

Clouded leopard (*Neofelis nebulosa*) in captivity: A Scenario in Indian zoos

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Abstract

The clouded leopard (*Neofelis nebulosa*) is a medium-sized cat having distinct cloud-shaped patches. In India, its range mainly consists of the northeastern states. The species has a long history of being housed in captivity, i.e., in Indian Zoos, and a breeding program for clouded leopards was also initiated in an Indian Zoo. It has been reported that the species is difficult to manage in captivity and little is known about it in terms of its breeding success. The study aims to learn about the history and population scenario of the clouded leopard in Indian zoos. The study of populations serves as an important tool both in terms of management and *ex-situ* conservation. The data regarding the history of housing clouded leopards in Indian zoos, their sex ratio, birth data, death data, acquisition, disposal, and founder animals were collected from the Central Zoo Authority (CZA) and National Studbooks. The study's results revealed the history of the clouded leopard being housed at 11 zoos in India, with a decrease in the number of breeding pairs and more mortality compared to the number of births over the years. This study indicates that the genetic management of species and knowing the present constraints in managing species in captivity needs further examination to conserve species more effectively in captivity. An effective species-specific management plan needs to be implemented for the species.

Keywords: Conservation, Clouded leopard, zoos

Introduction

The clouded leopard (*Neofelis nebulosa*) is listed in Schedule I of the Wild Life (Protection) Act, 1972, and listed as Vulnerable under IUCN Red List (Gray et al., 2021). They are medium-sized felids with distinct cloud-shaped patches on their pale-yellow to brown-colored fur that help them to camouflage in dense forests (Sunquist & Sunquist, 2002). They live in the dense evergreen forests and are found in the Himalayan foothills in Nepal through Mainland Southeast Asia into

China (Nowell & Jackson, 1996). In India, they are found in northeastern India which includes Valmiki Tiger Reserve in Bihar (Shafi et al., 2019) with recent records from protected areas in at least Sikkim (Bashir et al., 2011), West Bengal (Jhala et al., 2020), Assam (Borah et al., 2014), Arunachal Pradesh, Meghalaya, and Mizoram (Mukherjee et al., 2019). Mukherjee et al. (2019) reported on camera-trap studies from 10 sites across five northeast Indian states with Clouded Leopard present from six sites. The extensive camera-trapping and surveys for the 2018 All India Tiger census recorded Clouded Leopard from Kaziranga, Nameri, and Manas Tiger Reserves, Assam; Pakke, Kamlang and Namdapha Tiger Reserves, Arunachal Pradesh, Buxa Tiger Reserve, West Bengal, and Dampa Tiger Reserve, Mizoram (Jhala et al., 2020).

Little is known about their biology due to their elusiveness, so most information comes from captive individuals only (Nowak, 1999). In wild, it is reported to live upto 11 years while in captivity, 16-17 years (Wildlife Institute of India, 2018). Clouded leopard males' weight ranges from 16 to 18 kg and the weight of the female ranges from 11.5 to 13.5 kg (Grassman et al., 2005; Austin & Tewes, 1999). An elongated long tail, large paws, and flexible joints in their hind feet assist them in arboreal life (Sunquist & Sunquist, 2002). They are also unique in possessing the longest canine teeth in proportion to their size of all cats (Brakefield, 1993).

Further, clouded leopards exhibit variability in estrous cycle length. They can be both induced and spontaneous ovulation and estrous is not easily recognizable due to their secretive behavior (Howard et al., 1996; Pelican et al., 2006). Many females do not show marked behavioral changes while others display lordosis, treading, and rolling (Fazio, 2010) and the estrous cycle takes place for 24 days with estrous lasting for 6 days (Brown et al., 1995).

There is no marked sexual dimorphism in clouded leopards except for the difference in size. The females are slightly smaller in size in comparison to males. Age at first reproduction for both males and females is an average of 26 months while age at last reproduction is 12 years-15 years with most litters born to males and females between 2-4 years (Yamada & Durrant, 1989). Breeding in clouded leopards takes place around the year in the wild and there is no fixed mating season. Gestation was reported to be 93 ± 6 days with a litter size of 1-5, most often 3 (Yamada & Durrant, 1989).

