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Grazing patterns of sambar deer (*Cervus unicolor*) and red deer (*Cervus elaphus*) in captivity

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Abstract Grazing behaviour was recorded in sambar deer and red deer for 24-h continuous periods, at 2-monthly intervals, over 12 months from March 1990 to March 1991. Scan-sampling was used, with observations made every 12 min. Both groups of deer grazed separate but adjoining areas of the same pasture for the duration of the study. Sambar deer grazed most actively during the night (0100–0500 h), late afternoon, and evening (1700–2100 h), whereas red deer grazed most intensely during early morning (0500–0700 h), afternoon, and early evening (1500–2000 h). This species difference in grazing pattern was not altered by season or month. Total grazing time was similar for sambar and red deer (9.1 versus 9.4 h/24 h), but sambar deer spent more time grazing during the night (6.2 versus 4.9 h/24 h; $P < 0.01$) and less time grazing during the day (2.9 versus 4.5 h/24 h; $P < 0.01$) than red deer. The ratio night grazing:daytime grazing was much greater for sambar deer (2.3:1.0) than for red deer (1.1:1.0; $P < 0.001$). During the day, sambar deer spent more time resting than red deer (6.4 versus 5.1 h $P < 0.001$), but time spent ruminating was similar (2.1 versus 1.9 h) for the two species. Rate of prehending biting was greater for sambar deer than for red deer (65 versus 48 bites/min; $P < 0.001$). It is suggested that longer night grazing by sambar deer may have evolved to reduce thermoregulatory stress in tropical environments and as a defensive strategy against attack by predators. Pasture mass/ha and surface height changed with season of the year, but areas grazed by both species of deer were always of similar height and mass, indicating that grazing pressures were similar. However, herbage in areas grazed by sambar deer had higher total N content and organic matter digestibility during winter, the period of lowest pasture mass/height, indicating that relative to areas grazed by red deer, grazing by sambar deer had modified forage nutritive value at this time.

Keywords sambar deer; red deer; grazing behaviour; season; *Cervus unicolor*; *Cervus elaphus*

INTRODUCTION

Sambar deer (*Cervus unicolor*) are native to tropical southeast Asia (Whitehead 1972; Grzimeck 1990) and have been successfully liberated in Australia (1857), the United States (1908), and New Zealand (1870) (Wodzicki 1950; Bentley 1978; Lewis et al. 1990). Sambar deer are the largest of the tropical Asian deer and prefer a habitat of thick and dense cover (Whitehead 1972; Bentley 1978). They usually avoid direct contact with humans (Harris 1966; Anon. 1979) and because of their secretive nature, little is known about their natural feeding pattern. Sambar deer run wild in the Manawatu coastlands of New Zealand, where their habitat includes much dense cover (Kelton 1981; Douglas 1983; Lo 1985).

The objectives of this study were to construct time budgets of feeding activities of sambar deer over

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full 24-h periods, to establish if these changed with season, and to compare these measurements for tropical sambar deer with those of age-matched temperate red deer (*Cervus elaphus*) grazing identical pastures.

MATERIALS AND METHODS

Experimental design

Sambar deer and red deer grazed separate but adjoining areas of pasture for 12 months. The red deer were domesticated and the sambar deer semi-domesticated. Measurements of grazing behaviour were recorded continuously for 24-h periods using scan-sampling at 12-min intervals, at 2-monthly periods from March 1990 to March 1991.

Location

The study was carried out at AgResearch, Flock House Agricultural Centre, Bulls, Manawatu, New Zealand. Mean annual rainfall is 875 mm with a dry period from January to March (summer), and strong westerly winds during October and November (spring). The mean monthly air temperature ranges from 9 to 20°C.

Animals

Nine sambar deer comprising two adult stags (initially 2–4 years old), four adult hinds (2–4 years old), and three juveniles (8–9 months old) were used. The adult sambar deer had been captured and kept in captivity on a farm near Rongotea, before being moved to Flock House. The young sambar were all born on the Flock House deer farm. Nine red deer of similar sex and age were compared with the sambar deer. After the first month of observation (March 1990), one adult sambar hind died from an injury, but no subsequent adjustment was made to the red deer group size. As the hinds calved, the fawns were removed for artificial rearing studies, hence the present study was not complicated by lactation in either deer species.

