DEMOGRAPHY OF CAPTIVE ASIAN ELEPHANTS *ELEPHAS MAXIMUS* LINNAEUS IN THREE MANAGEMENT SYSTEMS IN TAMIL NADU, INDIA

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Captive Asian elephants *Elephas maximus* are managed in three systems in Tamil Nadu namely, private, Hindu temples and forest department. We studied the population size and structure, natality and mortality during 2003-05 in the three systems to assess their long-term viability. The population in the three systems totalled 133 individuals in 2005 with adult class constituting over 75% of the population. Sex ratio of the population was biased towards females in private establishments (male to female 1:10) and temples (1:21), but male biased in the forest department (1:0.5) with adult males constituting 50% of the total population. There was no breeding in private and temple populations. In the forest department population, fecundity has dropped (0.065/adult female/year) over the past 10 years (1996-2005) compared to an earlier (1969-1989) estimate (0.155/adult female/year). Mean mortality estimated together for the three systems is higher (3.9%) than reported earlier (1.9%). Given the aging population trends and with no breeding and fewer chances of additions from the forest department due to ban on elephant sale, captive populations in private establishments and temples may not survive in the long run. Sustainability appears rather remote for population of the forest department system with a male bias, increase in mortality and a decrease in fecundity.

Key words: Asian elephant, *Elephas maximus*, captive elephants, population, natality, mortality

INTRODUCTION

The Asian Elephant *Elephas maximus* Linnaeus, listed as an 'endangered' species by the IUCN (International Union for Conservation of Nature Red List 2008), presently exists as fragmented population in southern and south-eastern Asia. Currently, wild Asian elephants are estimated to be 36,000-52,000 individuals distributed across 13 Asian countries (Sukumar and Santiapillai 2006). The Asian elephant is considered an integral part of the culture and mythology of India, and elsewhere in Asia; the people of Indus Valley civilization first captured it probably about 4,000 years ago (Carrington 1959). There were about 19,500 captive Asian elephants in 1997 with Myanmar holding the largest captive population (6,000-7,000) followed by Thailand (3,800-4,000) and India (2,800-4,000) (Lair 1997). The IUCN Asian Elephant Specialist Group estimates the captive Asian elephant numbers within the range countries at 16,365 and less than 2,000 in non-range countries, including about 1,000 in North America and Australia, and 296 in Europe (Hedges 2006).

In India, captive elephants are distributed across almost all states (including numerous non-range states), as this animal is an integral part of the country's cultural and religious landscape. According to Project Elephant (MoEF 2004), about 3,400-3,600 captive elephants are distributed across 23 states and union territories, including the Andaman and Nicobar Islands. A majority of these are found in the north-eastern (55%) and southern (25%) states. In Tamil Nadu, southern India, elephants are managed in captivity by the state forest department, religious institutions and individual owners for various purposes. The Government of Tamil Nadu has categorized these elephants into three captive systems: forest department captive elephants (managed at timber camps and zoos), temple elephants (managed at Hindu temples), and private elephants (managed by trusts, charities, mosques and individual owners).

Several studies have been made in the past on captive elephant management in Tamil Nadu, but these have been sporadic, isolated, short term, and/or have not been comprehensive (Sukumar *et al*. 1988; Gokula 1993; Krishnamurthy 1995; Krishnamurthy and Wemmer 1995; Sukumar *et al.* 1997). Additionally, little long-term quantitative data are available on their numbers; a comparative analysis of different captive management systems and their influence on elephants' natural behaviour has not been attempted. Further, most of the data available on captive elephants in India pertain to timber camp elephants managed by the state forest department and hardly any information exists on those managed by private owners and Hindu temples, which constitute over 50% of the captive population in southern India (Lair 1997).

Lair (1997) in his global comprehensive review on captive Asian elephants states that India, the birthplace of

elephant captivity, has very little published data on captive elephant numbers. Further, he concludes that captive elephant numbers estimated in India are clearly an underestimation, and highlights the need for a detailed survey to fulfil the basic information. A recent report by Project Elephant (MoEF 2004) puts the maximum number of captive elephants in India at 3,600, and recommends a detailed survey and assessment for their welfare. In addition, the available data on the population and demographic status of captive elephants in India are scarce. The data on the number of individuals alone are inadequate to predict future trends of any population. The age structure, age specific fecundity, and mortality, age at first conception, and last calving, and mean-calving interval are important parameters to understand population dynamics and predict future trends (Laws and Parker 1968; Corfield 1973; Caughley 1977; Laws 1981; Lindeque 1991; Stearns 1992), are lacking for most of the captive populations. In this paper, we present the data on population demography of captive Asian elephants in Tamil Nadu, India, collected between 2003 and 2005, as part of a long-term comparative study on the status and management of captive Asian elephants in Tamil Nadu.

