Ranomafana National Park. (h) *M. baroni*, near Vohiparara, Ranomafana National Park. (i) *M. cowani*, Antoetra region; (j) *M. haraldmeieri*, Manantantely. (k) *M. nigricans*, Marojejy. (l) *M. crocea*, near Moramanga/Andasibe, without precise locality information. (m) *M. milotympanum*, Fierenana. (n) *M. madagascariensis*, near Vohiparara, Ranomafana National Park. (o) *M. pulchra*, An'Ala near Andasibe. All photos by F. Glaw and M. Vences except (i) by F. Andreone.

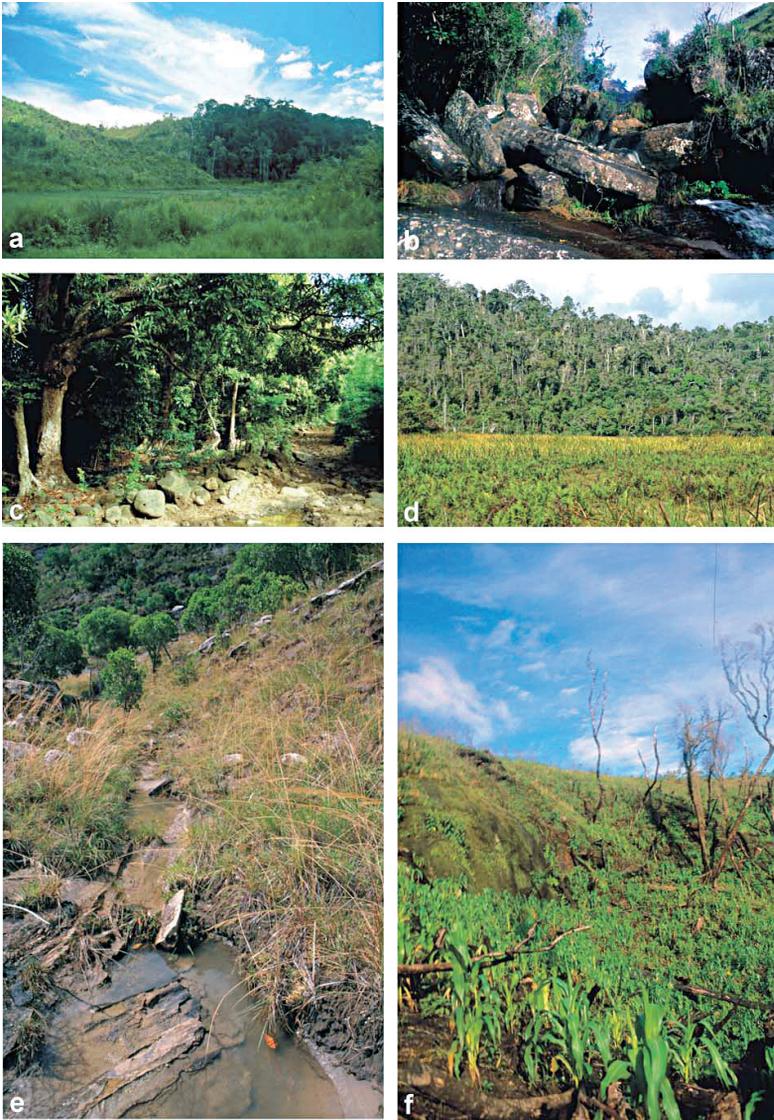


Fig. 2. Habitats of *Mantella* species. (a) Forest fragments near Tolongoina, habitat of *M. bernhardi*. (b) Stream with remains of forest at Antakasina near Antoetra, habitat of *M. cowani*. (c) Habitat of *M. viridis* in northern Madagascar. (d) Forest surrounding large swamp at Ambohimanarivo north of Moramanga, habitat of *M. crocea*. (e) Small stream at Malaso, Isalo region, habitat of *M. expectata*. (f) Forest destruction in *M. cowani* habitat through small-scale slash-and-burn agriculture at Ampasimpotsy near Antoetra. All photos by F. Andreone except (c) by V. Mercurio and (d) by M. Vences.

of the numbers traded. At present, five species are listed as critically endangered (*M. aurantiaca*, *M. cowani*, *M. expectata*, *M. milotympanum*, and *M. viridis*), two endangered (*M. bernhardi* and *M. crocea*), three vulnerable (*M. madagascariensis*, *M. pulchra*, and *M. haraldmeieri*), one near threatened (*M. laevigata*), three of least concern (*M. baroni*, *M. betsileo*, and *M. nigricans*), and one as data deficient (*M. manery*) (The World Conservation Union, IUCN, 2004; Andreone et al., 2005), add: “but in a separate in this same volume (Andreone et al., 2008), change in these categories for *M. expectata* and *M. viridis* are being proposed. A further species, *Mantella ebenau*, has only recently been resurrected from the synonymy of *M. betsileo* (Glaw & Vences, 2006). At the time of analyzing the data for the present paper, it had not yet been classified in any threat category, and it is not further considered here.

The present paper provides data on the reported numbers of species and individuals of *Mantella* traded as well as the structures operating in the trade of *Mantella*. A review of the numbers encountered in the trade and the collection network structures in operation can provide a basis to identify and promote potential conservation benefits from the trade. For example, the exports of *M. aurantiaca* prior to 1994 generated an income of more than 100,000 US\$ per year (Food and Agriculture Organization of the United Nations, FAO, 2003), which is a relevant value considering that per capita income in Madagascar remains low (\$234 in 1998) and 72.3% of the population is under the poverty line (FAO, 2000).

