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Leaf Monkeys in Captivity and the Role of Zoological Gardens in their Conservation

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Abstract: Colobinae is a threatened subfamily of primates—72 of the currently recognized species have been assessed as threatened. In order to assess the impact of zoological gardens on colobine conservation, we analyzed the available information from the Zoological Information Management System (ZIMS) to provide an overview of the species already held in zoos. A total of 28 species (34.1% of the existing species) are currently kept in ZIMS institutions, with an additional nine species listed in the Zootierliste database. African species are scantily represented in zoological gardens (four species out of 24) but over one third of captive individuals are represented by the non-threatened *Colobus guereza*. The majority of captive colobines are kept in Asian, European, and North American institutions, with Asian ones keeping a higher number of species (26) than those in Europe and North America. In the past 12 months, 10 species bred with 105 individuals born in 60 institutions. Europe is the region with the highest number of births while Asia has the highest number of breeding species. While the contribution of zoological gardens seems somewhat marginal, a number of *in situ* initiatives have been carried out by zoological gardens especially in South-East Asia. Zoos should strengthen these initiatives and use species common in captivity as flagships for threatened species and ecosystems.

Key words: Colobinae, *in situ* conservation, *ex situ* conservation, zoological gardens

Introduction

The subfamily Colobinae is one of the two extant subfamilies of the Cercopithecidae. It is characterized by a mainly folivorous diet (Huan *et al.* 2020). It is a very threatened taxon, as 96% of the 24 African species and 84% of the 58 Asian species currently recognized for conservation purposes have been assessed as threatened (Butynski and de Jong, 2022; cf. Sha *et al*. 2022). About 95% of the assessed species are declining (IUCN 2024). Zoological gardens have a fundamental role in the conservation of threatened species (Conde *et al.* 2011; Fa *et al.* 2014; Robovský *et al.* 2020) through both *in situ* and *ex situ* actions (Byers *et al.* 2013; Barongi *et al.*, 2015), but to our knowledge no global review of colobines in zoos has been published in recent decades. As the veterinary literature reports, captive colobines tend to be very susceptible to gastrointestinal diseases (Amato *et al.* 2016) making them somewhat delicate animals to keep in captivity (Hollin 1973). Among the species which have been reported to succumb to gastrointestinal diseases in captivity, we can cite *Colobus guereza*, *Nasalis larvatus*, *Pygathrix nemaeus*, *Semnopithecus entellus*, *Semnopithecus vetulus*, *Trachypithecus auratus*, *Trachypithecus cristatus*, *Trachypithecus francoisi*, and *Trachypithecus obscurus* (Agoramoorthy *et al.* 2004; Calle *et al.* 1995; Ensley *et al.* 1982; Heldstab 1988; Janssen 1994; Loomis and Britt 1983; Osman Hill 1964; Overskei *et al.* 1994; Pereira *et al.* 2021; Ruempler 1998; Shelmidine *et al.* 2013).

Amato *et al.* (2016) stated that the problematic long-term health conditions of colobines could prevent the long-term establishment of populations for successful captive breeding. The authors did not justify this statement with any references and their assertion has not been confirmed nor disproved by any further study. As species-holding data from the Zoological Information Management System (ZIMS) have been recently used to investigate the taxonomic and conservation coverage of captive populations of amphibians (Jacken *et al.* 2020), birds (Wahle *et al.* 2024), reptiles (Ginal *et al.* 2023; Ziegler *et al.* 2017; Rech *et al.* 2023) and, among mammals, the cercopithecines (Fraschetti and Gippoliti 2024), this paper will serve as a review of the current status of the colobines in zoological gardens worldwide in order to assess if captive colobine populations, and eventually of which taxa, can be defined as successful or if zoological gardens should shunt their colobine initiatives towards *in situ* conservation.

Methods

Data on captive colobines were extracted from the Zoological Information Management System (ZIMS 2024) on 9 April 2024. In this study we carried out descriptive analyses on the species of colobines held in zoos, the number of institutions based on available data on living individuals from ZIMS, their individual numbers, and the breeding records. This has been done both at a global and regional level. In order to assess the successful management of *ex situ* populations, we calculated at a regional level the variation of the number of individuals for each species in the past 20 years. We assumed as successful the populations represented by 50 or more individuals that had undergone an increase in the past 20 years or populations represented by 100 or more individuals which underwent a decrease lower than 5%. Historical data were also used to investigate, also at a regional level, the species which are no longer kept in captivity. As not all zoological gardens are members of ZIMS, the public species-holding database Zootierliste (Zootierliste 2024) was consulted on 9 April 2024 as it also provides information on the holdings of institutions that are not members of ZIMS. Zootierliste data were used only for worldwide holding analyses as the number of individuals is not always reported and may not be up to date, and only ZIMS data were used for individuals and regional analyses. We followed the taxonomy adopted by IUCN (IUCN 2024) and adapted the one proposed by ZIMS when needed. Individuals for which only the genus was reported were not included in the analysis. Graphs were produced using the package *ggpolt2* (Wickham 2016) from R (R Core Team 2018).

