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Changes in home ranges of rhesus monkey (*Macaca mulatta*) groups living in natural habitats*

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Abstract. Changes in home range size in 7 groups of rhesus monkeys were observed in urban and forest habitats in north India. In three groups home range size decreased due to either emigration or trapping of the alpha male. The average reduction in home range size was 30·48%. In one group the home range decreased from 1·12 km² to 0·46 km² after the removal of all group members except alpha male. The home ranges of 3 groups increased slightly due to disturbance caused (a) by elephants, (b) by trapping and (c) by conspecific group. The increase in the home range was for a short period (less than 15 days) as long as the disturbing variable was present. However, the decrease in home range due to loss of alpha male was almost permanent. The importance of the personality of alpha male and his personal experiences in the maintenance of home range has been discussed.

Keywords. Home range; alpha male rhesus; evolution; rhesus monkey; *Macaca Mulatta*.

1. Introduction

In primates the members of one group cooperate with others to live in a circumscribed area of a particular niche. This area is known as home range, and it remains stable for years except minor seasonal fluctuations (Altmann 1962; Simonds 1965; Lawick-Goodall 1967; Pirta 1977–78). Even small groups of infants reared under natural conditions develop their home ranges without any experience of adult individuals (Pirta and Singh 1978). In another study, Singh and Pirta (1978) reported an unusual movement of a bonnet (*Macaca radiata*) group out of its home range in which the mutual cooperation of the group members decreased causing the death of four animals. Although all primatologists have emphasized the importance of home range for a group (DeVore 1965; Rahaman and Parthasarthy 1969; Jewell 1966; Carpenter 1942), the variables responsible for the maintenance of home range are yet unknown. It has been

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reported that removal or loss of alpha male (Carpenter 1942; Bernstein 1966; Neville 1969; Southwick and Siddiqi 1967), his personality and experience (Itani *et al* 1963; Rowell 1972) are crucial for changes in home range size. In the present paper, observations on the changes in size and location of home range are reported.

2. Methods and study area

Most of the observations are based on 13 groups of rhesus monkeys inhabiting an area of 32 km² in Asarori Forest, North India (for description of groups and forest see Pirta 1977–78). Four groups were observed in an urban habitat, Khair, about 40 km from the city of Aligarh (for description of habitat see Southwick *et al* 1961). Instances of changes in the size and location of home ranges were observed at different occasions during the period of study (table 1). Whenever a change was noticed or artificially induced, the group movement, daily activity and other behaviours of the group were recorded. The hierarchical relations of a few adult males and females in each group were also noted at the time of artificial feeding.

3. Observations

The changes recorded in the size and location of the home range of each group and the variables causing such changes are described in the following sections.

3.1. *Group* 1. *Emigration of alpha male*

Group I was dominated by the alpha male. The group consisted of two more adult males, the central shy male and peripheral erect tail. The alpha

Table 1. Information about the groups studied and changes in their home ranges.

Group location	Period of study	Group size	Home range (km²)		Cause of change
			before	after	
G1 Asarori	June 1973–June 1976	30	5·06	3·60	Emigration of alpha male
G10 sarori	do.	32	2·25	1·71	do.
G11 Asarori	do.	37	5·06	3·75	Removal of alpha male
G3 Asarori	do.	11	1·12	0·46	Removal of all members except alpha male
G4 Asarori	do.	77	9·56	Minor increase	Invasion of home range by elephants
KG2 Khair	1 May—19 June 1976	67	0·60	do.	Aversive trials in a trapping net in core area
KG3 Khair	do.	42	0·60	do.	Invasion of core area by KG2

male was last seen in his group on 3 June 1974, when the group was in the extreme south-west part of its home range. On 5th, the alpha male was seen in the periphery of group 2 which was also moving in the same area. Group 1 moved to the central part of its home range. Although alpha male came in contact with his natal group (G 1) on several occasions, he did not return to the group and was rather noticed threatening its members. The alpha male was not seen even in the group 2 after the last week of January 1975.