## METHODS

Interviews were carried out between July 2003 and April 2004 by N. Raminosoa (NRR), F. Rabemananjara (FR) and P. Bora (PB) using the “Méthode d’Analyse Rapide et de Planification Participative” (MARP) (Groupe Urgence Réhabilitation Développement, Groupe URD 2002) to the following stakeholders: (1) local collectors, (2) intermediaries, and (3) exporters. These levels of actors were the same as recorded by Carpenter et al. (2005). A fourth level of stakeholders was also interviewed, that of local authorities including the regional agents of the authorities for environment, waters, and forests (Ministère de l’Environnement, des Eaux et Forêts, or “MinEnvEF”). Exporters were asked their purchase and selling prices, the quantities bought, and whether held in stock or sold directly upon capture only, as well as packaging and shipping methods. Intermediaries were asked the structure of the trade network, the species and numbers harvested, purchase and selling prices, and the level to which revenue from the trade contributed to their household economy. Collectors were asked the collection methods, collection periods, frequencies, species harvested, selling prices, and the amount of time assigned to collecting compared with their principal activity. Interview data were corroborated by repeated surveys at many sites in each region that recorded a certain *Mantella* species.

A total of 105 stakeholders throughout Madagascar were orally interviewed. Tab. I and Fig. 3 provides locality names, coordinates, period of interviews and the

species discussed with interviewees. Several of the localities are also known under different toponyms and quoted as such in different research papers. Ampasimpotsy is also known as FarihimaZava or Farimazava, Soamantsaka is also known as Soamazaka or Soamahazaka, Vohitsokina is also known as Vohisokina (or Fohisokina), and An'Ala is also known as Andohan'i Sity.

Area	Locality	Coordinates	Periods	Species concerned
Andranomandy	Andobo	19°02.373'S, 48° 10.576'E	21 - 25/01/2004	<i>Mantella aurantiaca</i>
			17 - 21/04/2004	
An'Ala	Andohan'i Sity 1	18°55.142' S, 48° 29.257' E	30/07/2003 - 03/08/2003	
			08 - 12/01/2004	
Fanjavala	Fanjavala	19°04.019' S, 48° 17.686' E	24 - 28/08/2004	
			21 - 25/08/2003	
Antoetra	Ampasimpotsy Nord	20°50'02.4''S, 47°19'59.5''E	15 - 19/01/2004	<i>M. baroni</i>
			11 - 15/04/2004	
Antoetra	Ampasimpotsy Sud	20°50'08.2''S, 47°19'57.6''E	28 - 31/07/2003	
			05 - 08/12/2003	
Ranomafana	Mangevo Menavava River	21°23'14.8''S, 47°27'22.8''E	24 - 28/02/2004	
			14 - 18/08/2003	
Ranomafana	Mangevo Farihy	21°23'01.6''S, 47°27'56.8''E	10 - 13/12/2003	
			14 - 18/08/2003	
Tolongoina	Forêt de Kirenabe	21°28'35.8''S, 47°33'10.2''E	10 - 13/12/2003	<i>M. bernhardi</i>
			16 - 19/12/2003	
Tolongoina	Lavadia	21°28'46.9''S, 47°33'30.6''E	18 - 22/03/2004	
			20 - 24/08/2003	
Ankarana	Ankadirano	12°58.481'S, 49°07.328'E	16 - 19/12/2003	
			18 - 22/03/2004	
Kirindy	Rivière Kirindy	20°04'34.8''S, 44°40'30.0''E	10 - 14/09/2003	<i>M. betsileo</i>
			02 - 05/12/2003	
Isalo	Andrehitogna	22°32'19.1''S, 45°24'39.9''E	06 - 10/03/2004	
			02 - 06/09/2003	
Antoetra	Soamantsaka	20°44'52.0''S, 47°17'42.6''E	12 - 16/01/2004	<i>M. cowani</i>
			01 - 06/04/2004	
Marovoay Gara	Vohitsokina	20°42'18.9''S, 47°17'14.1''E	05 - 08/12/2003	<i>M. crocea</i>
			27/02/2004	
Isalo	Ilakaka region	22°37'08.9''S, 45°21'40.7''E	05 - 09/02/2004	<i>M. expectata</i>
			27 - 31/03/2004	
Tolagnaro	Manantantely	24°59'14.8''S, 46°55'33.3''E	02 - 06/09/2004	
			12 - 16/01/2004	
Marojejy	Camp Mantella	14°26.333' S, 49°46.566' E	01 - 06/04/2004	<i>M. haraldmeieri</i>
			13 - 18/04/2004	
Fanjavala	Fanjavala	19°04.019' S, 48° 17.686' E	16 - 18/09/2003	
			26 - 29/01/2004	
Fierenana	Sahamarolambo	18°32.378'S, 48°26.728'E	19 - 21/04/2004	<i>M. milotympanum</i>
			25 - 29/09/2003	
Anjanaharibe Sud	Andranomenabe	14°44.543'S, 49°23.617'E	19 - 23/12/2003	<i>M. laevigata</i>
			19 - 23/03/2004	
Marojejy	Camp Marojejia	14°25.948'S, 49°45.588'E	21 - 25/08/2003	<i>M. madagascariensis</i>
			15 - 19/01/2004	
An'Ala	Andohan'i Sity 2	18°55.173'S, 48°29.603'E	11 - 15/04/2004	
			14 - 18/08/2003	
Antongombato	Antongombato	12°22.962'S, 49°13.496'E	29/01/2004 - 02/02/2004	<i>M. nigricans</i>
			04 - 08/04/2004	
Montagne des Français	Montagne des Français	14°25.948'S, 49°45.588'E	18 - 22/09/2003	<i>M. pulchra</i>
			13 - 17/03/2004	
Montagne des Français	Montagne des Français	14°25.948'S, 49°45.588'E	25 - 29/09/2003	<i>M. viridis</i>
			19 - 23/12/2003	
Montagne des Français	Montagne des Français	14°25.948'S, 49°45.588'E	19 - 23/03/2004	
			19 - 23/03/2004	

