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Source: Tropical Conservation Science, 2(1) : 25-33

Published By: SAGE Publishing

URL: <https://doi.org/10.1177/194008290900200105>

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SHORT COMMUNICATION

The harvest of endemic amphibians for food in eastern Madagascar

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Abstract

Deliveries of edible, endemic amphibians to a restaurant in eastern Madagascar were monitored over a five-month period in the 2008 austral summer. Each frog collector was interviewed on arrival and information was obtained on collection locality, methods, frequency, as well as recording the number of frogs delivered. A total of 3,233 frogs were delivered to the restaurant during the study, averaging 249 per week. All of the 21 interviews concerned frogs collected in forest habitats at night by teams of between one and three people. Collection occurred in four localities, one of which (Fierenana) necessitated public transport to deliver the frogs. Effort at Fierenana was typically higher than at other sites with collectors frequently spending at least one night in the forest and traveling around 8.3 hours between their homes and forest collection locations. Income generated went directly to the collectors, who always delivered the frogs in person, and supply was determined by their available time, frog abundance, and weather conditions. Although the restaurant had no stated minimum quantity for purchase, small frogs were refused and collectors aimed for a minimum of 60 large frogs per delivery. The income generated by local amphibian collectors at Fierenana was similar for non-threatened edible species destined for domestic consumption (0.29 US\$) and the Critically Endangered *Mantella milotympanum* collected for overseas export (0.32 US\$). The harvest of edible frogs provides important income for individual hunters but additional study is needed to investigate its impact on frog populations and to develop methods to link sustainable collection practices with forest management.

Key words: Amphibian, bushmeat, harvest, Madagascar, Moramanga, *Mantidactylus*, trade

Résumé

Les livraisons des amphibiens comestibles et endémiques au restaurant dans l'Est de Madagascar ont été suivies en plus d'une période de cinq mois pendant l'été austral 2008. Chaque chasseur a été interrogé à son arrivée et les informations sur le site de collecte, les méthodes, la fréquence, aussi bien que les nombres des grenouilles livrés, ont été obtenus. Un total de 3 233 amphibiens a été livré avec une moyenne de 249 par semaine. Tous les 21 livrés ont été des amphibiens collectés dans les habitats forestier pendant la nuit par une équipe composée de une à trois personnes. La collection a eu lieu dans quatre localités, l'une d'elles (Fierenana) a nécessité un transport public pour délivrer les amphibiens. L'effort à Fierenana a été typiquement plus élevé que dans les autres sites avec des chasseurs passant fréquemment au moins une nuit dans la forêt et en moyenne 8,3 heures de route entre leurs maisons et les sites de collecte dans la forêt. Les bénéfices viennent directement aux collecteurs qui ont toujours livrés personnellement les amphibiens, et la livraison est déterminée par leur disponibilité, l'abondance des amphibiens et les conditions climatiques. Bien que le restaurant n'eût aucune quantité minimum fixe pour l'achat, les petits amphibiens ont été refusés et les collecteurs ont visé un minimum de 60 grandes grenouilles par livraison. Le prix par amphibien comestible de Fierenana (0,29 US\$) est similaire à celui calculé pour l'amphibien gravement menacé *Mantella milotympanum* collecté dans le même site pour l'exportation (0,32 US\$). La récolte des amphibiens comestibles semble offrir un revenu important pour les chasseurs individuels mais une étude supplémentaire est nécessaire pour explorer ses impacts sur les populations d'amphibiens et de développer des méthodes pour lier la pratique de collection soutenable avec la gestion de la forêt.

