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Contact Matters: Local People's Perceptions of *Haplemur alaotrensis* and Implications for Conservation

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Abstract Understanding factors that influence local community support for conservation projects is critical to their success. Perceptions of wildlife are particularly important in countries where people rely heavily on natural resources for their survival, as is the case in Madagascar. Renowned as one of the “hottest” regions for global biodiversity, Madagascar hosts an exceptional assemblage of lemurs. Yet little is known concerning the knowledge and perceptions of local people toward lemurs. The Lake Alaotra gentle lemur (*Haplemur alaotrensis*) is classified as Critically Endangered on the IUCN Red List and restricted to marsh habitat in the Lake Alaotra New Protected Area. Habitat destruction and hunting have brought the lemur to the brink of extinction. In this study

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we characterize local people's knowledge, awareness, and perceptions of *Hapalemur alaotrensis*. We conducted an initial survey with 180 participants in 6 villages with varying distance to Park Bandro, a high-priority conservation zone. During a second survey, we interviewed 50 people in the village adjacent to the park. Our findings demonstrate that fishers are the most knowledgeable local resource users despite having the lowest education levels, and they also are the most concerned with the endemic lemur's decline. There is a link between environmental awareness and distance in both a literal and figurative sense; the more often people encounter *Hapalemur alaotrensis*, the more they know about it, and the more likely they are to be concerned about its future. Our study further shows that despite this concern, subsistence is prioritized over conservation in the Alaotra region. Ecological knowledge in the fishers' communities is a valuable resource that can benefit the conservation of *Hapalemur alaotrensis* and its marshland habitat if conservation planning and management can align the resource users' concerns and livelihood needs with biodiversity values.

Keywords Awareness · Biodiversity · Conservation · Lemurs · Livelihoods · Madagascar · Stakeholders · Values · Wetlands

Introduction

Linking conservation values with the livelihood needs of local communities is essential for any conservation strategy, particularly in a region where people rely heavily on natural resources for survival and income (Mehta and Kellert 1998; Nepal and Spiteri 2011; Nyaupane and Poudel 2011; Salafsky and Wollenberg 2000). Agrawal and Gibson (1999) demonstrated that local support for conservation projects was crucial and that conservation management would be more likely to be successful if the communities' perceptions and values were understood. Qualitative information gained from ethnographic studies provides valuable insights toward the understanding of conservation problems (Setchell *et al.* 2016) and is invaluable in ensuring the inclusion of local community concerns within conservation planning.

Madagascar, renowned as one of the “hottest” regions for global biodiversity (Ganzhorn *et al.* 2001; Myers *et al.* 2000), hosts an outstanding assemblage of primates—lemurs—found nowhere else in the world (Mittermeier *et al.* 2008; Thalmann 2006). The number of described lemur species has increased from fewer than 50 to more than 105 different taxa over the last two decades (Tattersall 2013; Waeber *et al.* 2015), primarily owing to increased efforts in field research and advancements in molecular biology. However, lemurs are increasingly threatened with extinction (Schwitzer *et al.* 2013). Little is known concerning the knowledge and perceptions of local people toward lemurs.

While most lemur species are forest dwellers occupying a variety of forest types throughout Madagascar (Mittermeier *et al.* 2008), the Lake Alaotra gentle lemur (*Hapalemur alaotrensis*, known locally as bandro) is unique because of its restriction to the marshlands of the Lake Alaotra New Protected Area, where it feeds on sedges (particularly *Cyperus* spp.), reeds, and grasses (Mutschler *et al.* 1998). *Hapalemur alaotrensis* is the only primate species in the world known to live exclusively within a marsh habitat (Waeber *et al.* 2017a, b). It is one of five extant species in the genus

Hapalemur along with the southern bamboo lemur (*Hapalemur meridionalis*), northern bamboo lemur (*Hapalemur occidentalis*), lesser bamboo lemur (*Hapalemur griseus*), and the golden bamboo lemur (*Hapalemur aureus*) (Ballhorn *et al.* 2016; Mittermeier *et al.* 2014).

Hapalemur alaotrensis is classified as Critically Endangered on the IUCN Red List (IUCN 2014). The species is at high risk of extinction due to a significant decline in population size and an ongoing reduction in area, extent, and quality of marsh habitat at Lake Alaotra. The species has been on a continuous decline since the first monitoring undertaken by Mutschler and Feistner (1995), who estimated 7500–11,000 individuals. Subsequent monitoring reported fewer than 2500 individuals between 2003 (Ralainasolo 2004) and 2005 (Ralainasolo *et al.* 2006). Current numbers are assumed to be even less due to ongoing habitat loss (Ratsimbazafy *et al.* 2013). Although former intensive hunting pressure had declined (Andrianandrasana *et al.* 2005; Mutschler *et al.* 2001), increased marsh fragmentation and lack of local enforcement appear to have resulted in renewed poaching both for bushmeat and the local pet trade. At the same time, marsh destruction continues unabated and presents a serious threat to the species survival (Ratsimbazafy *et al.* 2013; Waeber and Wilmé 2013).

Lake Alaotra is located in the eastern-central highlands of Madagascar, in the Alaotra–Mangoro Region (Fig. 1). It is the largest lake in Madagascar, covering some 20,000 ha of open water, surrounded by 23,000 ha of marshland (Andrianandrasana *et al.* 2005). The area is of high socioeconomic importance as Madagascar's greatest producer of rice and fish (Copsey *et al.* 2009b; Ranarijaona 2007; Wallace *et al.* 2015). Human pressure on the ecosystem is high, with more than 550,000 people living around the lake (INSTAT 2012). Marsh burning, draining, conversion to rice fields, and siltation from erosion of topsoil have reduced the marshes around Lake Alaotra to <25% of its historic 60,000–80,000 ha levels (Bakoariniaina *et al.* 2006). Located at the southeastern shore of the lake, Park Bandro is a small (originally 85 ha) protected area within the larger New Protected Area (Fig. 1) that was established as a special conservation zone in 2004. The park is of high conservation importance, as it hosts the biggest known subpopulation of *Hapalemur alaotrensis* (Ratsimbazafy *et al.* 2013). It was created by the local VOI (*vondron' olona ifotony*, a local community association for natural resource management) from the nearby village of Andreba with support from the conservation organizations Durrell Wildlife Conservation Trust and Madagascar Wildlife Conservation. Durrell Wildlife Conservation Trust has been working in the region since the mid-1990s, and Madagascar Wildlife Conservation has been present since 2003. Durrell Wildlife Conservation Trust has focused on creation of the Lake Alaotra New Protected Area and ecological monitoring (Andrianandrasana *et al.* 2005), supporting 90 local people carrying out weekly patrols in the marsh around the lake, while Madagascar Wildlife Conservation has focused on environmental education and ecotourism (Maminirina *et al.* 2006; Rendigs *et al.* 2015).

