ECO-BEHAVIOURAL OBSERVATIONS

Home Ranges of Rhesus Monkey and Langur Groups

The animals of different species living either alone or in social groups occupy more or less restricted area in their living habitats. They usually spend most of their life times by ranging in such areas where they would meet their biological needs like choice for food resources and selection of mating partner (Barash, 1982). Such ranging areas are commonly known as their home range. Long back, Burt (1943) defined home range as that area in which an individual or a group of individuals traversed in order to accomplish such activities as "food gathering", "mating" and "caring for the young". Furthermore, the home range of several animal species was usually constant for a certain period of time and might reduce or extend further depending on some factors, such as changes in the habitat ecology (for example, shortage of food resources) and changes in the social structure within the group (for example, increase in the group size).

The home range is a familiar setting with which the individuals identify through their daily usages (Washburn & Hamburg, 1965). Through continuous ranging the area becomes familiar to its inhabitants, and through continuous association the inhabitants become familiar with each other. A common home range for a group in a natural environment promotes social integration among its members since these members of the group
develop adaptive tolerance to their home range environment. This adaptive tolerance is facilitated primarily due to continuous interaction with the environment. Moreover, the size of the home range area varies from species to species as well as from group to group depending upon the ecological pattern of the habitat they live in and the social structure of the group as a whole. Each social group of primates has a home range or an area of land on which the troop ranges, although some parts of the range of a troop may be used by other troops of the same or different species. Generally on rare occasions, overlapping of use occurs in those parts of the home range containing food resources or sleeping sites. The troops which move, feed and rest habitually in these areas are generally called the resident troops. The tendency of defending the ranging territory against intrusion by conspecifics is not uncommon in several species of primates. Dolhinow & Bishop (1970) noted that high population density and food scarcity are probably the contexts in which the troops will tend to defend their living space when other conspecifics from other peripheral troops make abrupt attempts to intrude into their living area. However, living within a restricted area acquaints the individuals well with the details of their living habitat-food resources, travel routes, sleeping sites and the like.

Rhesus monkeys and Hanuman langurs live in social groups in a wide range of habitats from "tropical Jungle to desert margin, and from undisturbed forest to bustling village" in the Indian
subcontinent (Curtin & Dolhinow, 1978). In some parts of their living habitats rhesus monkeys and langurs move, feed and rest in the same area with their home ranges overlapping with each other, whereas in other habitats both the species occupy exclusively isolated home range areas.

In the urban areas of Shimla where this field study was carried out, a number of rhesus and langur groups were found to range within certain areas, and thus their home ranges overlapped to a great extent.

Each of the four groups (2 rhesus and 2 langur) observed in the present study was found to occupy a specific home range. Both the rhesus groups (G1 and G2) restricted their home range (0.39 km² ± 0.12 for G1 and 0.33 km² ± 0.08 for G2) between Kalibari temple and Himachal Pradesh State Museum. The langur study groups (G3 and G4) were observed to move, feed and rest in restricted areas estimated to be about 1.31 km² ± 0.27 for G3 and 1.10 km² ± 0.23 for G4. In the literature on the socioecology of primates, no attention has been devoted (excepting a few studies, e.g. Mitchell, Boinski, & van Schaik, 1991; Terborgh & Janson, 1986) to compare the home ranges between two or more species living in the same habitat (Richard, 1985; Dunbar, 1988). Some investigators have revealed varied home ranges of both the rhesus monkeys and Hanuman langurs. Sugiyama (1976), in his study on the socioecology of the Himalayan langurs in the Shimla region, estimated the average moving range for 7 langur troops at 1 km² which is, by and large, similar to our home
range estimation for the 2 langur groups in the present study. At Jodhpur, Rajasthan, bisexual groups of Hanuman langurs ranged in restricted areas which were estimated to vary between 1.03 and 1.47 km² (Mohnot, 1984). Mohnot (1984) also reported that the overall home ranges of all-male bands were 10 times larger (varying between 10.5 km² and 14.7 km²) than that of bisexual troops. Earlier, Mohnot (1971) reported that for 32 urban and semiurban langur groups in Jodhpur, the average home range was 0.5 km². Almost similar average home range was estimated by Hrdy (1974) for 7 langur troops at Mt. Abu, Rajasthan. Sugiyama, Yoshiba, and Parthasarathy (1965) reported that at Dharwar, the bisexual troops of Hanuman langurs occupied smaller area than did all-male bands. The home ranges of bisexual groups were estimated at 10 ha. for bisexual troops and at 35 ha. for all male bonds. In Bhimtal (Uttar Pradesh, India) and Sariska (Rajasthan), the home ranges of langur groups were reported to be exceptionally small (0.1-0.5 km²) (Vogel, 1971). In Nepal, Boggess (1980) observed 6 multi male troops of langurs and noted that their home ranges varied from 2.5 to 12 km² with a mean home range size of 6.6 sq.km.

Except for a few studies (e.g. Sugiyama, 1965; Mohnot, 1984), the reports about the home ranges of langur groups varied widely across several study sites. Like Hanuman langur groups, the two rhesus groups studied in the present study also occupied certain home ranges which were found to be considerably smaller (i.e. 0.39 km² ± 0.12 for G₁ and 0.33 km² ± 0.08 for G₂) as
compared to that estimated for the 2 langur groups (i.e. 1.31 km$^2$ ± 0.27 for G3 and 1.10 km$^2$ ± 0.23 for G4). A few studies have reported the home ranges of rhesus groups at Shimla study site (Wade, 1984; Camperio-Ciani, 1984). Studying the socioecology of 10 groups of rhesus monkeys in Shimla, Wada (1984) reported that the maximum diameter of the home range of each rhesus group was 0.5km$^2$. Camperio-Ciani (1984) reported that 6 troops of rhesus monkeys living between the eastern area of the town of Shimla and a high mountainous forested area of on Jakhoo hill ranged in an area of 1.05 km$^2$. At other study sites as reported by other investigators, rhesus groups also did occupy varied home ranges. Neville (1968) studied the socioecology of two groups of the Himalayan foot hill rhesus monkeys at Haldwani town in Uttar Pardesh and reported that the average home range of these two study groups was about 0.05 km$^2$. On the basis of periodic sightings of recognizable groups, Neville (1968) also estimated home ranges for four groups in forested areas to vary approximately between 1 km$^2$ and 3.1 km$^2$.

In a field study on the ecology of rhesus monkeys in a Shiwalik forest in North India, Lindburg (1977) partly focused on the ranging behaviour in relation to resource distribution and reported that the main group at Asarori Forest area utilized 15 km$^2$. Earlier, Lindburg (1969, 1971) studied a rhesus population inhabiting a forest area in the Forest Research Institute (FRI), Dehra Dun and found 115 individuals in five groups confining their activities to an area of about 2.59 km$^2$. Teas (1978), in
her study of free-ranging rhesus monkeys in Kathmandu, Nepal, found that the home ranges of 5 rhesus troops varied from 0.06 km$^2$ to 0.15 km$^2$ at Swayambhu, and that the home ranges of 7 rhesus troops varied from 0.025 km$^2$ to 0.24 km$^2$ at Pashupati. Pirta and Singh (1981), in their study of two urban rhesus groups at two different temple sites in Varanasi, Uttar Pradesh, estimated the home ranges of these two groups at 0.017 km$^2$. Five rhesus troops living in a suburban habitat at Tughlaqabad, Delhi were found ranging in an area of approximately 5 km$^2$ (Malik, 1986).

The above reports about the home ranges revealed a great variability in the estimates of moving ranges of the rhesus and langur groups at different study sites in India. Home range estimates as reported in some studies (e.g. Sugiyama, 1976; Mohriot, 1984) were nearly similar to our estimates for both the species. In rhesus monkeys, our estimated home ranges of 0.39 km$^2$ ± 0.12 for the Museum rhesus group ($G_1$) and of 0.33 km$^2$ ± 0.08 for the Chaura Maidan rhesus group ($G_2$) were, of course, were much less than the home ranges reported by Lindburg (1977, 1969, 1971), and Malik (1986). However, two studies (e.g. Teas, 1978; Pirta & Singh, 1981) have reported a home range size smaller than our estimate. It can, however, be thought that the discrepancy in the home range estimates for both the species in this study may be attributed to a difference in methods, or a difference in habitat quality, or some combination of these. In this study, the langur groups occupied larger home ranges than did the rhesus groups (the average moving range of the langur
Because we are not certain as to why the rhesus groups had occupied a smaller home range than the langur groups at the present study site, several possible explanations relating to the habitat pattern as well as to the population dynamics of the two species may be considered in order to analyze such discrepancy in a comparative perspective.

Both the Museum rhesus and the Chaura Maidan rhesus groups lived in a rather thickly populated area with their maximum moving range covering mostly residential areas around the H.P. State Museum and the Kalibari temple, respectively. In these areas, the local residents used to dispose large quantities of discarded food from their houses in the roadside refuse bins. The rhesus study groups were, of course, familiar to the locations of the refuse bins, and they mostly preferred to raid these garbage sites to feed on the food (discarded vegetables, fruits and other artificial food items). There were 8 such refuse bins at the H.P. State Museum and 17 at the Kalibari temple and its nearby areas. These refuse bins were the regular feeding sites for the rhesus groups. Unlike the rhesus groups, the two langur study groups had the home range spread mostly in forested areas. These areas provide a good source of natural food to the langur groups. The Museum langur group very often spent maximum of its time nearby the residential area at the H.P. State Museum, but its major food resources were a variety of climbers, plants, shrubs which are sparsely scattered within its home range. These
natural food resources bear seasonal fruits, buds, flowers, young leaves which are perhaps the favorite food for the langur groups. The Institute langur group also utilized a large forested area as its home range probably due to the fact that the seasonally available food resources are sparsely scattered in a large area within the present study site. Our probable explanation is that langurs occupied larger home range due to their species typical preferences for the natural foods in the study area where the natural food resources were widely distributed. This was, however, consistent with the explanation by other investigators that the home range size increased as the amount of food available decreased (e.g. Sugiyama, 1976; Oppenheimer, 1977). The evidence from the Asarori Forest, Uttar Pradesh, shows that the home range size (as large as of 15 km²) for a rhesus group was probably due to the lack of sufficient food resources for a large group within the living habitat of the group (Lindburg, 1977). From the above analysis, it seems that the home range size of the macaques and langurs may be related to the nature of the food distribution within their living habitat as well as their food preferences. Therefore, it can be partly concluded that the larger home range size of the langur groups as compared to that of the rhesus groups in the present study may be considered on two related fronts: (i) Species-specific food habits of langurs in favour of natural food resources; and (ii) Sparse distribution of natural food resources within the present study area of Shimla.
The population density of rhesus monkeys (including the rhesus population used in the present study) living within the study site was estimated at about 117 per km² [total number of rhesus monkeys (276) living in an area divided by the size of the area (2.17 km²)]. The population density of langurs was 53 per km² [Total number of langurs (315) living in an area divided by size of the area (5.99 km²)]. Therefore, it can be concluded that the higher population density of the rhesus population within a smaller home range may be a possible cause of restricting the moving range to a relatively small area. Such an explanation in support to our observation is consistent with Jay's (1965) observation of north Indian langurs that the lower population densities (2.6-16.6/km²) are most typical of populations living in open grassland or agricultural fields where the langur groups have large home ranges (1.5-13.0km²). Furthermore, Jay noted that higher densities of population (57.9-134.6/km²) are most typical of forest dwelling populations where the groups have small home ranges (0.05-0.20/ km²).

