

Captive Conditions of Pet Lemurs in Madagascar

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Key Words

Lemurs · Madagascar · Africa · Pet · Trade · Capture

Abstract

Live extraction of wildlife is a threat to biodiversity and can compromise animal welfare standards. Studies of the captive environments and welfare of pet primates are known, but none has focused on Madagascar. We aimed to expand knowledge about the captive conditions of pet lemurs in Madagascar. We hypothesized that captive lemurs would often be kept in restrictive settings, including small cages, would be fed foods inconsistent with their natural diets and, as a result, would be in bad physical or psychological health. Data were collected via a web-based survey (n = 253 reports) and from the websites and social media pages of 25 hotels. Most lemurs seen by respondents were either kept on a rope/leash/chain or in a cage (67%), though some lemurs were habituated and were not restrained (28%). Most of the time (72%) cages were considered small, and lemurs were rarely kept in captivity together with other lemurs (81% of lemurs were caged alone). Pet lemurs were often fed foods inconsistent with their natural diets, and most (53%) were described as being in bad health. These findings point to a need to undertake outreach to pet lemur owners in Madagascar about the captivity requirements of primates.

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Introduction

The trade of primates occurs throughout the tropics and is a threat to their conservation [Cowlshaw and Dunbar, 2000; Nijman et al., 2011; Schwitzer et al., 2015]. For example, the pet trade has been identified as one of the greatest immediate threats facing lorises (Lorisidae), surpassing habitat loss [Schulze and Groves, 2004]. Live cap-

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ture may affect up to 40,000 primates annually [Karesh et al., 2005] with recent studies confirming that thousands of live primates are legally traded per year, many of which are sourced from the wild, for personal and commercial reasons [Bush et al., 2014; Harrington, 2015]. The trade of live primates can compromise animal welfare standards [Bush et al., 2014], and associated traumas can cause behavioral changes that persist for years (decades in chimpanzees [Lopresti-Goodman et al., 2013]). It can be difficult to collect information on these aspects of the trade because primates and other mammals tend to be traded in smaller numbers than birds and reptiles and not via markets where they might be more easily observed by outside researchers [Bush et al., 2014]. Studies addressing the captive environments and animal welfare of pet primates have been conducted in various countries where they are indigenous (e.g. Mexico [Duarte-Quiroga and Estrada, 2003], Peru [Shanee, 2012], Indonesia [Malone et al., 2003; Jones-Engel et al., 2005; Shepherd et al., 2005; Lopresti-Goodman et al., 2013], Sierra Leone [Kabasawa, 2009]). No study has examined this issue in Madagascar.

Madagascar is home to the highest number of threatened primate taxa in any one country and has primate endemism at family, genus, and species levels (all primates in Madagascar are endemic to the island [Myers et al., 2000; Mittermeier et al., 2010]). Although it is illegal to capture, sell, and trade lemurs, the live capture and ownership of lemurs is ongoing with an estimated 28,000 individuals kept in illegal captivity from 2010 to mid-2013 [Reuter et al., 2015]. The only study to date on pet lemurs in Madagascar found that lemur ownership was widespread and affected a variety of taxa, though the live capture of lemurs was not highly organized; individuals tended to extract their own lemurs, and organized extraction routes and mechanisms were not used [Reuter et al., 2015]. The study confirmed that lemurs are kept in captivity both by individuals and by hotels [Goodman, 1993], potentially to attract tourists [Schwitzer et al., 2013].

Published information regarding the captive conditions of pet lemurs in Madagascar is anecdotal. It has been suggested that while some pet lemurs in Madagascar are well managed in captivity, they are often kept in inadequate conditions [Schwitzer et al., 2013; Reuter et al., 2015]. This can include restrictive environments (e.g. small cages), inadequate husbandry (breeding of hybrids that would not ordinarily occur in the wild), and the provision of foods that are inconsistent with their natural diets, such as cooked rice [Schwitzer et al., 2013; Reuter et al., 2015]. It appears that pet lemur ownership in Madagascar is often short-lived [Andrews et al., 1998; Reuter et al., 2015]; whether this is because of inadequate captive conditions (e.g. inability to keep the pet lemur alive) or for other reasons (e.g. high cost of ownership, aggressive behaviors exhibited by the lemur) is not clear. Animal welfare can be compromised during various stages of removal from the wild, and adjustment to captive conditions can involve large changes in behavior and diet [Bush et al., 2014]. During removal from the wild and subsequently while in captivity, cage sizes are generally smaller than required by animals (both primates and otherwise), and it is often not feasible to keep animals in natural-sized groups; animals exposed to these and other stressors may exhibit abnormal and/or aggressive behaviors [reviewed by Jones-Engel et al., 2005; Bush et al., 2014]. Increasing understanding of how lemurs are kept in captivity in Madagascar is important for policy and management initiatives, and could improve the quality of captive environments as well as inform outreach to pet lemur owners. In addition, well-managed captive lemurs could contribute to global breeding programs [Schwitzer et al., 2013].

