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Ranging Behaviour of Hanuman Langurs (*Semnopithecus entellus*) in Three Different Habitats

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Abstract: We studied the ranging patterns of three troops of Hanuman langur (*Semnopithecus entellus*) in Kumbhalgarh Wildlife Sanctuary, 200 km south of Jodhpur, in the western Aravalli Hills of Rajasthan, India. The home ranges were 106, 45, and 70 ha. This study suggests that the availability of preferred foods, including farm crops and provisioned food, determine the day range of langurs. Comparison of the day ranges of these troops suggests that langurs will raid crops whenever the opportunity is available. They also readily accept foods supplied by humans. Their exploitation of these foods reduces day lengths and range size compared with troops living in forested areas.
Key Words: Ranging behavior, *Semnopithecus entellus*, Kumbhalgarh Wildlife Sanctuary

Introduction

The home range is the area normally traversed by an individual or group of animals during activities associated with foraging, resting, mating, and shelter seeking (Burt 1943). The ways in which primates use their home ranges vary enormously. Groups of the same species may differ in their ranging temporarily or permanently, during different times of the day, different seasons, and years, besides showing spatial differences across habitats. A number of factors such as the quality and abundance of food items, their distribution in time and space, the size and composition of the foraging group, body weight, and population density may influence the ranging behavior of primates (Dunbar 1988). Human influences such as provisioning (Wada 1983), and habitat disturbance, such as logging (Johns 1983), also strongly affect home range size and ranging behavior. In Hanuman langurs, home ranges often overlap, even quite extensively. In bisexual troops home ranges can vary from 7 to 1,300 ha, and can be even larger for all-male bands—430 to 2,200 ha (Jay 1965; Sugiyama *et al*. 1965; Vogel 1971; Mohnot 1974; Roonwal and Mohnot 1977; Rajpurohit 1987; Srivastava 1989; Rajpurohit and Sommer 1993; Bennett and Davies 1994; Chalise 1995; Schuelke 1998; Chhangani 2000).

We recorded the ranging behavior of three troops of Hanuman langur at the Kumbhalgarh Wildlife Sanctuary (KWS) in northwestern India. Although living in areas that appear generally similar, the langurs confront subtle differences in a number of ecological aspects that affect the resources available to them.

Methods

Study site

The Kumbhalgarh Wildlife Sanctuary (KWS) of 585 km² is between 20º05′ and 23º3′N, and 73º15′ and 73º45′E, 200 km south of Jodhpur in the western Aravalli Hills of Rajasthan, India (Fig. 1). Altitude ranges from 288 m to 1,215 m a.s.l. KWS has distinct winter, summer and monsoon seasons. Summer temperatures generally fluctuate between 30ºC and 35ºC, but can get as high as 46ºC during May and June. The mean temperature in winter is 5ºC, and it can be as cool as 2ºC in December–January. The average annual rainfall during the 4-year study period was 725 mm: maximum 950 mm and minimum 403 mm (Chhangani 2000). The forest is broadly dry deciduous or woodland type, dominated by gorya dhawa (*Anogeissus latifolia*), salar (*Boswellia serrata*), gol (*Lannea coromandelica*), kherni (*Wrightia tinctoria*), dhawa (*Anogeissus pendula*), kumbat (*Acacia senegal*), khair (*Acacia catechu*), ber (*Ziziphus mauritiana*), and dhonk (*Butea monosperma*). The undergrowth consists mainly of jharber (*Ziziphus nummerlaria*), ardnsa (*Adhatoda vasica*), gangan (*Grewia tenex*), franger (*Grewia flavescens*), kanter (*Capparis*