Tab. I. Sites of interviews in the local level with locality names, periods and species concerned. The people interviewed are those closest to the species locality. Localities were visited more than one time to allow the survey of local people activities in each period.

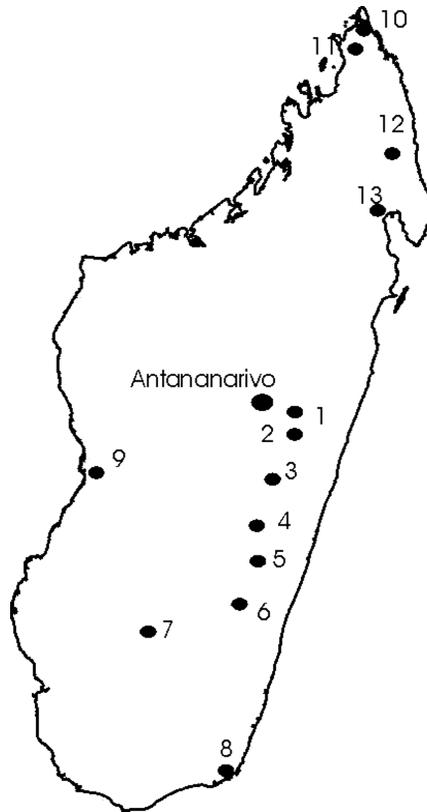


Fig. 3. Sites for interviews at national level located in Antananarivo; and at local level in Moramanga (1), Andranomandry and Fanjavala (2), Antoetra (3), Ifanadiana (4), Tolongoina (5), Andringitra (6), Isalo (7), Manantantely (8), Morondava and Kirindy (9), Antsiranana (Montagne des Français and Antongombato) (10), Ankarana and Nosy Be (11), Andapa (12), and Maroantsetra (13).

Trade data for *Mantella* were compiled from the UNEP-WCMC CITES database on 2 May 2005 and represent the reported net imports and exports recorded by trading states. Data were also obtained from the Malagasy CITES Management Authority, the MinEnvEF, for reported exports between 1988 and 2003. Price data were collected during interviews with the stakeholders, while retail prices were extracted from available price lists. The taxonomy of several species (*M. baroni*, *M. cowani*, *M. haraldmeieri*, *M. pulchra*) was not stable over the period surveyed, and therefore, some caution is required over the numbers reported. For example, *M. nigricans* was originally reported as “*Mantella veronica*” in the database, which is a nomen nudum (Vences et al., 1999).

A certain number of *Mantella* exports per year are for scientific purposes, such as taxonomic studies and biodiversity surveys. These dead preserved specimens or tissue samples are included in the surveyed numbers and we are currently unable to precisely quantify them. However, we are confident that the number of specimens exported for scientific purpose is small enough to be considered insignificant in terms of resource exploitation.

## RESULTS

### *Species and volumes recorded*

The number of *Mantella* reportedly exported from Madagascar totals 233,893 individuals between the periods 1994 to 2003 (Tab. II). Despite the uncertainties over taxonomic assignment, the data highlight a great increase in the number of species of *Mantella* reported as involved in the trade, from one in 1994 to 14 known species in 2002/2003. This increase in species is largely due to the fact that there was no legal requirement before 2000 to report trade in species other than *M. aurantiaca* to CITES, and our anecdotal observations in 1991 and 1994-1996 indicate that already at that time many *Mantella* species were in the trade. Indeed, most species of *Mantella* described in the 1980s and 1990s (*M. bernhardi*, *M. crocea*, *M. expectata*, and *M. viridis*) had initially been collected for the trade, and the type specimens were supplied by exporters. The number of recorded individuals also increased during this period to over 21,000 in 2003, with peaks in 1998 of over 38,000 and 2001 of over 50,000 individuals being traded. Since only *M. aurantiaca* was CITES listed from 1995-2000, the actual trade figures may have been higher and the peak in 2001 be an artifact caused by the need of declaring all *Mantella* exports after the inclusion of all species on CITES Appendix II in 2000.

In 1999, a sudden decrease in the number of species involved in the trade was observed. These variations were probably due to changes in national governance in Madagascar, and in international regulations, as mentioned for the trade of chameleons (Carpenter et al., 2004).

*M. aurantiaca* accounts for approximately 50% of the total number of individuals reported as traded between 1994 and 2003 (Tab. II). Although this may partly due to the fact that other species were not CITES listed and their exports had not to be declared prior to 2000, it probably also reflects an actual emphasis on this species which still today is the most prominent and well-known *Mantella* species among hobbyists in Europe and North America. The second most traded species are the complex *M. baroni-madagascariensis-pulchra* (approximately 19%). This group contains several species with very similar colour patterns that have probably led to confusion over the species actually being traded by collectors and exporters (Vences et al., 1999). In fact, in the past the highest proportion of specimens exported as *M. madagascariensis* were actually *M. baroni* and *M. pulchra* (Glaw F. & Vences M., personal observation). However, the reliability of the trade data is likely to

improve in the future as new identification guides become available (e. g. Jovanovic et al. 2007, Glaw & Vences 2007).