Within the home range there was a smaller area where the group spends most of its time. Such area(s) was known as the core area. The core area usually included the important sleeping sites and the places where major food resources were available. In the present study, both the rhesus and langur populations were found to spend most of their times ranging in certain areas within their home ranges (see Figure 4.6 & 4.7). The core area of the Museum Rhesus group was approximately one-tenth of its home range.
size and included the main residential area on the front side of the H.P. State Museum and the main bazaar at the Chaura Maidan. The core area of the Chaura Maidan Rhesus group (G2) was split up and located at two different sites covering an area of approximately one-fifth of its home range. Of these two split areas, the one (i.e. as illustrated by the letter "A" in Figure 4.6) which centered around a thickly populated residential area by the side of the Kalibari temple was the primary ranging site of G2. The second such area was, however, included a bazaar area in front of the A.G. Office on the Western end of the Chaura Maidan. In these two core area sites, there were a number of refuse bins which probably attracted the G2 to remain within that area. The food resources in the remaining areas within the home ranges of both the groups were, however, scanty. The groups often used these areas for night roosting.

The two langur groups (G3 and G4) also had core areas within their home ranges. The Museum Langur group (G3) utilized maximum of its time within three different sites (so called core areas, as illustrated by the letters "A", "B", "C" in Figure 4.7). A major section of the core areas, "A" and "B", was covered with residential and other buildings nearby the H.P. State Museum. The other parts of these core areas lying in the back side of the State Museum were dominated by a thick forest cover, and was a good food resource for the group. It was later observed that the G3 shifted its core area from the Museum area to another site adjoining to the All India Radio (AIR). This abrupt shifting of
the core area by the G3 might probably due to the construction of a huge building behind the State Museum. After enquiring from the workers at this construction site, I came to know that about 70 big trees were cut from the core area "A". It may, therefore, be reasoned that probably such a large cutting of trees and the construction work posed continuous threat to the free-ranging of the group members thus forcing the group to shift its ranging to another core area (see Figure 4.7). During our study period, one all-male langur group was observed mostly ranging the area nearby the Museum and its adjoining area. On two occasions, both the all-male group and the Museum Langur group fought with each other and at each such encounter the all-male group appeared to be dominant over G3 thus probably forcing it to retreat to another site. Keeping the dominance status of that all-male group in mind, it may be reasoned that the ranging of the all-male group apparently posed threat to the individuals of the G3. Such a perceived threat on the part of the G3 might be another reason for the shifting of its core area to another safety place where the group was later found ranging freely without any interference.

Like the Museum Langur group, the Institute langur group (G4) was also found to occupy an area where it usually spent maximum of its time in an area illustrated by the letters "P", "Q" & "R" in Figure 4.7. Except in some parts of the core area "P", the entire area was forested and had a variety of fruit bearing plants, shrubs, climbers and thick undergrowth. These areas not
only provided abundant food resources to the Institute group, but also gave a protective and undisturbed environment for the group.

At Gir forest, the food trees were evenly scattered throughout the home range so that the core area was undefinable (Rahaman, 1973). Sugiyama, Yoshiba, and Parthasarathy (1965) estimated the core areas for seven forest-living langur groups at about 0.09 km² (range: 0.05-0.16). This core area size accounted for approximately one-half the size of the home ranges of these seven langur groups. Within the village habitat of Singur, the core area was 0.12 km², about one-quarter the home range size (Oppenheimer, 1977). In the very dry area around Jodhpur, the average core area was 0.26 km² (range: 0.14-0.42) which was also about one-quarter of the average home range size (Mohnot, 1974). At Kaukori and Orcha, as reported by Jay (1985), the langur groups lived in larger core areas which had a range between approximately 0.8 km² and 2.0 km², about one-fifth to one-third home range size. Furthermore, it was also reported that at both Kaukori and Orcha, the location of core areas within the home ranges changed with the season. Moreover, the size of the core area relative to the home range depends on the distribution and density of food and sleeping trees and upon the amount of food available. Thus, if the food trees are concentrated at a few places within the home range, the core area may be relatively quite small (Oppenheimer, 1977).
The home ranges of both the rhesus groups overlapped considerably. The area of overlap accounted for 41% of the range for the Museum Rhesus group, and 51% of the range for the Chaura Maidan Rhesus group. About two-thirds of this area of overlap covered a thickly populated residential as well as a bazaar area. A number of refuse bins were scattered at several locations. The local residents used to dispose the discarded foods regularly from their houses in the refuse bins. This could be a probable cause which would attract the resident as well as the immediate neighboring groups to such areas primarily in search of food. During our first year of study, we very often observed the Chaura Maidan Rhesus group visiting the core area of the Museum Rhesus group. When both the groups met they would show agonistic responses towards each other. Our ad libitum records revealed 127 episodes of agonistic interactions between the Chaura Maidan Rhesus group and the Museum Rhesus group in the area of overlap within their home ranges.

The home ranges of both the langur study groups studied were also found overlapping with each other extensively. The area of overlap accounted for approximately 74% in relation to the home range of the Museum Langur group and 60% in relation to the home range of the Institute Langur group. There were abundant food resources available within the forested area of overlap. The langur groups most often utilized the forest areas probably because the undisturbed atmosphere of such areas might have made it comfortable for them to range freely, feed enough food and
rest without disturbance. Unlike the overlapping home range areas of the rhesus groups, the human interference in the area of overlap of the langur groups was rare. Therefore, the langur groups ranging in such areas often preferred to remain at one place by utilizing the same roosting site continuously for days. Nevertheless, during our study period both the langur groups were never found ranging nearby.

Like in the present study, several reports on primate behaviour and ecology have also revealed the cases of overlapping of home ranges among neighboring groups. For example, at the Asarori Forest in Uttar Pradesh, several rhesus groups ranged in overlapping home ranges (Lindburg, 1977). At Haldwani, Neville (1968) also observed that two neighboring rhesus groups lived occupying specific home ranges which overlapped extensively. Studying several groups of rhesus population in the Jakhoo forest at Shimla, Camperio-Ciani (1984) reported that the home ranges of Jakhoo rhesus groups overlapped considerably, and major section of their area of home range fell within an area which constituted a major feeding site for them. Camperio-Ciani in the same study also reported the occurrences of inter-group agonistic interactions. In a recent paper, Gupta and Kumar (1992) reported that the minimum-maximum limit in the home range size of free-ranging rhesus groups at Kurukshetra, India, was 0.251-1.575 km$^2$. These authors studied six different troops and calculated the average home range size of their study groups at 0.864 km$^2$. 
On the basis of the above discussions, it can be concluded that the availability of food resources and the habitat condition may be the two important factors determining the size of the home range and the core areas of rhesus monkeys and langurs. The group size may also be responsible in determining the home range of that group. From our eco-behavioural observations with regard to the home range for the two rhesus and two langur study groups, we found a larger home range for the langur groups as compared to that for the rhesus groups. The home range areas overlapped extensively within the species as well as between the species. The larger home ranges of the langur groups may be attributed either to species-specific factor or to their natural food consumption habit. The rhesus monkeys, on the other hand, ranged within a smaller area probably due to their preference for man-made food items.

AGONISTIC BEHAVIOUR

Species Difference

The primary focus of this study was the agonistic behaviour between rhesus and langur. The primate family of Cercopithecidae includes rhesus as well as langur. Rhesus belongs to the subfamily, Cercopithecidae, whereas langur belongs to the subfamily, Colobinae. In order to compare rhesus and langur for the agonistic behaviour, focal group data were collected by observing two groups of each species. All these four study groups lived in overlapping home ranges at the study site.
Besides focusing on the species effect, the effects of season and time-of-day were also examined on the agonistic behaviour. With regard to the species main effect, the ANOVA revealed a significant difference between rhesus and langurs for the agonistic behaviour. As compared to langurs, rhesus monkeys showed significantly more agonistic behaviour. The mean agonistic scores as compared between these two species were 2.07 for rhesus and 0.25 for langurs (see Figure 4.10). Although the socioecology of rhesus monkeys and Hanuman langurs has been well studied at different study sites in the Indian subcontinent, no field study has yet compared the agonistic behaviour of these two species living sympatrically. In a laboratory study, Manocha (1966) examined the effects of some testing situations on the behaviour of rhesus monkeys and langurs. He reported that the rhesus monkeys performed more submissive behaviour than did the langurs. However, in several other studies (see for a review Southwick, 1969) rhesus mankeys have been found to be more aggressive than other primate species, for example, bonnet monkeys, Japanese macaques, lion-tailed macaques and stump-tailed macaques. Several other researchers have noted that the rhesus monkeys are well known for their intense aggression (e.g. Lindburg, 1971; Southwick, 1972; Teas, Feldman, Richie, & Taylor, 1982; Bernstein, Williams, & Ramsay, 1983). After studying the socioecology of langurs at different hilly regions of North India, Dolhinow (1972) noted that the north Indian langurs are quiet and peace loving.
In the light of the present finding that there is significant difference in agonistic behaviour between the rhesus monkeys and langurs, some explanations can be suggested to show why rhesus monkeys exhibit more agonistic expression than langurs. In several species of primates, the form and frequency of agonistic behaviour is related to social as well as to environmental conditions. Emphasizing this point, Hall (1964) long back wrote, "it is now obvious that the characteristic expressions and frequencies of aggression within and between groups cannot be meaningfully considered without detailed reference to their ecological context". The availability of food resources and their nature of distribution in a particular species' environment can constrain or permit opportunities for various social relationships to emerge (Southwick, 1967; Boccia, Laudenslager, & Reite, 1988; Nakagawa, 1990). Under the circumstances of limited availability or clumped distribution of resources, the agonistic behaviour within the group may be expected to increase. Several studies have discovered relationships between the expression of agonistic behaviour and access to limited resources of food. Lee (1991), for example, found that groups of baboons and vervets had higher rates of agonistic interactions over restricted food during dry season. Our study findings that rhesus monkeys were significantly more agonistic than langurs can be analyzed on the basis of this "food resource distribution" parameter of their living environment. Although both the species' groups lived in similar environmental condition, the rhesus groups, however,
mostly restricted their living range within a thickly populated area. The main food resources available in their living range were man-made items, and such food resources were primarily available to the monkeys from the artificial garbage sites. Therefore, it can be expected that when monkeys in large number gather at such feeding sites within the present study area, the probability of competitive interactions will increase.

