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Sixteen-year review of the population trends and mortality causes for captive Woolly monkey *Lagothrix* spp

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Woolly monkeys *Lagothrix* spp are difficult to maintain and breed successfully. These species are threatened in the wild and conservationists need to be aware of their plight in captivity if attempts to sustain the species are ultimately required. Written survey reports, International Species Information System record analysis and Woolly monkey studbook record analysis were completed to gather data on the survivability of the Woolly monkey population in captivity from 1990 to 2005. The Woolly monkey population decreased by 11% and the number of institutions holding these species also decreased. In addition, the birth to death ratio is negatively inverted (0.65:1.00). This is most pronounced in ♀♀ (0.47:1.00). The primary causes of death were infant mortality and complications during pregnancy, heart and hypertension disease, and bacterial and protozoan disease. The primary known causes of death in Woolly monkeys and both the genetic and nutritional relationship to reproductive success need further examination to conserve these species in both captivity and the wild.

Key-words: breeding; management; New World monkey; survey reports; survivability; woolly monkey.

INTRODUCTION

When this study was initiated, Woolly monkey *Lagothrix* spp were considered either Near Threatened (NT) or Vulnerable (VU) in the wild (IUCN, 2007). However, since that time the conservation status for all Woolly monkey species has worsened (Table 1) (IUCN, 2009; UNEP-WCMC, 2009). Therefore, both international trade and proper management must be maintained and controlled

to ensure that these species do not become even more threatened (Nowak, 1999; IUCN, 2007, 2009). This retrospective analysis was conducted in an attempt to understand better the longevity and reproductive success of Woolly monkeys in captivity. Woolly monkeys have been reported to have high incidences of health problems, including cardiomyopathy (heart disease), hypertension and reproductive disorders (Ange-van Heugten *et al.*, 2008), which may have a nutritional and/or stress-related origin. Woolly monkeys are historically considered by holding institutions as more sensitive or less reproductively successful and healthy than many of their closely related New World primate counterparts (ILAR, 1998). Thus, the current study was initiated to test the hypothesis that the Woolly monkey population size is gradually declining in captivity and to determine whether the causes of death may be linked to nutritional and reproductive disorders.

ANIMALS AND METHODS

Information was gathered using two primary methods. The first method was by distributing written surveys to all 20 institutions listed in International Species Information Systems (ISIS) as housing Woolly monkeys (ISIS,

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SPECIES	IUCN STATUS
Geoffroy's or Peruvian woolly monkey <i>Lagothrix cana</i>	EN
Humboldt's woolly monkey <i>Lagothrix lagotricha</i>	VU
Colombian woolly monkey <i>Lagothrix lugens</i>	CR
Poeppig's woolly monkey <i>Lagothrix poeppigii</i>	VU

Table 1. Status of woolly monkey *Lagothrix* spp as at October 2009 (IUCN, 2009): CR, Critically Endangered; EN, Endangered; VU, Vulnerable.

2005) (see Appendix S1 for questionnaire). This survey included questions about the animals housed at each institution currently and in the previous 15 years. The information requested included all birth, death, gender and health information available for the animals within this time period. The second method was completed by reviewing all written records from the American and the European species studbooks for the following parameters: zoological institution, number of housed Woolly monkeys per year, gender, age, birth and death records, and reasons for death (Taylor, 1998; Jens, 2005). Information was collected for the years 1990–2005. All numbers reported per year are based on the total population as on 31 December of that year. Free-ranging Woolly monkeys are separated into four species: *Lagothrix cana* (NT), *Lagothrix lagotricha* [Low Risk/least concern (LR/lc)], *Lagothrix lugens* (VU) and *Lagothrix poeppigii* (NT) (Di Fiore & Campbell, 2007; IUCN, 2007; see also IUCN, 2009 for more recent conservation status). However, classifications have changed over the years and no distinction was made in most historical information between the four species or their hybrids. Thus, no separation is accounted for in this report.

Surveys were distributed either via mail or in person to all institutions reported to hold Woolly monkeys worldwide. The survey results were compiled with the historical information available via ISIS records and the Woolly monkey studbook records. Data

were available for Woolly monkeys over 16 years.