Results

According to ZIMS, 28 species of colobines are kept in 230 zoos worldwide, while the Zootierliste reports that 36 species are kept in captivity. Four of these species have been assessed as non-threatened while the others (24 on ZIMS, and 32 on the Zootierliste) are threatened. The species *Presbytis comata* (Vulnerable), *Presbytis natunae* (Vulnerable), *Rhinopithecus bieti* (Endangered), *Rhinopithecus brelichi* (Critically Endangered), *Trachypithecus barbei* (Vulnerable),

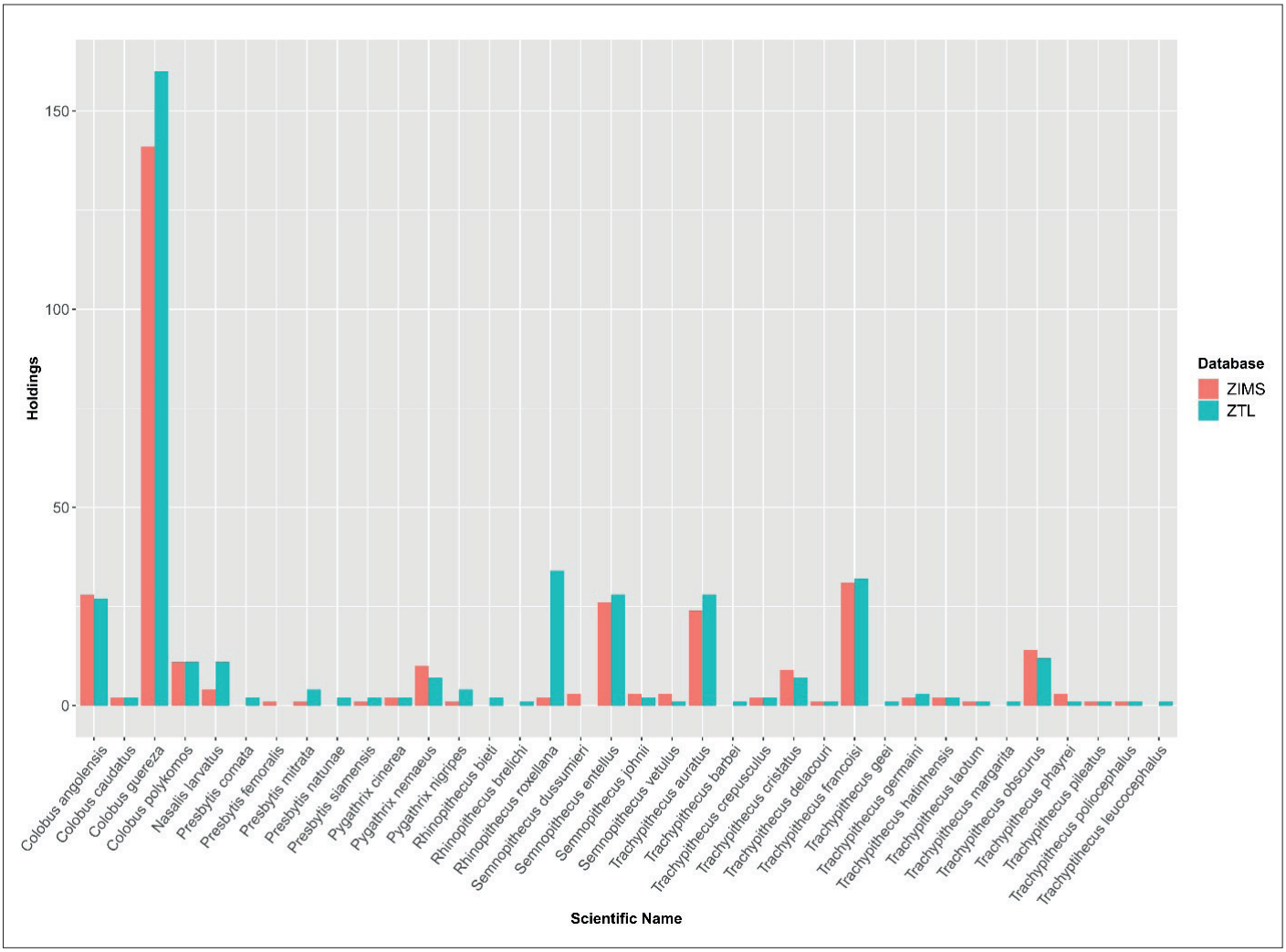

Figure 1. Number of institutions that keep each of the colobine species according to both ZIMS and Zootierliste (ZTL).

Trachypithecus geei (Endangered), *Trachypithecus margarita* (Endangered), and *Trachypithecus leucocephalus* (Critically Endangered) are kept in captivity according to the Zootierliste but do not feature in ZIMS among the species currently held in captivity. The most common species in captive collections is *Colobus guereza* (Least Concern)—in 141 institutions according to ZIMS and 160 according to the Zootierliste (Fig. 1). The other species are kept in fewer institutions, as no species, according to both ZIMS and the Zootierliste, is kept in more than 35. According to ZIMS the other common species are: *Trachypithecus francoisi* (Endangered: kept in 32 institutions); *Colobus angolensis* (Vulnerable: kept in 28 institutions); *Semnopithecus entellus* (Least Concern: kept in 26 institutions); and *Trachypithecus auratus* (Endangered: kept in 24 institutions). The Zootierliste reported that 63.89% of the species (23) are held in less than five institutions worldwide and, according to ZIMS, 12 species are kept only in a single institution.

A total of 1,815 individuals are kept in institutions that have ZIMS membership (Fig. 2). *Colobus guereza* represents more than one-third (37.24%) of captive individuals (674), as reported on ZIMS. Five other species are represented by more than 100 individuals: *T. auratus* (153 individuals), *T. francoisi* (153 individuals), *S. entellus* (138 individuals), *C. angolensis* (138 individuals), and *T. cristatus* (Endangered; 108 individuals).

At a regional level, colobines are scarcely found in zoos in Africa, South America, and Oceania. They are more common in Asian, European, and North American zoos. In particular, *C. guereza* is the only colobine species held in African and South American institutions. In both regions it is kept by two institutions for a total of six individuals in Africa and seven in South America. Three species are kept in Australian institutions: *C. guereza* for a total of 15 individuals, *T. francoisi* (Endangered) for a total of seven, and *T. obscurus* (Endangered) for a total of three.