Mots clés: Amphibiens, commerce, exportation, Madagascar, *Mantidactylus*, Moramanga, viandes sauvages

Received: 9 October 2008; Accepted 23 October, 2008, Published: 23 March, 2009

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Cite this paper as: Jenkins, R. K. B., Rabearivelo, A., Chan Tak C. W. M. A., Randrianavelona, R. and Randrianantoandro, J. C. 2009. The harvest of endemic amphibians for food in eastern Madagascar. *Tropical Conservation Science* Vol.2 (1):25-33. Available online: www.tropicalconservationscience.org

Introduction

Since 1994, more than 233,893 *Mantella* poison frogs have been collected from the forests of Madagascar for international export in a trade regulated by the Convention on International Trade in Endangered Species (CITES) [1]. By contrast, the extent of collection of endemic edible frogs from Madagascar's forests for the domestic food trade is poorly understood, although there is evidence for a high demand [2]. In a recent assessment, 25% of Madagascar's amphibians were considered threatened with extinction, with deforestation the main menace [3]. The collection of 11 species from the wild for international export was considered a potential threat for only a few taxa [3]. However, as current international quota are mostly conservative and only a few species are highly sought after, the impact of this harvest was considered negligible [3]. Three endemic amphibian species are known to be regularly collected for the domestic food market in Madagascar: *Mantidactylus grandidieri*, *Mantidactylus guttulatus*, and *Boophis goudoti*, and all require forest vegetation and riparian microhabitats to survive. Although these species have a wide distribution they are certainly declining as the native forest recedes in the face of expanding agriculture [5-7]. The extent to which the collection of edible frogs is exacerbating declines associated with forest fragmentation and degradation is unknown, but there is some concern that local harvests may be unsustainable [4]

There is very little known about the ecology of Madagascar's large edible amphibian species [8]. Similarly, there are few data on the geographical extent of the commercial collection or the impact it has on edible amphibian populations and peoples' livelihoods. Indeed, this reflects a global pattern whereby more data are available on the international trade in amphibians (for food and pets) than for domestic food markets [9-10]. Jenkins *et al.* [2] suggested that the income to some rural people in Madagascar from amphibian collection was important, but there were no data available on the magnitude of the harvest. In this study we report on five months monitoring of the trade in edible frogs in a town in eastern Madagascar, which was undertaken as a pilot study to develop a longer-term project to track the exploitation of edible frogs.

Methods

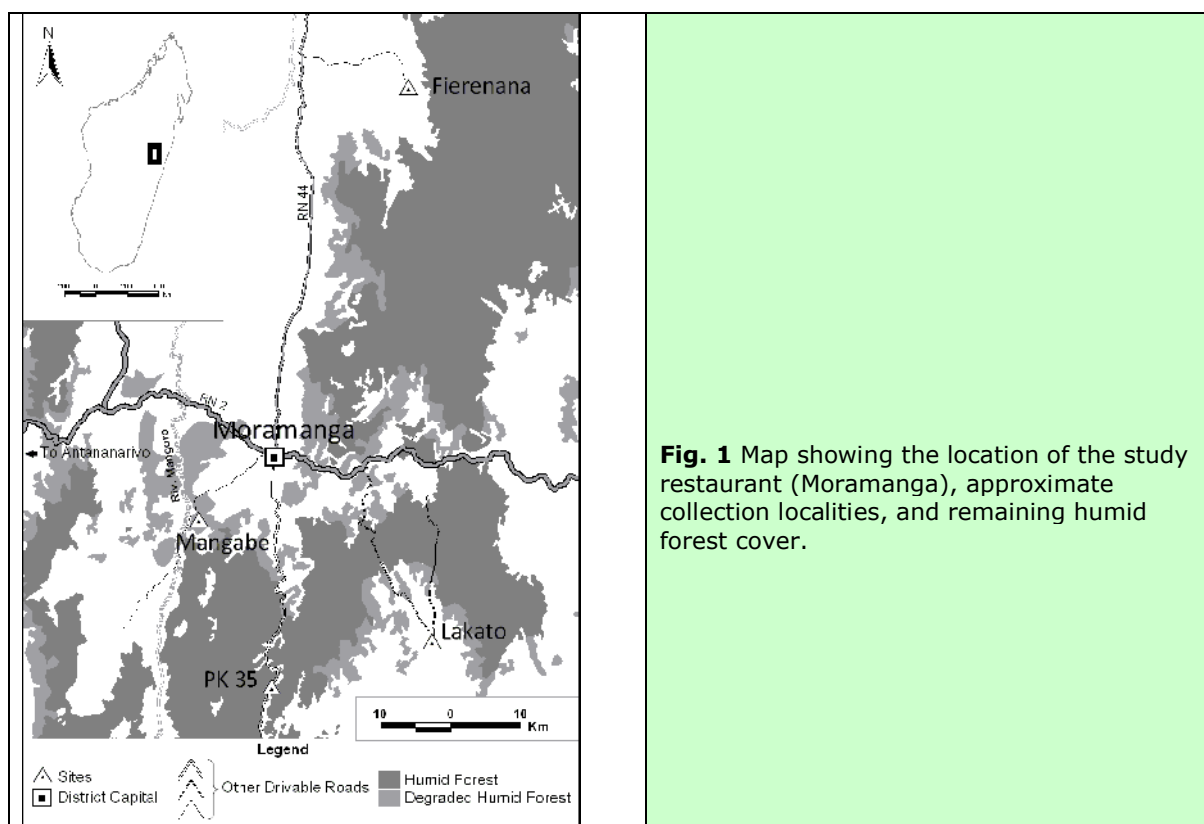
The study was undertaken in Moramanga (18°57'S; 48°13'E), Alaotra Mangoro Region, in eastern Madagascar and was performed between January and May 2008. We conducted 21 interviews with collectors as they delivered frogs to a restaurant in this town that serves a mixture of Malagasy, Chinese, and European cuisine. The restaurant owner contacted our project team when the collectors arrived and interviews usually commenced within 30 minutes. Full interviews were performed by the same person (AR) but on occasions of his unavailability, basic information was collected by the restaurant owner (CTWMA).

