Studies on the *Mantella viridis* amphibian for the purpose of reopening international trade in the species

EU-CITES Capacity-building project
No. S-422

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CITES Secretariat

About the EU-CITES Capacity-building project

The project *Strengthening CITES implementation capacity of developing countries to ensure sustainable wildlife management and non-detrimental trade* was approved for funding by the European Union in 2009.

A major challenge for many countries is the difficulty in meeting the requirements for trade in CITES-listed species, ranging from legal sourcing and sustainability requirements, to the effective control of legal trade and deterrence of illegal trade. Mechanisms exist in CITES and in both exporting and importing countries that promote and facilitate compliance – although Parties are often hampered by a lack of capacity or a lack of current biological or trade information with respect to certain species. This can result in levels of trade which are unsustainable, which in turn can impact on economic growth and local livelihoods, and reduce options and incentives for conserving and managing wild resources effectively.

The overall aim of EU's support is to strengthen capacities to implement the Convention and satisfy the CITES-related requirements of trading partners (such as the European Union), to prevent overexploitation and to ensure legal international trade in wild fauna and flora does not exceed sustainable levels.

This publication is one of the reports and tools developed under this project, which provide information and guidance to Parties in a particular area of concern based on needs identified by developing countries.

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FINAL REPORT

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Résumé

Mantella viridis is endemic to the northern part of Madagascar. This species is listed in CITES Appendix II and its export has been suspended since 2010. Additional information on *Mantella viridis* is required in order to reopen international trade in the species. Ten sites, including three in areas located within Madagascar's system of protected areas and others in areas managed and monitored by local communities, or in open access areas, have been visited. Two methods, namely capture-mark-recapture and observation along transect lines, have been used to study the population abundance and density. Habitat use and preference, as well as the population structure of the *M. viridis* species have been determined. The density and abundance of the species vary from site to site. While the species occurs in different forest formations, i.e. primary forest, degraded forest and plantation areas, it prefers humid places with stagnant water, or streams, normally rocky and with extensive vegetation. Most of the individuals observed are adults, with males more numerous than females. These results when compiled with those of the study carried out by Crottini and her team in 2012, showing a difference in populations of the western and eastern parts, indicate that the area of distribution of the *M. viridis* species is becoming increasingly restricted and that the collection sites identified are located on the outskirts of the protected area. Therefore, a zero quota will be maintained. A taxonomic revision of the *Mantella* populations (*M. viridis, M. ebenaui, M.* cf. *ebenaui* and *M.* cf. *viridis*) of the northern part of Madagascar and an assessment of the viability of the population of these species is required to ensure their conservation and sustainable trade.

Contents

I. Context and objectives

Madagascar is a country rich in biodiversity. It has a strong potential for international trade in wild species. Malagasy highly endemic herpetofauna is among the most traded groups. Among Malagasy amphibians, the *Mantella* genus is in great demand on the international market. Since the species is included in CITES Appendix II, this trade is regulated by the CITES Convention (Convention on International Trade in Endangered Species of Wild Fauna and Flora). Export in the *Mantella viridis* species, which is listed in the « Endangered » category on the IUCN Red List, was suspended in 2010 following a failure to implement the recommendations issued by CITES.

A study aimed at updating information concerning *Mantella viridis* has been conducted with a view to reopening international trade in the species. To this end, several objectives have been set, including:

- To collect additional data on the distribution of the species;
- To assess its conservation status in relation to the system of protected areas of Madagascar (SAPM);
- To study the size and structure of the population;
- To study habitat use and preference;
- To identify pressures on the species and its habitat;
- To determine a quota supported by a non-detriment finding (NDF).

II. Methodology

1. Species description

Mantella viridis is a small, brightly coloured amphibian which measures on average between 25 and 30 mm. Its back and flanks are yellow-green (photo 1). Its belly is black with blue spots which extend up to the throat. Its limbs are greenish and its hind legs are sometimes striped (Glaw and Vences 2007).

Photo 1: *Mantella viridis* in its natural habitat.

2. Choice of sites and study period

The chosen study sites are all located in the area of distribution of *Mantella viridis*. However, as this study is focused on the reopening of international trade in the species, the sites have been chosen in advance on the basis of the literature. The results of past research, such as that conducted by Mercurio and Andreone in 2008, and Rabemananjara and his teams in 2008, have been used to select the sites. They have been placed either in protected areas which sometimes contain least disturbed habitats where collection is formally prohibited, or in unprotected areas (degraded, plantation) where collection is authorized. This difference in the status of the sites is essential for the assessment of the conservation status of *M. viridis* in relation to SAPM (system of protected areas of Madagascar). The sites located in unprotected areas are sometimes collection sites from a historical point of view and are therefore located in accessible places.

All the sites have been numbered. The following table summarises the numbering system and gives a description of the habitat on each site, its location in relation to SAPM and the existing pressures (table 1).

Table 1: List and description of its habitat on each site.