With the enactment of the Wild Life (Protection) Act of 1972 and the establishment of the Central Zoo Authority (CZA), which oversees the functions and management of zoos in India, efforts in breeding programs have been undertaken. In India, zoos follow the guidelines/norms prescribed by the Central Zoo Authority, including Recognition of Zoo Rules (2009) and National Zoo Policy (2008). The CZA initiated the Conservation Breeding Programme for clouded leopards in 2010 by designating Sepahijala Zoological Park as the coordinating zoo for the clouded leopard

conservation breeding program and Assam State Zoo-cum-Botanical Garden, Guwahati as a participating zoo for the program (Central Zoo Authority, Conservation Breeding Programme). A coordinating zoo is a zoo wherein the conservation breeding facility in the form of off display center or in the form of a satellite facility has been created for the targeted species while participating zoos are the zoos in the habitat range of the targeted species for the breeding program.

Courtenay & Santow (1989) reported that captive animals are shown to benefit from good upkeep and healthcare. However, in a study by Karstad & Sileo (1971), captive animals have been reported to suffer from various health problems, limited exercise, and poor adaptation to captive conditions, and injury due to exhibits. All these may result in the loss of their natural behavior, which in turn affects the reproduction of captive animals. Besides, the survival and reproductive success of the captive population can also be decreased due to various other reasons like inbreeding depression, lack of population management in the captive stock, poor husbandry practices, etc. Therefore, population management is considered an important tool for maintaining a long-term viable captive population and also for preserving genetic viability.

The Wildlife Institute of India (2014), has reported the housing of clouded leopards in captivity since the early 1900s around the world, and the first zoo birth was reported in the 1950s. In the year 1989, the Clouded Leopard Species Survival Plan (SSP) was formed which addressed the issues regarding captive management, stabilization of the population, genetic management, and development of conservation efforts in the clouded leopard's range countries. During the 1990s, the SSP focused on improving the genetics of the population and recommended the breeding of 16 individuals whose bloodlines were not overly represented in the captive population. However, these recommended pairing and breeding have resulted in limited young ones. Therefore, in the year 1998, a need to add younger born to the aging population becomes important to stabilize the demographics due to which, all compatible pairs were recommended for breeding with a target level of 11 births per year. Hence, the SSP population was declared a research population which relaxed the need to make breeding recommendations based strictly on the genetic or demographic needs of the population. Instead, the primary goal of the SSP became to carry out fundamental research into clouded leopard behavior in order to improve captive management and artificial reproduction (The Clouded Leopard Project, 2009).

Research into the management and husbandry requirements of the clouded leopard has been going on, but the main problem remains mate incompatibility, which leads to injuries and even the killing of females by males (Wildlife Institute of India, 2018). A study by Yamada & Durrant (1989) suggested that the best solution was to establish pairs of animals when the animals were

still sexually immature. Ecological studies on clouded leopards show the use of semi-evergreen forest greater than other vegetation types with arrhythmic activity with increased levels during crepuscular and nocturnal periods (Austin & Tewes, 1999), behavioural assessment using two separate methods to determine temperament and behavioral differences within the species, including behavioral observations and a keeper, rated temperament assessment was also conducted which were found to be significantly correlated to reproductive success (Fazio, 2010). Further, a study regarding reproductive parameters by Yamada & Durrant (1989) revealed that 75% of all litters were born to females between the age of one and five years, 63% of males had sired litters by four years of age with reproduction declining after six years of age. There was a significantly higher incidence of estrus in fall and winter compared with spring and summer over latitudes ranging from 36°–45° and 51°–55° ($P < .005$) with the highest frequency of mating occurring during the month of December corresponding with a birth peak in March. However, studies on the history of housing of the clouded leopard, its scenario, and its breeding program in Indian zoos have not been undertaken so far.

