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Captive populations of lemurs in European zoos: mismatch between current species representation and *ex-situ* conservation needs

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Abstract
Captive breeding programmes in zoological institutions can be important tools for conservation. Lemurs are popular zoo animals and are present in hundreds of zoos outside of Madagascar. But are captive lemur populations integrated into ex-situ conservation efforts? Are lemur species in zoos chosen because of their conservation value, popular appeal, or some other considerations? Here, we address these questions, focusing on zoological institutions of the European Association of Zoos and Aquaria (EAZA) network. We assess whether lemur species presence in EAZA zoos is linked to taxonomy, International Union for the Conservation of Nature (IUCN) threat category and/or biological traits (body mass and diet). We find that a total of 22 of 109 lemur species are currently kept in EAZA zoos (July 2021). Our results show that some species (e.g. *Lemur catta*, *Varecia variegata*) and genera (e.g. *Eulemur*) are over-represented in zoos, whereas some species-rich genera are poorly represented (*Microcebus*) or not represented at all (*Lepilemur*). Body mass and diet are strong indicators of presence in captivity, with larger or frugivorous species overrepresented, and small or folivorous species underrepresented. A total of 15 species are currently bred under collaborative European ex-situ programmes. There is no link between severity of IUCN status and species presence in zoos, and endangered or critically endangered species are not more likely to be found in captivity. These results suggest that species in EAZA zoos have predominantly been chosen due to their appeal to the public, ease of husbandry or other practical and administrative constraints, rather than based on potential benefits for conservation. Addressing the imbalance between the EAZA's current collection of captive lemur species and the lemur species of conservation priority would lead to better representation of the threatened biodiversity of lemurs under active *ex-situ* population management, potentially acting as a failsafe against extinction.

Introduction
Lemurs are a diverse but highly endangered group of primates endemic to the island of Madagascar. Of the 109 extant species of lemur, 103 (94%) are considered threatened by the International Union for Conservation of Nature (IUCN), that is, they are currently classified as vulnerable, endangered or critically endangered (IUCN, 2021). Given the large number of species at risk and the increasing level of threats (habitat destruction, hunting), lemur conservation efforts have become multifaceted and employ a variety of strategies (Schwitzer *et al*., 2013*a*) These strategies must focus on assuring viability of wild populations in their natural habitats, but, given the rise of anthropogenic threats in Madagascar, it has also become increasingly important to maintain conservation-focused captive breeding ex-situ programmes (Schwitzer *et al*., 2013*b*). Ex-situ conservation through captive assurance colonies can have multiple advantages: complementing and supporting local conservation programmes in Madagascar, maintaining genetic diversity, aiding population recovery and reintroductions, as well as raising awareness through educational and visibility activities (Kleiman, 1989; Zimmermann, 2010; Schwitzer *et al.,* 2013*b*). Several lemur ex-situ conservation programmes are currently running in Madagascar, with strong links to in-situ management initiatives (King *et al*., 2013; Schwitzer *et al*., 2013*b*). Beyond Madagascar, captive breeding with conservation purposes has also been set up in various countries all over the world. Under the "One Plan" approach, populations of a lemur species within and outside of Madagascar, in the wild and in captivity, should all be managed as a metapopulation, increasing the chances of success in an unpredictable future (Byers *et al*., 2013; Schwitzer *et al*., 2013*b*).
In addition to ex-situ captive-breeding programmes, lemurs are also currently kept in zoos worldwide due to their attractiveness and ability to attract visitors (Carr, 2016). Due to their cuteness, exoticism and popularity, lemurs have gone global – they are found in zoological institutions on six continents. While many populations in zoological collections have a link to conservation (often indirect, through raising awareness), lemurs are not always held in captivity with the aim of protecting them and many lemur populations are not part of formal ex-situ conservation programmes. Lemurs are often kept for purely commercial or entertainment purposes (e.g. roadside zoos or tourist attractions) both in Madagascar and abroad (Reuter *et al*., 2019). Previous research in mammals has shown that the selection of mammalian families represented in zoos is strongly linked to body size and the degree of human-perceived attractiveness (Frynta *et al*., 2013). Mammals that are perceived as less attractive to zoo visitors tend to be underrepresented in zoos, even if they are of high conservation priority (Frynta *et al*., 2013). Therefore, we can expect the representation of lemurs in zoos to also not be tightly correlated with conservation needs, but to be driven by other considerations. For example, some lemur species, such as the ring-tailed lemur (*Lemur catta*), are zoo "stars", able to attract visitors due to their recognizable morphological features and behaviour, and are frequently portrayed in popular culture, nature documentaries and cartoons (Sauther *et al*., 2015; Clarke *et al.,* 2019). Furthermore, unlike ring-tailed lemurs, which are omnivorous and have a flexible behaviour and ecology, not all lemur species are easily and viably kept in zoos, as husbandry constraints can influence welfare, survivorship and ability to breed under captive conditions (Caravaggi *et al*., 2018; Bailes *et al*., 2020).
In this study, we focus on the species of lemurs that are currently being held in zoological institutions that are members of the European Association of Zoos and Aquaria (EAZA). The EAZA currently has over 400 member institutions in 48 countries, most of them in Europe, but also includes a

