Spatial Organization of Captive Monkeys (*Macaca nemestrina*)

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ABSTRACT. An artificial group of 18 pigtailed monkeys, selected by sex and size (age) to simulate the composition of natural groups of macaques, was formed. All were strangers to each other. Observations were made over five months. Data on the monkeys' resting and clustering locations in the compound were analyzed in two ways.

Spatial organization emerged about one month after the group was formed when the group acquired a competent leader. The leader, certain high ranking females, and/or females in estrus were seen consistently in a geographically central area of the compound and therefore were termed central monkeys. This central subgroup, coherent in terms of area and roles, persisted throughout the study. Development of increased group structure was also indicated by increased stability of dyadic affectional relationships.

The study indicates that social organization of the pigtailed macaque will develop when some of the environmental and prior experience variables are controlled. The results highlighted the leader's role and suggest that it is at least as essential in social organization as kinship and factors inherent in a natural environment. Estrous cycles of females and seasonal variations of temperature in the compound were other factors affecting spatial and social relationships of the group members.

The social organization of natural groups of Japanese macaques has been conceptualized in terms of a central and peripheral subgroup(s) (ITANI, 1954). In general the leader male is likely to be in a closer relationship with the subleader male(s), the females, the juveniles, and the mothers with infants. More distant or peripherally located are the lower ranking adult males and some juveniles. Diagramatically two basic subgroups are indicated as concentric circles. This representation of the social organization was derived from the synthesis of long periods of observation, a year or longer; the pattern is not necessarily observable in any one situation. The differentiating relationship reflect social factors such as kinship bonds, play, and dominance hierarchy. The usual organization may change as a result of social dynamics such as consort relationships. Natural groups of rhesus macaques in Northern India (SOUTHWICK, BEG, & SIDDIQI, 1965) and crab eating macaques (FURUYA, 1965) form subgroups with an organization similar to the Japanese macaques.

The individual distance relationship in captive bonnet and a captive pigtail macaque groups have been studied. Bonnet macaques showed significantly more passive contact (huddling) than did the pigtailed macaques (ROSENBLUM, KAUFMAN, & STYNES, 1964).

This study was designed to learn about the characteristics of the spatial organization of a captive group of *Macaca nemestrina* and the factors that determine its development. The spatial structure of the group was expected to change during the first month, but to stabilize within three months. We hypothesized that central and peripheral subgroups would form and that during these early months the central subgroup would consist of the leader or control male, adult females, and juveniles. The juveniles were expected to associate with both the peripheral males and monkeys in the central subgroup.

METHODS

The compound (10 m×9.5 m×2.5 m) was located on the sixth floor of the Regional Primate Research Center at the University of Washington (Fig. 1). Opaque walls minimized extraneous visual stimuli and visual interaction with humans or monkeys in adjacent areas. Observations were made through a one-way vision glass, from a sound-shielded booth. Permanent lines on the floor divided the compound into 15 different areas. Wall and ceiling beams, a two-meter high jungle gym and a one-half meter diameter climbing wheel provided climbing opportunities and elevated resting areas.

Six food bins located at two-meter intervals on two walls of the compound were filled with monkey chow at 9:00 AM and 12:30 PM daily and continuously running water was provided. A 1.5 meter wide strip of the floor contained heating elements which were turned on about three months after the group was formed.

Lacking field reports of *Macaca nemestrina* group organization in the wild, we designed the composition of our group of 18 monkeys in respect to sex, age, and body weight (Table 1) based on reports of naturally-living rhesus and Japanese macaque groups. The one-year-old infants, a male and a female, had been born and raised in our laboratory; they were separated from their mothers just prior to the onset of the study. All adults and juveniles were newly imported and were caged individually in the laboratory in quarantine for two months. All were fitted with letter-coded abdominal bands (see Table 1) to facilitate rapid and accurate identification. To insure the safety of caretakers and to avoid capture by force during compound cleaning the four adult males were trained to enter capture cages located behind a solid wall of the living compound (Fig. 1).

On July, 5, 1966, all females, juveniles, and infants were introduced into the com-

Table 1. Composition of group of 18 *Macaca nemestrina*.