The present study was carried out to know about the scenario of clouded leopards in Indian zoos: their history, founder population, number of zoos housing the species, number of individuals housed, their sex, acquisition, birth, death, and disposal. The breeding program for the species initiated at the Sepahijala Zoological Park, Tripura, was also taken into account during the study. This study is an attempt to learn about the population trend of the species and its conservation in Indian zoos, identify the existing constraints, and recommend measures for conserving the species in captivity

Material and methods

The methodology used for the study included the collection of secondary data. The data was gathered from the Central Zoo Authority (CZA) published annual inventory of animals in Zoos for the year 1995 to 2018 (Central Zoo Authority, Annual reports of animals in Zoos) and the annual reports of the CZA for the year 1995 to 2018 (Central Zoo Authority, Annual reports of the zoos) which were freely accessible from the website of CZA. The information on the breeding program of clouded leopards initiated by CZA and other information related to clouded leopards were also collected from the archives of the CZA (which includes- published, unpublished reports, conference/workshop proceedings, etc.). National studbooks of the Clouded Leopard were also used for collecting the data and information.

The information collected included the name of the zoo that housed the species, birth, death, sex, acquisition, disposal, founder animals, age, etc. For knowing the population trend of the species, birth and death trends, the data collected from the CZA (for the years 1995–2018) was used as a

benchmark. All the numbers of individuals reported per year are based on the total population as of March 31st of that year.

The report submitted by the Sepahijala Zoological Park, Tripura to the CZA on the study of clouded leopards under the conservation breeding program of the CZA for clouded leopard has also been taken into account during the study and used as records obtained/collected from the CZA. The results were obtained for the population trend in the form of graphs and tables, which depict the change in population over the years and the zoos that housed the species.

Results

Clouded leopard in Indian Zoos

The clouded leopard in Indian zoos owes its origin to the wild-caught founder animals. The first recorded entry of the species into captivity was at Ahmedabad in the year 1985 with 2 specimens of unknown sex and origin, which survived there for 7 years, i.e., from 1985 to 1992. According to the Wildlife Institute of India (2018), the first wild-caught male clouded leopard was taken into an Indian zoo in 1992 in Assam, followed by a male in Sepahijala in 1996. According to Acharjyo & Mishra (1981) and also according to Acharjyo & Patnaik (1990), the Nandankanan Zoological Park, Odisha received one female clouded leopard in April 1966 from an animal dealer in Calcutta. The Wildlife Institute of India, 2014, also reported the housing of clouded leopards at zoos in Kanpur (in the year 1994) and Patna (during 1996-2003).

As per Central Zoo Authority (CZA) records, the first rescue of the clouded leopard by the Sepahijala Zoological Park, Tripura was reported in 1992 (named Nandan), and between 2005 and 2015, six individuals were rescued from the wild and included in the breeding program (Central Zoo Authority website). The acquisition of wild-caught individuals led to an increase in the captive population from 1996 to 2000 in Indian Zoos. The Sepahijala Zoological Park, Tripura, became the first zoo in India to have so far bred this species in captivity. In zoos, from 1995 to 2018, a total of 32 (19:12:1) acquisitions were carried out and 7 (5:2:0) disposals have been reported, which is the transfer of clouded leopards between the Indian zoos. The zoos at Itanagar, Darjeeling, and Aizawl have acquired clouded leopards from Sepahijala Zoological Park.

As of March 31, 2018, there were 7 (4:3) clouded leopards in the conservation breeding program at Sepahijala Zoological Park, and 3 (2:1) clouded leopards on display at the zoo. The CZA records revealed that the Sepahijala Zoological Park tried pairing 11 different pairs for breeding purposes, out of which only 3 male breeders provided maximum offspring. However, the offspring of a male named Taju did not survive long and died within a few days or months. Therefore, only two male breeders named Nandan (rescued) and Ghaura (rescued) have been

reported to be successful male breeders in the history of the Clouded Leopard breeding program in the Indian zoo by contributing 11 offspring each, but unfortunately, both Nandan and Gaura died in the years 2017 and 2014, respectively. In the case of the female clouded leopard, two successful breeders were reported, namely Reshmi (contributed 11 offspring) and Shilpi (contributed 8 offspring). Both the male and female successful breeders were of wild origin. According to the analysis shown by the Wildlife Institute of India (2014), the 11 breeding pairs (3 males and 8 females) produced a mean of 1.4 litters/breeding pair, which includes 1.9 cubs/litter, and the births did not take place from September to January, and 68% of the births took place during the month of March. Wildt et al., (1986) mentioned the highest number of births occurred in March and April, but births were also recorded in nine other months of the year. The year-wise scenario of Indian zoos housing/housing the species as per CZA is shown in table 1.

