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Field Ecology and Behaviour of the Rhesus Macaque (*Macaca mulatta*): I. Group Composition, Home Range, Roosting Sites, and Foraging Routes in the Asarori Forest

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ABSTRACT. The data presented here resulted from about 1,100 observation hours in a nine-month field study of rhesus monkey from January to October 1976 in the Asarori Forest, Dheradun. Six groups were studied, the group size varied from 6–90 individuals. With the exception of one group, all were of the bisexual multimale type. The number of adult males per group varied from two to seven, and of adult females from 4 to 27. The adult sex ratio was male 1 to females 2.2–3.7 (mean 1:2.7). The exceptional group originally consisted of five juveniles only (3♂, 2♀); later on an adult male joined the group. Home ranges varied from 1.3–13.4 km^2 and overlapped extensively with another. The area of home range showed straight line relationship with group size. Roosting sites were not fixed but changed from night to night. The straight line distance between one night to the next varied from 75–2,500 m. Foraging routes per day ranged from 1,050–3,500 m (mean 1,803.3 $\pm$ 160.2). There is a significant relationship between the foraging route (L) and the straight line distance between roosting sites (D). The ratio D/L varies from 0.14–0.87.

INTRODUCTION

The rhesus macaque, *Macaca mulatta* (ZIMMERMANN) (Primates: Cercopithecidae), is common in Southeast Asia (see ROONWAL & MOHNOT, 1977, for detailed distribution). In recent years considerable field work has been done on this species in the wild state, but many lacunae in our knowledge still remain to be filled, especially regarding roosting sites, foraging routes, inter- and intra-group relations, social changes, etc.

In the present account are presented some new data on group size and composition, home ranges, roosting sites, and foraging routes, which were gathered by me during 1976 in the Asarori Forest (Dehra Dun Division, northern Uttar Pradesh). Observations on other aspects will be published later.

LOCATION AND MATERIAL

The Asarori Forest (ca. 30°15′ N latitude, 77°68′ E longitude) lies about 700 m above sea-level and 10 km southeast of Dehradun on the Saharanpur-Dehradun Road on the northern slopes of the Siwalik Hills facing the Himalayas (Fig. 1). The forest is of moist deciduous type, with sal (*Shorea robusta*) as the predominant tree. The climate is rather hot and dry in summer and freezing cold in winter. The average annual rainfall, about 165 cm, comes mostly in the monsoon months (mid-June to mid-September) and some winter rains are also received.

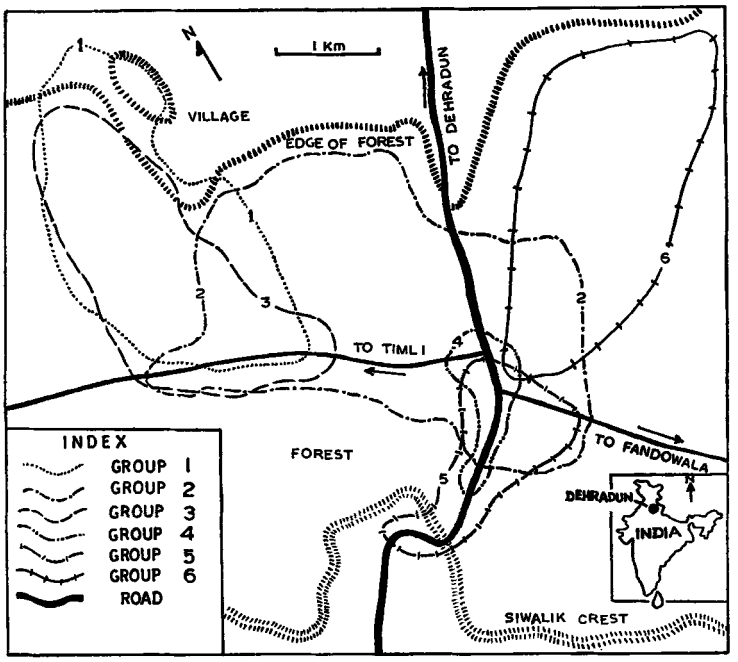

Fig. 1. Home ranges of six groups in the Asarori Forest, 1976.

Here there is an abundant population of the rhesus macaque—about 500 individuals gathered into 14 groups of varying sizes of which six were studied in detail. In addition, a small, scattered population of the Hanuman langur, *Presbytis entellus,* coexists with the rhesus. No other primates are found here.

For taking observations the author permanently lived in the forest almost continuously for a period of nine months, during January to October 1976, with a total of about 1,100 observation hours.