For each delivery of frogs we asked the following questions:

1. Which area were the frogs collected from?
2. Date and duration (nights and hours) of the collection
3. Time needed to travel between the collector's house and hunting location
4. Time needed to travel between the collector's house and restaurant
5. Mode and cost of transportation between the collector's house and restaurant
6. Collection method, habitat, and the size of the collecting team
7. Reasons that influence the frequency of collection
8. Average size of delivery and frequency
9. Minimum number of animals required per collection trip

The number of individual frogs in each delivery was counted. There is taxonomic uncertainty surrounding the status of *M. guttulatus* and *M. grandidieri*, and we did not try to distinguish between them during this study. Rapid assessments were made to search for the presence of *B. goudoti* and the introduced *Hoplobatrachus tigerinus* but this was not always possible because we had to work within strict time limits imposed by the restaurant owner to reduce any interference in the frog processing which was done by the collectors.

Collectors were not asked their names and so all respondents were effectively anonymous. In a small number of cases ($n = 1-3$), we may have obtained information from questions 1-8 from the same hunting team on more than one occasion. All monetary information is quoted in US\$ based on the conversion rate of 1 US\$ = 1,400 Malagasy Ariary (MGA).



Results

A total of 3,233 frogs were delivered to the restaurant during our study at an average of 249 per week. The collectors was paid 0.29 US\$ (400 Ariary) per frog. All deliveries that were checked consisted of *Mantidactylus* species (*M. guttulatus* or *M. grandidieri*). Although we collected data continuously throughout the study period there were no deliveries between the 19th March and 20th April 2008 because of cyclone "Ivan," and our data therefore span 13 weeks.

Twenty-one interviews were conducted during the study and 62% of the hunters had collected the frogs in Fierenana, 19% in Mangabe, 14% in PK 35 and 5% in Lakato. These localities are located to the northeast, southwest, south, and southeast of Moramanga town, respectively, with Fierenana the farthest from the restaurant (Fig. 1).

The time between the onset of hunting and delivery varied between one and five days, with two (14%) and four days (24%) the modal categories. This duration varied according to locality, and mean duration was longest at Fierenana and shortest at Mangabe (Table 1). Collectors at Fierenana, however, also spent longer in transit between their homes and collection localities and usually stayed at least two nights in the forest (Table 1). This was also evident in the total number of hours spent per collection visit because only hunters at Fierenana averaged more than 10 hours, while hunting sorties in the other forests lasted a single night and usually less than seven hours (Table 1). Hunting teams consisted of a mean of 2.1 people, and were smallest at PK 35, but there was no indication that teams were notably larger in Fierenana than the other forests.