Area	Site	Site number	Location in relation to SAPM	Description of the habitat on each site
Montagnes des Français	Andamilamy S 12° 22' 51.5'' E 49° 18' 33.7'' Altitude : 179 m	1	Within SAPM	Temporary stagnant water with aquatic vegetation. Highly disturbed gallery forest.
Montagnes des Français	Antaolanaomby S 12° 22' 17.6'' E 49° 20' 27.5'' Altitude : 283 m	2	Within SAPM	Presence of a permanent stream with rocks. Vegetation is dominated by mango trees; some remaining tree stumps of forest species can be seen.
Montagnes des Français	Andranonakanga S 12° 23' 15.3'' E 49° 19' 42.8'' Altitude : 254 m	3	Outside SAPM	Stagnant water with rocks. Vegetation is made up of a few tree stumps.
Montagnes des Français	Ambodimanary S 12° 22' 51.5'' E 49° 18' 33.7'' Altitude : 179 m	4	Outside SAPM	Stagnant water with rocks. Vegetation is dominated by mango trees; some remaining tree stumps of forest species can be seen in the gallery forest.
Ambodimanga	Ambodimanga S 12° 22' 12.9'' E 49° 17' 37.9'' Altitude : 136 m	5	Outside SAPM	Permanent stream with rocks. Vegetation is dominated by mango trees.
Montagne d'Ambre	Andohananketrabe S 12° 26' 37.4'' E 49° 12' 11.6'' Altitude : 294 m	6	Within SAPM	Permanent running water with rocks. Natural humid forests.
Antongombato	Analamanga S 12° 22' 53.2'' E 49° 13' 50.5'' Altitude : 114 m	7	Outside SAPM	Temporary running water with rocks and aquatic vegetation. Vegetation is degraded; however, there are a few mango tree stumps.
Antongombato	Andranotomendry S 12° 23' 13.5'' E 49° 13' 53.1'' Altitude : 121 m	8	Outside SAPM	Temporary streams. Vegetation is highly degraded.
Antongombato	Taninimara S 12° 23' 22.5'' E 49° 13' 43.1'' Altitude : 127 m	9	Outside SAPM	Temporary stream with rocks. Vegetation is degraded; however, there are a few mango tree stumps.
Antongombato	Analamagnondro S 12° 23' 54.7'' E 49° 13' 14.9'' Altitude : 135 m	10	Outside SAPM	Permanent running water with rocks. Vegetation is made up of shrubs.

The field study was conducted from 14 September to 10 October 2013. This period is said to correspond to the period of hibernation of the species, when it is easy to count the individuals of each population surveyed (Ramilijaona et al., 2004, Rabemananjara et al., 2008).

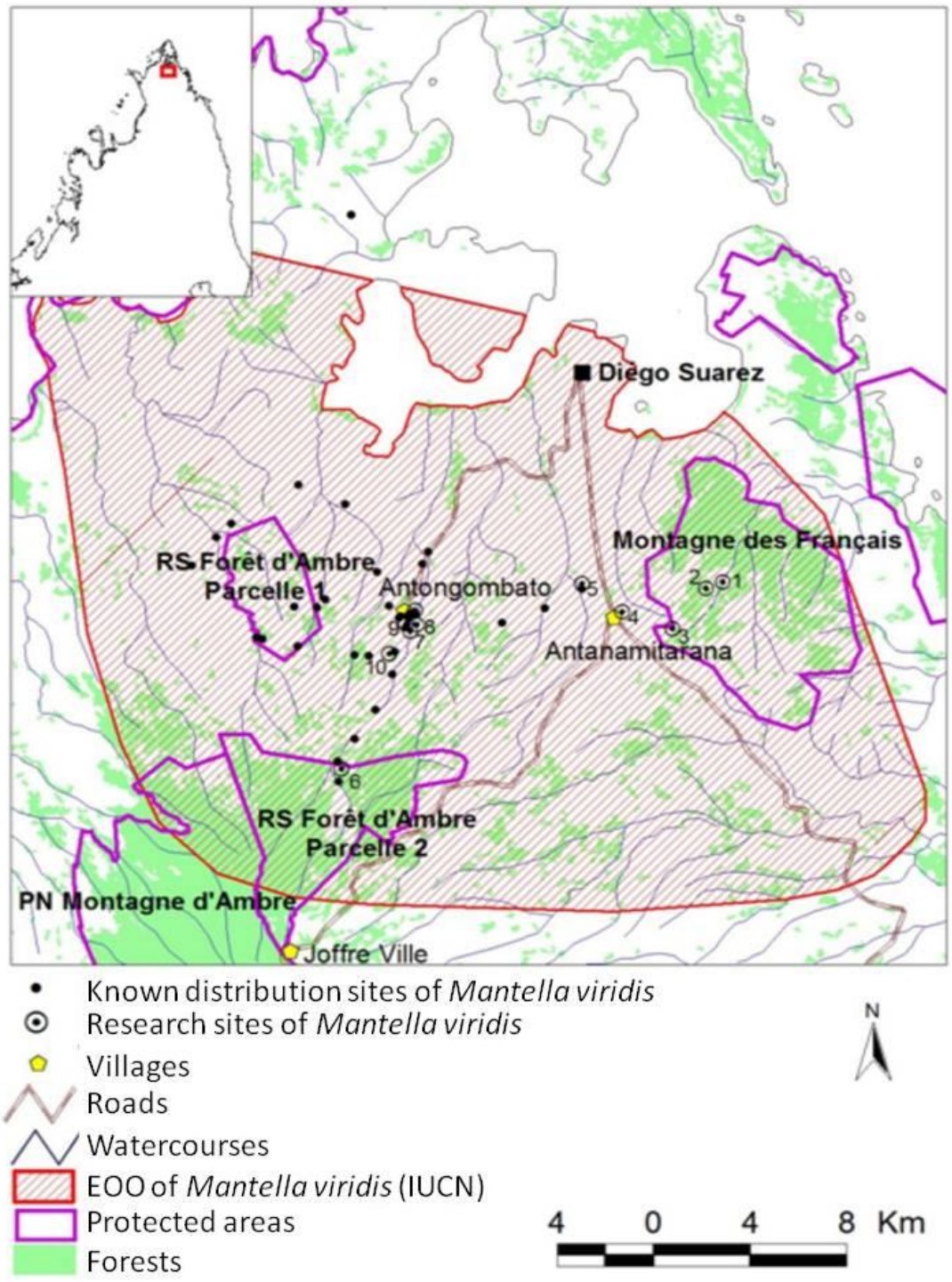
3. Field methodology

❖ Species distribution

In order to update information concerning the area of distribution of *Mantella viridis*, the study sites used for this research have been positioned within its range which is described in past literature. However, these sites are distributed among different areas, with different characteristics. Some are located in conservation areas which are part of the system of protected areas of Madagascar, while others are not. The study areas visited are, respectively: in and around Montagne des Français, Ambodimanga, the Forêt d'Ambre Natural Reserve and Antongombato, which have been identified on the basis of previous studies carried out by Mercurio and Andreone in 2008 and by Rabemananjara et al., in 2008. Geographic coordinates of these areas as well as those of each research site have been recorded.