METHODS

Data on population size and structure, natality and mortality were collected from: (1) the Tamil Nadu forest department – captive elephants managed at the timber elephant camps at Mudumalai and Anamalai wildlife sanctuaries, and Arignar Anna Zoological Park (AAZP), Chennai, (2) Hindu temples, and (3) private owners in Tamil Nadu.

Population Size and Structure

A comprehensive list of captive elephants maintained under the three different management regimes, with special emphasis on temple and private collections (as data on these two systems was lacking), was first prepared. The list was compiled by examining governmental records and from enquiries with veterinarians and elephant researchers. This was later found to comprise of *c*. 90% of the temple and *c*. 80% of the private elephants in the State. The presence and information on the remaining elephants were obtained during intensive surveys carried out through enquiries with temple authorities, *mahouts* (elephant keepers) and private owners. Altogether, data was collected on 34 facilities in the private system, 41 in temple systems, and 3 (namely, the elephant camps at Anamalai and Mudumalai, and the Arignar Anna Zoological Park, i.e., two camps and one zoo) in the forest department system. During the survey, data was collected on the age and sex of all the elephants through enquiries with the *mahouts* and by verifying with studbooks/registers (where available). Age was estimated by the shoulder height method (Sukumar *et al*. 1988) if proper age records were not available. Data were additionally collected from temple and private elephants at the one month long annual rejuvenation camps conducted jointly by the Tamil Nadu Hindu Religious and Endowment Charity (HR & CE) and Tamil Nadu Forest Department at Mudumalai Wildlife Sanctuary during 2003-2005.

Natality and Mortality

Data on natality and mortality of elephants in the three systems of captive management was collected from register of records and through monitoring during the study period. Natality generally refers to the addition of newborn individuals into the population, but in this study, it also includes the addition of individuals through purchase/transfer/ confiscation/rescues, as these additions add to the captive population size. Fecundity was calculated by dividing the total number of calves that were born during the study period by the total number of sexually mature female elephant-years following Sukumar *et al*. (1997). Elephant-years refer to the summation of all individual elephants multiplied by their number of year(s) representation/ survival in a given system for a particular period. For example, out of 25 different elephants managed in a given system over a two-year period, 20 of them represented for 2 years and the remaining five only for a one-year period, which translates to 45 elephant-years (i.e. 20*2 + 5*1 = 45). Age-specific mortality was computed by dividing the total number of individuals that died within a given age class by the total number of elephant-years lived in that age class (Sukumar *et al*. 1997) during 2003-2005 in the three systems. Data available on the number of elephants managed and that died as per the Forest Department records for the period 1996-2002 was also used to have a larger sample size in the mortality rate analysis.

Data analysis: The elephants were categorized broadly into four major age classes: calf (<1-year old; 90-120 cm height), juvenile (1-5 years; 121-180 cm), subadult (5-15 years; 181-210 cm for female and 181-240 for male), and adult (15 years and above; >210 cm for female and >240 cm for male) based on shoulder height (Sukumar *et al*. 1988). The trend in population size of elephants in the forest department system from 1996 to 2005 was tested using linear regression. Year-wise differences in the age-sex composition of elephants during the study period (2003-05) within each system and among the three systems were analyzed using likelihood-ratio chi-squared statistics (G^2) (Agresti 1996).

RESULTS

Population Size

The total population size of captive elephants in the three management systems in Tamil Nadu was *c.* 132-135 elephants between 2003 and 2005 (Table 1). The total number of elephants at the end of the year was the same in 2003 and 2004 (135 elephants), but dropped to 133 in 2005. Within a given system, the number of elephants at the beginning and at the end of each year of the study varied due to addition of individuals (births, capture, transfer from other systems and purchase) and reduction due to mortality, sale and transfers. Although the overall number of individuals was almost the same, there was little turnover within the three-year period.