The study groups of hanuman langurs, on the other hand, restricted their moving range primarily in forested areas, although their home ranges covered a small section of the town area. The food resource availability in the forested area was abundant, and its distribution pattern was, however, sparse. Taking into account such ecological condition of the living habitat of the langur groups, it can be expected that the langurs occupying such habitats are less likely to show competitive interaction. A number of laboratory as well as field studies have revealed relationships between levels of agonistic behaviour and access to limited resources in the form of preferred or restricted food sources. Southwick (1967), in an experimental study on the intragroup agonistic behaviour in rhesus monkey, found that the level of agonistic interaction significantly increased when the distribution of food was restricted. In a similar observation confirming our expectation that food shortages would cause marked increases in the frequency and intensity of agonistic behaviour, Koford (1963) earlier observed that rhesus monkeys at Cayo Santiago are especially quarrelsome and competi-
tive when food supply is restricted. Studying the intertroop agonism of rhesus macaques in town and forest areas in Shimla, Camperio-Ciani (1986) suggested that since in the forest of Shimla food resources are more or less evenly distributed over large areas monkeys are less likely to show agonistic interaction. He, however, noted that escalated aggressive encounters between troops are more likely to occur when contacts are made over highly valued food resources that are available in highly concentrated areas (e.g. local food markets, garbage dumps or temple sites). Few other studies (e.g. Vessey, 1968; Southwick, Siddiqi, Farooqui, & Pal, 1974), however, reported that wild ranging rhesus monkeys may respond mildly if encounters occur in areas with less valuable resources.

Our ad libitum records for the contexts of agonistic behaviour revealed that a total number of 124 episodes of agonistic interactions were recorded for the rhesus groups and 31 such episodes for the langur groups in the context of human feeding during the study period. For both the species, the episodes of agonistic behaviour were noted in ten other contexts (see Table 4.8), and it was clear that as compared to other contexts, the episodes of agonistic behaviour occurred more in rhesus than in langur in the context of human feeding. Similar instances of agonism in other species of macaques, although indirectly related to our study findings have been reported by other investigators. Boccia, Laudenslager, and Reite (1988), for example, studied the impact of manipulation of the distribution of food resources on
agonistic behaviours in a laboratory housed group of bonnet macaques and found that the monkeys expressed greater amount of both aggressive and submissive behaviours when they gained access to the food resources available to them in a narrow space. These authors also suggested that the increased level of agonism during dumped distribution of the food resource might be the result of the increased competition which they further attributed to the established order of dominance status among the members in the group. Nakagawa (1990) noted that the frequency of agonistic interactions per individual significantly increased from 181 in the ground patch to 84 individual-hours in the crown patch. In the same paper, Nakagawa gave an explanation that in small but high quality patches, the cost of agonistic interactions may be higher in terms of "net benefit" per individual. On the basis of these reports, it may be further reasoned that the instances of relatively more agonistic interactions in the rhesus monkeys as compared to langurs in the present study would have occurred because of the limited food resources for the former species. As observed during this study, the langurs primarily depended on natural food resources which include leaves, flowers, buds, barks and fruits of a wide variety of plant species. Some of these natural foods are seasonally available, whereas some others are available round the year.

Another explanation to our study finding of a significant species difference in the agonistic behaviour may take into account the role of crowded human environment as a predictable
parameter that might evoke considerably more within-group agonism in rhesus monkeys than in langurs in the present study. This basis of explanation is in line with Hall's (1964) suggestion that primate aggression cannot be meaningfully considered without detailed reference to ecological context. Several studies have found relationships between primate aggression and environmental conditions of the living habitat of the primate groups. Our study finding that revealed a significant difference in the agonistic behaviour of macaques and langurs suggests that the major portion of the home range of the two rhesus study groups fell in crowded human habitat, which might have an influence on the agonistic behaviour of monkeys. Because the rhesus monkeys, as observed in the present study, primarily restricted their ranges within a crowded residential and market areas, they were more susceptible to an obvious urban stress (due to humans, vehicles, physical man-made structures) which might evoke agonism within their groups. Singh (1968) found that rhesus monkeys living in urban habitats showed more aggression as compared to their forest-dwelling counter parts. In another paper, Singh (1969) concluded that "the urban way of life causes monkeys to change their feeding behaviour and sleeping habits, alters their behaviour toward one another, increases their aggressiveness, makes them highly responsive and manipulative in their approach to novel or complex features of the environment and in general chances of their psychological complexity but it does not advance their intelligence, although their behaviour may appear
to exhibit a high degree of shrewdness". Hence, the findings by some other investigators that in uncrowded and undisturbed nature of the forest habitat monkeys experience comparatively less food-oriented tension and thus have almost peaceful coexistence (i.e. Lindburg, 1971; Dolhinow, 1972; Southwick, 1972) provide support for our explanation. Several primate researchers have emphasized that the density of population of a primate species in a restricted area may regulate their both within-group and between-group agonistic behaviour (e.g. Southwick, 1967; Anderson, Erwin, Flynn, Lewis, & Erwin, 1977; Eaton, Modahl, & Johnson, 1981). In the field situations, several reports have documented the instances of relationships between the agonistic behaviour within a species group and the size of their population density in their living habitat. After studying the langur behaviour at Orcha and Kaukori, Dolhinow (1972) noted that langurs at these two sites lived almost a peaceful life without showing agonistic interactions. She further contended that low population density of langurs at Orcha and Kaukori was possibly an important cause of the rare occurrences of the agonistic contacts in their social groups. But langurs studied by other primate researchers at Abu (Hrdy, 1974, 1977) at Jodhpur (Mohnot, 1971) and at Dharwar (Sugiyama, 1965, 1966, 1967) were observed to manifest serious agonistic interactions which often resulted in fatal injuries to infants. One possible explanation for the high level of agonistic interaction among langurs at these three study sites was the high population density (Curtin & Dolhinow, 1978). In the
present study, the population density of rhesus monkeys was estimated to be 127 per km$^2$, whereas it was 53 per km$^2$ for langurs. The larger population density of rhesus monkeys in the present study area was probably an important factor producing more agonistic conflicts within both the Museum Rhesus and the Chaura Maidan Rhesus groups. It might also be reasoned that the relatively low population density of the langurs at the present study site was the possible cause why both the langur study groups manifested significantly less agonistic interactions within their groups as compared to the macaques. Such explanation for our study finding agrees with the predictions by Camperio-Ciani (1984) that the infanticide in a rhesus group at Jakhoo hill in Shimla occurred possibly due to the exceptionally high population density (217 per km$^2$) of the rhesus monkeys. Teas (1978), in her field study on rhesus monkeys in Kathmandu, Nepal, suggested that environmental factors (especially high population density) might be responsible for the high level of aggression in the Kathmandu rhesus monkeys. Kaplan (1986) also noted that in crowded environments, the rates of aggression would tend to be relatively high. In a recent study, Bercovitch and Lebron (1991), however, examined the impact of artificial troop fissioning on the patterns of aggression and affiliation. They predicted that fissioning would result in a decrease in aggression if population density was a major factor for aggression, and that fissioning would increase the frequency of aggression if social stability was an important factor for
determining the levels of agonistic activity. These authors found that there was an increase in the levels of both aggressive and affiliative behaviour following an artificial troop fissioning. Furthermore, they concluded that the levels of aggressive and affiliative activity in nonhuman primates are not determined by population density. Social stability is a more important determinant of primate aggression than is population density. In spite of such contrasting observations, our data suggest that population density may play an important role in increasing the level of agonistic interactions. This explanation is in line with some study observations of clear increase in agonistic interactions with decreasing space (Southwick, 1967; Alexander & Roth, 1971). Few other studies, however, have found little effect of spatial density on aggression (McGuire, Cole, & Crookshank, 1978; Eaton, Modhal, & Johnson, 1981; Nieuwenhuijsen & de Waal, 1982).

The size of the age-sex-class distribution within the rhesus and langur groups may also be an important factor in producing greater species-variability in agonistic behaviour. We observed that for the rhesus groups there were average number of 4.83 adult males, 11 adult females, 15.83 juveniles and 8.33 infants. For both the langur groups, there were, however, average number of 2.66 adult males, 14.67 adult females, 10.67 juveniles and 9 infants. Probably the presence of a greater number of adult males within the rhesus group and relatively smaller size of the same age-sex-class within the langur groups was an important
factor for creating more agonistic interactions within the rhesus groups.

In contrast to males, female mammals invest much time and energy in rearing their young, whereas males play an important role in reproduction. Because of this difference between the sexes, current evolutionary theory predicts that, males primarily show mate competition to maximize their reproductive success (Williams, 1966; Trivers, 1972; Hrdy, 1977). There is sexual dimorphism in rhesus as well as in langurs, the males are larger and more healthier than the females. Therefore the males dominate the females and other age-sex-class during competitive encounters, particularly feeding (Singh, 1969).

Season Effect

With respect to the agonistic behaviour, the second major factor studied in the present investigation was "season". The agonistic behaviour of the macaques and langurs was compared across four seasons of the year arbitrarily divided like Summer: from June 15 to September 14, Fall: from September 15 to December 14, Winter: from December 15 to March 14, and Spring: from March 15 to June 14. The distinctive features associated with each of these four seasons are typical of the Himalayan climatic conditions. During the summer season, the weather usually remained hot and humid with the average temperature ranging from 12 to 30°C. Most of the rain occurred during the later half of the summer season (August-September). The average annual rainfall
was about 1,500mm. The fall season was characterized by a sunny and cool weather. About 24% of the total annual rainfall occurred during the fall. During the later half of summer and in the early fall, there was luxuriant growth of herbs and shrubs as well as new branches and leaves on the trees. The winter season was characterized by a cold weather. During the coldest months, (December and January), the temperature reached to -3°C. Snowfall took place during the mid-winter. Most of the large trees were denuded of leaves except the Oak trees. By this time no undergrowth of herbs was left. The spring season started from around mid-March and was generally characterized by rise in temperature. The mean temperature during this season varied from 17°C to 24°C. The weather during the early part of spring usually remained cold, but towards the later part the weather gradually became warm. During this season, most of the undergrowth vegetation started growing up. Some shrubs and climbers bore new seasonal fruits and flowers.

Keeping in view the typical nature of environmental changes during these four seasons, our present study was aimed at examining the effect of seasonal changes on the agonistic behaviour of rhesus monkeys and langurs. The season-wise focal group data for the agonistic behaviour of the rhesus monkeys and langurs revealed no significant effect of the season on the agonistic behaviour. The mean score for each of the four seasons was nearly same for the four seasons and thereby revealing a signif-
icant variation in the expression of agonistic behaviour throughout the year (see Figure 4.11).

Inspite of the fact that similar studies are lacking in the primate literature, our findings with respect to the effect of the season on the agonistic behaviour can be compared with some field reports.