We developed the current research project to understand levels of environmental awareness and what lemurs mean to resource users around Lake Alaotra, specifically whether there were differences in levels of knowledge and concern among user groups and among villages located at varying distances from the high-priority conservation zone Park Bandro. With this explorative qualitative research we characterize local people's knowledge and awareness of *Hapalemur alaotrensis*. We further explore their

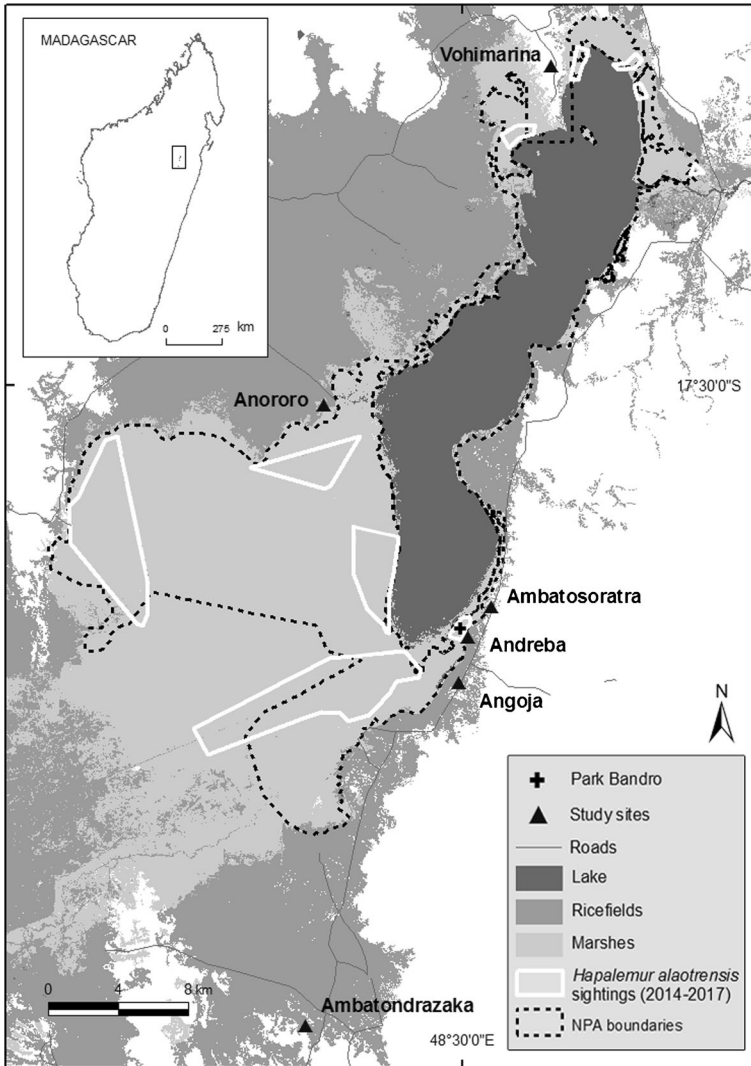


Fig. 1 Lake Alaotra with surrounding marshes and rice fields. The map shows the Lake Alaotra New Protected Area (NPA) boundaries, the location of Park Bandro, and the six study sites. We recorded sightings of *Hapalemur alaotrensis* since 2014 in three participatory mapping workshops with local experts in January 2017.

attitudes toward, and values concerning the lemur within the context of developing future environmental awareness and conservation management plans.

Methods

We carried out two questionnaire surveys in 2015 to examine local people's knowledge, awareness, and perceptions of *Hapalemur alaotrensis*. Ethnographic experiences gained during previous studies (Rakotoarisoa *et al.* 2015; Ralainasolo 2004; Reibelt

et al. 2014) and the composition of our research team (locals from various areas around Lake Alaotra) helped in questionnaire design, pretesting, and data analysis. To examine differences in levels of awareness between sites and user groups we compared years of schooling between smaller, remote villages around the lake (Anororo, Vohimarina, Ambatosoratra, Andreba, Anjoja) and the regional capital Ambatondrazaka, as well as between user groups. In July 2015 we carried out survey 1 and involved 180 participants from 6 sites around Lake Alaotra (Fig. 1). We chose villages to represent varying distances from the community managed ecotourism and conservation area at Park Bandro near Andreba. In September of the same year, we interviewed 50 participants from Andreba in survey 2. We collected baseline data on the participants including their main livelihood activity in both surveys (Table I).

Survey 1 focused on quantifying people's knowledge of *Haplemur alaotrensis* at the scale of the entire lake. Questions focused on whether, when, where, and how many lemurs they had encountered. Survey 2 explored people's perceptions of the value of different animal types at Andreba, the village nearest to Park Bandro. We asked participants to rank wild and domestic animals according to importance and to provide the reasons for their ranking. Both surveys contained questions concerning the conservation value of *H. alaotrensis*.

We applied purposive sampling (Bernard 2006) by interviewing people at the lake, close to the marshland border, and along the main route between each village market and the lake shores. We assumed that these people are natural resource users and that they influence or depend on the marsh and/or lake in some way. For the second survey we focused on people who we encountered along the border of the lake or marsh near Andreba to focus on direct resource users who earn their living by working on the lake or in the marsh. In both surveys we divided the interviews equally among morning, mid-day, and evening. Participation was voluntary, and we informed all participants about the aims and scope of the research project before obtaining their consent to take part in the study. A small number of participants were 14–16 years old (Table I). We treated these participants in the same manner as those in other age groups, as it is common for younger people to be engaged in livelihoods reliant on natural resource use and we did not want to exclude them from the survey.