Asian zoos keep 26 species of colobines (Fig. 3A). The most common is *C. guereza* kept in 10 institutions, *Pygathrix nemaeus* (Critically Endangered) is kept in nine, *S. entellus* is kept in eight, and *T. obscurus* is kept in six. The other 21 species are kept in four institutions or less and eight species are kept in just one institution. No species is represented by

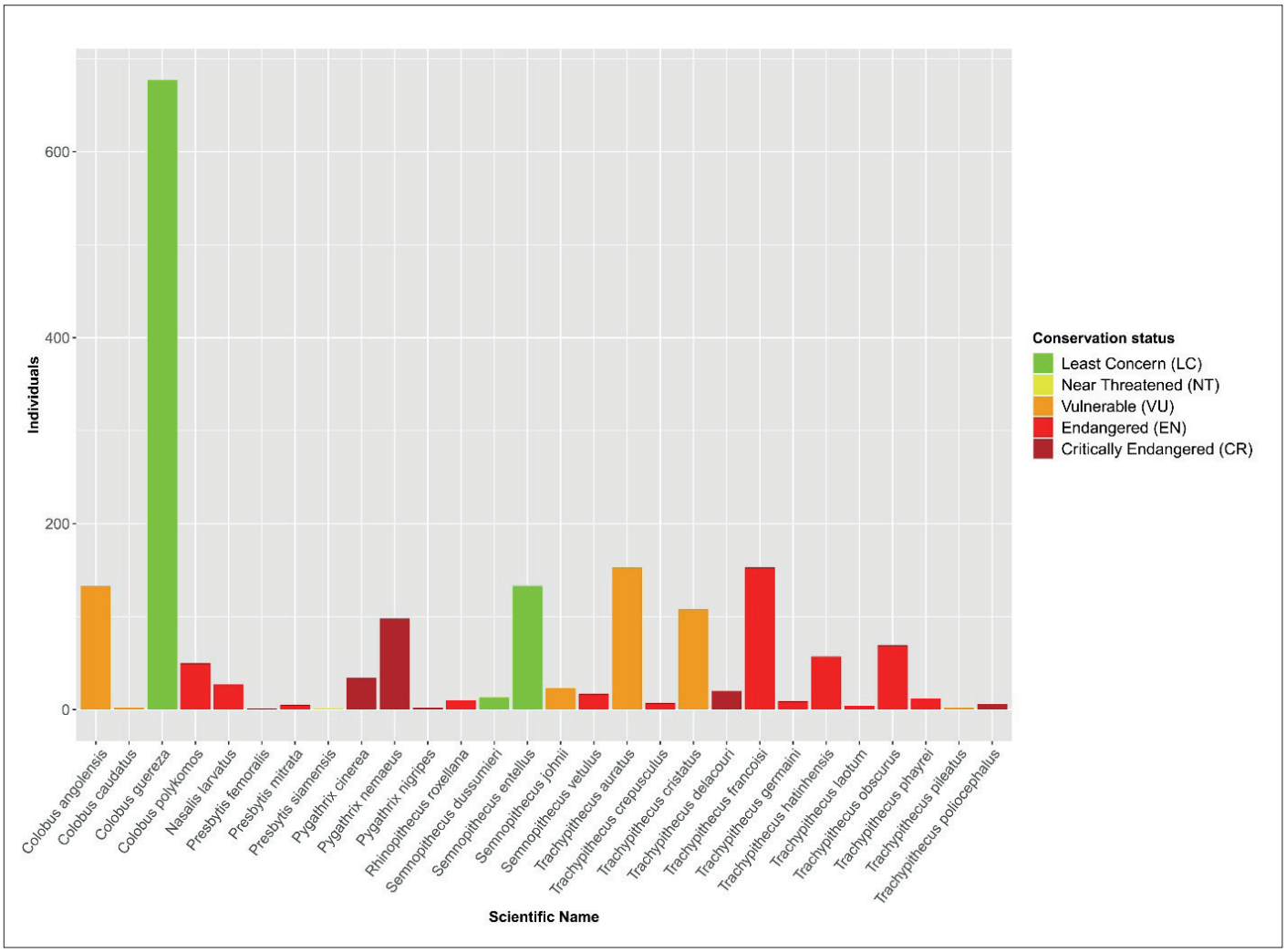

Figure 2. Number of captive individuals of each colobine species according to ZIMS. The species are color- coded according to their IUCN risk categories.