RESULTS AND DISCUSSION

Woolly monkeys included in this research project were from institutions that report to the species studbook, update their ISIS information or responded to the written survey. Thus, some monkeys were likely unaccounted for; however, these omissions are believed to represent only a relatively small part of the worldwide captive Woolly monkey population (K. A.-v. H., pers. obs).

Results from 37 institutions were included in our study (Table 2). Of the 20 worldwide institutions contacted via the written survey, 14 of these still held Woolly monkeys and responded to some portion of the survey. Four institutions indicated that they no longer had the species but did not elaborate and two did not return the survey. According to all the historical records and survey results, the Woolly monkey population in captivity gradually decreased by 11% during the period of 16 years (Fig. 1). There were 86 [48.36.2 (♂.♀.?)] confirmed Woolly monkeys by the end of 2005, compared with 97 (41.52.4) at the end of 1990. The number of institutions housing Woolly monkeys changed considerably since 1990. In total, 37 institutions housed these species during some portion of the 16 year study period. However, the total number of institutions that housed these species only decreased from 16 in 1990 to 14 in 2005.

Woolly monkeys, which are known to be sensitive to stress or travel, have been transported to numerous facilities that may not recognize their unique health concerns. Poor captive success and reproduction could potentially be related to the numerous relocations of these sensitive species.

Only 15 (40%) of the 37 zoos reported Woolly monkey births at their location, while 32 (86%) reported deaths. Of the zoos reporting more than two births, only one (Apenheul Primate Park, the Netherlands) had more births than deaths (65 births and 56 deaths). The next most prolific conservation facility

AUSTRIA	PERU
Tiergarten Schönbrunn, Vienna	Parque Zoológico Huachipa, Lima
Wild & Freizeitpark Ferleiten, Fusch-Ferleiten	
BELGIUM	PORTUGAL
Antwerpen Zoo, Antwerp	Parque Zoológico do Cavado, Quinta de Santo Inácio
	– Fines, Avintes (formerly Parque Animal Quinto de Santo Inácio)
BRAZIL	SPAIN
Fundação Parque Zoológico de São Paulo, Sao Paulo	Faunia, Madrid
	Monkey Park, Los Cristianos
COLOMBIA	SWITZERLAND
Zoológico de Cali, Cali	Zoo Basel, Basel
Zoológico de Barranquilla, Barranquilla	
FRANCE	UK
La Vallée des Singes, Romagne	Howletts Wild Animal Park, Bekesbourne
Parc Zoologique Lisieux, Lisieux	Monkey Sanctuary, Looe
Zoo d'Asson, Asson	Monkey World, Wareham
Bioparc Zoo de Doué la Fontaine, Doué La Fontaine	Twycross Zoo, Atherstone
GERMANY	USA
Zoo Duisberg, Duisberg	Columbus Zoo and Aquarium, Powell, OH
Münchener Tierpark Hellabrunn, Munich	Gladys Porter Zoo, Brownsville, TX
	Kansas City Zoo, Kansas City, KS
ITALY	Los Angeles Zoo, Los Angeles, CA
Parco Faunistico 'La Torbiera', Agrate Conturbia	Louisville Zoo, Louisville, KY
	Tampa's Lowry Park Zoo, Tampa, FL
JAPAN	Lubee Foundation, Gainesville, FL
Japan Monkey Centre, Inuyama Yokohama Zoological Gardens, Yokohama	Pittsburgh Zoo and PPG Aquarium, Pittsburgh, PA
	San Antonio Zoo, San Antonio, TX
THE NETHERLANDS	Woodland Park Zoo, Seattle, WA
Apenheul, Apeldoorn	
GaiaPark Kerkrade Zoo, Kerkrade	
Primate Preservation and Education Centre, Bergijk	

Table 2. Information from 37 institutions was included in a review about life expectancy for captive Woolly monkeys *Lagothrix* spp. Woolly monkeys included in this research project were only from institutions that report to the species studbook, update their ISIS information or responded to the written survey.

breeding programme had equal numbers of births and deaths (14 of each). The third most prolific had 19 births and 25 deaths although they stopped breeding towards the end of the survey period owing to Woolly monkey health concerns (♀ death during or after pregnancy). A few holding facilities did not allow breeding or could not breed because of gender or age limitations.