The districts of Madurai (n = 9) and Tiruchirapalli (n = 8) had more private elephants, and Thanjavur (n = 7) and Madurai (n = 6) had the most number of temple elephants. All the elephants in the private and temple systems were purchased either from the forest department (mostly before 1982 when the ban on capture of elephants for sale came into force) or recently from other state private systems, except for one from birth in the private facility. The source of origin (captive born and wild-caught) for many of these elephants was not available due to improper maintenance of register records. Among the 53 elephants managed between 2003 and 2005 in the forest department, 24 were captured from the wild, 16 were captive born, 9 were wild 'orphans', and 1 was confiscated from a private owner in 2003. The origin of the remaining three (including one transferred back in 2004 from a temple due to difficulty in handling) could not be ascertained due to absence of records. Long-term data from 1996 to 2005 on the population size of captive elephants managed by the forest department (Fig. 1) indicate a significantly declining trend (linear regression of population against time $R^2 = 0.6679$, $P < 0.01$, $n = 10$) over the past ten years.

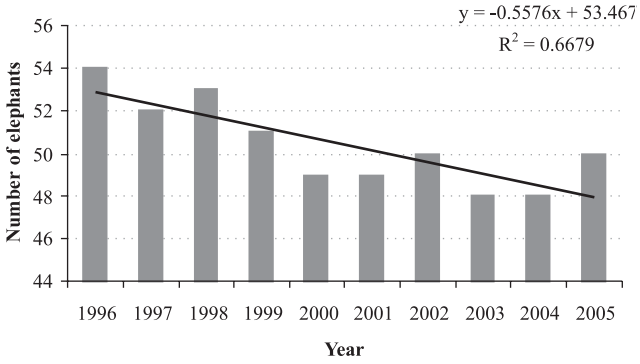

Fig. 1: Number of captive elephants with the Tamil Nadu Forest Department between 1996 and 2005

Population Structure

Age structure data revealed an aging population trend with the adult class forming more than two-thirds of the total population size in all the captive systems (Table 2). Among the three captive systems, the proportion of adult class was the highest in the private system (87%) followed by the forest department system (75%). The subadult class was the highest in the temple (30%) followed by forest department system (16%). Juveniles and calves were mostly found in the forest department system (Table 2).

The age-sex composition of elephants did not vary during the three-year study period (2003-05) within each system (private: $G^2 = 5.68$, $df = 10$, $P = 0.84$; temple: $G^2 = 6.41$, $df = 6$, $P = 0.42$ and forest department: $G^2 = 6.96$, $df = 14$, $P = 0.94$), but it was statistically different among the systems within each year (2003: $G^2 = 63.17$, $df = 12$, $P = 0.0000$; 2004: $G^2 = 67.06$, $df = 10$, $P = 0.0000$ and 2005: $G^2 = 64.51$, $df = 12$, $P = 0.0000$). The age-sex composition data reveal that the captive elephant populations were female-biased (male: female ratio = 1: 2.4) across the three systems (Table 2). However, while females formed the major proportion (>90%) of the population with adult class having a significant share in private and temple systems, males (66%) outnumbered females (34%) across all the age classes in the forest department system.

Natality

Natality was the highest in the forest department system (n = 12) compared to private (n = 4) and temple (n = 2) systems

Table 1: Population size of elephants managed in the three captive systems in Tamil Nadu during 2003-2005

Management system	Population size					
	2003		2004		2005	
	Initial	Final	Initial	Final	Initial	Final
Private	40	43	43	44	44	42
Temple	42	44	44	43	43	41
Forest Department	50	48	48	48	48	50
Total	132	135	135	135	135	133

Initial and final refer to population size in the beginning (January) and end (December) of the year.

(Fig. 2). There were 4 births from the 14 sexually mature females in the age class of 15-60 years in forest department. This works out to 39 sexually mature female-elephant years over the last three years. Only one birth was observed in the private system (with 93 sexually mature female-elephant years) and none in the temples (with 81 sexually mature female-elephant years) during the study period. All the new additions to the temples were by purchase from other states. There was one transfer from a temple to the forest department. The only female in the private system that gave birth to a calf was purchased from a timber camp on the Andaman Islands - the gestation period indicating that the cow had conceived in the timber camp (which has bulls). There were no other records of captive birth in private and temple systems during the study period, and purchase was the only mode of addition in these systems. Three elephants were added to the private system and two to the temple management through purchases from other states, mostly from the north-eastern states of Assam and Arunachal Pradesh. The forest department system, which mostly manages its captive elephants in semi-natural condition at the timber camps of Anamalai and Mudumalai, had the highest addition by capture (n = 7), mostly 'orphans' from the wild. The birth of 4 calves during 2003-05 among the 39 sexually mature female-elephant years in the forest department works out to a fecundity rate of 0.10 calf/adult female/year. Long-term data (1996-2005) from the forest department showed that the fecundity rate had declined considerably (0.065 calf/adult female/year; Vanitha 2007) compared to an earlier estimate of 0.155 calf/adult female/year; Sukumar *et al*. 1997) for the period between 1969 and 1989.