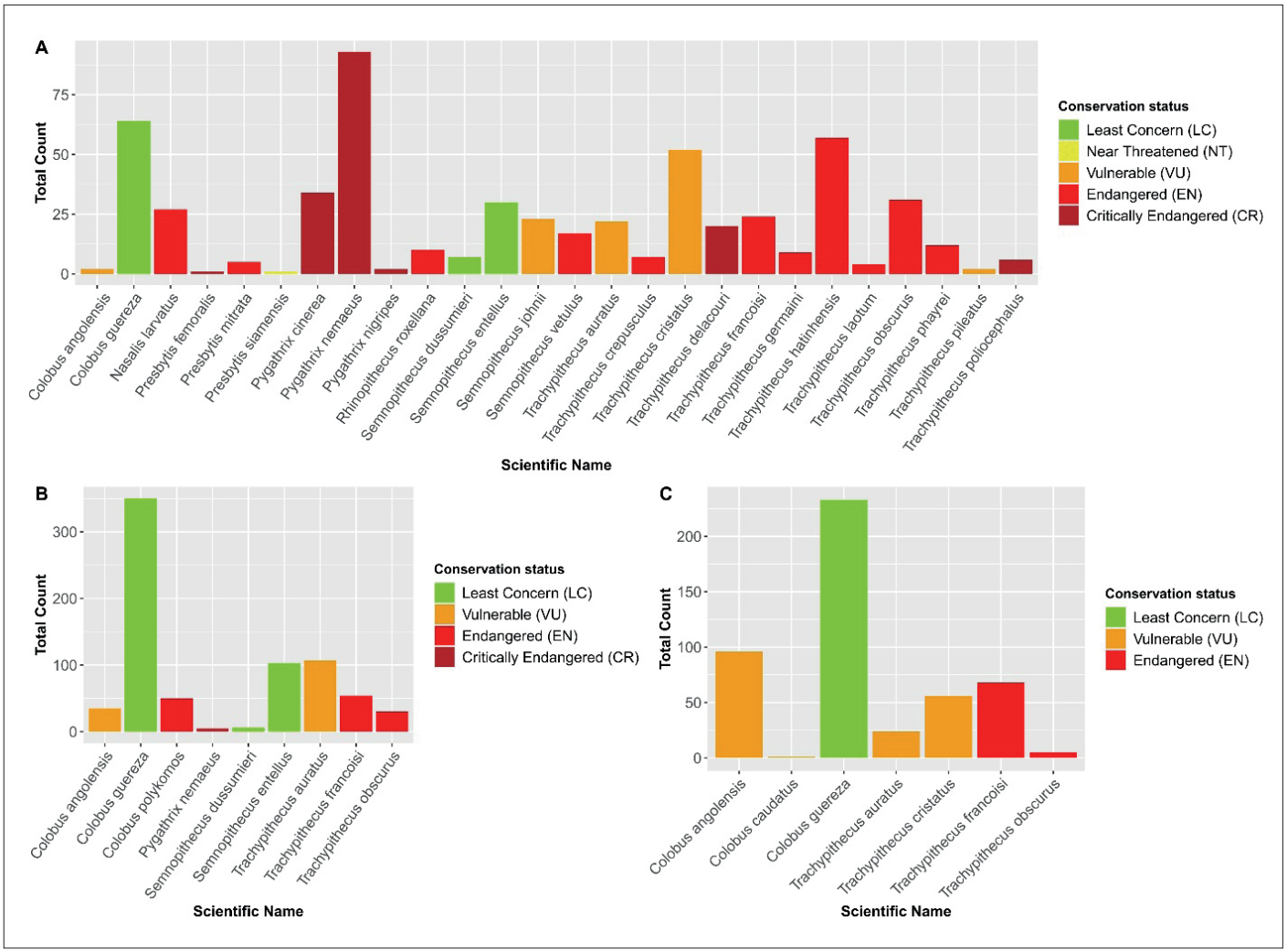

Figure 3. Number of captive individuals of each colobine species according to ZIMS in the Asian (A), European (B), and North American (C) regions. The species have been color coded according to their IUCN risk categories.

100 or more individuals and four species make up roughly half of the individuals kept in Asia. *Pygathrix nemaeus* is represented by 93 individuals (16.79% of the individuals in Asian zoos), *C. guereza* by 64 (11.37% of the individuals in Asian zoos), *Trachypithecus hatinhensis* (Endangered) by 57 (10.29% of the individuals in Asian zoos), *T. cristatus* by 52 (9.38% of the individuals in Asian zoos). Each of the other species is represented by less than 35 individuals.

Nine colobine species are kept in European zoos (Fig. 3B). *Colobus guereza* is the most common as it is kept in 66 institutions and is represented by 350 individuals (47.15% of the individuals in European zoos). The other most common species are *T. auratus* with 107 individuals (14.50% of the individuals in European zoos) kept in nine institutions, and *S. entellus* with 103 individuals (13.96%) in 18 institutions. North American zoos keep seven species of Colobines (Fig. 3C). *Colobus guereza* is also the most widespread and common species in this region as it is kept by 58 institutions and is represented by 233 individuals (48.24% of the individuals in North American zoos). The second most common species is *C. angolensis*, which is kept in 20 institutions and is represented by 96 individuals (19.87% of the individuals in North American zoos). The other species are represented by less than 70 individuals. *Trachypithecus francoisi* is represented by 68 individuals kept in 16 institutions while *T. cristatus* is represented by 56 individuals and is kept in six institutions.

In the past 12 months, 10 species (37.04% of captive species according to ZIMS) bred—a total of 105 individuals born in 60 institutions (Fig. 4). Two of these species were not threatened (Least Concern), while eight were threatened (two Vulnerable, three Endangered, three Critically Endangered). Asia is the region with the highest number of threatened colobines that bred in the past 12 months, as six species bred (three Critically Endangered) producing a total of 24 offspring (75% of all births in the region). Europe is the region with the highest number of births with 52 individuals (49.52% of all births worldwide). Six species bred in the last 12 months. Two non-threatened species, *C. guereza* and *S. entellus*, made up roughly 54% of these births. Three species (one non-threatened and two threatened) bred in North American collections in the past 12 months, producing 17