In total, 229 Woolly monkey deaths were recorded in 16 years. These numbers include some animals that were likely stillbirths but this was not clear from the records. In contrast, 148 monkeys were born. These numbers may also reflect a small percentage of

stillbirths erroneously reported as births. Over the whole survey period, the total number of deaths exceeds the number of births by 81 animals (148 births and 229 deaths) (Fig. 1; Table 3). More ♂♂ were born than ♀♀ (births: 71.52) and more ♀♀ than ♂♂ died (deaths: 96.110). The demographics of the population, with high mortality and a relatively small number of ♀♀, are causing concern for the future genetic health of the population. Reproductive problems and failure to increase numbers via reproduction in captivity have previously been documented in these species (Rüedi & Heldstab, 1980; Müller *et al.*, 1989; Debyser, 1995).

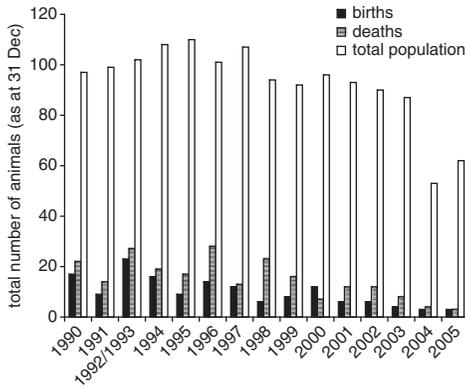


Fig. 1. Total Woolly monkey *Lagothrix* spp population in captivity, including births and deaths per year, in the period from 1990 to 2005. Information presented here was collected from institutions that report to the species studbook, update their International Species Information Systems information or responded to the written survey.

	MALE	FEMALE	UNKNOWN GENDER ¹	TOTAL
Total births	71	52	25	148
Total deaths	96	110	23	229
Birth to death ratio	0.74	0.47	1.09	0.65

Table 3. Overview of total births, deaths and birth to death ratios per gender for captive Woolly monkeys *Lagothrix* spp in the period from 1990 to 2005:¹ when a death was reported many institutions did not provide gender information, although this was primarily true for newborn monkeys.

Table 4 provides a summary of deaths with reported ‘causes’, although for numerous monkeys these causes were unknown or not investigated (e.g. ‘infant mortality’ or ‘pregnancy complications’). Infant mortality, defined as any animal that was born and died before its first birthday, was the most common reason listed for death (53% of deaths) but often no actual cause was given; although some appeared to be premature births, animals that never nursed or sudden illnesses. Aborted foetuses were not included in this number and every attempt was made not to

AGE AT DEATH	LIKELY CAUSATIVE FACTOR	NUMBER OF ANIMALS
Birth–1 year (infant mortality)	Not listed in records	65
> 1 year	Anaemia	1
	Bacterial or protozoan infection	16
	Heart or hypertension related disease	18
	Injury (fall or suspected fall)	5
	Kidney disease	3
	Liver disease (hepatitis included)	11
	Pregnancy complications	4

Table 4. Reported likely causes of death of Woolly monkey *Lagothrix* spp in captivity 1990–2005. Of the 229 deaths recorded over the 16 year period, likely causes were only reported for the 123 (53%) listed above. Some animals may appear in more than one category because cause of death was multifactorial. For many Woolly monkeys there were no necropsy results available nor was there a list of possible causes that could be summarized appropriately.

include stillborn animals. Some animals may be included in more than one category because some causes of death were multifactorial. The second most common reason for death was heart and hypertension related complications, and the third most common reason was bacterial and protozoan infections, including at least eight animal deaths from toxoplasmosis. These three top causes of death have been previously documented in these species (Gyimesi *et al.*, 2006; Ange-van Heugten *et al.*, 2008). It is important to note that records do not indicate how close to parturition a ♀ was when her death occurred. Therefore, maternal death in relation to pregnancy or parturition is unknown.