Sex	Age class	Number	Weight range (kg)	Letter code
Male	Full adult	2	8.2–13	*X, J*
	Subadult	2	4.4–6.1	*R, Q*
	Juvenile	2	2.8–3.7	*Y, O*
	Infant	1	1.9	+ (plus)
Female	Full adult	8	3.4–6.7	*P, G, K, D, T, U, M, A*
	Subadult	1	3.6–4.1	*E*
	Juvenile	1	3.6–3.9	*I*
	Infant	1	—	— (minus)

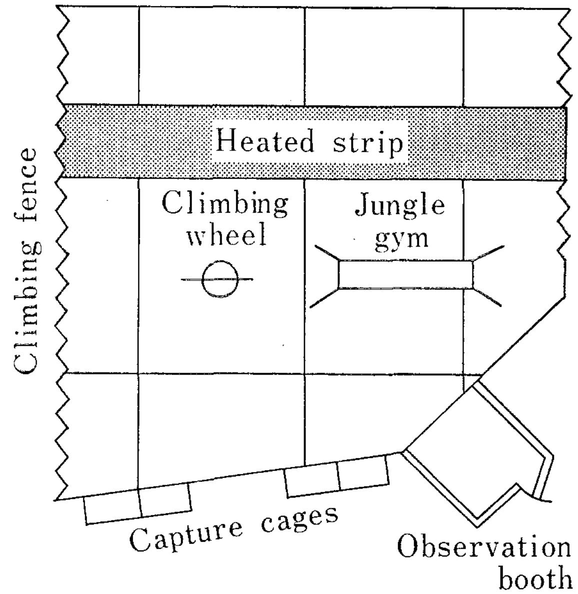

Fig. 1. The compound (10 m × 9.5 m × 2.5 m) was located on the sixth floor of the Regional Primate Research Center, University of Washington. Opaque walls minimized but did not totally eliminate extraneous visual stimuli and visual interaction with humans or monkeys in adjacent areas. Observations were made through a one-way vision glass from a sound-shielded booth (I.A.C.). Lines crossing the floor at right angles indicated permanent lines on the floor which divided it into 15 different areas. Wall and ceiling beams, a two-meter high jungle gym and a one-half meter diameter climbing wheel provided climbing opportunities and elevated resting areas.

pound. They got along reasonably well, and the next day all adult males were released into the compound. From then on the group remained in the compound, no new animals were introduced, and animals were removed only because of illness or death. Four days after group formation the female infant died from internal injuries inflicted by larger animals. On August 2 the male infant was removed permanently because of recurrent severe lacerations. Data on these infants are not included in this report.

Observations were made daily for approximately one hour according to a time schedule predetermined by randomized periods between 9:00 AM and 4:00 PM. When the monkeys were least active, the locations of all subjects at rest were plotted on a map of the compound. When two or more animals rested close to each other (within about one meter), they were considered clustered. Aggressive-submissive interactions, estrous cycles of females, health of monkeys, and the noon temperature in the compound were noted. The map was called "location map."

The experimental design originally called for regularly spaced two-week observation periods referred to as blocks, but a sudden major change in dominance hierarchy seven days after the end of the first block necessitated making the second set of observations sooner than was originally planned. Dates of the observation blocks were as follows: Block 1, July 6–22; Block 2, August 3–16; Block 3, September 21–October 4; Block 4, November 11–23.

CLUSTER LOCATION ANALYSIS

This procedure was developed to determine the locations at which monkeys tended to cluster when at rest. For each observation period the code letters of the monkeys who were clustered (i.e., resting within one meter of each other) were plotted on a space map of the compound similar to Figure 1. Inspection of these maps indicated that for the majority of observation periods, the monkeys tended to congregate in two of the areas demarcated in the compound; the jungle gym and the right central area of the floor strip with the heating elements. Therefore, for this analysis we divided the compound into three areas, the above two and the remainder of the compound. The following procedure was used to determine the predominant location of clusters for each observation period. When a specific monkey's code letter was noted in any of the three areas more often than the average number of times that a monkey appeared in that same area, his code letter was placed in that area on a space map of the compound. For example, in Block 1 (Fig. 2) the average number of times a monkey was located on the jungle gym was six. *Q* was located there nine times. Having determined where each monkey tended to locate in a cluster, the next step in analysis determined which monkeys tended to cluster together in each of the three areas of the compound. When a given monkey was in a cluster with another monkey more than half the number of times he was in clusters with any monkeys, he and the other monkey were plotted adjacent to each other. Their individual code letters were encircled, the circles adjacent or overlapping slightly. When each of two or more monkeys were clustered with each other more than half the number of times that each one was observed to be clustered with any other monkey, the code letters of the two or more monkeys so clustered were encircled on the diagram. For example, in Block 2 the data