Table 1. A summary of the collection effort used by edible-frog hunters in four forest localities in eastern Madagascar; samples sizes in parentheses.

Collecting localities	Days between first hunting date and day before delivery	Duration (hours) walked between house and collection site	Number of nights per collection trip	Number of hours collecting frogs per trip	Number of people in hunting teams
Fierenana	3.8 ± 0.5 (8)	8.6 ± 0.6 (8)	2.4 ± 0.3 (10)	11.0 ± 1.4 (11)	2.2 ± 0.3 (10)
Mangabe	1.5 ± 0.5 (2)	4.0 ± 0.0 (2)	1.0 (1)	6.4 ± 1.5 (2)	2.0 ± 1.0 (2)
PK 35	2.7 ± 0.7 (3)	5.0 (1)	1.0 ± 0 (2)	4.7 ± 0.8 (3)	1.3 ± 0.3 (3)
Lakato	3.0 (1)	-	1.0 (1)	7.0 (1)	3.0 (1)

All of the 15 hunters who described the habitat, collected frogs from inside humid forest. For hunters who supplied information, all (n = 17) collected frogs at night, and nine used a battery powered torch, while the remainder used a combustible tree as a torch (*hazo hatao jiro ala*). After collection all respondents who provided information reported that they returned to their houses before traveling on to Moramanga to sell the frogs.

The duration of travel from the collectors' houses to Moramanga varied as a function of distance and mode of transport. All hunters from Fierenana traveled on foot and then by public transport (taxi brousse) on journeys that averaged 18 hours (Table 2). These hunters therefore incurred transport costs of between 3.5 US\$ and 10.7 US\$ for the round trip. Collectors paid one-way bus trips (3.5 US\$) and obtained free transport on the return journey from passing trucks, or paid for two-way bus trips (7.1 US\$). Sometimes, collectors from Fierenana also needed to pay the services of a porter between their home and bus station (3.5 US\$).

We did not obtain satisfactory information on the average number of deliveries made by each hunter. The collectors rarely replied to this question with a succinct and quantitative answer, preferring long explanations that were difficult to understand and standardize. We were however able to obtain some information on the factors that determined the number of hunting trips (17 out of 21 interviewees). Seven reported that the main limiting factor on the frequency with which they collected frogs was the opportunity cost of their time because of conflict with other activities such as farming. Nine collectors reported that they would collect more often if the frog abundance was higher and two cited that they only collected according to orders received from restaurants.

Table 2. Summary of the duration, cost, and mode of transport used to deliver edible frogs from eastern forest sites to Moramanga town. * Includes costs of employing porters.

Collecting locality	Duration (h)	Method of transport			Cost (US\$)*
		Walk/bus	Walk	Bicycle	
Fierenana	18.3 ± 1.1 (7)	11	0	0	7.8 ± 9.03 (11)
Mangabe	7.0 ± 0 (2)	0	1	1	0
PK 35	6.0 (1)	0	3	0	0
Lakato	-	-	-	-	-

A mean minimum of 60.3 ± 4.2 animals we deemed necessary before a hunter considered traveling to the restaurant in Moramanga, but this was lower from the farthest site (54.4 ± 2.4 animals, $n = 9$, Fierenana) than PK 35 (65.0 ± 7.6 animals, $n = 3$). The mean number of frogs delivered to the study restaurant was 153.9 ± 17.5 (range 70-420). This varied monthly and there appeared to be a decline during the study period when collection effort was accounted for (Table 3).

Table 3. Mean number of edible frogs per delivery (\pm SE) and number of deliveries (in parentheses) to a restaurant in eastern Madagascar between January and May.

