Study the Dominance Hierarchy and its Role in Social Organization in Hanuman langur, *Semnopithecus entellus entellus* (Dufresne, 1797)

Abstract of

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ZOOLOGY

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2005

This humble work is dedicated to my elder brother
Shri SHAITAN SINGH RAJPUROHIT
who always inspired me for higher education and to the succeeding generations of field Primatologists for deeper and wider research on the subject.

Contents

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CERTIFICATE

*This is to certify that the work presented in this thesis entitled "**Study the Dominance Hierarchy and its Role in Social Organization in Hanuman Langur**, **Semnopithecus entellus entellus** **(Dufresne, 1797)**"- submitted for degree of Ph.D. (in Zoology) is a bonafied research work carried out by **Mr. Durg Singh Rajpurohit**, Research Scholar, Department of Zoology, JNV University, Jodhpur under my supervision. It is his own original work and denotes a new approach to the topic. I also certify that no part of this thesis has been submitted for the degree or diploma in India or abroad.*

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Residential Certificate

It is certified that Mr. ***Durg Singh Rajpurohit****, Research Scholar, Department of Zoology, worked under my supervision w.e.f. 01.05.2002 to 14.04.2005 towards his Ph.D. Degree. He remained in the municipal limit for more than two years during above period as per ordinance 211.*

Place: Jodhpur
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Place: Jodhpur (Durg Singh Rajpurohit)
Date:

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Chapter 1

INTRODUCTION

CHAPTER-1

INTRODUCTION

From the evolutionary point of view primates constitute the highest order of class mammal. The recent-day understanding of the order Primate is that it encompasses six sub-orders or six natural groups-the lemurs; the lories and galagos; the tarsiers; the new world monkeys; the old world monkeys; and finally apes and humans. The first three of these groups are often collectively referred to as the Prosimians while the remainders are the Simians, although in reality the tarsiers fit uncomfortably within the simian and are through of by many people as an intermediate between the Prosimian and Simians (Blanford, 1992).

Structurally, Primates show, very little deviation from the basic primitive mammalian pattern; they retain a collar bone or clavicle and their hands and feet still have five digits, with a few species, a limited reduction of bones within each digit. One very obvious primate feature is the development of the forward facing eyes at the expense of a reduced muzzle and an accompanying reduction in the sense of smell.

At the same time, the movement of the eyes on the front of the head has allowed expansion of the brain case and the enlargement of the brain. It is this combination of a highly mobile skeleton of primitive design but with a greatly developed brain, which has led to the success of the primate as a group.

The study of nonhuman primates has a close bearing on the understanding of human, social and psychological problems are widely realized. Indeed, students of primate behaviour have perhaps more often been social scientists, anthropologists and psychologists than zoologists. In addition to its relevance to the study of social evolution, the study of primates is important in a number of other fields, such as medicine (human and veterinary) and agriculture (protecting crop from primate pests).

Evolutionarily, biologically and culturally nonhuman primates are the closest relatives of humans. A shared ancestry with humans is responsible for many common characteristics in nonhuman primates-tool use, long-lasting social relationships, physiological characteristics, etc. The study of nonhuman primates has contributed to the understanding of basic biological phenomena, human diseases, social behaviour and life styles of human societies.

Non-human primates, comprising monkeys, langurs, apes, lemurs and Lories, etc. inhabit most part of the biodiversity rich, 4 major biogeographically tropical and subtropical regions of the world. They perform ecological services such as seed dispersers, pollinators, primary consumers and as food for top predators. They are therefore, good indicators of the general health of the ecosystem and are helpful in conservation planning.

The nonhuman primates are represented with 63 genera and about 600 species or subspecies in about 92 countries, Brazil topping in the list with 77 species. A total of 21 species are recorded from the Indian subcontinent.

India has an exceptionally rich heritage of non-human primate population altogether 15 species and 39 subspecies. This richness exhibits the biological and environmental diversity of India, ranging from mountain habitats in the Himalayas, the deserts of Rajasthan, agricultural plains of the Gangatic basin, subtropical forests of the northeast, mangrove estuaries of coastal India, tropical forests and the coral reefs of the south India.

Primates are important components of the Indian biota and its culture. They play a major role in both the natural and the cultural environments, and have contributed to the health and welfare of the entire world by virtue of their role in scientific research. Therefore, it is very important that the aspect of this country's biodiversity be concerned.

The Hanuman langurs, *Semnopithecus entellus*, a member of family Colobinae of old world monkeys are a highly adaptive leaf-eating monkey. It is widely distributed in India, Sri Lanka, Nepal and Bangladesh. Among the

25 species of non-human primates found in the Indian sub-continent (see Appendix 1).

It is the most common species which survive in all kinds of environments from the snow-clad peaks of the Himalayas (up to 4000 m) in the north to deciduous forests in the south and in parts of the Great Indian Desert in the west to rain forests in the east. Of all the known Colobines, it is the most abundant of all the six species found in south Asia.