We aimed to expand knowledge about the captive conditions of lemurs kept as pets in Madagascar. Based on anecdotal observations described in Reuter et al. [2015], we hypothesized that (1A) captive lemurs would often be kept restrained (e.g. on a leash or in a cage) and that (1B) these settings would usually be small or allow limited room for movement. In addition, we hypothesized that (2A) lemurs would be kept in solitary housing (i.e. most owners would own only 1 lemur). Given that hotels might have the resources to keep more than 1 pet lemur, however, we hypothesized that businesses like hotels would own more lemurs than private individuals (2B). In regard to nutrition, based on Reuter et al. [2015], we hypothesized that (3A) lemurs would be fed foods inconsistent with their natural diets (e.g. human foods). As a result of restrictive captive environments and improper nutrition, we hypothesized that (4A) most lemurs would be considered to be in bad mental or physical health. Given no information to the contrary, and where sample sizes allowed us to test this statistically, we did not expect differences among genera for any of the hypotheses.

Methods

We collected data from January to June 2015 from two sources: (1) the public via a web-based survey, and (2) from the websites and social media profiles of hotels in Madagascar.

Ethical Research Statement

We followed international standards of research ethics, and research protocols were reviewed and approved by an ethics oversight committee (University of Utah Institutional Review Board). All researchers completed ethics training through the Collaborative Institutional Training Initiative. This research did not involve work on animals. All laws relevant to the survey of adult populations were followed.

Definition of a Pet Lemur

The purpose of this research was to examine a wide range of domestic, captive, and pet ownership settings of lemurs (hereafter referred to as 'pet lemurs'). We aimed to describe any type of ownership where lemurs had been removed from their natural habitats, where they relied almost exclusively on humans for food, or where it was apparent that a human 'owned' the lemur. We did not provide survey participants with a definition for a pet lemur; this was done intentionally so as to solicit a wide range of responses given that not much is known about captive lemur ownership in Madagascar.

Web-Based Survey

We collected data from the public (January to June 2015) via a web-based survey. The survey contained 14 questions (see online suppl. materials; see www.karger.com/doi/10.1159/000444582 for all online suppl. material) asking for details about captive lemurs observed by respondents. In order to decrease bias we did not prompt respondents to provide details about all aspects of captive conditions. Instead, we prompted respondents to provide any information they could recall via the following open-ended question: What type of captive environment was the lemur kept in? (Instructions/prompt: Any details you can provide about the captive environment of the lemur would be appreciated. For example, was the lemur restrained? How? What sort of food was the lemur fed? Was it kept in a cage?) Surveys were available in English and French and were designed to take less than 5 min to complete. Surveys were not available in Malagasy because, with more than 19 different Malagasy dialects, it would have been difficult to translate questions accurately into translate questions into each dialect without losing or changing the meaning of the questions (subtle changes in the phrasing of a question can affect survey respondent interpretation). Re-

spondents were free to leave any question unanswered. We recognize that a web-based survey may have limited the extent to which the general public in Madagascar could participate in the survey and therefore the survey may be biased towards instances of pet lemur ownership that would be observed in urban areas or by tourists.

We used direct e-mail recruitment to recruit researchers and conservation managers into the project; we used Listserv and social media outreach to collect data from the public. We made efforts to contact researchers who had worked across Madagascar to decrease geographic bias; researchers contacted had undertaken work in all 22 administrative regions of Madagascar. More information regarding recruitment strategies can be found in the supplementary materials.

Websites and Social Media Profiles of Hotels

We viewed the websites and social media profiles of 171 hotels (in 33 towns across 16 regions) across Madagascar (January to March 2015). More information regarding the online search for hotels can be found in the supplementary materials. From these websites and social media profiles, we recorded whether images of pet lemurs were shown and the number and species of lemur(s) pictured. Eligible pictures needed to show a restrained lemur (e.g. in a cage) or suggest that human-lemur contact would be possible at the establishment. We excluded photographs when captions indicated that human-lemur contact was not taking place at the hotel.