Rani, a dominant female of the group, used to accompany alpha male during artificial feeding, grooming and resting times. The shy male was rarely seen during artificial feeding and other group activities. The erect tail was young and lived at the periphery with three juveniles. After the emigration of alpha male some peculiar social changes were observed in the group. The female Rani, carrying an infant, started controlling group activities and monopolised at artificial feeding sites. The erect tail also started making attempts to move into the central part of the group, and fights became frequent between Rani and him. Rani formed a coalition with shy male and both helped each other when erect tail attacked any one of them (table 2). But erect tail continued his efforts and participated prominently in all group activities, especially when there was external danger to the group or some disturbance within the group. He occasionally threatened the group members approaching a monkey trapping net. Rani's dominance activities increased when she lost her infant in the last week of June 1975. In the mating season of 1975–76, the coalition of Rani and shy male weakened. During October, November and December 1975 the erect tail was seen in consort relations with most of the females of group including Rani. By January 1976, the alpha position of erect tail was fully established. The shy male was rarely seen with Rani and the latter accompanied now the erect tail.

Table 2. Changing dominance relations between three members of group 1 in Asarori forest.

Attacker		Attacked*		
		Rani (1)	Shy male (2)	Erect tail (3)
Soon after alpha male left	1	..	13	20 ; 0**
	2	3	..	0 ; 3**
	3	3	5	..
During transition period	1	..	1	3 ; 10**
	2	..	..	0 ; 8**
	3	18	10	..
After the erect tail became alpha	1	..	4	0 ; 1**
	2	..	..	..
	3	18	5	..

* Total instances observed from the time of emigration of alpha male till the end of study.
** Cooperative attacks of Rani and shy male.

The group never visited the south-west part of its home range shown by hatched lines in figure 1 till the end of the study in June 1976. There was about 29% loss in home range size of the group after the emigration of alpha male.

3.2. *Group* 10. *Emigration of alpha male*

There were four adult males M1, M2, M3 and M4 in this group, having respective positions in the dominance hierarchy. M2 was overtly aggressive and threatened not only its group members, but also attacked human beings, dogs, crows and domestic animals when they came in his proximity (table 3). M3 and M4 were

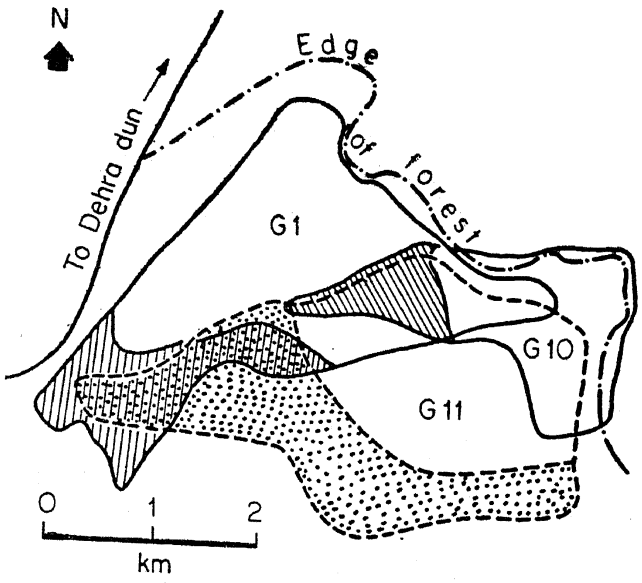

Figure 1. Home ranges of group 1, group 10 and group 11 before and after the loss of alpha male. The decrease in home range is shown by hatched and stippled area.

Table 3. Instances of threat toward group members and other animals by males 1, 2 and 3 of group 10 in Asarori forest.

Objects of threat		Instances of threat*		
		Male 1	Male 2	Male 3
Group members	Males	15	18	8
	Females	16	20	14
	Youngs	3	8	2
Humans		2	15	0
Dogs, crows and domestic animals		4	17	2
	Totals	40	78	26

* Total instances observed at different occasions, till the emigration of male 1.

young peripheral males. On 10 February 1975, M1 was seen moving alone in the core area of his group with a deep, longitudinal fresh cut on its lower lip. The group was about half kilometer away from him. On 26 February 1975, M1 was observed lurking on the periphery of G1 in the latter's home range.

