Gajah 32 (2010) 27-34

Group Size and Age-Sex Composition of Asian Elephant and Gaur in Mudumalai Tiger Reserve, Southern India

M. Ashokkumar[1]. R. Nagarajan[1] and Ajay A. Desai[2]

[1]Dept. of Zoology and Wildlife Biology, A.V.C. College, Mannampandal, Mayiladuthurai, India
[2]B.C. 84 Camp, Belgaum, Karnataka, India
[2]Agriculture Department, Missouri State University, Springfield, USA

Introduction

Asian elephant *Elephas maximus* and Indian gaur *Bos gaurus* are listed as endangered species (IUCN 2009). Both species are mega-herbivores, and live in forested habitats. There is little detailed information on population structure and social organization available for the elephant across much of its range and even lesser data on gaur. Therefore age-sex composition and even population status is uncertain for many populations. This is basic information required to formulate proper management and conservation strategies.

While disease is regarded to be the greatest threat to gaur populations (Arrendaran 2000), elephants are susceptible to the effects of habitat fragmentation and degradation (Daniel *et al.* 1987; Riddle *et al*. 2010). Both species are threatened by poaching, which affects gaur by reducing their numbers while selective poaching of males for ivory leads to a highly skewed sex ratio in elephants (Daniel *et al*. 1987). Studies on group composition would yield useful information on population characteristics and trends. A comparison of the population structure of elephant (highly skewed sex ratio) and gaur (less skewed sex ratio) could enable us to understand differences in their group structure and social organization.

The Asian elephant population is estimated to be 30,000 – 50,000 with approximately 60% of the population being present in India (Riddle *et al*. 2010). Mudumalai Tiger Reserve (hereafter termed 'MTR') forms a part of a contiguous forest tract of about 5520 km^2 known as the Nilgiri Biosphere Reserve (NBR). It is an important area in terms of elephant conservation since it provides habitat contiguity, allowing wide ranging elephants access to the Eastern Ghat forests (Desai 1991). This area also supports the highest gaur population in India (Choudhury 2002). Davidar (1997) has reported that the gaur population had recovered significantly since the outbreak of Rinderpest epidemic in the mid 1960s, which nearly wiped out the MTR population.

The present study provides baseline data on age-sex composition of gaur. This investigation compares the group size of elephants that has a highly social hierarchical pattern of grouping, long distance seasonal migrations, and long gestation and inter-calving periods with gaur, which is less cohesive and has a relatively smaller inter-calving interval. It also compares the population composition of elephants, which have been affected by poaching that has created a skewed sex ratio with a normally growing gaur population.

Study area

MTR is located in the Nilgiri District of Tamil Nadu (11º 32´ and 11º 42´ N and 76º 20´ and 76º 45´ E). It extends over an area of 321 km^2 and forms a part of the Nilgiri Biosphere Reserve (Fig. 1). The sanctuary is located in the Western Ghats, which is one of the 25 biodiversity hotspots of the world (Myers *et al*. 2000). The altitude varies from 485 m to 1226 m above MSL with a general elevation of about 900 m to 1000 m. There are densely populated human settlements on its south-eastern boundary and also some smaller settlements inside the reserve. The study area has three major forest types namely Tropical Moist Deciduous (here after termed MDF), Tropical Dry Deciduous (DDF) and Southern Tropical Thorn forest (TF) (Champion and Seth, 1968). Rainfall varies from 600 mm in the eastern part



Figure 1. Map of Mudumalai Tiger Reserve.

to 2000 mm in the western part of the sanctuary. Corresponding to the gradient in rainfall, the vegetation varies from tropical thorn forest in the east to tropical moist deciduous forest in the west. In between these two lies a dry deciduous forest.

The large herbivores include elephant and gaur, three species of cervids *viz*., chital (*Axis axis*), sambar deer (*Cervus unicolor*) and barking deer (*Muntiacus muntjak*) and two species of antelopes *i.e*. the four-horned antelope (*Tetracerus quadricornis*) and the blackbuck (*Antilope cervicapra*). Predators such as tiger (*Panthera tigiris*), leopard (*Panthera pardus*) and wild dog (*Cuon alpinus*) also can be seen. Elephant and gaur are threatened by habitat degradation from weed invasion, overgrazing, poaching and human disturbance.