Table 1. Year-wise housing of Clouded leopards in Indian zoos

Year*	Indian Zoos (M:F:U)											Total
	1	2	3	4	5	6	7	8	9	10	11	
1995-96	-	-	3:2:0	1:1:0	0:1:0	2:0:0	1:1:0	-	1:0:0	-	-	13
1996-97	-	-	3:1:0	1:1:0	0:1:0	2:0:0	1:1:0	-	1:0:0	-	1:0:0	13
1997-98	-	-	3:1:0	2:2:0	0:1:0	2:0:0	1:0:0	-	1:0:0	-	Died	13
1998-99	-	-	3:1:0	1:0:0	0:1:0	3:0:0	1:0:0	0:1:0	1:0:0	-		11
1999-2000	-	-	2:1:0	1:0:0	0:1:0	3:0:0	1:0:0	died	1:0:0	-	2:0:0	12
2000-01	-	-	2:0:0	1:0:0	-	3:0:0	1:0:0		1:0:0	-	3:2:0	13
2001-02	-	1:0:0	2:2:0	died	-	2:0:0	1:0:0	1:0:0	died	-	3:4:0	16
2002-03	-	1:0:0	1:2:0	-	-	2:0:0	1:0:0	1:0:0		-	3:2:0	12
2003-04	-	1:0:0	2:0:0	-	-	2:0:0	died	1:0:0		-	4:3:0	13
2004-05	-	1:0:0	2:0:0	-	-	2:0:0	-	1:0:0		-	5:4:0	15
2005-06	-	1:0:0	2:0:0	Acquired and died	-	1:0:0	-	1:0:0	-	-	6:4:0	14
2006-07	-	1:0:0	2:0:0	-	-	1:0:0	-	1:0:0	-	-	8:7:1	20
2007-08	0:1:0	1:0:0	2:0:0	-	-	1:0:0	-	1:0:0	-	-	7:6:3	22
2008-09	0:1:0	1:1:0	2:0:0	-	-	1:0:0	-	1:1:0	-	-	7:5:3	23
2009-10	0:1:0	1:1:0	2:0:0	-	-	1:0:0	-	1:1:0	-	-	4:5:6	23
2010-11	0:1:0	died	died	-	-	1:0:0	-	1:1:0	-	0:1:0	7:4:4	20
2011-12	0:1:0	-	-	0:0:1	-	1:0:0	-	1:1:0	-	0:1:0	6:4:7	23
2012-13	0:1:0	-	-	0:0:1	-	2:1:0	-	1:1:0	-	1:0:0	4:3:6	21
2013-14	1:1:0	-	-	0:0:1	-	2:1:0	-	1:0:0	-	1:0:0	4:3:8	23
2014-15	1:1:0	-	-	0:0:1	-	2:1:0	-	1:0:0	-	1:0:0	2:3:8	21
2015-16	1:1:0	-	-	0:0:1	-	2:1:0	-	1:0:0	-	1:0:0	7:5:1	21
2016-17	1:1:0	-	-	0:1:0	-	2:1:0	-	1:0:0	-	died	7:5:0	19
2017-18	1:1:0	-	-	0:1:0	-	2:1:0	-	1:0:0	-	-	6:4:0	17

1-Aizwal Zoological Park, Mizoram; 2- Zoological Park, Kohima, Nagaland; 3- Assam State Zoo cum Botanical Garden, Guwahati, Assam; 4- Lady Hydari Park Animal Land, Meghalaya; 5-Jaipur Zoo, Jaipur, Rajasthan; 6- Biological Park, Itanagar, Arunachal Pradesh; 7- Sanjay Gandhi Biological Park,

Patna, Bihar; 8- Padmaja Naidu Himalayan Zoological Park, Darjeeling, West Bengal; 9- Manipur Zoological Garden, Manipur; 10- Himalayan Zoological Park, Bulbuley, Sikkim; 11- Sepahijala Zoological Park, Tripura

*Central Zoo Authority, Annual inventory of animals in the zoos (<https://cza.nic.in/page/en/inventory-of-animals-in-zoos>)

