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Original Investigation

Group size, sex and age composition of chital (*Axis axis*) and sambar (*Rusa unicolor*) in a deciduous habitat of Western Ghats

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A B S T R A C T

Knowledge of the social structure of a population is important for a range of fundamental and applied purposes. Group characteristics and population structure of chital (*Axis axis*) and sambar (*Rusa unicolor*) were studied in a deciduous habitat of Mudumalai Tiger Reserve, Western Ghats, India, during 2008–2009. Vehicle transects were monitored monthly to gather information on group–size and age–sex composition of chital and sambar. The average mean group size and crowding for chital and sambar was 13.1 ± 0.5 ($n = 1020$), 3.6 ± 0.2 ($n = 377$) and 33.3, 11.0 respectively. The average adult male:adult female:fawn ratio was 63.4:100:22.3 ($n = 9391$) and 43.9:100:23.7 ($n = 1023$) in chital and sambar respectively. The mean group size of chital and sambar varied significantly between seasons (Kruskal–Wallis test, $p = <0.001$). Peak fawning season was observed from February to May for chital and May to August for sambar. Group's sex–age composition influenced group formation in both species between seasons at different level. Adult male and fawn were the important predicting variables of change in group size. Skewed female sex ratio was probably due to selective male predation by large predators. Although fawning occurred throughout the year, both species showed seasonality in fawning. The above mentioned patterns differed between species depending upon their ecological adaptation in foraging strategies and habitat preference.

Introduction

Some mammals often live in groups, the size of which constitute the simplest and most basic elements of their social organization (Eisenberg, 1966; Crook et al., 1976). Group size varies widely within and between species (Altman, 1974; Geist, 1974; Jarman, 1974; Clutton-Brock and Harvey, 1977; Rodman, 1981). Differences between species in the use of habitat, temporal and spatial resources are known to promote species to have different ecological adaptation. Ungulate groups tend to be larger in open habitats than dense vegetation thereby hindering the formation of larger groups and this is assumed to be a biological adaptive response (Lagory, 1986; Barrette, 1991). Most of the Cervids are gregarious animals and groups are centered around adult females. A family consists of different age categories that exert an important influence on formation and shaping up of different groups (Krasiński, 1978). Ecological variables correlated with group size have been documented in a variety of species (Altman, 1974; Jarman, 1974), but the underlying proximate and ultimate causes of group size variation are not clear (Pulliam and Caraco, 1984). This variation needs to be explained, if it is to be considered as a part of the species adaptation to its environment (Southwell, 1984). However some species are casual about group formation (Cohen, 1971; Lott and Mania, 1983). It does not necessarily mean that group size has no biological significance in such cases. Indeed, in such species most group members are not cemented to each other by social bonds but are free to leave or join a given group. The size of their groups is more likely to be a sensitive reflection of the immediate effect of such important ecological parameters as habitat structure, spatio-temporal distribution of food and predation pressure on group formation (Barrette, 1991; Raman, 1997). Current hypotheses about grouping led to the reasonable expectation that individual fitness varies with group size (Rodman, 1981). The group vigilance level increases with group size (Sartaj et al., 2010). The vigilance level provides safety from predators. This kind of behaviour is expected in an open environment.

The sex ratio is one of the important demographic parameters as in some species adult males have significantly altered the sex ratio in their populations due to poaching (Clutton-Brock and Albon, 1989). De and Spillet (1966) suggested that more or less 1:1 sex ratio may usually be found in an area free from selective shooting or predation. The skewed female ratio is probably due to the solitary

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male dispersing from mixed group experience greater mortality and is more vulnerable to predation by large carnivores (Karanth and Sunquist, 1995; Ramesh et al., 2009; Ramesh 2010), and in most ungulate populations the intensity of intra-male competition results in greater male mortality (Berger and Gompper, 1999). Male ungulates are selected for rapid growth rates and driven to risky behaviour by high testosterone levels (e.g., wider movements into less well known areas, reduction of alertness during pursuit of females, fighting between rivals, etc.) which results in greater mortality (McCullough, 1999).