Methods

Group size and age-sex composition was determined based on direct sighting of elephants and gaur in the field. Data was collected systematically across the entire study area to ensure that all strata were well sampled. The tiger reserve area was covered on foot every month from May 2003 to August 2004. Data on group size and composition was collected while monitoring line transects and on road strip counts, conducted to estimate ungulate densities (Ashokkumar *et al*. 2004). Forty-two line transects, 2 km in length and placed in a stratified random fashion were marked for all three vegetation types. The line transects were monitored on a seasonal basis for two seasons (wet and dry). Transects were walked twice during the dry season, and three times in the wet season, adding up to a total of 504 km distance walked. In addition, road-strip counts were conducted every month in different vegetation types. Each road transect was monitored during both morning and evening hours. A total distance of 829, 308 and 124.5 km was covered by foot in DDF, MDF and TF areas respectively. The time spent in each habitat was in proportion to its size.

Elephants were classified into various age-sex categories based on relative height and morphological characteristics (McKay 1973; Daniel *et al.* 1987; Sukumar 1989). Younger elephants (<15 years) were classified by comparing their height to the oldest adult female in the group. Elephants were placed in broad age groups such as calves (<1 year), juveniles (1-5 years), sub-adults (5-15 years) and adults (>15 years; Fig. 2). Gaur was classified into different age and sex classes such as calves (<6 months), juveniles (1), sub-adult (2.5) and adults (<3) based on height, body colour, size and shape of horn, criteria prescribed by Schaller (1967) and Krishnan (1972; Fig. 3).



Figure 2. Elephant herd feeding in saltlick of MTR.

The sighting data was pooled for both the years to derive frequency distributions of group size, sex ratios, mean group size (MGS), median group size (MDG), and typical group size (TGS) following Barrette (1991). TGS is an animal-centred measure of group size, reflecting the experience of an average individual in a group and is better, compared to MGS and MDG, which are observer-centred estimates of group size. Proportions of age and sex classes in the populations were derived from complete classified groups during the study period. Solitary males were not considered in mean group size calculations as males of both species spend part of their lives as solitary animals and only join female herds for breeding. Males do form social groups but such groups lack social cohesion.

One-way analysis of variance (ANOVA) was used to test the significance of differences in MGS values among seasons and habitats (thorn forest area was excluded as there were only very few sightings). Statistical analyses were performed by using Windows based statistical packages viz. Microsoft Excel and SPSS (Nie *et al*. 1975). Statistical inferences were made following Sokal and Rohlf (1995).

Results

Group size

During the study a total of 423 and 209 sightings of gaur and elephants respectively were recorded; of these bulls (male groups and solitary males) constitutes 26% (n=108) and 7% (n=14) of the sighting for gaur and elephant respectively. Of 195 elephant groups sighted, 99% of sightings were completely classified into different age-sex classes. Of 315 sightings of gaur groups only 46% (n=146) were completely classified into different age-sex classes.

The group size ranged from 1 to 26 individuals for elephants and 1 to 47 individuals for gaur. Both species showed positively skewed group size with smaller group sizes being more common than larger groups. In probability theory, positive skew indicates that the tail on the right side is longer than the left side and the bulk of values lie to the left of the mean. The group size frequency of sightings was higher for smaller group size than larger group sizes.

The mean group size of elephants was (4.32±3.2) while gaur had a mean group size of (9.76±7.6). The other group size measures such as median group size and the most frequented group size (mode) also showed that elephants had smaller



Figure 3. Herd of gaur feeding in tropical dry deciduous forest of MTR..

Table 1. Mean group size (±SD) of gaur and elephant in different habitats and seasons at MTR.

Habitat	Species	N	Dry	I wet	II wet	Overall
Dry deciduous forest	elephant	128	3.5±1.6	3.9±2.6	5.9±3.9	4.1±2.7
	gaur	214	7.9±5.4	10.4±8.4	10.9±8.7	10.1±8.1
Moist deciduous forest	elephant	61	4.8±3.4	4.3±2.7	6.0±7.5	4.8±4.0
	gaur	79	9.3±6.6	8.2±7.3	9.9±7.4	9.3±6.9
Overall	elephant	195	4.1±2.7	4.0±2.7	5.6±5.0	4.3±3.2
	gaur	315	8.7±6.2	10.1±8.1	10.2±7.9	9.8±7.6

group sizes than gaur. The median group size for elephants was 3 and the mode was 2, while for the same measures it was 8 and 5 for gaur. TGS value was higher than MGS for both species (elephant 6.4±3.3; gaur 13.54±3.69).