❖ Distribution of research sites in relation to SAPM

Ten research sites have been selected in the four study areas (map 1). Three of them are located within SAPM: Andamilamy (1), Antaolanaomby (2) and Andohananketrabe (6), and the seven others are outside SAPM : Andranonakanga (3), Ambodimanary (4), Ambodimanga (5), Analamanga (7), Andranotomendry (8), Taninimara (9) and Analamagnondro (10).



Map 1: *Mantella viridis* research sites.

❖ **Study of *Mantella viridis* populations**

The size of each population found on the sites was estimated using the capture-mark-recapture method and the transect method in order to estimate relative abundance.

The capture-mark-recapture method was applied in quadrats. The sites were visited on a daily basis and each quadrat was visited at least four times. Each quadrat was searched for 15 minutes by four people, i.e. a total effort of one hour per visit. Every individual sighted for the

first time was captured, marked then released at the same place. The marking method adopted: a "raffia" thread was tied around the pelvic girdle of each individual (photo 2). During each visit to the quadrat, all previously marked individuals (caught recapture) and unmarked individuals (capture) were counted. The density of the population found on each site was estimated on the basis of the number of individuals detected and the surface area visited on the site. The result obtained was extrapolated in hectares. The number of individuals in each quadrat (N) was determined using the Schnabel method (1938) used for mark and recapture and multiple recapture methods. This number depends on the number of individuals captured during a single visit, the number of already marked individuals captured during a visit and the total number of marked individuals.

As far as transects are concerned, they were laid at random in places which could be inhabited by *M. viridis*. Individuals detected on these transects were counted without being marked. Observations on these transects were not time-bound and, in general, were made within 6 m from the centre of observation, which was normally a stream.

Several sites have been considered in the course of this work. It should be noted that each site has its own population of *M. viridis* and each population has a density.

The structure of each population is determined during the marking of each individual by identifying the sex and determining the age of the individuals detected both in quadrats and on transects. The sex ratio of the population, i.e. the number of male individuals in relation to that of female individuals, is determined by establishing the sex of the individuals.

For the purpose of illustration, photos are taken during all the research work.

- **Habitat**

The species' habitat was assessed along transects and in quadrats other than those used for the capture-mark-recapture method. These quadrats differed in size by 5m x 5m from those in which the method for estimating the population had been used, and individuals found in these quadrats were not marked. A few parameters, such as the percentage of canopy cover (CC), litter cover (LC) and rock cover (RC) were all determined. These parameters were assessed on the basis of their presence in the quadrat studied and the assessment was made in relation to the total surface area of the quadrat. The type of watercourse was identified, its surface area considered (S water) and vegetation described in general terms. This habitat description was based on the presence or absence of the animal; each parameter was tested to determine whether it differed significantly in these two environments.

In order to determine the ability of the species to adapt depending on the different types of habitat present in its living environment, it will be very useful to compare population densities depending on these habitat types. It should be pointed out that three main types of habitat have been detected: degraded forest with or without rocks, shrub formations dominated by mango trees, and natural forest.

❖ Pressures

Pressures were identified during habitat assessments based on transects, as well as through direct observation at various locations around the study site.

❖ Quota determination for *Mantella viridis*

With a view to having a reasonable quota based on the data that currently exist, it is preferable to calculate a national quota based on the average population density of the *M. viridis* species in general. The quota is calculated using the calculation method for amphibians adopted by the Malagasy Scientific Authority for Fauna (SA Fauna) in 2009, in which the quota is a function of the population density**,** natural parameters such as range and reproduction method, and anthropogenic parameters such as habitat and collection, as well as the number of suggested collection sites.

Potential collection sites are identified among study sites located outside protected areas, in particular on the basis of the population size and the habitat quality.

Five main elements have to be provided in order to start up the non-detriment finding (NDF) process for a given species. One of them is its geographic distribution, which in the case of *M. viridis* means that the extent of occurrence of the species will need to be mapped taking into account the status of each area, namely whether it is intended for the protection or the exploitation of the species concerned. In order to know the size of the available population, the status of the species' populations is determined based on the number of individuals in each population. On the other hand, this study has not described the dynamics within the populations. Since *M. viridis* is not yet being collected, there is no system in place for managing collection; however, if trade in *M. viridis* is reopened, a collection procedure should apply. In addition, these management systems still need to be set up and the rate at which the species can be collected in the wild still needs to be set. In order for the finding to indeed be non-detrimental, collection must be monitored and verified to ensure its sustainability and to reduce illegal exploitation. The last element of NDF is species conservation and the precautionary principle which consists in introducing protective measures to ensure the survival of the representative natural population and of the phenotypic and genetic diversity of the populations affected by collection.

III. Analyses

1. Population size

The analysis used to estimate the number of individuals per population of *Mantella viridis* is the Schnabel method (1938).

The total number of captured individuals in a population is calculated in accordance with the Schnabel model (1938), for which the formula is:

$$N = \frac{\sum C_t * F_t^2}{\sum R_t * F_t}$$

Where :

N: total number of individuals;
C_t : number of individuals captured during a single visit;
R_t : number of already marked (recaptured) individuals captured during a visit;
F_t : total number of marked individuals.

The population density is deduced from the approximate number of individuals making up this population (N) and the surface area on which they have been captured.

For transects of different length, the relative abundance of the population is determined directly based on the number of individuals per 100 m of observation. If the transect considered is shorter or longer than 100 m, the number of individuals sighted on this transect is extrapolated to 100 m.