few institutions on other continents. The current collection of lemur species in EAZA institutions has been partly shaped by historical and regulatory contingencies. EAZA institutions often do not have a choice as to the species of lemurs they can include in their collections, as there are several bodies at play which help decide which species will be housed. Information on the origin of lemur populations in EAZA institutions is patchy, with most founders coming from the wild in Madagascar or others from institutions elsewhere (Zootierliste, 2021). Records show that several species of lemur have been imported from Madagascar to European zoological collections over the years (Zootier-liste, 2021), often with mixed results, with some species doing well and others not surviving in captivity. For example, eight indris (*Indri indri*) imported from Madagascar to the Jardin des Plantes in Paris in 1939 died within a month of arrival due to stress and malnutrition (Crandall, 1964; Zootierliste, 2021). The first European zoos were mostly interested in collecting rare or "exotic" species to show to European audiences, and were not focused on conservation. As attitudes towards conservation changed, zoos felt the need to combine efforts, and the first European-based captive breeding programs with conservation goals in mind were set up in 1985 (Nogge, 2007). This eventually led to the creation of the current EAZA-run European Ex-situ Programs (EEP's), which aim to maintain long-term viable healthy captive populations of various threatened species (Nogge, 2007). EAZA's EEP's are typically managed by a zoo which holds the species and acts as a coordinator. The EEP programme manages population size, genetic diversity and demography of the species, coordinates exchange of individuals between partner institutions, and facilitates fundamental research. EEPs involve inter-zoo collaboration on husbandry, studbooks (registry of the captive individuals of a species) and exchange of individuals to preserve genetic diversity.

Shortly after the first EEPs were established, a review of lemur captive breeding was published, entitled "The role of zoos and captive breeding in lemur conservation" (Durrell, 1989). In that review, the author referred to a total of 22 extant species of lemur, 17 of which were being held in ex-situ programs at the time. There have been substantial changes since the publication of the review by Durrell – for example, since 1989 dozens of new species have been discovered and described (Mittermeier *et al*., 2008, 2014). Therefore, a review of the status of captive breeding of lemurs is overdue and it may allow us to gain insight into current gaps in lemur species representation.

In this study, we list and characterize the lemur species that are currently kept in captivity in EAZA member institutions. We assess whether species currently held in captivity were chosen mostly for conservation reasons, popular appeal, or biological constraints. We aim to answer the following questions: i) what is the species composition of lemur populations in European zoos and how are these integrated into ex-situ conservation programmes? ii) which characteristics have influenced the choice of lemur species that are currently represented in ex-situ collections? To answer ii) we focus on taxonomy, IUCN threat category, body mass and diet of the lemur species. If species have been chosen based on their conservation priority, we would expect species with more severe IUCN threat statuses (e.g. endangered, critically endangered) to be well represented in zoos. If species have been chosen for their popular appeal, we may expect larger-bodied species to be overrepresented, as visitors are known to show greater interest in large animals (Moss and Esson, 2010). Finally, we may expect species with generalist or less specialized diets to be favoured in living collections, given that replicating natural diet as accurately as possible is essential for species survival in captivity, with some species with specialized diets being particularly challenging or costly to feed (Sha, 2014).

Methods

All data used in this study are provided in Tab. S1 (available at: https://data.mendeley.com/datasets/6wxpfmjz25/1). From the IUCN website (IUCN 2021), we obtained the list of extant lemur species currently recognized by that organisation. For each species we gathered their IUCN Red List status (as of July 2021). For completeness, we added one recently described lemur species that is not currently on the IUCN list, *Microcebus jonahi* (Schüßler *et al.,* 2020), which we classified as 'not evaluated'. We obtained mean body mass data for each species from a published dataset of body masses of wild lemurs (Taylor and Schwitzer, 2012). We classified species into the following categories: <0.2kg; 0.2kg to 1kg; 1kg to 2kg; >2kg. For 13 recently described species, body mass data were not available in Taylor and Schwitzer (2012), so for those species we gathered data from other sources or inferred the mean body mass category based on the modal body mass category for the genus. All these cases and respective references are indicated in Tab. S1. Data on diet were obtained from the IUCN website (IUCN, 2021). Lemur diets can be difficult to categorize, as diets can be diverse, highly seasonal and are often insufficiently studied or unknown (Godfrey *et al*., 2004; Beeby and Baden, 2021). We chose to classify species into broad categories based on their most common dietary categories: "bamboo", "frugivorous", "folivorous", "gummivorous", "insectivorous", "omnivorous". These diets are not rigid and are "fluid", but using this classification scheme we aimed to highlight general patterns in diet. For several species, diet data were not available on the IUCN website, and for these we assumed their diet to be the same as for other congenerics (based on the genera for which data on diet were available on the IUCN website, diet under the broad categories we use is highly conserved within genera).