	Jan.	Feb.	Mar.	Apr.	May
Mean delivery (number of frogs)	101.7 ± 6.0 (3)	132.5 ± 25.9 (6)	141.6 ± 22.6 (6)	235.0 ± 97.3 (3)	180 ± 24.5 (4)
Mean delivery (frogs/hunting night/person)	83.3 ± 14.8 (3)	81.7 (1)	46.5 ± 14.5 (3)	64.2 ± 16.8 (3)	21.7 ± 1.7 (4)

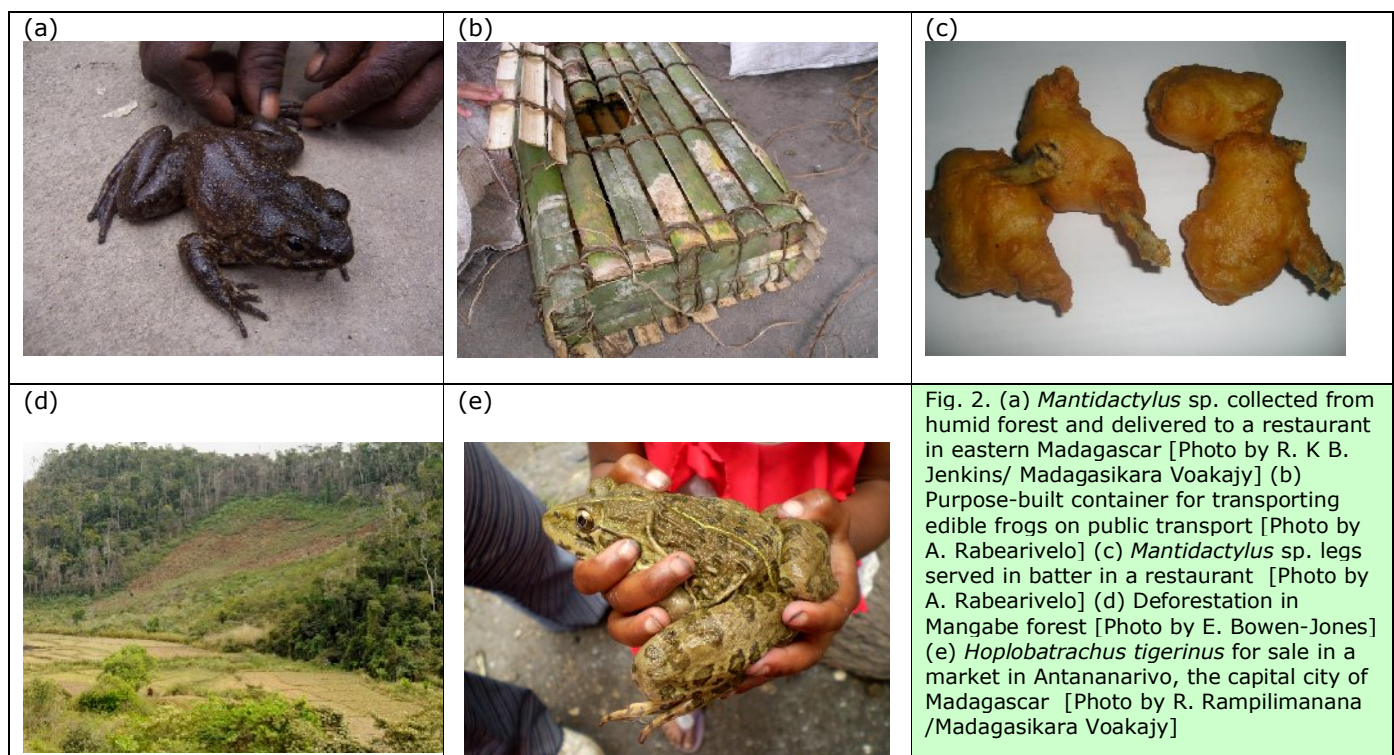
The mean income per delivery was calculated by multiplying the quantity of frogs in each delivery by the standard price (0.3 US\$) per edible frog paid by the restaurant to collectors in 2008. Each delivery therefore generated a mean of 43.9 ± 5.00 US\$ for collectors. The income for collecting teams from Fierenana was higher than from Mangabe or PK35, even after deducting the public transport costs (Table 4). However, after also controlling for the number of collection nights per hunting trip, deliveries from Fierenana generated the least revenue per person.

Table 4. Means (\pm SE) and sample sizes (n) of the revenue generated from sales of edible frogs to a restaurant in eastern Madagascar between January and May 2008. Transport costs are taken from Table 2.