Grouping characteristics

More solitary individuals were sighted in elephants (11%) than in gaur (2%). Smaller groups were more frequently seen than larger groups (Fig. 4). The group sizes from two to six animals, collectively constitutes 68% and 40% of all sightings for gaur and elephants respectively.

Mean group size did not vary significantly among habitats and seasons for elephant ($F=0.06$; $p>0.05$) and gaur ($F=0.92$; $p>0.05$). Elephants had lower group size in the dry season and the first wet season, the highest mean group size being recorded in the second wet season in both DDF (5.9±3.9) and MDF (6.0±7.5). Gaur group size was lower in dry season (8.7±6.2) in the dry deciduous forests than both the wet seasons (Table 1).

Age-sex composition

The proportion of adults, sub-adults, juveniles and calves in the population were calculated from sightings of 859 and 993 individuals in 209 and 143 groups of elephant and gaur respectively. The bulk of the population was composed of adults, 48% in elephant and 60% in gaur. The other age classes such as sub-adults, juveniles and calves constituted 17%, 14% and 21% respectively in elephants and 16%, 15% and 9% in gaur.

The age-sex composition of the elephant and gaur in MTR is given in Figure 5. The proportion of adult males was higher in gaur (11%) than elephant (2.3%). The proportion of sub-adult and juvenile age-sex classes between elephant and gaur did not vary. The proportion of calves was more in elephants than in gaur.

Sex ratio

The sex ratio appears to vary significantly from the expected ratio of 1:1 in sub-adult and adult age classes of both species (Table 2). In adults a highly skewed sex ratio (1:21; ^{2}=361.8; df =1; p<0.00) was recorded for elephants and (1:5; ^{2}=280; df =1; p<0.00) for gaur.

Discussion

Group size

The social organization of elephant and gaur are based around the family unit or the herd consisting of one or more related adult females and their offspring (Daniel *et al*. 1987; Sukumar 1989; Schaller 1967). In elephants the most cohesive unit is the family unit and it represents a tightly knit unit both socially and structurally (Moss 1988). At puberty, young females remain with the natal group, while the males leave the herd and they tend to form temporary groups with weak social bonds (Laws *et al*. 1975). Little

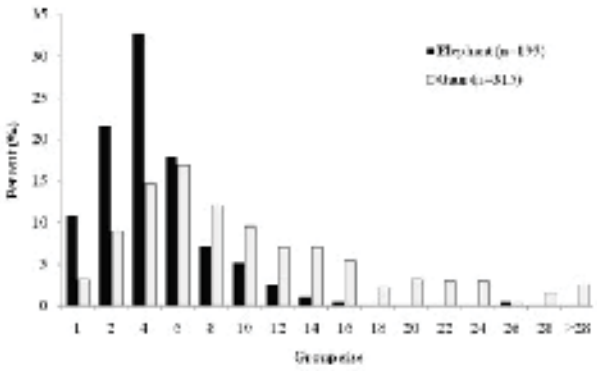


Figure 4. Frequency distribution of elephant and gaur group size in MTR from May 2003 to August 2004.

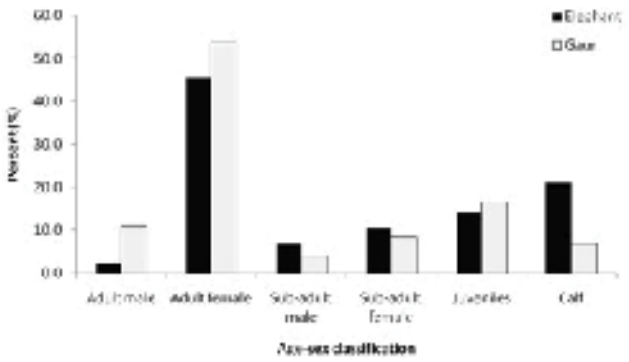


Figure 5. Proportion of different age-sex classes of elephant (n=209) and gaur (n=146) in MTR.

however is known about gaur social structure or about male dispersals.

Of the total number of sightings, the solitary bulls constituted 7% and 21% in elephant and gaur respectively. Adult males associated only transiently with the family units. Bulls remain together only a day or two. Bull groups were not recorded for elephants whereas 5% of sightings constituted bull groups for gaur. An earlier study in this area (Daniel, *et al.* 1987) had reported bull groups in elephants. However during that period the adult male to female ratios were far less skewed (1:4.7) than the current ratio of 1:21. This indicates that the adult male population has declined significantly from the mid 1980's and this could be the reason for non-sighting of bull groups during the present study; there are too few males to form groups. This decline in adult male population in elephants is largely due to poaching of males for their tusks (Daniel *et al*. 2008).