RESULTS

The six groups studied in detail were the Bada, Choki, Harbhajwala, Harbhajwala 'A', Rest House, and the Tibbet groups.

GROUP SIZE AND COMPOSITION

Group Size

Group size varied from small to very large (6 to ca. 90 individuals). Besides these, four isolated males were observed in the area; except one, all were very shy and showed flight behaviour at the approach of an observer.

Group Composition

The smallest group was composed of five juveniles (3 ♂, 2 ♀) in the beginning of the study period, but later on an outside adult male joined the group in the second

Table 1. Group composition of six groups in Asarori Forest (Dehradun), 1976.

Group name	Month of count (1976)	Group size	Group composition: Ad ♂	Ad ♀	SA	Ju	Infant 2	Infant 1	Adult sex ratio ♂:♀	Ratio Ad ♀: Infant 1
Bada	February	ca.90	7	27	←——56——→				1:3.7	—
Tibbet	May	38	5	11	5	5	7	5	1:2.2	1:0.4
Harbhajwala	May	31	3	7 (3 ♂, 2 ♀)	5	←—11—→		5	1:2.3	1:0.7
Harbhajwala 'A'	September	19	2	6	0	2	5	4	1:3.0	1:0.7
Rest House	July	13	2	4 (2 ♂, 1 ♀)	0	3	0 (3 ♂, 1 ♀)	4	1:2.0	1:1.0
Choki	August	6	1	0 (♀)	2 (2 ♂, 1 ♀)	3	0	0	—	—
Range		6–ca.90	1–7	0–27	—	—	—	—	1:2.2–3.7	1:0.4–1.0
Mean		32.8	—	—	—	—	—	—	1:2.7	1:0.7

Ad: adult. SA: Subadult. Ju: Juvenile. Infant 1: young infant, under one year of age. Infant 2: older infant, above one year.

week of August. (MAKWANA, in press). The remaining five groups were of the multimale bisexual type (size 13–ca. 90). The number of adult males in the groups varied from two to seven and of adult females from 4 to 27. The adult sex ratio was ♂1: ♀2.2–3.7. In four groups the mean ratio of adult females to "Infants-1"[1] was 1:0.7, which indicates high reproductivity (about 70%) in wild females.

During the course of study one adult male from the Rest House group disappeared in the second week of April; from the beginning it was sickly and may have died of some disease. In the Choki group a male juvenile was killed by a dog in the last week of March. These events, however, did not change the strength of the above groups, since an adult male (of unknown origin) joined the Rest House group in the second week of April (a little before the sickly male's death), and a juvenile female (also of unknown origin) joined the Choki group in the first week of April.

HOME RANGES

The boundaries of the home range of each group were determined on the basis of the outermost points visited by the group members as actually observed. Home ranges varied from 1.3 to 13.4 km² according to groups, and there was extensive overlapping, to the extent of 23.5–100% (mean 61.1%). The most extensive overlapping was in the case of the Choki group, whose home range lay entirely within the home ranges of neighbouring groups (Fig. 1).

Home Range and Group Size

Analysis shows that the area of a home range is correlated with group size, the correlation coefficient (r) being 0.936, which is significant ($p=0.01$), and a linear regression equation of home range (Y) on group size (X) worked out to $Y = 1.65 + 0.13X$ (Fig. 2).

1) Infants were separated into two categories, viz., "Infant-1" (up to ca. 1 year old and still being carried by the mother) and "Infant-2" (1–2 years old and, while feeding independently, still followed the mother).

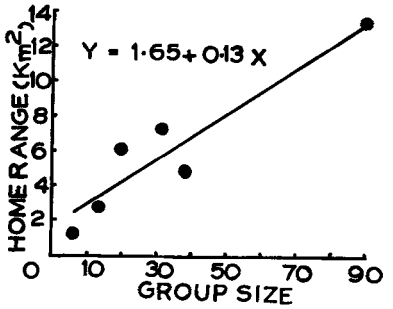

Fig. 2. Relationship of area of home range (Y) with group sizes (X) in six groups in the Asarori Forest, 1976.

Table 2. Area of home ranges (and percentage overlapped by six neighbouring groups) in Asarori Forest, 1976.