	Prices US\$			
	Fierenana (n = 13)	Mangabe (n = 2)	PK35 (n = 3)	Lakato (n = 1)
Income per delivery	49.1 \pm 6.9	34.3 \pm 7.1	26.2 \pm 2.9	70.0
Transport costs per delivery	7.8 \pm 0.93	0	0	0
Net income per delivery	44.2 \pm 7.4 (n = 10)	34.3 \pm 7.1 (n = 1)	26.2 \pm 2.9 (n = 2)	70.0 (n = 1)
Income per night/person	13.0 \pm 2.9	20.00	20.7 \pm 5.0	23.3

Discussion

The demand for edible frogs in Madagascar comes mostly from restaurants that sell frogs' legs as culinary delicacies for snacks or first courses and is widespread across the island [2, 4]. Although a significant part of the supply comes from the introduced *H. tigerinus* [2, 4] our study has demonstrated that in Moramanga at least, there is regular collection of endemic edible frogs. Large size is the main criterion used by frog collectors in Madagascar (Fig. 2) and, although in Indonesia taste preferences have been reported for endemic over edible frogs [9], there is no evidence yet of this operating in Madagascar.



An average of 249 frogs per week were delivered to the restaurant in our study, but because of reported seasonal differences in hunters' effort, it is difficult to extrapolate this over a 12-month period and between seasons. Nevertheless, it seems reasonable to estimate that a minimum of 4,980 frogs are delivered to the study restaurant during the 20-week peak collection period between December and April each year. If we assume that two of the other restaurants in

Moramanga also receive similar quantities of edible frogs, then a minimum of 14,940 frogs are delivered to Moramanga during the peak collection months. In monetary terms, this total equates to 4,332 US\$ (0.29 US\$ per frog) income for the collectors. The value of a single frog to the restaurant is 0.9 US\$ and 14,940 frogs would generate 13,339 US\$ income. Edible-frog collectors exert control over which restaurant they deliver to and always make the transaction in person; a system that is notably different for amphibians collected for the pet trade in Madagascar or for the food trade in Indonesia where intermediaries are involved [1, 9].

The sustainable exploitation of the reptiles and amphibians of Madagascar for international export markets is viewed as a legitimate way of generating income from biodiversity [11] but less attention has been given to the economics of the edible-frog market. Although the international trade of Malagasy amphibians is an important source of foreign currency (250,000 US\$ 2001-2003 for *Mantella*) [1], because of the presence of intermediaries, who are often professional collectors, the people who live in and around the collection site either receive no financial benefit or only a very small proportion (< 1%) of the amphibians' final retail value [1].

Table 5 Current values of commercial amphibians from Fierenana. The relative differences between each part of the commodity chain were calculated from median values in Rabemananjara et al. [1]. US (United States of America), MG (Madagascar).
*www.fullspectrumexotics.com/frogs/mantellas.html ** Rabemananjara et al. [1].

	Prices US\$			
	US retailers	MG exporters	MG intermediaries	MG collectors
<i>M. milotympanum</i>				
2001-2003	6.5	2.5	0.13	0.06
% of US retail value**		38.6	2.0	1.0
2008	40.0*	15.20	0.80	0.32
<i>Mantidactylus spp.</i>				
2008	-	-	-	0.29

The forests in the Fierenana area are currently the only known collecting locality for the critically endangered *Mantella milotympanum*, a small, bright-orange frog, which has an annual CITES export quota of 1,000 animals. Assuming a full quota is exported at the June 2008 retail value in the US (ca. 40 US\$), the annual quota is worth 40,000 US\$. Based on the relative values in the commodity chain for *M. milotympanum* given by Rabemananjara et al. [1] a locally-based collector could expect 0.95% of the US retail value, which would amount to 0.32 US\$ per animal in 2008 (Table 5). The annual collection quota for *M. milotympanum* in 2008 could therefore generate 320 US\$ (1,000 x 0.32 US\$) for local collectors. If the additional 10% is included that exporters usually add to orders to compensate for mortality, the total becomes 352 US\$. This figure is a maximum because sometimes the "intermediaries" conduct the collection and local people are not involved at all. Based on our data, 353 US\$ is equivalent to between seven and eight average-sized deliveries of *Mantidactylus* edible frogs. To the individual collector, a single *M. milotympanum* is worth 0.32 US\$ and a single edible frog is worth 0.29 US\$ (Table 5). *Mantella* collectors respond to seasonal orders from intermediaries and exporters and the quantity of frogs collected is related to the annual CITES quota [1]. Collectors of edible frogs respond to a constant demand from restaurants and there is no apparent external influence on the quantity harvested, even though it is only legally permitted between February and May [12]. Collectors of frogs for export receive 1% of the final retail value, while collectors of edible frogs receive 17% of the price that frogs' legs are sold for in Moramanga. It therefore appears that the domestic edible-frog trade makes a more significant contribution to local livelihoods than