Association of adult males is considered an anti-predatory strategy in African buffalo (Prins 1996) and it is conjectured to be related to the establishment of dominance ranks among young adult male elephants (Vidya & Sukumar 2005). It is possible that male gaur also show antipredatory strategy. However the formation of bull groups in gaur seemed to be opportunistic when two bull gaurs met and they remained together only for a few hours to a few days. The differential foraging of males (Sinclair 1977) and male mating strategy (Clutton-Brock 1982) may influence the formation of male groups and further studies on these aspects are needed in both species we studied. More elephants (11%) were seen in the solitary group size class (females) than gaur (3%). Most sightings of solitary females were of older adult females. It is possible that a lack of dependent calves or close siblings or inability to move fast along with the herd resulted in them lagging behind and remaining solitary.

Group formation and sizes can be influenced by foraging behaviour (Jarman 1974) and predation (Geist 1998). Both the range of group size and mean group size was lower for elephant (4.32) than for gaur (9.76). Apparently, gaurs tend to forage and live in larger groups than elephants. As individual elephants have greater resource requirements, there might be a need for smaller groups to avoid competition within the clan/kin group. So breaking up into smaller groups during foraging would be a good strategy to avoid competition, especially when food resources are highly patchy or foraging conditions are not optimal.

Predation pressure increases the probability of formation of larger group as it reduces individual risk and increases vigilance. However, predation is not a serious threat to elephants although elephant calves are occasionally killed by tigers. Large carnivore diet profile studies suggest that gaur in the diet composition of tiger ranges from 1.87 to 30.4% (17.4%- Karanth & Sunquist 1995 in Nagarahole; 1.87%- Swaminathan *et al*. 2002 in Mudumalai; 30.4%- Kumaraguru 2006 in Indira Gandhi Wildlife Sanctuary; 23.9%- Andheria *et al*. 2007 in Bandipur Tiger Reserve). Schaller (1967) reported that 50% of calf mortality was due to predation. Carnivore studies in Nagarahole based on scat and kills has shown that among different age-sex classes of gaur preyed up on by tiger, young ones (calves and juveniles) constituted a greater proportion

Table 2. Age-sex ratio of elephant and gaur in MTR.

Age-sex classes	Elephant (n=859)	Gaur (n=993)
Adult (male : female)	1:21 (χ^2=361.8; df=1; p<0.00)	1:5 (χ^2=280; df=1; p<0.00)
Sub-adult (male : female)	1:2.5 (χ^2=28.96; df=1; p<0.00)	1:2 (χ^2=15.9; df=1; p<0.00)

(58.8%), than adult females (22.6%) and adult males (14.6%). Thus tigers selectively preyed upon young gaur and the variation in population age-structure could influence prey selection.

When the population age structure of gaur in Nagarahole (Karnath & Sunquist, 1995) and Mudumalai (Ashokkumar *et al.* 2004) were compared, there was no difference in the proportion of different age-sex classes. Thus the variation in the proportion of young and adult males could be due to predation. Thus for gaur, predation remain a serious threat and it could have a far more significant influence on group size than it does in elephants. Additionally individual resource needs of gaur are far less than those of elephants possibly allowing for larger group sizes in similar habitats.

Mean group size of elephant and gaur did not vary significantly across habitats and seasons. Social organization of a species has been considered as one factor governing seasonal variation in group sizes, it can cause the group sizes to vary in some ungulates and not in others (Rodgers, 1977). The group size in certain species exhibit open membership of social structure (e.g. chital, swamp deer) and may show temporal variation not only on a seasonal basis but also during different times of the day (Sharatchandra & Gadgil 1975; Barrette 1991). However, the group size of gaur and elephant appears to be based on strong social bonds, with influences from factors like avoiding competition for food and predation risk. The fact that elephant group sizes were highest in the second wet season when the entire habitat is at its richest in terms of food resources indicates that there is some seasonal impact and that competition avoidance could be the cause for smaller groups sizes in this species. Similarly gaur in the dry deciduous forest showed the smallest group sizes relative to the wet seasons, again indicating that competition was at play in determining group size and that there were seasonal influences.