Age structure of a population is useful for understanding dynamics of population growth and estimating life history parameters (Spillet, 1966; Stearns, 1992). Age structure of a population expressed as the distribution of the number of individuals in each age group reflects fecundity, mortality, reproductive status and population increase. It is an important measure of demographical change over time (Caughley, 1977). A high percentage of young as compared to adults generally indicates a fast growing or thriving population in contrast to a relatively smaller percentage of young that usually indicates a sluggish rate of population increase. A population with more females than males generally has a higher reproductive potential than the one that is predominantly composed of males (De and Spillet, 1966).

The chital (*Axis axis*) is the third largest deer in the Indian subcontinent and has been well studied in Corbett (De and Spillet, 1966), Kanha (Schaller, 1967), Bandipur (Johnsingh, 1983), Nagarahole (Karanth and Sunquist, 1992), Sariska (Sankar, 1994), Gir (Khan et al., 1995), Guindy (Raman, 1997, 1998), Pench (Sartaj et al., 2010), Chitwan (Mishra, 1982), Karnali-Bardia (Dinerstein, 1980) in Nepal, and Wilpattu, in Sri Lanka (Eisenberg and Lockhart, 1972). Sambar (*Rusa unicolor*), the largest deer in the Indian subcontinent is widely distributed. Its population biology and habitat requirements were studied in Kanha (Schaller, 1967), Bandipur (Johnsingh, 1983), Nagarahole (Karanth and Sunquist, 1992), Sariska (Sankar, 1994), Gir (Berwick, 1974; Khan et al., 1995), Mudumalai (Varman and Sukumar, 1993), Karnali-Bardia, Nepal (Dinerstein, 1980). Although chital and sambar are listed as Least Concern and Vulnerable respectively by IUCN (Duckworth et al., 2008; Timmins et al., 2008), their population is decreasing due to ever growing human population which in turn results in rapid loss and fragmentation of forests, diseases and illegal hunting in the Indian subcontinent (Sankar and Acharya, 2004). Moreover very little is known about their biology in tropical forests. The present study was undertaken to understand grouping patterns and population structure of chital and sambar which would be useful in understanding their life history parameters.

Study area

Mudumalai Tiger Reserve (11° 32′–11° 43′ N; 76° 22′–76° 45′ E) is situated at the tri-junction of Tamil Nadu, Karnataka and Kerala states, at an elevation that varies from 960 to 1266 m. This 321 km^2 Tiger Reserve includes 100 km^2 of National park bounded with Wayanad wildlife Sanctuary on the west, Bandipur Tiger Reserve in the north and Nilgiri North Forest Division in the south. According to Champion and Seth (1968), the vegetation types in Mudumalai are classified into Southern Tropical Dry Thorn Forest, Southern Tropical Dry Deciduous Forest, Southern Tropical Moist Deciduous Forest, Southern Tropical Semi Evergreen forest, Moist Bamboo Brakes and Riparian Forest. The present study was carried out in the deciduous habitat of Mudumalai Tiger Reserve covering 107 km^2 (Fig. 1). The tiger reserve has a long wet season and a short dry season. It receives rainfall from south–west and north–east monsoons. The south–west monsoon starts by May and ends by August while the north–east monsoon starts by September and ends by December. Based on the climate of the area, there are three distinct seasons recognized; dry season (January–April), first wet season (May–August) and second wet season (September–December) (Varman and Sukumar, 1993). The rainfall has a marked east–west gradient, with the eastern areas getting the least amount of the heaviest rains (1000–2000 mm). The temperature ranges from 8 °C in December to 35 ° C in April. Sambar and chital are the major prey species of large carnivores in the study area and their population estimate (per sq. km) was found to be 25.4 ± 6.7 and 4.8 ± 1.1 respectively (Ramesh, 2010). In addition to chital and sambar, ungulate species found in Mudumalai are muntjac (*Muntiacus muntjak*), wild pig (*Sus scrofa*), Indian chevrotain (*Tragulus meminna*), gaur (*Bos gaurus*), four-horned antelope (*Tertracerus quadricornis*) and black-buck (*Antelope cervicapra*). Mudumalai is characterized by the presence of several swamps in the interspersed patches of deciduous and semi-evergreen habitat provide suitable feeding areas for wild ungulates and wallowing grounds for sambar.