Paddock layout

The paddock was divided into two areas which were allocated to red deer (0.85 ha) and sambar deer (0.82 ha,) on 2 February 1990. In addition, an extra 0.15 ha of pine trees (*Pinus radiata*) was provided for shelter of sambar deer only. The paddocks were surrounded by 2-m-high double layer deer netting fence, with the divider fence being single netting.

The deer were observed from an elevated observation room, located at the end of the paddock, at the junction of the red deer and the sambar deer areas. The presence of the operator in the room did not appear to disrupt the animal grazing activities. The room was well sealed with a window and kept dark during the night, when a torch was used while recording the data.

Pasture vegetation

The sward was a mixed pasture, to which fertiliser had never been applied. Botanical composition (mean ± SE), determined in January 1991, was *Trifolium* sp. 13.6% (SE = 2.09), *Bromus* sp. 6.9% (2.01), *Agrostis* sp. 15.0% (3.40), *Holcus lanatus* 18.8% (3.74), *Ranunculus* spp. 4.9% (1.81), and *Cynodon dactylon* 11.3% (1.62). Areas grazed by sambar deer had similar botanical composition to those grazed by red deer.

Observation techniques

The activities of deer were divided into three major categories, namely: (i) grazing, defined as searching for and ingesting forage; (ii) ruminating, defined as regurgitating, masticating, and swallowing the bolus (Fierro & Bryant 1990); and (iii) resting, defined as any other activities.

Rate of prehending biting (ROB) was characterised by a distinctive upward jerk of the head while pulling the plants. Measurements were made by recording the time needed to complete 20 uninterrupted bites and expressed as bites/min (Jamieson & Hodgson 1979). Two typical adult male and two typical adult female animals from each group, balanced for age, were chosen to record ROB.

The three defined foraging categories and ROB were all recorded during the day, but during the night, only grazing activity was recorded. A telescope (Bisley Deluxe, D: 40 mm, zoom 10–40×, Japan) and binoculars (Nikon, 10 × 40 mm magnification, Japan) were used during the daytime observations. Observations after dark used a light-gathering night-scope (Noctron V, 132 mm, Japan), powered by two AA batteries to intensify the images.

Data collection

At each recording period, duplicate 24-h measurements were made 1 week apart, except in October

1990, when only one 24-h observation was made. Observations took place during the weekend and commenced at 1000 h on Saturday, when a minimum of other activity near the deer unit was expected. Operators were located in the observation room c. 30–60 min before commencing the measurements.

The behaviour of each animal was recorded every 12 min, by scanning each paddock from left to right. During the day, the number of animals in each activity category was recorded. At night, data were collected only on the total number of animals grazing. Two observers were used, to allow continuous 24-h recording.

ROB was recorded between 12-min scanning intervals, during daytime only. Each selected animal was recorded for 2 × 20 bites, before moving to other animals. Ambient air temperature was recorded hourly and weather conditions noted.

Pasture sampling and analysis

At the end of each recording period, pasture height was measured in both paddocks using 30 measurements with a falling plate meter per paddock (Hammond Doyle Co. Pty. Limited, Australia) and herbage mass was measured by cutting 15 quadrats (0.01 m^2) from each paddock. Before cutting, the height of each quadrat was also measured.

Subsamples of forages, cut to soil level, were taken from each paddock for laboratory analyses of DM, total N, and in vitro digestibility. All samples were stored at –20°C, freeze-dried, and ground to pass a 1 mm diameter sieve (Wiley mill, USA) before laboratory analysis. DM was measured by drying the samples in an oven at 110°C for 16 h. Total nitrogen (N) was determined by the Kjeldahl procedure, whereas in vitro digestibility was determined by the method of Roughan & Holland (1977).

Calculation of data and statistical analysis

Percentage of animals grazing was defined as number of animals grazing × 100/number of animals present. At 12-min intervals, the percentage of red deer and sambar deer that were either grazing, ruminating, or resting was calculated. These were then averaged over hourly intervals, to determine if the foraging behaviour of sambar deer differed from that of red deer over a 24-h period. The percentage data were transformed to arcsin (Zar 1974) and analysed by analysis of variance procedures to determine effects of type of deer (2), time of the day (24), month of the year (7), and their interactions, using the SAS (1987) statistical package. Mean values with the standard error of the means (SEM) are presented.