The comparison of age-sex composition between elephant and gaur did not show any significant variation in sub-adult and juvenile age classes. However the adult age class shows that 60% of the gaur population is in the adult age class whereas only 48% of elephants are in the adult age class. This is possibly due the severe poaching that has eliminated a significant proportion of males from the population. The present adult male to female sex ratio of 1:21 is a strong indicator of that. A normal male to female ratio for elephants would be 1:1.87 and 1:1.85 as reported for Rajaji National Park (Williams 2007) and Ruhuna National Park, Sri Lanka (Katugaha *et al*. 1999) respectively. If a normal 1:2 male to female ratio existed in the study area then the proportion of adults would be nearly 57% or more, which is close to that seen in gaur. Thus poaching has significantly affected the age structure of the elephant population.

In the 1960s the gaur population was affected by Rinderpest and foot and mouth disease (Davidar 1997). In the total population of Mudumalai and Bandipur only a few hundred survived. We did not have any data in the mid 90s to show how the population recovered. However the current population estimate is 7/km2 (Ashokkumar 2007). In 1990 the outbreak of Rinderpest killed about 3000 gaurs in Bhadra Sanctuary located in Karnataka state of Southern India (Raju & Heggde 1995). All age-sex classes are vulnerable to epidemics and there is no specific age-sex classes affected due to epidemics. Poaching is mainly on adult gaur for meat, one or two individuals being poached every year. As a management measure the Forest Department established anti-poaching camps to control poaching. We do not know the impact of poaching on group size of gaur.

In conclusion we can say that gaur have larger group sizes than elephants. The age-sex structure of the elephant is strongly influenced by selective poaching of males where many of the older males have been killed. At present gaur have a larger proportion of their population in the adult age class than elephants. However, if a normal adult male to female sex ratio is assumed then the percentage of elephants in the adult age class would be similar to that of gaur. It is important to establish and systematically monitor population age-sex structure to detect impacts of poaching and also to monitor the long term well being of these populations.

Acknowledgement

We thank the Tamil Nadu Forest Department for permission to conduct research within Mudumalai Tiger Reserve. We thank the Hill Area Development Program (HADP) for funding the study. We thank Bombay Natural History Society, Nilgiri Wildlife and Environment Association and A.V.C. College Department of Zoology and Wildlife Biology for their support. We thank Mr. Swaminathan and Dr. N. Kalaivanan for their support and guidelines. We thank Dr. T.N.C. Vidya and our lab colleagues in JNCASR, Jakkur, Bangalore for their guidance. We thank our field assistants Maran and Bomman for their help in the field.

References

Andheria, A.P, Karanth, K.U & Kumar, N.S. (2007) Diet and prey profiles of three sympatric large carnivores in Bandipur Tiger Reserve India. *Journal of Zoology* **273:** 169-175.

Annon (2009) *Asian Wild Cattle Specialist Group Action Plan*. IUCN/SSC.

Arrendran, G. (2000) *Ecology of Gaur (Bos gaurus) in Pench Tiger Reserve, Madhya Pradesh*. Ph.D. thesis, Wildlife Institute of India, Dehra Dun, India.

Ashokkumar, M. (2007) *Tamilnadu Forest Department Census Report 2007*. Report submitted to Tamilnadu Forest Department, Mount Stuart Hill, Ootacamund.

Ashokkumar, M., Swaminathan, S., Desai, A.A. & Daniel, J.C. (2004) *A Study on Ecology and Conservation of Gaur (Bos frontalis) in Mudumalai Wildlife Sanctuary and National Park*. Report submitted to Tamilnadu Forest Department, Ottacamund.

Barrette, C. (1991) The size of axis deer fluid groups in Wilpattu National Park, Sri Lanka. *Mammalia* **55:** 207-220.

Champion, H.G. & Seth, S.K. (1968) *Revised Survey of Forest Types in India*. Manager of Publication, New Delhi.

Choudhury, A. (2002) Distribution and conservation of gaur (*Bos gaurus*) in the Indian subcontient. *Mammal Review* **32:** 199-226.

Clutton-Brock, T.H., Guinness, F.E. & Albon, D. (1982) *Red Deer: Behaviour and Ecology of Two Sexes*. University of Chicago Press, Chicago, IL.

Daniel, J.C., Desai, A.A., Sivaganesan, N. & Rameshkumar, S. (1987) *The Study of Some Endangered Species of Wildlife and Their Habitats - The Asian Elephant*. Bombay Natural History Society, Bombay.

Daniel, J.C., Desai, A.A., Mohenraj, N., Ashokkumar, M. & Sakthivel, C. (2008) *Evaluating Population Enumeration Methods and Human Elephant Conflict Mitigation Methods in Mudumalai Tiger Reserve, Tamil Nadu, India*. Bombay Natural History Society, Bombay.

