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Ecology of Sambar in Mudumalai Sanctuary, Southern India

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ABSTRACT. The sambar (*Cervus unicolor*) is the largest and most widely distributed deer in India. This paper looks at ecological correlates of sambar density, habitat utilization, group structure and composition and reproductive phenology in the tropical deciduous forests of Mudumalai Sanctuary, southern India, during 1988–1991. Sambar densities as estimated by vehicle and walking transects varied significantly, with the latter method giving higher and less biased figures. Average sambar density in the study area was 8.0 animal/km^2; this translates into a biomass of 1059 kg/km^2. Tiger (*Panthera tigris*) showed a high preference for sambar in their diet. Group size ranged from one to 50 individuals, with an average of 3.1 animals. The larger groups tended to form during the wet season, probably due to increased food availability. Sambar preferred moist deciduous forest during the dry seasons and dry deciduous forest with tall grass during the wet seasons and this may be related to foraging behaviour. Sex ratio showed a bias in favour of females (2.7:1). Fawn to adult-female ratio was more or less constant in different seasons. Proportion of males in hard antler was high during dry and second wet seasons. There seems to be no distinct seasonality in reproduction. The paper also discusses other possible ecological implications of these results.

Sambar is the largest and the most widely distributed among eight species of cervids in India. It is found in thorn forest, dry and moist deciduous forest, and semi-evergreen and evergreen forest throughout the sub-continent up to the snow line in the Himalayas. In Asia the sambar has a wide geographical distribution from the Philippine Islands in the east, through Indonesia, southern China, Indochina, Thailand and Burma, to India in the west. Sixteen subspecies of sambar are recognised of which *Cervus unicolor nigar* is found in India. Although the sambar is a widespread forest dweller of southern Asia, its ecology and behaviour has not been much investigated. The only accounts available are those of Schaller (1967), Krishnan (1972), Johnsingh (1983) and Ngampongsai (1987).

The present study forms part of an ongoing long-term monitoring of large mammals in the deciduous forests of Mudumalai Sanctuary, southern India. This paper reports on seasonal densities, habitat utilization pattern, social organization and predation of the sambar population.

MATERIAL AND METHODS

Study Area

The present investigation was carried out within a 130 km^2 area of Mudumalai Wildlife Sanctuary (321 km^2) situated in the Nilgiri district of Tamilnadu (latitude 11° 30' to 11°39' N and longitude 76°27' to 76°43' E) (Fig. 1). The rainfall shows a distinct gradient from the southwest (high rainfall, average of 1800 mm per annum) to the northeast (low rainfall, 800 mm per annum). Corresponding to this rainfall

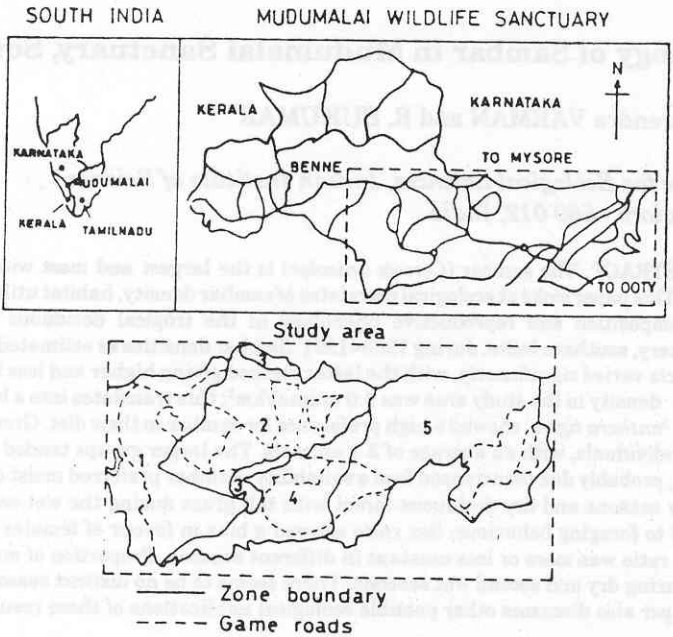

Figure 1. Mudumalai Wildlife Sanctuary – Showing study area with different zones and game roads

gradient, a range of vegetation types from small patches of semi-evergreen forest, through moist deciduous and dry deciduous forest, to dry thorn forest can be seen. Descriptions of floristics and vegetation structure are available elsewhere (Sharma et al. 1978, Sukumar et al. 1992).