Methods

Data on group size, sex ratio and age structure of chital and sambar was collected between February 2008 and December 2009 (Dry season - January to April; First wet season - May to August and second wet season - October to December). Five vehicle based transect routes ranging from 15 to 23 km were monitored within deciduous habitat of Mudumalai tiger Reserve to record chital and sambar sightings. The total length of 93.5 km was monitored twice in a month during early morning and late afternoon which resulted in a total effort of 3740 km. On each sighting of chital and sambar along the vehicle transects, the following information was recorded; group size, sex and age classes. The most frequently used group size measure is fruitful when the distribution of group size approaches a normal distribution (Reiczigel et al., 2007). Exclusion of highly skewed data such as solitary groups and outliers of large groups would lead to loss of information with parallel changes in crowding (Reiczigel et al., 2007). Reiczigel et al. (2007) used a group size measure called 'crowding' which is the group size in which an individual lives or is referred to group size experienced by any individuals. Earlier studies did not take crowding into account within their data set on these species. Here we calculated 'crowding' phenomenon and mean group size including solitary animals using program Flocker 1.0 (Reiczigel and Rozsa, 2006) following the crowding measure used by Reiczigel et al. (2007). The sex and fawn ratio was calculated by the number of adult male and fawn to adult female respectively. Age classification of chital and sambar was done based on earlier studies (Schaller, 1967; Johnsingh, 1983; Sankar, 1994). Age class of female chital was categorised as adult (≥30 kg) while that of sambar was ≥70 kg. Height of individuals above the mother's belly was categorised as sub adult female chital (<30 kg) and sambar (<70 kg). The male chital and sambar deer were classified into; adult (>1 feet antlers) and sub-adult (spike and <1 feet antlers). Fawns were considered if the size was equal or less to the height of the mother's belly. Vehicle transect sighting data was pooled for two years together and analyzed season wise to estimate frequency distribution of group size, sex ratio, mean group size, crowding and age structure. Mann Whitney test between two seasons and Kruskal–Wallis test for all three seasons (Fowler et al., 1998) were used to determine significant differences observed in group size of chital and sambar between seasons. Group size is a sum of the number of individuals in the different age classes. However, in a simple manner the group size need not respond to the changes in the number of individuals in the different age group classes because of the complex association possibly occur within them. The effect of age–sex categories on group size was studied through multiple linear regression analysis taking monthly overall mean group size as dependent variable and monthly mean group

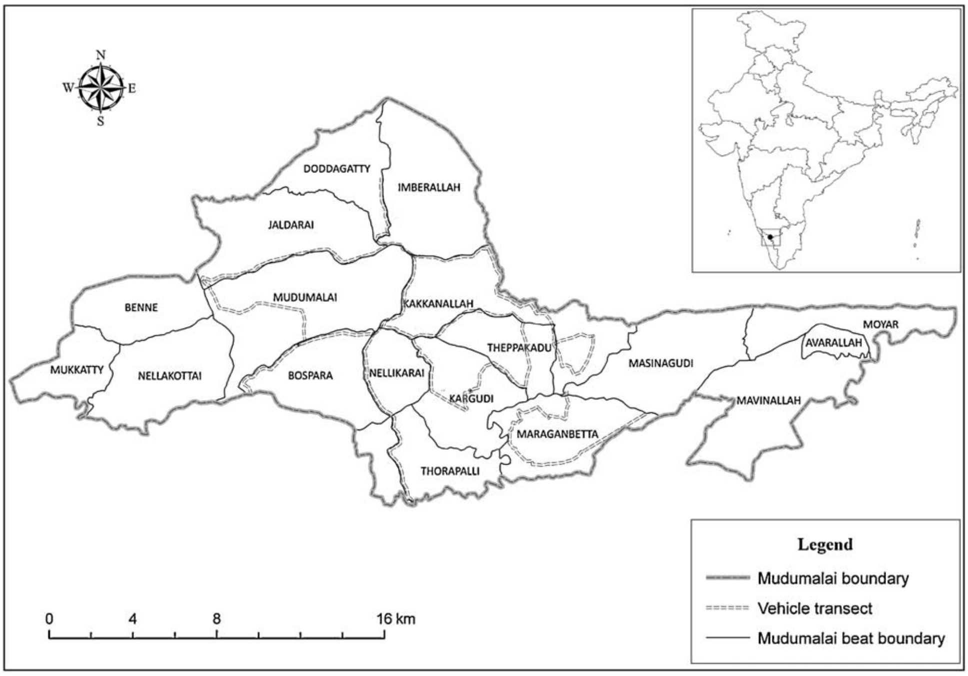

Fig. 1. Location of intensive study area and vehicle transects in Mudumalai Tiger Reserve, Western Ghats.

size of each age–sex category as independent variable. We used General Linear Model (GLM) to compare changes in each age class group size between seasons. Tamhane's T2 post hoc test was computed using a Least Significant Difference (LSD) procedure with the assumption of equal variances not assumed. Both analysis were done using SPSS 16.0/PC + software (SPSS, 2007).