Davidar, E.R.C. (1997) *Cheetal Walk-Living in the Wilderness*. Oxford University Press, Chennai.

Desai, A.A. (1991) The home range of elephants and its implications for management of the Mudumalai Wildlife Sanctuary, Tamil Nadu. *Journal of Bombay Natural History Society* **88:** 145-156.

Geist, V. (1998) *Deer of the World: Their Evolution, Behaviour and Ecology*. Stackpole Books, Mechanicsburg, Pennsylvania.

Jarman, P. J. (1974) The social organization of antelope in relation to their ecology. *Behaviour*. **48:** 215-220.

Karanth, K.U. & Sunquist, M.E. (1995) Prey selection by tiger, leopard and dhole in tropical forest. *Journal of Animal Ecology* **64:** 439-450.

Katugaha, H.I.E., de Silva, M. & Santiapillai, C. (1999) A long-term study on the dynamics of the elephant (*Elephas maximus*) in Ruhuna National Park, Sri Lanka. *Biological Conservation* **89:** 51-59.

Krishnan, M. (1972) An ecological survey of the large mammals of Peninsular India, *Journal of Bombay Natural History Society* **69:** 297-315.

Kumaraguru, A. (2006) *Studies on the Influence of Vegetation Types and Prey Composition on the Feeding Ecology of Tiger, Leopard and Wild Dog in Indira Gandhi Wildlife Sanctuary and National Park, Tamil Nadu, India*. Ph.D. thesis, Bharathidasan University, Trichirapalli.

Laws, R.M., Parker, I.S.C. & Johnstone, R.C.B. (1975) *Elephants and Their Habitats: The Ecology of Elephants in North Bunny, Uganda*. Oxford University Press, London.

McKay, G.M. (1973) Behaviour and ecology of the Asiatic elephant in Southeastern Ceylon, *Smithsonian Contribution to Zoology* **125**, Smithsonian Institution, Washington, DC.

Moss, C. (1988) *Elephant Memories*. William Morrow & Co., New York.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., Fonseca, G.A.B. & Kent, J. (2000) Biodiversity hotspots for conservation priorities. *Nature* **403:** 853-858.

Nie, N.H., Hull, C.H., Jenkins, J.G., Steinbrenner, K. & Bent, D.H. (1975) *SPSS: Statistical Package for the Social Sciences. 2nd Edition*. McGraw-Hill, New York.

Prins, H.H.T. (1996) *Ecology and Behaviour of African Buffalo: Social Inequality and Decision Making*. Chapman and Hall, London.

Raju, R. & Heggde, S.N. (1995) Bhadra wildlife sanctuary – A fragile ecosystem. *Indian Forester* **121:** 938-948.

Riddle, H.S., Schulte, B.A., Desai, A.A. & Meer, L.V.D. (2010) Elephants – a conservation overview. *Journal of Threatened Taxa* **2:** 653-661.

Rodgers, W.A. (1977) Seasonal change in group size amongst five wild herbivore species. *East African Wildlife Journal* **15:** 175-190.

Schaller, G.B. (1967) *The Deer and the Tiger. A Study of Wildlife in India*. University of Chicago Press, Chicago.

Sharatchandra, H.C. & Gadgil, M. (1975) A year of Bandipur. *Journal of Bombay Natural History Society* **72:** 625-647.

Sinclair, A.R.E. (1977) *The African Buffalo: Study of Resource Limitation on Population*. Chicago University Press, Chicago, Illinois.

Sokal, R.R. & Rohlf, F.J. (1995) *Biometry the Principles and Practice of Statistics in Biological Research. 2nd Edition*. W. H. Freeman and Co., New York.

Sukumar, R. (1989) *The Asian Elephant: Ecology and Management*. Cambridge University Press, Cambridge, UK.

Swaminathan, S., Desai, A.A. & Daniel, J.C. (2002) *Large Carnivores in Mudumalai Wildlife Sanctuary and National Park*. Report submitted to Bombay Natural History Society, Bombay.

Vidya, T.N.C & Sukumar, R. (2005) Social and reproductive behaviour in elephants. *Current Science* **89:** 1200-1207.

Williams, C. Johnsingh, A.J.T. & Krausman, P.R. (2007) Population estimation and demorgraphy of the Rajaji National Park elephants, North-West India, *Journal of Bombay Natural History Society* **104:** 145-152.

Corresponding author's email: hyeashok@gmail.com