Surveys were anonymous and administered in Malagasy by two local research assistants whom we trained before starting the data collection. A female research assistant presented the survey verbally, and a male assistant recorded responses, allowing for an open discussion style interview. The open questions allowed participants to express knowledge and perceptions in their own words so that qualitative information was not lost (Drury *et al.* 2011; Setchell *et al.* 2016). We administered surveys over 1–4 days per site. Questionnaires contained open questions as well as ranking and yes/no questions. For open questions we conducted quantitative content analysis with inductive creation and establishment of categories (Lamnek 2005). We discussed and adapted the categories in an iterative process within the research team. During analysis, we calculated summary statistics including percentages of all answers. To test for differences between sites and between professions, we used Fisher's exact test, the *t*-test, and the Wilcoxon rank-sum test using R (versions 3.0.3 and R 3.2.1; R Core Team 2015).

Table 1 Overview of participants of two surveys at six study sites at Lake Alaotra to determine local knowledge of *Hapalemur alaotrensis* in 2015

| Site | Sample size | Region | Distance to Park Bandro (km) | Number of men/women | Age range (years) | Mean schooling (years) | Range of schooling (years) | Top three livelihood |
|----------------|-------------|--------|------------------------------|---------------------|-------------------|------------------------|----------------------------|--------------------------------|
| Survey 1 | | | | | | | | |
| Ambatondrazaka | 30 | S | 24.0 | 16/14 | 14–60 | 10.1 | 5–14 | Student; farming; housework |
| Anororo | 30 | W | 14.7 | 24/6 | 16–67 | 7.3 | 4–12 | Fishing; weaving; farming |
| Vohimarina | 30 | N | 32.4 | 17/13 | 15–75 | 6.9 | 1–12 | Farming; fishing; weaving |
| Ambatosoratra | 30 | E | 2.1 | 26/4 | 18–60 | 5.8 | 1–10 | Fishing; farming; duck walking |
| Andreba | 30 | E | 0.7 | 30/0 | 15–75 | 7.3 | 2–14 | Fishing; farming; student |
| Angoja | 30 | E | 3.1 | 25/5 | 15–75 | 7.0 | 2–14 | Fishing; fish collection |
| All | 180 | — | — | 138/42 | 14–75 | 7.4 | 1–14 | Fishing; farming; student |
| Survey 2 | | | | | | | | |
| Andreba | 50 | E | 0.7 | 33/17 | 15–73 | 7.7 | 0–14 | Farming; fishing; student |

Ethical Note

Our research followed the principles outlined in the ethical code for research by Wilmé *et al.* (2016).

Results

Survey Participants

Of the 180 participants from the initial survey, the median age was 35 yr. (mean 36, range 14–75), and the median years of schooling was 8 yr. (mean 7.4, range 1–14, Table I). Participants from the city of Ambatondrazaka had significantly more years of schooling than any of the villages (two-sample *t*-tests with Bonferroni correction, all $P < 0.001$; details in [Electronic Supplementary Material \[ESM\] Table SI](#)). Of the 50 participants from survey 2 in Andreba, the median age was 37 (mean 38, range 15–73), and the median years of schooling was 8 yr. (mean 8, range 0–14 yr.; Table I).

Local Knowledge of *Hapalemur alaotrensis*

Of the 180 participants in the initial survey, 89% said that they knew of *Hapalemur alaotrensis*. When describing the lemur, 63% of the participants drew comparison with humans, cats, and other lemurs (Fig. 2, Table SX). Sixty-one percent of those who knew of *H. alaotrensis* mentioned physical characteristics related to color, size, pelage, and body shape while 8% described the lemur's character as shy, gentle, or sympathetic

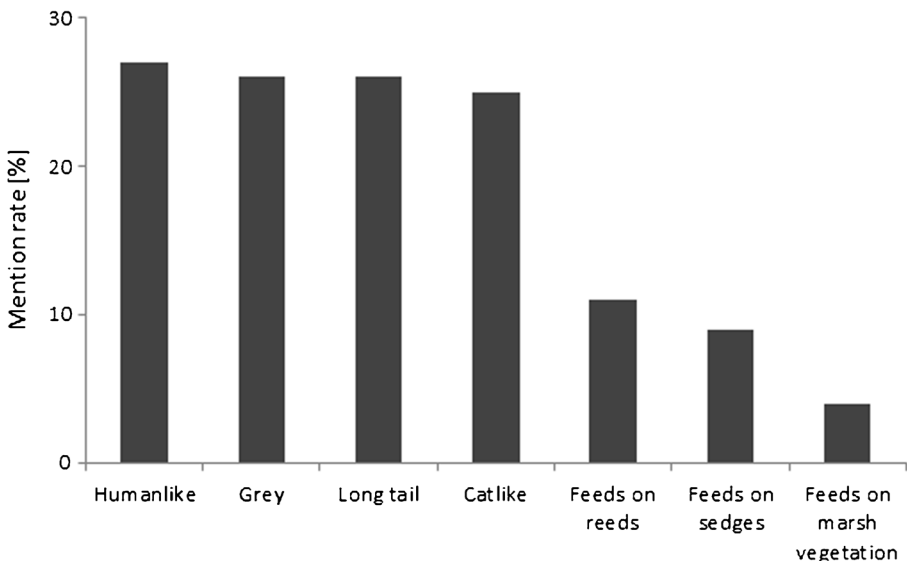


Fig. 2 The most common responses to “What do you know about *Hapalemur alaotrensis*, called bandro?” in survey 1 ($N = 180$) at Lake Alaotra in 2015. Percentages are from the “Yes” subsample of 160 people who knew the lemur (89% of total sample). Overall, participants gave a range of 1–6 answers, with a mean of 2 (median = 2). See Table SVIII for a complete list of descriptions of the lemur.

(Table SX). Twenty-four percent pointed out that *H. alaotrensis* has a diet based on marshland vegetation, including mentions of specific vegetation such as reeds (11%) and sedges (*Cyperus* spp.; 9%).