We obtained data on the lemurs that are currently held in zoological institutions that are members of EAZA (Tab. S1). Our focus on EAZA collections is due to the fact that there is relatively up-to-date recordkeeping and a good overview of the data for zoos that are part of this association. The Species360 Zoological Information Management System (ZIMS), a database of wild animals under care, was used to extract data on: identity of lemur species currently held in captivity, number of species and number of zoos that keep each lemur species (ZIMS, 2021). In addition, we used the database Zootierliste, which compiles information on current and former holdings in EAZA member institutions, to obtain information on lemur species that were held in the past but are not currently held (Zootierliste, 2021). When compiling data from these databases, no data were excluded, hybrids were included under one of the parent species and subspecific taxa were lumped together. The number and identity of species that are currently held in EAZA institutions reported by ZIMS and Zootierliste were the same. The number of institutions currently holding lemurs varies between both databases, so for this metric we favoured using ZIMS, as it is a more formally managed database. We obtained information on current EAZA *ex-situ* programmes (EEPs) from the EAZA website (EAZA, 2021).

We assessed whether the fact that a species is currently held in captivity within an EAZA institution is related to the species' taxonomic classification (genus), IUCN Red List status, body mass and diet. These explanatory variables were plotted against the proportion of all species for

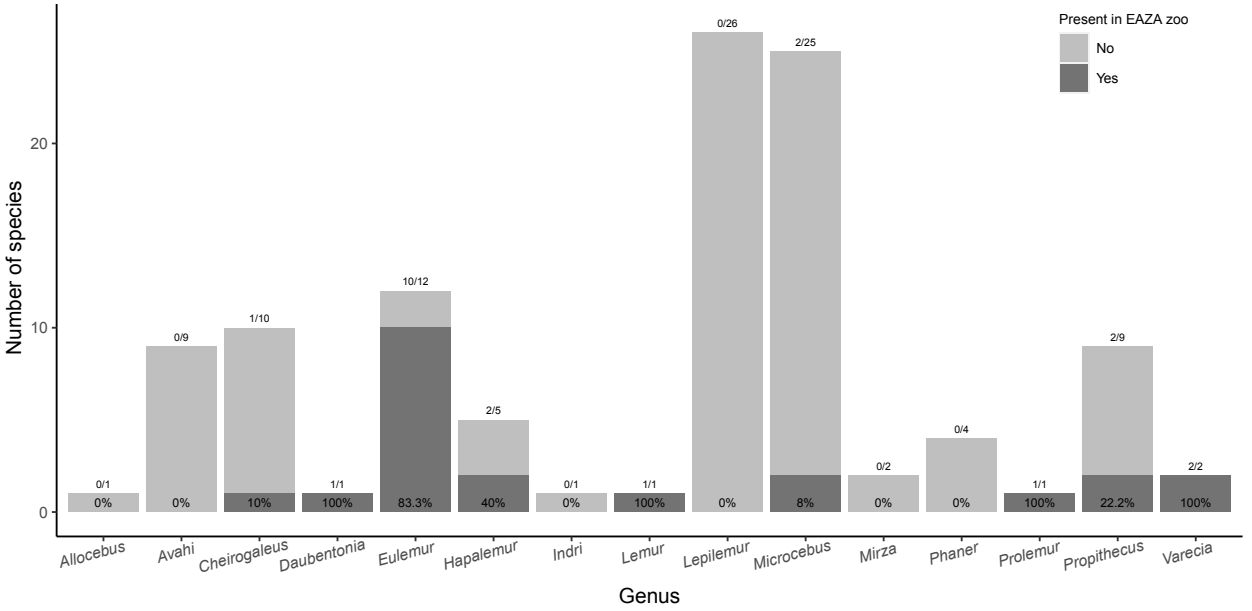

Fig. 1: Number and percentage of species of lemurs held in EAZA institutions as of July 2021. Numbers above the bars represent number of species in captivity/ total number of species in the genus. Percentage numbers shown on bars represent percentage of species present in EAZA zoos for each genus (July 2021).

each variable category that are currently held in captivity. We statistically tested for an effect of IUCN status, body mass and diet on the proportion of species under captivity using a test of equal proportions, where we compared the proportion of species of each category that are present in captivity, testing the null hypothesis that the proportions in several categories are the same. We used the function 'prop.test' in R, which is part of R's basic "stats" package. As sample sizes are low, we did not test for interactions between variables, and treated each variable separately. However, we acknowledge that variables can be correlated, and that the interaction of different variables (e.g. diet and body mass) may influence the representation of species in captivity.