Group name	Home range (km²)	Area of home range (km²) (and percentage overlapped by other groups)						Total area of home range overlapped (and its percentage)
		Gr. 1	Gr.2	Gr.3	Gr.4	Gr.5	Gr.6	
Harbhajwala	7.2	—	2.26 (13.4%)	5.15 (71.5%)	—	—	—	5.93 (82.4%)
Bada	13.4	2.26 (16.9%)	—	2.54 (19.0%)	0.88 (6.6%)	1.00 (7.5%)	1.13 (8.4%)	5.54 (41.3%)
Harbhajwala 'A'	6.1	5.15 (84.4%)	2.54 (41.6%)	—	—	—	—	4.9 (80.3%)
Choki	1.3	—	0.88 (67.7%)	—	—	0.82 (63.0%)	0.06 (4.6%)	1.3 (100%)
Rest House	2.8	—	1.00 (35.7%)	—	0.82 (29.3%)	—	0.03 (10.7%)	1.44 (51.4%)
Tibbet	4.8	—	1.13 (23.5%)	—	0.06 (1.2%)	0.03 (0.6%)	—	1.13 (23.5%)
							Range	23.5–100%
							Mean	63.1%

Table 3. Area of home ranges and group sizes in six groups in Asarori Forest, 1976.

Group name	Group size	Area of home range (km²)	
		Of whole group	Per individual (including infants)
Bada	ca.90	13.4	0.15
Tibbet	38	4.8	0.13
Harbhajwala	31	7.2	0.23
Harbhajwala 'A'	19	6.1	0.32
Rest House	13	2.8	0.21
Choki	6	1.3	0.22

ROOSTING SITES

Roosting sites consisted of groups of tall trees on which the animals roosted for the night. The sites were not fixed (see below, Discussion), but changed from night to night, as noted in detail in two groups on consecutive nights for a period of over a month each.

The time of roosting and the duration of night rest varied with the season. In winter

the monkeys started roosting about 5.00 p.m. and in summer about 5.45 p.m. They woke up at dawn but came down from the roosting trees about 9.30 a.m. in winter and 7.15 a.m. in summer. The time between waking and descending is spent in mutual grooming, sunning, etc.

Roosting Area

Within a home range certain areas are most used by a group for roosting; these areas may be called "roosting areas". In the two groups studied, the roosting areas comprised 45% and 49% of the home range, suggesting that the percentage is nearly constant irrespective of the actual size of the home range. The pattern of roosting may, however, vary from group to group. Thus, in the Harbhajwala group it is more or less concentrated (68% of the sites lie in one area, Fig. 3), while in the Bada group (almost all sites are widely scattered, Fig. 4).

Distance between Individual Roosting Sites

As studied in two groups for 30 and 33 consecutive nights, the straight line distance between consecutive roosting sites varied considerably from night to night, from 75–2,500 m (mean values: 431±56 in the Harbhajwala group and 1,247.5±110 in the Bada group). Thus, the mean distance is nearly three times longer in the later. This

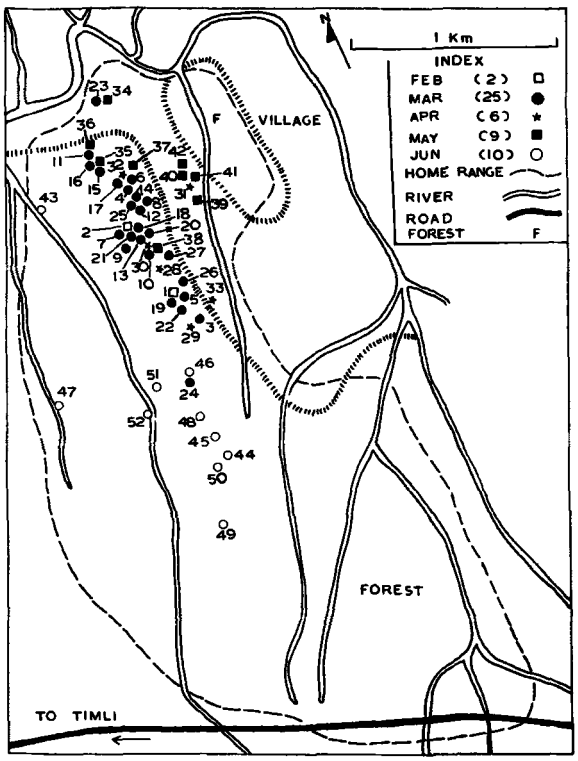

Fig. 3. Roosting sites of the Harbhajwala group for 52 days (March–June, 1976) in the Asarori Forest.