When we asked participants whether they knew where *Hapalemur alaotrensis* lived, 83% said yes, and 17% didn't know. Of the participants, 83% replied that the lemur lived in Madagascar, and of these, 13% said this lemur lived throughout the Alaotra region while others (87%) cited specific sites or villages around the lake. Of the 180 participants, 81% stated that *H. alaotrensis* lives in the marshes, while 2% wrongly referred to the open landscape and 1% mentioned forest. Significantly more fishers knew where *H. alaotrensis* lived ($N = 94$; 90% of fishers) when compared to nonfishers ($N = 55$; 72% of nonfishers; Fisher's exact test, 95% confidence interval [0.110, 0.676], odds ratio: 0.281, $P = 0.002$; Table SIV).

When asked for information about personal encounters with *Hapalemur alaotrensis*, 86% of participants answered they had seen the lemur at some point during their life, with no significant difference among the six study sites (Table SVIII). Of these, 20% had seen the lemur in Park Bandro, 70% in the marshes outside of the park, and 10% in captivity (Fig. 3). These differences in lemur sighting locations between sites were significant between the regional capital of Ambatondrazaka and the villages of Anororo and Andreba (closest to Park Bandro), and also between Anororo and Vohimarina (Fisher's exact test with Monte Carlo simulation, all $P < 0.001$; Table SVIII). Respondents from Ambatondrazaka stated that they had either seen *H. alaotrensis* in the marshes outside Park Bandro (55%) or in captivity (45%), while in Andreba, 69% of people surveyed had seen lemurs outside of Park Bandro compared to 31% within the park. None of the people interviewed from Andreba reported having seen *H. alaotrensis* in captivity. Fifty-eight percent of the respondents in Ambatondrazaka had last seen a *H. alaotrensis* more than a year ago, compared to a sighting during the

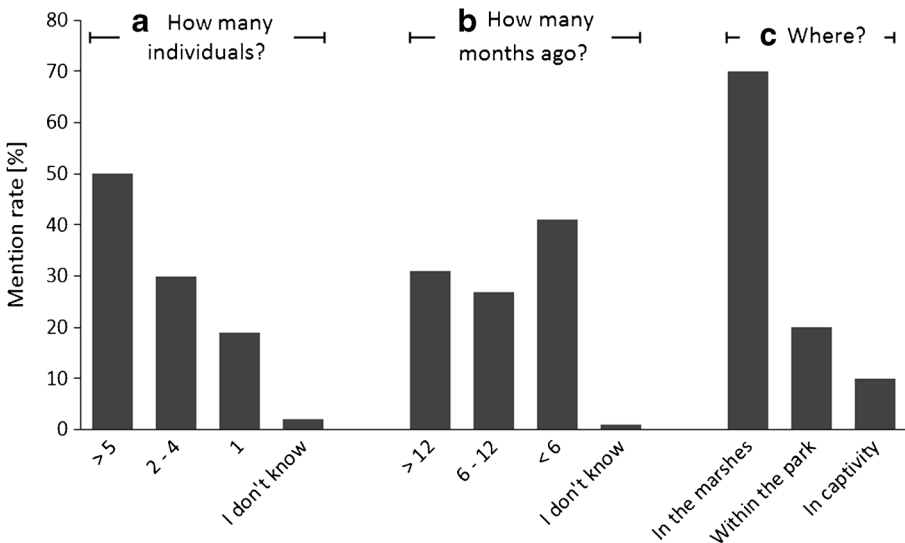


Fig. 3 Sightings of *Hapalemur alaotrensis* reported by local people at six study sites around Lake Alaotra during survey 1 ($N = 180$) in 2015. Percentages are from the “Yes” subsample of 155 people who had already seen the lemur (86% of total sample).

last 6 mo for 58% of the people interviewed at Andreba (Fisher's exact test with Monte Carlo simulation, $P = 0.003$; Table SVIII).

Of the 160 respondents who knew *Hapalemur alaotrensis* (Fig. 2), 61% were fishers and 39% were nonfishers, and significantly more fishers knew of *H. alaotrensis* than nonfishers (Fisher's exact test, 95% confidence interval [0.082, 0.805], odds ratio: 0.273, $P = 0.015$; Table SIV).

Local Perceptions of and Values Concerning *Hapalemur alaotrensis*

When we asked participants to provide three open statements that best described what *Hapalemur alaotrensis* meant to them, the most common answers were that the lemur "lives in the marshes," "feeds on marsh vegetation," and is "catlike." Other common replies were that the lemur "attracts tourists," is a "mammal," and is a "richness for the region" (Table II).

When we asked people whether they were personally affected by a decline in lemur numbers (survey 1, $N = 180$), 64% of participants said they were concerned while 20% said they were not concerned. Significantly more fishers than nonfishers were

Table II The most common replies to "What is *Hapalemur alaotrensis*, called bandro for you?" of local people ($N = 50$) surveyed at Andreba in 2015

| Reply | No. of mentions | Percentage |
|---------------------------------|-----------------|------------|
| Lives in the marshes | 45 | 90 |
| Feeds on marsh vegetation | 23 | 46 |
| Catlike | 12 | 24 |
| Humanlike | 9 | 18 |
| Attracts tourists | 8 | 16 |
| Mammal | 8 | 16 |
| Richness for the region | 5 | 10 |
| Endangered species | 4 | 8 |
| Peculiar species | 4 | 8 |
| Endemic species | 4 | 8 |
| Owens the marshes | 3 | 6 |
| Provides prestige | 3 | 6 |
| Wildlife | 3 | 6 |
| Protected species | 2 | 4 |
| Primate species | 2 | 4 |
| Cultural heritage | 1 | 2 |
| God's creation | 1 | 2 |
| Prohibited to keep in captivity | 1 | 2 |
| Source of income | 1 | 2 |
| Forbidden to hunt | 1 | 2 |
| Puppylike | 1 | 2 |

We asked each participant to provide three answers

concerned by the decline in number of lemurs (Fisher's exact test, 95% confidence interval [0.171, 0.909], odds ratio: 0.397, $P = 0.019$, Table SIV; Fig. 4). The sites with the highest concern were Ambatosoratra, Andreba, and Angoja, and those with the least concern were Anororo and Vohimarina (Fisher's exact test with a Bonferroni correction; all $P < 0.003$, Table SIX; Fig. 5).