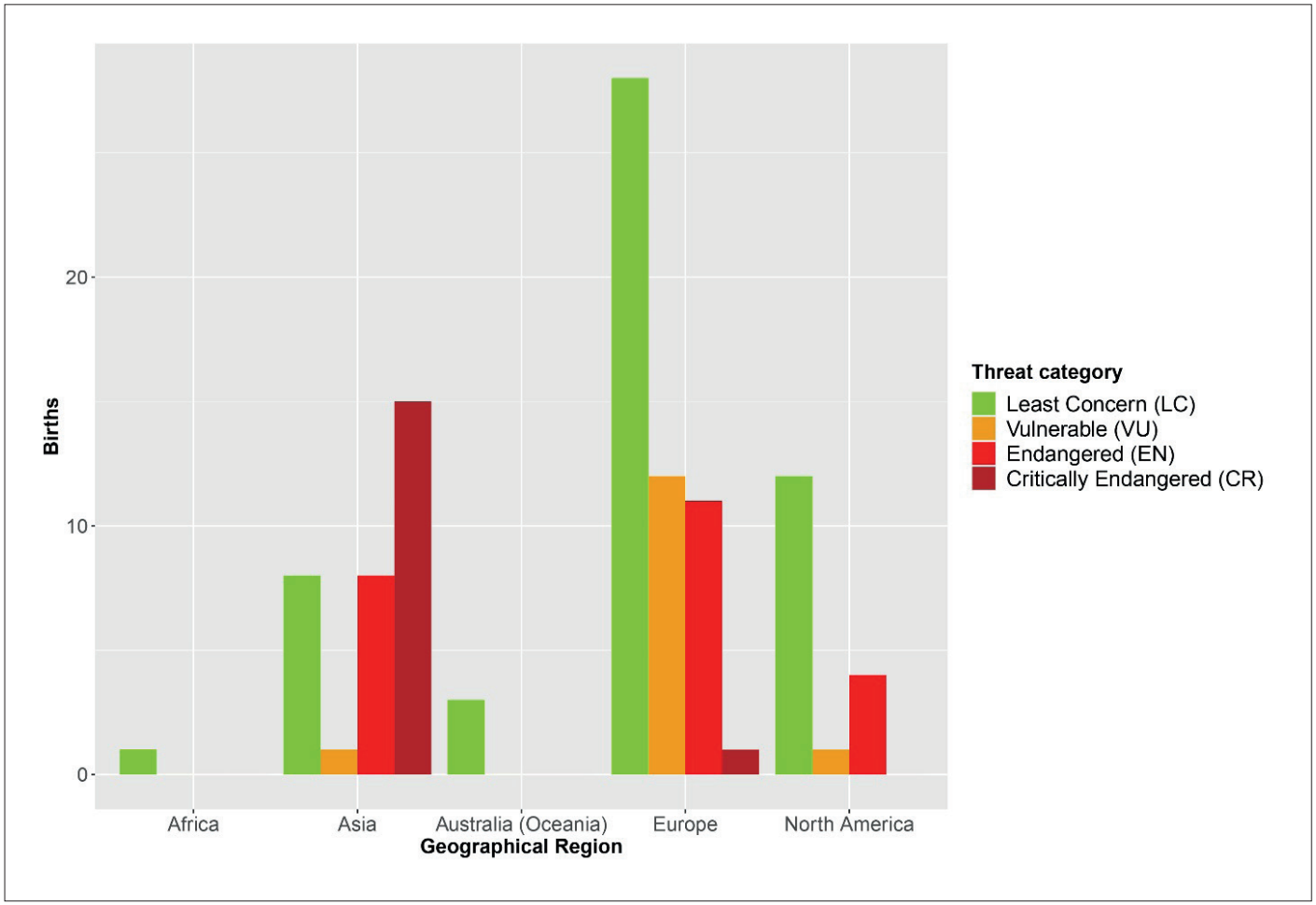

Figure 4. Number of captive colobines born in each region in the past 12 months for each risk category.

offspring (70.6% of them of the non-threatened species). *Colobus guereza* bred in Africa and in Oceania in the past 12 months.

In Asian zoos, 20 species out of 26 increased in the number of captive individuals over the last 20 years, with 11 more than doubling their numbers (Table 1). According to our criteria the breeding of only four could be deemed successful: *C. guereza*, *P. nemaeus*, *T. cristatus*, and *T. hatinhensis*. In European zoos, four species have increased in numbers, one of which, *T. francoisi*, underwent a more than four-fold increase, two remained constant in their size, and one a moderate decrease (*T. auratus*) (Table 1). Four species out of nine in European zoos can be considered successful, despite nine species (eight of which were threatened) having disappeared in the last 20 years (Table 2). In North American zoos, four species underwent an increase, with one (*T. cristatus*) having more than doubled its population, while three species underwent a decrease. Overall, the breeding of four species in this region can be considered successful (Table 1), while two have disappeared in the last 20 years (Table 2). No colobine species collections in African, Oceanian, and South American zoos can be defined as successful

Discussion

In situ contributions of European zoos

European zoos have contributed to a number of *in situ* initiatives for langurs in Vietnam. In 1992, Allwetterzoo Münster signed a memorandum of agreement with the Vietnamese authorities for the conservation of primates (i.e. langurs) in the Cuc Phuong National Park, where *Trachypithecus delacouri* (Critically Endangered) is endemic, with the aims of providing rangers better equipment (through financing from the Zoological Society of Frankfurt), integrating poachers in the conservation work for the park and establishing facilities for captive breeding of threatened taxa (Peter and Alder 1995).

In the same year, the Zoological Society of Frankfurt helped to establish the first rescue center for primates in Indochina, named the Endangered Primate Rescue Center, which over the years has increased its number of threatened species also through the establishment of captive breeding programs (Nadler 2013). In 2012, the financial support of the center passed from Frankfrut Zoo to Leipzig Zoo, which supports it to this day (Nadler 2013). The center is the only

Table 1. Regional breakdown of the different colobine species according to ZIMS data. For each species, we show the current number of individuals (2024), the number in 2004, and the percentage change. Species which we deemed to be breeding successfully are highlighted in **bold**.

