

Social Organization and Reproductive Biology of Himalayan Grey Langur (*Semnopithecus entellus ajax*) in Machiara National Park, Azad Kashmir (Pakistan)

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Abstract: - Social organization and reproductive biology of Himalayan Grey Langur (*Semnopithecus entellus ajax*) was studied from April, 2006 to April, 2007 in Machiara National Park, Azad Jammu and Kashmir. During the study nine troops and three male bands were found distributed in the study area. Out of these, only three focal Langur groups, including, two bisexual troops and one all male band were selected for detail study. Langurs are social animals and live in groups in the form of uni-male bisexual troops (UMBS), multi-male bisexual (MMBS) troops and all-male bands (AMB). Langurs of three focal groups spent 31.71% of their active period in feeding, 22.75% in monitoring, 21.08% in dozing, 12.43% in movements, 10.02% in grooming and only 2.01% in sexual and other activities. In Machiara National Park, langurs breed from February to September with maximum births in months of March to June, representing a birth peak while no birth was recorded in the months of October to January during the year 2006-07. In nine study troops, 61 births were recorded during the study period with average birth rate of 0.3.

Key words: Himalayan Grey Langur, Machiara National Park, social organization, reproductive biology.

INTRODUCTION

Primates belongs to the highest order (Primata) of class mammalia which encompasses six sub-orders or six natural groups (the lemurs, the lorises and galagos, the tarsiers, the new world monkeys, the old world monkeys, apes and humans) (Blanford, 1992). The nonhuman primates are represented with 63 genera and about 600 species or subspecies in about 92 countries, Brazil topping the list with 77 species. Twenty five species of these animals have been recorded from the Indian subcontinent (Rajpurohit, 2005). The Grey Langur or Hanuman Langur (*Semnopithecus entellus*) is a most widely distributed animal species of the non-human primate species, found in the Indian subcontinent (Roonwal and Mohnot, 1977). These langurs belong to the family Cercopithecidae and subfamily Colobinae having folivorous feeding habits, complex sacculated stomachs and lack cheek pouches (Thorington and Anderson, 1984). Himalayan Grey Langurs (*Semnopithecus entellus*

ajax) are one of the sub species of the Grey langur distributed in India and Nepal (Walker and Molur, 2004). Roberts (1997) has recorded this subspecies in Pakistan distributed in Azad Kashmir, District Mansehra and Kohistan Pallas. In Azad Kashmir, these beautiful monkeys are distributed in Neelum Valley (Machiara National Park and Salkhala Game Reserve), Jehlum Valley (Moji Game reserve and surroundings) and Hillan and Phalla game reserves in District Bagh (Ahmed, 1999; Dar, 2006). According to a base-line study by Azad Kashmir Wildlife Department in 2004, about 1500-2000 individuals are distributed in the Machiara National Park (Baig, 2004).

Langurs live in groups, numbering 40-60 (Roberts, 1997). The feeding competition is conventionally believed to constrain group size, and infanticide may be another factor limiting sociality in langurs (Koenig *et al.*, 1997). The social system of these animals also varies upon location including one-male bisexual troops, multi-male bisexual troops and all-male bands. Multimale-multifemale troops can have a size up to 125 individuals and the higher densities result in larger defensive coalitions and higher numbers of females per group (Mohnot, 1971; Treves and Chapman, 1996). Bisexual troops

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are generally matrilineal, and females remain for life in their natal troops while males emigrate, usually as juveniles, to join all-male bands. Resident males of troops are usually replaced, on the average after 2.5 years. Two types of resident replacement processes have been reported, abrupt changes and gradual changes. During the process of an adult-male replacement, invading males of an all-male band first drive out the resident. The highest ranking of the invaders subsequently installs himself as the new resident male of the invaded troop, and this is followed by the expulsion of weaned male juveniles (Rajpurohit *et al.*, 1995, 2003).

In uni-male troops, the resident male is under constant pressure from other males attempting to take over the troop. When a group of males takes over a troop they will kill the infants (Strusaker and Leland, 1987) and mate with the females (Sugiyama, 1965; Mohnot, 1971; Vogel and Loch, 1984). Females allow other females to hold and to care for their youngs (allomothering). Immature females spend significantly more time in proximity to other group members, groom more and have more physical contact than immature males. Other immature females are their preferred social partners. Immature males also prefer like-aged females and restrict their relationships with other immature males to proximity (Nikolei and Borries, 1997). Social grooming, a type of tactile communication, is used to reinforce the bonds between individuals. In vocal communication, whooping is a call given by the adult male of the troop that keeps animals in touch and maintaining group cohesion when feeding undisturbed in the branches. This call is also emitted before troop movements and the first individual, when sights a threat utters a warning cough, then the entire group scatters in to the tree tops (Tritsch, 2001).

When a group of males takes over a troop, they will kill the infants and one male will establish himself as the resident male (Newton, 1986; Strusaker and Leland, 1987; Borries, 1997). It has been noted that the new male will mate with the females shortly after takeover (Sugiyama, 1965; Mohnot, 1971; Vogel and Loch, 1984). Males may kill infants to gain a reproductive advantage, because females will go into oestrous shortly after the loss of their infants (Hrady, 1974).