2. Population structure

The structure of each population is defined on the basis of the sex ratio and the age structure. The sex ratio is obtained using the ratio of the number of male individuals to that of female individuals. The age structure is calculated by comparing the number of individuals making up each age group present in the populations considered.

3. Habitat preference

Habitats were assessed on the basis of parameters considered one by one depending on the presence or absence of the animal. The average of each parameter in an environment in which the animal was encountered was compared to its average in an environment where no animal was encountered. The Mann Whitney (U) test was used to determine whether the difference between the values of each parameter in environments where the animal was sighted and in those where it was not, was significant. Population densities in various types of habitat were compared to determine the extent of adaptation of the species to various habitats.

4. Quota calculation

The formula used to calculate the quota for amphibians is as follows:

$$Q = D\ (f_n * f_a)\ n_p$$

Where:

Q = quota ;
D = population density in individuals per hectare;
f_n = t * r (natural parameters) ;
f_a = h * c (anthropogenic parameters) ;
n_p = number of proposed sites;
t = range according to IUCN;
r = reproduction method;
h = habitat;
c = impact of collection.

The different criteria such as range (t), reproduction method (r), habitat (h) and impact of collection (c) are expressed as coefficients (table 2).

Table 2: Coefficients of natural and anthropogenic parameters.

Criteria	**Types**	**Coefficient**
Habitat	Degraded	1
	Secondary	0.5
	Primary	0.25
Collection	Strong	0.25
	Medium	0.5
	Low	1
Reproduction method	Type r	1
	Type k	0.5
Range	A	0.25
	B	0.5
	C	1

IV. Results

1. Species distribution

The study sites were located in four different areas: Montagne des Français, Ambodimanga, Montagne d'Ambre and Antongombato. The number of study sites in each area varied depending on changes in the habitat. There were a total of ten sites: Ambodimanary, Andamilamy, Andranonakanga, Antaolanaomby, Ambodimanga, Andohananketrabe, Analamanga, Andranotomendry, Analamagnondro and Taninimara. Among these sites, there were those which could become collection sites should trade in *Mantella viridis* be reopened, and sites intended for species conservation. However, individuals of *M.* cf. *viridis* were detected on three sites of the Montagnes des Français area: Andamilamy, Antaolanaomby and Ambodimanary. This division is based on the research conducted by Crottini et *al*., 2012. As regards other sites, the site in the Ambodimanga area and all those in the Antongombato area, they are home to populations of the *M. viridis* species.

2. Conservation status of the *Mantella viridis* species in relation to SAPM.

Mantella viridis populations were detected within and outside SAPM. Nevertheless, most populations were found outside SAPM (table 3). Among populations found outside SAPM, the highest densities were recorded in the Antongombato and Ambodimanga areas. On the other hand, the *M.* cf. *viridis* population was more abundant within SAPM than outside it. The highest density was recorded on the Amndamilamy site which was located at the hard core of the new protected area of the Montagne des Français.

Table 3: Density of the *Mantella viridis* populations in relation to SAPM.

Area	Species	Position of the area in relation to SAPM	Density (individuals/ha)	Standard error
Montagne des Français	*M.* cf. *viridis*	Outside SAPM	4,210.81	2,723.40
Montagne des Français	*M.* cf. *viridis*	Inside SAPM	6,358.65	
Montagne d'Ambre	*M. viridis*	Inside SAPM	100.00	
Ambodimanga	*M. viridis*	Outside SAPM	4,880.40	2,261.65
Antongombato	*M. viridis*	Outside SAPM	14,959.44	5,811.82

3. Population size and structure

❖ Population size

In the course of this work, 19 quadrats with a total surface area of 7,175 m^2 and 13 transects, 1,235 m long were visited. The distribution of these quadrats and transects differed depending on the site considered (table 4).

The capture-mark-recapture method showed that the size of the *Mantella viridis* population varied depending on the site considered. The average density of *M. viridis* was 7,766.51 individuals/ha and the most abundant population was detected in Analamangondro,

with 60,400.00 individuals/ha and Andranotomendry in the Antongombato area, which was located outside protected areas, with an estimated 27,173.68 individuals/ha. On the other hand, the average density of *M.* cf. *viridis* was 5,131.31 individuals/ha, with the maximum value of 19,075.97 individuals/ha observed in Andamilamy, at the hard core of the new protected area of Montagne des Français, and in Ambodimanary, outside protected areas, with an estimated 8,150.19 individuals/ha.

Table 4: Distribution of transects and quadrats on study sites.

Area	Site	Collection proposed	Total surface quadrats (m2)	Estimated Density/hectare
Montagne des Français*	Andamilamy	No	100	19,075.97
Montagne des Français*	Antaolanaomby	No	200	0.00
Montagne des Français*	Andranonakanga	Yes	200	271.42
Montagne des Français*	Ambodimanary	Yes	200	8,150.19
Ambodimanga	Ambodimanga	Yes	200	4,880.40
Forêt d'Ambre SR	Andohananketrabe	No	300	100
Antongombato	Analamanga	Yes	200	6,275.68
Antongombato	Andranotomendry	Yes	100	27,173.68
Antongombato	Taninimara	Yes	100	20,112.73
Antongombato	Analamagnondro	Yes	300	60,400.00

* : *Mantella* cf. *viridis* population

Based on the transects surveyed on the site, the lowest relative abundance of the *Mantella* cf. *viridis* population was below 1 individual/100 m in Andranonakanga, reaching 116 individuals/100 m in Ambodimanary (table 5). As regards *M. viridis*, its minimum relative abundance was around 2 individuals per 100 m in Andohananketrabe and reached 66 individuals per 100 m in Analamagnondro.

Table 5 : Relative abundance (RA) of individuals detected along transects.