The highly aggressive male, M2 became the alpha of G10 after the emigration of M1; M3 and some females occasionally threatened M2. The only member of the group to help M2 at such occasions was M4, who started living in the central part of the group after M2 became the leader. On 16 June 1975, M4 was trapped. Soon after this, in the last week of June 1975, M2 disappeared from the group. M3 became the alpha male and remained in this position till the end of this study. M2 was observed living with three subadult males. All these four monkeys lived together in the home range of G10, but never mixed with it. M4 was released after frontal lobe damage on 6 July 1975, and he joined natal group (G10) in January 1976. He was week and very docile, and highly afraid of his group members.

From February 1975 onwards G10 never visited the western part of its home range, covering approximately 24% area. Due to military establishments, G10's home range further reduced on the north-east side, even then no increase was observed in the other sides of the ranging area (figure 1).

3.3. *Group* 11. *Removal of alpha male*

In G11, Rama and Shyama were too old but healthy males, respectively on alpha and beta positions in the hierarchy. Both males used to remain together in the central part of the group. However, Rama was accompanied by a female, Sundari, while Shyama was followed by Sarkatti. There was an another young peripheral male in the group.

On 4 June 1975, the alpha male Rama was trapped. Shyama became the alpha male of G11 and his female companion Sarkatti also rose higher to Sundari. There was approximately 38% loss in the size of home range as the group was never seen in the south-west portion shown by stippled area in figure 1.

3.4. *Group* 3. *Removal of all group members except alpha male*

There were one alpha male, 3 females, 4 juveniles and 3 infants in group 3, living in a home range of 1·12 km^2. The group was habituated to artificial feeding inside a wiremesh cage (2 m × 2 m × 2 m) fitted with a sliding door and kept in rest house lawn. On 14 May 1974 when all group members except the alpha male were feeding inside the cage, the door was dropped. The group members were confined upto 19 May inside this cage, but on 20 May they were removed to laboratory. During first 6 days of partial separation the alpha male confined its activity to the rest house area. After total removal of group members its ranging area increased, but only upto 0·46 km^2 (figure 2). About 6 months later when new females were introduced, again a group was formed. The ranging area slowly increased but not more than the old one (1·12 km^2), although there were 11 members in the group.

3.5. *Group* 4. *Elephants invasion*

On the evening of 29 January 1975, G4 was left at a spot (see G4 in figure 2) about one kilometer from our base camp. Next morning, the group was found absent

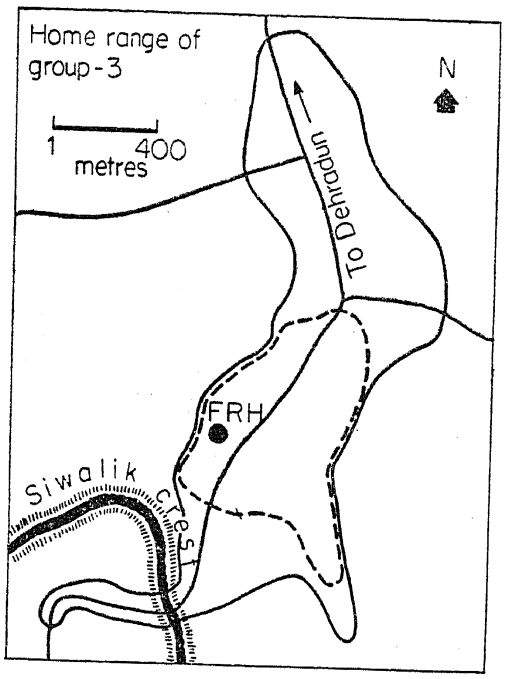

Figure 2. Home range of group 3 before (solid line) and after (broken line) the removal of group members.