Males usually breed at the age of six or seven years and mature males prevent any of the males below this age from mating, though they may be sexually mature. Females come into oestrous at about three and a half year of age (Roberts, 1997) whereas in captivity they reach reproductive maturity between 3 and 5 years (Harley, 1988). The menstrual cycle varies widely in length, with an average of 26.8 days and menstruation lasts about 5-6 days (David and Ramaswami, 1969). Furthermore, oestrus length significantly increases in multi-male groups, where females tend to mate with as many resident males as available (Borries *et al.*, 1991). In captivity, menstrual cycle length varies from 18 to 45 days with a mean of 26.3 ± 3.6 days and menstruation lasts for 2 days (Lohiya *et al.*, 1988). Ecological conditions, feeding competition and ranging behavior as well as physical condition influence the timing of reproductive events in females (Koenig *et al.*, 1997).

Breeding season also varies with location and gestation from 190-210 days (Roonwal and Mohnot, 1977). Young are usually born between January and March (Prater, 1965) until June, with most births around the energetically worst period of the year. The results indicate that, in contrast to several other non-human primates, most females of this species gave birth too early to meet the optimum lactation requirements (Koenig *et al.*, 1997). Langur normally gives a single birth, but twins and three births have also been recorded (Mohnot, 1974; Rajpurohit, 1987).

Study area

The study was conducted in Machiara National Park (MNP) (34°-31' N latitude and 73°-37' E longitude), Azad Kashmir. The area of Machiara National Park was declared in 1982 as Game Reserve under the Azad Jammu and Kashmir Wildlife Act, 1975 which was upgraded to a National Park in 1996. It covers 135.32 ha km² (33,437 acres) area falling at altitudinal range between 1,300 m to 4,733 m above the sea level (asl). The Park is bordered by the Kaghan Valley (North West Frontier Province, Pakistan) and the Neelum Valley on its western and eastern sides respectively at a distance of about 32km from Muzaffarabad, the capital city of the State of Azad

Jammu Kashmir. It is encircled from the southern periphery by three Union Councils of Bheri, Machiara and Serli Sacha comprising 30 main villages with 7,635 households and 52,000 persons (Awan *et al.*, 2004; Qamar and Minhas, 2006). Because of poverty, lack of alternate subsistence means and more dependence on land resources, the people keep large number of livestock of different kinds for agriculture, domestic and commercial purposes. Therefore, the livestock forms an integral part of the village economy in Park area. Surplus animal products and heads are sold for the generation of income. The total livestock population of the area has been estimated to be 37,000 heads of different kinds (Qamar *et al.*, 2008).

The climatology of the area varies according to the aspect and elevation. The region is influenced by the southwest monsoon and thus has extra tropical mountain climate with moderate monsoon conditions. The main climatic features of the area are extreme cold and severe winter, pleasant and agreeable spring, summer rains, and clear and dry autumn and considerable winter precipitation (Awan *et al.*, 2004).

From biological point of view, the area harbours a variety of ecozones, including Himalayan temperate mixed-forest/alpine-scrub-rangeland ecosystem providing habitats to thousands of wild species. Important vegetation comprises *Taxus wallichiana*, *Cedrus deodara*, *Pinus wallichiana*, *Pinus roxburghii*, *Picea smithiana*, *Juniperus communis*, *Abies pindrow*, *Juglans regia*, *Aesculus indica* and *Quercus incana* while among wildlife *Uncia uncia*, *Panthera pardus*, *Prionailurus bengalensis*, *Moschus chrysogaster*, *Selenarctos thibetanus*, *Naemorhedus goral*, *Capra ibex*, *Macaca mulatta*, *Presbytus entellus ajax*, *Tragopan melanocephalus*, *Catreus wallichii*, *Gyps himalayensis*, *Lophophorus impejanus*, *Pucrasia macrolopha*, *Lophura leucomelana*, *Lerwa lerwa* and *Tetraogallus himalayensis* are important species found in the area (Awan *et al.*, 2004; Qamar and Minhas, 2006).

MATERIALS AND METHODS

The study was conducted from April, 2006 to April, 2007. During the study nine troops and three

male bands were found distributed in the study area (Table I). Five surveys were conducted throughout the study area, including all langur groups to determine the current distribution and composition of langur troops. Afterward, bisexual troops were visited on monthly basis to record the births carried out during the month. However, to study the social and reproductive behavior of the animal, three “focal groups” of the langur were marked and selected for detailed study. The focal groups were selected because of easy approach and average sized permanent residency including two bisexual troops {one uni-male bisexual (UMBS-III) and one multi-male bisexual (MMBS-II)} and one all-male band (AMB-III). The first focal bisexual troop (UMBS-III) was found at localities Sila Da, Purana Chanj, Koledaber and Thora Gahatian, about 6-8 km north to village Bheri. The second troop (MMBS-II) was located at Thora, Kuthiali and Domailan, about 3-4 km north to village Machiara while the all-male band (AMB-III) was found around Jugian. Animals are easy to observe, since they are not shy and spend most of the daytime on the ground.