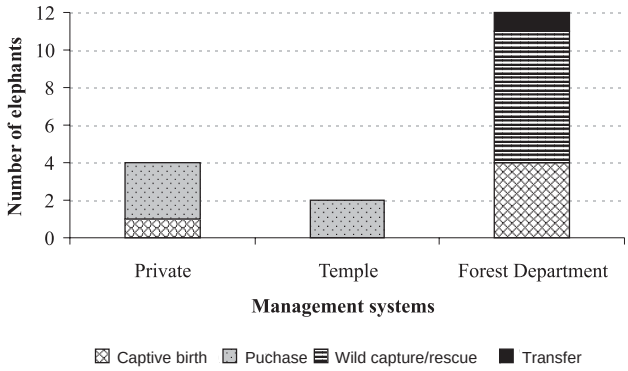

Fig. 2: Recruitment of elephants in the three management systems in Tamil Nadu between 2003 and 2005

Mortality

Totally, there were 149 individual elephants (44 in private, 43 in temples and 62 in forest department) during 2003-05. This works out to 419 elephant-years over the three-year period. Sixteen elephants died during 2003-05: 2 elephants each in the private and temple systems (all in

Table 2: Age structure, age-sex composition and sex ratio of the elephants managed in the three captive systems in Tamil Nadu during 2003-2005

Management Systems	Major age class	Mean age-sex composition (2003-2005)					
		Age structure (%)	Male (%)	SD*	Female (%)	SD*	Sex ratio M:F
Private	Adult	86.8	4.4	1.4	82.4	3.1	1: 20.9
	Subadult	8.8	0.9	1.6	7.9	2.7	1: 3
	Juvenile	3.5	3.5	1.4	0.0	-	1.3: 0
	Calf	0.9	0.9	-	0.0	-	0.3: 0
	Total	100	9.6	1.3	90.4	1.3	1: 9.5
Temple	Adult	68.0	4.7	0.2	63.3	2.3	1: 13.5
	Subadult	29.7	0.0	-	29.7	2.7	0: 12.7
	Juvenile	2.3	0.0	-	2.3	3.9	0: 1
	Calf	0.0	0.0	-	0.0	-	-
	Total	100	4.7	0.2	95.3	0.2	1: 20.7
Forest Department	Adult	75.4	50.0	2.1	25.3	2.2	1: 0.54
	Subadult	16.4	9.6	2.1	6.9	1.3	1: 0.7
	Juvenile	5.5	4.1	2.1	1.4	1.2	1: 0.3
	Calf	2.7	2.0	2.0	0.7	1.2	1: 0.3
	Total	100	65.8	1.1	34.2	1.1	1: 0.5

* SD = Standard Deviation: Calculated based on variation in % composition of each age-sex class during 2003-05.

2005) and 12 elephants in forest department system (4 each in 2003, 2004 and 2005), which works out to a mean annual mortality of 3.8% for the three systems. Of the 16 deaths, adult mortality accounted for 9 individuals (3%), followed by 4 for calves (4.4%), 2 for subadults (2.6%) and 1 juvenile (7.7%). Overall, males experienced a higher proportion of mortality (5.7%; 9/158 elephants) than female (2.8%; 7/246 elephants) segments. The mortality rate was much higher in the forest department system (7.6%) than private (1.5%) and temple (1.5%) management systems. Five (42%) out of 12 cases of deaths occurring in the forest department were of calves (4) and juveniles (1) indicating a higher mortality of younger elephants. There have been reports of increase in mortality (three cases during the past 3-4 years) among younger age classes due to *Herpes* virus in the forest department system, especially at the timber camps (Forest Department Register Records 1996-2005). A few elephants in the timber camps were suspected for tuberculosis (Forest Department records), a widespread disease among the global captive populations. A year-wise analysis of mortality across the three systems indicated that 50% of the 16 mortalities occurred during 2005 and the rest were spread equally during 2003 (25%) and 2004 (25%). Age-specific mortality, worked out incorporating additional data from the forest department for the period 1996-2002, showed a mean mortality rate of 3.9% based on 784 elephant-years (Table 3).