from its night resting place. The foot prints and dung of elephants, uprooted and denuded trees were seen at every few feet in the forest area. The study area was searched out thoroughly for three days but the group could not be traced out. On 4 February 1975, the group was located near a village area out of its home range (shown by arrows in figure 3). The elephants were seen roaming till 5 February 1975 all over the study area, except the hillocks and Siwalik crest. After 5th, the elephants restricted their movement to a limited area, and moved away in the first week of March 1975. Although G4 came back to its home range on February 5, it slept at night on elevated areas, inaccessible to the elephants. The daily activity of the group was disturbed and characterized by high level of activity (figure 4). The night lodging sites of G4 for February 1975 were markedly different as compared to those of February 1974. When the elephants left the area, the group resumed its normal activities. It was also noticed that group 2, which was resting near G4 on the night the elephants invaded the area, also disappeared on the following morning and migrated to Siwalik crest out of its home range. Three other groups (G1, G10 and G11) also migrated towards the village near the forest edge.

3.6. *Khair Group 2. Trapping in the core area*

Four groups were observed in a town Khair near Aligarh. These groups had overlapping home ranges (figure 5). The resting and sleeping places of each group were at fixed places on the roof tops, and were not shared by each other. The intergroup dominance hierarchy was in the order of Khair Group (KG) 1 (first), KG2 (second) KG3 (third) and KG4 (fourth).

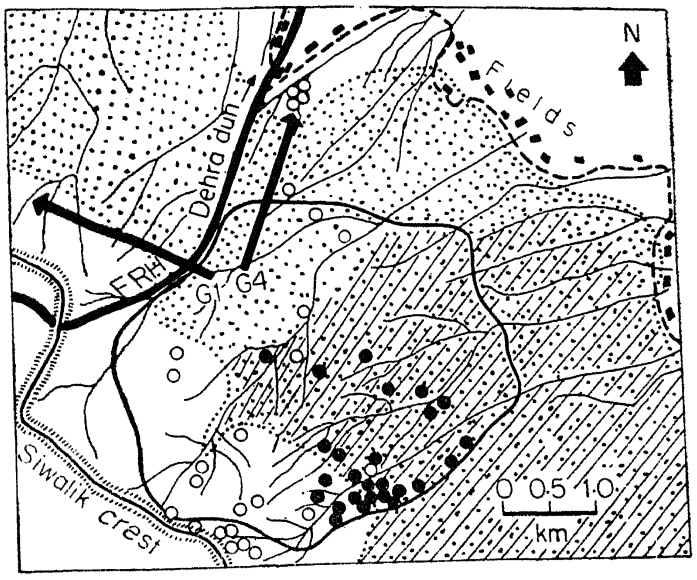

Figure 3. Home range of group 4. Black circles are the night lodging sites of February 1974 and empty circles are the night lodging sites of February 1975. G2 and G4 are the night lodging sites on the evening of 29 January and arrows indicate the direction of movement after elephants' invasion. The elephants roamed in the stippled area during first five days, but they remained in the hatched line area for the month of February.