Identification

To keep track and avoid mixing, the animal groups were assigned the names on the basis of the group composition and were recognized by the identification marks such as cuts, scars, tail carriage, deformity if any, facial features, postures, gestures, etc. (Table I).

Social behavior and reproductive biology

By using the scan and focal animal sampling method following Altmann (1974), all events such as multi-male situation in troops, male-male tolerance, oestrous female sharing, group splitting, inter-troop and intra-troop interactions (interaction with neighboring troops as well as among themselves) and interaction with other species, which frequently share their home range, all were noted. All components of birth records, missing, emigration, demographic changes, resident male changing process, male strategies, daily activity pattern, reproductive profiles and other behaviors were also recorded. Similarly, by using the same sampling methods, the focal bisexual troops and

Table I.- Group composition and identification of Langur troops found in MNP during the year 2006-07

Sr. #	Name of troop	Composition (Number of individual)				Identification	Locality	Location	Elevation (m)
		Adult male	Adult female	young	infant				
1	UMBS-I	1	14	17	0	This is smaller troop with a resident male with curved and brushy and banded end tail	Jobsar, Lohedandi, Kala Jabra	N 34°33. 611 E 73°32. 126	2732
2	UMBS-II	1	17	28	3	Unimale bisexual troop with an old female having hanging black spotted belly. Always remained at the end as walking	Moosa Gali-Biarian Wali Mori	N 34°33. 468 E 73°35. 078	2684
3	UMBS-III	1	21	40	9	Permanent resident troop with a female having cut on face and upper lip exposing teeth in normal posture	Sila Da-Prana Chanj-Thora	N 34°32. 640 E 73°36. 124	3134
4	UMBS-IV	1	16	32	6	Unimale bisexual troop	Pathra-trakana-kachlan-kaila wala Parr-Seri	N 34°29. 603 E 73°42. 583	2201
5	UMBS-V	1	14	54	5	Unimale bisexual troop	Baga Jhath-Dnna-Jaba-Reveri	N 34°29. 386 E 73°42. 764	2515
6	UMBS-VI	1	24	51	6	Long cut on the right ear of the resident male	Jhugian-Danna magri	N 34°29. 687 E 73°37. 322	1851
7	UMBS-VII	1	15	45	6	A unimale bisexual troop	Drra Nerian-Nala Jargi	N34°28.367 E73°41. 148	1790
8	MMBS-I	3	11	26	3	The troop is multimale bisexual troop. Hind limb of an adult female is half missing. Thus walks crawling	Pakhlan, Ban	N 34°31. 899 E 73°31. 956	2660
9	MMBS-II	9	43	109	23	Very large multi male troop with very healthy, aggressive and large resident male	Thora-Khuthiali-Domallan	N 34°31. 719 E 73°37. 026	2266
10	AMB-I	22	0	13	0	Band is lead by an old male with half tail	Sila Da-Prana Chanj-Thora	N 34°32. 640 E 73°36. 124	3134
11	AMB-II	33	0	35	0	Very large and only band in Co. 9B	Thora-Khuthiali-Domallan	N 34°33. 097 E 73°35. 837	2534
12	AMB-III	14	0	11	0	A smaller male band permanently found in the area lead by a very brave and big old male with curved tail	Jhugian-Danna magri	N 34°31. 719 E 73°37. 026	2143

For abbreviations see Figure 1.

male bands were scanned. Besides this the troop and band situation, composition, social change, disappearance from group, new birth, etc. were also recorded. All the births in study troops were recorded in the last week of every month, and the birth rates (b) were calculated by using the formula: $b=It/Ft$, following Rajpurohit *et al.* (1994), where 'It' is the total number of infants born in one year and 'Ft' is the total number of reproductive females in the sample throughout the year.

Scanning of focal individual langur (selected on unique morphological characters) was carried out for its movement, activity, sub grouping, interaction with other wild and domestic animals and any other

important events relevant to individual behavior, *e.g.* resting, feeding, moving, sleeping, grooming, jumping, clamping, mating, whooping, barking, grunting and drinking were recorded by this sampling method.

RESULTS

During the study period (April, 2006-April, 2007), the entire langur population in Machiara National Park was organized in seven uni-male bisexual troops, two multi-male bisexual troop and three all-male bands, distributed over 48.9 km² (4,890 ha) area of the mixed coniferous and sub-

Alpine scrub forests. Each troop composed of an adult male (uni-male bisexual) and occasionally more than one adult male (multi-male bisexual), several adult females and their immature offsprings. A male band composed of only males of different age classes excluding the breast feeders. They were found distributed in different localities and elevation during the different months of the year (Table I).

Social organization

Langurs are social animals. Variable social organization was observed in the Himalayan grey langurs. In these animals usually two basic types of social groups were bisexual troops and the all-male bands. Bisexual troops were generally matrilineal groups composing adult and sub-adult females, infants and juveniles with an adult male (uni-male bisexual troop) or more than one adult male (multi-male bisexual troop). The number of individuals in uni-male versus multi-male troops and the corresponding number of extra troop band males varied from place to place. Usually bisexual troops were more organized associations than the all-male bands as they were the loose gathering with weak social hierarchy.

