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Group Fission in Free-Ranging Rhesus Monkeys of Tughlaqabad, Northern India

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*A population of rhesus monkeys (*Macaca mulatta*) at Tughlaqabad on the southeastern outskirts of New Delhi has grown rapidly in the past 4 years, and the largest group (Group A) has given rise to three smaller groups. Fissioning, or new group formation, was not consistently associated with any particular season of the year or stage of the reproductive cycle, but it did occur in each case when the parent group reached approximately 120 monkeys. The fissioning process was not preceded or accompanied by unusual aggressive behavior. It occurred quietly and appeared to be a loss of cohesion within the large group by which a subgroup achieved behavioral and spatial independence. Some aggressive interactions did occur following each fission when the new group approached or attempted to reenter the parent group. Each newly formed group was subordinate to the parent group and all other groups in the population.*

KEY WORKDS: *Macaca mulatta;* rhesus; India; fissioning; group formation; population growth.

INTRODUCTION

Field studies on group fission of free-ranging rhesus populations have been done by Prakash (1960, 1962) on rhesus monkeys of Rajasthan (India) and Missakian (1973) on the rhesus of Cayo Santiago (Puerto Rico). Rela-

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tively little is known, however, about the patterns of fission in rhesus monkeys in typical habitats of northern India. Although varying reports about the growth and decline of rhesus populations of northern India have appeared in the past few years (Seth and Seth, 1983; Southwick *et al.*, 1983; Southwick and Siddiqi, 1983; Tiwari, 1983), no recent reports are available on fissioning in natural rhesus populations.

The present work is part of a population study begun in 1980 of two groups occupying an archaeological site near New Delhi (Malik, 1983). It was not an intentional study of group fissioning, but events have led in that direction. The unusual circumstance of rapid population growth in the rhesus of Tughlaqabad (pronounced Tuk-lak-a-bod) was accompanied by the fission of the largest group three times in three years. The possibility of additional fissioning still exists because of continuing population increase.

Many aspects of primate behavior and ecology may vary to a surprising extent, not only between species but, at times, among populations of the same species living in different environments or under changed conditions of population density. A rich, spacious, and diverse environment at Tughlaqabad has favored the growth of the rhesus population living there. The demographic aspects of this growth have been described previously (Malik *et al.*, 1984). This paper describes the behavioral pattern of fissioning which occurred in the Tughlaqabad rhesus as the population has grown, and discusses some of the factors contributing to growth and fissioning.

STUDY AREA

Tughlaqabad is an ancient city site (14th century) situated on the southeastern outskirts of New Delhi at 28° 32′ north latitude and 77° 15′ east longitude.

The Tughlaqabad area was selected because it provides (a) a large number of rhesus monkeys habituated to people; (b) excellent conditions for the study of free-ranging animals, i.e., good visibility and access to all parts of the home ranges of the monkeys; (c) easy accessibility from New Delhi; and (d) a variety of habitats including forest patches, grasslands and pasture, agricultural fields, a neighboring village, and roadside habitats. The monkeys are fully protected and receive their major food supply from local people, although abundant natural foods also occur.

The home ranges of the rhesus monkeys under study encompass approximately 5 km^2 (2.5 × 2.0 km). The fort is built on a low rocky hill surrounded by a flat and fertile area of farms, pastures, and forest patches. A road runs through the length of the area in an east–west direction, separating the fort, which is ruins, from the restored tomb of the Tuqhlaq emperor,

Ghias-ud-Din Tuqhlaq, founder of the Tughlaq dynasty who built Tughlaqabad in 1321 AD. The trees lining the road are used by the monkeys for sleeping at night, for daytime resting, and for refuge from disturbance by dogs or people. The fort itself constitutes one-fourth of the area, the forest outside the fort occupies another one-fourth, and open land, either pasture or cultivated fields, makes up the other half of the total area (Fig. 1). Figure 2 shows a central part of the study site.

The area has a subtropical climate, with marked seasonal changes. During the months of May and June, temperatures may reach 40 to 45°C, and during December and January, temperatures often fall to 7–9°C. The monsoon season ranges from the end of June to mid-September, with an average of 567 mm of rain; the driest months are mid-April to June, with the lowest humidities below 20%.