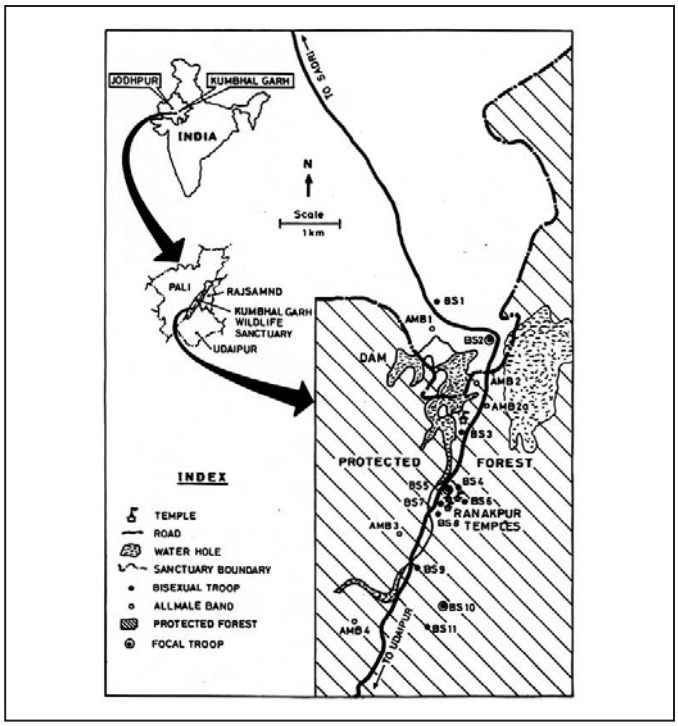

Figure 1. Location of Hanuman langur troops and bands in Kumbhalgarh Wildlife Sanctuary.

Table 1. Home ranges of the three focal Hanuman langur troops BS-2, BS-5 and BS-10. during the period January 1996–December 1999.

Troop	Size	Approximate home range size (ha)
Savika BS-2	38–43	106
Ranakpur temple BS-5	31–37	45
Forest BS-10	32–34	70

separaia), and lantana (*Lantana camara*). Some climbers and grasses are also found.

Other notable animals of the KWS include leopard (*Panthera pardus*), hyaena (*Hyaena hyaena*), Indian wolf (*Canis lupus*), jackal (*Canis aureus*), sloth bear (*Melursus ursinus*), four-horned antelope (*Tetracerus quadricornis*), chinkara (*Gazella g. bennetti*), porcupine (*Hystrix indica indica*), samber (*Cervus unicolor*), blue bull (*Boselaphus tragocamelus*), toddy cat (*Paradoxorus hermaphordiatus*), jungle cat (*Felis chaus*), fox (*Vulpes bengalensis*), crocodile (*Crocodilus palustris*), and rock python (*Python molurus*).

Study groups and ranging

The three focal troops of this study were the Savika troop (BS-2), the Ranakpur temple troop (BS-5) and the Forest troop (BS-10) (Table 1). The home ranges of these troops were plotted on the basis of the marked quadrates they used (each quadrate was 100 m × 100 m). Quadrate numbers and the position of the animals were recorded at the point between every two focal samples. The study period was January to December 1996. Day range size was calculated by the number of quadrates used from dawn to dusk and was recorded for a minimum of eight consecutive days (range, 8–10 days) in a month.

Results

Home range and day range

During the study period (January–December 1996), the Savika troop (BS-2) used 106 quadrates; a home range of approximately 106 ha. Similarly, the Ranakpur temple troop (BS-5) and the Forest troop (BS-10) used 45 and 70 quadrates, respectively; home ranges of 45 ha and 70 ha (Table 1).

Savika troop (BS-2): The number of quadrates used per day by the Savika troop (BS-2) ranged from 10 to 30, and the annual mean day range size was 21.1 ha. The smallest number of quadrates were used in April (mean of eight days: 17.8) and maximum number of quadrates in June (mean of eight days: 26.3) (Table 2; Fig. 2).

Ranakpur temple troop (BS-5): During the study period the number of quadrates used per day by the Ranakpur temple troop (BS-5) varied from 6 to 22, and the annual mean day range size was 12.27 ha. The smallest numbers of quadrates were used in January (mean of 8 days: 8.3) and the maximum number of quadrates in July (mean of 8 days: 16.1) (Table 3; Fig. 3).

Forest troop (BS-10): The total number of quadrates used by the Forest troop (BS-10) ranged from 9 to 28, and the annual mean day range size was 19.74 ha. The smallest number of quadrates were used in March (mean of 8 days: 15.8), and the maximum number in July (mean of 8 days: 23.0) (Table 4; Fig. 4).

The langur troops traveled most during the months of June and July. This is probably related to food shortage—April, May, June, and July are the driest months in KWS—and animals are forced to move over a wider area to procure food and water.

Factors influencing ranging pattern

The availability of food in the home range, its distribution, and type and abundance in time and space influence day range size. In this study we recorded the percent time spent in eating different types of food and compared them with day range size and number of quadrates used by the three focal troops in different months. For this we took the largest and smallest day range traveled in each month by the three different troops. We also calculated the percent time dedicated to their natural diet and to crops by the Savika troop (BS-2), and the percent time dedicated to natural food and provisioned food by the Ranakpur temple troop (BS-5). We also calculated the percent time dedicated to different plant parts, such as leaves, flowers, and fruits by the forest troop (BS-10) on each of those days.