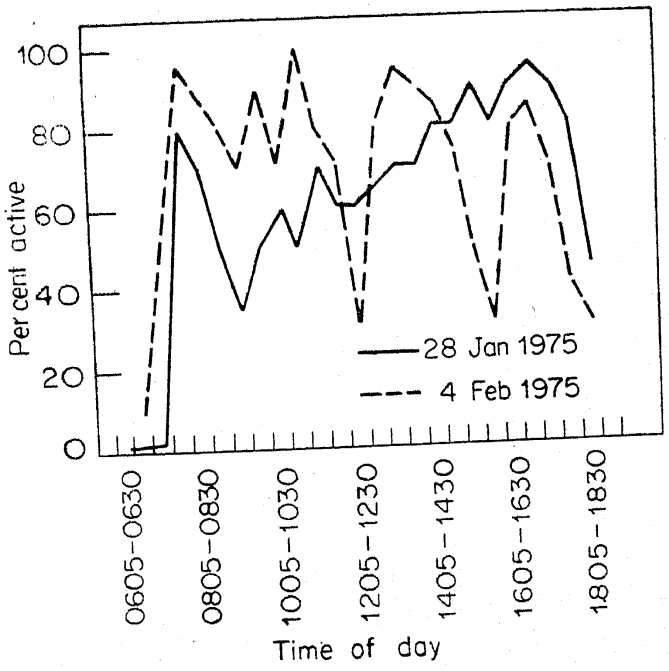

Figure 4. Daily activity patterns of group 4 before (solid line) and after (broken line) the disturbance.

On 22 May 1976, a cotton thread net, fitted with a sliding door, was fixed in the core area of KG2. The net covered approximately 18 × 9 × 2 m space on a house roof. The monkeys of KG2 received several aversive trials inside the net, i.e. brief confinements of one member to almost all members in the net. Finally 13 animals were trapped from the group on 28, 29 and 30 May. Soon after trapping on 30th morning, the whole group left its core area and moved out of the home range. KG2 ousted KG3 from the latter's core area and stayed there during nights till 17 June 1976. The changes in the daily activity pattern of the group are shown in figure 6. The group visited its core area for short periods during mornings, afternoons and evenings during these days.

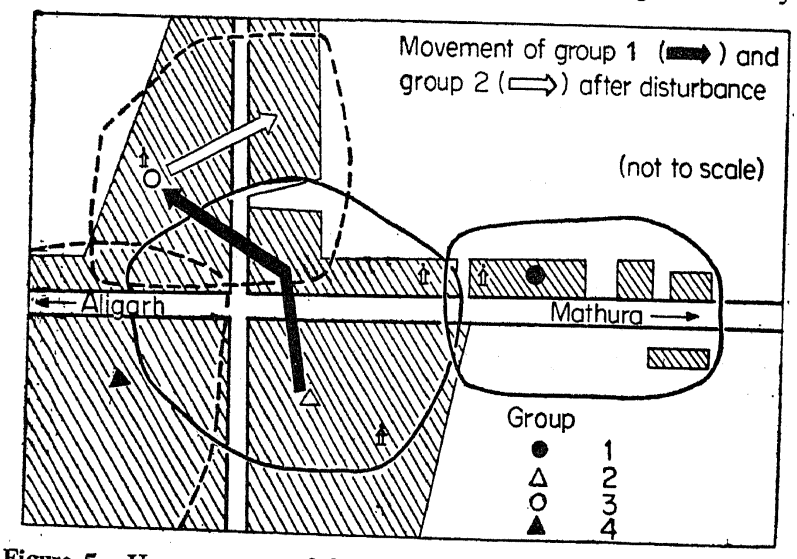

Figure 5. Home ranges of four groups at Khair, Aligarh. Arrows indicate the direction of movements of groups (KG2 and KG3) after disturbance.