Area	Species	Site	Collection proposed	Total length (m)	RA	Standard error
Montagne des Français	*Mantella* cf. *viridis*	Andamilamy	No	200	7.00	4.04
Montagne des Français	*Mantella* cf. *viridis*	Antaolanaomby	No	200	13.00	1.00
Montagne des Français	*Mantella* cf. *viridis*	Andranonakanga	Yes	125	0.33	
Montagne des Français	*Mantella* cf. *viridis*	Ambodimanary	Yes	50	116.00	
Ambodimanga	*Mantella viridis*	Ambodimanga	Yes	50	6.00	2.00
Forêt d'Ambre SR	*Mantella viridis*	Andohananketrabe	No	200	1.00	0.61
Antongombato	*Mantella viridis*	Analamanga	Yes	200	7.50	4.34
Antongombato	*Mantella viridis*	Taninimara	Yes	100	10.50	2.50
Antongombato	*Mantella viridis*	Analamagnondro	Yes	110	66.36	

❖ Population structure

The sex ratio exceeded 1 in all the quadrats and transects surveyed (table 7). In addition, as seen from the following figures (figures 1 and 2), more male individuals than female have

been encountered in the course of this research. This applies to *Mantella viridis*, as well as to *M.* cf. *viridis*.

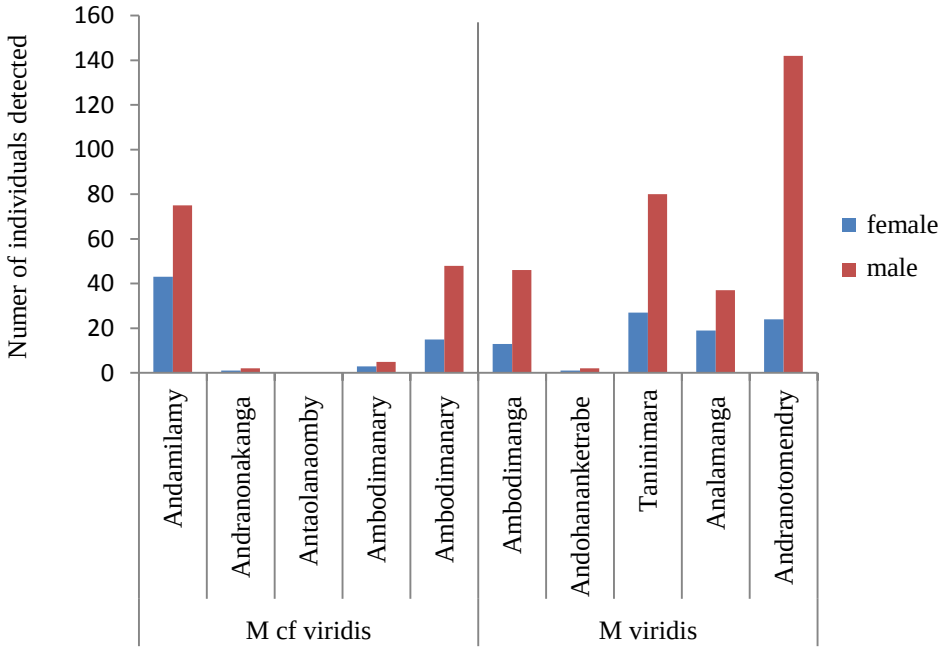


Figure 1: Sex ratio of *Mantella viridis* and *M.* cf. *viridis* detected in quadrats.

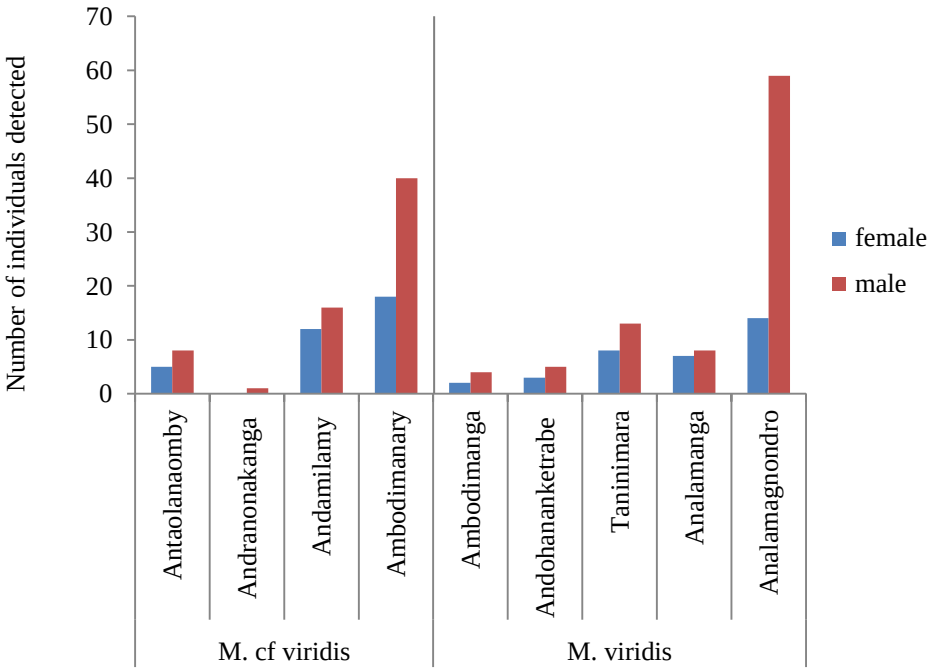


Figure 2: Sex ratio of *Mantella viridis* and *M.* cf. *viridis* detected in transects.

Table 6: Sex ratio on each site.