The Savika troop (BS-2) covered 26.08 quadrates (range, 22–30) every month in their largest day range. On these days 78% (range, 61.9%–92.6%) of their feeding was dedicated to their natural diet, and 21.9% (range, 7.4%–38.1%) to crops. They covered 15.8 (range, 10–21) quadrates every month on the smallest day range when 56% (range, 45.1%–68.9%) of their feeding was dedicated to their natural diet, and 44% (range, 26.3%–54.9%) to crops. This clearly suggests that Savika troop BS-2 had a larger day range when eating more

of their naturally occurring food than when they were raiding crops. The details of the largest and smallest day ranges and relative proportions of feeding time spent on naturally occurring foods and crops are given in Tables 5 and 6.

The Ranakpur temple troop (BS-5) traveled a mean of 16.9 (range, 11–25) quadrates, when their diet was composed of 65% naturally occurring foods and 35% provisioned food. The smallest average day range was 7.9 (range, 6–12) quadrates, and the diet averaged 57% naturally-occurring foods and 43% provisioned food, indicating that they tended to travel less on days when they spent more time eating provisioned foods (see Tables 7 and 8).

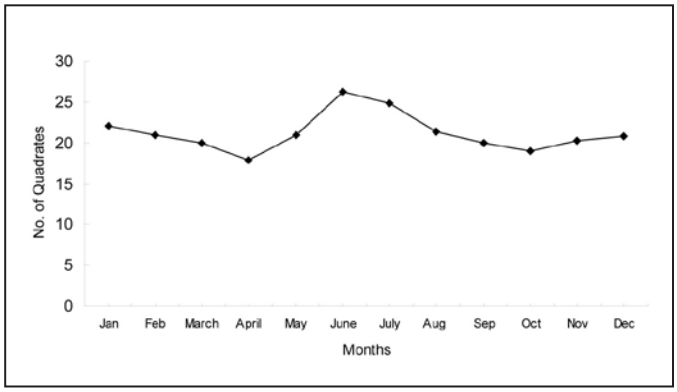

Figure 2. Mean monthly use of quadrates by troop BS-2 in 1996.

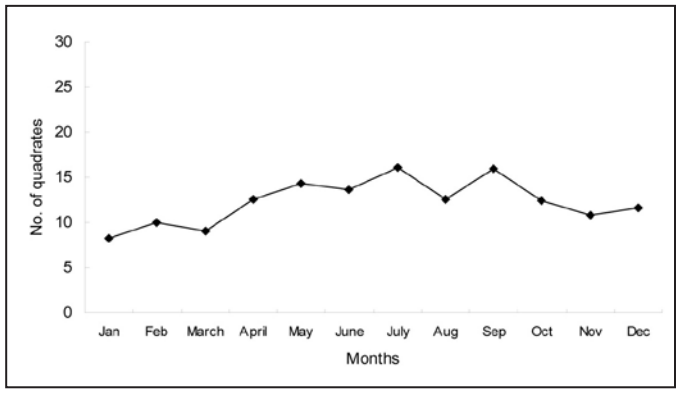

Figure 3. Mean monthly use of quadrates by troop BS-5 in 1996.

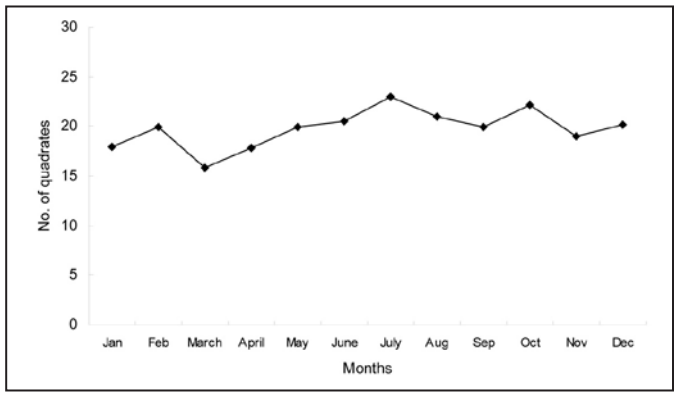

Figure 4. Mean monthly use of quadrates by troop BS-10 in 1996.

The day range size of the forest troop (BS-10) tended to be larger (mean, 24.4 quadrates used) when the troop ate more flowers (28%) and fruits (42%) and fewer leaves (26%). The BS-10 troop traveled over smaller day ranges (mean, 14.5

Table 2. Number of quadrates used by the Savika Hanuman langur troop (BS-2) during 1996.