Diurnal activities

The daily activities started from early morning and were always initiated by the resident male with morning "whoops". After descending from the roosting sites and before moving to foraging ground the troop usually stayed in the vicinity of their roosting site for some time and then started daily social activities *e.g.*, grooming, huddling, allogrooming, etc. for short duration. A brief description of each activity is given below:

Feeding

Much of the time was spent in feeding which began when an animal made first contact with any part of a food plant, excluding contacts as a locomotors substrate. Feeding sessions were considered terminated when the focal animal either moved away or stopped eating. For infants getting of milk from the mother was considered their feeding. The average monthly percentage time spent by the langurs on feeding during the study period was 31.71 % (Tables II, III; Fig. 1). The results also

suggested that the all-male bands spent more time in feeding than the bisexual troops did (Fig. 1).

Dozing

This activity included solitary behavior during which focal animals slept, rested or were motionless with closed eyes with slight body movements. Langurs spent about 21.08% of the time on this activity (Table III).

Movements

This includes all locomotory activities, *e.g.* climbing, walking, running, leaping and jumping between arboreal supports. Most of the time langurs remained on the ground busy in feeding, walking, running and jumping. Locomotion took 12.43% of the daily langur's time (Table III).

Monitoring

This activity was also a solitary behaviour in which an animal was neither feeding nor sleeping nor engaged in social behaviour. But it was observing around, watching and remaining vigilant (the resident male and adult females). Langurs spent about 22.75% time on these activities (Table III).

Grooming

It included all kinds of grooming behaviour (allogrooming and auto grooming or self grooming) when a focal animal developed contacts with an other member for grooming purpose. Allogrooming may be between female-female, female-male or adult female-juvenile female or adult individual with the young ones. The langurs of the focal study groups spent 10.02% average of their time on grooming (Table III).

Other optional activities

Besides the above mentioned activities some optional activities were also carried out by the langurs in which the focal animal's behaviour was directed towards another individual. These were playing, copulation, chasing, displacement, aggression etc.

It has been observed that the langurs spent most of the time on the ground (almost 80%) in different activities. Estimates of the proportions of time spent in different activities for the study period

Table II.- Percentage feeding time spent by the focal troops and male band during the year 2006-07.

Troop	Percentage feeding time spent in each month												Average
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
UMBS-III	23	27	31	34	37	34	35	36	33	33	37	39	33.25
MMBS-II	19	19	25	31	34	27	32	34	23	24	34	37	28.25
AMB-III	27	29	34	31	35	29	40	32	35	36	42	34	33.67
Average	23.0	25.0	30.0	32.0	35.3	30.0	35.6	34.0	30.3	31.0	37.6	36.0	31.65

For abbreviations see Figure 1.

Table III.- Percentage time spent with seasonal variation in different activities by focal groups of langurs during the year 2006-07.

Sr. #	Activities	Time spent (%)						Average in summer	Average in winter	Overall average
		UMBS-III		MMBS-II		AMB-III				
		summer*	winter**	summer	winter	summer	winter			
1	Movements	10.03	12.88	8.48	13.66	14.78	14.78	11.09	13.77	12.43
2	Feeding	32.0	34.43	29.42	27.12	31.14	36.27	30.82	32.6	31.71
3	Grooming	9.89	7.01	13.34	14.99	8.36	6.49	10.54	9.5	10.02
4	Monitoring	22.15	17.58	26.56	23.07	24.11	23.03	24.28	21.22	22.75
5	Dozing	23.95	25.23	20.03	18.55	20.28	18.34	21.44	20.72	21.08
6	Others	1.98	2.87	2.17	2.61	1.33	1.09	1.83	2.19	2.01

For abbreviations see Figure 1.