A grazing cycle was defined as the period where there was a gradual increase in the percentage of animals grazing, followed by a gradual decline. The duation of grazing (h/24 h) for each deer species was calculated using Equation 1.

$$\text{Grazing time (h/24 h)} = \frac{\sum \text{animals observed as grazing} \times 24}{\sum \text{animals observed}} \quad (1)$$

Total time (h/24 h) spent ruminating, grazing, and resting during daytime only was calculated in a similar manner (Hodgson 1982). Daytime was taken as the time between 0600 and 1800 h (12 h) and the period 1800–0600 h represented the night time (12 h).

RESULTS

Air temperature

Highest temperatures were noted in January, whereas the coldest weather occurred between July and September, coinciding with New Zealand summer and winter seasons, respectively (Fig. 1). Temperatures were coldest between 0100 and 0700 h, and hottest between 1200 and 1400 h.

Herbage mass, height, and nutrient quality

The seasonal patterns of the herbage mass (Fig. 2A) and pasture height (Fig. 2B) show a common trend, being lowest towards the end of winter and highest in spring. Nitrogen content and organic matter digestibility (OMD) were significantly higher ($P < 0.05$, Fig. 3) in the sambar deer area than in the red deer area in July (winter) and September (early spring); however, these were lower in the sambar deer area during May ($P < 0.10$; autumn).

Grazing observations

Figure 4 shows the 24-h grazing pattern averaged over all monthly periods. There was a significant interaction between deer species and time of day ($P < 0.001$). Sambar deer actively grazed at night (0100–0500 h) and in the late afternoon and late evening (1700–2100 h), with only a few sightings

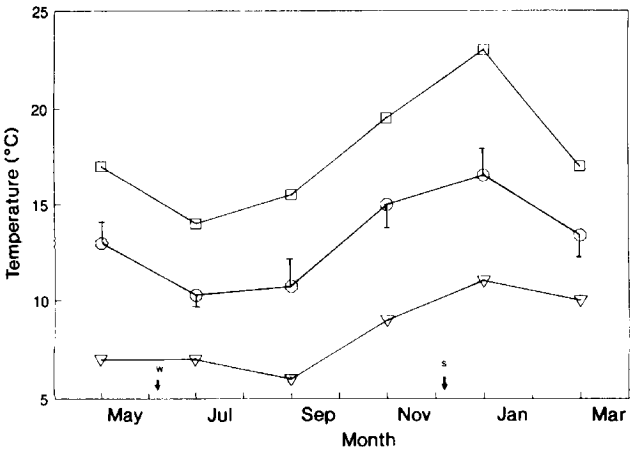

Fig. 1 Mean (○), maximum (□) and minimum (▽) ambient air temperature (°C) taken at bimonthly intervals during the study. S = summer solstice; W = winter solstice.

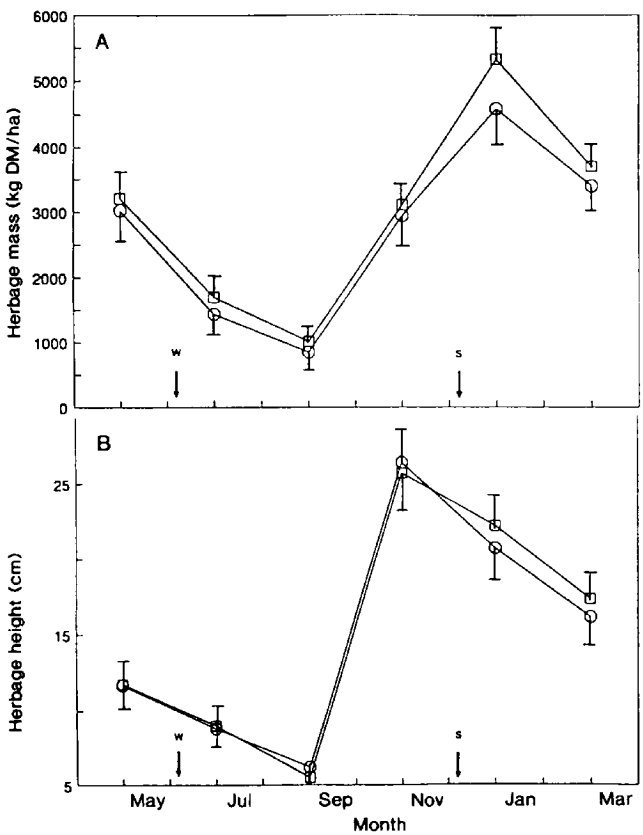

Fig. 2A Mean standing herbage mass (kg DM/ha) of pastures grazed by sambar deer (○) and red deer (□) during the study; **2B** Mean herbage height (cm) of pastures grazed by sambar deer (○) and red deer (□) during the study. S = summer solstice; W = winter solstice. Vertical bars represent SE.