Tab. 1: Lemur species that were previously held in European zoological institutions, but which are no longer held, according to ZIMS and Zootierliste (2021).

Species	First record	Last record	IUCN status 2021
Allocebus trichotis	1991	2002	EN
Cheirogaleus crossleyi	1952	1961	VU
Cheirogaleus major	1906	2019	VU
Eulemur sanfordi	Unknown	2003	EN
Hapalemur griseus griseus	1893	2011	VU
Indri indri	1939	1939	CR
Lepilemur ruficaudatus	1986	1993	CR
Microcebus myoxinus	1890	Unknown	VU
Microcebus rufus	1970	2005	VU
Mirza coquereli	1885	1917	EN
Mirza zaza	1986	2009	VU
Phaner furcifer	1908	1996	EN
Propithecus diadema	1908	Unknown	CR
Propithecus verreauxi	1900	1912	CR

Results

As of July 2021, 22 different species of lemur are represented in zoological institutes that are members of EAZA, representing 20.2% of all extant lemur species (total 109). A total of 236 EAZA zoos currently hold at least one lemur species. According to ZIMS and Zootierliste (ZIMS 2021; Zootierliste 2021), at least 14 lemur species previously held in European collections are currently absent. These species are shown in Tab. 1. None of these were part of the priority list by Schwitzer *et al.* (2013b), but several of them are currently highly threatened.

Taxonomic coverage

The percentage of lemur species per genus currently held in captivity is unequal (Fig. 1). Of the largest genera in terms of numbers of species, the most widely represented in zoos is *Eulemur*, with 10 out of 12 species currently in captivity. Genus *Hapalemur* has less than half of its species in EAZA zoos (2 out of 5). Four species-poor genera have all their species in zoos: *Daubentonia,* (n=1 species); *Lemur*, (n=1 species); *Prolemur*, (n=1 species); and *Varecia*, (n=2 species). By contrast, the most species-rich genera are poorly represented: no species of *Lepilemur* (out of 26 species) and fewer than 10% of *Microcebus* species (out of 25 species) are represented in EAZA zoos. In fact, 6 out 15 genera of lemurs are not present at all in EAZA zoos.

At the species level there is also great unevenness (Fig. 2). If we use the number of institutions keeping a species as a proxy for number of individuals, just three species (*Lemur catta, Varecia variegata* and *Varecia rubra*) make up over 60% of the captive lemur 'population', while the other 19 species combined make up around 40%. *Lemur catta* is by far the most commonly kept species in EAZA zoos, held in 212 institutions. The majority of species are kept in fewer than 20 zoos (Fig. 2).

Body mass and diet

The presence of a particular lemur species in zoos is strongly linked to body mass and diet. Large body sized species are overrepresented in zoos and small body sized species are underrepresented (Fig. 3, test of equal proportions: χ^2= 30.61, df = 3, p<0.001). Species with frugivorous and omnivorous diets are more likely to be currently kept in captivity (Fig. 3, test of equal proportions: χ^2= 22.855, df = 5, p<0.001). The three