*Summer months, May-September; **Winter months, October-April

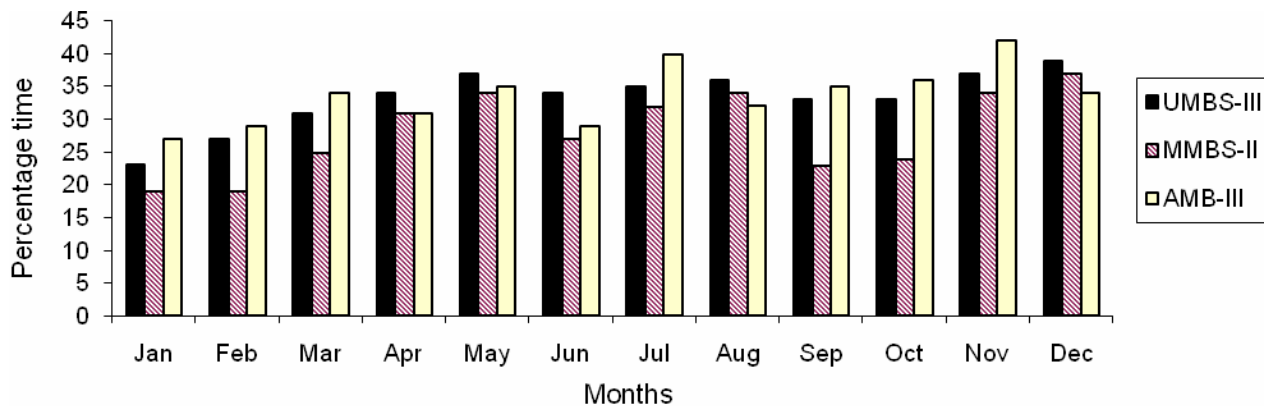


Fig. 1. Percentage time spent in feeding activities by two focal troops and one of focal AMB during different months of the year 2006-2007 in MNP.

Abbreviations used: MMBS, multi-male bisexual troop; UMBS, uni-male bisexual troop; AMB, all-male band.

in three focal study groups (UMBS-III, MMBS-II and AMB-III) suggested that, of the total activity budget, langurs spent one third of the active period in feeding (31.71%) followed by monitoring (22.75%), dozing (21.08%), locomotion (12.43%), grooming (10.02%) and sexual and other social activities (2.01%) (Fig. 2, Table III).

Seasonal variation

Langurs relaxed more in the midday and remained more active in the morning and evening hours in summer than in winter, when they were observed to be more active during midday. Similarly, more time was spent in the locomotion during winter months (13.77%) as compared to the

summer (11.09%) months (Table III, Fig. 3). It was observed that although the langurs remained busy in feeding somewhat throughout the day, most of them however, concentrated on feeding in the afternoon as compared to other parts of the day, especially during the winter months. Similarly, a little more time was spent in feeding activities during the winter (32.6%) months than during the summer (30.82%) (Table III, Fig. 3).

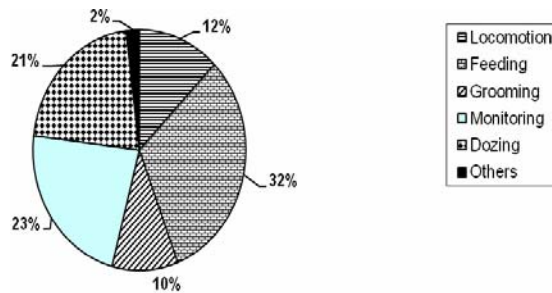


Fig. 2. Average time budget for different activities of langurs in MNP during 2006-2007.

The data analysis showed that langurs spent more time in grooming activity during the summer (10.54%) than in the winter (9.5%). Like grooming, the monitoring also took a little more time of langurs during summer (24.28%) months than the winter (21.28%) (Table III, Fig. 3).

Dozing was almost the same throughout the year and no remarkable variations were observed during the study. On other social and sexual activities langurs spent more time during winter months (2.19%) than the summer (1.83%) (Table III, Fig. 3).

Ranking

Ranking in bisexual troops

In a bisexual troop, usually a single resident male occupies the top rank in his group. Ranking among the females was determined during the resource competition and other social activities. This determination of ranking system in females of the troop was usually according to the age of the individual *e.g.*, the older females get the next rank to the resident male and the others are behind these. The juvenile males usually left the troop and joined all-male bands in the leadership of an adult male.

Ranking in all-male bands

It was observed that, all the juveniles and adult males joined together to form a male band, which stayed together using the same habitat and resources. All the males of different ages in the band were ranked accordingly. An adult male usually led the band during different activities, while for invading movements, experienced males would move first. At the time of such invasion on the bisexual troops, Juveniles moved first followed by sub adults, young males and adults that moved the last of all. When the resident male of the bisexual troop was defeated by the invading male band, the former strongest male emerged out as the new resident withdrawing away rest of the males. In most cases ousted resident males rejoined their original male band from where they had come, but in some other cases, they became solitary or might form separate male gangs by sweeping away male juveniles with them on their ousting from the troop.

Competition

Like other nonhuman primates, langurs live in groups. Sociality has numerous benefits (increased protection from predators, cooperative defense of food resources and collective rearing of offsprings) and drawbacks such as. Like most group living animals, scarce resources such as food, water and mates were the basic cause of competition among the langurs.

The most obvious manifestation of competition within langur groups was aggressive behavior which often took the form of display, signals exchanged between two or more animals that rarely led to physical contact but usually result in one animal gaining a particular resource.