Results

Chital group size and composition

Formation of large groups of chital (>35 individuals) occurred throughout the year. The seasonal group size varied from 1 to 131 individuals with a mean (±SE) group size observed to be 13.1 ± 0.5 (n = 1020) and overall mean crowding was 33.3 (Table 1). Forty percent of individuals were observed under group size <5. During seasonal analysis, mean group size significantly varied between first wet and dry season (Mann Whitney U = 5.6, df = 1, n = 452, 285, p = 0.002) and second wet and dry season (Mann Whitney U = 3.6, df = 1, n = 283, 285, p = 0.038) while first wet season did not vary significantly from the second wet season (Mann Whitney U = 6.1, df = 1, n = 452, 283, p = 0.41). However the overall mean group size showed significant variation between seasons (Kruskal–Wallis X^2 = 9.2, df = 2, p = 0.009). In accordance with mean group size, crowding changed season wise. The analysis of multiple regressions between group size and different age–sex categories indicated that a substantial part of variation in group size was accountable by the adult male in the group, followed by fawn and sub adult male (Table 2). Tamhane's T2 post hoc test showed major seasonal change in mean group size (p = < 0.05) of all the age classes of chital between dry and first wet seasons (Table 3). Sub adult male (p = 0.000) and female (p = 0.001) showed significant variability in group size between dry and second wet season while adult female (p = 0.075) and fawn (p = 0.084) had marginal significance (Table 3). The group size of fawn had major variability between first wet and second wet seasons (p = 0.000) whereas marginal significance was observed in sub adult male group size (p = 0.063).

Chital sex ratio and age composition

Chital new born fawns were seen throughout the year with a peak fawning period observed from February to April in 2008 and March to May in 2009. The average adult male:adult female:fawn ratio in chital was 63.4:100:22.3 (N = 9391) combined data (Table 4). Average male and female ratio did not vary considerably between seasons (Table 5). Average fawn ratio in the second wet season was different from other two seasons.

Sambar group size and composition

In Mudumalai, seasonal group size of sambar varied from 1 to 45 individuals with a mean (±SE) group size of 3.6 ± 0.2 (N = 377) (Table 1). More than 75% of sambar groups were observed with group size ranging from 1 to 5 individuals. The largest aggregation of 36–45 individuals was observed in swampy grasslands during the month of July in the first wet season. On several occasions (N = 14) > 15 individuals were seen between April and October around swampy grasslands. When the data was analyzed on a seasonal basis, the mean group size significantly varied between first wet season and dry season (Mann Whitney U = 7347, df = 1, n = 168, 117, p = 0.000) and between first and second wet season (Mann Whitney U = 4030, df = 1, n = 117, 92, p = 0.001). Mean group size in the dry season was similar to the second wet season (Mann Whitney U = 4030, df = 1, n = 168, 92, p = 0.934). Overall mean group size showed significant variation between seasons (Kruskal–Wallis X^2 = 16.5, df = 2, p = 0.000). In multiple regression models adult female and fawn were the main predictor variables of group size, followed by sub adult female and sub adult male while adult male was negatively related to mean group size (Table 2). The substantial variability in mean group size of sambar fawn occurred between dry and first wet seasons, and first and second wet seasons (p = 0.001, p = 0.000 respectively) while there was no significant variability observed between dry and second wet seasons (p = 0.541) (Table 3). Sub adult female showed significant variability in group size between dry and first wet seasons (p = 0.001) whereas adult female had marginal significance (p = 0.055) while there was

Table 1
Seasonal grouping patterns of chital and sambar in Mudumalai Tiger Reserve, Western Ghats, India (January 2008–December 2009).