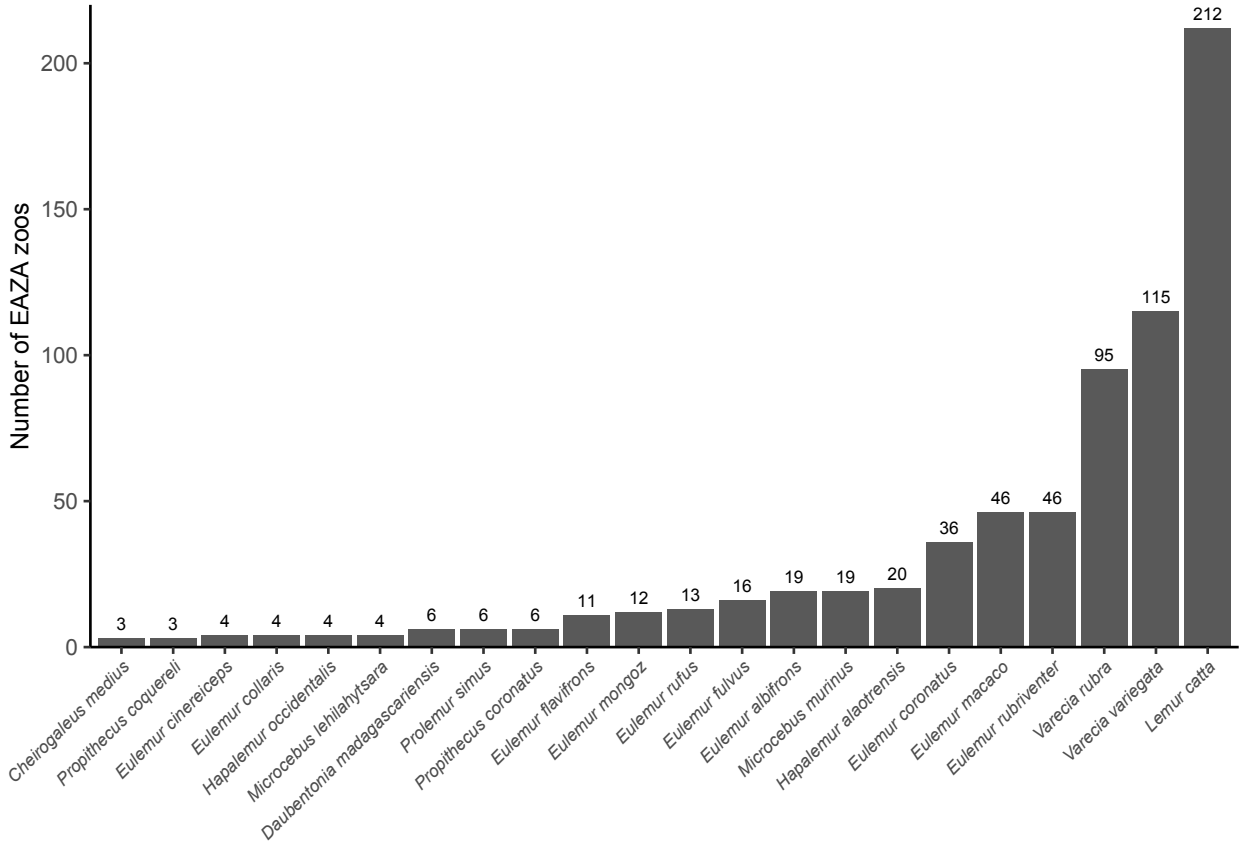

Fig. 2: Number of EAZA institutions that hold at least one lemur species, as of July 2021. Numbers on top of bars represent number of zoos that hold the given species.