The most common reasons cited for being concerned about population declines were "bandro could go extinct," "bandro is humanlike," and "loss of richness" (Table III). Other reasons were "loss of prestige," "environmental destruction," "loss of pleasure," "marsh destruction," and "no tourism." For those people that were not concerned, the two reasons cited were "it's not important" and "the decline is a myth."

When looking at the four closed questions regarding the lemur that could be answered with a yes or no, we summarized the number of "yes" answers to build a composite variable for awareness and concern. The composite variable correlated negatively with distance to Park Bandro (Kendall correlation: $z = -4.165$, $P < 0.001$, $\tau = -0.26$; Fig. 6); in other words, more people from sites near Park Bandro were aware of and concerned about *Hapalemur alaotrensis* than in villages further away. Years of schooling did not have a significant effect on the composite variable (we compared more vs. less than mean years of schooling ≥ 8 yr. vs. < 8 yr., with a Wilcoxon rank sum test: $W = 4410$, $P = 0.092$).

The ranking of wild and domestic animals revealed that the study participants considered zebu and fish to be the most important, followed by pigs and chickens. Study participants ranked *Hapalemur alaotrensis* and ducks (domestic and wild) as least important (Fig. 7). The most common reasons for a high ranking were linked to income, e.g., fish, and usefulness, e.g., zebu as working tool, while interviewees justified the lowest ranking for wild ducks by being "difficult to hunt" and "forbidden to hunt." For *H. alaotrensis*, the explanations for the least important ranking were that it is a "protected species" and "forbidden to hunt" (Table IV).

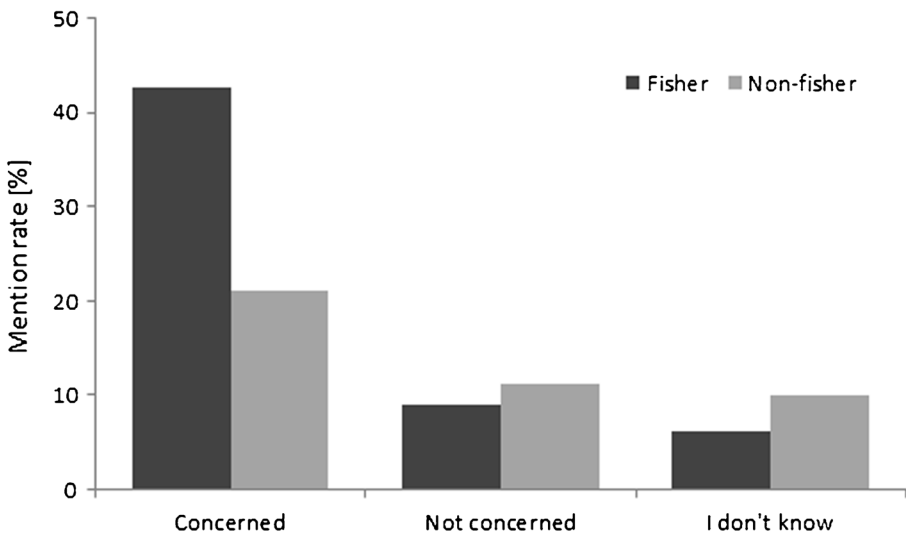


Fig. 4 Answers to "Are you concerned about the population declines in *Hapalemur alaotrensis*?" Differences in concern among fishers and nonfishers in survey 1 ($N = 180$) at Lake Alaotra in 2015.

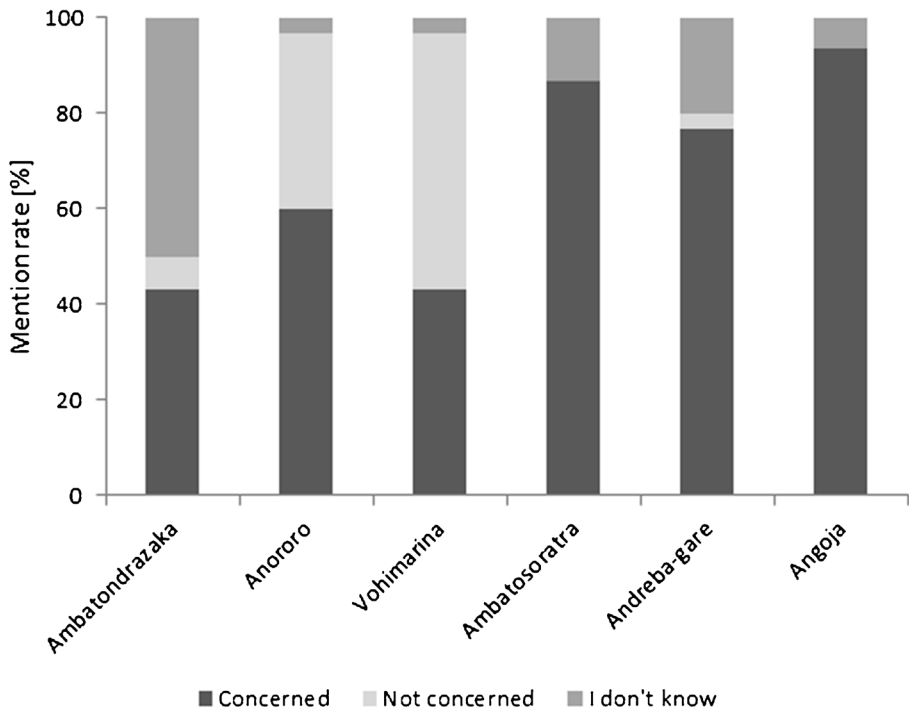


Fig. 5 Answers to “Are you concerned about the population declines in *Hapalemur alaotrensis*?” Differences in concern between villages surveyed in survey 1 ($N = 180$) at Lake Alaotra in 2015.