Observation days	1	2	3	4	5	6	7	8	Mean
Months	Quadrates used								
January	18	19	20	21	24	28	25	21	22.0
February	19	21	20	19	20	29	19	20	20.9
March	17	18	15	21	24	23	20	21	19.9
April	18	22	14	12	21	18	22	15	17.8
May	14	20	19	26	22	19	26	21	20.9
June	20	25	27	23	28	30	27	30	26.3
July	28	22	25	21	27	22	28	26	24.9
August	19	22	18	27	16	19	28	21	21.3
September	10	21	15	27	19	23	20	24	19.9
October	20	21	19	13	16	20	22	21	19.0
November	16	19	18	28	20	24	18	19	20.3
December	23	19	22	18	24	16	22	22	20.8

Table 3. Number of quadrates used by the Ranakpur temple Hanuman langur troop (BS-5) during 1996.

Observation days	1	2	3	4	5	6	7	8	Mean
Months	Quadrates used								
January	8	7	11	10	9	6	8	7	8.3
February	13	10	11	8	10	9	12	7	10.0
March	11	8	7	10	9	12	8	8	9.1
April	10	12	9	16	11	15	12	16	12.6
May	18	14	17	18	13	16	11	7	14.3
June	8	15	12	18	14	19	13	10	13.6
July	21	18	15	19	12	16	15	13	16.1
August	9	12	17	14	10	15	11	13	12.6
September	25	9	19	11	22	19	13	9	15.9
October	6	14	10	9	17	11	15	17	12.4
November	16	9	14	7	11	9	11	9	10.8
December	18	8	12	10	13	12	9	11	11.6

Table 4. Number of quadrates used by the Forest Hanuman langur troop (BS-10) during 1996.

Observation days	1	2	3	4	5	6	7	8	Mean
Months	Quadrates used								
January	15	20	14	22	18	16	21	17	17.9
February	17	18	21	15	24	20	23	21	19.9
March	25	9	19	22	18	9	13	11	15.8
April	18	20	18	12	19	21	14	20	17.8
May	21	10	27	15	23	19	24	20	19.9
June	16	22	24	18	23	20	19	22	20.5
July	28	22	20	25	22	21	26	20	23.0
August	14	21	25	19	26	18	20	25	21.0
September	17	21	20	19	22	18	23	19	19.9
October	18	21	19	20	28	23	26	22	22.1
November	20	19	21	13	16	20	22	21	19.0
December	16	18	23	19	23	18	20	24	20.1

Table 6. Savika troop (BS-2): The smallest day range size in each month and percent time dedicated to their natural and cultivated food on those days (Chhangani, 2000).

Months	Quadrates used	Natural food (%)	Cultivated food (%)
January	18	51.2	48.8
February	19	65.3	34.7
March	15	50.6	49.4
April	12	45.4	54.6
May	14	53.5	46.5
June	20	68.9	31.1
July	21	73.7	26.3
August	16	60.5	39.5
September	10	48.9	51.1
October	13	45.1	54.9
November	16	50.7	49.3
December	16	58.2	41.8
Mean	**15.08**	**56**	**44**

Table 7. Ranakpur temple troop (BS-5): Largest day range in each month by and percent time dedicated to their natural and provisioned food on those days (Chhangani, 2000).

Months	Quadrates used	Food consumption (%)	
		Natural	Provisioned
January	11	53.4	46.6
February	13	58.1	41.9
March	12	64.5	35.5
April	16	70.5	29.5
May	18	73.8	26.2
June	19	71.3	28.7
July	21	74.6	25.4
August	17	62.8	37.2
September	25	69.7	30.3
October	17	57.2	42.8
November	16	61.3	38.7
December	18	59.4	40.6
Mean	**16.9**	**65**	**35**

Table 8. Ranakpur temple troop (BS-5): Smallest day range in each month and percent time dedicated to their natural and provisioned food on those days (Chhangani, 2000).

Months	Quadrates used	Food consumption (%)	
		Natural	Provisioned
January	6	41.8	58.2
February	7	37.6	62.4
March	7	56.7	43.3
April	9	62.2	37.8
May	7	64.9	35.1
June	8	58.2	41.8
July	12	73.3	26.7
August	9	66.6	33.4
September	9	68.5	31.5
October	6	52.4	47.6
November	7	55.1	44.9
December	8	46.8	53.2
Mean	**7.9**	**57**	**43**

quadrates used) when they ate relatively more leaves (62%) and fewer flowers (16%) and fruits (20%) (see Tables 9 and 10).