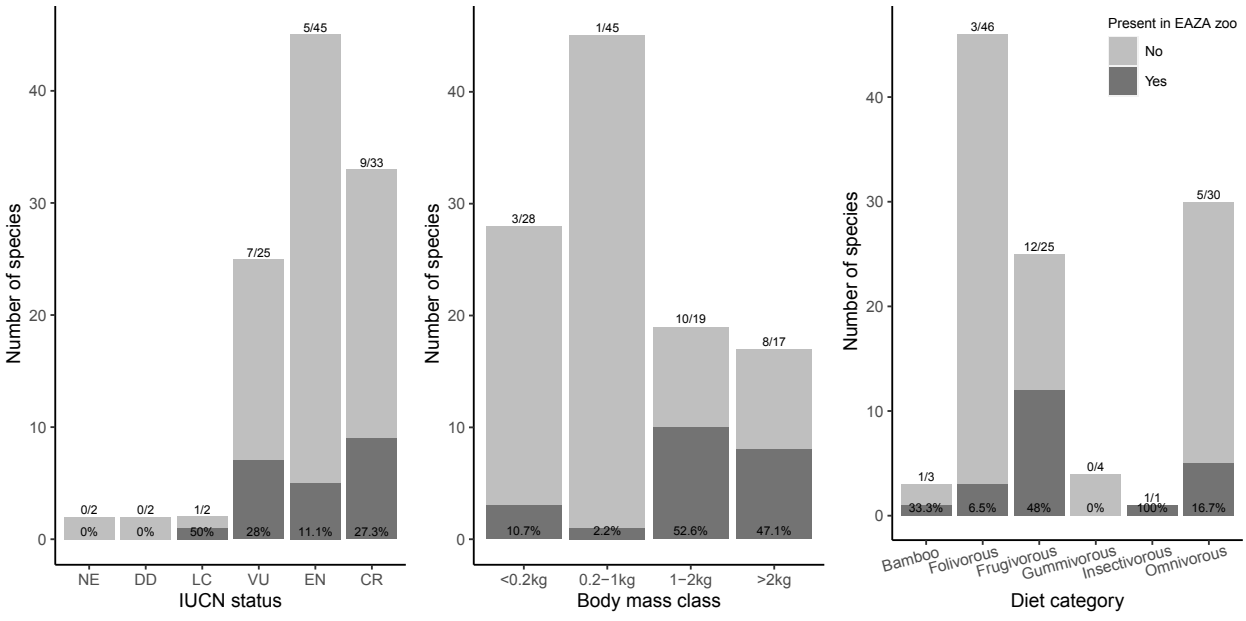

Fig. 3: Representation of lemur species in EAZA zoos by IUCN status (a), body mass class (b) and diet (c). Number and percentage of species for each class held in EAZA zoos, as of July 2021. Numbers above the bars represent number of species in captivity/ total number of species in the category. Percentage numbers shown on bars represent percentage of species present in EAZA zoos for each category (July 2021).

most common diet types across all lemur species are folivory, frugivory and omnivory, all with more than 20 species each. However, species that are mostly frugivorous are clearly overrepresented, with 12 out of 25 species in zoos, whereas species that are mostly folivorous are underrepresented, with only 3 out 46 species in zoos.

Conservation status and EEPs

Of the 22 species currently held in EAZA zoos, 21 are classified as threatened with extinction by the IUCN (threat categories 'vulnerable', 'endangered' or 'critically endangered'), and one as 'least concern' (*Microcebus murinus*). The fact that the majority of species in captivity are threatened

is not surprising, given that only two out of all lemur species are currently classified as non-threatened ("least concern"). Importantly, for the threatened lemur species in captivity, there is no link between severity of threat status and the existence of an ex-situ program. The level of threat according to IUCN status is not a good predictor of the presence of an ex-situ population (Fig. 3, test of equal proportions: χ^2= 6.392, df = 5, p>0.05). In other words, more threatened species are not more likely to be currently found in captivity than expected by chance. Finally, out of the 22 species currently held in captivity, 15 receive active coordination in captive breeding in the form of an EEP (July 2021).

Discussion

A total of 22 lemur species, about one fifth of all extant species, are currently held in at least one EAZA member zoo. Many species of lemurs have only been discovered in the last 20 years, are extremely rare or difficult to find in the wild (Mittermeier *et al.,* 2014). Thus, the number (22) and percentage (20.1%) of species currently held in zoos can be considered respectable. Lemurs may have an "advantage" over many other taxa when it comes to zoo representation, as prosimians (which include strepsirrhines) were ranked as the second most attractive group of mammals to zoo visitors (Whitworth, 2012), which likely makes it economically beneficial for zoos to add species of lemur to their collections. With one in five species held in zoos, lemurs are well represented compared to threatened terrestrial vertebrates in general, for which the value is one in seven (Conde *et al*., 2011).

Our analysis of the current situation of lemur ex-situ population composition in Europe suggests that there is bias in the species that are currently represented. We found that representation of lemur species in EAZA zoos is uneven with regards to taxonomy (genus), body mass and diet, with some categories being more widely represented than others. By contrast, we find that IUCN threat status does not play a role in which species are currently represented in zoos. While there may be species not present in EAZA zoos that are currently held in captivity in non-member institutions (e.g., on other continents), we do not expect that number to be high. For example, all the 12 species of lemur that are currently held in captivity (July 2021) in the most diverse collection of lemurs outside of Madagascar - the Duke Lemur Center in the USA – are all also currently held in EAZA zoos (Duke Lemur Center, 2021). Our results and discussion in terms of species representation are therefore likely demonstrative of the global status of lemur captive colonies outside of Madagascar. However, it should be noted that our results regarding lemur species representation are to some extent dependent on active bookkeeping and regular updates on ZIMS.

Biological traits that influence current representation in zoos

Two key predictors for the presence of a lemur species in zoos were found to be body mass and diet. Species with large body mass are clearly overrepresented in zoos. A total of 18 out of the 22 captive species (82%) weigh more than 1kg, despite large body mass species making up only 33% of the total species of lemurs. Small body size categories (below 1kg) are rarely represented in zoos, despite representing a majority of lemur species. The fact that large species are favoured in zoos is well known also in other types of animals (Moss and Esson, 2010; Frynta *et al*., 2013). Large animals are appealing to visitors and easier to spot in enclosures, and this may be behind the decision to favour these types of lemurs in European zoos. Indeed, the level of attraction and interest of zoo visitors was previously found to be positively correlated with body size (Moss and Esson, 2010). Perhaps for these reasons, zoo animal species tend to be larger than their close relatives not held in zoos (Martin *et al*., 2014).