Table III Answers to “Why are you concerned about the population declines in *Hapalemur alaotrensis*?” Reasons cited by local people ($N = 115$) during surveys conducted at six villages around Lake Alaotra in 2015

| Reason for concern | No. of mentions | Percentage |
|--|-----------------|------------|
| Bandro could go extinct | 48 | 42 |
| Bandro is humanlike | 23 | 20 |
| Loss of richness | 14 | 12 |
| Loss of prestige | 5 | 4 |
| Environmental destruction | 5 | 4 |
| Loss of pleasure (in seeing the lemur) | 4 | 4 |
| Marsh destruction | 3 | 3 |
| No tourism | 3 | 3 |
| Accustomed to seeing the lemur | 1 | 1 |
| Environment and conservation | 1 | 1 |
| Loss of a gentle animal | 1 | 1 |
| Loss of income | 1 | 1 |
| No disadvantage to the lemur being there | 1 | 1 |
| Loss of the lemur makes me unhappy | 1 | 1 |
| I don't know | 4 | 4 |

Percentages are from the Yes subsample of 115 persons who had expressed concern (64% of total sample)

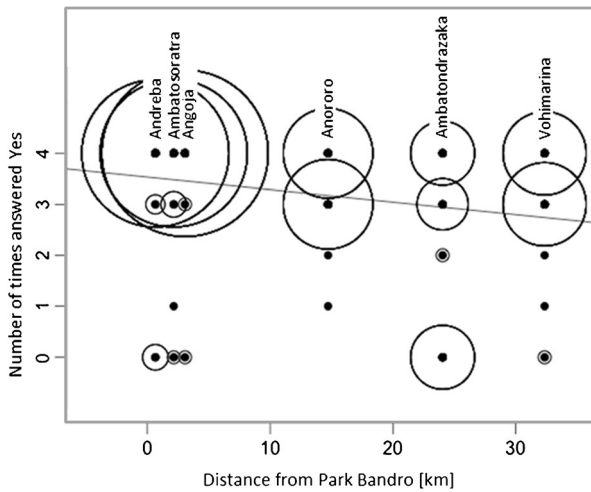


Fig. 6 The relationship between distance of a village to Park Bandro and a composite variable measuring awareness/knowledge of *Hapalemur alaotrensis* based on surveys carried out at Lake Alaotra in 2015. The composite variable includes all closed questions regarding *Hapalemur alaotrensis* (answerable either yes or no; Fig. S1). The size of the bubbles indicates how many people answered yes at the respective distance/ study site.

Discussion

Encouragingly, 89% of the people we surveyed around Lake Alaotra were aware of the existence of *Hapalemur alaotrensis*. Most participants could describe the lemur's appearance, but fewer than half of the respondents could provide more detailed

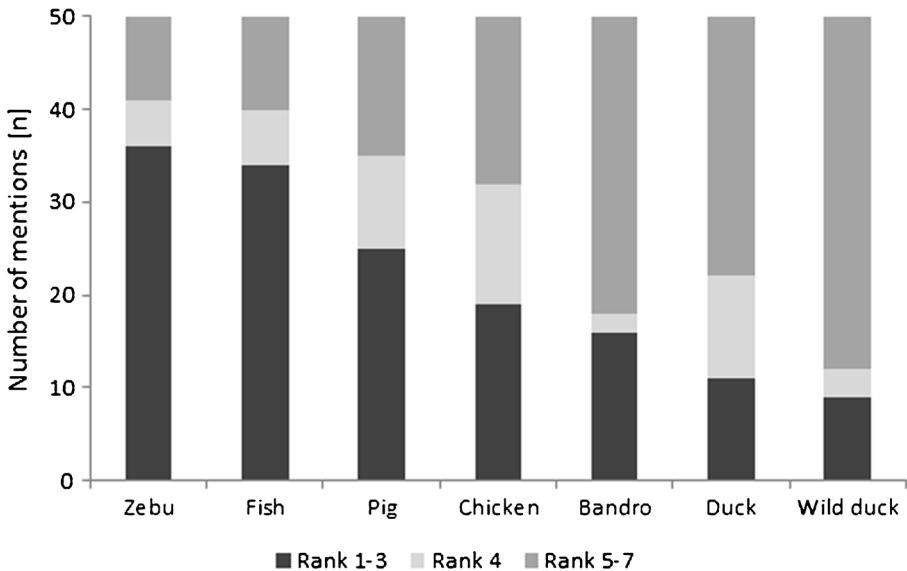


Fig. 7 Ranking of animals by importance (1 = very important to 7 = not important at all) by 50 participants from the village of Andreba in 2015. We summarized ranks 1–3 and 5–7 for simplicity; see Fig. S3 for a detailed breakdown of rankings.

Table IV The most common reasons provided for value rankings of animal types by local people at the village of Andreba in 2015

| | Zebu | Fish | Pig | Chicken | Bandro | Duck | Wild duck |
|--------------------------------|--------------------------------|-------------------------------|---|----------------------------------|--------------------------------------|--------------------------------|--------------------------------------|
| Reasons ranked least important | Too expensive | Impossible to breed | Expensive to keep, destroys cultivation | No direct benefit, common animal | Protected species, forbidden to hunt | Difficult to breed | Difficult to hunt, forbidden to hunt |
| Reasons ranked most important | Working tool, source of income | Source of income, subsistence | Source of income | Source of income, can be bred | Prestige, endangered species | Source of income, easy to feed | — |

characteristics such as its diet. Years of schooling did not have a significant influence on levels of awareness and knowledge of *H. alaotrensis*. To the contrary, fishers exhibited the highest levels of knowledge and awareness despite having the lowest educational levels. Awareness and knowledge of participants from the city of Ambatondrazaka were lower than those of participants in the smaller, remote villages around the lake, although participants from the city had the highest levels of schooling. This supports findings by Reibelt *et al.* (2014) that the local natural environment is usually not addressed in primary schools in the region, a situation replicated throughout Madagascar (Dolins *et al.* 2010; Ratsimbazafy 2003; Reibelt *et al.* 2017).

A majority (86%) of the people we surveyed had seen *Hapalemur alaotrensis* at some time during their lives. This is likely representative of people living at or working on the border of, or close to and in the marshes and highlights local communities' reliance on the marshes. Participants from all the surveyed villages had seen lemurs in the marshes, mainly in groups of two to four or more individuals. This shows that there still are patches of quality habitat for *H. alaotrensis* outside Park Bandro, and it is critical to protect and reconnect such key areas of marsh habitat to ensure the species' survival in the long term.