Analysis

We treated individual records as replicates [e.g. we did not first aggregate within a town or region and treat prior to analysis, because survey respondents did not provide information evenly across different regions or evenly across different species, limiting the use of regions or species as replicates and the sample size for the numbers of lemurs observed on the websites and social media sites of hotels was small ($n = 55$ lemurs)].

We used Pearson χ^2 tests to test whether: (1) the proportion of lemurs kept restricted (all types of captive conditions in which the lemur was not simply habituated) or unrestricted (habituated) differed by genus; and (2) the proportion of records which indicated that a lemur was habituated, kept in a cage, kept on a rope/leash/chain, or in other captive conditions differed by genus. In these tests, genera with 10 or less records were placed together into an 'other' category. Samples were too small to test for differences among genera for hypothesis 3A (pet lemurs would be fed foods inconsistent with their natural diet) or 4A (pet lemurs would be in poor health). It should be noted that the determination of 'health' in a pet lemur was based only on information provided by the respondents. When respondents provided information about the health of a lemur, they typically described it as being in 'good health' (with no explanatory or background information to support this claim) or as being in 'bad health' (generally with some limited explanatory or background information provided).

We used an analysis of variance to examine hypothesis 2B (businesses would own more lemurs than individuals). Because of unequal variances, we used a nonparametric Kruskal-Wallis rank sum test to examine whether the total number of lemurs held by an owner differed by the genus of lemur in captivity. Averages are shown as means \pm 95% confidence intervals.

Results

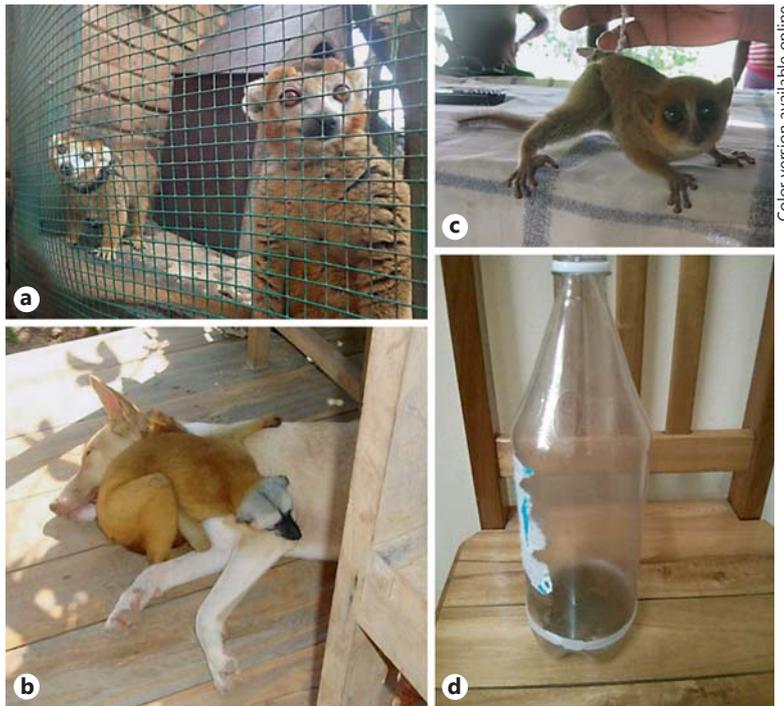
Parameters of the Data Set

Web-Based Survey. Approximately 229 individuals (199 unique IP addresses; about 30 via e-mail) submitted information on 302 different sightings of pet lemurs from 19 of Madagascar's 22 administrative regions in both urban and rural areas; 235 of these 302 records provided information about captive conditions. Sometimes the same lemur was observed in more than one captive condition or lemurs owned by the same person were kept in different manners resulting in 265 records of captive conditions.

Table 1. Information about captive conditions (%) of pet lemurs in Madagascar from the web-based survey and hotel websites

	Survey	Hotel websites
Captive housing	n = 265	n = 25
Rope/leash/chain	35	96
Cage	32	8
Habituated	28	–
Basket	3	–
Island	2	–
Bottle	<1	–
Number of lemurs owned	n = 273	n = 25
1	52	33
2	22	33
3	12	17
4	4	17
5 or more	11	4
Foods	n = 45	n = 8
Fruits		
Banana	71	50
Litchi	7	25
Mango	7	13
Pineapple	2	–
Rice	29	–
Leftovers	16	–
Vegetables	9	–
Meat	2	–
Khat (<i>Catha edulis</i>)	2	–
Coconut wine	2	–
Bamboo	–	13
Health	n = 38	–
Aggression	29	–
Good health	31	–
Bad health	52	–
Anxious, stressed	26	–
Underweight	11	–
Overweight	5	–
Lacerations/wounds from rope/leash/chain	5	–
Dehydration	5	–
Frequent diarrhea	3	–
Near death	3	–
Stereotypies	3	–

Since different subcategories (e.g. different types of captive housing) are not mutually exclusive, the percentages may sum up to greater than 100%.