Study Methods

Based on vegetation type, the study area was stratified into a number of zones. There were five major zones: moist deciduous forest (MDF), dry deciduous forest with tall grass (DDFT), dry deciduous forest with short grass (DDFS), riparian forest (RPF) and dry thorn forest (DTF). Several sub-zones were identified within each of these, but we report results summarized for the major zones only. Three seasons, dry (January – April), first wet (May – August) and second wet (September – December) were defined.

Our basic data come from transects established in the study area and monitored regularly. Transects were of two types: vehicle transects along roads and walking transects. The good network of roads inside the sanctuary made it possible for us to cover these regularly by vehicle. The total distance covered by road within each vegetation zone was broadly representative of the proportion of the total study area covered by that zone. In addition, six straight-line transects of 2–4 km each were

walked, covering all the zones proportionate to their areas. Transects were covered once in the morning (0700–0930) and once in the evening (1600–1830) each month. Recording of data basically followed line transect methods described by Burnham et al. (1980) and used by Karanth and Sunquist (1992) in a similar forest type in southern India. For each animal sighting the perpendicular distance from the centre of the group to the transect line (or road) was recorded using a range-finder, in addition to details of group composition. Sambar were classified as adult female, yearling female, hard- and velvet-antler males, yearling males with spike antlers, and fawns.

Densities were estimated using probability density function theory (we used a Fourier Series function) as described by Burnham et al. (1980), using the programme TRANSECT (White 1987). Densities were computed zone-wise for each season in order to understand patterns of habitat utilization. Biomass of the population was computed using mean animal weights reported in the literature (Schaller 1967, Karanth and Sunquist 1992). To assess the importance of sambar as a prey species for the major predators in the area, all dead sambar found in the field were aged and sexed whenever possible and the cause of death ascertained. Scats of the major predators, dhole (*Cuon alpinus*), leopard (*Panthera pardus*) and tiger were collected.

RESULTS

Density and Biomass

Sambar density estimated by vehicle transects was significantly lower than that estimated by walking transects during 1991 when both methods were used. As there could be significant bias in estimates from vehicle counts because sambar may tend to avoid roadsides, the estimates from walking transects would be more unbiased. These indicate a sambar density of 7.9 animals/km^2 (Table 1). Taking a mean sambar weight of 134 kg, the average biomass of sambar works out to 1058 kg/km^2 for the study area. This constitutes 29% of the biomass of important prey species at Mudumalai (Table 2).

Table 1. Density of sambar as determined by vehicle and walking transects.

Mode	Year	Dry		First Wet		Second Wet		Annual	
		D	CI	D	CI	D	CI	D	CI
Vehicle	1988	0.07	± 0.35	1.71	± 0.44	0.69	± 0.30	0.94	± 0.23
Vehicle	1989	1.99	± 0.48	1.92	± 0.64	0.51	± 0.21	1.32	± 0.33
Vehicle	1990	0.87	± 0.27	0.60	± 0.22	0.64	± 0.29	0.96	± 0.23
Vehicle	1991	—	—	—	—	—	—	1.79	± 0.48
Walking	1991	—	—	—	—	—	—	7.99	± 2.10

D = number/km^2; CI = 95% confidence interval

Table 2. Biomass of prey species in the study area.

Prey species	Prey weight (kg)	Prey density (per km^2)	Prey biomass (kg/km^2)	Prey biomass (%)
Chital	41	31.2	1279	35.0
Sambar	134	7.9	1059	29.0
Gaur	450	2.4	1080	29.6
Langur	9	25.2	227	6.4
Total			3645	

Table 3. Prey preference of major predators.