AFRICA	**IUCN**	**Number 2024**	**Number 2004**	**Change**
Colobus guereza	LC	7	5	40%
ASIA	**IUCN**	**Number 2024**	**Number 2004**	**Change**
Colobus angolensis	VU	2	4	-50%
Colobus guereza	LC	64	34	88.24%
Nasalis larvatus	EN	27	11	145.45%
Presbytis femoralis	CR	1	2	-50.00%
Presbytis mitrata	EN	5	0	n. a.
Presbytis siamensis	NT	1	0	n. a.
Pygathrix cinerea	CR	34	11	209.09%
Pygathrix nemaeus	CR	93	31	200.00%
Pygathrix nigripes	CR	2	2	0.00%
Rhinopithecus roxellana	EN	10	8	25.00%
Semnopithecus dussumieri	LC	7	5	40.00%
Semnopithecus entellus	LC	30	17	76.47%
Semnopithecus johnii	VU	23	15	53.33%
Semnopithecus vetulus	EN	17	13	30.77%
Trachypithecus auratus	VU	22	13	69.23%
Trachypithecus crepusculus	EN	7	3	133.33%
Trachypithecus cristatus	VU	52	21	147.62%
Trachypithecus delacouri	CR	20	12	66.67%
Trachypithecus francoisi	EN	24	21	14.29%
Trachypithecus germaini	EN	9	4	125.00%
Trachypithecus hatinhensis	EN	57	27	111.11%
Trachypithecus laotum	EN	4	1	300.00%
Trachypithecus obscurus	EN	31	10	210.00%
Trachypithecus phayrei	EN	12	3	300.00%
Trachypithecus pileatus	VU	2	2	0.00%
Trachypithecus poliocephalus	CR	6	2	200.00%
EUROPE	**IUCN**	**Number 2024**	**Number 2004**	**Change**
Colobus angolensis	VU	35	18	94.44%
Colobus guereza	LC	350	349	0.28%
Colobus polykomos	EN	50	38	31.58%
Pygathrix nemaeus	CR	5	7	-28.57%
Semnopithecus dussumieri	LC	6	6	0%
Semnopithecus entellus	LC	103	78	32.05
Trachypithecus auratus	VU	107	138	-22.46%
Trachypithecus francoisi	EN	54	14	285.71%
Trachypithecus obscurus	EN	30	30	0%
NORTH AMERICA	**IUCN**	**Number 2024**	**Number 2004**	**Change**
Colobus angolensis	VU	96	61	57.38%
Colobus caudatus	VU	1	4	-75.00%
Colobus guereza	LC	233	245	-4.90%

Table 1. *Cont'd.*

AFRICA	**IUCN**	**NUmbere 2024**	**Number 2004**	**Change**
Trachypithecus auratus	VU	24	13	84.62%
Trachypithecus cristatus	VU	56	23	143.48%
Trachypithecus francoisi	EN	68	50	36.00%
Trachypithecus obscurus	EN	5	31	-83.87%
OCEANIA	**IUCN**	**Number 2024**	**Number 2004**	**Change**
Colobus guereza	LC	15	14	7.14%
Trachypithecus francoisi	EN	7	0	n. a
Trachypithecus obscurus	EN	3	2	50%
SOUTH AMERICA	**IUCN**	**Number 2024**	**Number 2004**	**Change**
Colobus guereza	LC	7	3	133.33%

Table 2. Species which are not kept in captivity in Europe and North America according to ZIMS. For each species the number of individuals and institutions from 20 years ago and the year they were last recorded are shown.

EUROPE	**IUCN**	**Holdings**	**Number 2004**	**Last reported**
Colobus caudatus	VU	3	13	2022
Presbytis comata	VU	1	11	2015
Presbytis melalophos	EN	1	22	2016
Presbytis mitrata	EN	1	4	2008
Semnopithecus johnii	VU	1	7	2015
Semnopithecus priam	NT	4	17	2010
Semnopithecus vetulus	EN	2	13	2014
Trachypithecus cristatus	VU	2	11	2020
Trachypithecus phayrei	EN	1	1	2009
NORTH AMERICA	**IUCN**	**Holdings**	**Number 2004**	**Last seen**
Pygathrix cinerea	CR	2	5	2018
Semnoptihecus entellus	LC	1	5	2018

Asian institution keeping *T. delacouri*, and one of the two which hold *Pygathrix cinerea* (Critically Endangered) and *T. hatinhensis*, which have all bred in the past 12 months. In the second half of the 2000s, the center built, with the support of Frankfurt Zoological Society and Köln Zoo, a 20-ha semi-wild area in Phong Nha-Ke Bang National Park in preparation for the reintroduction of eight captive-bred *T. hatinhensis* (Nadler 2013). The reintroduction process was never completed but the individuals developed a small population in the semi-wild area. Between 2011 and 2012, the center successfully released five individuals of *T. delacouri* into the wild (Nadler 2013; Elser *et al.* 2015).

Zoo Ostrava financially supports the conservation of *T. delacouri* in the Van Long Reserve in the Ninh Binh province located in North Vietnam (Zoo Ostrava 2024a). The initiatives supported by Ostrava Zoo include the production of educational panels, the training of rangers in the use of mobile applications that allow them to evaluate the effectiveness of the protection of the area through law enforcement, and the expansion of the Van Long Reserve in the neighboring Hoa Binh province (Zoo Ostrava 2024a). Zoo Ostrava is also contributing financially to a Conservation Program for *Rhinopithecus avunculus* (Critically Endangered) led by the Vietnamese Center for Resources, Environment and Climate Change (Zoo Ostrava 2024b).

Another species for which zoos provide support for *in situ* conservation is the Cat Ba langur, *Trachypithecus poliocephalus* (CR), endemic to Cat Ba Island (Rawson *et al.* 2020). In 2000, Allwetterzoo Münster and the Zoologischen Gesellschaft für Arten- und Populationsschutz (ZGAP) founded the Cat Ba Langur Conservation Project, then supported by Leipzig Zoo (Allwetterzoo Münster 2024), which

aimed to improve the species conservation status by founding a langur sanctuary located inside Cat Ba National Park and a buffer zone in Ha Long Bay, where 58% of the population lives. It also aims to implement a langur-guarding program to protect the remaining 42% of the population through the joint control of the national park and local people, who patrol the ranges and offer community conservation education (Rawson *et al.* 2020).