Color version available online

Fig. 1. Photographs illustrating some of the different types of captive conditions reported for lemurs in Madagascar, including: 2 *Eulemur coronatus* in a cage (**a**, with some enrichment provided; note the collar which is used when the lemur is taken out of the cage); a habituated *Eulemur fulvus* resting on a domestic dog (**b**); a *Microcebus* sp. kept on a rope in a private home (**c**), and a *Microcebus* sp. kept in a plastic bottle (**d**).

Hotels. We found that 25 hotels showed images of 55 pet lemurs; lemurs were identified as being different individuals when they were of different species and/or when multiple individuals of the same species were featured in one photograph.

Captive Conditions of Pet Lemurs

Captive Housing. In accordance with hypothesis 1A, pet lemurs were often seen in restrictive settings such as on a rope/leash/chain (35%) or in a cage (32%; fig. 1, table 1). In contrast, most hotels (96% of 25 hotels) showed what appeared to be habituated but free-roaming lemurs. The proportion of lemurs kept restricted or unrestricted did not differ by genus (Pearson χ^2 test: $n = 183$, d.f. = 5, $\chi^2 = 2.411$, $p = 0.789$). The type of captive housing in which lemurs were kept did not differ by genus (Pearson χ^2 test: $n = 183$, d.f. = 15, $\chi^2 = 8.489$, $p = 0.5132$; fig. 2). Some web-based respondents provided additional information about the cages in which lemurs were kept (fig. 3). Out of 84 records of lemurs being kept in cages, 19% reported multiple lemurs in the same cage together, and 2% reported lemurs in cages with tortoises and rabbits. Many of the 84 records ($n = 42$, i.e. 46%) provided an estimate of the cage size in relative (small/medium/large) or absolute terms (size in square meters or cubic me-

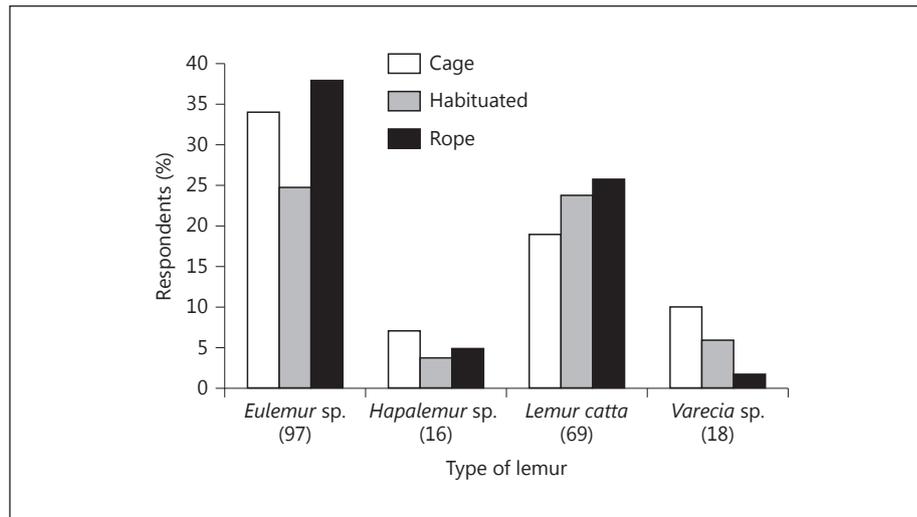


Fig. 2. The percentage of individual lemurs seen in different types of captive settings (including only genera with a sample size of >10 and captive settings seen by at least 10 respondents). Sample sizes are listed in parentheses for each lemur genus/species.