Prey species	Prey remains in predator scat				Prey preference (ratio*)				
	Wild dog	%	Panther	%	Tiger	%	W. Dog	Pan	Tiger
Chital	424	61	149	59	57	51	1.7	1.8	1.4
Sambar	269	39	98	39	51	46	1.3	1.3	1.8
Gaur	0	0	0	0	4	3	0.0	0.0	0.1
Langur	0	0	3	2	0	0	0.0	0.2	0.0

* % Prey remains divided by % prey biomass

Predation on Sambar

Tiger, panther and wild dog are the major predators in Mudumalai. Sambar, chital, gaur and langur are the main prey species for these predators. Of all these prey species, sambar hair constituted 38.8% in wild dog scat (n = 269), 39.2% in panther scat (n = 98) and 45.5% in tiger scat (n = 51) (Table 3). The sambar biomass, however, constitutes only 29% of the total prey biomass.

Habitat Utilization Patterns

The proportion of the sambar population found seasonally in different habitat zones in relation to the proportional availability of the zones shows the changing habitat utilization pattern (Table 4 and Fig. 2). Sambar clearly utilized the DDFT zone in greater proportion (by a factor of two) than its availability during the first and second wet seasons. But during the dry season there is a distinct shift to the MDF zone. The DDFS zone was utilized only in proportion to area during the dry season and under-utilized during other seasons. DTF was clearly shunned throughout the year. The riparian vegetation was again underutilized, but this could be because of vehicular disturbance here along the transect route. Also, this zone adjoins the DDFS, which is not preferred.

Social Organization

Group size. The group size ranged from one to about 50 individuals. The largest group that formed seasonally was 19 during the dry season, about 50 during the first

Table 4. Habitat utilization pattern of sambar in different vegetative zones.

Zone	Area	%	% sambar in different habitats		
			Dry %	First wet %	Second wet %
DDFT	31.75	24.16	21.90	50.60	56.9
MDF	33.05	25.10	62.50	28.10	35.9
DDFS	18.04	13.70	17.30	8.80	3.9
RPF	3.50	2.81	2.50	2.10	0.94
DTF	44.97	34.23	6.80	10.40	2.9

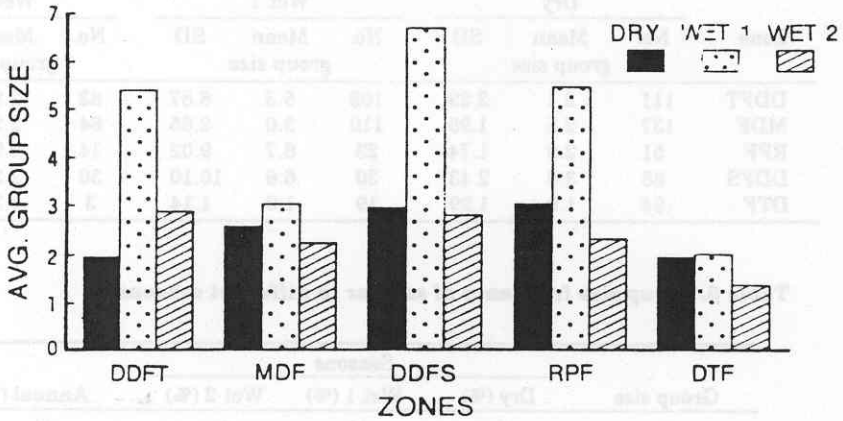

Figure 2. Seasonal group size of sambar in different zones.

wet season and 44 during the second wet season. The average group size of sambar over all seasons was 3.1 animals. This varies from one season to another; the mean group size of 4.23 animals during the first season differed significantly from those of other seasons (dry = 2.55, second wet = 2.66) (Table 5a and 5b). The frequency distribution of group size (Table 6) was significantly different between dry and first wet seasons ($G = 81.6$, $df = 6$, $p<0.005$), between first and second wet seasons ($G = 27.0$, $df = 6$, $p<0.005$), and also between dry and second wet seasons ($G = 18.5$, $df = 6$, $p>0.005$). However the difference between dry and second wet season may be an artifact of the higher frequency of groups, three to four as compared to two animals during dry season and may not reflect any biological significance in grouping behaviour. Thus it is clear that the larger group sizes tended to form during the first wet season, while during the dry season sambar tend to break up into smaller groups (Fig. 3).