Nevertheless, the export files for the years 2001-2003 (Table II), since the listing of *Mantella* on CITES Appendix II, are to be considered as reliable and corroborate that thousands of specimens were exported each year. Although the values only report the legally exported specimens, we do not expect the actual exported numbers to be much higher during this time. Smuggling is unlikely to take place at a large scale in species of rather low commercial value such as *Mantella*, contrary to what may happen in species of higher value and that are less fragile for transport, such as tortoises.

Species	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	TOTAL	%
<i>Mantella</i> spp.	0	0	0	230	620	200	6760	9853	1420	1291	<b>20374</b>	8.71
<i>M. aurantiaca</i>	100	11965	16693	17406	31941	8850	11445	10335	4780	2681	<b>116196</b>	49.68
<i>M. baroni</i>	0	0	0	0	0	0	0	0	10	650	<b>660</b>	0.28
<i>M. bernhardi</i>	0	0	0	0	0	30	490	1005	650	60	<b>2235</b>	0.96
<i>M. betsileo</i>	0	0	0	1000	435	175	150	4040	1215	1465	<b>8480</b>	3.63
<i>M. cowani</i>	0	0	0	0	52	150	425	975	1520	500	<b>3622</b>	1.55
<i>M. crocea</i>	0	0	0	0	395	250	1157	1750	630	100	<b>4282</b>	1.83
<i>M. expectata</i>	0	0	0	100	624	105	1260	1790	2585	1100	<b>7564</b>	3.23
<i>M. haraldmeieri</i>	0	0	0	0	0	0	240	310	380	350	<b>1280</b>	0.55
<i>M. laevigata</i>	0	0	0	100	435	415	2537	2795	1170	1581	<b>9033</b>	3.86
<i>M. madagascariensis</i>	0	0	0	125	2182	1535	6195	8805	5945	4848	<b>29635</b>	12.67
<i>M. milotympanum</i>	0	0	0	0	0	0	0	0	1270	1780	<b>3050</b>	1.30
<i>M. nigricans</i>	0	0	0	100	200	0	155	490	80	0	<b>1025</b>	0.44
<i>M. pulchra</i>	0	0	0	0	784	905	3277	4430	2990	2560	<b>14946</b>	6.39
<i>M. viridis</i>	0	0	0	125	690	385	1951	3825	2495	2040	<b>11511</b>	4.92
<b>TOTAL</b>	<b>100</b>	<b>11965</b>	<b>16693</b>	<b>19186</b>	<b>38358</b>	<b>13000</b>	<b>36042</b>	<b>50403</b>	<b>27140</b>	<b>21006</b>	<b>233893</b>	<b>100</b>

Tab. II. Export of *Mantella* between 1994 and 2003 from Madagascar as reported in the UNEP-WCMC trade database (date collated on 2 May 2005). The species *M. baroni*, *M. cowani*, *M. haraldmeieri*, *M. madagascariensis*, and *M. pulchra* have gone through stages of profound taxonomic rearrangements between 1991-1999, and they have been largely confounded also in the pet trade. The trade figures of these species therefore need to be viewed with extreme caution. In addition, most of the zero values refer to cases in which no data were available (especially for the years 1994-1996) or different names were used in the trade (especially for the names *M. baroni* and *M. milotympanum*).

The data show that high levels of *M. aurantiaca* were exported between 1996 and 1998, peaking in 1998 with 31,941 individuals, although this certainly includes some *M. milotympanum* traded as *M. aurantiaca*. Exports of *M. aurantiaca* decreased on 2002 and 2003 when a quota system came into force. In this system, the Malagasy authorities decide, for each species, quotas of maximum numbers of individuals per year for which export permits will be issued. For example, the quota for *M. cowani* is currently (since 2005) set to

zero for commercial exports, due to the critical status of this species. Since 1999, all *Mantella* species in addition to *M. aurantiaca* were present in the trade with the exception of *M. manery*. *M. aurantiaca* numbers progressively decreased while those of the complex *M. madagascariensis-baroni-pulchra* increased (Tab. II).

Several unpublished reports have provided numbers of Malagasy poison frogs in the trade. These data have often been used in previous conservation decisions in Madagascar. Tab. III summarizes these data, which provide higher numbers than those reported in the UNEP-WCMC database (a total of 275,576 exported specimens between 1988 and 2003).