Table 2. The percentage of owners with different numbers of lemurs

Lemurs owned, n	Business (n = 135)	In someone's home (n = 83)	Other (n = 58)
1	49	59	47
2	21	22	22
3	13	8	14
4	4	6	0
5+	13	4	16

ters); all estimates of cage size were linked to observations of *Eulemur*, *Hapalemur*, *Lemur*, and *Varecia*. Of the 29 records detailing cage size in relative terms, and in support of hypothesis 1B, many cages were described as small (72% of cages; 10 and 17% described as medium- or large-sized, respectively). Four of the respondents who described cages as 'small' also described the types of movement that the space permitted the captive lemur: was not able to move at all (n = 1); could not walk but could sit and lie down (n = 1); could only move a little (n = 1); was able to climb around in cage (n = 1). Eleven records provided estimates of cage sizes in absolute terms in both cubic meters and square meters, ranging from 0.25 to 12 m³ and 1.09 to 5.76 m².

Social Housing. In accordance with hypothesis 2A, most lemurs were kept in solitary housing; owners rarely owned more than 1 lemur (table 1). The number of lemurs owned, as reported by web-based respondents, differed among different types of owners (business, in someone's house, other; ANOVA, d.f. = 2, F ratio = 3.7990, p = 0.024; table 2) supporting hypothesis 2B. Businesses owned 2.5 ± 0.4 lemurs



Color version available online

Fig. 3. Photographs illustrating the range of cages in which pet lemurs are kept in Madagascar, including: 2 *Eulemur albifrons* in a wire cage (**a**, private owner); *Lemur catta* kept in a cage with some enrichment (**b**, at a restaurant); an enclosure built on private property that held 2 lemurs (**c**, *Eulemur coronatus* and *E. albifrons*) which were only taken out by their owners; 2 *E. coronatus* were kept in this enclosure (**d**, made using fishing nets; at a beach side hotel/restaurant), and 1 *Eulemur collaris* was kept in this caged environment for several days at a time (**e**, at a hotel/restaurant).



Color version available online

Fig. 4. Only one hotel website indicated that habituated lemurs could not be fed. The hotel in question did so by having this photograph on its website, which also illustrates other rules that guests must follow to minimize their impact on the native fauna and flora.

(n = 134), private owners owned 1.8 ± 0.3 lemurs (n = 82), and owners in situations not involving a business or a private owner had 2.4 ± 0.6 lemurs on average (n = 58). The number of lemurs owned by the same person did not differ by the genera of lemur observed in captivity (Kruskal-Wallis rank sum test, $\chi^2 = 8.7254$, d.f. = 6, p = 0.19). Based on the photographs found on websites and social media pages, 52% of the 25 hotels kept 2 or more individuals of the same species in captivity at the same time (table 1).

Nourishment Given to Lemurs. Forty-five records from web-based survey respondents provided information about the foods which lemurs were fed. As per hypothesis 3A, lemurs were given foods inconsistent with their natural diets (table 1). Web-based respondents provided no evidence to suggest that specialized diets were accommodated (e.g. bamboo for *Haplemur* sp. or foliage for other folivores), though a caged *Haplemur griseus* was pictured with bamboo on a hotel website. One hotel website showed a photograph of a sign prohibiting guests from feeding lemurs (fig. 4).

Health and Aggression. Thirty-eight records provided information about the physical and psychological health of pet lemurs as well as incidents of aggression towards owners. In accordance with hypothesis 4A, most lemurs were considered to be in bad mental or physical health (table 1). Of 38 records, 52% indicated that the captive lemur was in bad health while 31% indicated the captive lemur was in good health. The most commonly stated reasons for concluding that a lemur was in bad health are listed in table 1. None of the respondents provided evidence for why they felt that lemurs were in good health.

Some of the records noted that lemurs had a history of being aggressive, including 4 lemurs that had also been described as being in good physical health (table 1). Nine out of the 11 lemurs that were described as aggressive had bitten a person before, and all 11 lemurs were described as being adults. One record indicated that a lemur had had its tongue split so that it could not bite people.

Discussion

The regulation of primate ownership is limited in many areas of the world. Regulations of publicly funded institutions (in the USA and other countries) provide a baseline for the examination of captive conditions. Generally, these regulations require that nonhuman primates be provided a diet appropriate for the species, have adequate space for the expression of species-typical behaviors, including locomotor activities such as climbing and jumping, have environmental enrichments to provide for psychological well-being, and be socially housed (except for species which are naturally solitary; see, for example, the Animal Welfare Act, 7 USC §§ 2131–2159, 2013; National Research Council [2011], European Parliament [2010]; Bayne and Morris [2012]). In many instances, the captive conditions for the pet lemurs reported in our study did not meet these minimum requirements.

Captive Housing

Most lemurs seen by respondents were either kept on a rope/leash/chain or in a cage (67%), though some lemurs were habituated (28%). In contrast, most pet lemurs featured on hotel websites and social media pages appeared to be habituated (96%). This may be because hotels habituate lemurs that naturally live near the property be-

cause it is more aesthetically appealing to show lemurs – at least online – in natural environments rather than in cages.