In terms of diet, frugivorous lemur species are found in zoos at higher numbers than expected by chance, while folivorous and gummivorous are underrepresented. While diet is unlikely to influence the level of attractiveness for visitors, it affects the chances of sustaining an ex-situ population. Species with narrow dietary requirements (e.g. feeding on leaves of specific plant species) are more difficult to keep in a captive environment. In the field of animal husbandry, folivorous diets are considered to be one of the most difficult to replicate (Sha, 2014). Leaves of endemic plants to which species are specialized may contain compounds that are difficult to provide in a captive setting. For example, indri (*Indri indri*) are particularly difficult to keep in captivity (LaFleur *et al*., 2020) which may be partly due to the fact that this species has a largely folivorous diet (Quinn and Wilson, 2002).

We also found that certain genera are overrepresented in zoos. *Eulemur* and *Varecia,* both genera with large body-sized and mostly frugivorous species, are well represented in zoos. Species-rich genera with poor representation in zoos are either exclusively folivorous (*Avahi*, *Lepilemur, Propithecus*), or exclusively composed of species with small body mass (*Microcebus*). There are likely other factors at play that we did not consider here that may have also influenced the choice of species brought in captivity. For example, a good candidate is activity pattern (diurnal/nocturnal), as nocturnal species may be harder to maintain in zoos, require special conditions for visitors to be able to see them, and species with low diurnal activity may be less attractive to visitors (Moss and Esson, 2010). Indeed, several lemur genera with poor or no representation in zoos are exclusively nocturnal (*Lepilemur, Microcebus, Phaner)*. Nevertheless, nocturnal lemurs are not completely absent from zoos. The aye-aye (*Daubentonia madagascariensis*), and the fat-tailed dwarf-lemur (*Cheirogaleus medius*), are examples of nocturnal lemur species that are currently held in EAZA facilities, the aye-aye even being part of an EEP. *Eulemur* species, many of which are in zoos or are subject of an EEP, can be both diurnal or nocturnal. Other traits that may be interesting to examine in the future are mating system, arboreality, or behavioural traits related to stress, all of which can affect the ability of species to survive and/or breed in captivity. Finally, it is likely that the interaction between traits rather than a specific trait per se may be the determining factor for the selection of lemurs for captive breeding.

Ex-situ populations and conservation

A total of 87 species of lemurs are currently absent from EAZA zoos, including 40 endangered and 24 critically endangered species that are of high conservation priority (IUCN 2021). A key result of our study is that the current representation of lemur species in European zoos is not linked to the severity of their IUCN status. For example, critically endangered or endangered species are not more likely to be found in zoos than species classified as vulnerable. If the choice of species were mostly conservation driven, it would seem good practice to give higher priority to species that are more endangered, but that does not seem to be the case. Research on birds and mammals has previously showed that current species representation in zoos is not related to conservation needs (Frynta *et al*., 2013; Martin *et al*., 2014). In the case of lemurs, there may be several reasons for this: threatened lemur

species may be intrinsically more difficult to breed in captivity (e.g., diet, habitat or climate specialists), captive programmes are costly and funding is limited, or highly threatened species may by chance be less attractive to visitors (e.g., small body size, nocturnal). Another possible reason could be linked to the finding of Frynta *et al.* (2013) that species-rich mammalian clades tend to be poorly represented in terms of proportion of species, as a few individuals are perceived as sufficient to represent the group to most visitors.

Another noteworthy result is the fact that only 15 species are currently managed under EEPs, which means that several species currently held in captivity are not actively managed as part of European-wide breeding programmes. Species currently in captivity but not formally part of an EEP include one taxon classified as critically endangered (*Eulemur cinereiceps*) and one classified as endangered (*Eulemur collaris)*. In 2013, Schwitzer and colleagues (Schwitzer *et al*., 2013*b*) proposed a list of priority lemur species for ex-situ conservation. However, many of those priority species are still not yet held in captivity in EAZA institutions, including critically endangered *Cheirogaleus sibreei*, *Lepilemur sahamazalensis*, *Microcebus berthae* and *Propithecus candidus*. Of course, expanding species breadth for ex-situ conservation is not a simple endeavour, as it may require extensive preparation to ensure animal welfare. Therefore, embarking on improved husbandry methods to make it possible to incorporate priority species into EEPs should be an important next step. However, even if good captive conditions can be established, adding new species to the global zoo collection is challenging, particularly if new founding populations need to be established from the wild, as permits and public opinion make it difficult to capture and export wild individuals.