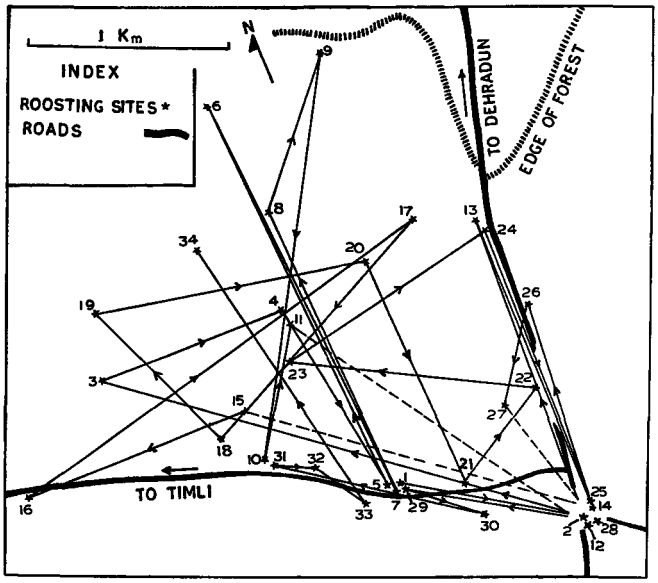

Fig. 4. Straight line distance of roosting sites of the Bada group for 30 consecutive nights (16 January to 23 February, 1976) in the Asarori Forest.

difference seems to be directly correlated with the size of the home range, which is 13.4 km^2 for the Bada group and 7.4 km^2 for the Harbhajwala group.

FORAGING ROUTES

To determine the relationship between the straight line distance of the roosting sites on consecutive nights and the lengths of the daily foraging routes for the corresponding day, observations were made on the Bada group for 15 days in February. The group was followed from dawn to dusk and the foraging routes were marked on a forest map with reference to the central (main) group (Fig. 5). The length of the foraging routes ranged from 1,050–3,500 m (mean 1,803.3$\pm$160.2).

Correlation between Roosting Sites and Foraging Route

It appears that the length of the foraging route (L) also determines the straight line distance (D) between two consecutive roosting sites for the day, and the two are closely related. The correlation coefficient (r) is 0.63, which is significant ($p = 0.01$), and a linear regression equation of L on D worked out to $Y = -1.11+0.6\ X$ (Fig. 6). The ratio D/L rises with the increase of D up to about 1,200 m, and then levels off.

DISCUSSION

Group Sizes

Group sizes have been recorded in both forest, urban, and semiurban areas by a number of workers, e.g., SOUTHWICK et al. (1965), JAY and LINDBURG (1965), MUKHERJEE and GUPTA (1965), NEVILLE (1968), SINGH (1969), LINDBURG (1971), and MAKWANA (present account) in forests; and by PRAKASH (1962), SOUTHWICK et al.

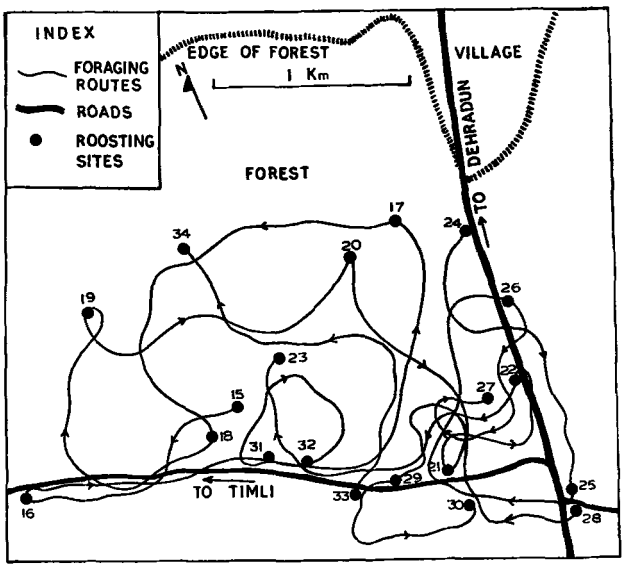

Fig. 5. Foraging routes of the Bada group for 15 days (February, 1976) in the Asarori Forest.