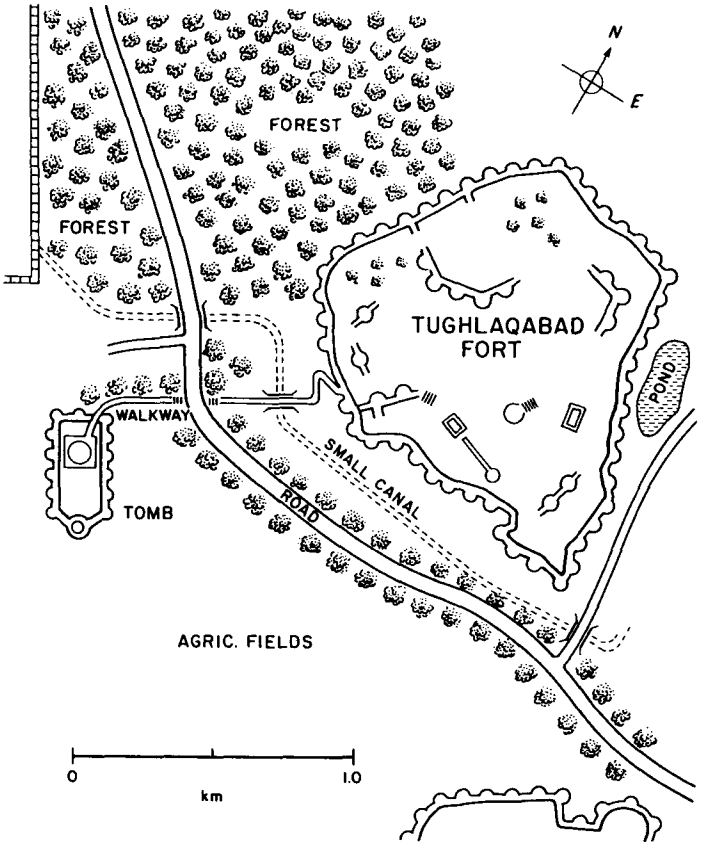

Fig. 1. Map of the Tughlaqabad area.

Fig. 2. Southwestern part of the Tughlaqabad area, showing Tughlaq's tomb.

Natural vegetation inside the fort consists of xerophytic grasses and weeds, whereas outside it is more mesophytic, including trees, shrubs, and agricultural crops. Crops grown by local people include wheat, pulses, millet, and mustard. The main trees present are Indian jujube (*Zizyphus jujuba*), date palm (*Phoenix dactylifera*), gum tree (*Acacia arabica*), margosa (*Azadirachta indica*), sissoo (*Dalbergia sissoo*), oak (*Quercus incana*), and pipal (*Ficus religiosa*).

The dominant fauna, other than humans, includes rhesus monkeys, cattle, water buffalo, donkeys, mules, occasional camels, goats, dogs, lizards, snakes, mongoose, jackals, rats and mice, and bats. The avian assemblage is varied, with both migratory species and residents including vultures, peacocks, partridges, mynahs, hoopoes, sparrows, pigeons, crows, and kites.

FIELD METHODS

Direct observations were made on the free-ranging rhesus monkeys of Tughlaqabad during 5800 contact hr from January 1980 through August 1983, covering four birth seasons. The monkeys were not trapped, marked, artificially fed, or otherwise disturbed by the investigators. Many individuals were recognizable by unique characteristics. Censuses were conducted when the animals progressed across a roadway or through a definite restricted area. Behavioral observations were based on time-sampling methods and scan techniques discussed by Altmann (1974). Observation periods were randomly distributed throughout the daylight hours from 6:00 AM until 7:00 PM. Criteria for age classification have been discussed elsewhere (Malik *et al.*, 1984).

RESULTS AND DISCUSSION

At the beginning of this study in January 1980 the Tughlaqabad rhesus population numbered 120 monkeys, consisting of two groups, Group A of 92 monkeys and Group B of 28. By the summer of 1983, the population had grown to 286 monkeys, and the number of groups had increased to five, A, B, C, D, and E (Table I). Groups C, D, and E were splinter groups of A, which remained the largest group in the area. None of the members of Group B joined either C, D, or E, nor did Groups C and D contribute to each other or to Group E. Group B remained an intact group throughout the study period, growing from 28 to 65 individuals, but it had not yet undergone fission by August of 1983.

The plausible reason for the fissioning of Group A seemed to be the noncohesiveness of its members. Group A individuals spread themselves wide-

Table I. Census Data for Tughlaqabad Groups, 1980–1983

Date of census	Group	Adult males	Adult females	Juveniles and subadults	Infants	Group total	Population total
Mar. 1980	A					92	
	B					28	120
July 1980	A	20	43	28	32	123	
	B	5	12	11	9	37	160
July 1981	A	17	34	51	21	123	
	B	5	13	19	10	47	
	C	3	11	7	10	31	201
July 1982	A	10	30	66	27	133	
	B	4	14	28	9	55	
	C	3	12	16	10	41	
	D	3	4	4	4	15	244
July 1983	A	6	22	80	15	123	
	B	5	14	36	10	65	
	C	3	12	25	10	50	
	D	3	4	8	4	19	
	E	4	8	9	8	29	286

ly; it was often difficult to locate more than half the total number of the group during midday. Group B, and subsequently C and D members, stayed together more closely within their respective groups. All major activities within these groups, resting, feeding, movement, and play, were characterized by closer proximities of individual group members than Group A when considered as a whole.