Although 64% of respondents were concerned with the decline of *Hapalemur alaotrensis*, some felt that the decline was unimportant while others believed that its decline is a myth. Real-life experiences shape environmental attitudes, and are believed to be stronger than indirect experiences such as specific programs or learning in school aiming to change attitudes (Newhouse 1990; Rajecki 1982). This should be considered when shaping educational interventions. If local resource users learn or are told by nongovernmental organizations and educators that *H. alaotrensis* is highly threatened, but encounter these individuals on a regular basis in their environment due to the species being locally common in small fragments, they may not believe other messages from conservation organizations. This pattern seems to be confirmed in Andreba, where lemur encounters are most common because of the proximity to Park Bandro. No participants from this site explained their concern about *H. alaotrensis* with the species' risk of extinction while 42% of all survey participants did.

People in general are attached to the environments they live and work in and can provide information on wildlife in these areas (Gandiwa 2012). In the Alaotra region, the marshes are a cultural heritage and its unique biodiversity creates prestige for the region. For many local people the marshes are a working environment needed for survival (Waeber *et al.* 2017c). Positive experiences in the natural environment lead to environmental awareness and concern (Chawla 1998), but in settings where people's dependency on natural resources is high, the experience of loss and degradation of their environment can also lead to increased concern (Korhonen and Lappalainen 2004).

Our results demonstrate that fishers were the most knowledgeable local resource users and were more concerned about the decline and possible extinction of *Hapalemur alaotrensis* than nonfishers. Fishers are in the marshes and on the lake daily, and appear to have an intimate link to these ecosystems. Their experiences and frequent contact with wildlife have increased their awareness of the species' existence and shaped positive attitudes toward them. We recommend further studies to explore in more detail the knowledge and perceptions of the various stakeholder groups, given that most inhabitants of the Alaotra region rely on several professions to pursue their livelihoods (Rakotoarisoa *et al.* 2015).

While fishers can be a valuable stakeholder in lemur conservation at Lake Alaotra, the extent to which different resource users, including fishers, are involved in lemur hunting at Alaotra is unclear. Trapping of *Haplemur alaotrensis* was a major concern at Alaotra in the 1990s (Mutschler *et al.* 2001) and although this has declined significantly in recent years as a result of conservation efforts, there is anecdotal evidence that lemur trapping has begun to rise again with increased marsh fragmentation. Rapid social change leading to the degradation of historical taboos has resulted in an escalation in lemur hunting for bushmeat throughout Madagascar (Golden 2009; Jenkins *et al.* 2011; Reuter *et al.* 2016). Gardner and Davies (2014) found that bushmeat collection was primarily carried out opportunistically by people entering the forest for other reasons, rather than by specialist hunters. During the current study, 10% of people surveyed stated that they had seen *H. alaotrensis* in captivity at some point during their life, although there was a major difference between the city of Ambatondrazaka and Andreba, the village closest to Park Bandro. Forty-five percent of people surveyed in the city had seen *H. alaotrensis* in captivity compared to 0% in Andreba. To better understand dynamics among user groups and potential risks linked to poaching, we recommend that research be carried out at Alaotra to determine the typology of poachers, motivations, and the extent of collection of *H. alaotrensis*. The literature review by Muth and Bowe (1998) may provide a useful heuristic framework for empirical studies in the Alaotra, while this knowledge can then be incorporated within regional lemur conservation and environmental education programs.

We found a link among environmental knowledge, awareness, and concern, with distance in both a literal and figurative sense. The more often people encounter *Haplemur alaotrensis*, the more they know about it, and the more likely they are to be concerned about its future. This is most obvious in the sites Andreba, Ambatosoratra, and Anjoja which are the three closest to the park, where the highest lemur densities occur. In the city (Ambatondrazaka), where people have the highest educational levels but no direct access to the marsh, people know the least about *H. alaotrensis*. Half of the interviewees in the city replied “I don’t know” when asked whether they were concerned about population decline of *H. alaotrensis*, suggesting that they have a weak relation to the lemur. In Anororo and Vohimarina, despite knowledge levels similar to those in the other villages, about half of the interviewees said they were not concerned about the declining numbers of the lemur. It is not clear whether this is related to fewer lemur encounters in their marshes, to social tensions between pro and contra conservation groups in these villages, or to other factors.

Waeber *et al.* (2017c) reported a strong negative effect of distance on local peoples’ awareness levels of the high-priority conservation zone Park Bandro, which can be explained by the fact that Park Bandro is a single site, whereas lemur encounters as in the current study are possible throughout the marshes surrounding Lake Alaotra. Studies elsewhere have also reported a significant influence of distance on awareness of and attitudes toward wildlife and other natural resources. At Manompana in eastern Madagascar, interest in the preservation of forest fragments was related to walking distance between people’s homes and forest resources (Urech *et al.* 2012). People closer to forest fragments were more appreciative of the benefits provided by those fragments. In Kenya, proximity to a national reserve significantly increased positive attitudes toward conservation of the reserve in community members (Shibia 2010).

Similarly, in the United States, distance was a significant factor in explaining knowledge and perceptions of residents concerning two creeks in Texas (Brody *et al.* 2004). In contrast, studies in Ecuador (Fiallo and Jacobson 1995) and Botswana (Parry and Campbell 1992) found increasingly negative attitudes with decreasing distance to protected areas. Negative attitudes were primarily based on the perceived negative influence of animals foraging on crops, land-use restrictions, and loss of land or livestock. Similar negative attitudes and perceptions were reported in various studies in settings with human–wildlife conflicts (Hill 1998; Hill and Webber 2010; Lee and Priston 2005; Oli *et al.* 1994). These different findings suggest that contact with wildlife can shape attitudes and perceptions both positively and negatively, depending on the nature of the experience. Neither Park Bandro nor *Hapalemur alaotrensis* carry negative connotations, likely because they are not perceived to have a restrictive impact on the primary natural resource uses of residents around Lake Alaotra. This is similar to the attitudes of local residents toward black howlers (*Alouatta nigra*) and a conservation sanctuary for their protection in Belize (Alexander 2000). Local people supported the conservation of the howler and its habitat but also stated that there was no negative impact on their lives associated with the sanctuary.