Area	Species	Site	Sex-ratio (quadrat)	Sex-ratio (transect)
Montagne des Français	*Mantella* cf . *viridis*	Andamilamy	1.74	1.33
Montagne des Français	*Mantella* cf . *viridis*	Antaolanaomby	0.00	1.60
Montagne des Français	*Mantella* cf . *viridis*	Andranonakanga	4.00	1.00
Montagne des Français	*Mantella* cf . *viridis*	Ambodimanary	5.00	2.22
Ambodimanga	*Mantella viridis*	Ambodimanga	3.53	2.20
Montagne d'Ambre	*Mantella viridis*	Andohananketrabe	2.00	1.66
Antongombato	*Mantella viridis*	Analamanga	1.94	1.14
Antongombato	*Mantella viridis*	Andranotomendry	5.91	
Antongombato	*Mantella viridis*	Taninimara	2.96	1.62
Antongombato	*Mantella viridis*	Analamagnondro		1.84

The two age groups present in the course of this work are juvenile individuals and adults. However, the proportions of these classes differ, with adults predominating regardless of the site and species considered (figures 3 and 4).

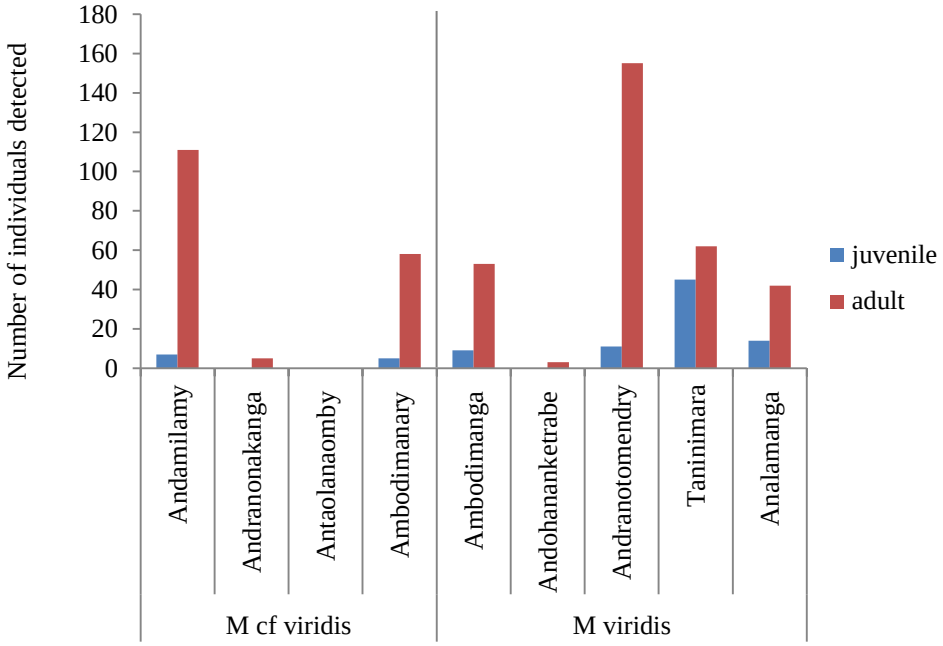


Figure 3: Age structure of the individuals captured in quadrats.

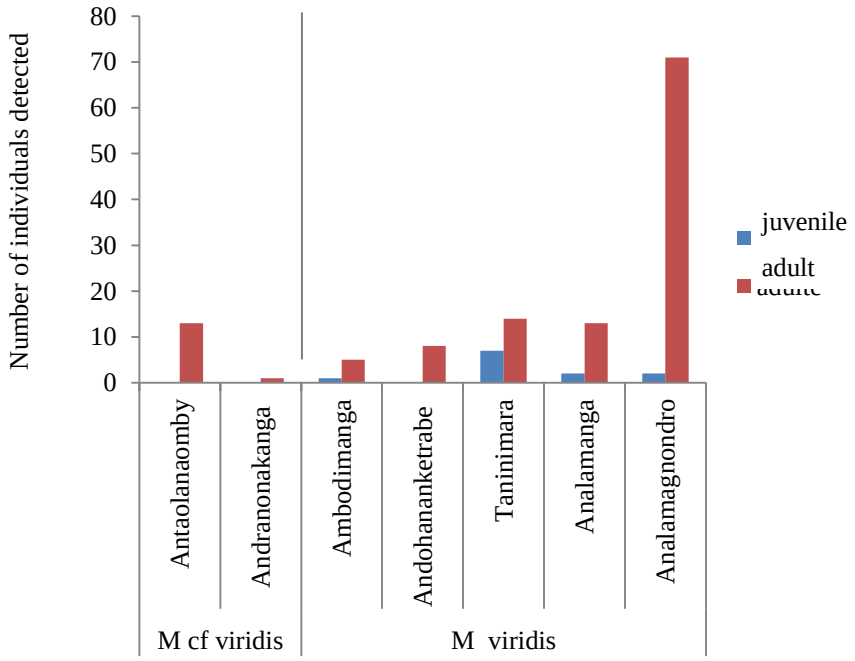


Figure 4: Age structure of the individuals detected in transects.

4. Habitat use and preference

Mantella viridis observed in the course of this research used different types of habitat depending on the sites visited. These habitats were located at altitudes ranging between 36 and 1,016 m. In general, the species was encountered under small rocks. Sometimes it was found under leaves and dead branches. In all cases, these places of refuge used by the species were close to a temporary or permanent water source. Among all the micro-habitats adopted by the species, the one under rocks was the most widespread. It accounted for around 45.66 % of micro-habitats used. Mango leaves accounted for 36.99 % of observations. In around 17.34 % of cases, the species was found under the debris of dead leaves. As regards *M.* cf. *viridis*, it mostly sought shelter under rocks (80.82 %) and in holes in the ground (19.17 %).

Habitat descriptions are based on five parameters:

Canopy cover (CC) varied from 0 % to 95 % in environments where *Mantella viridis* individuals were sighted. If the environment was closed, the canopy height varied between 3 and 12 m. In environments where no *M. viridis* individuals were captured, the canopy cover varied as much as in environments where they were captured, i.e. 0 % to 95 % canopy cover. On the other hand, the canopy was higher in environments where no individuals were registered, ranging from 7 to 12 m. In the case of *M.* cf. *viridis*, the canopy cover varied between 0 and 90 %.