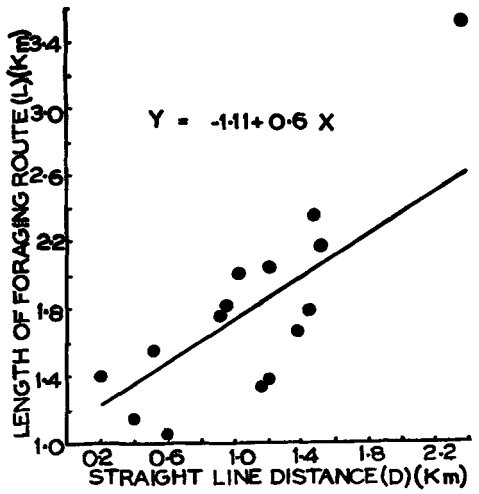

Fig. 6. Relationship of length of foraging route (L) with straight line distance (D) for 15 days in the Asarori Forest, 1976.

(1965), and MUKHERJEE and MUKHERJEE (1972) in urban and semiurban areas. The mean group size varies from about 9.8–41 (50 in one case) in forests and 10–42 in urban areas, from which it is evident that there is no marked difference between group sizes in these two habitats, as has been claimed by some workers.

Group Composition

As studied by various workers in the field, group composition varies fairly widely, a group usually consisting of one to several adult males, several adult females, and a

number of subadults, juveniles, and infants. Most of the groups recorded are of the multimale type, with up to eight adult males and 27 adult females. One of my groups in the Asarori Forest (the Bada group, ca. 90 individuals) contained seven adult males and 27 adult females. All male groups (which are common in the Hanuman langur, *Presbytis entellus*) seem to be wanting in the rhesus. Occasionally, groups without adult males occur (NEVILLE, 1968). One of my groups in the Asarori Forest, the "Choki" group, was initially a small group of five juveniles only, but was later on joined by an outside male. The published data are unfortunately inadequate to state whether group composition in the rhesus has any relationship with ecological habitat.

Adult Sex-ratio

Adult male-female ratios are available in several published works, a summary of which is given in Table 4. It is seen that females are more numerous in forests than in urban and semiurban areas.

Home Range

The home ranges of the rhesus, as recorded by several workers, vary widely (1–16 km^2, see ROONWAL, 1976) and neighbouring ranges often overlap extensively.

In the Asarori Forest, as shown above, the size of the home range is closely correlated with the group size. Field data from other sources are not adequate enough to determine whether the same correlation exists elsewhere.

Roosting Sites

The characteristics of roosting sites have been discussed by a number of workers: SOUTHWICK et al. (1965) in temple areas in Aligarh town, SINGH (1969) in urban areas, and LINDBURG (1971) in the Asarori Forest (the same area as mine). SOUTHWICK et al. and SINGH noted that roosting sites in urban situations are fixed, a group returning night after night to that site. In forest situations, however, the data of LINDBURG as well as my own indicate that the roosting sites change from night to

Table 4. Adult sex-ratios in forest and in urban and semiurban habitats (From various sources).

Source		Adult ♂:♀ ratio
Forest Habitats		
SOUTHWICK et al. (1965)...5 groups		1:3.4
MUKHERJEE & GUPTA (1965)...28 groups		1:3.5
NEVILLE (1969)...6 groups		1:2.4
LINDBURG (1971)...8 groups		1:3.3
MAKWANA (present account)...6 groups		1:2.7
	Range	1:2.4–3.5
Urban and Semiurban Habitats		
SOUTHWICK et al. (1965)...230 groups		1:2
MUKHERJEE (1969)...2 groups		1:1.6
SINGH (1969)... Certain		1:2.0
MUKHERJEE & MUKHERJEE (1972)...83 groups		1:2.0
	Range	1:1.6–2.0

night. According to my data, the straight line distance between consecutive roosting sites varies from 75–2,500 m (mean 431±56 in the Harbhajwala group and 1,247.5± 110.4 in the Bada group); LINDBURG's (1971) figures were 100–2,850 m (mean 785).

As discussed above, the mean distance between consecutive roosting sites seems to vary directly with the size of the home range. Further, it seems (from my limited data) that the total roosting area of a group comprises a little less than half (45–49%) of the home range (Figs. 3 & 4). Unfortunately, there are no observations in this aspect by other field workers, and so comparisons are not possible.

Foraging Routes

The length of the foraging routes in the Asarori Forest varied from 1,050–3,500 m (mean 1,803.3±160.2). In the same area, LINDBURG (1971) gave the length as 350–2,820 m (mean 785). Similar data are also available for some other primates, e.g., for the langur, *Presbytis entellus* (360 m, SUGIYAMA, YOSHIBA, & PARTHASARTHY, 1965 and for the Bonnet macaque, *Macaca radiata* (1–3 km, RAHMAN & PARTHASARTHY, 1969).