The fact that distance to Park Bandro also influences awareness of the lemur, and not only on knowledge and awareness of Park Bandro (Waeber *et al.* 2017a, b, c), may be due to the increased conservation efforts and awareness raising campaigns by conservation organizations such as Madagascar Wildlife Conservation and the Durrell Wildlife Conservation Trust who have focused much of their environmental awareness and education work around Park Bandro. At the same time, this highlights a challenge in undeveloped and economically depressed areas like Madagascar where infrastructure and means of communication are poorly developed. It suggests that communication tools that are more effective in reaching wider areas need to be prioritized around Lake Alaotra, for example, communication outreach workshops targeting specific segments of a society (Steinmetz *et al.* 2014).

Fish and zebu cattle were identified as culturally, socially, and economically significant. Fish is an important source of income and zebu are valuable working animals for agriculture and transport. Animals that provided direct benefits for subsistence and economic, e.g., fish, and/or social, e.g., zebu, well-being, the latter of which also represent social prestige (Kaufmann and Tsirahamba 2006), ranked the highest. *Hapalemur alaotrensis* and waterfowl (wild and domestic ducks) ranked lowest in terms of value, as they are either under protection and illegal to hunt, or they are difficult to catch or breed. The low ranking of *H. alaotrensis* suggests that the creation of Park Bandro as an ecotourism site where visitors can stay and pay to observe the lemur in the marshes has not provided a sense of economic importance of the lemur to people in Andreba. This may be because tourist numbers are too low to be economically significant (Rendigs *et al.* 2015) and it can also be challenging to understand how benefits from ecotourism interact with other economic, social, and cultural values (Waylen *et al.* 2009). Local people at Alaotra appear to prioritize direct livelihood benefits over conservation values. For example, despite the negative ecological impact of the invasive fish *Channa maculata* (Copsey *et al.* 2009a), primary school teachers in the Alaotra region did not perceive this to be an environmental problem, because it provided a source of food (Reibelt *et al.* 2014). Unless conservation and sustainable development projects ensure more than a minimal and short-term socioeconomic

benefit, local people in areas with high levels of rural poverty will be unable to change their way of living (Marcus 2001).

Since the political crisis in Madagascar in 2009, the conversion of marshlands has been accelerated by wealthy and powerful nonlocal individuals who do not rely on local resources for survival. This has been facilitated by the vulnerability of the rural poor to follow illegal activities on behalf of these powerful individuals who are mostly based in the big cities (Ratsimbazafy *et al.* 2013; Waeber and Wilmé 2013), low levels of law enforcement, and the lack of formal legal protection for the marshes prior to the permanent status granted for the Lake Alaotra New Protected Area in June 2015. The combination of these factors has brought *Hapalemur alaotrensis* to the brink of extinction. However, the concern for the future of *H. alaotrensis* in villages around Lake Alaotra is encouraging and local people are also willing to discuss conservation zones, as long as areas are designated where they can pursue their daily livelihood activities such as fishing or rice farming (Waeber *et al.* 2017c). Fishers, in particular, preferred clear and effectively managed zoning for the benefit of resource users and biodiversity, including *H. alaotrensis*. Fishers prefer many, small no-take zones that correspond with important fish spawning areas (Wallace *et al.* 2015, 2016), confirming their awareness of the links among marsh vegetation, fish reproduction, and livelihood benefits to the fisher communities at Lake Alaotra. In Zambia, as awareness of the consequences of environmental degradation on livelihoods increased, so too did the likelihood of behavioral change by small-scale farmers to reduce the degradation (Wu and Mweemba 2010). This suggests that awareness raising and educational campaigns should target specific groups in the communities around Lake Alaotra, such as farmers, to increase the collective readiness to respect conservation areas and change behaviour. Increased contact with nature led to increased positive attitudes toward nature in children (increased biophilia and decreased biophobia), and biophilia significantly influenced their willingness for animal conservation in China (Zhang *et al.* 2014). Moreover, in line with the city–villages divide suggested by our study, children in urban areas had less biophilia and less readiness for conservation than most children from rural areas with more nature contact (Zhang *et al.* 2014).

The fact that local people are willing to discuss conservation zonation at Lake Alaotra provides hope for the future conservation of *Hapalemur alaotrensis*. However, conservation and development organizations need to ensure alignment between resource management planning and local community needs to avoid a disconnection between conservation policy and community needs. Such a disconnection has reduced the effectiveness of large-scale and long-term international and nation-wide conservation and development efforts in Madagascar in the past (Waeber *et al.* 2016). Restricting local livelihood needs also increases the risk of human–wildlife conflicts which could facilitate a shift toward negative perceptions of wildlife, and conservation in general.

Our findings for Lake Alaotra can also inform conservation in other regions of Madagascar. However, conservation planning is context dependent and it is important not to simplify cultural aspects (Keller 2009). Nevertheless, taboos can have important impacts on local perceptions and attitudes in Madagascar and are different from region to region (Lingard *et al.* 2003; Mittermeier *et al.* 1994; Rakotomamonjy *et al.* 2015; Ramanantsoa 1984).

Although based on a modest sample size of 230 participants, our study identified trends in local community knowledge, awareness, and perceptions of *Hapalemur alaotrensis*. We found differences between fishers and nonfishers and a negative correlation between levels of knowledge and distance from the high-priority conservation zone Park Bandro. People who encountered the lemur most often showed the highest levels of awareness and concern for the lemur's future. Qualitative research examining people's perceptions and priorities should be expanded at Lake Alaotra beyond fishers and farmers to provide further evidence of trends in conservation attitudes among a wider group of stakeholders. Community values, perceptions, and knowledge of *H. alaotrensis* should be used to guide future conservation planning, environmental education, and livelihood improvement activities at Lake Alaotra. The marshes and the Lake Alaotra gentle lemur can be protected only if local resource users are part of the solution and conservation and development organizations utilize information gained through qualitative studies to align resource users' concerns and livelihood needs with biodiversity values.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that there is no conflict of interests.

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