Species	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
<i>M. aurantiaca</i>	280 (6)		3237 (6)		12000 (6)		100 (8)	12110 (8)	16767 (8)	13700 (8)	26598 (6)	8599 (7)	11545 (6)	9785	570	0
<i>M. bernhardi</i>								230 (6)	10 (6)	400 (6)	2709 (6)		896 (6)	1005	650	305
<i>M. betsileo</i>			330 (6)	500 (6)						1000 (8)	1068 (6)		2677 (6)	3971	1215	1555
<i>M. crocea</i>				150 (5)			1000 (4)				1608 (6)		4049 (6)	3633	1830	1025
<i>M. cowani</i>			5094 (2)	3045 (2)				3732 (3)					1723 (6)	963	1320	170
<i>M. expectata</i>										100 (8)	1115 (6)		1730 (6)	4398	2385	1785
<i>M. haraldmeieri</i>													506 (6)	310	380	280
<i>M. laevigata</i>				100 (6)						100 (8)	1505 (6)		4003 (6)	2875	1170	2368
<i>M. madagascariensis</i>				525 (6)						125 (8)	8626 (6)		11668 (6)	9560	5800	6238
<i>M. milotympanum</i>													650 (6)	800	1260	3115
<i>M. nigricans</i>										100 (8)	200 (8)		335 (6)	2	0	175
<i>M. pulchra</i>											1958 (6)		5896 (6)	4047	3290	2890
<i>M. viridis</i>			1470 (1)	3000 (2)				2055 (3)		125 (8)	515 (8)		4167 (6)	3910	2395	2415
<b>TOTAL</b>	<b>280</b>		<b>10131</b>	<b>7320</b>	<b>12000</b>		<b>1100</b>	<b>18127</b>	<b>16777</b>	<b>15650</b>	<b>45902</b>	<b>8599</b>	<b>49845</b>	<b>45259</b>	<b>22265</b>	<b>22321</b>

Tab. III. Compilation of information on numbers of *Mantella* specimens exported from Madagascar in the period 1988-2003 as reported in "gray literature" sources. Data were compiled from various unpublished reports, mainly from Rakotomavo (2000), who himself referred to the following unpublished sources without providing complete references: (1) Biodev 1992 1991; (2) Biodev 1993; (3) Biodev 1995; (4) Ferraro & Ramandimbison 1994; (5) Biodev, without precise date; (6) data from the MinEnvEF. Furthermore, data are included from (7) a report of the University of Antananarivo (Département de Biologie Animale) from 2001, and (8) from the IUCN-SSC Wildlife Trade Program. The data for 2001-2003 are from the CITES reports of the Malagasy government. In the case of contradicting information, we chose the source that reported the highest numbers. See caption to Table II regarding taxonomic uncertainties. Since *M. baroni* was not quoted in any of the reports due to taxonomic confusion with *M. madagascariensis*, it is not included in the table.

The discrepancy between data sets can be afforded, in part, to the fact that re-exports were reported as greater than the original imports for certain countries or years (Tab. IV), especially for 1995 to 1998 and 2000 to 2002. These refer to specimens shipped from Madagascar to a certain country but then, often immediately, re-exported into another country. A further caveat in the interpretation of the numbers from the various data sources is that until

recently, Madagascar reported the number of specimens for which CITES documents were issued, not the number of actually exported specimens, which may have been lower in some cases. On the other hand, due to relatively high mortalities during transport to exporters, and especially in the farms and animal keeping facilities of some exporters in the past (Glaw F., Vences M. & Andreone F., personal observations), we estimate that up to 50-100% more *Mantella* individuals were collected from the wild than were actually exported.

Country	Imp. Quantity	(Re-)Exp. Quantity	Total	% of Imp. Quantity	% of Total Trade
Austria	0	120	120	0.00	0.04
Bangladesh	0	400	400	0.00	0.12
Belgium	6200	3480	9680	4.46	2.97
Canada	6320	5410	11730	4.55	3.60
Switzerland	2646	2716	5362	1.90	1.65
Czech Rep	70	190	260	0.05	0.08
Germany	7212	6510	13722	5.19	4.21
Denmark	868	540	1408	0.62	0.43
Spain	1425	1302	2727	1.03	0.84
France	3090	3780	6870	2.22	2.11
Great Britain	1499	2800	4299	1.08	1.32
Hong Kong	0	670	670	0.00	0.21
Hungary	0	130	130	0.00	0.04
Indonesia	10	100	110	0.01	0.03
Italy	270	850	1120	0.19	0.34
Japan	2682	6690	9372	1.93	2.88
Mauritius	0	120	120	0.00	0.04
Malaysia	0	102	102	0.00	0.03
Netherlands	7577	5905	13482	5.45	4.14
Philippines	0	10	10	0.00	0.00
Reunion	0	10	10	0.00	0.00
Russian Federation	0	16	16	0.00	0.00
Slovak Rep	50	90	140	0.04	0.04
El Salvador	0	1380	1380	0.00	0.42
Thailand	450	1070	1520	0.32	0.47
Taiwan	0	30	30	0.00	0.01
United States	98641	142094	240735	70.96	73.91
South Africa	0	200	200	0.00	0.06
<b>TOTAL</b>	<b>139010</b>	<b>186715</b>	<b>325725</b>	<b>100</b>	<b>100</b>

Tab. IV. Number of individuals imported and re-exported for trade purpose per country between 1994-2003 according to the UNEP-WCMC database (collated on 2 May 2005). See caption to Table II regarding taxonomic uncertainties.

### *The trade network structure*

Collectors were local peasant people with a good knowledge of their local fauna and flora. They traded in *Mantella* species present in their locality or, for more specialized collectors, traveled to sites for the purpose of collecting. About half of the collector positions were occupied by family fathers. Younger

collectors and women who occupied collector positions were mostly affiliated with the same family as the principal collector. The number of collectors varied according to the international demands from the trade. Collections of specimens were mainly made during the wet season, often after the period of rice harvesting.

The next level in the export network is constituted by the intermediaries. Unlike the local collectors, these stakeholders are solely involved in the wildlife trade. They are equipped with mobile phones to permit quick communication. They are located across different provinces of Madagascar and usually have stable homes and a family. Several intermediaries are concentrated in the Moramanga area, not far from the Malagasy capital Antananarivo.