collection of brightly colored amphibians for export, but that the impact of removing large quantities of edible amphibians on forest ecosystems and the persistence of populations is unknown and requires further study.

There were clear differences in collection effort between the two closest sites to Moramanga and the farthest site at Fierenana. Collectors in the latter site appeared to use significantly higher effort for marginally higher, or even lower, returns. It is not clear whether the economics of collecting edible frogs in Fierenana is influenced mainly by the distance to Moramanga or the distance from the collectors' homes to the forest, as both were longer than reported at the other sites. Furthermore, it was unclear from our questionnaire whether the collectors were involved in the trade of other animal species, and this too could profoundly influence the economics. A range of fauna is collected legally from the forests in the Moramanga District, including crayfish, eels, crabs, and tenrecs for food, and amphibians, day geckos, and leaf-tailed geckos for international trade. A better understanding of the commercial value of forest fauna in eastern Madagascar, for domestic and international markets, is needed so that future management plans can incorporate sustainable harvesting and promote equitable income generation for communities.

Implications for conservation

Given the importance to livelihoods of the income generated from edible frogs, it is advantageous to collectors, as well as to conservation biologists and restaurateurs, to protect the remaining forests and amphibian populations. While we were unable to georeference the collection sites, it seems that two, Fierenana and Lakato, are inside a recently created protected area (Corridor Zahamena Ankeniheny) and two others inside a recently proposed protected area (Mangabe and PK 35). Local communities in these sites are being encouraged to take responsibility for managing the forest in line with the needs of ecosystems, culture, landscape, biodiversity, and livelihoods. The opportunity therefore exists to integrate edible-frog collection as a permitted sustainable activity within certain forest zones. And while there is an obvious need for more data and over a longer time period, we are in favor of establishing a closer link between the income generated from the edible frogs and community groups charged with forest management. In the longer term, it might be beneficial to make a more thorough assessment of *H. tigerinus* as a mini-livestock species in Madagascar [13], because an increase in the supply of this species may reduce the demand for edible endemic species [4]. Because the natural history of the large *Mantidactylus* edible frogs is poorly understood (e.g., the eggs and larvae have yet to be described by herpetologists [M. Vences pers. comm.]), it is difficult to consider the impact of the harvest on population structure. These frogs are thought to inhabit streams in closed humid forest and the degradation of these habitats is surely a threat to both the amphibians and the income that they generate for collectors. Conversion of the humid forest for agriculture is the main cause of habitat loss and it will be important to understand the impact of this on the edible-frog populations and collector livelihoods.

Acknowledgements

We thank Dr Daniel Rakotondravony and Professor Olga Ramilijaona for their assistance with this project. We are also grateful to the Ministry of the Environment, Forests and Tourism for granting permission (# 0154-08/No. 298/07 6 December 2007) for this study under the project entitled "*Inventaire et conservation des espèces herpétofaunes endémiques incluses dans la liste rouge de l'IUCN et importantes à la exportation CITES.*" The work was conducted under a protocol of collaboration between the Département de Biologie Animale, Université d'Antananarivo, the University of Aberdeen, and the Association Nationale pour la Gestion des Aires Protégées. We are indebted to all the frog collectors who participated in the research. This

work was supported by a grant to Roma Randrianavelona from the Rufford Small Grants. Dr Julia Jones and Professor Miguel Vences helped us improve an earlier version of the manuscript. We thank two anonymous reviewers for helpful comments on an earlier draft of this paper.

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