Pet lemurs were kept in cages one third of the time, and three fourths of these cages were described as small, though the identification of cage size as small, medium, or large is subjective. Of the 11 records that specified cage size, the smallest (0.25 m³) is just above the minimum requirements for a lemur-sized primate within the USA (the Animal Welfare Act, 7 USC §§ 2131–2159, 2013; National Research Council [2011]). Of the photos submitted, some do show primates housed in cages that are of sufficient size to allow freedom of movement (fig. 1, US standards). As pointed out by some respondents, however, this does not mean that cages are large enough to allow for a wide range of locomotor activities such as climbing or jumping (European Union standards [European Parliament, 2010]). While many regulatory bodies specify cage size based on species' body mass (which can represent a trade-off between species' welfare and economic and practical needs), numerous other factors such as physiological, ecological, locomotor, social, and behavioral characteristics are also important [Buchanan-Smith et al., 2004]. For instance, both *Propithecus* and *Indri* species would require considerably more space than that required based on body mass alone to engage in species-typical vertical clinging and leaping locomotion. It should be noted that the discrepancy between a species' home range size in nature and their cage size in captivity appears to be a factor in the development of stereotypical behaviors such as pacing [Moore et al., 2015]. As such, larger enclosures are likely an important factor in the well-being of pet lemurs.

It is worrying that many lemurs were kept on ropes, leashes, and chains. Several respondents noted that these restraints were too tight on the lemur(s). In addition, one respondent indicated the lemur was on a retractable leash. Lemurs kept in these types of restraints could be unintentionally injured, especially when leashes are too long or become tangled. In Mexico, the most common causes of death for pet primates (39% of individuals) was asphyxiation by strangulation as a result of ropes becoming tangled in housing structures or trees [Duarte-Quiroga and Estrada, 2003].

Lemurs were seldom kept in captivity together with other lemurs (52% of owners owned only 1 lemur; 81% of lemurs in cages were housed alone). Isolation from conspecifics has also been a noted issue in the captivity of other pet primates (77% of slow lorises in online videos, *Nycticebus* sp. [Nekaris et al., 2015]). Several studies of captive primates conducted in the USA have recommended social housing for nonhuman primates (see Novak and Suomi [1991] and Tardif et al. [2013] for reviews). In addition, numerous international regulating bodies have added social housing as one of the minimum requirements for primates in captivity (see, for example, the Animal Welfare Act regulations, 7 USC §§ 2131–2159, 2013; National Research Council [2011], European Parliament [2010]; Bayne and Morris [2012]). Given that many lemur species typically live in social groups [Mittermeier et al., 2010], housing lemurs individually is not ideal.

Housing multiple lemurs together requires owners to manage conflict between the individuals kept in captivity [Vick and Pereira, 1989; Palagi et al., 2005] and both intentional and unintentional captive breeding. Our study provides evidence that these are concerns for lemur owners in Madagascar. Private owners were often observed keeping multiple lemurs in separate or different captive environments (e.g. keeping multiple lemurs in separate cages; keeping one lemur in a cage while others remained habituated and free-ranging); this may have been to decrease conflict be-

tween multiple lemurs or to separate particularly aggressive lemurs from those that were less aggressive.

Unintentional breeding of captive lemurs is likely also occurring, albeit at low levels. Several hotels (28%) housed juveniles and these may have been born in captivity (though anecdotal reports indicate that juvenile lemurs are often kept as pets after adults are killed by hunters [Sauther et al., 2013]). Schwitzer et al. [2013] noted that captive facilities in Madagascar have inadequate husbandry standards, leading to – among other things – the hybridization of species that would not generally occur together in the wild. It is unlikely that private owners and hotels in Madagascar have the resources or technical expertise to adequately house multiple lemurs together in such a way that avoids this and other unintended consequences [Schwitzer et al., 2013].