Group composition and structure. Out of a total of 1242 sambar classified, adult females formed 58%, yearling female 7%, hard-antler male 15%, velvet antler male 6%, spike-antler male 2%, shed-antler male 0.5%, and fawns 12% (Fig. 4). Adult sex ratio was thus biased 2.7:1 in favour of females.

Table 5a. Average group size of sambar in different seasons

Season	No	Average Group	SD	Max
Dry	338	2.55	2.10	19
Wet 1	203	4.20	5.50	50
Wet 2	153	2.60	4.30	44
Annual	694	3.06	3.90	50

Table 5b. Average group size of sambar in different zones in different seasons.

Zone	Dry			Wet 1			Wet 2		
	No.	Mean group size	SD	No.	Mean group size	SD	No.	Mean group size	SD
DDFT	111	2.1	2.29	108	5.3	6.87	83	2.9	5.00
MDF	137	2.5	1.95	110	3.0	2.65	64	2.2	2.39
RPF	51	2.9	1.74	23	6.7	9.02	14	2.9	4.53
DDFS	88	3.0	2.43	30	6.6	10.10	30	2.3	2.28
DTF	34	1.9	1.29	19	1.9	1.14	3	1.3	0.47

Table 6. Group size frequency of sambar in different seasons.

Group size	Seasons			
	Dry (%)	Wet 1 (%)	Wet 2 (%)	Annual (%)
1	40	30	51	40
2	21	25	23	22
3–4	27	23	14	23
5–8	11	9	7	10
9–16	1	9	3	4
17–32	0	4	1	1
33–64	0	0	1	0

When we look at the propensity of females and males to form unisexual groups (this excludes solitaries and female plus fawn groups) as opposed to bisexual groups, we see that females have a much greater tendency to form unisexual groups (75%, n = 476 individuals) as compared to males (37%, n = 104 individuals).

The frequency distributions of groups of different composition—all-female, female-plus-fawn, all-male and bisexual—in relation to group size, is given in Table 7. As the group size increases the proportion of fawns in the group also increases (Fig. 5). Similarly, the proportion of bisexual groups also increases with group size; the larger groups were invariably bisexual groups.

Phenology in Reproduction

The proportion of males in hard antler was high during dry and second wet

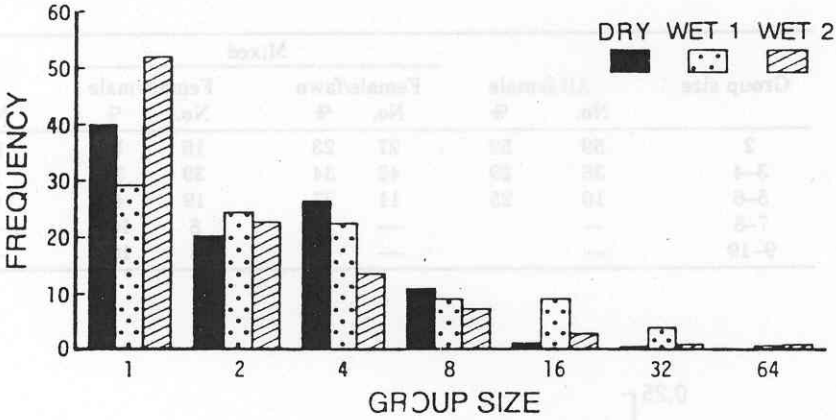

Figure 3 . Group size frequency of sambar in different seasons.

