**Scientific Reports in Life Sciences 5 (6): 67-72**

**DOI: https://doi.org/10.5281/zenodo.11080986**


# Seasonal population structure and size variation of the endangered *Harlequin mantella* from East Betsileo, Madagascar

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Received: 12 December 2023 / Revised: 15 March 2024/ Accepted: 23 15 April 2024/ Published online: 29 April 2024.

**How to cite:** Andriantsimanarilafy, R.R, Ramahefason, A., Andriafidison, D., De Rpland, L.A.R., Raselimanana, A.P. (2024). Seasonal Population structure and size variation of the harlequin mantella Endangered frog from east Betsileo, Madagascar, Scientific Reports in Life Sciences 5(6), 67-72. **DOI**: https://doi.org/10.5281/zenodo.11080986

## Abstract

We studied the harlequin mantella along 18 transects from Fohisokina and Soamasaka during three different seasons of the year. Transects were installed in three dominant habitats at both sites. In total, we encountered the target species 62 times from all of our surveys. Several encountered animals vary between sites and seasons. No frog was observed during the winter. However, frog size is significantly different between sexes which females are larger than males.
**Keywords**: Abundance index, Amphibian, Antoetra, Biology, Habitat, *Mantella cowanii*

## Introduction

Madagascar is home to at least 411 species of amphibians as 408 are endemic to the island (AmphibiaWeb, 2023; Frost et al., 2023). Mantellidae is the largest family composed by 12 genera with 267 endemic species which represent more than half of Malagasy amphibians. The Mantella genus is convergent with aposematic Neotropical poison frogs of the family Dendrobatidae in the presence of a variety of similar skin alkaloids, and variously convergent in a few other traits (Vences et al., 1999). They are small-sized frogs, largely diurnal, and often colourful frogs. The genus contains 16 described species divided into six groups based on morphological and genetic criteria. *Mantella cowanii* is the best example of color pattern convergence to a Dendrobates (Vences et al., 1999).

The harlequin mantella, *Mantella cowanii* is a typical terrestrial member of the genus *Mantella*, distinguished by its distinct colour pattern (Fig1). The dorsum and flanks are usually black, while at the insertion of the limbs, there are red-orange or rarely orange-yellow spots. The species is known only from the Central Highland of Madagascar, where it occurs at a higher elevation than other *Mantella* species between 1300-2140 m a.s.l (Glaw & Vences, 2007). All recorded localities of *M. cowanii* are situated around four isolated areas: Antakasina, Antoetra, Betafo, and Itremo (Andreone et al., 2020). The species has been intensively collected for the pet trade since the late 1980s. Trade in live specimens was suspended in 2004, applying a zero export quota in 2005 (UNEP-WCMC, 2005). Data on the UN Environment Programme World Conservation Monitoring Centre website indicated that Madagascar exported 3642 individuals of *M. cowanii* between 1998 and 2004. The maximum was in 2002 with 1520 individuals. This led to the inclusion of *M. cowanii* and other *Mantella* species in CITES Appendix II. The species was assessed as Endangered in 2014 based on the species range of about 253 km² and the decline of its range and habitat quality (IUCN/ASG, 2014).

## Material and methods

### Study sites

We surveyed the harlequin mantella from two sites within the Antoetra cluster sometimes called by other authors as the east Betsileo within Ambositra II district and Amoron'i Mania Region. We surveyed the species at two localities, in Fohisokina (Latitude S20°42'; Longitude E47°17') and in Soamasaka (Latitude S20°44'; Longitude E47°17'). The first site is located within Ivato-Centre municipality and Soamasaka within Antoetra. Both sites are composed mainly by the rock bolder and dominated by savannah and grassland. The altitude range from

Fohisokina montane is between 1 440 – 1 770 m a.s.l but Soamasaka is lower and the altitude maximum is 1 630 m a.s.l.

## Field data collection

Field work was carried out from March to December 2022 and divided into three periods of surveys for both sites. The first visit was in March-April which coincided with the end of the rainy season; the second in July-August corresponding to the winter characterized by a low temperature, and finally in November-December which coincided with the start of the rainy season. Nine transects of 50 m were installed at each site from three habitat types including the riparian zone, the savannah and the rock bolder. Animal search was effectuated twice during the day, the first early in the morning (05h00-9h00) and the second, late in the afternoon (16h30-18h00). A Transect survey was done every two days. We surveyed all transects for four days for each season of fieldwork. All encountered frogs were captured for biometric measurement using callipers for the snout-vent-length (SVL) and the weight with the digital scale. The sex and age of all captured animals were identified.

**Figure 1**. *Mantella cowanii* in lateral view (left) and in ventral view (right)

Because of the low encounter rate of *Mantella cowanii* from all of the survey; we decided to use the relative abundance instead of calculating population size or animal density. Abundance index from each season of the survey was calculated using the formula below.

$$\text{Relative Abundace} = \frac{\text{Number of encountered animal}}{\text{Total effort}} \text{x}100$$

We calculated first the abundance index from each day of survey from all transect before computing the mean from the season.

Data analysis was done using RStudio with R version 4.3.1 (R core team, 2002). The mean comparison of animal size between sites and sex was done using the parametric test, especially the Mann-Whitney test.