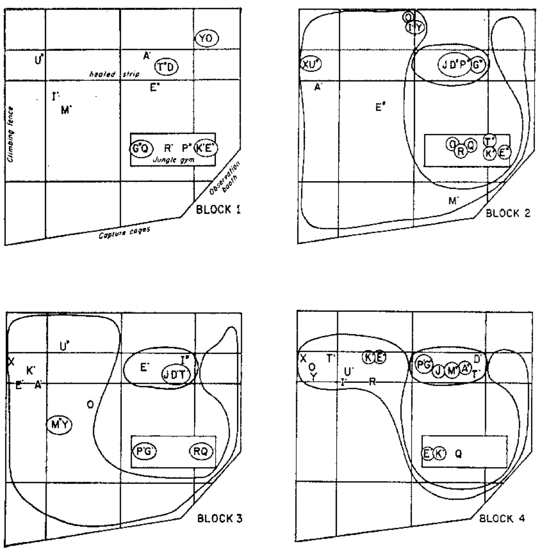

Fig. 2. Cluster-locations for Blocks 1–4. Circles indicate clustering. Dots indicate females. Asterisks indicate females in estrus. For Blocks 2–4 the central areas and remaining resting sites on the floor are encircled (see text).

for the right central area showed *J*, *P*, and *D* each clustered with another monkey(s) five times. These clusters contained two, three, or four monkeys. *J* was with *D* in four of the five clusters he was in, and with *P* in three of them. *D* was with *P* in three of the clusters. Since these clusterings were more than half of the total number of clusters for each monkey, *J*, *P*, and *D* were shown in a common circle. Clusters and locations of the rest of monkeys were also determined by such as procedure.

Dyadic Affectional Analysis

In the data obtained from the location maps, occurrences of dyads (pairs of monkeys) in the clusters, irrespective of location, were tabulated for each observation by block. When a dyad occurred more frequently than the quotient derived by dividing the total frequency for dyads by the total number of different dyad combinations, that pair of monkeys was described as having a particularly close association, or what could be called an affectional bond.

RESULTS

Cluster Location Analysis

The clusters for Block 1 (Fig. 2) showed no particular spatial structure, and the locations or the makeup of clusters did not reflect dominance (Tokuda & Jensen, 1969) or estrus which were also studied (Tokuda, Simons, & Jensen, 1968). Two clusters (*KE*, *TD*) were present which were also seen in one or more later blocks.

Block 2 (Fig. 2) was quite different. *J* generally rested in the right-central area and two females in estrus (*D* and *P*) clustered with him. Three high-ranking females in estrus (*P*, *G*, *D*) clustered together in this same area. During Block 2, *J* controlled the aggression within the group and the mating attempts of other males. *J* was responsible for 76 per cent of all matings observed in Block 2. He often showed group protective behavior by interposing himself between the group and strangers outside the compound. Figure 2 shows two clusters on the jungle gym. Note that *X* was generally clustered with *U*, a female in estrus, in a peripheral area of the compound.

The cluster locations for Blocks 3 and 4 (Fig. 2) were consistent with Block 2 in spatial arrangement. The most dominant male, *J*, was found in the same area with several females in estrus and the high ranking adult females *D* and *T* even though not in estrus. After Block 2, *X* continued to remain at the periphery, but in no particular relationship to any monkey. In the final block (4) all monkeys tended to locate somewhere in the heated strip, probably because the noon temperature averaged 14.6°C, compared with 23.9°C during the earlier observation blocks. Note, however, that the location previously preferred by *J* and the females in estrus remained the same.