For captive breeding outside of Madagascar to be meaningful, it should have a measurable positive effect on in-situ conservation in the country, with captive colonies acting as a reservoir of individuals and genetic diversity stock for the future of the species, and not just be used for human entertainment or commercial reasons. Arguably the most direct way to do this is to eventually release animals into the wild. Releases and translocations of lemurs into wild settings are rare and have had mixed results (Donati *et al*., 2007; Day *et al*., 2009; Schwitzer *et al*., 2013*b*). An attempt was made to release 13 captive-born black and white ruffed lemurs (*Varecia variegata,* CR) into their native wild range (Britt *et al*., 2004). Five of them survived in the wild for more than a year and three of them had offspring. The project was found to be a relative success, showing how captive breeding can reinforce wild lemur populations (Britt *et al*., 2004). Another advantage of captive breeding is that it provides a 'failsafe' population in case the animal goes extinct in the wild. The benefit of ex-situ populations also lies with the education opportunities they offer. If the public is to care for conservation of lemurs, it first needs to learn about them. A zoological institution is a place where that can happen, potentially forming a bond and giving visitors motivation to care for the natural environment (Scott, 2012).

We hope our analysis offers insight into the representation of biological diversity of this threatened group of primates under captive breeding programmes, highlighting points for improvement when considering which species to keep in zoos. Biases in the selection of species in zoos have previously been shown in mammals (e.g. Frynta *et al*., 2013), so we would not expect the situation for lemurs to be different. However, we may have expected to see a shift in lemur species held in captivity for conservation programmes since the publication of the strategic prioritization plan for lemur *ex-situ* conservation (Schwitzer *et al*., 2013*b*). In order for zoos to truly represent the diversity of Madagascar's unique primates, more attention needs to be paid to species selection and new collaborative breeding programs should be established. This is particularly the case for genera that are currently not represented (*Allocebus, Avahi, Indri, Lepilemur, Mirza* and *Phaner*) in EAZA collections. Furthermore, the fact the ring-tailed lemur (*L. catta*) is being kept in over 200 different institutions could be seen as excessive, given that so many lemur species in urgent need of protection are not represented at all.

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Survey of nocturnal lemurs of Mangabe-Ranomena-Sahasarotra Reserve, Moramanga District, Alaotra-Mangoro Region

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Abstract
We conducted the first focused survey of nocturnal lemurs in the Mangabe reserve in order to assess their status within the reserve and provide recommendations for their conservation. We combined distance sampling and camera trapping to determine species occurrences and estimate their relative abundance within the reserve. The fieldwork was done in January to February 2018 in the northern and February to March 2019 in the southern part of the reserve. We surveyed 30 transects of one kilometer and each transect was visited three times. We installed eight camera traps; three in October 2017 and a further five were added in May 2018. Five species, *Avahi laniger, Cheirogaleus major, Daubentonia madagascariensis, Microcebus lehilahytsara* and *Lepilemur mustelinus*, were encountered and abundance differed between sites. *D. madagascariensis* and *L. mustelinus* are rare and should be prioritized for conservation actions in the future. The other lemur species including *M. lehilahytsara, C. major* and *A. laniger* can be used as key attractions for ecotourism within the reserve given their higher density.

Keywords: Nocturnal, Lemurs, Conservation, Density, Mangabe

Résumé
Nous avons mené une première recherche focalisé sur les lémuriens nocturnes dans la réserve de Mangabe depuis sa création afin d'évaluer leur statuts dans cette réserve et de donner des recommandations pour leur conservation. Nous avons utilisé la méthode d'itinéraire échantillon et la piège photographique pour étudier leur distribution et abondance. Les travaux sur terrain ont été faits entre Janvier et Février 2018 dans la partie nord ainsi que Février et Mars 2019 pour la partie sud de la réserve. Trente transects de 1 km ont été utilisé dont chaque transect a été visité trois fois. Nous avons installé huit pièges photographiques dont trois sont installés depuis Octobre 2017 alors que cinq ont été placé en Mai 2018. Cinq espèces ont été recensées et leur abondance varie pour chaque site. *D. madagascariensis* et *L. mustelinus* sont rare et doit être priorisé dans les activités de conservation dans la future alors que les autres espèces comme *M. lehilahytsara, C. major* et *A. laniger* peuvent être utilisées parmi les attraits touristiques de la réserve vu qu'elles sont abondantes et facile à observer.

Mots-clés: Nocturne, Lémuriens, Conservation, Densité, Mangabe

Introduction
All of Madagascar's five lemur families are endemic to the country and represent more than 20% of the world's primate species and 30% of family-level diversity (Schwitzer *et al.*,