The ages of the Woolly monkeys that were alive by the end of 2005 were 0–36 years. The average age of the ♀♀ was 15 ± 11.0 years (mean ± SD), and the average age of the ♂♂ was 12 ± 7.4 years. The average age at death between 1990 and 2005 was 11 ± 8.1 years for ♀♀ and 8 ± 7.6 years for ♂♂. It is clear that a few geriatric animals skewed the

overall average age for the Woolly monkeys. In addition, the oldest animal in this research was 36 years and the average age of the animals was 13.6 years indicating that most of the animals die young. Interestingly, the oldest ♀♀ appear to be animals that never bred or were not reproductively successful. Wild Woolly monkeys are thought to mature sexually at 4–5 years for both ♂♂ and ♀♀ with ♀ reproduction until age 20 (Robinson & Redford, 1986; Mooney & Lee, 1999). The oldest ♀ in the present study to give birth was 27 years and the average age of giving birth was 12.7 years.

An important facet of the captive Woolly monkey population studied in the survey was that most institutions stopped importing wild animals for breeding during the study period. Animal numbers were replenished previously from monkeys captured in the wild, donated by the public, or rescued from the pet trade. Replenishing Woolly monkey populations in captivity from free-ranging animals is now more difficult owing to both tougher government restrictions and institutional concerns regarding their potential inability to manage these sensitive species successfully. The number of Woolly monkeys in captivity is theorized to continue to trend downward as reflected in Fig. 1 because wild animals are now rarely added to captive populations. Thus, there is little doubt that the captive population of these species is in need of further attention to prevent it from dying out. The further decline of this already small population will also inhibit important potential research studies in the future.

Numerous monkeys in the survey either were born in the wild or were public animal donations with unknown birth location and unknown genetic information. Thus, it was often unreported which species the monkeys belong to or whether they were hybrids. Therefore, comparisons could not be made regarding the difference in Woolly monkey longevity between birth locations or among Woolly monkey species. However, this would be interesting to examine for future studies especially if genetic variability could be examined. It must also be noted, however, that all four Woolly monkey species are very

closely related and all are reported to have health problems in captivity.

Only one institution has managed to breed several generations of the Woolly monkey. This colony of animals seems to have provided the majority of the reproductive events analysed either at this institution or when transferred to other facilities. Thus, lack of diversity in Woolly monkey genetics (i.e. the small number of breeding animals, possible inbreeding and possible subspecies hybridization) may have a negative influence on reproductive success within this captive population.

Owing to the historical nature of the current research trial we were not able to compare captive housing situations or social groups between Woolly monkey species or among different housing institutions. While this information could potentially affect the results about kinetics in the numbers of the population presented, the authors feel this would not change the outcome of the paper being that housing and social grouping vary considerably among and within all institutions regardless of species housed or institution location.

CONCLUSIONS

These retrospective data regarding the plight of the Woolly monkey in captivity are a potential for alarm. It is known that these species are threatened in the wild and it would appear that zoological institutions have limited success when maintaining them in captivity (Nowak, 1999; IUCN, 2007, 2009; UNEP-WCMC, 2009). In order for the Woolly monkey population to be successful in captivity, immediate action is needed. The following important possible research questions are proposed: (1) do Woolly monkeys in captivity have distinctly lower reproductive rates than their wild counterparts; (2) do Woolly monkeys have unique nutritional susceptibilities (e.g. in order to prevent hypertension, obesity and/or diabetes mellitus) or housing requirements when compared with their close New World primate relatives; (3) do Woolly monkeys acquire stress-related

conditions more easily than their close relatives, and therefore social and immune system parameters should be investigated? A comprehensive follow-up study comparing housing, management and diet at multiple institutions that house Woolly monkeys along with data from wild animals is vital.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

APPENDIX S1. Questionnaire survey sent to 20 institutions listed in the International Species Information System as housing Woolly monkeys *Lagothrix* spp.

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