National Studbooks of Clouded leopard

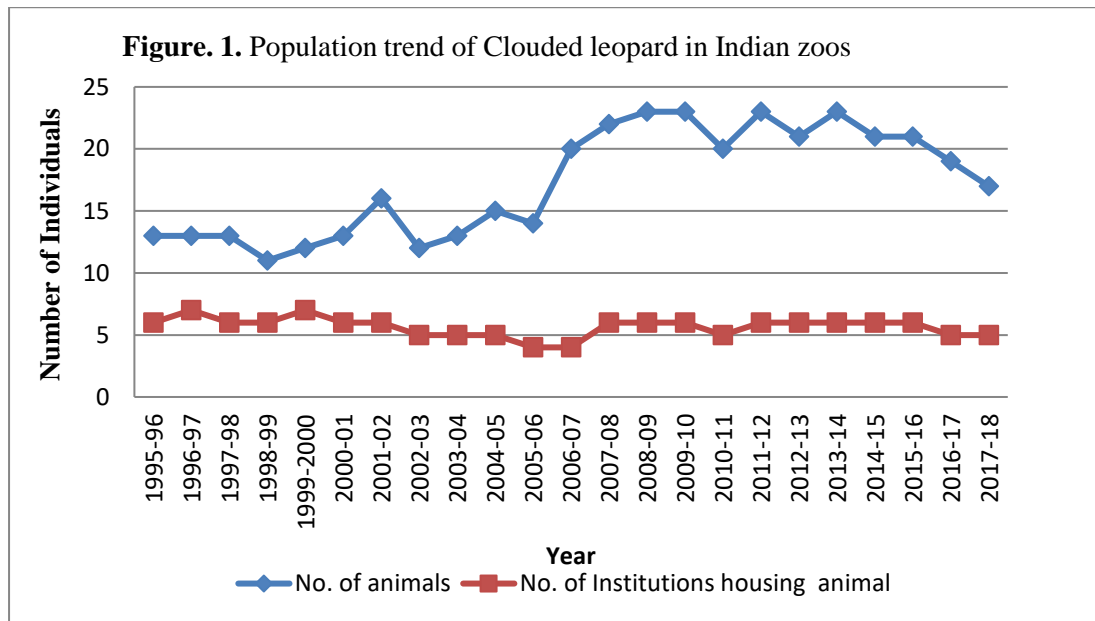
In India, a total of three national studbooks have been published on the clouded leopard. The details mentioned for the species in the National Studbooks are shown in table 2.

Table 2. National studbooks published for Clouded leopards in India

Edition & Year	Historical Population (M:F:U:T)	Current population (M:F:U:T)	Founders	Total Captive births	Total Wild origin	Breeding individuals (M:F:U)
Ist Edition December 2009	18:16:2:36	13:12:0:25	6	19	17	Not given
IInd Edition & November, 2014	23:27:3:53	10:15:1:26	6	28	23	2:5:0
III Edition & August 2018	30:26:3:59	10:7:0:17	5	35	24	0:1:0