Food

Food was the major cause of the langurs competition in the troop, especially during the unfavorable weather conditions and in scarcity of food. During study period, it was observed that the food resource was one of the main factors responsible for competition and dominance. The observation was taken by focal animal sampling methods. The competition for food usually involved one individual using threat or substantial attack to

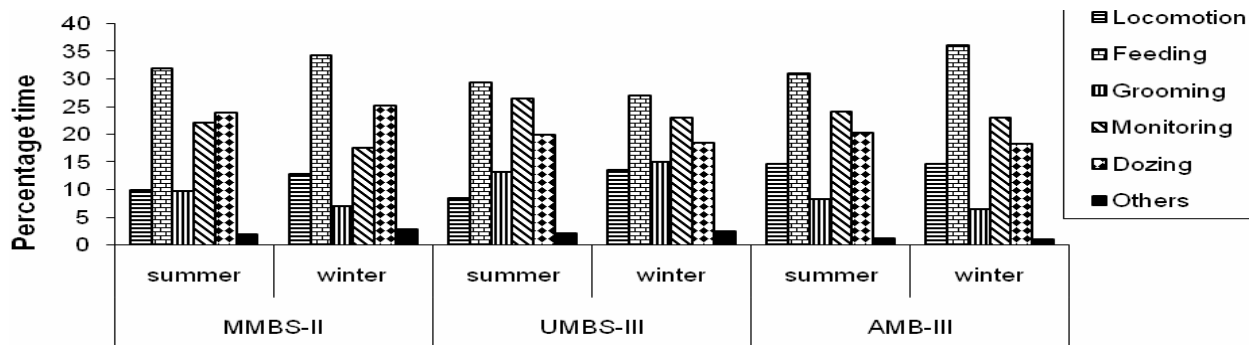


Fig. 3. Seasonal variations in different activities of the three focal groups of langurs during 2006-2007. Abbreviations used: MMBS, multi-male bisexual troop; UMBS, uni-male bisexual troop; AMB, all-male band.

displace some other individuals from a food patch or to avert access of another individual to a food patch that was suitable for utilization.

Shelter

Dominant or high ranking langurs always tried to get a good place for their rest or sitting for the monitoring purposes. But in female-female selection of a good place created a competition especially in smaller home range groups. Within this home range every troop member tried to get good place for shelter during rest time. The focal troops had almost fixed home ranges and within these home ranges they had some preferred areas for roosting. This place was always used by high ranking females and the resident male and whenever that place was occupied by other members (low ranking females or juveniles), the adult higher ranking female showed aggression towards individuals which had occupied that place.

Allomothering

The infant transfer or allomothering by real mothers to other troop members is a peculiar character of colobine social behaviour. This type of behaviour was observed in the bisexual focal troops (UMBS-III and MMBS-II). In study troop (UMBS-III) there were females having 4-7 infants during the course of this study. The remaining group females (who had no infants) always tried to get and carry the infants of troop, while sometimes several mothers resisted or rejected to all or particular troop members to carry away their babies for

allomothering.

High ranking females were found less interested in carrying infants but by their own choice, they could take infants against baby's mother choice. While due to low rank, mother could not refuse or object to allomothering. It was observed that infant carrying mother always tried to sit in a secluded place where nobody could disturb her. In many situations, mother was not interested in allomothering and tried to threaten and hit the allomother.

Mating behavior

A bisexual troop comprised of an adult male, several adult and sub adult females and their offsprings. All male bands comprised of different aged males only. However multi-male bisexual troops were uncommon in the study area. In study area, bisexual and all male bands are the social structures in these animals. In case of mating competitive behavior was observed when there was more than one female in the cycle and high ranking females always mated first. During the mating season the resident male acted usually aggressively towards the other members of the troop showing its dominance.

Displacement

Displacement was observed on food procurement, drinking, possession of resident male and for better sites for feeding, resting, grooming etc. during the process the higher ranked displaced the lower ranked animal.

Grooming

Langur spent 10.31% of their activity time on grooming. It was observed in most of the grooming observations that high ranked females were always groomed by low ranked females. Similar types of observations were also noted in all-male band. Resident male was mostly groomed by top ranked females.

Resident male replacement

Social change is a natural process and the resident male replacement is an important and regular phenomenon of social change but was no such incident recorded during the study period. However, it was reported by some locals that sometimes extremely noisy and horrible battles had been observed among the langur troops residing in the areas. Furthermore, by the presence of solitary adult males and other injured male in the male-bands, it is assumed that the resident replacement did occur in the study area after intervals.

Vigilance and home range defense

The troops depended on the vigilance of resident male for the home range defense and inter-troop encounters. In bisexual langur troops, resident males were also assisted by the adult especially the old females which were extremely vigilant. The vigilance started from early in the morning and was always initiated by the resident male with morning whoops, which continued until the day's activity came to an end in the evening. Usually more than two individuals were found participating in this activity at the same time, watching in different directions. The vigilant individuals *e.g.*, resident male or the old females often climbed a tree or on the top of the rocks from where they could keep an eye on the troop and its range and scan the entire area carefully and meticulously.

The home range was found to be influenced by the resistance of the other groups around the area. They often aggressively defended against incursion by other troops or even by all male bands. During present study only one such instance of inter troop contact was observed in overlapping home range of UMBS-II and UMBS-III troops near Koledabar in August 2006 where females gave a warning vocalization (barks), alerting other troop

members about the imminent danger from the neighbouring troop. Meanwhile the resident male jumped continuously and whooper showing its eagerness and became aggressive. He resisted the invaders, and the adult females and juveniles supported him in intercepting invaders. They lined up against the invading males and the resident male ran after the males and chased them away. But it was reported by locals that sometimes the resistance by the invaders by hitting and biting may result in severe injuries especially to the males. The situation becomes very crucial when an all male band encounters a bisexual troop. The process may last for about a few minutes to one hour or sometime even longer.