A Model Through Dyadic Affectional Analysis

The dyadic relationships were modeled by representing the monkeys by balls (♀) and cubes (♂) and the bonds between them by connecting sticks with same length giving a concept model of dyadic relationships. The concept model for Block 1 (Fig. 3) had a structure of two parts and an isolated unit. The most dominant male, *X*, was a member of the smaller structure. As more interconnecting bonds developed, par-

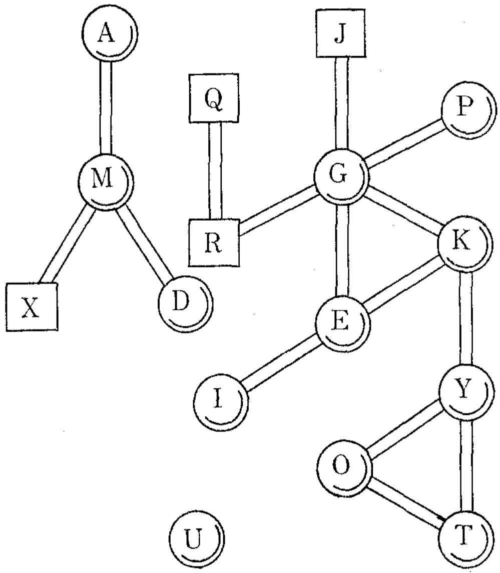

Fig. 3. Drawing of model of dyadic relationships for Block 1. Code letters of monkeys as in Table 1. The model is arrangeable on two-dimension.

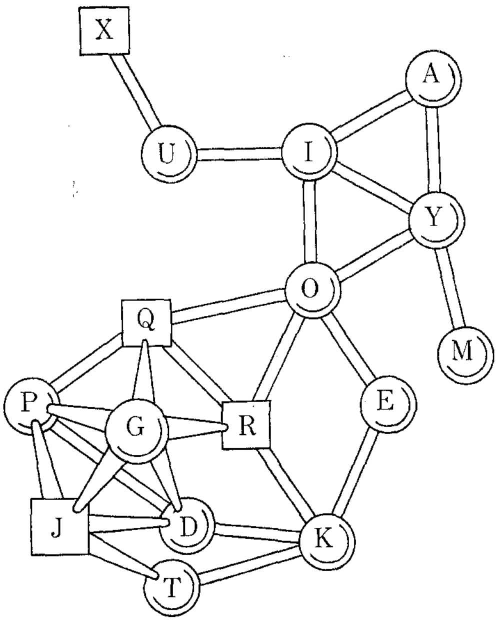

Fig. 4. Drawing of dyadic relationships for Block 2. Note three-dimensional structure involving leader male, *J*, and several females in estrus (see text). The figure is drawn as observed from upper side of the model. The model is not formed without a three-dimensional configuration.

ticularly for a single monkey, degrees of freedom of each balls and cubes are restricted. And a configuration of the model innevitablily forms a three-dimensional structure emerged for Block 2 (Fig. 4). *J* was connected directly with four females in estrus. In contrast, *X*, whose rank change will be described later, was connected with only one female (*U*). The models for later observation also had three-dimensional configurations, with the most dominant male a part of the major structure as in Block 2.

DISCUSSION

No particular group structure was evident in the first two weeks; the group appeared undifferentiated and somewhat chaotic. Approximately one month after the group formation a meaningful spatial and social organization appeared and was continued in each subsequent analysis of resting location. These marked changes were probably caused by the following change in dominance hierarchy: four days after the completion of the first observation period, *X*, the most dominant male, developed diarrhea. All four adult males were removed from the group, placed in individual cages and given the same diarrhea medication. *X* appeared well after four days, and the four males were returned to the group. *J* attacked *X* several times and established his permanent dominance.

The group organization one month after formation supported our original hypothesis that a central subgroup would form around the leader or control male although there were fewer monkeys in this subgroup than we expected. The best composite picture of spatial organization was provided by the analysis of cluster location. The right central area was occupied by the leader male, *J*, and three females in estrus. The social behaviors that emanated from this nucleus were similar to those that distinguish the central subgroup of a Japanese macaque society in nature, i.e., the control of aggression and control of mating behavior among group members (IMANISHI, 1960). The right central area was therefore termed the central area and the monkeys in it the central subgroup. Once occupied, this area was the resting site primarily for the highest ranking male and estrous females for the duration of the study. No other clusters with similar role characteristics were geographically coherent. For example, in Block 4, *K* and *E* were located about two meters from the right central area, but were low ranking adult females not in estrus. Thus, the central area was coherent both geographically and in terms of the roles of the animals located there. The majority of the plots in the central area on space maps of Blocks 2, 3, and 4 were encircled (Fig. 2). A line was drawn around the majority of plots on all the other floor area. In the late fall, as the weather became colder, all monkeys tended to rest on the warm portions of the floor.