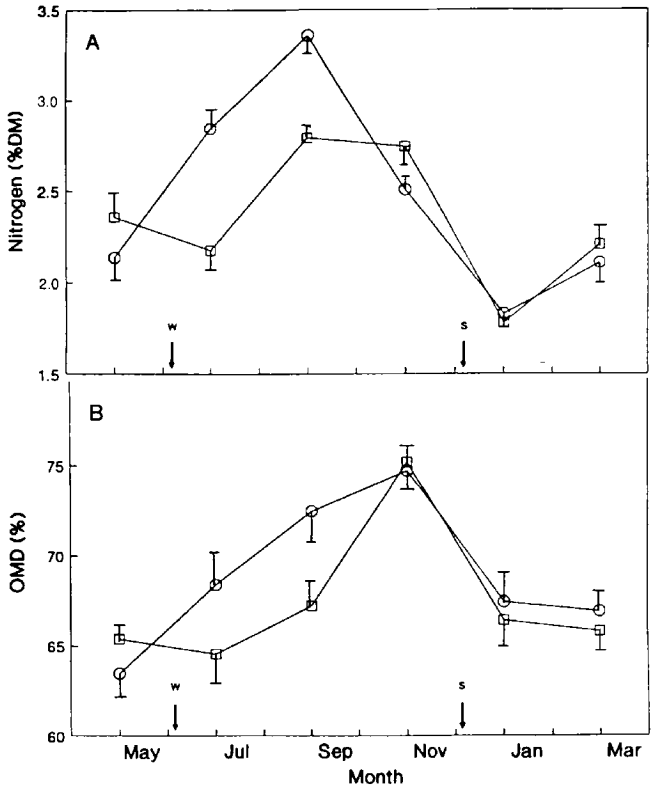

Fig. 3A Mean total nitrogen concentration (%DM) of pastures grazed by sambar deer (○) and red deer (□) during the study; **3B** Mean herbage organic matter digestibility (% OMD) of pastures grazed by sambar deer (○) and red deer (□) during the study. S = summer solstice; W = winter solstice. Vertical bars represent SE.

during the morning and the middle of the day. By contrast, red deer actively grazed during the morning (0500–0700 h) and in the afternoon–early evening (1500–2000 h). Both species showed less active grazing during late morning–early afternoon (1000–1400 h).

Sambar deer and red deer had similar total grazing time (day + night, Table 1), with this being evident in all seasons, but grazing time for both species was less in spring ($P < 0.05$) than in other seasons. Sambar deer spent significantly longer grazing at night (+1.3 h, $P < 0.01$), and spent significantly less time grazing during the day (–1.6 h, $P < 0.01$) than red deer. The ratio night:day grazing was much higher for sambar deer (2.3:1.0) than for red deer (1.1:1.0; $P < 0.001$)) and there was no interaction between species of deer and season ($P > 0.05$).

During the day time, sambar deer spent more time resting (6.4 h/11 h, SE = 0.27; $P < 0.001$) compared