With regard to African colobines, in 2000 Heidelberg Zoo founded West African Primate Conservation Action (WAPCA), which operates in Ghana through both *in situ* and *ex situ* activities to safeguard of endemic primate species, notably *Colobus vellerosus* (WAPCA 2024).

Captive breeding: current status

A relatively small percentage of colobine species is kept in captivity. It amounts to 43.9% according to the Zootierliste, while ZIMS institutions keep roughly one-third (34.1%). As not all zoological gardens have ZIMS membership, the picture presented by ZIMS data is incomplete. The nine species present in captivity according to the Zootierliste are kept in either one or two institutions. The holding numbers of the two databases are broadly similar indicating that, while some species are not kept in ZIMS institutions, ZIMS does not underrepresent any species with the exception of *N. larvatus* and *Rhinopithecus roxellana* (Endangered). *Nasalis larvatus* is kept by four institutions according to ZIMS and by 11 according to the Zootierliste (in both cases only in Asia), while *R. roxellana* is kept in two institutions according to ZIMS and in 34 according to the Zootierliste. As *R. roxellana* is endemic to China (Yongcheng and Richardson 2021), the fact that Chinese zoological gardens do not have ZIMS membership explains the difference between ZIMS and the Zootierliste. The species has been kept in Chinese zoos since 1956, and 407 births took place between 1972 and 2017 (Xiang *et al.* 2017). The role of captive breeding for the potential reintroduction of this species has been highlighted by Li *et al.* (2018).

Figure 5. The guereza, *Colobus guereza*, at the Parco Faunistico Valcorba, Italy in 2024. Photograph by Spartaco Gippoliti.

A negative bias can be found regarding African species. While they represent 29.27% of extant Colobine species (24 species), they only represent 11.1% (four) of the captive species according to the Zootierliste. There is no discrepancy between ZIMS and the Zootierliste over the African species kept in zoos, as both databases report that *C. angolensis*, *C. guereza* and *C. polykomos* (Endangered) are kept in captivity. *Colobus caudatus* (Vulnerable) is represented by a single individual in a North American zoo. The non-threatened *C. guereza* (Fig. 5) is the most common species in captivity—kept by more than 150 institutions, it represents over one third of the individuals as recorded in ZIMS. Although *C. guereza* is not a globally threatened species, it has eight recognized subspecies, including *C. guereza gallarum* in eastern Ethiopia that is categorized in the IUCN Red List as Data Deficient but is evidently of high conservation concern (Zinner *et al.* 2019). According to ZIMS, the only *C. guereza* subspecies kept in captivity in considerable numbers is the non-threatened *C. guereza kikuyensis*. Species belonging to *Piliocolobus* (17) and *Procolobus* (one) are not kept in captivity, and neither are two *Colobus* species *C. satanas* (Vulnerable) and *C. vellerosus* (Critically Endangered). In the past, European and North American zoos tried to keep red colobus monkeys such as *P. kirkii* (see Gijzen *et al.* 1966), *P. badius* and *P. foai* (see Kitchener 1969) but they never survived for long. *Piliocolobus* has a highly specialized diet, which has not been successfully replicated in captivity unlike that of *Colobus*, and this may have prevented the establishment of any captive population (Butynski and de Jong 2022). Linder *et al.* (2021) indicated that their historically over-lumped taxonomy (Groves 2007; Oates and Ting 2015) and the lack of zoo populations as the cause of the lack of awareness by the general public. As such, they have failed to attract conservation attention in comparison to other more charismatic and zoo-widespread taxa, such as lemurs and great apes. Protecting *in situ* populations and using translocation has been described as a better option for the conservation of African colobines than captive breeding (Butynski and de Jong 2022).

Asia is not only the most species-rich ZIMS region due to the fact that local zoos tend to hold endemic species but is also the region with the highest number of Critically Endangered colobines held in zoos (six according to ZIMS and eight to the Zootierliste). Asian zoos keep a large number of colobines that have failed to thrive in western zoos, possibly due to their access year-round to a wider range of native tree species for feeding them. (Agoramoorthy *et al.* 2004). No species has disappeared from Asian zoos in the last 20 years but this could also be due to local recruitment of wild individuals. While the majority of species in Asian zoos has undergone an increase in the last 20 years, only four can yet be considered as breeding successfully according to our criteria. Among these *P. nemaeus* is the most represented species, and in the last 12 months it bred in seven of the nine institutions which hold it. Today, this species is kept in just one European institution, but at the end of the 20th

century it was kept and bred by more in Europe and in North America (Hollihn 1971; Schmidt 1986). Although some actions aimed at the *ex situ* conservation of this species in western zoos such as the establishment of a global studbook in 1977 and of a European breeding program in 1989 were carried out, in the late 1990s it was already assumed that establishing a successful captive population in Europe was quite unlikely (Ruempler 1998). On the other hand, it appears the potential of *ex situ* contribution of Asian zoos is reduced as the majority of the threatened species, including the ones which breed regularly (i.e. *N. larvatus*, *P. cinerea*, and *T. delacouri*), are not represented by a high number of individuals (less than 50), which are kept in a small number of institutions. Despite the establishment of some studbooks at national level, Asian zoos do not have regional breeding programs comparable to the EEPs or the SSPs and may lack reciprocal coordination in such initiatives. While some *ex situ* initiatives for threatened species are carried out at the national level, as in the case of *R. roxellana* (see Xiang *et al.* 2017), others are carried out at the level of single institutions such as the Endangered Primate Rescue Center where large colonies of threatened species such as *P. cinerea*, *T. delacouri*, and *T. hatinhensis* are kept and bred (Nadler 2013).