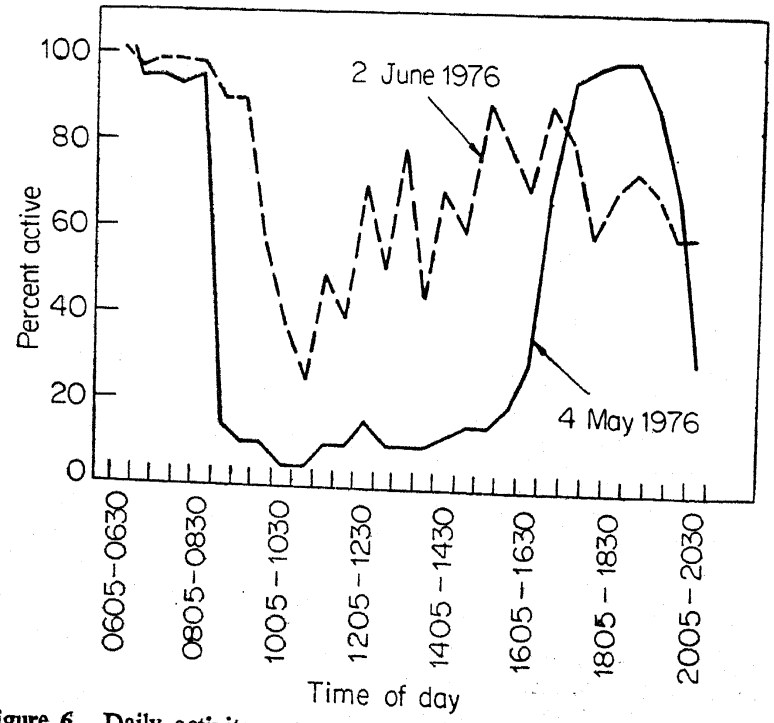

Figure 6. Daily activity patterns of Khair Group 2 before (solid line) and after (broken line) the disturbance.

3.7. *Khair Group* 3. *Invasion by KG2*

When the disturbance increased in the core area of KG2, it moved out of its home range, and occupied the core area of KG3. The latter group withdrew as it was low in dominance from KG2. KG3 selected a roof of an abandoned house for its night and day resting which was located on the periphery of its home range (figure 5). The daily activity of KG3 was also disturbed showing the pattern of KG2. The intergroup encounters were frequent between KG2 and KG3. Foraging areas of both groups remained unchanged. When KG2 returned to its home range, the KG3 also occupied again its core area.

4. Discussion

4.1. *Removal of alpha male*

The observations reported above support the findings of Carpenter (1942) and Southwick and Siddiqi (1967) in which removal or loss of alpha male resulted in a significant reduction in the home range size. However, Vessey (1971) noted no change in home range size after the removal of alpha male in artificially fed free ranging groups of rhesus monkeys at La Paraguera Island. Marsden (1968) reported that the removal of peripheral males resulted in the loss of intergroup dominance which consequently caused reduction of space used by that group. We also observed that Khair Group 3 left its core area when a dominant group KG2 occupied it. This suggests that intergroup dominance hierarchy affects the area utilised by a group. Although removal of small number of adult females, juveniles and infants (Pirta 1977–78) caused no change in home ranges of groups, but total removal of these individuals in case of G3 resulted in a decrease in home range. When some new adult females were introduced, the home range increased to the original size (Pirta 1980). These observations suggests the multiplicity of factors responsible for the maintenance of home range.

4.2. *Disturbances inside home range*

Southwick and Siddiqi (1967) noted that the home range of a group might increase to avoid the disturbance caused by trapping. In the present study, when a large trapping net was fixed in the core area of KG2 and a few aversive trials were given to its members, it moved out of its home range. When the core area of KG3 was occupied by KG2, the former moved to another area. Similarly when elephants invaded the study area at the Asarori forest, G4 and G2 migrated to different places out of their home ranges. All these migrations were to short distances and were for a period of less than 15 days. Singh and Pirta (1978) reported a migration for a longer period (37 days) and to a longer distance (about 2 km) in a bonnet group, which resulted in abnormal behaviour patterns and the mortality of four individuals.

4.3. *Personality of males*

Several workers have emphasised the role of personality factors in achieving a dominant role (Southwick and Siddiqi 1967) and in maintaining spatial

relations (Itani *et al* 1963). In the present study, few instances were observed in which some factors of the personality of males were found to affect their alpha position in the group. Shyness and high aggressiveness effected negatively in the maintenance of rank. The formation of cooperative relationship (or coalitions) with other members of the group positively influenced the achievement of alpha position. The coalition formation by adult males have been reported by several primatologists and has been discussed in detail elsewhere, especially in case of rhesus (Pirta 1980). These observations suggest that those males who possess the personality characteristics like : social familiarity, less aggressiveness, cooperativeness, etc. are more capable of achieving alpha position. But further changes in home range size will depend on alpha's knowledge of that particular habitat. This further indicates the importance of a migratory trait in males because such males roam over a larger area than the group. The point to be emphasised here is that it is only after gaining alpha position that a male will be able to induce a following response in his group members and take them to new areas. The migratory males will be most fit for these changes. In this way the personality characteristics of males decides their alpha position and indirectly the change in home range.