During the period 2003-2004, there were 17 accredited animal exporters in Madagascar, based in both Antananarivo and Toamasina. For most exporters, if not all, animal and plant export is the main source of income. Exporters usually place specific orders with an intermediary, which includes margins of at least 5-10% higher than the actual needs of the exporter to account for mortality during transport. The intermediaries then travel to the main areas of collection, obtain specimens from the local collectors and either transport personally or ship the consignment to the exporters in Antananarivo. Often after a short period, exporters ship the consignment of specimens by airfreight to their destinations in America, Europe [but currently not to the European Union (EU) due to the ban on most *Mantella*], or Asia. The distinction between local and intermediary collectors is not always a clear one. Some intermediaries do also carry out collection of *Mantella* themselves, such as *M. bernhardi*, *M. betsileo*, *M. haraldmeieri*, *M. laevigata*, and *M. viridis*, which occur in areas without a well-developed and structured collecting network. Alternatively, exporters may also choose in some cases, such as the collection localities close to main roads, to obtain specimens directly from local collectors.

Field surveys and interviews indicate that, for several species (*M. baroni*, *M. crocea*, *M. madagascariensis*, *M. milotympanum*, and *M. pulchra*), an average of five collectors work at a site, with each collecting approximately 300 individuals per day during the peak period (October through January) and 100 individuals per day during the off-peak season (February through April). Based on information gathered during interviews with local collectors, and during times of high exploitation for *M. aurantiaca* (before its inclusion on CITES Appendix II), on average 10 collectors harvested between 500-1000 individuals in peak periods and 100 during off-peak periods. In northern Madagascar about 3000-5000 *M. viridis* individuals were collected per year. Collection of *M. laevigata* and *M. nigricans* is occasional and in low numbers of individuals per year. Collecting of *M. haraldmeieri*, from Manantantely, is occasional. *M. betsileo*, a widespread species in Madagascar, is not exploited in high numbers because of its low demand. There is some trade of this species to the EU, where it is the only species that, currently, can legally be imported.

Collecting is usually carried out in the period between October and March, coinciding with the main activity and reproduction period of *Mantella* (Figs. 4-

6). Previous legal regulations restricted collecting of *Mantella* to between May and September but were not respected. In 2005, this legislation was changed, now allowing collecting during the peak season. After an order has been placed with a collector, collecting takes place, on average, one day per week during the peak season and more often during the off-peak season. Specimens are usually “delivered” within a week after the order being placed. At some localities, such as Andranomandry and Fierenana, each collector has a distinct collecting area, whilst at other sites, such as Alakambato, An’Ala, Beparasy, Fanjavala, and Marovoay, various collectors work at the same sites. Usually, upon placing an order, the exporter pays part of the money (up to 50%) to the intermediary. The intermediary uses this amount to pay the collectors and receives the balance upon delivery of the specimens to the exporter or between a week and a month after delivery.

In terms of governance, the MinEnvEF, through its General Direction (DGEEF), regulates the wildlife trade on Madagascar. Exporters need to obtain approval and be accredited by the DGEEF, which implies that they have the necessary basic infrastructures for the housing and storage of live animals. The collecting permits which the DGEEF issues to the exporters rather than to the local collectors must be renewed every 3 years. Each single consignment exported requires a further export permit from the DGEEF. These export permits need to be agreed by the Scientific Authority, which, since 2003, is



Fig. 4. Local collector searching for *M. cowani* at Soamatsaka near Antoetra, photographed in 2003. Photo by F. Andreone.



Fig. 5. Individual of *Mantella aurantiaca* from Andromena south of Moramanga, one of the areas where this species is intensively collected for the pet trade. Photographed by M. Vences in December 2001.



Fig. 6. Large numbers of *M. aurantiaca* in a cage of a commercial exporter near Antananarivo. Photo by F. Andreone.

formed by the “Département de Biologie Animale” at the University of Antananarivo. Export permits for species included on the Appendix of CITES usually have a validity of 6 months, extendable to 12 months. A schematic representation of the trade network and its legal regulation is shown in Fig. 7.

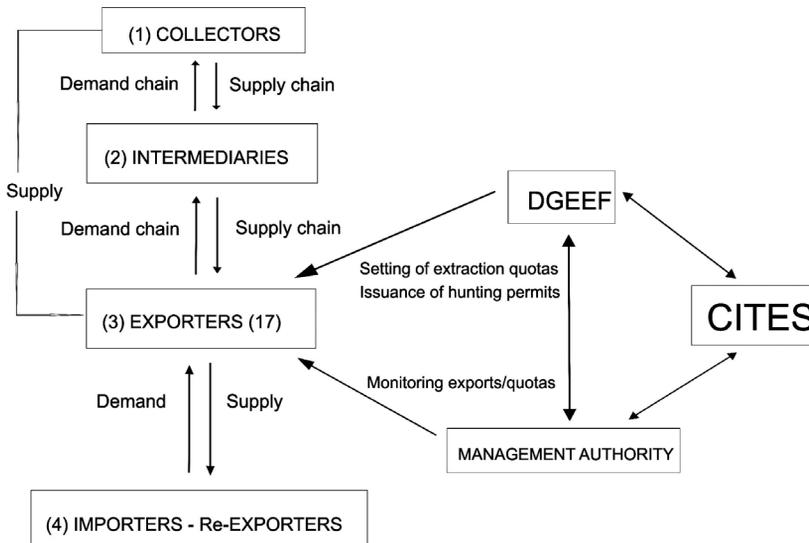


Fig. 7. Schematic flowchart representation of the network for collecting and trade in *Mantella* in Madagascar. See Results for further explanations.