Species	Season	NG	NA	Lgo	Mc	Mdgs	Mgs	SE	Group Size in %								
									1	2–5	6–10	11–15	16–20	21–25	26–30	31–35	>35
Chital	Dry	285	2875	70	22.4	6.0	10.0	0.6	8.8	34.1	23.2	10.9	5.8	5.7	5.1	2.1	4.3
Chital	I Wet	452	6704	131	37.1	8.0	14.8	0.8	8.0	33.8	16.9	13.2	5.5	7.9	4.3	0.8	9.6
Chital	II Wet	283	3787	109	34.7	7.0	13.3	1.0	7.4	33.0	23.4	10.8	7.6	3.5	5.0	1.7	7.6
	CD	1020	13,366	131	33.3	7.0	13.1	0.5	8.0	33.7	21.2	11.6	6.3	5.7	4.8	1.5	7.1
Sambar	Dry	168	498	27	8.7	2.0	3.0	0.3	42.9	37.7	13.8	4.1	1.5*				
Sambar	I Wet	117	566	45	13.0	2.0	4.8	0.5	26.5	50.0	11.9	8.5	3.2*				
Sambar	II Wet	92	277	35	10.9	2.0	3.0	0.5	43.5	47.8	6.3	0.0	2.4*				
	CD	377	1341	45	11.0	2.0	3.6	0.2	37.9	44.9	10.7	4.2	2.3*				

SE, standard error; Mgs, mean group size; Lgo, largest group observed; NG, number of groups; NA, number of animals; CD, combined data; *, No more categories available and >16 individuals; Mc, mean crowding; Mdgs, median group size.

Table 2
Influence of age classes of chital and sambar on group size changes using multiple regression models in Mudumalai Tiger Reserve India (January 2008–December 2009).

Species	Age classes	Regression coefficient	Standard error	t	p Value	R^2
Chital	Adult male	1.42*	0.31	4.52	0.000	0.80
	Sub adult male	0.96*	0.36	2.64	0.019	0.66
	Adult female	0.32	0.37	0.88	0.393	0.87
	Sub adult female	0.39	0.31	1.28	0.223	0.55
	Fawn	1.11*	0.50	2.24	0.042	0.86
Sambar	Adult male	−0.17	0.17	−0.99	0.337	0.35
	Sub adult male	0.34*	0.09	3.88	0.002	0.33
	Adult female	0.86*	0.11	7.80	0.000	0.81
	Sub adult female	0.43*	0.14	2.98	0.010	0.57
	Fawn	0.61*	0.18	3.43	0.004	0.83

* The mean difference is significant at the 0.05 level.

Table 3
The measure of general linear model (GLM) of Tamhane's T2 post hoc test on seasonal group formation by different age classes of chital and sambar in Mudumalai Tiger Reserve India (January 2008–December 2009).

Age classes	(I) Season	(J) Season	Chital			Sambar		
			Mean difference (I–J)	Standard error	p Value	Mean difference (I–J)	Standard error	p Value
Adult male	Dry	I Wet	−0.90*	0.35	0.029	−0.11	0.12	0.763
		II Wet	−0.33	0.36	0.736	−0.23	0.17	0.438
	I Wet	Dry	0.90*	0.35	0.029	0.11	0.12	0.763
		II Wet	0.57	0.35	0.277	−0.13	0.18	0.870
	II Wet	Dry	0.33	0.36	0.736	0.23	0.17	0.438
		I Wet	−0.57	0.35	0.277	0.13	0.18	0.870
Sub adult male	Dry	I Wet	−0.43*	0.16	0.022	−0.02	0.13	0.998
		II Wet	−0.95*	0.22	0.000	0.21	0.11	0.162
	I Wet	Dry	0.43*	0.16	0.022	0.02	0.13	0.998
		II Wet	−0.51	0.22	0.063	0.23	0.13	0.215
	II Wet	Dry	0.95*	0.22	0.000	−0.21	0.11	0.162
		I Wet	0.51	0.22	0.063	−0.23	0.13	0.215
Adult female	Dry	I Wet	−2.01*	0.45	0.000	−0.8	0.37	0.096
		II Wet	−1.05	0.47	0.075	0.07	0.29	0.993
	I Wet	Dry	2.01*	0.45	0.000	0.8	0.37	0.096
		II Wet	0.96	0.50	0.152	0.87	0.37	0.055
	II Wet	Dry	1.05	0.47	0.075	−0.07	0.29	0.993
		I Wet	−0.96	0.50	0.152	−0.87	0.37	0.055
Sub adult female	Dry	I Wet	−1.07*	0.28	0.001	−0.36*	0.13	0.015
		II Wet	−1.33*	0.36	0.001	−0.2	0.15	0.434
	I Wet	Dry	1.07*	0.28	0.001	0.36*	0.13	0.015
		II Wet	−0.26	0.40	0.881	0.16	0.18	0.761
	II Wet	Dry	1.33*	0.36	0.001	0.2	0.15	0.434
		I Wet	0.26	0.40	0.881	−0.16	0.18	0.761
Fawn	Dry	I Wet	−0.34	0.18	0.171	−0.58*	0.15	0.001
		II Wet	0.36	0.16	0.084	0.1	0.09	0.541
	I Wet	Dry	0.34	0.18	0.171	0.58*	0.15	0.001
		II Wet	0.70*	0.17	0.000	0.69*	0.16	0.000
	II Wet	Dry	−0.36	0.16	0.084	−0.1	0.09	0.541
		I Wet	−0.70*	0.17	0.000	−0.69*	0.16	0.000