Group A apparently could contain only a certain number of individuals, approximately 120, and still maintain coordinated activities as a social unit. Once the number exceeded this general limit, a splinter group was formed. This did not occur by immediate aggressive behavior, but rather by subgroup independence—a cluster or subgroup of monkeys simply becoming increasingly independent of the main group. Aggressive interactions did occur, however, when new group members attempted to return to the parent group. These interactions seemed to reinforce and perpetuate the fissioning process rather than precipitate it.

This general pattern is supported by the earlier observations of Prakash (1960, 1962) on rhesus monkeys in Rajasthan. He observed, in a desert habitat, that "a critical maximum size for a group is 50–70, beyond which the group tends to split into a number of groups, each headed by a male leader and sometimes by a number of sub-leaders." The Tughlaqabad Group A underwent fission three times when its size exceeded 120 individuals. On two occasions, fissioning occurred when the group contained 123 individuals, a figure which we consider a coincidence and of no specific significance.

After each fissioning, the new group was not as easily visible as the older groups. The new group was rarely seen in the vicinity of the larger groups, and definitely seemed to avoid older groups. Southwick *et al.* (1965), while studying the temple population of Aligarh, noted that subordinate groups also avoided the dominant ones and that the groups were generally agonistic to each other.

Missakian (1973) described the fission of a large group, comprised of a number of subgroups, in the Cayo Santiago Colony in five chronological stages. This group fissioning was first noted in March 1968 but was not completed until August 1969. Missakian established two criteria for the fission: cessation of grooming between adult males and females of the different subgroups, and stabilization of the population of adult females within each subgroup. Fission was seen to be a gradual process rather than a rapid break in social relations. The subgroups were considered new permanent groupings when both criteria had been met for three continuous months. Later observations in October–December 1970 confirmed this stability. During the five stages of division, there was a progressive decrease in social grooming between members of different subgroups of the original group and a progressive increase in grooming within subgroups. The relative dominance between

individuals and between kin groups remained unchanged. With some exceptions, the group divided primarily along genealogical lines. The new groups consisted not just of low-ranking members within the hierarchy. Sade (1980) recently reviewed several cases of fission and new group formation of rhesus monkeys on Cayo Santiago, noting that some arose from environmental or social changes such as a sudden reduction in population density (as when a group was removed), the loss of a key individual, or the addition of immigrant males. These were more or less artifactual causes of fission, in contrast to the natural occurrences at Tughlaqabad.

At Tughlaqabad, the first fission of Group A took place in December 1980, toward the end of the mating season. The group size was 123 individuals, and a subgroup of 21 separated to form Group C. This subgroup seemed to be composed mostly of low-ranking individuals, although the exact social status of all subgroup members was not known. Fifteen months later, in March 1982, at the beginning of the birth season, the total group size of Group A was 120, and the second fission occurred when 11 individuals left to form Group D. Group A was reduced to 109 individuals, but after the birth season of 1982 in June, Group A numbered 133 and the total of all four groups had risen to 247. The third fissioning occurred in the spring of 1983 when Group A numbered 137 individuals, and 29 left to form Group E. By July of 1983, Group A had been restored to a level of 123 through births, and the total population consisted of 286 individuals in five distinct social groups. If this trend of growth and fission continues, another fission in Group A may occur in late 1984 or early 1985.

The behavioral responses of the new groups after fissioning were similar in all three cases. When Group C formed in December 1980, with a membership of 21 monkeys, it was the most insecure of the three groups, A, B, and C, which then existed. Most of the members of this group were scarred or wounded in various ways, but these scars and wounds had resulted largely from interactions with dogs and people rather than from monkey-to-monkey aggression. Several attacks between dogs and monkeys were seen in which monkeys received dog bites, and altercations between people and monkeys were also observed in which monkeys were wounded by sticks and stones thrown by people. One juvenile was missing a left hand from an injury, but the cause of this injury was unknown.

After fissioning, Group C was driven away by members of both Group A and Group B when it approached either group or attempted to enter an area jointly occupied. It was not unusual for the new group to forsake its food or resting place when members of Group A or B approached. Group C was so insecure and hesitant in its behavior that it spent most of its waking hours in or nearby its sleeping sites and made few or no attempts to move extensively. Clearly, the dominance of Groups A and B impaired Group C's ability to move freely.