Reproductive biology

In Machiara National Park the langurs breed from February to September (Table IV). In nine study troops, 61 births were recorded during the year 2006-07 with an average birth rate of 0.3 (Table IV). The annual birth distribution data suggested that maximum births occurred in months of March to June, representing a birth peak, while only one birth was recorded in the months of February and August. Similarly three births were recorded in the month of September while no birth was recorded during the period October to January in year 2006-2007 (Table IV).

The study reveals that births in general, varied from troop to troop during the study period, leading to an uneven birth rate. The birth rate in the whole population for the year 2006-07 was almost the same. Maximum birth rate was recorded in the focal troop MMBS-II (0.53 infants/female/year) while the minimum birth rate in the troop UMBS-II (0.18) (Table V). The troop visited the area during the months of November to March when no births in the troop were recorded.

It was also reported by locals and hunters that most female langurs delivered their infants at safer sites, which were very difficult to explore. It was observed and also reported by many locals that mating usually occurred in the months of September and October. In a uni-male bisexual troop, only one resident male has to mate with all the adult females of the troop. In bisexual troop UMBS-III, there were 21 adult females while troop MMBS-II had 43 adult

Table IV.- Annual distribution of births recorded in 9 langur troops in MNP during 2006-07.

Troop name	No. of births												Total number of births	
	2006						2007							
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar		Apr
UMBS-I	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UMBS-II	0	1	0	2	0	0	0	0	0	0	0	0	0	3
UMBS-III	0	2	2	1	0	0	0	0	0	0	0	1	3	9
UMBS-IV	1	2	1	1	0	1	0	0	0	0	0	0	0	6
UMBS-V	0	2	0	1	0	0	0	0	0	0	0	1	1	5
UMBS-VI	1	2	1	0	0	1	0	0	0	0	0	1	0	6
UMBS-VII	0	0	1	1	0	0	0	0	0	0	0	2	2	6
MMBS-I	0	1	0	1	0	0	0	0	0	0	0	0	1	3
MMBS-II	4	3	5	2	1	1	0	0	0	0	1	2	4	23
Total	6	13	10	9	1	3	0	0	0	0	1	7	11	61

For abbreviations see Figure 1.

Table V.- Troop composition and births in 9 study troops during the year 2006-07.

Sr. #	Troop name	Troop size	Number of males	Number of adult female	Number of births	Birth rate
1	MMBS-I	43	3	11	3	0.27
2	UMBS-I	32	1	14	0	0.00
3	UMBS-II	49	1	17	3	0.18
4	UMBS-III	69	1	21	7	0.33
5	MMBS-II	184	9	43	23	0.53
6	UMBS-IV	55	1	16	6	0.38
7	UMBS-V	74	1	14	5	0.36
8	UMBS-VI	82	1	24	6	0.25
9	UMBS-VII	67	1	15	6	0.40

For abbreviations see Figure 1.

females where it was observed that some times more than one female were observed in oestrous at the same time and higher ranked females mated first with the resident male showing dominance on the low ranking female who also tried to mate with the same male. It was observed that hours the resident male remained very aggressive as long as the female was in oestrous.

DISCUSSION

The Himalayan Grey Langur (*Semnopithecus entellus ajax*) can be distinguished from other subspecies of *Semnopithecus entellus* found in the lower altitudinal areas as its size is larger and outer sides of both the fore and hind limbs covered with silvery-dark colored hair (Wilson and Reeder, 1992; Roberts, 1997). The similar observations have been

recorded during the present study. The long tail of these langurs found in Machiara National Park, always forms a broad arc over their back curved towards the head as reported by Jay (1965).

Social organization

Langurs are social animals with variable social organization. There are several potential benefits of sociability *e.g.*, increased protection from predators, cooperative defense of food resources and collective rearing of off-springs (Rajpurohit, 2005). At the same time however, social life has many drawbacks. Group living animals must compete with one another for scarce resources such as food, water, and mates (Walters and Seyfarth, 1987).

The expression of competition within the primate group is obviously dominance and

aggressive behaviour, which often takes the form of displays and signals exchanged between the animals that rarely lead to physical contact but usually result in one animal gaining a particular resource (Janson, 1985). There are two types of competitive interactions among primates known as “approach-retreat-interaction” and competitive-exclusion. (Rowell, 1960; Hardin, 1960). Approach-retreat and competitive-exclusion interactions are common in species having well established dominance relations and the langurs are known to have established dominance hierarchy (Rajpurohit, 2005). According to Jay (1965) dominance hierarchy is probably the most important component of social cohesion and social regulation in nonhuman primate society.

Being social animals, langurs are usually found in the organized groups. These groups may be uni-male bisexual, multi-male bisexual or all male band. Uni-male bisexual or multi-male bisexual troops are more organized than the all male bands. Like the bisexual troop social hierarchy, like displacements during the food procurements, to possess oestrous females or to show the dominance when resting, chasing and in emitting whoops etc. is also found in all male bands. Although all functional rank orders are found in all male bands but the banding of all males is usually weak associations Mohnot (1984) considered a band as a loose gathering.