* The mean difference is significant at the 0.05 level.

Table 4
Sex ratio of chital and sambar in Mudumalai Tiger Reserve India (January 2008–December 2009).

Species	Season	Adult male	Adult female	Fawn	*N*
Chital	Dry	70.6	100	28.0	2128
Chital	I Wet	61.2	100	24.0	4862
Chital	II Wet	62.0	100	14.4	2401
	CD	63.4	100	22.3	9391
Sambar	Dry	31.6	100	17.0	376
Sambar	I Wet	25.2	100	36.3	436
Sambar	II Wet	49.2	100	10.6	211
	CD	43.9	100	23.7	1023

N, number of individuals classified; CD, combined data.

no significant variation observed in male age classes between seasons (Table 3).

Sambar sex and age composition

Sambar new born fawns were observed throughout the year with a peak fawning period from April to July in the first year and May to August in the second year. Average adult male:adult female:fawn ratio was 43.9:100:23.7 ($n = 1023$) (Table 4). Average adult male and adult female ratio did not show much variation between seasons (Table 5). Fawn ratio in the second wet season was much lower than the other two seasons.

Discussion

Knowledge of the social structure of a population is important for a range of fundamental and applied purposes (Whitehead, 1999). The basic social unit in chital is a matriarchal family group normally consisting of an adult female, her offspring from the previous year and a fawn (Ables, 1974; Putman, 1988). The usual herd is composed of two or more family groups and is often accompanied by individuals of mixed sex and age classes. Application of the word 'herd' describes groups of chital as a misnomer (Graf and Nichols, 1966; Schaller, 1967). Group composition of chital was observed to change frequently during feeding periods (Dinerstein, 1980; Raman, 1997). In Mudumalai, average mean group size of chital differed significantly between seasons and this may be attributed to the availability of food varying between seasons. The observed mean group size of chital in Mudumalai was second highest after Pench (Acharya, 2007) in the sub-continent followed by Karnali-Bardia, Chitawan, Wilpattu, Sariska, Gir, Guindy Ramthambhore, and Bhadra (Dinerstein, 1980; Mishra, 1982; Barrette, 1991; Sankar, 1994; Khan et al., 1995; Raman, 1997; Bagchi et al., 2003; Jathanna et al., 2003). Increased chital mean group size and crowding occurred during the wet season when there was increase in food availability due to monsoon in the study area. Moreover large chital aggregations were observed in the study area when young grass sprouts were available as a result of forest fire and road side vegetation clearings. In Sariska, absence of open grassy patches may have prevented formation of larger groups in chital (Sankar and Acharya, 2004). Sartaj et al. (2010) observed that chital group size was larger in open habitats such as water inundated areas in Pench. Chital group size may vary from 1 to 150 individuals or more depending upon circumstances (De and Spillet, 1966; Schaller, 1967; Eisenberg and Lockhart, 1972; Krishnan, 1972; Fuchs, 1997; Balasubramanium et al., 1980).