When Group D formed 15 months later, Group C had become more at home and more sure of its strength. Group B's size had increased from 21 to 41, and it was clearly dominant to Group D, which consisted of only 11 individuals. A similar sequence of behavioral events occurred with Group E. Although the social status of Group E was not definitely established by the end of this study, it was initially subordinate to Group D even though it contained more individuals (29 monkeys in group E in July of 1983, compared to only 19 in Group D by that date). Upon its formation in the spring of 1983, Group E was the least visible and least assertive group.

Thus, there was a clear dominance pattern in intergroup encounters. In every case, the newest group was the most subordinate regardless of its size. Group A remained the most powerful group, as well as the largest, at the termination of the study in August 1983, as it had been since January of 1980. Marsden (1971) also observed that intergroup dominance was the main principle governing use of space by rhesus monkeys in island enclosures in Puerto Rico. From the developments seen in Group C, we predict that Groups D and E will both become stable and fearless enough to hold their own against other groups and to maintain reasonable home ranges and activity patterns.

An interesting outcome of new group formation is the high natality rates (100% in Group D) that have occurred in the birth season immediately after fissioning. This suggests that fissioning increases the birth rate of the new group members even though it initially limits their movements and further reduces their apparent social status, at least on an intergroup basis. Chepko-Sade and Sade (1979) have shown on Cayo Santiago that low-ranking lineages tend to fission, and this seems to be the case at Tughlaqabad. Hrdy (1984) has suggested that fissioning females may reduce their social status relative to the natal group but increase it individually within the new group since fewer females would rank above them. Hrdy also raised the interesting hypothesis that the increased fertility of the females in the new group may result from "releasing" these females from the presence of oppressively dominant females in a large hierarchy. Increased fertility might also result from some aspect of male–female consort relationships in a small group compared to a large group.

From the standpoint of population growth, the most amazing aspect of the Tughlaqabad rhesus is the more than 100% increase in population in 4 years. The ecological factors responsible for this are discussed in a previous paper (Malik *et al.*, 1984) and can be summarized as follows: (1) the addition of special guards at the archaeological site of Tughlaqabad in 1979 who provided an extra measure of protection for the monkeys; (2) an improving habitat following the growth of tree plantations established 10 to 15 years ago; (3) abundant food, occurring not only naturally, but in the form of handouts by tourists and passersby who come often to feed the mon-

keys; (4) several favorable monsoon seasons and light winter rains, which have given good agricultural production and vegetative growth in this part of northern India throughout these years; (5) the remarkably good health of the monkeys, possibly attributable to the fact that there are no bazaars, waste depots, temples, villages, or other concentrations of people and animals in the immediate home ranges of the monkeys; (6) a lack of predators; and (7) a favorable diversity of cover, water, and topography. As a result of these favorable factors, birth rates have been high (averaging 82%) and annual mortality rates very low (less than 5%). All of the ecological and behavioral needs of the monkeys are met in this area, and they have no reason to leave the area. This may change in the future if population growth continues and if the available habitat shrinks due to encroaching suburban and commercial development around the area.

The process of fissioning at Tughlaqabad appears to be a response to increasing group size and consequent reduction of group cohesiveness. The smaller groups, B, C, D, and E, are cohesive, whereas Group A could never be considered cohesive—hence the hypothesis that noncohesiveness due to its large number had led to the fissioning of Group A. The first splinter group, C, absorbed all scarred or wounded members of Group A, but most of the scars were due not to inter-intragroup aggression, but rather to interspecies aggression (largely from dogs), electrocution from power lines, falls, and accidents due to heavy traffic on the road passing through the terrain. The process of fissioning in all three cases was gradual and peaceful, with no aggression or fights before or during the fission.

CONCLUSIONS

Rhesus groups apparently can contain a limited number of individuals in a given habitat and ecological niche. Exceeding this number, the group tends to divide, as observed in the free-ranging rhesus monkeys of Tughlaqabad. Apparently the social behavior, interacting with environmental parameters, determines the number of rhesus monkeys that may exist in a group before fission occurs. On three occasions when the number of animals in Group A reached 120 to 130, it seemed as if the group or community became too large to hold all the members together. Consequently some animals broke away to live separately and to have an autonomous status with their own dominant male and hierarchy.

Fissioning was not preceded by an unusual amount of aggressive behavior, nor was it consistently associated with any season of the year or stage of the reproductive cycle. The first fissioning occurred in December, at the end of the mating season, and the next two occurred in the spring, just prior

to the main birth season. After fissioning the new group and the parent group were rarely seen together or in proximity. During their daily activities they always maintained distance between themselves. Fissioning apparently involved low-ranking lineages, although not all members of the new group were of low rank. All new groups formed did have a low intergroup status. Any attempts by members of the new group to approach members of the parent group were met by aggressive threats. Fissioning appeared to have a fitness benefit for the new groups, however, as evidenced by the high birth rates in the first season after fissioning and by the low infant mortality rates.

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