Sleeping sites

All groups tended to use large trees for their sleeping sites in limited portions of their home ranges (about 100–150 m²). Sites were one large tree, or two to six small trees, or a combination. The Savika troop (BS–2) used four sleeping sites during the year: all were along the road. Of these, one was a single *Ficus benghalensis* tree, and the other three sites were three to five *Azadirachta indica*, *Ficus racemosa*, and *Eucalyptus camaldulensus* trees (Table 11). The Ranakpur temple troop (BS-5) used three sleeping sites: two were a single large tree, one was *Ficus benghalensis* and the other was a *Tamarindus indica*, whereas the third site was two trees — *Tamarindus indica* and *Azadirachta indica* (Table 11). The Forest troop (BS-10) used five sleeping sites, all of them of two to six trees, including *Lannea coromandelica*, *Boswellia serrata*, *Azadirachta indica*, *Albizia procera*, and *Anogeissus latifolia*. The

Table 9. Forest troop BS-10: Largest day range in each month and percent of feeding time dedicated to leaves, flowers, and fruits on those days (Chhangani, 2000).

Months	Quadrates used	Percent consumption of plant parts			
		Leaves	Flowers	Fruits	Others
January	22	28.4	56.3	7.2	8.1
February	24	25.4	68.7	1.4	4.5
March	25	31.9	60.3	6.3	1.5
April	21	28.4	51.6	18.2	1.8
May	27	18.4	21.9	56.2	3.5
June	24	12.9	15.8	68.2	3.1
July	28	13.6	15.2	70.5	0.7
August	26	29.4	8.2	61.4	1
September	23	39.5	5.3	49.7	5.5
October	28	24.6	7.3	59.2	8.9
November	20	32.5	8.4	55.4	3.7
December	24	35.4	9.6	51.3	3.7
Mean	**24.3**	**26**	**28**	**42**	**4**

Table 10. Forest troop BS-10: Smallest day range in each month and percent of feeding time dedicated to leaves, flowers and fruits on those days (Chhangani, 2000).

Months	Quadrates used	Percent consumption of plant parts			
		Leaves	Flowers	Fruits	Others
January	14	58.2	28.4	12.5	0.9
February	15	54.5	31.4	8.9	5.2
March	9	73.4	20.7	4.3	1.6
April	12	69.5	18.5	9.6	2.4
May	10	71.6	14.8	12.6	1
June	16	65.3	6.4	21.8	6.5
July	20	58.4	9.4	29.2	3
August	14	67.3	8.9	19.7	4.1
September	17	57.9	12.5	29.1	0.5
October	18	49.2	19.2	31.4	0.2
November	13	64.4	13.4	21.3	0.9
December	16	51.9	11.2	35.2	1.7
Mean	**14.5**	**62**	**16**	**20**	**2**

heights of the sleeping trees of the three groups ranged from 6 to 20 m (Table 11).

Shifting sleeping sites

Temporary shifts in sleeping sites were observed on a number of occasions in bisexual (including the three focal groups) as well as all-male bands. Sleeping site "b" of the Savika troop (BS-2; see Table 11) was next to a farm: the troop moved there to raid the maturing crops. When chased by the farm owners and their dogs they would revert to sleeping sites "a" and "c." The temple guards would chase the Ranakpur temple troop (BS-5) from sleeping site "a," because they would spoil their offices. Sleeping sites used by the Forest troop (BS-10), on the other hand, were evidently related to the presence of predators. The toddy cat (*Paradoxorus hermaphordiatus*), for example, would cause females carrying infants to move to the canopy or thin branches of neighboring high trees). Larger predators would result in the troop moving to a different sleeping site the next day, choosing especially the thin branches of such high trees as *Lannea cormandelica* or *Anogeissus latifolia*. Some trees, such as *Ficus benghalensis*, have branches that are big and low and easier for panthers (*Panthera pardus*) and other cats to climb. Other reasons for shifting sleeping sites included attacks by honeybees (*Apis dorseta*) and Black-rumped Flameback (*Dinopium benghalense*). Although roaming bands of male langurs would sometimes sleep with the bisexual troops, at other times they could be the cause for them to move away. Two large troops (B-8 with 113 and B-9 with 74 individuals), for example, would often flee when confronted by an all male band (AMB4) of only 21 individuals.