4.4. *Evolutionary mechanism*

It was observed that after leaving the group, some males visited other groups totally out of their own home ranges. By doing so the migratory male acquires a wider knowledge of other groups and habitat. This type of knowledge is helpful not only for the male's own survival, but is also beneficial for the group. If a group has such an experienced alpha male, it can explore a larger area for food and protection. Therefore males who leave the group after juvenile age and live in partial isolation under the natural conditions, would be more fit as leaders if they join a group and acquire alpha position. We find that emigration and immigration is a regular phenomenon in rhesus monkeys (Lindberg 1969), the selection, therefore, might be favouring such traits in the repertoire of males.

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References

Altmann S A 1962 A field study of the sociobiology of rhesus monkeys, *Macaca mulatta* ; *Ann. N.Y. Acad. Sci.* **102** 338–435

Bernstein I 1966 A field study of the male role in *Presbytis cristatus* (lutong) ; *Primates* **7** 402–403

Carpenter C R 1942 Societies of monkeys and apes ; *Biol. Symposia* **8** 177–204

DeVore I 1965 *Primate behavior : Field studies of monkeys and apes* (New York : Holt Rinehart and Winston)

Itani J, Tokuda K, Furuya Y, Kano K and Shin V 1963 The social construction of natural troops of Japanese monkeys in Takasakiyama ; *Primates* **4** 1–42

Jewell P A 1966 The concept of home range in mammals ; in *Play, exploration and territory in mammals* eds. P A Jewell and Caroline Loizos (London : Academic Press) pp. 85–109

Lawick-Goodall J V 1967 *My friends wild chimpanzees* (Washington : National Geographic Society)

Lindburg D G 1969 Rhesus monkeys : mating season mobility of adult males ; *Science* **166** 1176–1178

Marsden H M 1968 Behavior between two social groups of rhesus monkeys within two tunnel-connected enclosures ; *Folia Primatologica* **8** 240–246

Neville M K 1969 Male leadership change in free-ranging troop of Indian rhesus monkeys (*Macaca mulatta*) ; *Primates* **9** 213–227

Pirta R S 1977–78 Observations on group size, group composition and home range of rhesus monkeys in Asarori Forest, North India ; *J. Sci. Res.* (*BHU*) **28** 123–135

Pirta R S 1980 Cooperative behaviour in rhesus monkeys living in urban and forest areas , Ph.D. Thesis, Kashi Vidyapith University, Varanasi

Pirta R S and Singh M 1978 Establishment of home range, intraspecific and interspecific relations in rhesus monkeys (*Macaca mulatta*) under infant-infant rearing conditions ; *Proc. Indian Acad. Sci.* **B87** 267–278

Rahaman H and Parthasarthy M D 1969 The home range, roosting places and the day ranges of the bonnet macaque (*Macaca radiata*) ; *J. Zool.* (*London*) **157** 267–276

Rowell T 1972 *The social behavior of monkeys* (Baltimore : Penguin Book Inc.)

Simonds P E 1965 The bonnet macaque in South India ; in *Primate Behavior*, ed. I DeVore (New York : Holt Rinehart and Winston) pp. 111–160

Singh M and Pirta R S 1978 Movement out of home range and disturbed behavior patterns in a group of bonnet monkeys *Macaca radiata* ; *Am. J. Phys. Anthrop.* **49** 265–270

Southwick C H and Siddiqi M R 1967 The role of social tradition in the maintenance of dominance in a wild rhesus group ; *Primates* **8** 341–353

Southwick C H, Beg M A and Siddiqi M R 1961 A population survey of rhesus monkeys in villages, towns and temples of northern India ; *Ecology* **42** 538–547

Vessey S H 1971 Free-ranging rhesus monkeys : behavioral effects of removal, separation and reintroduction of group members ; *Behaviour* **40** 216–227