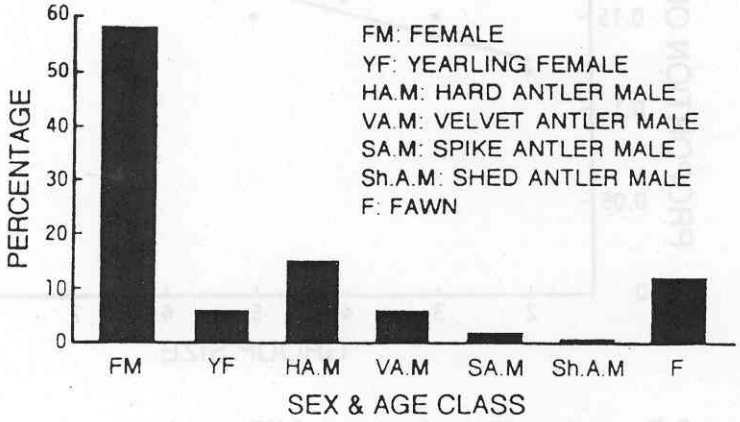

Figure 4. Proportion of different sex and age classes in sambar.

seasons with peak during dry season, when overall 66.7% of males were in hard antler. During the first wet season a majority (62.2%) of sambar were seen in velvet antler but a substantial number of males were also in hard antler (37.7%) (Table 8 and Fig. 6). These observations indicate that rutting in sambar is spread over several months during the second wet and dry seasons, with perhaps a peak during the dry season, but with no distinct seasonality. The fawn-to-female ratio was also more or less constant in all seasons (Table 9) supporting the contention that there may be no distinct seasonality in reproduction.

Table 7. Composition of social groups in sambar.

Group size	All-female		Mixed				All-male	
			Female/fawn		Female/male			
	No.	%	No.	%	No.	%	No.	%
2	59	52	27	23	16	14	12	10
3–4	36	29	42	34	39	31	6	4
5–6	10	25	11	27	19	47	0	0
7–8	—		—		8	100	—	
9–19	—		—		4	100	—	

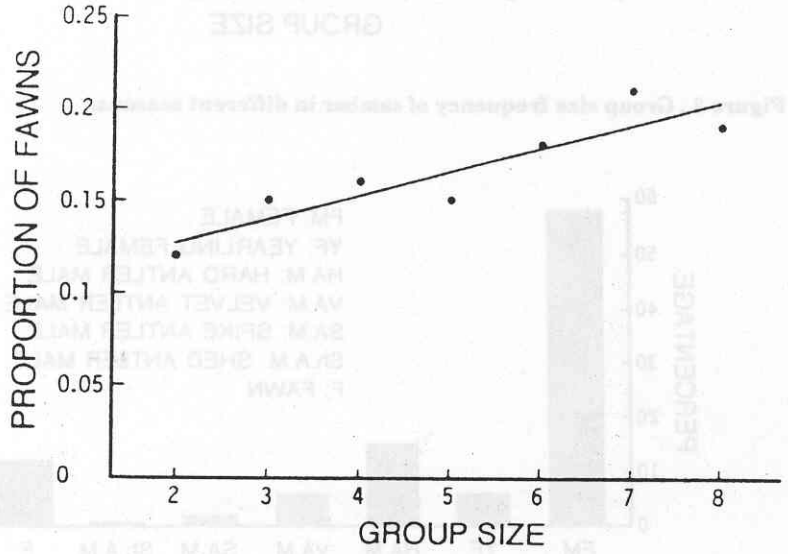

Figure 5. Proportion of fawns in groups of different sizes.

Table 8. Seasonal proportion of hard- and velvet-antlered males in sambar.