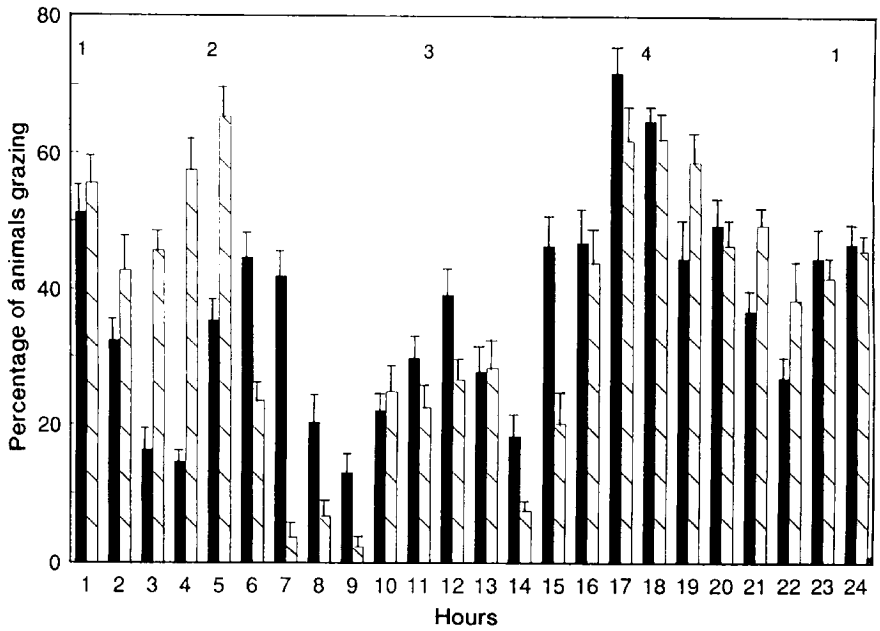

Fig. 4 Percentage of sambar deer (▨) and red deer (■) observed to be grazing at hourly intervals, over a 24-h period. Data are the means (SE) of observations made at bimonthly intervals, over a 12-month period (1, 2, 3, 4 = numbers of grazing cycles). Vertical bars represent SE.

Table 1 Annual and seasonal grazing time (h/24 h) of sambar deer and red deer.

	Sambar deer	Red deer	SE
Season			
Spring	7.8	7.1	0.41
Summer	9.4	10.7	0.65
Autumn	9.9	9.9	0.46
Winter	9.3	10.1	0.65
Mean over all seasons*			
Day time	2.9	4.5	0.25
Night time	6.2	4.9	0.25
Day + night	9.1	9.4	0.28
Night:day	2.3	1.1	0.15

*Mean values over all seasonal time observations

Table 2 Annual and seasonal grazing cycles per 24 h of sambar deer and red deer.

	Sambar deer	Red deer	SE
Seasonal			
Spring	5.2	3.2	0.51
Summer	4.0	4.0	0.81
Autumn	4.0	4.5	0.57
Winter	3.5	4.5	0.81
Mean over all seasons*			
Day time	1.4	1.7	0.13
Night time	3.2	2.3	0.19
Day + night	4.6	4.0	0.27

*Mean values over all seasonal time observations

to red deer (5.1 h/11 h, SE = 0.27), but there was no difference between the two species in ruminating time (2.1 versus 1.9/11 h, SE = 0.27).

Sambar deer tended to have a greater number of grazing cycles (day + night) than red deer in spring ($P < 0.05$; Table 2). Also, sambar deer had more grazing cycles at night (+0.9, $P < 0.05$) and less (–0.3, $P < 0.10$) during day time than red deer.

Mean rate of prehending biting was greater in sambar deer than in red deer ($P < 0.001$) and the difference was consistent in all months (Table 3).

Table 3 Rate of prehending biting (number/minute) of sambar deer and red deer.

	Sambar deer (SE)	Red deer (SE)
Month		
May 1990	61.7 (1.31)	42.8 (0.99)
Jul 1990	68.0 (1.49)	49.9 (1.08)
Sep 1990	72.4 (1.45)	50.8 (1.19)
Oct 1990	69.3 (1.28)	47.6 (1.09)
Nov 1990	52.4 (1.13)	39.9 (1.01)
Jan 1991	59.7 (1.14)	51.0 (0.89)
Mar 1991	67.7 (1.11)	52.1 (0.97)
Mean	64.5 (0.48)	47.7 (0.39)

DISCUSSION

Sambar deer and red deer had different grazing patterns (Fig. 4; Table 1); sambar deer grazed mainly in the night, late afternoon, and late evening, whereas red deer grazed mainly during the morning and afternoon–early evening. These patterns were stable with season and month of the year. The commencement and cessation of grazing in sambar deer was closely related to sunset and sunrise, as reported by Kitchener (1961) and Bentley (1978). On the other hand, the feeding behaviour of red deer did not show a close relationship with the sunset/sunrise cycles.