Teas (1978), for example, studied the effect of the season factor on the aggressive behaviour in 12 groups of free-ranging rhesus monkeys at Kathmandu, Nepal. She collected seasonal data by distributing the observations equally among four seasons of the year (i.e. Summer: from June 22 to September 21; Fall: from September 22 to December 21; Winter: from December 22 to June 21). Her study encompassed two types of aggression, "intra-specific (monkey-to-monkey)" and inter-specific (monkey-to-other)". But she did not clearly distinguish between intergroup and intragroup aggression within the intra-specific category. Her field data on monkey aggression were based on the observations of both intragroup and intergroup interactions in monkeys involving a number of troops. Teas found a significant seasonal variation in monkey-to-monkey aggression. The rate of such aggression was nearly doubled from summer to fall and from fall to winter such aggression, however, decreased significantly. She, however, did not find significant influence of season on "monkey-to-other animal" aggression. Teas interpreted such findings in her study with four explanations: (1) During the fall mating season, the number of adult males in the Kathmandu rhesus
groups increased by about 14%. According to Teas, such an increased proportion of adults in the rhesus groups would cause an increase in monkey-to-monkey aggression. She confirmed this explanation by revealing her another finding in the same study that adult males were four times as aggressive as juveniles; (ii) Most of the sexual activities of the Kathmandu rhesus monkeys occurred during the fall mating season. She also found that there was 146% increase in the rate of male-initiated "monkey-to-monkey" aggression as against 88% increase in aggression as initiated by females during the mating season. On the basis of those observations, Teas speculated that the aggressive patterns of males might have been influenced by seasonal changes of the fall; (iii) In the fall, the human food was available in abundance for the Kathmandu rhesus population. Teas suggested that the increased amount of food availability in the fall might have influenced the male aggression. In addition to these explanations, Teas also attributed the increased rate of male aggression in the Kathmandu rhesus to the probable changes in level of sex-hormone secretion during the mating period. Several field studies conducted prior to that of Teas (1978) have reported that during the mating season, the male rhesus monkeys exhibited more aggression (e.g. Vandenbergh & Vessey, 1968; Wilson & Boelkins, 1970; Lindburg, 1971). For example, Wilson and Boelkins (1970) noted that the increase in testosterone level during the mating season might be a stimulating factor for both sexual behaviour and higher level of aggression in male rhesus monkeys.
Over the years, several primate researchers have been focusing on the physiological mechanism (especially the role of plasm testosterone level) responsible for the male aggression in several macaque species. In rhesus monkeys, plasma testosterone levels and testes size reach maximum values during the fall and early winter (Gordon, Rose, & Bernstein, 1973). From the above reports, it can be concluded that researchers are trying to understand the relationship between aggressive behaviour and hormones, which in turn depend on external factors (especially seasonal changes of the environment). However, there is still controversy among several groups of primate researchers with regard to three related questions: (1) Whether the seasonal changes in the weather condition affect the male aggression during the mating period; (ii) Whether the increase in the secretion of plasma testosterone during the mating season affects the aggressive behaviour in male rhesus; and (iii) Whether the combined effect of the seasonal condition and secretion of more testosterone contribute towards increasing the male aggression in rhesus.

In a series of laboratory studies on the rhesus monkeys at the Yerks Regional Primate Research Center, Georgia, U.S.A., I.S. Bernstein and his research team has documented evidence of the correlation between the male aggressive behaviour and testosterone secretion during the breeding season. Rose, Gordon, and Bernstein (1972) noted that adult males exhibited more dominant behaviour in the form of frequent threat or chase when they were
introduced to females during the breeding season. Furthermore, it was found that during the same breeding period the plasma testosterone levels of the male rhesus monkeys increased significantly.

Taking into account the typical seasonal mating of rhesus monkeys, Bernstein and his team conducted a series of experiments to clarify the relationship between mating season aggression and levels of circulating testosterone in male rhesus monkeys. Gordon, Rose, and Bernstein (1976) studied the effect of season (mating season) on the plasma testosterone secretion levels in the rhesus monkeys. They reported that in the fall breeding season, the plasma testosterone levels in the rhesus increased significantly from the summer season. The rate of male aggression also increased in the same period. In yet another follow-up study, Bernstein, Rose, and Gordon (1977) examined the consequences of introduction of adult males to females in the breeding season (from the end of October until January) and non-breeding or "null season" (from July to early September). These authors found that at each period of male introduction to female, there were brief agonistic interactions between the male and female before they engaged in sexual, grooming and other positive social interactions. During the null season, the female aggression towards the male was high. Furthermore, the testosterone levels in the adult males were found to increase in the breeding and non-breeding season. However, such hormone secretion levels were significantly higher during the breeding season. Bernstein
(1975) studied a group of gelada monkeys (Theropithecus gelada) living in an outdoor enclosure, under hot, rainy and cold weather conditions. He reported that the agonistic responses were found to occur at the lowest rates (2.5 per hour) during the rainy and hot weather conditions. However, these monkeys expressed active agonistic responses at the rate of as high as 16/hour during the cold weather condition. Similar findings were also found for other macaque species studied under nearly identical conditions (stumptail monkeys, Macaca arctoides: Bernstein, 1980, Celebes black apes, M. nigra: Bernstein & Baker, 1988).

Some other field studies have also reported on relationship between the seasonality and aggressive behaviour in rhesus macaques. Lindburg (1971), for example, in an eco-behavioural study of the rhesus monkeys in north India, found that on an average aggressive behaviour in a rhesus group occurred once every 22 minutes of observations time in July (wet season), one every 12 minutes in November (cool season) and once every 150 minutes in March (hot season). Lindburg (1969) also reported that during the mating peak in November, adult males move from one group to another. Such male shifting occurred frequently in rhesus groups. Lindburg did not directly observe frequent actual fighting between the males during the mating peak period. He, however, observed the occurrence of a number of severe wounds in adults of both sexes during the transition period which suggests that the mating season mobility of adult males results in intra sexual aggression in rhesus groups. Eaton (1974) found that
during the breeding season, there was increased aggression in captive group of Japanese macaques. Loy (1971), in his study on free-ranging rhesus monkeys at Cayo Santiago, found that during the mating season male rhesus monkeys showed more dominant behaviour and fought frequently with other females. Kaufmann (1967) studied the free-ranging group of rhesus monkeys at Cayo Santiago and found seasonal differences in the proportion of agonistic versus nonagonistic and aggressive versus submissive behaviour of males. He further reported that in the mating season, the males performed relatively higher proportion of agonistic behaviour than in the rest part of the year.

Season-oriented aggression in rhesus groups has also been studied by Wilson and Boelkins (1970). According to Wilson and Boelkins (1970), the mating season begins around July to August and is over by the end of December, whereas the birth season begins from January and continues upto May. Their study revealed that the male rhesus monkeys were inflicted with significantly more wounds during the mating season than at any other time. In females, the wounding occurred slightly more during the birth season. Furthermore, 86.6% of all male deaths occurred during the mating season.

From the direct research evidences about the relationship between the aggressive behaviour and seasonality in the secretion of the plasma testosterone in male rhesus, it seems clear that male aggression during the mating season is not only controlled by the secretion of testosterone, but also the seasonal changes
influence. However, several investigators have documented contrasting reports. For example, in an experimental study, Nieuwenhuijsen, de Neef, Bosch, and Slob (1987) reported that there was no significant seasonal variations in the frequencies of aggression of adult males. Furthermore, no significant correlation was found to exist between aggression frequencies and testosterone levels of adult males. Inspite of such contrary findings, the authors in this study did not explain clearly as to why in their study the male aggression did not show seasonal variations.

Several other studies, however, have found contrasting results with regard to the seasonality in male aggression. For example, Ruehlmann, Bernstein, Gordon, and Balcaen (1988) studied the incidence of wounding in captive groups of rhesus (Macaca mulatta), pigtail (M. nemestrina) and Stumptail (M. arctoides) for 21 months. They compared the wounding patterns between the two seasonal periods: the non-breeding or birth season (March - July) and the breeding season (September-January). The aggressive behaviour patterns (both contact and noncontact forms of aggression) were correlated with the wounding patterns. Such correlations were made on the basis of their assumption that if the wounds occurred accidentally due to aggressive behaviour patterns, then an association between the contact aggression and patterns of wounding could be possible. Their findings with regard to the seasonality of the wounding patterns revealed that in the rhesus group, the frequency of wounding was significantly
higher in the non-breeding or birth season than in the breeding season. In this regard, the average number of wounds was found to be 6.9 wounds/month during the March-July birth season and 3.5 wounds/month during the September-January breeding season. The investigators, however, did not find significant seasonal effect on wounding in pigtail or stumptail macaques. Such findings are contrary to that reported previously on aggression and wounding seasonality in free-ranging groups (Vandenbergh & Vessey, 1968; Wilson & Boelkins, 1970). The investigators suggested that they did not find increased male aggression during the breeding season probably due to the captive conditions of their study sample. They further noted that unlike free-ranging groups, in the captive conditions the male rhesus monkeys had no opportunity to migrate from one group to another during the breeding season. In this report, the investigators did not describe clearly as to what might be the possible reason for an increased male aggression during non-breeding or birth season. The comparative lists of studies reporting mating season, mating peak, birth season and birth peak have been given in table 5.1 for the rhesus and table 5.2 for the langur. Inspite of the fact that our observations show some similarity with the other studies, no significant differences in the agonistic behaviour of the two species were observed during the four seasons.

Our finding for a significant species difference in agonistic behaviour, as discussed in the light of other studies, indicates that agonistic behaviour is a species-specific phenome-
Table 5.1
Comparative Chart Showing the Mating Season, Mating Peak, Birth Season, and Birth Peak for Rhesus Monkeys (Macaca mulatta)

<table>
<thead>
<tr>
<th>STUDY AREA</th>
<th>MATING SEASON / BIRTH SEASON</th>
<th>REFERENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cayo Santiago, Puerto Rico</td>
<td>July-January (September &amp; October)</td>
<td>Conway &amp; Koford (1965)</td>
</tr>
<tr>
<td>Cayo Santiago, Puerto Rico</td>
<td>30% of sexual mountings occur from September through December</td>
<td>Loy (1971)</td>
</tr>
<tr>
<td>Kathmandu, Nepal</td>
<td>April-August (May &amp; June)</td>
<td></td>
</tr>
<tr>
<td>Kathmandu, Nepal</td>
<td>October-January</td>
<td></td>
</tr>
<tr>
<td>Kathmandu, Nepal</td>
<td>Fall season : September22-December21</td>
<td></td>
</tr>
<tr>
<td>Kathmandu, Nepal</td>
<td>January-February</td>
<td></td>
</tr>
<tr>
<td>Kathmandu, Nepal</td>
<td>March-June</td>
<td>Malik, Seth, &amp; Southwick (1984)</td>
</tr>
<tr>
<td>Kathmandu, Nepal</td>
<td>July-December</td>
<td></td>
</tr>
<tr>
<td>Kathmandu, Nepal</td>
<td>October-February</td>
<td></td>
</tr>
<tr>
<td>Kathmandu, Nepal</td>
<td>November</td>
<td></td>
</tr>
<tr>
<td>Kathmandu, Nepal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tughlaqabad, New Delhi, India</td>
<td></td>
<td></td>
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<tr>
<td>Tughlaqabad, New Delhi, India</td>
<td></td>
<td></td>
</tr>
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<td>Tughlaqabad, New Delhi, India</td>
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<td></td>
</tr>
<tr>
<td>Tughlaqabad, New Delhi, India</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shimla, India</td>
<td>September - February</td>
<td></td>
</tr>
<tr>
<td>Shimla, India</td>
<td>April-August (May &amp; June)</td>
<td>Present Study</td>
</tr>
<tr>
<td>Shimla, India</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shimla, India</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shimla, India</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 5.2
Comparative Chart Showing the Mating Season, Mating Peak, Birth Season and Birth Peak for the Hanuman Langurs (Presbytis entellus)