#### *Trade fluctuations and revenues*

Only 5 out of 28 importing countries accounted for more than 90% of the total numbers of *Mantella* traded from Madagascar (Tab. IV). The USA (71%) was the greatest importer followed by The Netherlands (5.5%), Germany (5.2%), Canada (4.6%), and Belgium (4.5%). The levels of trade fluctuated between 1994 and 2003 due in part to governance changes (Tab. II). For example, exports to Europe dropped after a decision by the European Commission, in 2001, to suspend all commercial importation of *Mantella*, except for *M. betsileo*. The trade in wildlife can generate enormous commercial benefits. However, this is not necessarily the case for *Mantella*, due to their lower prices, compared with chameleons, for example.

To some degree, captive-bred animals are traded, especially in the EU where the import of wild-caught specimens of most *Mantella* species is banned. However, we

estimate that this applies only to a small percentage of the traded individuals. Our surveys in Madagascar also provided no evidence for any successful farming of *Mantella* in that country; such a process (rearing of captive-bred individuals in the country of origin) is extremely laborious, especially at the stage of metamorphosed froglets (Glaw et al., 2000), compounding the difficulty of any attempts to captive-breed these frogs commercially.

Table V summarizes the prices paid for individuals of *Mantella* at different levels of the trade network. When no price at the level of collector is given, the specimens are both collected and delivered by the intermediary.

Considering the high number of individuals exported, the trade in *Mantella* constitutes a relevant factor of foreign currency revenue. A calculation based on numbers of exported specimens and mean export prices estimates a total of almost 250,000 US\$ for merely 3 years of low-to-moderate export activities (2001-2003) (Table VI).

Species	Collectors (FMG)	Intermediary (FMG)	Export (US\$)	Retail abroad (US\$)
<i>M. aurantiaca</i>	400 – 500	1000 – 1500	2 – 3	6 – 12
<i>M. baroni/madagascariensis</i>	300 – 500	750 – 1500	2 (3)	5 – 15
<i>M. bernhardi</i>	no data	4000 – 6000	2 – 3	5 – 19.5
<i>M. betsileo</i>	250 – 500	1000	2 (3)	5 – 5.2
<i>M. cowani</i>	1000 – 2000	4000 – 6000	4	6 – 19.5
<i>M. crocea</i>	300 – 500	1000 – 1500	2 (3)	6 – 6.5
<i>M. expectata</i>	1000 – 2000	4000 – 6000	2 – 3 (4)	7.8 – 15
<i>M. haraldmeieri</i>	1000	4000	3	5
<i>M. laevigata</i>	250 – 500	1500	2 (3)	5 – 7.8
<i>M. milotympanum</i>	300 – 500	1000 – 1500	2 – 3 (4)	6.5
<i>M. nigricans</i>	no data	5000	2	10.4
<i>M. pulchra</i>	300 – 500	700 – 1000	2 (3)	5 – 15
<i>M. viridis</i>	no data	4000	2	5 – 6.5

Tab. V. Prices paid for individual specimens of *Mantella* at different levels of the trade network in 2003-2004. Collector, intermediary, and export prices are based on results of interviews in 2003-2005. Retail prices were compiled from price lists of importers (wholesale; lower end of values) and larger retail companies (final retail in small pet stores may have been higher). Export prices in parentheses are current figures (as of May 2005), indicating the rise of prices due to restrictions caused by the unofficial quota system; at this time, retail prices per specimen in some cases were up to ca. 30-40 US\$. Exchange rate at the time of survey was ca. 1 US\$ = 6500 Franc Malagasy (FMG).

Year	2001	2002	2003	Total
Total number of individuals exported	50,403	27,140	21,006	98,549
Foreign currency generated (US\$)	126,007	67,850	52,515	246,372

Tab. VI. Global estimation of foreign currency revenue in US\$ for Madagascar from the *Mantella* trade, estimated for the 3 last years 2001 to 2003. Calculations are based on total numbers of exported specimens as given in Tab. II, and the mean (2.5 US\$) of export prices as given in Tab.V.

## DISCUSSION

The current system of regulation and control of the animal trade involves different entities (MinEnvEF, CITES Scientific Authority of Madagascar, airport customs), which are, as are the exporters themselves, based in the capital Antananarivo. If correctly implemented, this system should be effective to avoid overexploitation and control the number and identity of exported specimens relative to national and international legislation and quotas. The recent establishment, within the system, of a scientific authority, with the ability to carry out research on focal, heavily traded species and to suggest maximum quotas for the export, is a positive novelty as well. All issued documents at present (2005) state that they can only be used for an export from Ivato airport at Antananarivo. This restriction should also increase the quality of the controls, although there are still rumors of shipments leaving from Toamasina instead.

In contrast, all problems directly related to the local actors and the sites of collection totally escape from the influence of the regulation system. The fact that the collection permits are issued to the exporters instead of the local collectors, and because of the low prices paid to these per individual, this becomes counterproductive in terms of implementation of a system of sustainable harvesting in which locals would efficiently protect the natural habitat because of the economic benefit created by the collecting of animals. A system assigning control of some areas of *Mantella* habitat to local communities would enable them to demand higher prices and thereby alleviate the price bias of the trade system.