Enrichment of the captive environment in Madagascar merits further research. Only 4 respondents mentioned observing enrichment being provided to pet lemurs (branches, trees, plants, or other habitat structures within the caged environment), and similar enrichment methods were observed in only 4 photographs submitted by web-based survey respondents (out of 28 photographs of lemurs in cages/enclosures) and 3 photographs from hotel websites. Enrichment (including structural, olfactory, social, or object enrichment) promotes psychological well-being, physical activity, performance of natural behaviors, and can decrease stress and stereotypical behaviors. Several studies have found that enrichment can positively impact lemurs in captivity (feeding enrichment [Kerridge, 2005; Dishman et al., 2009]). Not all enrichment, however, results in positive behavioral change and this, therefore, requires testing [Shepherdson, 1998; Mehrkam and Dorey, 2015]. For example, group cohesion in long-tailed macaques (*Macaca fascicularis*) can be disrupted when a single toy is introduced into the captive environment, thereby causing competition [Ballesta et al., 2014], while multiple enrichment strategies (spatial, structural, lighting, and object enrichment) for captive *Galago senegalensis* had no effect on behavioral profiles [Schaefer and Nash, 2004]. Nevertheless, given that most pet lemurs in this study were housed alone, enrichment could be one method for increasing the quality of captive conditions in cases where owners do not have the capacity to provide social housing.

Nourishment Given to Lemurs

Pet lemurs were almost always fed foods inconsistent with their natural diets, including a variety of human foods such as cooked rice. The inadequacy of lemur diets reported in this study may be why at least 1 pet lemur was described as having frequent diarrhea. In only one case was there evidence of a single folivore's (*Hapalemur* sp.) diet being of 1 individual folivore's diet (*Hapalemur* sp.) being accommodated, though approximately 25% of pet lemurs (15% reported through the online survey and 10% from hotel websites) are categorized as folivores (e.g. *Hapalemur*, *Propithecus*) in this study. While frugivorous lemurs were more commonly kept as pets (e.g. *Lemur*, *Eulemur*, *Varecia*), they were generally fed fruits (e.g. bananas and mangos) that are not typically, or consistently, part of their natural diet [Mittermeier et al., 2010]. These results echo the findings of several studies of captive primates in other parts of the globe. Soulsbury et al. [2009] and Hevesi [2005] note that poor and inappropriate diets for pet primates are fairly common. Inadequate diets might result in poor health; the smaller sizes of privately owned slow lorises (*Nycticebus* spp.), compared to their wild counterparts, were attributed to their diets (primarily boiled

rice [Ratajszczak, 1998]). Given that one third of pet lemurs were observed being fed rice (table 1), it would be beneficial for future research to examine the differences in health between lemurs in the wild and those kept as illegal pets.

No respondents commented on the quantity of food provided to pet lemurs. It may be that pet lemurs are both underfed and overfed, depending on why they are kept in captivity. For example, pet lemurs kept as tourist attractions in urban areas are often fed bananas by tourists. In a public park in urban Brazil, interactions between humans and marmosets, *Callithrix penicillata*, occurred up to 4 times per hour [Leite et al., 2011]; if human-primate interactions take place at similar rates in urban Madagascar, and if pet lemurs are usually fed during these interactions, then they might be at risk of being overfed. As another example, pet lemurs are also often habituated by tourist guides in or near national parks (who encourage tourists to feed lemurs as part of staged photographic opportunities). In a national park in Brazil, 79% of 380 interactions between habituated capuchins (*Cebus libidinosus*) and humans involved food [Sabbatini et al., 2006]. Therefore, it may be that pet lemurs habituated near national parks are overfed on days when a large number of tourists visit the parks.

Health and Aggression

The health of primates and whether or not they show aggression towards humans can be due to the captive environment [Birkett and Newton-Fisher, 2011]. Our study provides evidence to suggest that many pet lemurs are not kept in adequate environments and when respondents provided information regarding the health of a pet lemur, 53% described the lemurs as being in poor health (e.g. underweight, lacerations due to tight restraints). In addition, at least 1 lemur was described as exhibiting stereotypical behavior (repetitive pacing in a pet lemur kept in a cage). Stereotypical and abnormal behaviors have also been recorded in legally captive lemurs such as those in regulated zoos [Tarou et al., 2005]. Early evidence suggests that there may be an increased risk of disease transmission among and between lemurs and humans in areas where they come in close contact [Rasambainarivo et al., 2013; Zodhy et al., 2015]. Additional research is needed, however, to examine how this plays a role in both lemur and human health when lemurs are kept as pets.