Belovsky & Slade (1986) in the United States, and Clutton-Brock et al. (1982) in Scotland found similar foraging behaviour in red deer as recorded here. Such a marked behavioural difference between sambar deer and red deer species in the same environment may reflect the evolution of different strategies for survival in their natural habitats. Nocturnal activity is characteristic of tropical deer such as chital (*Axis axis*, Dinnerstein 1979; Mishra 1982) and Bawean deer (*Axis kuhli*, Blouch & Atmosoedirdjo 1987), and has been inferred for sambar deer in Sri Lanka (Santiapillai et al. 1981). Nocturnal foraging by large African herbivores appears to be in part a thermoregulatory adaptation (Owen-Smith 1988), avoiding grazing in the heat of the day. Thus nocturnal foraging patterns may have reduced the thermoregulatory challenge for sambar deer evolving in their normal tropical habitat. Selection for behaviour to avoid predators may also have contributed to nocturnality in sambar deer (Kitchener 1961; Johnsingh 1983; Rice 1986). The discovery that red deer may be nocturnal in the Mediterranean area (Carranza et al. 1991) indicates that temporal foraging patterns in this species may vary with environmental conditions.

The amount of time spent grazing by both species was within the range found for domesticated ruminants, but was less than for wild red deer recorded by Clutton-Brock et al (1982) (Table 4). Day length, ambient temperature, pasture availability, and the composition, maturity, and water content of pasture all influence grazing time (Black 1990). The shorter grazing time found here for red deer resulted from higher food availability compared with that on the island of Rhum (Clutton-Brock et al. (1982), or is the product of more frequent grazing/ruminating cycles. We observed four grazing cycles/24 h, double that reported by Clutton-Brock et al. (1982) and Belovsky & Slade (1986). Our finding that sambar deer completed 4.6 cycles/24 h is the first record of grazing cyclicity in tropical deer. Both species spent least time grazing in spring when pasture mass and nutritional value were highest.

The rate of prehending biting was 35% faster in sambar deer than in red deer and comparable with rates measured in cattle, whereas red deer exhibited rates similar to sheep (Table 5). Prehending biting does not change greatly with sward type in domestic sheep and cattle (Forbes 1982), and did not vary with

Table 4 Time spent grazing (h/24 h) for several domesticated and wild ruminant animals compared to the present study.

Species	Grazing time (h/24 h) Mean	Range	Method of study	Authors
		Domesticated		
Suckling cows		5–12		Dulphy et al. (1980)
Dairy cows		6–11		
Sheep		3–13		
Sheep	8	7.8–11	Focal	Bueno & Ruckebusch (1979)
Sheep	9	4.4–10.6	Scanning	Arnold (1984/85)
Horses	11.3	4.1–16.0		
Cattle	7.7	2.3–12.7		
Sambar deer	9.1	8.5–9.7	Scanning	Present study
Red deer	9.4	8.8–10.0	Scanning	Present study
		Wild		
Red deer				
Hinds		11.1–11.8	Focal	Clutton-Brock et al. (1982)
Stags		10.4–12.9		

Table 5 Rate of prehending biting (number/min) among several domesticated animals compared to the present study.

Species	Value		Authors
	Mean	Range	
Sheep		48–52	Forbes (1982)
Cattle		60–62	
Red deer:			
Stags		50–68	Clutton-Brock et al. (1982)
Hinds		54–66	
Red deer:			
Stags	44.2	43.6–44.7	Present study
Hinds	51.3	50.8–51.8	
Sambar deer:			
Stags	66.2	65.5–66.9	Present study
Hinds	62.7	62.9–63.4	

changes in the sward in wild red deer (Clutton-Brock et al. 1982). As there was no difference in pasture height or mass between areas grazed by either sambar deer or red deer in any season of the year (Fig. 2), it seems that 8 sambar deer and 9 red deer produced similar grazing pressure, accounting for the larger size of sambar deer. However, grazing by sambar deer at the time of lowest herbage availability (winter) produced pastures of higher OMD and total N content than pastures grazed at this time by red deer. The difference in bite rate may further reflect differences in grazing strategy between sambar deer and red deer, perhaps including bite depth and bite size, which should be measured in future studies and related to diet selection.

The faster rate of biting and longer night grazing show that sambar deer have evolved a different grazing strategy to red deer. Diet selection and dietary preference studies are currently being undertaken to investigate if their different grazing strategy has resulted in sambar deer being more or less selective than red deer.

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