Chital sex ratio in Mudumalai was skewed towards females and similar findings were reported in other studies (Graf and Nichols, 1966; Schaller, 1967; Dinerstein, 1980; Johnsingh, 1983; Karanth and Sunquist, 1992; Khan et al., 1995; Sankar and Acharya, 2004). The average fawn ratio to adult females was lower in Mudumalai than other areas such as Royal-Karnali Bardia, Bandipur, Sariska and Pench (Dinerstein, 1980; Johnsingh, 1983; Sankar, 1994; Acharya, 2007) and the reason for the same is attributed to low-detectability of young fawns due to low visibility along road sides because of dense *Lantana camara* cover where fawns were hidden.

In sambar, group size was small, numbering fewer than six individuals (Schaller, 1967). The characteristic social unit is one hind and one fawn or one hind, one yearling and one fawn (Schaller, 1967; Kelton, 1981; Downes, 1983). Family groups usually travel in a single file led by the adult female (Kelton, 1981). Eisenberg and Lockhart (1972) reported that chital and sambar do not remain in permanent social groups. Lewis et al. (1990) recorded that during the rut, dominant stags were frequently seen with hinds and occasionally with other stags who may challenge the dominant stag for breeding rights. Smaller group size of 1–5 individuals was recorded >75 percent throughout the year in Mudumalai. Eisenberg and Lockhart (1972) commented that water holes are places where sambar populations come together in late evenings to form temporary aggregations before dispersing for food. Higher mean group size was seen in the first wet season while more crowding occurred both in the first and second wet season when food and dense cover increased drastically due to monsoon. This variation between mean group size and crowding in both the wet seasons show crowding could be a better measure as crowding predicted the variation in the inner structure of group size in the second wet season (Reiczigel et al., 2007). In Mudumalai large aggregations of sambar were seen near water holes, swampy grasslands, salt licks and burnt areas.

Table 5
Age structure of chital and sambar in Mudumalai Tiger Reserve, India (January 2008–December 2009).

Species	Season	Adult male		Sub adult male		Adult female		Sub adult female		Fawn		*N*
		No.	%	No.	%	No.	%	No	%	No.	%	
Chital	Dry	757	26.3	271	9.4	1071	37.3	476	16.6	300	10.4	2875
Chital	I Wet	1607	24.0	625	9.3	2625	39.2	1217	18.2	630	9.4	6704
Chital	II Wet	844	22.3	537	14.2	1360	35.9	849	22.4	197	5.2	3787
	CD	3208	24.0	1433	10.7	5056	37.8	2542	19.0	1127	8.4	13,366
Sambar	Dry	80	16.0	74	14.8	253	50.7	48	9.6	43	8.6	498
Sambar	I Wet	68	12.0	54	9.6	270	47.8	76	13.5	98	17.3	566
Sambar	II Wet	65	23.5	21	7.6	132	47.7	45	16.2	14	5.1	277
	CD	213	15.9	149	11.1	655	48.8	169	12.6	155	11.6	1341

N, number of individuals classified; CD, combined data.

Johnsingh (1983) also recorded large association of sambar near water holes and feeding sites in Bandipur (Johnsingh, 1983). During the present study the mean group size of 3.6 ± 0.2 recorded for sambar in Mudumalai was much similar to Ranthambhore (Bagchi et al., 2003) and Sariska (Sankar, 1994) and higher than other studies (Karanth and Sunquist, 1992; Varman and Sukumar, 1993; Khan et al., 1995; Jathanna et al., 2003; Acharya, 2007). This may be attributed to large aggregation of sambar in and around swampy grasslands that provide feeding and wallowing grounds throughout the year.

In Mudumalai, the observed low adult male: adult female ratio might be due to selective predation by predators on male sambar as reported in other studies (Johnsingh, 1983; Schaller, 1967; Karanth and Sunquist, 1995; Ramesh, 2010). In south Asian ungulates, solitary habits, proneness to injuries from intra-specific aggression, lack of antlers after rut, and dispersal behaviour have been considered as some of the factors which make males more vulnerable to selective predation (Karanth and Sunquist, 1992). The observed average fawn ratio in Mudumalai was lower than Texas, Bandipur, Sariska, Nagarahole and Pench (Richardson, 1972; Johnsingh, 1983; Karanth and Sunquist, 1992; Acharya, 2007) and the reason for the same could be as earlier stated for chital. Fawning season in sambar in the study area delayed for a month in the second year when compared to the first year from the usual fawning season due to delay in the onset of monsoon. The presence of fawns throughout the study period indicates their breeding throughout the year.