Several respondents raised the issue of aggression in adult lemurs. As primates reach sexual maturity, they become more aggressive and their increased size and strength makes them difficult to control, dangerous, and less appealing as a pet [Jones-Engel et al., 2005]. This can impact captive conditions. For example, one respondent indicated that a lemur's cage was not cleaned frequently enough because the handlers felt the lemur was too aggressive to approach. Respondents also noted that lemurs were caged or killed when they became too aggressive. In Mexico, owners killing their pet primates following an aggressive incident was the cause of primate death 11% of the time [Duarte-Quiroga and Estrada, 2003]. In Indonesia, 8% of owners had been bitten by their pet primates [Jones-Engel et al., 2005]. Additional research is needed to understand how often pet lemurs are aggressive towards their owners and how this changes the captive requirements of lemurs as they age. In particular, it is not clear whether aggressive incidents are provoked by interactions with humans. In Brazil, 47% of 380 interactions between habituated capuchins and tourists were initiated by humans and 17% of interactions involved capuchins threatening or chasing visitors [Sabbatini et al., 2006].

Conservation and Next Steps

Poor captive conditions of pet primates are not unique to Madagascar and have been reported in many countries. For example, in Indonesian wildlife markets, mortality of the wildlife is high due to poor conditions with up to 50% of all traded animals dying in the first 24 h of captivity [Shepherd et al., 2005]. This is often due to lack of proper care or to health problems acquired in transport and within the animal markets [Nekaris and Jaffe, 2007]. Furthermore, many individuals – up to a quarter of the primate species in Indonesian markets – exhibited physical or behavioral abnormalities [Clubb and Mason, 2007; Nekaris et al., 2010; Nijman et al., 2015]. Nijman's [2006] study of pet gibbons (*Hylobates* sp.) reported 'appalling' conditions. In a study of 179 pet primates in Mexico City, respiratory infections, gastrointestinal problems, skin and viral infections, burns, electric shocks, and intoxication were reported [Duarte-Quiroga and Estrada, 2003]. Since cage space and hygiene may be predictors of primate welfare [Nijman et al., 2015], establishing guidelines for the keeping of pet lemurs may improve their survival as well as their overall mental and physical well-being.

In Madagascar, improved regulation, monitoring, and enforcement could have a positive effect on primate captivity (e.g. ensuring adequate cage sizes and diets). Our study shows that despite evidence that many owners are keeping lemurs in substandard conditions, many other owners keep their lemurs in minimally acceptable conditions. For example, 17% of respondents described cages as 'large' and when a lemur's health was described, 32% of the time it was described as good. Therefore, dozens if not hundreds of illegal private owners appear to want to create an acceptable captive environment for their pet lemurs. This is also the case with hotels, where lemurs provide an 'added value' for tourists [Reuter and Schaefer, in preparation], and where the health of captive lemurs could be linked to the brand or image that hotels are aiming to portray to their guests.

Most of these lemur owners (both private and business) are probably not equipped with adequate information regarding the requirements of keeping lemurs as pets [K.E.R., pers. observation; Schwitzer et al., 2013]. Many owners of exotic pets lack the knowledge of their pets' ecology and behavior, and this can lead to poor welfare for their pets [Soulsbury et al., 2009]. In Madagascar, owners might have a particularly hard time accessing information given that few individuals have access to the Internet (2.2% of the population [World Bank, 2015]) or speak the languages (e.g. English) in which guidelines are typically published. This presents openings for targeted outreach. Free access to guidelines on the captivity of pet lemurs could provide information to illegal owners on how to provide adequate captive care to their pet lemurs. Many respondents to our web-based survey specifically asked how they could help improve the conditions of the pet lemurs that they had observed. Beyond reporting illegal lemurs to the authorities in Madagascar, this targeted outreach might be one mechanism by which the public could help improve the captive conditions and well-being of pet lemurs in Madagascar. Such guidelines must be carefully considered and marketed, and should not be confused as an endorsement of illegal ownership of lemurs. The involvement of experts on primate captivity, government officials, and nonprofit organizations (who can help translate technical language into guidelines that nonexperts can understand) would be key.

There were several other outreach and conservation opportunities related to improving the captive conditions of lemurs in Madagascar. For example, outreach tar-

geted at tourists could help increase awareness that most pet lemurs are actually being kept illegally (and thereby potentially decrease the demand from tourists for pet lemurs at businesses like hotels). In addition, a limited number of establishments in Madagascar are legally allowed to keep lemurs in captivity (less than 30; includes zoos, nature parks, and rehabilitation facilities for lemurs confiscated from illegal trade), and it would be beneficial to work with these establishments to ensure that they meet the international standards for primate captivity and are widely recognized as being the only legal captive facilities in the country. Finally, targeted education programs aimed at deterring ownership of illegal pet lemurs would, of course, also be beneficial. These outreach and conservation opportunities, and further investigations into the motivations behind pet lemur ownership, can have positive impacts on wild populations.

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