Season	Hard-antlered males		Velvet-antlered males	
	No.	%	No.	%
Dry	107	91	11	9
Wet 1	37	38	61	62
Wet 2	49	63	29	37
Annual	203	67	101	33

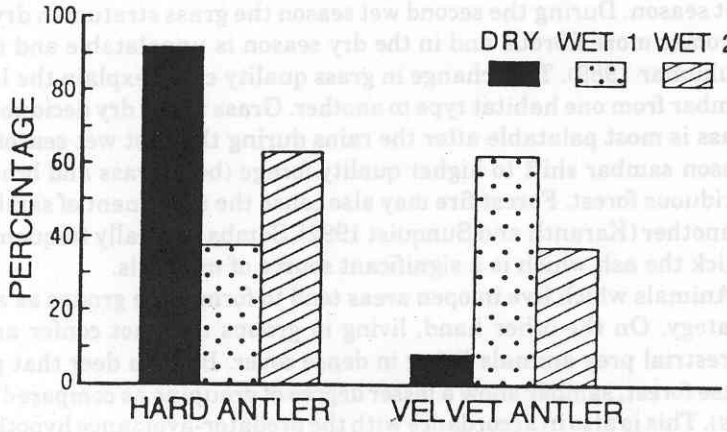

Figure 6. Seasonal proportion of hard and velvet antlered males.

Table 9. Fawn to female ratio in different seasons.

Season	No. females	No. fawns	Fawn/female ratio
Dry	408	96	0.24
Wet 1	234	53	0.23
Wet 2	138	23	0.17

DISCUSSION

Sambar generally seem to prefer forest with dense vegetation cover over more open forest and roadside clearings. The substantially higher density estimate arrived at by walking transects than by vehicle counts along roadsides is one clear indication of this preference. Similarly, the highest densities of sambar are attained in moist deciduous forest or dry deciduous forest with tall grass cover as opposed to drier and more open forest. Sambar density (7.9/km^2) and biomass in Mudumalai are among the highest reported in Asian forests. Only Johnsingh's (1983) estimate of 9 sambar/km^2 (1399 kg/km^2) during wet and 7 sambar/km^2 (1244 kg/km^2) during dry season in the adjoining Bandipur National Park compares with the Mudumalai figures. However, this applies only to a small 23 km^2 study area where the large number of water holes could have caused the high density. Other estimates include 158 kg/km^2 for Wilpattu National Park, Sri Lanka (Eisenberg and Lockhart 1972), 443 kg/km^2 in Chitwan, Nepal (Seidensticker 1976) and 736 kg/km^2 in Nagarhole, southern India (Karanth and Sunquist 1992).

The higher predation on sambar than any other prey species by tiger may be a consequence of the tiger's prey choice as moulded by optimal foraging considerations.

The sambar's seasonal preference for different habitat types may be related to forage quality. Although the sambar is both a browser and a grazer, they seem to

mainly graze when fresh green grass is available (Schaller 1967) as during the first wet season. During the second wet season the grass stratum in dry deciduous forest becomes more fibrous and in the dry season is unpalatable and nutritionally poor (Sukumar 1989). This change in grass quality could explain the local movement of sambar from one habitat type to another. Grass in the dry deciduous forest with tall grass is most palatable after the rains during the first wet season. During the dry season sambar shift to higher quality forage (both grass and browse) in the moist deciduous forest. Forest fire may also cause the movement of sambar from one area to another (Karanth and Sunquist 1992). Sambar actually frequent fire-burnt areas to lick the ash which is a significant source of minerals.

Animals which live in open areas tend to form large groups as an anti-predatory strategy. On the other hand, living in groups does not confer any advantage for terrestrial prey animals living in dense cover. Being a deer that prefers relatively dense forest, sambar show a lesser degree of grouping as compared to axis deer (*Axis axis*). This is also in accordance with the predator-avoidance hypothesis propounded by others (e.g. Dasmann and Taber 1956, Hirth 1977). In dense cover a single animal can be efficiently concealed, whereas this concealing effect is lost with a larger group.

As studies on a variety of other ungulates have shown, the group size and social organization may also be influenced by relative amounts and distribution of food resources (Clutton-Brock et al. 1982). The increase in mean group size during the first wet season could be due to higher food availability at that time. When food is not a limiting factor, there would be little or no competition among individuals foraging in large groups.