Group size differences observed between study species may be attributed to vegetation cover characteristics may be related to deer group size. Since sambar, a large-bodied browser prefers thick vegetation cover (Schaller, 1967; Sankar, 1994; Ramesh, 2010) and forms smaller group size (Lagory, 1986). While the medium-sized chital which is largely a grazer (Johnsingh and Sankar, 1991) inhabits valley habitats and open areas. Chital's preference towards forest edges and open habitat (Schaller, 1967; Mishra, 1982; Sankar, 1994; Ramesh, 2010) are known to facilitate formation of larger group size by maintaining contact with other group members. Increased attention is needed on how sex and age structure affects group formation in ungulate populations. The general predictions of change in group size in chital are directly related to percentage availability of rutting stags and fawns (Raman, 1997). Among all age categories, adult male and fawn were the major predicting variables of group formation in chital. These were mainly due to adult males joining female groups during the rutting season, and peak fawning season was due to availability of forage and adequate cover after rain. However, this trend was not noticed in adult male sambar while adult and sub adult females were important predictors in sambar unlike chital. In addition sub adult males contributed to significant variation in group formation in sambar which was similar to chital. Interestingly sub adult male was one of the predicting variable in group formation and not adult male sambar. In ungulates, generally sub-adult males seemed to increase their reproductive activity when there was female-biased sex ratio or adult males scarce (Mysterud et al., 2002). In the present study, the group size of adult and sub adult male sambar did not vary between seasons. The reason for the same may be attributed to very high skewed female ratio in sambar as compared to chital and their habitat segregation. However, animals may actually be more vulnerable to predation despite dense vegetation which provides increased concealment from predators (Lagory, 1986). Larger groups are more likely to spot a predator than smaller groups and are thus more likely to flee. Ramesh (2010) observed very high adult male sambar predation (82%) by tiger as compared to adult female in Mudumalai. The skewed female ratio in both the species was mostly due to male biased predation by large carnivores (Karanth and Sunquist, 1995; Ramesh, 2010). In comparison to chital, sambar males are more vulnerable to predation because of their solitary habits (38%). In chital, adult male and female group formation changed between dry and first wet seasons. This may be due to prime aged adult males first coming to rut during the annual peak in female oestrus, a little later sub adults come to rut and end rutting after adult male peak rutting (Hirotani, 1994; Raman, 1997). It is presumed that this may be the reason why adult and sub adult males chital varied in group formation. In addition seasonal availability of food resources also may play a major role in group formation in chital especially during monsoon due to the increased availability of young grass sprouts (Schaller, 1967; Mishra, 1982; Johnsingh, 1983; Sankar, 1994; Raman, 1997). In sambar other than fawn, only sub adult female showed significant seasonal variation in group formation between dry and first wet seasons while adult female had marginal variation between first and second wet seasons. The lack of significant effect in group formation of different age classes of sambar was not clear like chital. This may be attributed to its preference towards dense vegetation cover and habitat segregation from chital. Food choice, abundance, and dispersion also vary with cover density and these may influence the size of ungulate groups (Lagory, 1986). Jarman (1974) hypothesized that interspecific variation in the size of ungulate groups is a consequence of differences in foraging strategies based on the characteristics of food supply. Timing of births is regarded as crucially important for the survival of newborns (Rutberg, 1987). The substantial variation in fawning of chital was not seen between dry and first wet season because the peak fawning months covered both the seasons (February–May). For sambar, fawning significantly varied in first wet season as compared to dry and second wet seasons, with peak fawning occurred only in the first wet season. The variability observed in peak fawning seasons in Mudumalai between chital and sambar may be due to their distinct food preference (Schaller, 1967; Sankar 1994) and adaptability to varied environmental responses. The observed patterns in chital and sambar sex-age composition influences the group formation of the study species at different level depending upon the species' ecological need, however the change in group size was substantially influenced by fawn and adult males in Mudumalai. Therefore, further detailed research is needed to investigate other advantages to grouping in Cervids such as social interactions, vigilance and predator detection or avoidance. Understanding demographic patterns requires regular monitoring over time which facilitates long term effective conservation planning by wild life managers in the local landscape.

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