<table>
<thead>
<tr>
<th>STUDY AREA</th>
<th>MATING SEASON</th>
<th>MATING PEAK SEASON</th>
<th>BIRTH SEASON</th>
<th>BIRTH PEAK SEASON</th>
<th>REFERENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Central</td>
<td>-</td>
<td>-</td>
<td>Births occur</td>
<td>April &amp; May</td>
<td>Jay (1965)</td>
</tr>
<tr>
<td>India</td>
<td>-</td>
<td>-</td>
<td>throughout the year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dharwar, South</td>
<td>-</td>
<td>-</td>
<td>Births occur</td>
<td>Maximum births</td>
<td>Sugiyama,</td>
</tr>
<tr>
<td>India</td>
<td>-</td>
<td>-</td>
<td>throughout the year</td>
<td>occur between</td>
<td>Toshiba,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>December &amp; March</td>
<td>Parthasarathy</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&amp; May</td>
<td>(1965)</td>
</tr>
<tr>
<td>Jodhpur, Western</td>
<td>-</td>
<td>-</td>
<td>Births occur</td>
<td>Maximum birth</td>
<td>Mohnot</td>
</tr>
<tr>
<td>India</td>
<td>-</td>
<td>-</td>
<td>throughout the year</td>
<td>occur between</td>
<td>(1974)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>March &amp; May</td>
<td></td>
</tr>
<tr>
<td>Kaukori, India</td>
<td>-</td>
<td>Summer</td>
<td>-</td>
<td>-</td>
<td>Curtin &amp;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dohlinoow</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1978)</td>
</tr>
<tr>
<td>Jodhpur,</td>
<td>No breeding</td>
<td>-</td>
<td>Births occur</td>
<td>-</td>
<td>Sommer</td>
</tr>
<tr>
<td>Western, India</td>
<td>season</td>
<td></td>
<td>throughout the year</td>
<td></td>
<td>(1985)</td>
</tr>
<tr>
<td>Jodhpur,</td>
<td>-</td>
<td>-</td>
<td>Births occur</td>
<td>Maximum births</td>
<td>Sommer &amp; Rajpurohit</td>
</tr>
<tr>
<td>Western, India</td>
<td>-</td>
<td>-</td>
<td>throughout the year</td>
<td>occur in March &amp;</td>
<td>(1989)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>minimum births</td>
<td></td>
</tr>
<tr>
<td>Shimla, India</td>
<td>July-Sept.</td>
<td>-</td>
<td>January-June (some</td>
<td>April</td>
<td>Present</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>births were also</td>
<td></td>
<td>Study</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>observed in other</td>
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<td></td>
<td></td>
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<td>months)</td>
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non. Since our finding did not reveal a significant effect of season on the agonistic behaviour, it can be concluded that the greater expression of agonistic behaviour in rhesus monkeys is a species-specific phenomenon.

Diurnal Differences

The time-of-day was taken as the third main variable in this study. In order to study the effect of time of day on the agonistic behaviour in the rhesus monkeys and Hanuman langurs, observations were taken during morning and afternoon sessions divided by one hour break at noon. The morning session started early in the morning as soon as the focal group was located. Two focal group sessions, each 90-min duration, were taken in the morning and two in the afternoon.

The results of the analysis of variance on the mean agonistic scores for the morning and afternoon revealed no significant effect of time-of-day factor on the agonistic behaviour. The mean scores for the morning and the afternoon were almost similar (Morning=1.21; Afternoon=1.11). It is, therefore, clear that the agonistic behaviour of rhesus monkeys and langurs did not differ between morning and afternoon hours (see Figure 4.12). The Kathmandu rhesus monkeys, as reported by Teas (1978), were also similar in the expressions of agonistic behaviour in morning and afternoon sessions. Teas's finding further revealed a significant time-habitat interaction. The rhesus monkeys living at the temple site expressed higher level of aggression in the morning. While interpreting such findings, Teas suggested
that the higher level of aggression at the temple site in the morning hour might be associated with food-oriented competition. She also suggested that the monkeys living at the temple site were casually offered food by worshipers who used to visit the temple in large number in the morning hours. She, however, did not give any explanation as to why the agonistic behaviour as a whole in the Kathmandu rhesus monkeys did not vary with times of the day. The present finding can be compared with some other studies, but only indirectly. Bernstein (1975) studied the effect of diurnal changes on the activity patterns of a group of gelada monkeys (Theropithecus gelada). The test condition was divided into six different diurnal time periods in morning and afternoon hours: (1) sunrise-beginning at first light, for 2 hours; (2) early morning-beginning at 8 a.m. for 2 h; (3) late morning-beginning at 10 a.m. for 2 h; (4) early afternoon-beginning at 12.30 p.m. for 2 h; (5) late afternoon-beginning at 3.30 p.m. for 2 h and (6) Sunset-beginning 2 h before dark until dark. His study revealed that the gelada monkeys performed frequent agonistic behaviour during early afternoon hours. High levels of agonistic behaviour were found to continue during the late afternoon hours. At sunset some forms of agonistic behaviour were shown by the gelada monkeys. However, no statistical analysis was done. Only descriptive record has been given.

Bernstein (1980) studied the activity patterns of a group of stumptail monkeys (Macaca arctoides) under nearly identical captive conditions. The time periods used were same as used for
gelada monkeys. He found that agonistic interactions occurred at the highest levels at sunrise. During early morning hours, the contact aggression increased to a peak rather at a lower rate of occurrence not exceeding the rate of 2/h/animal. In the late morning hours, however, all forms of agonistic behavior occurred at the lowest rates.

In a recent paper, Bernstein and Baker (1988) examined the effect of time-of-day on the activity patterns of a group of Celebes black apes (Macaca nigra) also under similar testing conditions. The diurnal pattern of agonistic expression in the Celebes black apes was found to resemble that of the stumptails. The black apes showed the highest rates of both contact and non-contact aggression at sunrise. However, contact and non-contact aggression occurred at their lowest points in the early morning hours. The investigators suggested that such decline in the expression of aggressive behavior during the early morning hours may be due to the fact that many of the animals climbed into the elevated structures to get the warmth of the early morning sun. The submissive responses occurred at the highest levels during the late afternoon. At sunset, agonistic responses and submissive responses occurred at their lowest levels. The work by Hausfater (1971) revealed that intergroup interactions in rhesus monkeys at Cayo Santiago were most frequent in the morning hours from 8 a.m. to 9 a.m. and in the afternoon hours from 3 p.m. to 4 p.m.

From these series of studies on different primate groups by Bernstein and his research team, it is clear that agonistic
behaviour in geladas, stumptails and celebes black apes more or less varied with diurnal changes. But in none of such studies this diurnal variation in the agonistic expression was statistically tested.

In the present study, however, no significant difference was found in the expression of the agonistic behaviour between the morning and the afternoon hours. Although in some studies, the investigations have reported that agonistic behaviour varies at different times of the day (e.g. Bernstein, 1975, 1980; Bernstein & Baker, 1988), these studies have not analyzed such variations quantitatively. Rather in those studies, the primary emphasis has been on the qualitative analysis of the diurnal activity patterns.

By examining the effect of species, season and time-of-day factors on the agonistic behaviour, we did not find significant variation in agonistic behaviour with season as well as with time-of-day. However, rhesus monkeys showed significantly greater agonistic behaviour than the langurs. Therefore, it can be concluded that agonistic behaviour may be a species-specific phenomenon independent of the influence of the environmental parameters like season and time-of-day.

OTHER BEHAVIOURS

Besides the agonistic behaviour, we also studied the effects of species, season, and time-of-day factors on "Human feeding", "Looking", "Resting" and "Locomotion". The focal group data for
each of these behaviours were collected simultaneously with the agonistic behaviour and were analysed using similar methods.

The main purpose of analysing the data for human feeding, locomotion, looking and resting was to gain insight as to how season and time-of-day factors influenced agonistic behaviour of macaques and langurs.

In the following section, first, the main effects of species, season and time-of-day are discussed and second, how these findings help in analysing the results of the agonistic behaviour.

Human Feeding

The results of the analysis of variance for the human feeding revealed a significant effect of the species main factor. As compared to langurs, rhesus monkeys showed relatively more feeding of man-made foods (see Figure 4.28). In the present study, both of the rhesus groups obtained their food from the garbage sites, market areas as well as from human offerings. Unlike rhesus monkeys, the langurs, however, preferred natural food. The home ranges of rhesus and langur study groups covered almost same urban areas which had good vegetation also. We found that the rhesus monkeys showed agonistic interactions more than the langurs. It can be argued that probably more feeding from human resources increased aggression among the members of the rhesus group. Such food acquiring competition among urban monkeys has been reported by several investigators. Camperio-Ciani (1986), in his study on the free-ranging rhesus monkeys at
Shimla, reported that in town areas the monkeys got highly valued food resources from the markets, garbage dumps or temple areas. He found that rhesus monkeys in town areas showed relatively more aggression to limited food resources. Teas (1978) also gave similar explanation for the high aggressiveness of the Kathmandu rhesus monkeys at temple sites. Teas further suggested that since devotees at the temple site casually offered foods to the monkeys, the chances of escalated food-related competition were more likely, and, therefore, the rhesus monkeys at the temple site were more aggressive. It can be speculated that since rhesus monkeys showed more human feeding than langurs, they are likely to have more agonistic encounters among them. However, the time-of-day factor was not found to influence the human feeding behaviour. Feeding from human resources was almost same in morning and afternoon hours. The mean feeding score was 7.58 for the morning and 7.06 for the afternoon hours (see Figure 4.30). We also found that the expression of agonistic behaviour did not differ between morning and afternoon. On the basis of the preceding argument, it can be suggested that since scores are similar for human feeding activity in morning and afternoon, therefore, occurrences of the agonistic expression are also equal in the morning as well as in the afternoon hours. Teas (1978) reported that the human feeding behaviour of rhesus monkeys living in the parkland habitats at Kathmandu did not vary significantly between the morning and the afternoon. In the same study, she also found that the incidence of agonistic behaviour
as a whole did not vary significantly between the two times of day.

A precaution is needed to interpret these findings as cause and effects. If it is true that the greater the feeding from human resources the more are the agonistic interactions for one factor, it might not be true for the other factor. For example, there was a significant effect of season on the human feeding. The mean human feeding scores were, 15.95 for the summer, 2.06 for the fall, 4.65 for the winter and 6.60 for the spring season (see Figure 4.29). The agonistic behaviour, in contrary, did not vary with season.

Locomotion

The analysis of variance for the locomotion revealed no significant species effect. The rhesus monkeys performed nearly as much locomotion as did the langurs (see Figure 4.23). Locomotion is a type of behaviour which involves movement from one location to another by an animal or by a group of animals for exploiting food resources, to search for suitable resting sites, to get access to mating partners particularly during the breeding season, to elicit social interaction from other animals, to seek protection from predator's attacks, and to escape from the attacks by animals from some other groups. Rhesus monkeys preformed relatively more agonistic behaviour than did the langurs. However, with regard to the locomotion behaviour both these species were same. Since in the present study these two species groups lived under identical environment, their locomo-
tion behaviour can be expected to be similar, irrespective of the fact that they belonged to two phylogenetically different species.

Because both the species groups had scattered resting sites, their preferred food resources (artificial foods for the rhesus and natural foods for the langurs) were scattered over a large area in the study site. Since the macaques and the langurs ranged in similar areas, they tended to move from one feeding site to another in search of their preferred foods. This might be a possible reason why our statistical analysis for the species main effect on the locomotion was found to be non significant.