An interesting observation is that group sizes recorded by us at Mudumalai are larger than those reported by others for any region. Maximum number in a group recorded by others include 9 at Kanha by Schaller (1967), 15 at Mudumalai by Krishnan (1972) and 35 at Bandipur by Johnsingh (1983). Ganesh Prasanna (1990) observed a group of 45 sambar at Mudumalai. Krishnan (1972) speculates that these larger groups are aggregations of individuals from different family groups near waterholes or in open areas. However, we have seen large sambar groups away from such areas. The larger group sizes has led to the higher sambar densities at Mudumalai during our study.

The age and sex composition of the sambar population at Mudumalai is very similar to that observed in other regions, including at Kanha by Schaller (1967). The sex ratio of 2.7 females to one male is also similar to ratios observed elsewhere; 2.4:1 at Bandipur (Johnsingh 1983), 2.4:1 at Nagarhole (Karanth and Sunquist 1992), 3:1 at Kanha (Schaller 1967). Erroneous field classification could also cause female-biased sex ratio. In some cases, spike males and shed-antler males could have been classified as females when sighted from a considerable distance. However, this is not likely to change the sex ratio substantially, and a female-bias would still remain. One of us (R. S.) also observed that out of over 100 sambar seen at Bandipur during a two-week period in June 1992, most were adult females, yearling females, or fawns. Adult sambar males probably have restricted movement during day-time or lead a semi-nocturnal life and cause this bias in classification.

The explanation Schaller gives for such a female-biased sex ratio in sambar is a

higher rate of predation in males, both as fawns and as adults, or unequal sex ratio at birth. The latter explanation is unlikely; it is more likely that male sambar suffer higher mortality due to predation or other natural causes as observed in many other polygynous mammals.

The tendency for a higher frequency of fawns in larger groups may be an anti-predatory strategy in sambar. Fawns, which are highly vulnerable to predation, may be better protected in larger groups. The observation that larger sambar groups are invariably mixed groups of males and females may be partly a chance event, as random association of individuals is more likely to bring the sexes together as group size increases. However, this may also be related to reproductive activity and mate choice.

In cervids, changes in antler stage or presence of breeding stags in groups may indicate a seasonality in reproduction (Barrette 1987). In sambar the development of hard antlers in males, sore patch, territoriality, wallowing and courtship behaviour may indicate the rut (Johnsingh 1983). Johnsingh (1983) reported a higher proportion of hard-antlered males between November and April at Bandipur, but since hard antlers have been found to be associated with females from October to June, he concluded this to be the period of rut. In Kanha, Schaller (1967) reported a rut spread over a period of seven months with a peak during November and December. In the high altitude (>2000 m) Eravikulam National Park sambar gave birth in the post-monsoon, indicating a rut during the pre-monsoon (Rice 1986). Krishnan (1972) states that, based on shedding and regeneration of antlers, the evidence for seasonality in reproduction is confusing. Our own observations on males in hard antler and female/fawn ratios also indicates that at best there may be only a weak seasonality in reproduction.

In sambar, the sore patch is said to be one of the manifestations of the early part of rut, and sambar develop the sore patch only during certain months (Schaller 1967). We observed sore patches in sambar throughout the year and in almost all age classes in Mudumalai, although we do not have quantified data on the frequency. If we consider sore patch as an indicator of rutting season, this observation supports a seasonality in reproduction. Krishnan (1972), however, argues that the sore patch does not have any sexual significance, because he observed sort patches on hinds with very young fawns. As the hinds were still in the phase of lactation, they could not have been in breeding condition. In some places like Hazaribagh National Park at no time were sambar seen with sore patches.

Food and other resource availability, predator pressure, and climate are the main factors which determine the phenology of reproduction in any species. In Mudumalai where rainfall is spread over a period of about eight months, there may not be the distinct seasonality in ecological and behavioural attributes of a species as compared to the more seasonal habitats found at northern latitudes in India.

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