Discussion

A number of factors are responsible for variation in the langur home range size, including availability and abundance of food, the availability of agricultural crops and provisioned food, group size and composition, population density, predator pressure, and agricultural activity and human interference, besides other environmental factors (see, for example, Jay 1965; Clutton-Brock 1977; Isbell 1983; Kimura 1999; Masaaki and Imaki 1999). Hanuman langur troops are hardy and adaptable, and the availability of food and its distribution is the major factor (Raemakers 1980; Marsh 1981; Isbell 1983; Bennett 1986; Newton 1992), as we found at KWS.

In this study, the home range used by the Ranakpur temple troop (BS-5) was 45 ha, which is similar to those of the garden troops of Jodhpur (60–96 ha) studied by Mohnot (1974) as well as at Kailana, Jodhpur (40 ha) (Agoramoorthy 1987), and Mt. Abu (38 ha) as found by Hrdy (1977). The home range of the Savika troop (BS-2) was larger at 106 ha and approximates to those found for the open habitats of Jodhpur (74–132 ha) by Mohnot (1974), Borries (1989) (100 ha) and Srivastava (1989) (150 ha). At Shimla, Sahoo (1993) estimated a mean home range for langurs in forest habitat to be 136 ha. The Forest troop (BS-10) was 70 ha, which is closer to that found for the langurs at Sariska National Park, Rajasthan (60 ha), studied by Vogel (1971).

The day range sizes of the three groups varied markedly and were influenced by resource availability (crops and provisioned food) besides habitat quality. The density and diversity of trees, shrubs and herbs varied considerably. More than 50% of dissimilarity was of vegetation found between troop BS-2 and troop BS-10. Tree felling, farming, human interference,

Table 11. Sleeping sites, sleeping trees and their heights for the three focal troops in KWS study area.

Focal troops	Sleeping site	No. of trees in the sleeping sites	Plant species serving as sleeping trees	Height of sleeping trees (m)
Savika troop (BS-2)	a	1	*Ficus benghalensis*	15
	b	1 2	*Ficus racemosa* *Eucalyptus camaldulensis*	12 18, 15
	c	2 2	*Azadirachta indica* *Eucalyptus camaldulensis*	8, 6 20, 18
	d	1 1 1	*Ficus benghalensis* *Azadirachta indica* *Eucalyptus camaldulensis*	15 10 18 +
Ranakpur Temple troop (BS-5)	a	1	*Ficus benghalensis*	17
	b	1	*Tamarindus indica*	14 +
	c	1 2	*Tamarindus indica* *Azadirachta indica*	16+ 12, 10
Forest troop (BS-10)	a	4	*Lannea cormandelica*	10–14
	b	2 2	*Boswellia serrata* *Anogeissus latifolia*	14, 16 12, 15
	c	1 1 1	*Lannea carmandelica* *Azadirachta indica* *Albizia procera*	12 10 12
	d	2 2 1	*Lannea carmandelica* *Boswellia serrata* *Albizia procera*	10, 14 12, 15 10
	e	2 2 1	*Anogeissus latifolia* *Lannea cormandelica* *Boswellia serrata*	10, 12 12, 15 13

Photo 1. Tourists offering food to langurs.

Photo 2. Flower (*Albizia procera*) feeding by langurs.

Photo 3. Fruit (*Bombax ceiba*) feeding by langurs.

Photo 4. Cultivated feeding by langurs.

grazing pressure, and predation were factors varied among the troops and were also considered when studying their feeding and ranging behavior (Chhangani, 2000). The differences in home range size between focal troops were quite evident, while, interestingly, the day range size in general was quite similar. The Ranakpur temple troop (BS-5) with a home range of 45 ha traveled through a mean of 12.27 ha with a mean of 16.9 quadrates on larger day ranges and mean 7.9 quadrates on smallest day ranges per day. Whereas troops BS-2 and BS-10 with larger home ranges sizes of 106 ha and 70 ha, maintained similar day ranges sizes, averaging 21.10 ha and 19.74 ha. Both troops showed almost similar means for their largest (means 26.08 [BS-2] and 24.4 [BS-10]) and their smallest day ranges (means, 15.8 [BS-2] and 14.5 [BS-10]).

Home range size differs widely in different distributional zones of *Semnopithecus entellus*, and we may tentatively generalize that they are more extensive in open habitats than in forest (Mohnot 1974; Roonwal and Mohnot 1977). Sugiyama *et al*. (1965) observed that sparse food availability forced langurs to travel more widely.

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