Locomotion also involved when two or more groups are actively involved in the agonistic interactions both the groups may move toward each other, after fight one may chase the other, or the defeated groups would flee away to another location. In the present study, we did not focus on the intergroup agonistic behaviour. Instead, we recorded within group agonistic interaction—a behaviour occurring with the involvement of two or more members within a group. During any agonistic interaction within a group, the participants may not necessarily move too much distance leaving other members of the group. This might be a cause why locomotion was almost equal in the rhesus monkeys
and langurs, although we found remarkable difference in the agonistic behaviour between these two species. The ANOVA result for the season main effect, however, revealed that the locomotion behaviour varied significantly across the four seasons. The fall accounted for the maximum level of locomotion followed by winter, spring and summer season in decreasing order of its occurrence (see Figure 4.24). During the fall season (from September 14 to December 15), the weather usually remains clear and cool. Rain occurs very rarely during this period. The undergrowth vegetation on the surface of the hill terrains becomes less. As the langurs generally prefer the foods from the natural sources, they have to travel from one feeding site to another in search of their preferred food resources. Since during this period lessor number of tourists visit Shimla, the availability of food from human resources was probably less for rhesus monkeys. This might influence the monkeys to move more in search of natural food. This may be one reason for our finding that there is more locomotion during the fall season.

The mating behaviour of the Shimla rhesus monkeys and langurs occurs seasonally. Langurs usually start forming their mating consorts from the late summer (around August-September). In rhesus groups, on the other hand, the adult males and females form consort pairs from early October and their mating continues
to occur till December. During the mating season, the individuals mostly the adults tend to move from one location to another. Even a mating pair often tends to move perhaps in order to avoid any possible threat and/or attack by other adult individuals of the same or from other peripheral groups. An increase in locomotion is, therefore, expected during the fall season. Teas (1978) also reported that the Kathmandu rhesus monkeys engaged in locomotion significantly more during the fall season. She attributed such higher level of locomotion in the fall to the increased sexual activity during the fall mating season. Furthermore, she also suggested that during the harvest festival in the fall season, the highest number of monkeys preferred to feed on human food, and therefore engaged in more locomotion. In the same study, Teas also reported that the monkey-to-monkey aggression occurred more frequently during the fall mating season.

However, in the present study, we did not find any significant increase of agonistic interaction during the fall season. The season and species interaction for the locomotion was found to be significant. Rhesus monkeys and langurs performed locomotion at almost equal levels during the summer, fall and spring except during the winter season (see Figure 4.26). The ANOVA revealed that there was no significant effect of time-of-day factor on the locomotion. The mean number of monkeys engaged in locomotion in the morning and afternoon hours was almost equal
Such finding in our study is in line with the study finding for the Kathmandu rhesus monkeys (Teas, 1978). Teas (1978) reported that the mean number of monkeys engaged in locomotion did not vary significantly between morning and afternoon. Bernstein (1975) studied the pattern in a gelada monkey group living in an outdoor compound by comparing the activity of travel as an individual behaviour for six different times of the day and found that the gelada monkeys showed the greatest amount of movement at sunset. Similar peak of movement activity was also found for pigtail monkeys (Bernstein, 1972). In a follow up study, Bernstein (1980) examined the effect of similar times of day on the activity pattern of stumptail macaques and found that the probability of travelling at least one body length in a 30 Sec. interval varied from 0.25 to 0.41 over all times of day. He further noted that the probability of movement was the highest (0.34) during the early afternoon hours. The highest probability of travel for the stumptails was significantly greater than that for gelades (0.24) and significantly less than that for pigtailes (0.42). In a recent paper, Bernstein and Baker (1988) reported that the probability of moving one body length by a black ape varied from 0.27 to 0.43 over all times of day. They further reported that the highest probability of locomotion occurred at Sunrise (0.43) and Sunset (0.39). These investigators suggested that travel occurred at its lowest during the early afternoon hours. They also observed the early afternoon hours to be a period of inactivity. These investigators, however, did not give explanations for such findings.
The rhesus and langur groups in the present study used to leave their roosting sites (the places where they spent their previous night) early in the morning and often tend to travel to another nearby areas where they usually spend the morning hours. They engage mostly in feeding activity in the morning hours by searching for their preferred foods in wide areas. For this, they make frequent movement from one place to another. In the late afternoon hours, these animals usually remain active in feeding. Before the sunset the rhesus monkeys and langurs again tend to move towards the same roosting site where they had spent their previous night or towards a different site in the forest area. Such pre-roosting activity, in fact, involves locomotion. Therefore, it can be speculated that there will be equal amount of locomotion in the morning and afternoon.

From ad libitum observation records, it was noted that rhesus monkeys and langurs were less active during the mid-day (especially between 11 a.m. to 2 p.m.). The monkeys and langurs often move to a safe place where some, mostly adults, rest while others tend to engage in some forms of social interaction without movement. Our main focal group data were collected in the early morning and late afternoon sessions during which the monkeys and langurs are active. Hence, there was no effect of the time-of-day factor.

Looking

Another behaviour analyzed to supplement our main finding on the effects of season and time-of-day on the agonistic behaviour was looking. The ANOVA results revealed a significant main effect of the species factor. As compared to the rhesus monkeys,
the langurs engaged in relatively more in looking (see Figure 4.16). Looking involves the visual scanning of the surrounding areas. In their natural environment, the rhesus monkeys and langurs show active vigilance by looking around their immediate environment. Such tendency to keep vigil seems to be beneficial not only to the animal who performs it, but also to the resident groups as well. By looking around from a place, the animals of a group can serve several purposes. Firstly, when a predator attempts to attack any member of a group, the vigilant animals tend to emit alarm calls so that other members of that group who are otherwise engaged in other activities at that moment get alert to escape from the predator. In several species of nonhuman primates, vigilance appears to be an important element of the antipredator adaptations (e.g. Menzel & Juno, 1982; Terborgh, 1983; Caine, 1986). Caine (1984) noted that the visual scanning may serve a "maintenance-detection" form of vigilance. Caine further noted that animals maintain vigilance throughout the waking day in order to detect predators or other dangerous objects.

The rhesus study groups lived mostly in the thickly populated residential and market areas. In those areas, the dogs (domestic or stray) are the main predators of the rhesus monkeys. Besides dogs, the human beings living in the crowded urban complex may often become a source of danger for the free-ranging rhesus groups. Although the ranging area of the two langur study groups overlapped that of the rhesus study groups, we noticed from our ad libitum observations that langurs spent most of their time in the forested areas. During our observation periods, we did not find any wild animals other than dogs which would otherwise have
become a potential danger to the langur groups. In spite of the fact that there can be predation risk for the rhesus and langur groups, the rhesus monkeys are expected to be more susceptible to the predator attacks because they mostly move on roads, buildings and house compounds. The langurs, however, preferred to range on the trees. From these observations in the present field situation for the rhesus monkeys and langurs, it can be predicted that the rhesus monkeys are likely to be more vigilant than the langurs. However, our statistical analysis revealed that langurs engaged significantly more in looking than did the rhesus monkeys. There are several possible explanations for this. First, since the langurs mostly range through tree branches, it seems that they are undisturbed even if stray dogs are on the ground. So, in stead of getting frightened they would keep looking at the dogs or would passively look out for long time without concern for the dogs or other predators. When attacked by dogs, the rhesus monkeys would, however, tend to retaliate aggressively in order to avoid such attacks often forcing the attacking dog(s) to move away. Furthermore, the rhesus monkeys appear to be adapted to the dogs and human beings and move freely in the crowded residential and market areas. This might be an obvious cause that rhesus monkeys would not be more vigilant.

Second, the monkeys and langurs might locate their potential food resources by looking around their environment from top tree branches, buildings roofs and/or from ground levels. We have discussed earlier that langurs prefer natural foods which are in fact found scattered over a large area. The rhesus monkeys, however, mostly prefer human foods from the garbage, market and temple sites. The langurs lived in relatively larger home ranges.
Rhesus monkeys, in contrast, restricted their ranging within a limited area which was found to be comparatively smaller than that for the langurs (see Figure 4.5). From the above explanations, it can be understood why the langurs engaged in more looking than the rhesus monkeys.

Third, looking may also serve as an exploring behaviour in order to locate members of the group(s) of the same and/or different species. Within a group, the animals usually remain scattered. Therefore, the animals may monitor the activities by watching each other. Monitoring of the on-going activities within a group plays an important role and at the same time allows an animal not only to anticipate imminent events but also helps the animal learn the interactions of other individuals (Dunbar, 1988). The individuals in a langur group were spread over a larger area on the trees in comparison to rhesus monkeys who mostly remained in open urban habitat. The langurs, therefore, are expected to remain more vigilant in order to locate each other by looking passively. Infact, langurs mostly ranged in forested area in the vicinity of the urban area and utilized a wide space comparatively freely and remained scattered over a wide area.

Unlike the langurs, the rhesus monkeys congregate close to each other. On the basis of the above observations, we expected langurs to show more vigilance (looking) than the rhesus monkeys. Our statistical analysis revealed that langurs exhibited significantly more looking than the rhesus monkeys. Analysis also revealed a significant seasonal variation in the expression of the looking behaviour. The mean number of monkeys engaged in looking was nearly equal for the summer, fall and spring season. However, it was found to be high for the winter season (see...
Figure 4.17). During the winter season (from December 14 to March 15), the weather over Shimla remained extremely cool. During this period the human mobility on the road became less.

As Shimla usually experiences bitter cold with intermittent occurrences of snow during the winter, the rhesus and langurs moved very less and preferred to remain huddled with each other. Probably, this lead to increased looking in the winter season. Locomotion became less (18.22), whereas looking (42.32) increased. Significant seasonal changes of the looking behaviour were also reported by Teas (1978) for the Kathmandu rhesus population. She did not give any explanation for such findings.

Resting

During the focal group scan sampling sessions for the rhesus monkeys and langurs, the resting behaviour was also recorded. Like other activities, such as looking, locomotion and feeding, resting is an important behavioural state in all nonhuman primate species. Besides taking long night rest, most of the diurnal primate species also prefer to rest sometimes during the day. Resting is an inactive state of the animal(s) sitting or lying still with no other activity with eyes closed. Animals generally go to rest, (i) when they have foraged continuously for some duration, (ii) when it is about mid-day, the weather is warm, and they prefer to go to shady areas and take rest, (iii) when after severe cold night there is warm morning, the animals spend long hours in resting, and (iv) due to fatigue after moving and/or foraging.

On the basis of the ad libitum observations, we found that rhesus monkeys consumed food from the local garbage dumps, market and temple site. Rhesus monkeys were observed consuming natural
food also. The langurs also searched for potential food resources within their home ranges. The langurs preferred mostly natural foods, although they were sometimes observed feeding on human foods from the garbage dumps. The food resources (both man made food and natural food) were scattered over a large area. It is, therefore, expected that the rhesus monkeys and the langurs will perform locomotion equally in order to obtain food. The average locomotion score for rhesus (17.98) and langur (17.07) was almost equal which mainly included food related locomotion. However, the langur groups had a larger home range area in comparison to the rhesus groups (see Figure 4.1).

The habitat of rhesus and langur at Shimla is a mosaic of residential, government and other private buildings, hotels, shops, a temple roads and a variety of tree species interspersed by barren areas. However, some parts of their home ranges covered exclusively forested area which was greater in case of the langurs than the rhesus. Camperio-Ciani (1986) studied the free-ranging rhesus monkeys living in the town and forest area in Shimla and reported that their home ranges included both town (29%) and forested areas (71%). Furthermore, the rhesus monkeys spent 53% of their time in the town and 47% in the forested area.