Because of the apparent high density of many *Mantella* populations (e.g., Vieites et al., 2005) and their restricted and patchy distributions, these frogs may be well-suited for a controlled system of sustainable harvesting, although the economic feasibility of such a system requires investigation. Most species of *Mantella* are characterized by a rather high reproductive output, with up to 150 eggs per clutch (Glaw et al., 2000) and probably several clutches per season based on data from captive breeding. Despite the high to very high numbers of several *Mantella* species that have been continuously exported from Madagascar over the past 15 years, for most species there has been no apparent disappearance of populations or permanent decreases in population density. Due to the lack of a standardized monitoring system, this claim is only supported by anecdotal observations, but it is in agreement with the data assembled by the Global Amphibian Assessment for Madagascar (Andreone et al., 2005), where Madagascar differed from other areas in the world in that amphibian declines due to other factors than habitat disappearance have almost not been recorded thus far. For example, we visited populations of *M. aurantiaca* and *M. milotympanum* that local collectors claimed to have heavily exploited during the past years (Vences et al., 2004; Vieites et al., 2005), but *Mantella* were still very common at these sites. A clearly different situation is that of *M. cowani*, where intensive collecting has led to the near disappearance

of some of the most accessible populations, after the main habitat of these had been destroyed (Andreone & Randrianirina, 2003). In fact, the estimated population of *M. cowani* at a site near to Antoetra was of about 50 adult animals only (personal observation of F. Andreone). However, there remain few doubts that habitat destruction is a far more severe threat for many *Mantella* populations than overcollecting, especially considering that also the international demand for these frogs is certainly not unlimited. Hence, it may become important to transfer the focus of the trade regulation more toward the sites of collection, which are usually in nonprotected areas threatened by habitat destruction. Possible local measures could consist in (1) disseminating awareness and information on the value and habitat requirements of the respective species, (2) formation and capacity reinforcement of the local forestry authorities, and (3) professionalization of the system at the level of local collectors and intermediaries, possibly by delivery of local collection permits after passing basic tests of knowledge on natural resources. However, these measures imperatively need to be implemented in a flexible way without increasing bureaucracy and hindering the trade system itself.

At the scientific level, we propose to (1) perform surveys of population persistence and density, comparatively in areas with and without commercial collecting, at 2-year intervals, (2) gather more data about the functioning of the trade network and mortality rates at the different levels, (3) implement and survey prudent maximum export quotas for *Mantella* and all commercially relevant amphibian and reptile species of Madagascar, and (4) as test cases, delimit study areas to survey the impact of different collection modes, e.g., local quotas or permits for heavy local collecting at all times except the time of peak reproductive activity of these frogs (January). The goal of these studies should, however, not be to implement further trade restrictions but to optimize the collecting system, potentially even allowing an increase of quotas once that reliable scientific evidence on the trade impact on frog populations and on tolerable quota values has been assembled. Strict control measures should become only active when irregularities or local overcollecting is suspected by conspicuous changes in the number of traded individuals per species or by declines or disappearance of populations recorded by a standardized monitoring system, or noted by casual observations.

Considering the high number of *Mantella* specimens exported, these frogs take a relevant place in the economy of Madagascar. Compared with previous years, this system currently undergoes a crisis because of the ban of imports to the EU, and a decrease of the prices at the world-wide level. The recent announcement of the Malagasy government to significantly increase the country's protected areas, together with progress of professionalizing the wildlife trade, bears the opportunity for organizing this system in a way that provides benefits to the national and local economies as well as to the conservation of species which can be sustainably harvested.

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## RÉSUMÉ

*Les grenouilles venimeuses de Madagascar dans le commerce international: une analyse des niveaux d'exploitation dans le genre Mantella.*

Les Amphibiens du genre *Mantella* de Madagascar sont des grenouilles de couleurs vives qui sont en demande très élevée dans le commerce international des animaux de compagnie. *Mantella aurantiaca* a été inclus dans l'annexe II CITES en Février 1995 et le genre entier en 2000. Le rapport annuel CITES indiquaient des exports reportés de 230 000 spécimens entre 1994 et 2003. Le commerce rapporté de l'espèce *M. aurantiaca* a augmenté abruptement entre 1996 et 1998, avec plus de 30 000 spécimens exportés en 1998, mais a diminué après l'application de quota inofficieux à Madagascar. Des informations sur la distribution, les préférences de l'habitat et des impacts de menace, comme la chasse pour le commerce, sont très limitées, et beaucoup d'espèces sont actuellement classées comme Gravement Menacée. Basée sur les études du réseau commercial, les bénéfices obtenus par les collecteurs locaux sont très bas (équivalent de 0,05-0,02 US\$ par spécimen), avec habituellement 100 à 300 grenouilles collectées par jour. Les intermédiaires vendent les grenouilles aux exportateurs qui, à leur tour obtient un prix international de 2 à 4 US\$ par spécimen, avec prix de détail de 5 à 20 US\$ (prix de détail actuel en 2005, de plus de 40 US\$). Dus à la probable densité de population et au potentiel reproductrice élevées de ces grenouilles, il serait possible d'exploiter quelques-unes, mais non pas tous, de ces espèces *Mantella* de façon durable. Pour atteindre cet objectif, il est de priorité de transférer le point focal du système de régulation plutôt au niveau des collecteurs locaux et assurer que des bénéfices substantiels soient maintenues pour les communautés locales qui devraient gagner une contrôle partielle des habitats actuels de ces grenouilles. Un système de quotas d'exportation est un autre potentiel pour éviter la surexploitation des espèces.

Mots clés: Amphibia, CITES, Madagascar, *Mantella*, Pet-trade.

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