## Results

### Abundance index

In total, we encountered *Mantella cowanii* 62 times as 39 were found during the start of the rainy season and 23 recorded during the end of the rainy season. No animal was found during the winter (Table 1). The change of the abundance index between seasons is significantly different (*p-value=0.004).* On the other hand, the abundance index of the encountered animal from different seasons changes between sites. It is higher from Soamasaka than from Fohisokina during the start of rainy season but this difference is not significant (*p-value>0.99).* However, the abundance index is higher in Fohisokina than in Soamasaka during the end of the rainy season. But, this difference is also not significant (*p-value=0.47).*

The high abundance during the start of the rainy season might be related to ecological parameters such as temperature and humidity. Both are highest during this season which is favorable to the amphibian. Non-observation of the amphibian during the winter confirms results from previous studies indicating that the harlequin mantella is hibernating during the winter (Randrianantoandro et al., 2015). The hibernating sites are mainly composed of caves and big holes around the site. Thus, the low number of animals during the start of the rainy season marks the start of hibernation and most of the animals are still at their hibernating site. Also, this difference might be due to differences in weather conditions during that different season. The start of the rainy season was drier than the end of the rainy season. The variation of the number of encountered individuals and population structures from different seasons is commonly observed for amphibians such as the case of *Ichthyophis* cf. *kohtaoensis* from Mekong Valley (Kpfur et al., 2005).

**Table 1.** Abundance index of encountered animals from both visited sites during each season

| Seasons | Fohisokina<br>N (Ab±SE) | Soamasaka<br>N (Ab±SE) | **Total**<br>N (Ab±SE) |
|---|---|---|---|
| Start rain | 18 (1.00±0.32) | 21 (1.16±0.63) | **39** (1.08±0.33) |
| End rain | 14 (0.77±0.23) | 09 (0.50±0.29) | **23** (0.63±0.18) |
| Winter | 00 (00) | 00 (00) | **00 (00)** |

N: number of encountered animals; Ab: Abundance index; SE: Standard error

## Age, sex ratio and frog size

All of the encountered animals were adults except one individual recorded during the start of the rainy season from Fohisokina. We encountered more females than males from both seasons. The sex ratio was 0.33, but we heard numerous males calling from caves and holes during the start of the rainy season. Few females encountered during the start of the rainy season were gravid. The observation of gravid females means that the survey coincides with the species reproduction period which is the case for many Malagasy amphibians, especially for *Mantella* species (Glaw & Vences, 2007). However, we didn't find any eggs and tadpoles from all of our surveys.

The SVL of the encountered individual measured from 21.44 to 28.72 mm and weight between 0.91 and 2.09 g. The minimal size was found during the start of the rainy season which corresponds to the juvenile. Our results indicate a small difference in the animal size between sites on their SVL and weight. Individuals from Fohisokina are slightly larger for both parameters than those from Soamasaka but those differences are not significant (*p-value=0.27* for the SVL and *p-value=0.51* for the weight). The body length of the harlequin mantella is different according to the animal sex which females are larger than males. The same case was observed for the animal weight which females are heavier than males. The differences of both measurements between sexes are significant (Fig. 2).

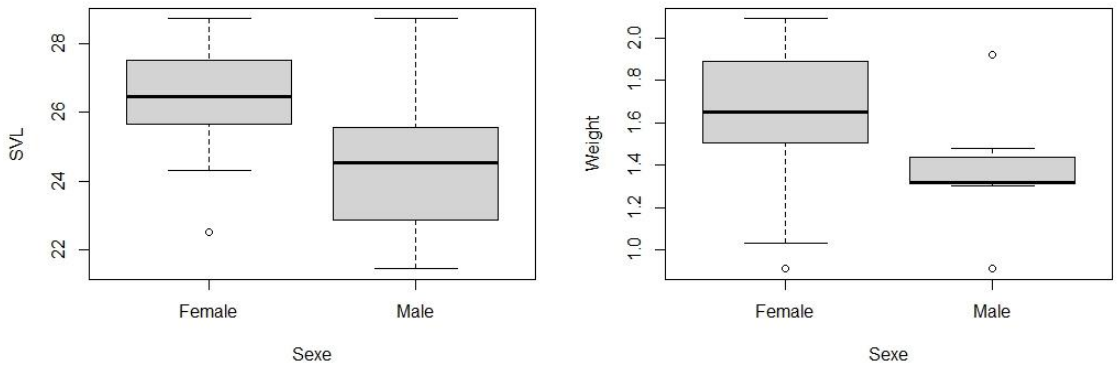


**Figure 2.** Animal size SVL (in the left) and weight (in the right) between sexes

## Conclusion

Our study indicates that the abundance of *Mantella cowanii* between both sites is not significantly different. The species abundance is low which means that it is vulnerable to extinction for both sites. In the other hand, the abundance index is significantly different

according to the season. This study confirms that the species has very specific ecological exigencies, especially in terms of humidity and temperature. Despite our efforts, we didn't find any eggs or tadpoles. Deep research on the species' reproduction location, egg number and tadpole development is recommended for understanding their needs. With this low abundance in its natural habitat; a captive breeding program might be needed to help this wild population by reintroduction for enrichment. Fire and illegal gold mining were the main threats to the species and its habitat that we found during our surveys. Both sites are dominated by an open area; tree planting for restoration might be needed to help the animals survive on their natural site against high solar radiation.

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