At Abu, India, much of the 40 hectare home ranges of some of the langur troops lay in the town area (Hrdy 1974,1977). Mohnot (1971a) reported that at Jodhpur, habitats of langurs were disturbed by human activities. During our study period, one core area of the Museum Langur group in a less crowded area near the Himachal Pradesh State Museum was greatly disturbed by human activities like the construction of a T.V. complex and a number of government buildings. On enquiring from the labourers working
at that construction site, we came to know that at least seventy big trees (mostly Oak and pine species) were clearly felled. The Museum Langur group was in fact frequently using that area as their suitable resting site before the tree grove was cleared.

The two rhesus groups spent their time in the exclusively forested areas to a lesser extent. Rather these groups preferred to range in the thickly populated areas. During the day time, the monkeys mostly preferred to rest on building roofs. They also rested on road side trees as well. The langur groups covered some parts of the crowded areas where their home ranges overlapped extensively with that of the two rhesus groups (see Figure 4.5). The forested area which covered more than half of the langur home range had, in fact, very less human activity. Dolhinow (1972) reported at Orcha and Kaukori, India, the langurs lived in the areas where there was less human disturbance. In spite of the facts that langurs ranged through the building roofs, trees and roads, they preferred to rest exclusively on tree branches during the day time.

The main water sources in the rhesus and langur home range are the man-made water tanks and the water tap connected with them. Unlike the langurs, the rhesus monkeys lived in the crowded area and spent most of their time in very limited areas near the artificial water sources. Rhesus monkeys mostly preferred to drink water from the artificial sources available at several locations within their home range. Langurs, however, rarely drank water from the artificial sources. But they preferred to drink water mainly from natural sources and nallahs. Such natural water sources were few in number. Those were also scattered over a large area. We, therefore, predicted that the langurs would spend
more time in locomotion for exploiting the water sources as they were supposed to do for exploiting the natural foods in the same area. In other words, there would be lesser amount of resting in the langurs. Instances of the langurs showing day-time resting have been found in several studies. Yoshiha (1967) reported that at Dharwar, India langurs spent 30 to 60% of the day light hours in eating activities and that resting counted for 80% of the diurnal activity. At Shimla, the langurs spent 40% of the day light in eating (Sugiyama, 1976). Oppenheimer (1973) reported that during the year, langurs devoted 30% of their time in eating activity and about 38% in resting. We found a significant difference for resting between rhesus and langur in the present study.

The difference in resting behaviour may be linked to the feeding habit of rhesus monkeys and langurs. The diet of the Hanuman langurs was almost entirely vegetarian (Jay, 1963) and mostly included leaves of a large variety of plants (Mohnot, 1984). Their diet also included flowers and fruits of a variety of trees and shrubs (Kankane, 1984; Khan, 1984). At Jodhpur, the diet of the langurs consisted of items from about 190 plant species (Rajpurohit & Sommer, 1991). The leaves of the herbaceous plants are low in nutritional value (Nakagawa, 1999). Taff and Dolhinow (1989) describing the food habits of langurs stated that they were able to eat and digest quantities of mature leaves which were relatively unnutritious. Since the diet of langur was nutritionally poor, they were likely to consume more amount of leaves in order to meet their energy requirements. For this, they were also expected to spend most of their time for searching and eating the natural foods. Therefore, their resting activity would be less.
The major diet of the Shimla rhesus monkeys mainly consisted of discarded human foods from the residential and hotel kitchens. Such foods are mainly found at the garbage sites. Besides that, the Shimla rhesus monkeys sometimes adopted other feeding strategies like snatching, begging and stealing. Camperio-Ciani and Chiarelli (1988) studied the feeding strategies of a free ranging rhesus group in Shimla and reported that in the town area of Shimla the primary food strategies of the rhesus monkeys were "searching the garbage, begging and stealing for food". According to these investigators, garbage searching activity involved searching for the edible food items. Begging involved following human in the town and visitors in the temple area and collecting the food items offered to them (mainly grams, sweets and biscuits). Furthermore, these authors suggested that the town food resources were highly beneficial because they might provide the best energy benefit to the monkeys. The human foods were, in fact, rich in nutrient contents like proteins, vitamins, minerals and carbohydrates. It is in this context we expected that the rhesus monkeys would get more time for resting. This might be a factor responsible for the Shimla rhesus monkeys to show resting significantly more than the langurs.

The temperature and rainfall varied during the study period (see Tables 3.2 & 3.3). Several types of underground vegetations which are consumed by langurs grow seasonally. During the winter months, such vegetation was very poor. Most of the broad leaved species were denuded of leaves. Sometimes during the winter the entire study area remained under snow. The artificial food sources from where the rhesus monkeys in particular and langurs in general eat the man-made foods, were also affected. During
the winter, there was by and large scarcity of foods resources for both the rhesus monkeys and langurs.

As the spring season started from the mid-Month following the harsh winter, the weather condition starts changing. The weather gradually became warm with the increase in the day temperature. Some of the ground vegetation and big trees which were denuded of their leaves, flowers and even fruits during the winter started bearing buds and young leaves. Some plants also bore seasonal fruits during this month. Besides occasional rains, the weather remained warm throughout the season.

In the present study, we found a significant season effect on resting with a minimum amount of resting occurring during the winter and maximum during the spring season (see Figure 4.20). During the winter season, the plants were denuded of their leaves, flowers and fruits. Not only that, but the snow covered the remaining vegetation for days together. Similarly, the roadside garbage dumps, the main food sources of the Shimla rhesus monkeys were also covered with snow. This lead to a lesser availability of food resources for the rhesus and langur. Since food resources are by and large scarce during the winter, the monkeys and the langurs have to spend more time in exploiting a large area in search of the potential food resources. This might be responsible for lesser resting during the winter.

As the winter passed, the day temperature gradually increased. During the spring season, a number of undergrowth plants bore new leaves, buds and flowers. These two species, especially langurs preferred to eat the young buds, leaves and flowers. So the langurs and the monkeys were expected to spend less time in exploiting for their food resources and more time in
resting. Actually, we found more resting in the spring than in other season of the year. However, Teas (1978) did not find seasonal differences in resting. But Starin (1973) reported that langurs at Gir forest spent almost half of the day in resting during April. The analysis for the time-of-day effect revealed a significant variation in the resting activity between the morning and afternoon hours. There was more resting in the afternoon than in the morning.

In langurs and rhesus monkeys, most of resting occurs at mid-day (Jay, 1965; Mohnot, 1974; Ripley, 1970; Starin, 1973; Lindburg, 1977; Teas, Feldman, Richie, & Taylor, 1982). Yoshiha (1967) studied the langurs at Dharwar and reported that resting accounted for the 80% of the diurnal activity of the langurs. Neville (1968) reported that in Himalayan foot-hill rhesus monkeys, resting occurred more in the morning than in the afternoon hours. Similar finding was reported by Teas (1978) for the Kathmandu rhesus population. Teas reported that resting was most frequent in the morning than in the afternoon hours. She further analyzed the resting data for adults and juveniles separately and found that adults preferred to rest in the morning than in the afternoon, whereas there was no difference between morning and afternoon resting for the juveniles.

From the above discussion on the four other behaviours (i.e. looking, human feeding, locomotion and resting), it is clear that in comparison to the langurs, rhesus monkeys engaged significantly more in human feeding and resting. The langurs, however, engaged significantly more in looking than the rhesus monkeys. With regard to locomotion behaviour the rhesus monkeys and the langurs did not differ significantly. Analyzing the
species main effect for the agonistic behaviour, we also found a statistically significant difference between the rhesus monkeys and the langurs. Rhesus monkeys performed the agonistic behaviour significantly more than did the langurs. Our finding of a significant species difference for the agonistic behaviour can be discussed in general in the light of our analysis of the species main effect for human feeding, locomotion and resting. Because the rhesus monkeys preferred to eat man-made food from the garbage dumps, temple and market sites, the chances of food-related competition among the members within the group might be high. The langurs, however, mostly preferred to eat the food from the natural sources, and since the natural food resources were widely scattered in a large area of the present study site, the langurs had to remain dispersed in a wide area during their feeding times. In such situation, food-related competition would be less likely to occur. This might be a reason supporting our main finding that agonistic interactions occurred significantly more in the rhesus groups than in the langur groups.

Agonistic interactions occurred in several contexts, such as human feeding, wild feeding, spatial, playing, grooming, mating-consort relation, predator threat, intraspecies interactions, interspecies interactions, approach avoidance and avoidance. However, maximum number of agonistic interactions occurred in the context of human feeding. Although, from such explanation it might appear that agonistic behaviour is modulated by the environmental factors like food resources, the food preference, in itself, might be a species-specific phenomenon. The agonistic behaviour did not vary significantly during the four seasons of the year (i.e. summer, fall, winter and spring).
However, there was a significant seasonal variation for looking, locomotion, human feeding and resting. This further indicated that unlike looking, locomotion, human feeding and resting behaviours, the agonistic behaviour might be a species-specific phenomenon.

The time-of-day factor was also not found to affect significantly the agonistic behaviour. The three other behaviours, human feeding, looking and locomotion also did not vary between the morning and the afternoon. However, there was a significant effect of the time-of-day factor on resting behaviour which occurred relatively more in the afternoon than in the morning hours. Thus, from our findings, it appears that the greater agonistic behaviour in rhesus monkeys than in the Hanuman langurs is a species-specific characteristic.

**DIFFERENCES IN MICROUNITS OF AGONISTIC BEHAVIOUR**

Besides observing the two rhesus and the two langur groups for focal group data in four seasons, we also collected data on focal animals to compare the microunits of the agonistic behaviour in 17 rhesus monkeys (2 adult males, 5 adult females, 5 juveniles and 5 infants) and 17 langurs (2 adult males, 5 adult females, 5 juveniles and 5 infants). The rhesus monkeys were selected from the Chaura Maidan Rhesus group, while the langurs from the Museum Langur group.

The focal animal observations were spread over a period of about 3 months. During this period, the focal animal observation sessions were equally divided among the rhesus monkeys as well as among the langurs. A focal animal was followed during 40 focal animal observation sessions, each of 15-minutes duration. Twenty
three microunits of agonistic behaviour (15 categories of aggressive and 8 categories of submissive) were used for comparing the macaques and langurs.