Litter abundance (LC) was a permanent feature of environments where individuals of the *Mantella* species were encountered. However, its proportion varied depending on the place or site. In the environment considered in relation to *M. viridis*, it varied between 10 % and 95 %; however, in the case of *M.* cf. *viridis*, it varied between 5 % and 75 %.

Rock abundance (Rc) was a feature of environments inhabited by *Mantella viridis* individuals. This rock abundance could be low (0.25 %) but could also reach 90% of the occupied environment. However, in some places rocks were 100% dominant but no *M. viridis* individuals were found. As regards *M.* cf. *viridis*, it also required the presence of rocks in order to inhabit an environment. These rocks occupied between 10% and 80 % of the environment.

Water surface (S water) was almost always present in environments in which *Mantella viridis* or *M.* cf. *viridis* individuals were encountered. On the other hand, its size differd from site to site. Sometimes, water covered only a very small surface area and was stagnant. In other cases, it took the form of a temporary or permanent stream.

Vegetation was normally dominated by shrubs and large trees, such as mango trees, the leaves of which were blown off by the wind. In addition to these terrestrial plants, there were aquatic plants when water present in the environment was not covered with little pebbles. This aquatic vegetation was sparse and made up of perennial herbaceous plants under 0.70 m in height. This applied to *Mantella viridis* and *M.* cf. *viridis*. However, only *M. viridis* was sighted in natural forest.

The following diagram represents the average of each parameter depending on the presence or absence of the animal (figures 5 and 6).

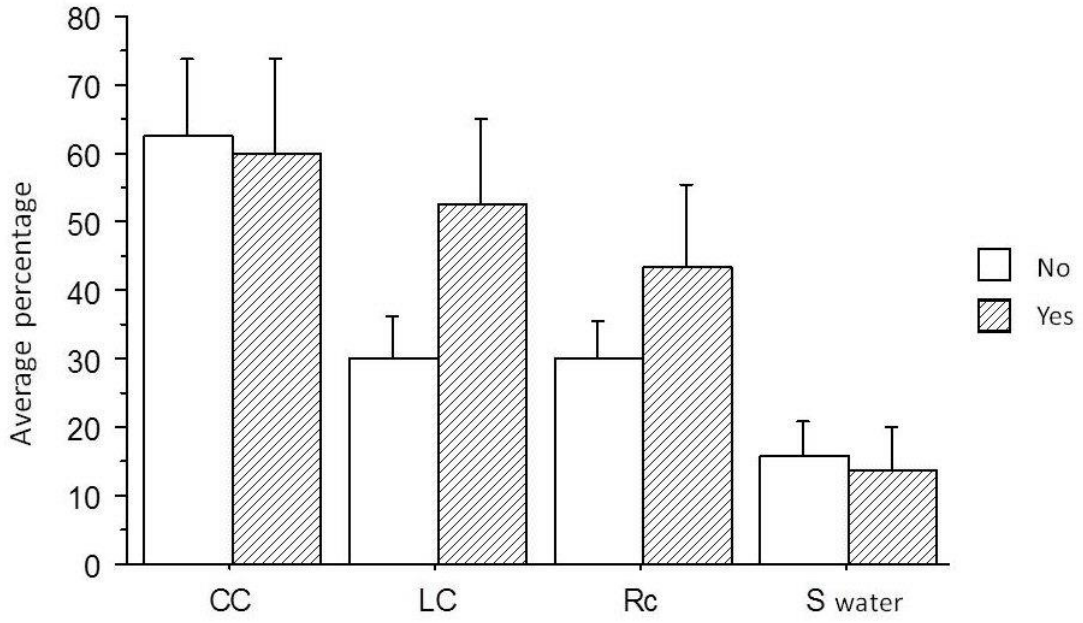


Figure 5: Average parameter values of habitats occupied or not occupied by *Mantella viridis*.

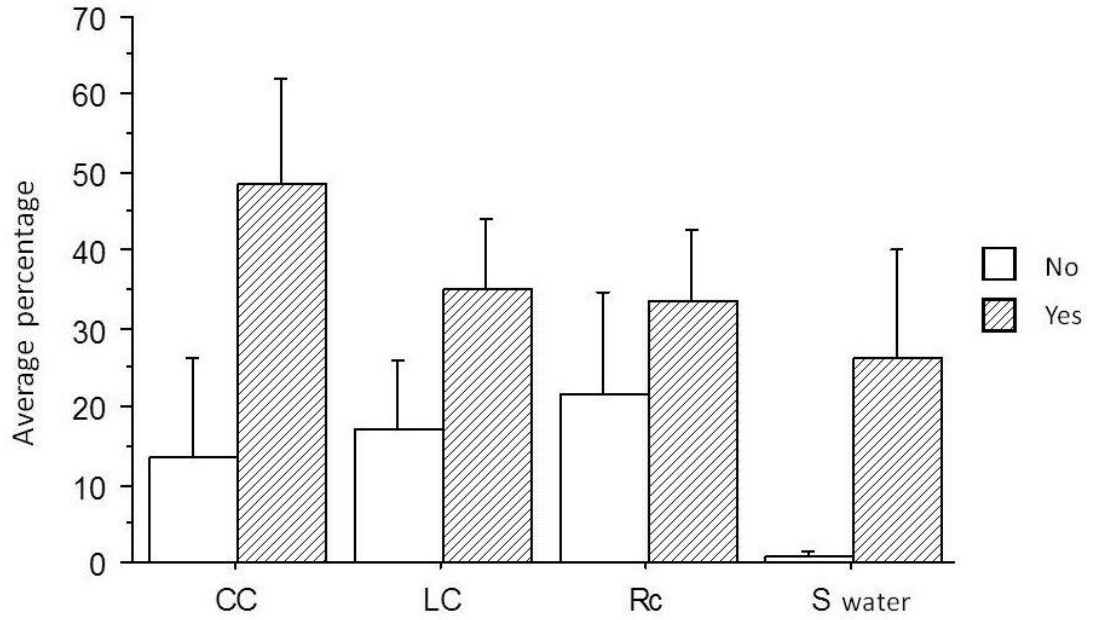


Figure 6: Average parameter values of habitats occupied or not occupied by *Mantella* cf. *viridis*.