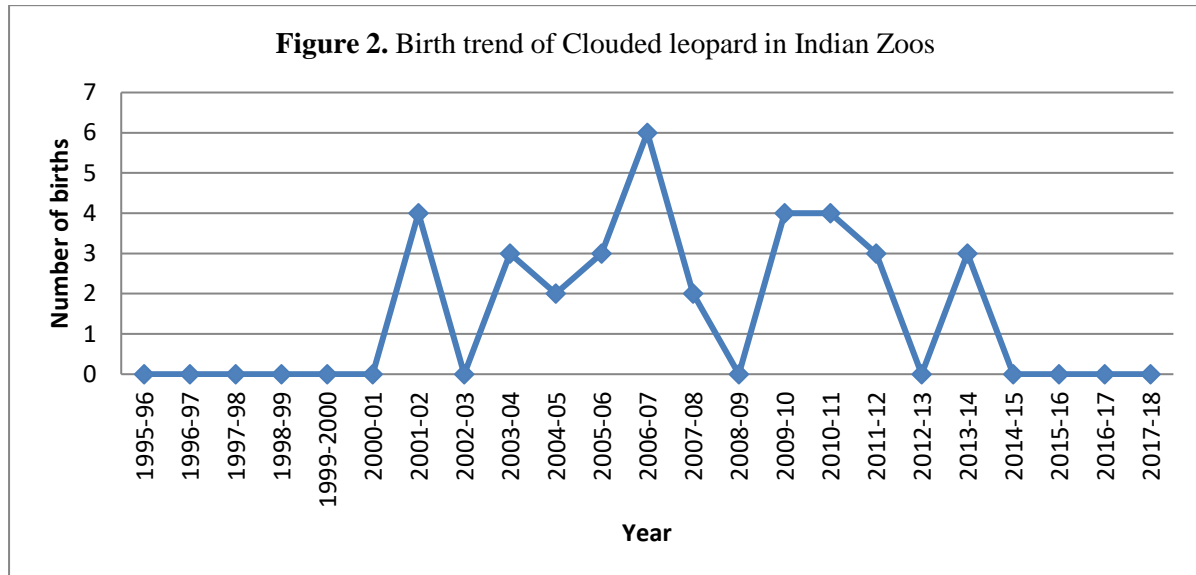
Population trend

An overview of the overall population trend along with the birth and death trend of clouded leopards during the year April 1995 to March 2018 at the Indian Zoo is shown in Figures 1, 2 & 3. Figure 1 shows the stock position of the clouded leopard for the period of April 1995 to March 2018, which subsequently showed a fluctuating trend up to the year 2005-06. After this period, the increase in the stock was observed from the year 2006-2007 till the year 2009-10 with 23 individuals. The trend again fluctuated and started showing a declining trend from 2015-16 till 2017-18. In the year 2017–18, there were 17 (10 male, 7 female) clouded leopards housed in a total of five Indian zoos with no births, 2 (1 male and 1 female) deaths, no acquisitions, and no disposals.



Birth trend

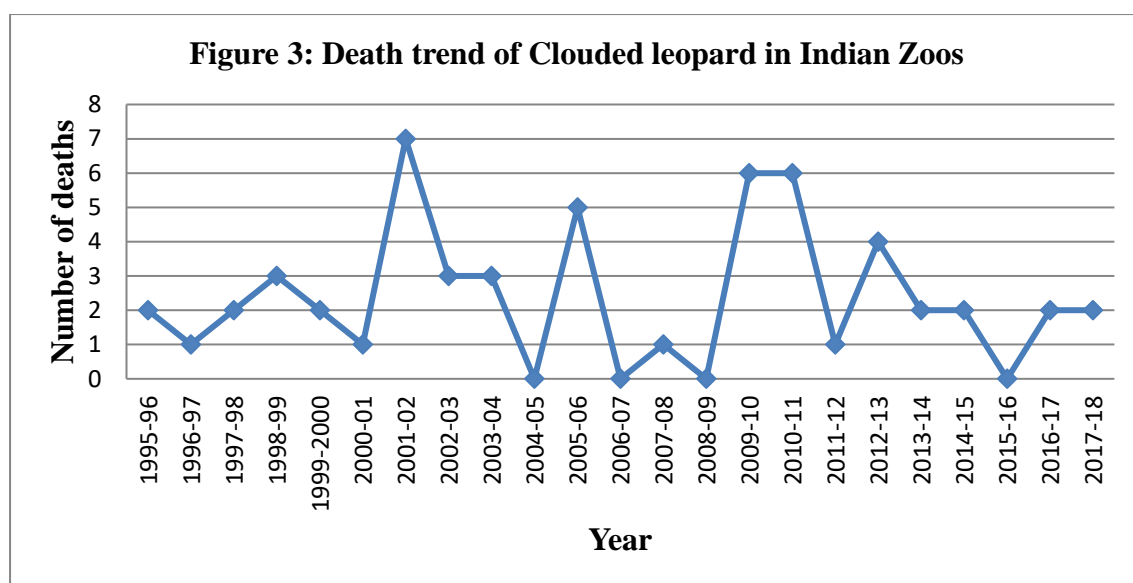
The fluctuating trend in the population was noticed and the birth of four cubs was noticed during the years 2001-02, 2009-10 & 2010-11, and a maximum number of six cubs was born during the year 2006-07. The birth trend mostly showed a fluctuating trend during the observation period, and from the years 2014-15 till 2018, no births occurred in any of the zoos (Figure 2).