The cluster-location diagrams show that the jungle gym was occupied by various animals throughout all observation blocks, but most consistently by the subadult males. The jungle gym, high above the floor, represents a rather special area in the compound since the adjoining compounds are visible from it. The gym may be considered analogous to trees where younger males of a group in habitat often locate and provide the first warning of outside threat to the group.

Some field workers have depicted group interaction by illustrating the most likely sequence of behavior patterns (ALTMANN, 1965) and by describing the relationships between subgroups or classes of animals in terms of certain kinds of behavior interactions (JAY, 1965). The present study, however, depicted individual affectional ties or social bonds between the *individual* animals. The concept model of dyadic relationship for Block 2 shows a stronger and more cohesive structure than for Block 1. From Block 2 onward the leader male formed more bonds with females in estrus, and the models show continued cohesive structure.

Social organization in this group, reflected in changing spatial relationships detailed by two kinds of analysis, appears to have developed from the change in dominance of the two highest ranking males. *X*'s loss of status cannot be entirely attributed to his illness since *J* might have overcome *X* in time. When *X* was the leader male he did not dominate *J* consistently (TOKUDA & JENSEN, 1969). Furthermore, when *X* was most dominant in the group he did not perform the functions expected of a leader. He failed to monopolize or control mating. He did not intervene in intragroup aggression and showed no group protective behavior. He could be termed an incompetent leader. On the other hand, when *J* became leader he performed all these functions, particularly control of aggression among group members, and consistently dominated the second ranking male.

J's behavior seems to have been the essential factor in the social organization of this group suggesting that the role of leader or control monkey is critical in the highly cohesive groups typical of macaques in nature. In the formation and early development of rhesus monkey bands observed on La Parguera Island, Puerto Rico, the critical role that the leader plays in the group's cohesiveness was evident (VANDENBERGH, 1966). It was noted that a leader was required for bands to persist. "Bands not 'adopted' by an adult male disintegrated usually within six months and the individuals joined other existing bands."

The present study shows that social organization can develop and persist in an artificially formed group of captive macaques. Since the monkeys of this experimental group did not have the kinship relationships or long-standing prior associations characteristic of natural groups, it follows that group organization can occur without these genetic and social bonds. The organization we observed resembles that observed in Japanese macaques in habitat and free-ranging rhesus macaques of Northern India (SOUTHWICK, BEG, & SIDDIQI, 1965) in terms of a central subgroup suggesting that natural conditions such as an extensive range, trees, and certain demands imposed by the natural environment are not essential for group organization. It is possible that artificial feeding in a relatively restricted area are variables of importance in determining this kind of spatial organization. Most free-ranging Japanese monkey groups which have been studied were provisioned (artificially fed).

A large group of Japanese macaques living in a large outdoor compound at the Oregon Regional Primate Center observed by ALEXANDER and BOWERS (1968) did not show evidence of the central-peripheral social organization. The authors suggest that the elimination of outside threats by the solid walls of the compound may have been a factor since it eliminated the need for troop defense, a primary function of the dominant male; the elimination of such function of the dominant males lessened the tendency for other monkeys to cluster around them. They further speculated that the absence of central-peripheral organization may have reduced the tendency for the dominant males to break up fights and control aggression among group members. It could be that the highest ranking male of the group was incompetent in performing the usual functions of a leader.

The social organization of pigtailed monkeys in habitat is too poorly known for comparison of the spatial structure developed in our laboratory group. Unlike Japanese macaque groups in habitat, most adult females and all juveniles of our group tended to rest in an area outside that of the clusters termed central. However, the central monkeys in our captive group functioned similarly to those in natural Japanese macaque groups (i.e., leader male or control monkey, certain high ranking females and/or females in estrus) which suggests a basic structure of natural macaque spatial and social organization.

Acknowledgement. This research was supported by Grant No. FR 00166 from the Division of Research Facilities and Resources, National Institutes of Health. The work was done at the University of Washington Regional Primate Research Center, Seattle, Washington.

Ruth A. Bobbitt provided consultation in experimental design.

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—Received *January 8, 1972*; Accepted *June 30, 1973.*

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