Both Europe and North America have fewer species than Asia. *Colobus guereza* represents roughly half of the individuals held in both regions. In Europe, six out of nine species namely *C. angolensis*, *C. guereza, C. polykomos*, *S. entellus*, *T. francoisi* and *T. auratus* are managed by an EAZA *Ex Situ* Programme (EEP) (EAZA 2024). Four of these species appear to be breeding successfully according to our criteria. Two other species, *C. angolensis* and *T. auratus*, are in an intermediate stage: the first, while being represented by less than 50 individuals has nearly doubled its size in 20 years, while *T. auratus* is represented by more than 100 individuals, despite a moderate decrease in number from 2004. The European population of *T. francoisi* underwent a more than four-fold increase in the last 20 years. Its founders were imported by European zoos in 1992 and a studbook was formally established in 2005 (Farré *et al.* 2022). A recent analysis of mitochondrial DNA indicates that the population, while being small, has a relatively good genetic diversity, which nonetheless could be rapidly lost (Farré *et al.* 2022). The Guangxi province in China has the largest captive breeding population of *T. francoisi* and, in 2012, the Guangxi Forestry Bureau launched a long-term reintroduction project (Sha *et al.* 2022). *Colobus polykomos* is only kept in Europe and is represented by 50 individuals with higher numbers of males in comparison to females (33.17). The first breeding group in captivity was established in the late 1960s (Mallinson 1969) and, despite its rarity in captivity, the species is seldom mentioned in zoo biology literature. In the last 20 years nine species have disappeared from Europe. All but one were represented by groups kept in one to four institutions. Four species were kept in colonies in a single institution (Fig. 6) and three of these belonged to the genus *Presbytis*, which is no longer present in European zoos.

In North America, only three colobine species are managed under a Species Survival Plan (SSP): *Colobus angolensis*, *C. guereza*, and *T. francoisi* (AZA 2024). These species and *T. cristatus* appear as successful. *Colobus guereza* is considered successful despite a moderate decrease as it is lower than 5% and it is represented by far more than 100 individuals. *Trachypithecus cristatus*, represented by 56 individuals (23.33), was managed as an SSP until a few years ago (Shelmidine *et al.* 2013) and has undergone a more than

Figure 6. The Nilgiri langur, *Semnopithecus johnii*, at Erfurt Zoo, 1997. Photograph by Spartaco Gippoliti. The species is no longer kept in European zoos.

two-fold increase in the last 20 years. The founders of this population (2.7) were imported in 1984, and 106 individuals were born in North American zoos between 1985 and 2008 (Shelmidine *et al*. 2013). Infant survivorship of this species in North American zoos (66% surviving to the first year of age) was not significantly different from that of other captive and wild populations (Shelmidine *et al.* 2013).

In situ initiatives, especially in South-East Asia, have been carried out by European zoos or with their support in full accordance with the One Plan Approach (Byers *et al.* 2013; Barongi *et al.* 2015) and this has contributed to the conservation of species which are not present in European zoos. At present, it seems that no *in situ* initiative supported by European zoos concerns species managed by *ex situ* programs. As common non-threatened species can be used as flagships for the conservation of threatened, closely related taxa (Kerr 2021), it should be possible to use populations of common species in such a way by just paying greater attention to infraspecific taxonomy, an often-neglected discipline (Groves 2007; Gippoliti and Groves 2020), and focusing public awareness campaigns and funds toward specific *in situ* activities that prioritize threatened subspecific taxa and/or species-rich primate communities (Gippoliti 2011; Visser *et al.* 2023). Since *in situ* initiatives supported by European zoos and involving African species are scarce, the *C. guereza* captive population could be used as a flagship species for subspecies of high conservation concern such as *C. guereza gallarum* in eastern Ethiopia (Zinner *et al.* 2019) or *C. angolensis prigoginei* in eastern Democratic Republic of Congo (Butynski and de Jong 2024) or for threatened ecosystems, such as Ethiopia's montane forests or the Omo River riparian forests (Carpaneto and Gippoliti 1994). It seems that the awareness potential of some species already managed in *ex situ* facilities, such as *C. polykomos*, is far from being fully exploited. The support of conservation initiatives on *C. polykomos* could have positive effects on other colobine species as it coexists in the same areas, such as in the Taï National Park (Côte d'Ivoire) with *Procolobus verus* (Vulnerable), and *Piliocolobus badius badius* (Endangered) (Butynski and De Jong 2022) and with *P. badius temminckii* (Endangered) in Guinea-Bissau (Gippoliti and Dell'Omo 2003; Bersacola *et al.* 2018).

Conclusions

Only a few species belonging to genera *Colobus*, *Semnopithecus* and *Trachypithecus* are currently thriving in zoos and *ex situ* options may be available for these taxa. *Rhinopithecus roxellana* appears to be doing well in Chinese zoological gardens as well. Limited success in Asian zoos is met with species of the genus *Pygathrix* and *N. larvatus*, and more scientific documentation would be welcomed, while *Presbytis* has so far failed to become well-established in *ex situ* centers despite some temporary successes. It appears that currently western zoos may have a negligible role in the direct conservation of colobine diversity, despite the fact that a number of regional captive breeding programs are active. The lack of coordination between Asian zoos (for example, regional breeding programs) diminishes their role in *ex situ* initiatives. In light of the progressive decrease of colobine species in European and American zoos and the scarcity of several species in Asian zoos, captive breeding of this taxon does not appear at present as the most successful conservation initiative, despite a small number of thriving populations. For this reason, it appears better for zoos to maintain the populations of their remaining species and increase their support to *in situ* initiatives for species they do not keep. In addition, western zoos could increase their support to already existing local *ex situ* initiatives (i.e. breeding centers) and support needed scientific research, local awareness projects, and reintroductions.

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