DISCUSSION

The population size of captive elephants in Tamil Nadu varied between 132 and 135 during the study period (2003-2005), which falls within the figures of the Project Elephant Report (MoEF 2004) between 127 and 145. The population size remained more or less the same in all the three captive systems, at 42-44 for private, 41-44 for temple and 48-50 for forest department. However, available long-term data over a 10-year period (1996-2005) from the forest department system revealed a significantly declining trend. The reasons for the decline (in spite of gradual increase in the number of orphaned calves rescued from the wild) over the ten-year period (1995-2005) compared to an earlier ten-year period (1985-1995) could be due to a reproductive decline (as shown by fecundity data) and increase in mortality. The absence of long-term data from temple and private systems did not permit the study to predict trends in these populations; but this is demographically not important, as there is no breeding in these systems.

Adults were the predominant age class in all the three systems of management comprising 87, 68 and 75% of the population in private, temple and forest department systems respectively. Private and temple captive populations consisted mostly of older animals due to absence of breeding and lack of recruitment of young elephants (especially from the state forest department due to the ban on elephant sale in recent years) and also due to the long lifespan of elephants. With no breeding, the elephant populations in the private and temple systems were female-biased (90%), as most of the facilities in these systems prefer to manage females due to the difficulty in maintaining bulls in captivity especially during *musth* (Krishnamurthy 1998; Sukumar 2003). In the forest department system, where breeding occurs, the overall sex ratio is skewed towards males with half the population being adult males. The system with low proportion of females in adult (25%, mostly above 40 years old) and subadult (7%) classes, does not promise self-sustainability in future. The reason for the aged population, and with male biased sex ratio

Table 3: Age-specific mortality of captive elephants managed in Tamil Nadu (pooled data from forest department records from 1996 to 2005, and of the private and temple elephants from 2003 to 2005)

Age class	Female		Male		Overall	
	Mortality rate (%)	*n**	Mortality rate (%)	*n**	Mortality rate (%)	*n**
0-1	28.6	7	33.3	9	31.3	16
1-2	0	4	12.5	8	8.3	12
2-5	15.4	13	4.3	23	8.3	36
5-10	4.4	45	10.0	30	6.7	75
10-20	1.8	57	1.2	86	1.4	143
20-40	3.4	119	3.4	118	3.4	237
40-60	1.8	164	1.3	79	1.6	243
60-80	14.3	21	0	1	13.6	22
Total	3.95	430	3.95	354	3.95	784

**n* refers to the number of individuals at risk (of death), expressed as the number of elephant-years over the age-class interval.

in the forest department system, could be due to selective disposal of young females in the past to Hindu temples, which mostly replenished their stock from the forest department system (Sukumar *et al*. 1997; Krishnamurthy 1998; Vanitha 2007). There is a female-biased population in the temple system and a female-biased elephant disposal (sale/gift) in the forest department system. Twenty of the 28 elephants sold between 1959 and 2004 to Hindu temples by the forest department were females and the majority were <10 years old (Vanitha 2007). The two peaks in disposal, first during 1971-72 (6 elephants) and second during 1995-96 (7 elephants), with the majority being females (8 elephants, <10 years old), resulted in the loss of prime reproductive age class (30-35 years) and younger adult class (15-20 years) that would have started breeding from 1995 and 2005 respectively in the forest department system. A remarkable decline in calving rate from 2.8 calves/year between 1971 and 1995 (69 calvings in 25 years) to just 0.9 calves/year between 1996 and 2005 (9 calvings in 10 years) (Vanitha 2007) also supports the hypothesis that the loss of prime reproductive age class is due to selective disposal of young female elephants in the past (1959-1996). Therefore, the fecundity dropped considerably from 0.155 (estimated for the period 1969-1989; Sukumar *et al*. 1997) to 0.065 during 1996-2005 (Vanitha 2007).

Being a polygynous species, elephant populations are naturally female biased. The elephants at the timber camps of the forest department are the only breeders in captivity in Tamil Nadu. With larger number of calves of the camp elephants sired by bulls from the wild, a female-biased population would not have been a problem for a sustainable growth rate in the captive population. Nevertheless, the prevalence of male-biased population in the forest department system and the non-breeding female-biased populations in the other two systems are not conducive for self-sustainability in the future.