In the primate literature, there is a growing number of studies involving direct comparisons of social behaviour in different primate species (Thierry 1985). In most of such studies, major emphasis has been placed on why individuals in different species adopt different strategies to achieve the same ultimate goal or to maintain cohesiveness in a group (Bernstein & Williams, 1983; Dunbar, 1988)? Behaviour patterns may vary from one species to another. Agonistic behaviour is such a behaviour which has a wide range of patterns in different primate species. Even within a species the patterns in the expression of agonistic behaviour can be manifested in a large number of behavioural forms. Southwick (1972) noted that agonistic expressions can occur in both offensive or aggressive forms and defensive or submissive forms. Scott (1974) suggested that the agonistic behavioural system incorporates both offensive patterns (especially in "assault" and "threat" forms) and defensive patterns (include "escaping", "freezing" and "crouching". In primate societies, the expressions of a wide variety of aggressive and submissive gestures may vary from one context to another. A class of agonistic expressions may also occur in various ways in different conflict situations (Fedigan, 1982). Van Hooff (1971) made a cluster analysis of the aggressive behaviour of chimpanzees and reported that the expression of aggressive behaviour in chimpanzees occurred in a series of behaviours. This included "tug", "brusque-rush", "shriii-bark", "arm away", "stamp", "hit", "trample" and "sway walk". Furthermore, van Hooff clustered the
attack behaviour into five categories, such as "tug", "brusque-rush", "bite", "grunt-bark" and "shrill bark". Rhesus monkeys have been considered to be the most aggressive and quick-tempered animals than any other species of nonhuman primates (Lindburg, 1971; Southwick, 1972; Teas, Feldman, Richie, Taylor, & Southwick, 1982; Bernstein & Williams, 1983). Hanuman langurs, on the other hand, have been well studied, and several investigators have suggested that langurs are by and large shy and docile (Jay, 1965; Sugiyama, 1965; Dolhinow, 1972; Oppenheimer, 1977). Some other investigators, however, have revealed that langurs living in bisexual and all-male groups sometimes show agonistic expressions towards the same and/or other group members of the same or different species. Competition for mates is one of the major contents that evoke intergroup and intragroup agonism in langur groups (Jay, 1965; Sugiyama, 1965; Hrdy, 1977; Sommer, 1988, 1989; Borries, Sommer & Srivastava, 1991; Rajpurohit & Sommer, 1992; Van Schaik, Assink, & Salafsky, 1992). Like rhesus monkeys, langurs also exhibit a wide variety of agonistic expression. After observing Hanuman langurs in the field situation as well as in captivity, Dolhinow (1978) prepared a behaviour repertoire of langurs. This included 14 categories of agonistic behaviour, such as "grimace", "lip smack", "head toss", "bite air", "bob", "slap ground", "face threat", "glare threat", "lunge threat", "hand threat", "hand threat with contact", "displace", "bite", "harassment, non-sexual" and "display". Furthermore, Dolhinow noted that some forms of agonistic expressions (for example aggressive type) are not fully independent, and can be modified by other behaviours of the animal by the condition of the context in which they occurred,
by the age/sex of the participants and by the experience and dominance status of the interactors.

Aggression is an important aspect of the primate social system in several primate species especially in rhesus monkeys. The term aggression stands for a conglomeration of a primarily offensive behaviours. In a large number of primate species, aggression forms a continuum of behaviours which may vary from mild threat to overt fighting. The expression of threat is the most common pattern of aggression in rhesus monkeys (Southwick, 1967; Bernstein & Ehardt, 1985). Besides the "threat" pattern of aggression, the other forms of aggressive expression common in rhesus are "chasing response", "fighting" and "display". The "threat response" in rhesus may occur in a variety of forms. It occurred primarily in two forms: The first form involves a typical threat with a tense crouched posture, pronounced stare, raised eye brows, flattened ears and open mouth. These forms may be accompanied by jerky bobbing of head, fast approaching toward the object of threat. The second form of threat in the rhesus involves bouncing on an erected object (e.g. tree branch, pole). This is sometimes called "branch shaking". Bouncing may also occur on a building or roof top. The first type of direct threat may lead to aggressive chasing (one monkey vigorously chasing another) and even fighting (it may sometimes be accompanied with vigorous threat and biting another animal).

The rhesus monkeys are well known for their intense aggression (Bernstein, Williams, & Ramsay, 1982; Thierry, 1985). Over the years since the start of the pioneering primate field work by Carpenter (1954), several investigators have studied
different forms of aggression in rhesus monkeys (e.g. Altmann, 1962; Hinde & Rowell, 1962; Kaufmann, 1967; Lindburg, 1971; Teas, 1978). Very few studies have been conducted comparing two or more primate species. In the present study, the two sympatrically living primates were compared for various micro-units of agonistic expressions. We predicted that the rhesus monkeys would show greater expression of these micro-units of aggressive behaviour than the langurs.

The One-Zero Scores on each micro-unit of agonistic behaviour obtained from observations on 17 rhesus focal animals and 17 langurs were compared by using Mann-Whitney U test. The results revealed that there was a significant difference between the rhesus monkeys and the langurs with respect to 12 micro-units of aggressive behaviour, such as attack, pursuit, defensive aggression, bluff charge, pucker face, displace, redirected threat, displace, stare, attempt to take object and inanimate object protection. The rhesus monkeys performed these aggressive expressions significantly more than the Hanuman langurs. The analysis also revealed that as compared to langurs rhesus monkeys performed significantly greater expressions of submissive behaviours, such as flight, crouch, attempted escape, passive-rigid-submit and screech (see Table 4.19). The One-Zero Scores for each micro-unit of agonistic behaviour were compared between macaques and langurs separately for adult female, juvenile and infant. The result of the Mann-Whitney U test revealed that the rhesus adult females expressed significantly more attack, threat, pucker face, defensive aggression, displace and display than the langur adult females. Langurs, however, expressed more foot-up and passivity than the rhesus adult females (see Table 4.20).
juveniles, the results indicated that the rhesus juveniles performed significantly more expressions of pursuit, threat, grimace, flight, pucker face, crouch, attempted escape and defensive aggression than did the langur juveniles. However, no significant species difference was found for passivity, withdrawal, screech and stare (see Table 4.21). For infants, a significant species difference was found with regard to crouch, attempted escape and passive-rigid-submit. Rhesus infants performed more of these expressions than did the langur infants (see Table 4.22).

Several investigators have studied the aggressive behaviours in rhesus monkeys. Southwick (1972) studied a group of rhesus monkeys at Tughlaqabad, New Delhi, India and reported that the most frequent type of aggressive expression was threat. Fighting was, however, found to be least frequent. Furthermore, of the total number of 4173 aggressive interactions he recorded in 160 hours of field observations, 2484 (59.5 percent) were threats; 1520 (36.4 percent) were aggressive chases; 153 (3.7 percent) were attacks; and only 16 (0.4 percent) were fights. On the basis of his observations of 10 different groups in urban, rural, and forest environments, Southwick recorded 15,574 aggressive interactions. Of these recorded episodes of aggression, 93.4 percent were threats or chases without physical contact, 6.2 percent were attacks with physical contacts, and only 0.4 percent were fights. Earlier, Southwick (1967) conducted an experimental study on the intragroup agonistic behaviour in a captive group of rhesus monkeys and reported that agonistic interactions occurred at the rate of 13.2 interactions per hour of observation. Such agonistic rate composed of 5.0 threats, 6.0 submissive responses,
2.1 attacks and 0.1 fights per hour. Bernstein & Ehardt (1985a) examined the overall expressions of aggression in a rhesus monkey group to see if there is evidence of channeling of agonistic behaviour. These investigators hypothesized that agonistic behaviour would be expressed more often in responses which served to avoid escalation and in responses with the least potential to inflict serious injuries (non-contact forms of aggression). During their 18 months of experimental study, they recorded 46,517 agonistic responses. Of these, 65.6% consisted of aggressive responses (both contact and non-contact forms of aggression). They recorded 4530 instances of contact aggression, 17,759 instances of non-contact aggression including 8078 instances of chase and 5792 threat. The two most common forms of non-contact aggression were chasing and threatening. These aggressive forms accounted for nearly 30% of all agonistic behaviour, 62% of all aggression, and 78% of all non-contact aggression. Bernstein and Ehardt (1985a), further suggested that contact forms of aggression were more likely to inflict serious injury, whereas non-contact forms of aggression have the least potential for inflicting serious injuries. We observed that within the rhesus group threat and pursuit expressions were the most frequent during the agonistic interactions. These two expressions were non-contact types which involved open mouth threat with protruded lips, erection of body hairs, and raising of eye brows (for "threat" category); and vigorous chasing behind another animal with coarse vocalization, pilo erection, raising of eye brows (for "pursuit" category). These two forms of aggressive expressions also occurred simultaneously during an agonistic interaction. During the time when the agonistic
interactors are involved in attack, fight and defensive aggression, threat and pursuit generally accompany these behaviours.

On the basis of our ad libitum observations, we recorded 547 complete episodes of agonistic interactions for the rhesus and 232 for the langurs (see Table 4.8). From the ad libitum scores for the aggressive forms of expression, it was clear that threat, fight, chase and attack constituted the most common forms of aggression in rhesus monkeys, although langurs performed these expressions relatively at lower levels. Of these four common aggressive forms, threat was more frequent (855 instances), followed by chase or pursuit (586), attack (467) and fight (107) in rhesus monkeys, whereas in langurs the attack was most frequent type of aggression (82 instances), followed by chase (33), threat (29) and fight (21). For other units of aggressive behaviour, the ad libitum scores were relatively high for the rhesus than for the langurs. Also, with regard to the micro-units of the submissive behaviour, the scores for the rhesus were high. The common submissive gestures shown by the rhesus monkeys were grimace, withdrawal, flight and screech.

From the above discussion on our ecobehavioural, focal group and focal animal observations, it is clear that very few studies have compared the rhesus monkeys and the langurs with regard to the influence of season and time-of-day on their agonistic behaviour. Our study findings revealed that rhesus monkeys lived comparatively in a smaller home range than did the langurs. Their home ranges also overlapped extensively not only between the
species but also within the species. A total number of 547 complete episodes of agonistic behaviour were recorded on ad libitum basis for the rhesus groups and 232 such episodes for the langur groups.

The ANOVA results for the effect of species, season and time-of-day on the agonistic behaviour revealed that the rhesus monkeys performed significantly more agonistic behaviour than the Hanuman langurs. The agonistic behaviour, however, did not vary significantly with season and time-of-day.

The ANOVA results for other categories of behaviour such as looking, locomotion, human feeding and resting revealed that there was a significant species difference in looking, human feeding and resting. The rhesus monkeys exhibited significantly more human feeding and resting than did the langurs. The langurs, however, showed significantly more looking than did the rhesus monkeys. For locomotion behaviour, these two species did not show significant variation. Looking, locomotion, human feeding and resting behaviours varied significantly with season. The time-of-day had no significant effect on looking, locomotion and human feeding behaviour. The resting behaviour, however, varied significantly with time-of-day. It occurred more in afternoon than in morning hours.

The species x season interaction effect was significant for locomotion, human feeding and resting. The season x time-of-day interaction was significant for locomotion only. The species x time-of-day, species x season x time-of-day interactions were not significant for resting, looking and human feeding behaviour categories.
As compared to the langurs, the rhesus monkeys showed significantly more expressions of the micro-units of the agonistic behaviour such as attack, pursuit, fight, threat, defensive aggression, bluff charge, pucker face, displace, redirected threat, display, stare, attempt to take object, inanimate object protection, flight, crouch, attempted escape, passive-rigid-submit and screech. With regard to our study finding on age-sex-class differences in the expressions of the micro-units of agonistic behaviour, we found that the rhesus adult females showed significantly more attack, threat, pucker face, defensive aggression, displace and display than the langur adult females. The rhesus juveniles performed significantly greater expressions of pursuit, threat, grimace, flight, pucker face, crouch, attempted escape and defensive aggression than the langur juveniles. The rhesus infants also showed significantly greater expression of withdrawal, flight, attempted escape, screech and passivity.

It can be concluded that the comparatively smaller home range size and the food preference habit of the rhesus monkeys may be the responsible factor for their intense aggressive and submissive behaviour within the groups. The observed variation in the agonistic behaviour between the rhesus monkeys and the langurs may be a species-specific phenomenon.