In environments in which *Mantella viridis* or *M.* cf. *viridis* is present, the average of each parameter is almost always high in comparison to its average in environments where no individuals have been sighted. However, there is no significant difference ($p>0.05$) between the values of habitat parameters in places with *M. viridis* and those without it (table 7). In the case of *M.* cf. *viridis*, there is a significant difference between the surface area of water in environments with *Mantella* and those without; however, other habitat parameters for this species do not differ significantly in these environments.

Table 7: Value of the significance test for each parameter depending on the presence or absence of an animal.

Species	**Parameters**	**Test value (U)**	**(*p*) value**
Mantella viridis	Canopy cover	30.50	0.87
Mantella viridis	Litter cover	20.50	0.22
Mantella viridis	Rock cover	26.0	0.52
Mantella viridis	Water surface	30.0	0.83
Mantella cf. *viridis*	Canopy cover	13.50	0.15
Mantella cf. *viridis*	Litter cover	11.0	0.08
Mantella cf. *viridis*	Rock cover	10.50	0.73
Mantella cf. *viridis*	Water surface	4.50	0.01

Among the habitat parameters considered, the canopy cover proves to be the most important as it determines the intensity of light which penetrates to the ground where *Mantella viridis* and *M.* cf. *viridis* carry out most of their activities. It is followed by litter cover and rock cover because it is a terrestrial burrowing species which normally seeks shelter in places made up of these parameters.

Depending on the type of habitat, the population density and relative abundance (RA) of the *Mantella viridis* species gradually decreases, i.e. they are the highest in shrub communities dominated by mango trees, and the lowest in natural forest, with degraded forest in between (table 8). On the other hand, *M.* cf. *viridis* does not inhabit natural forest, whereas shrub communities are widely used.

Table 8: Average density and relative abundance of the population depending on the habitat types.

Species	**Habitat type**	**Average density ± SE**	**Relative abundance ± SE**
Mantella viridis	Shrub communities	27,173.68	-
Mantella viridis	Degraded forest	8,484.98 ± 3,605.21	7.87 ± 2.19
Mantella viridis	Natural forest	100.00 ± 100.00	0.00 ± 0.00
Mantella cf. *viridis*	Degraded forest	45.37 ± 28.08	2.83 ± 2.28
Mantella cf. *viridis*	Shrub communities	1,933	116

RA : relative abundance
SE : Standard Error

Photos 3: Different types of habitat detected: (a) degraded forest; (b) shrub community; (c) natural forest; and (d) stream covered with rocks.

5. Pressures

The pressures on the species and its habitat, identified in the course of this work, are grazing, sometimes fire, tree cutting, deforestation, and construction of irrigation canals leading to paddy fields which results in the destruction of habitat and drainage of water.

Photos 4: Various pressures on the species and its habitat: (a) tree cutting; (b) deforestation; (c) irrigation canal; (d) drying up of streams.

6. Quota calculation

As a result of the possible division of this species in two, the zero quota is maintained. If one species actually represents two, the taxonomy should be revised and the vulnerability of each species should be assessed before deciding on whether to reopen trade. The proposal for a new quota will be decided upon once the viability of the population has been assessed. A management strategy will be put in place once the results of these assessments are ready.

7. Non-detriment finding

Establishing a quota of any kind would be detrimental because:

- It is currently difficult to identify the following species morphologically: *M. viridis, M. ebenaui, M.* cf. *viridis, M.* cf. *ebenaui* ;
- Uncertainty about the taxonomy of these species leads to the exact distribution of a species such as *M. viridis* being restricted;
- Most of the area of distribution currently known for the *M. viridis* species is located outside protected areas;
- The sites on which collection may be authorized are located on the periphery of the protected areas, which means that collection could have an impact on the species conservation.

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References

Autorité Scientifique « Faune » de Madagascar. 2009. Mode de calcul du quota des Amphibiens. Rapport non publié.

Crottini, A., Brown, J. L., Mercurio, V., Glaw, F., Vences, M. et Andreone, F. 2012. Phylogeography of the poison frog *Mantella viridis* (Amphibia: Mantellidae) reveals chromatic and genetic differentiation across ecotones in northern Madagascar. J Zool Syst Evol Res 50(4), 305–314.

Mercurio, V. & Andreone, F. (2008): New distribution data of the green mantella, *Mantella viridis*, from northern Madagascar (Anura: Mantellidae). *In* Herpetology Notes, volume 1: 3 – 7.

Glaw, F. and Vences, M. (2007): A fieldguide to the amphibians and reptile of Madagascar. Third edition. Vences und Glaw Verlags,Cologne.

Rabemananjara, F.C.E., Raminosoa, N.R., Ramilijaona, O.R., Andreone, F., Bora, P., Carpenter, A.I., Glaw, F., Razafindrabe, T., Vallan, D., Vieites, D.R. et Vences, M. (2008): Malagasy poison frogs in the pet trade: a survey of levels of exploitation of species in the genus *Mantella*. - In: Andreone F. (ed), *A Conservation Strategy for the Amphibians of Madagascar*. Monografie, 45. Museo Regionale di Scienze Naturali, Torino, *in press*.

Ramilijaona, R. O., Raminosoa, N., Rakotondravony, D., Bora, P. et Razafindrabe, T. J. 2004. Données sur les Grenouilles du genre *Mantella* spp. Endémique de Madagascar. AC 22 Doc. 10. 3. Annexe 3.

Schnabel, Z. E. 1938. The estimation of the total fish population of a lake. American mathematical monthly 45:348-352.