In the Asarori Forest, foraging routes (L) are always longer than the straight line distance (D) between consecutive roosting sites for the corresponding day, and a relationship exists between the two (Fig. 5). The ratio D/L is not constant but varies from 0.14–0.87 (mean 0.59±0.5) and seems to increase with the length of the foraging route. Such data on the rhesus are not available for other areas or for other Indian species.

SUMMARY

1. The data presented here resulted from a nine-month long study (totaling about 1,100 observation hours) in the Asarori Forest near Dehradun in Uttar Pradesh at the foot of the Himalayas.

2. Six groups were studied in detail. Group size varied from 6–90 individuals.

3. With one exception, all groups were of the multimale bisexual type. The number of adult males per group varied from 2–7, and of adult females from 4–27. The adult sex ratio was ♂ 1 to ♀ 2.2–3.7 (mean 1:2.7). The exceptional group originally consisted of five juveniles only (3 ♂, 2 ♀); later on an adult male joined the group.

4. Home ranges varied from 1.3–13.4 km² and overlapped extensively with one another. The area of the home range showed a straight line relationship with group size.

5. Roosting sites were not fixed but changed from night to night. The straight line distance between one night to the next varies from 75–2,500 m.

6. Foraging routes for the day ranged from 1,050–3,500 (mean 1,803.3±160.2). There is a significant relationship between the length of the foraging route (L) and the straight line distance between roosting sites (D). The ratio D/L varies from 0.14–0.87.

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REFERENCES

JAY, P. C., 1965. The common langur of North India. In: *Primate Behaviour: Field Studies of Monkeys and Apes*, I. DEVORE (ed.), Holt, Rinehart, & Winston, New York, pp. 197–247.

——— & D. G. LINDBURG, 1965. Quoted from LINDBURG, 1971.

LINDBURG, D. G., 1971. The rhesus monkey in North India: An ecological and behavioural study. In: *Primate Behaviour; Developments in Field and Laboratory Research*, Vol. 2, L. A. ROSENBLUM (ed.), Academic Press, New York, pp. 1–106.

MAKWANA, S. C., in press. Development and behaviour of an independent and stable all juvenile group. *Biology of Behaviour.*

MUKHERJEE, A. K. & S. GUPTA, 1965. Habits of rhesus macaque, *Macaca mulatta* (ZIMMERMANN) in the Sunderbans, 24-Parganas, West Bengal. *J. Bombay nat. Hist. Soc.*, 62: 145–146.

MUKHERJEE, R. P., 1969. A field study on the behaviour of two roadside groups of rhesus macaque, *Macaca mulatta* (ZIMMERMANN) in northern Uttar Pradesh. *J. Bombay nat. Hist. Soc.*, 66: 47–56.

——— & G. D. MUKHERJEE, 1972. Group composition and population density of rhesus monkey, *Macaca mulatta* (ZIMMERMANN) in Northern India. *Primates*, 13: 65–70.

NEVILLE, M. K., 1968a. Ecology and activity of the Himalayan foot-hill rhesus monkeys (*Macaca mulatta*). *Ecology*, 40: 110–123.

———, 1968b. A free-ranging rhesus monkey troop lacking adult males. *J. Mammal.*, 49: 771–773.

PRAKASH, I., 1962. Group organization, sexual behaviour and breeding season of certain Indian monkeys. *Jap. J. Ecol.*, 12: 83–86.

RAHMAN, H. & M. D. PARTHASARTHY, 1969. The home range, roosting places and the day ranges of the bonnet macaque (*Macaca radiata*). *J. zool.*, 157: 267–276.

ROONWAL, M. L., 1976. Dominance behaviour in South Asian Primates. *J. Sci. Industr. Res.*, New Delhi, 35: 244–260.

——— & S. M. MOHNOT, 1977. *Primates of South Asia: Ecology, Sociobiology and Behaviour.* Harvard Univ. Press.

SINGH, S. D., 1969. Urban monkeys. *Scientific Amer.*, 221: 108–115.

SOUTHWICK, C H., M. A. BEG, & M. R. SIDDIQI, 1965. Rhesus monkeys in north India. In: *Primate Behaviour: Field Studies of Monkeys and Apes*, I. DEVORE (ed.), Holt, Rinehart, & Winston, New York, pp. 111–159.

SUGIYAMA, Y., K. YOSHIBA, & M. D. PARTHASARTHY, 1965. Home range, mating season, male group and inter-troop relations in Hanuman langurs (*Presbytis entellus*). *Primates*, 6: 73–106.

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