A total of 34 (8 male, 9 female, 17 unsexed) births have been reported from April 1995 to March 2018 at only one Indian zoo, namely Sepahijala Zoological Park, Tripura. which may be due to the better stock position of the species, adequate housing facilities, experienced staff/officials, good mate compatibility, and also because the zoo falls in the natural habitat area of the species.

Death trend

In the case of the death trend in Clouded leopard, Figure 3 showed a fluctuating trend with the maximum number of deaths. There were 7 deaths reported in the year 2001-02, 6 in the year 2009-10, and also 6 deaths in the year 2010-11, respectively. Analysis showed that there was a greater number of deaths than births in captivity, which accounts for the total of 56 (32 male, 22 female, and 2 unsexed) deaths from 1995 to March 2018 in Indian zoos. In the recent years 2016-17 & 2017-18, the death rate decreased by 2 individuals in each of the last two years. Furthermore, there were four years (2004-05, 2006-07, 2008-09, and 2015-16) when no clouded leopard mortality was reported in captivity. There may be various factors that were responsible for the deaths, like disease outbreaks, issues with housing facilities, behavioral needs of the species, veterinary aspects, and other reasons.



Discussion

Clouded leopard in Indian Zoos

The results revealed that the clouded leopard has a history of being housed at a number of Indian zoos. The same has also been reported by the Wildlife Institute of India, in 2018. However, as per the CZA data, a single female clouded leopard was once housed in Jaipur Zoo, Jaipur, Rajasthan from the year 1995 to 2000. The housing of clouded leopards at the Jaipur Zoo has not been mentioned in any of the National Studbooks published for the species. Similarly, as per the Wildlife Institute of India (2014), a single female was housed at Kanpur (in 1994), which is not mentioned in the records of CZA. The species was also noticed to be housed in Patna at Sanjay Gandhi Biological Park as per CZA and Wildlife Institute of India (2014) for seven years as shown in table 1.

Table 1 also shows the housing of single or unpaired animals in the zoos at Meghalaya, Darjeeling, Gangtok, Jaipur, Patna, and Aizawl over the years. The Wildlife Institute of India

(2014), also reported the same and mentioned that 3 wild-born individuals were housed as unpaired animals in Aizawl, Gangtok, and Meghalaya. Therefore, it did not get a chance to contribute genetically to the population in Indian zoos.

The scenario showed that the species survived for many years in most of the zoos falling in the natural habitat region of the species in comparison to the zoos not present in the natural habitat region of the species, namely the facilities/zoos at Ahmedabad, Kanpur, Patna, and Jaipur. The species is housed and breeding well at Sepahijala Zoological Park, Tripura, which is the zoo located near the Sepahijala Wildlife Sanctuary & Clouded Leopard National Park, which is the natural habitat region for the species. However, as per Acharjyo & Mishra (1981), an adult female clouded leopard lived 13 years, 9 months, and 12 days in captivity (at Nandankanan Biological Park, Odisha) from the year 1966 to 1980 and died at the age of about 15 years, that may be because that individual was kept along either with one male and /or female clouded leopard in the zoo. This depicts that unpaired and/or lone/single animals may affect the survival of the species in captivity.

Further, the birth contribution of 11 breeding pairs in captivity has also been reported by the Wildlife Institute of India (2014). It has been observed that the rescued male (two) and female (two) clouded leopards at Sepahijala Zoological Park, Tripura have contributed to the maximum number of births and no captive-born male has been reported to be a successful breeder in captivity. The overrepresentation of the rescued male and female breeders in the population over the years, as reported by CZA, has also been mentioned by the Wildlife Institute of India, in 2014 and 2018.

National Studbook

Table 2 reveals that only 3 studbooks have been published for Clouded Leopard and there is a decrease in the number of founders and breeding population with time. The loss of breeding individuals with time is a cause of concern. The Wildlife Institute of India, 2018 shows that out of the total 59 (30:26:3) individuals reported in the historical population, only 10 individuals (3:7:0) were reported to be breeding individuals.