The higher mortality observed in the forest department system (7.6%) compared to private (1.5%) and temple (1.5%) systems could be attributed, to some extent, to the higher mortality of calves and juveniles than the other age classes as reported earlier for captive (Sukumar *et al*. 1997; Mar 2001) and wild (Sukumar 2003) populations. The absence or poor representation of such age classes in the private and temple systems may be the reason for lower mortality rate in these two systems. Nevertheless, excluding juveniles and calves, the mortality rate still work out to 5% (7 deaths out of 141 elephant years between 2003 and 2005) in the forest department system. Similarly, a higher age-specific mortality has been reported in all the age classes of the forest department elephants over the past 10 years from 1996 to 2005 (Vanitha 2007) compared to the earlier report for the same population using a larger database from 1925 to 1989 (Sukumar *et al*. 1997). The higher mortality is alarming and threatens the long-term survival of the forest department captive elephants. The rise in calf mortality (31.3%) in the recent 10 years compared to the earlier report (19%) could possibly be due to more arrivals of 'orphans' from the wild in the recent years and their higher susceptibility to mortality. Exclusion of orphans reduced the recorded levels of calf mortality to 14.3%, which is less than 19% reported by Sukumar *et al.* (1997). The mean mortality estimated for the three captive systems together based on 784 elephant-years was 3.9%, including orphans and 3.5% excluding orphans. This is higher than that (1.9% estimated from detailed age-class mortality figures) reported earlier for the captive population (based on 5,560 elephant-years, Sukumar *et al*. 1997) and for the wild population (3%, Daniel *et al*. 1987) in southern India. Even though, the present estimate of mortality is from a smaller sample size (<50 elephant-years) in age class categories such as 0-1, 1-2, 2-5 and 60-80 years, the remaining age classes where the sample size is reasonable (>50 elephant-years) also experienced mortality higher than reported earlier (Sukumar *et al*. 1997). Therefore, the present mortality rate should be a cause for concern. Diseases such as herpes and tuberculosis (Forest Department records and personal communication from Forest Department veterinarians) could also be contributing to the increased mortality besides higher susceptibility of the aging population.

The Asian Elephant in spite of its long history of captivity has not been bred sustainably in captivity (Kurt and Mar 2003). There are hardly any records of captive elephant births or breeding in Indian temples (Krishnamurthy 1998) – temples consider reproduction in the temple premises to be inauspicious. Private owners do not encourage breeding as maintenance of pregnant/ lactating cows is expensive (Krishnamurthy 1998). However, there are a number of cases of privately owned elephants breeding in captivity in the north-eastern states of Assam and Arunachal Pradesh (Bist *et al*. 2002; Sarma 2004), since they are managed in close quarters to forested areas, wherein cows have contact with wild bulls. However, there has been a declining interest among these owners to manage elephants due to loss of demand in forestry operations owing to the ban on logging (Bist *et al*. 2002). Thus, the future scope of captive breeding among private systems in the north-eastern states could virtually stop. The intensively managed captive populations of Asian elephants in the western zoos (Wiese 2000; Brown *et al*. 2006) and the extensively managed large population in Myanmar (Leimgruber *et al*. 2008) are also in a reproductive decline. Thus, it is only the extensively managed captive elephant

populations of forest department in the timber camps of India and the Pinnewala Elephant Orphanage in Sri Lanka, where the captive elephant populations breed at a sustainable level (Sukumar *et al*. 1997; Kurt and Mar 2003), that remain the last hope against the extinction of the species in captivity.

To ameliorate the negative trends in population structure and sex ratio and to retain the long history of forest department timber camp elephants, inputs from the wild, especially females of young adult and subadult classes, should be given priority. Capturing and transferring of problem elephants, especially herds ranging in isolated habitats with no sign of breeding and or long-term survival, to forest department timber camps could be considered as a solution for restructuring the captive population, which will also reduce human-elephant conflict in the natural habitats. The captive populations in the private and temple systems may not survive in the long run given that the (i) aged population structures and susceptibility to higher mortality, (ii) absence of breeding, and (iii) lesser chances of additions from the state forest department due to the ban on the sale of elephants. To improve this situation, the private and temple systems need to consider common elephant housing that would bring in opportunities for captive breeding apart from socialization with conspecifics.

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