Resident male replacements in the bisexual troop is a usual social change among the langurs and as a rule the most dominant male or rarely the beta male becomes resident when it is required. The vacant position of alpha or beta male is occupied by the next ranking male and this pattern of fillings and elevating of ranks goes on (Mohnot, 1984). The more organized and established associations can be observed among the bisexual troops and all the individuals in these troops are ranked in a specific pattern. The age sex class distribution indicates that there is most competition among adult females and the resident male, who displaces adult females several times more often than the adult females do (Rajpurohit, 2005).

Rajpurohit (2005) and many other authors show that most of the competition is found among the langurs on the food resources and the langurs are highly competitive for the finite food commodities

which are scarcely distributed in their home range. Similarly, Hrdy (1977) reported that when langurs are confronted with decreased food resources they appear to resort to increased competition. According to Rajpurohit (2005) all contexts of displacement behavior or dominance behavior strongly suggest that it is directly or indirectly related to the acquisition of resources.

Daily activities

For the ecological and behavioral study of an animal the analysis of its time spent among various activities is essential (Struhsaker and Leland, 1979). Activity profile is a way to approach the problem of how animals budget their time and may be useful in suggesting how a species utilizes resources and adapts to its environment (Rajpurohit, 2005).

Like other primates langurs are diurnal animals and during the day time they strictly follow the routine daily activities every day. They spend the day according to well organized activity budget plans. However, during interruptions, disturbances, human interference, and the presence of predators (leopards) these activity patterns may be delayed or even changed. These activity plans may also be disturbed due to the presence of other resource competing animals and weather conditions, such as rains, dust storms and extremes of temperature (Mohnot, 1974; Rajpurohit *et al.*, 1994).

During the present study langurs spent about 44.96% time in resting including monitoring (%) and dozing. Rajpurohit (2005) reported that in relatively rich environment the langurs spend more time (57.40%) in resting including monitoring (32.11%) and dozing (25.29%). In other similar studies on these langurs Winklar (1981) found this activity to be 48 % (24% + 24%). According to Yoshida (1967) *Presbytis* langurs in the forested environments spend 30 to 60% of their activity time in feeding, as found during the present study (30.80%). Sugiyama (1976) stated that of the total daily activities, feeding was 40%. All the above results and studies show that the langurs spend their time in different activities according to the available environments. In a rich environment with sufficient food supply, they spend more time on feeding than resting and vice versa.

Home range defense and encounter with neighbouring troops

Langurs usually remained in their home range and did not interfere with other neighbouring troops. In some cases, they might enter into the territory of each other and these violations of boundaries often caused the langur to become aggressive leading to inter-troop encounters. The encounters were usually for the whole home range defense or might be for the food resources. These home defenses were usually aggressive in case of troop-troop interaction. During the present study, one such encounter was observed between the langurs of the troop UMBS-II and UMBS-III. Similar observations have been reported by Rajpurohit (2005). Cheney (1986) has reported that many other factors *e.g.*, distribution and availability of food and troop composition affect range defense behavior in the langurs.

Reproductive biology

In Machiara National Park the langurs breed usually from February to September. It has been observed and reported by the locals that most of the female langurs usually give birth to their offsprings in the months of April and June. The earlier studies about birth seasons of the langurs at Rajaji National Park, Ranthambore, Wilpatu and Kanha showed very restricted birth seasons and similarly, in Jodhpur, Polonnaruwa, Dharwar and Orcha, the births are concentrated in some months (March-September) of the year (Newton, 1987). In the study of birth dynamics of the langurs in Jodhpur India, Rajpurohit *et al.* (1994) also recorded that most of the births took place in the months of March and April and low birth rates were recorded in November and December.

Most of earlier studies of langur populations from different habitats thus show difference in birth seasons. Such differences in reproduction may be due to crop raiding or provisioning during the dry periods that may allow langurs to breed throughout the year. Seasonality in the births is found in populations which are away from such conditions *e.g.*, the populations in the forest areas (Harley, 1985; Newton, 1987). Thus reproduction is linked with food availability. Koenig *et al.* (1997) reported that the ecological conditions, feeding and ranging behaviour, and physical condition of female

Hanuman langurs (*Presbytis entellus*) influence the timing of reproductive events. They observed that the most of the females gave birth too early to meet the optimum lactation requirements, as the conceptions were confined to the months of July to November, coinciding with the time of their best physical condition. Moreover, females which conceived were in a better physical condition than those that failed to conceive, suggesting a primary influence of nutrition on the probability of conception.

Similar results of seasonality in birth have been obtained from the present study. This seasonality and timing of births may be the result of a regular seasonal shortfall of resources influencing the ability of the females to ovulate and to conceive. The present study revealed that the most of the births occurred during the early summer when there was sufficient food supply while most of the mating were observed and reported in the months of September and October.

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