The decrease in the founder number has been observed with 5 founder animals as of March 31st, 2018. The present population retains 82.53% of the genetic diversity (limited genetic diversity) originating from these 5 founders, with founder genome equivalents of only 2.86 wild-origin individuals (Wildlife Institute of India, 2018). Besides, as per the Wildlife Institute of India (2018), there is an unequal representation of founders in the population and the population is characterized by the breeding of related individuals with a population mean kinship of 0.175, which is a cause of concern. This shows that the acquisition of new founders may be initiated to

continue the breeding program of the species in captivity so that a demographically stable and genetically viable population may be established in captivity for the survival of the species.

Population Trend

The increase in the population, as shown in figure 1, from the year 2006-2007 till 2009-2010, was due to the captive births and acquisition of rescued animals. The results are consistent with the Wildlife Institute of India (2014), which states that the decline in the population was offset by the acquisition of individuals from the wild, which contributed to the increase in population size.

Further, figures 2 and 3 showed a fluctuating trend with more deaths (32:22:2:56) and fewer births (8:9:17:34 births at only one zoo) during the period of April 1995 to March 2018 at Indian zoos. The same was also observed in the National Studbook Clouded leopard (Wildlife Institute of India, 2018). The clouded leopard population is stable at its current size with a 0.7% marginal growth rate and females showing a declining trend.

According to Srivastav & Nigam (2009), in the captive population of clouded leopards at Indian zoos, a cause of concern is the low fecundity levels and poor survival rate of offspring produced. Further, Srivastav & Nigam (2009) also mentioned that the possible causes of low fecundity might be improper housing and/or husbandry of clouded leopards.

The present study revealed that only Sepahijala Zoological Park has a history of maintaining a greater number of individuals in comparison to other Indian zoos and is the only zoo that has a history of breeding the species in captivity. The other zoos did not allow breeding or could not breed species. This may be due to a lower number of individuals or unpaired/single animals, inadequate breeding/other facilities, or mate compatibility issues.

The objective of cross-breeding is not only to produce a large number of individuals of a species but to maintain a high proportion of the gene diversity within the population. According to Leus (2011), in order to retain 90% of the wild gene diversity through a captive breeding program, three main things should be taken into account, i.e., (i) there has to be a sufficient number of founders, which forms the basis of the captive population, (ii) pairing of animals should be carefully managed, and (iii) there should be a large captive population. In the present study, a single breeding individual, a small number of founders base, a small captive population, and the non-management of compatible breeding pairs are a cause of concern at Indian zoos.

The successful breeding at Sepahijala Zoological Park, Tripura may be due to the compatibility of breeding pairs and the zoo's falling in the natural habitat region of the species. However, there is a need for adequate record-keeping for the species so that accurate breeding and population management strategies for the species in captivity might be implemented at all levels.

Besides, keeping in view of the secretive nature of the clouded leopard, the enclosure designs and husbandry must be taken into consideration as its arboreal lifestyle as well. Careful management of compatible pairs is also of utmost importance as the species has been reported to be managed with difficulties in captivity for breeding. According to Baudy (1971) and Fletchall (2007), the male and female should be paired at a young age, preferably before six months while still pre-pubertal. Wielebnowski et al. (2002) suggest that hand-reared cubs are better suited for captive propagation. Furthermore, to have a self-sustainable captive population, there is a need to have a species-specific captive management plan as per the species' natural behavior.

Conclusion

For managing and conserving the species in captivity, a planned breeding program is required to be prepared and implemented by the zoos. So far, no study has been carried out to know about the scenario of the clouded leopard in Indian zoos and its population trend over the years. The results of the study revealed the history of the clouded leopard in captivity in 11 different Indian zoos, the fluctuating population trend (birth, death, etc.) over the years, and the present status of the species in captivity. Therefore, the housing of clouded leopards in zoos which are present in the natural habitat regions with adequate housing and husbandry management is important alongwith the pairing of lone/single-sexed animals. The present small population size, small founder base, single female breeder, and less genetic diversity limit the mating choices for the species in captivity, which has resulted in breeding between closely related individuals over the years. Therefore, addressing the needs for the acquisition of a founder base, mate compatibility issues, and adequate housing and upkeep facilities for the species is a need of an hour. This study indicates that an effective species-specific management plan needs to be implemented for the ex-situ conservation of clouded leopards in captivity.

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