The Colobine monkeys have provided Primatologists with a rich array of ethological and ecological data upon which to generate models of the evolution of primate behaviour. Only a few of the thirty-odd species have, however, spawned most of the theories proposed to explain old world monkey's social system. In spite of a range of morphological and social adaptation that reveals any other primate taxon, most of what we know about this group is still based on only two species the Hanuman langurs, *Semnopithecus entellus* and red colobus, *Procolobus badius*.

Taxonomic references of Hanuman or common langur

- *Simia entellus* Dufresne (1797)
- *Semnopithecus entellus* Blanford (1988), Pocock (1939)
- *Presbytis entellus* Elerman and Morrison-Scott (1951), Khajuria (1954), Napier and Napier (1967)
- *Semnopithecus entellus* Groves (2001)

The first naturalistic report on Hanuman langurs was published by the Bengal sporting magazine in August, 1836. This was followed by articles written by Blyth (1843), Hutton (1867), Hughes (1884), and G.J.F. (1902) on different behavioural aspects. Blanford (1888-91) summarized the existing knowledge on this species.

Observation covering various other aspects like ecology, social behaviour, etc. have been provided by Dodsworth (1914), Hingston (1920), Logan-Home (1929), Champion (1930), Morris (1953), Kummar (1955), Khajuria (1956), Prakash (1962) and De Vore et al. (1965).

The first systematic research on this species in nature was carried out by Jay (1962, 1963, and 1965) on eco-behavioural and eco-ethological

aspects in Kakori village near Lucknow in U.P. and in Orcha, Madhya Pradesh. In Dharwar, South India, Sugiyama (1964, 1965 a, b, 1966, 1967), Sugiyama et.al. (1965) and Yoshiba (1968) carried out intensive studies on wild population of Hanuman langurs for their ecology, social organization and intertroop variability.

The first long-term socio-ecological field study of Hanuman langurs began in 1967 by Mohnot (Mohnot-1971, 1974, 1978, 1980, 1984 a, b, 95) in and around Jodhpur at the fringe of the Great Indian Desert, which is incidentally the western most geographical limit of the species.

Simultaneous studies by Kurup (1970) in Gir forests, Vogal (1971) at Sariska in Aravalli hills and Weber (1973) in Kumaon hills were carried out on its ecology and social organization. Sarah Hrdy (1974, 1977) carried out field studies on the reproductive strategies of this species in Mount Abu, Rajasthan bordering Gujarat. This was followed by studies by Moore on all male band organization at Mount Abu and Ranthambhore who compared male behaviour profiles of these two sites (Moore 1984, 1985) and at Jodhpur by Rajpurohit also on male social organization (Rajpurohit, 1987; Sommer and Rajpurohit, 1989).

Likewise, Laws and Laws (1984) studied langurs at Rajaji National Park. Newton (1985, 1992) examined behaviour and ecology of free ranging Hanuman langurs in Kanha National Park. In the Himalayas, studies were conducted at different sites like Bhimtal by Vogal (1971), and in Nepal at Melemchi by Bishop (1979), at Solu Khumbu by Boggess (1979, 1980, 1984), Chalise (1995) and Borries (1989, 1997).

In Sri Lanka, detailed socio-ecological studies in nature have been carried out by Ripley (1965, 1967, and 1970) and Muckenhirn (1972).

In Jodhpur German scholars in collaboration with S.M. Mohnot continued studies on different aspects. Vogal and his associates investigated the life history of langurs (Winkler, 1981, 1984 a, b, 1988). Vogal & Loch (1984) studied male-female reproductive strategies and Sommer (1985, 1988) studied male strategies. Agoramoorthy (1987, 1989) studied reproductive behaviour, Rajpurohit (1987, 1992), Rajpurohit, et.al. (1986)

male-social organization and Borries (1989) and Srivastava (1989, 1991) studied feeding ecology and behaviour.

Recently Chhangani (2000) provided a very good account of eco-behavioural diversity of langurs living in different ecosystems. Schulke (2001) described the different energy budget of harem holders and bachelors, while Bhaker (2001) provides the data on the vocal communication and Rajpurohit (2004) provides data on conflict and reconciliation in this species.

While more recent studied of resident male replacement in a unimale bisexual troop (Rajpurohit, et. al, 2003), resident male change and infanticide in free ranging troop (Rajpurohit & Chhangani, 2003); correlation between play and habitat in langur (Mohnot & Rajpurohit, 2001) and (Rajpurohit & Rajpurohit, 2004), and Rajpurohit (2004) provides data on conflict and reconciliation behaviour provided a very good account of social and ecobehavioural knowledge of this species.

Studies on feeding ecology came into focus already during 1977-78 (Winkler, 1981) at Jodhpur. The natural diet of langurs had been investigated earlier at Dharwar by Yoshiba (1967), at Polonnarawa (Sri Lanka) by Ripley (1970), in the Gir forest by Rahman (1973) and Starin (1978), in Singur by Oppenheimer (1973, 1977), in Jodhpur by Mohnot (1971, 1974), Srivastava (1989) recently work on social change due to artificial feeding (Rajpurohit & Rajpurohit, 2002) and habitat differential play behaviour in rich and poor habitats quality (Rajpurohit, 2004) and in Jaipur by Mathur, et.al. (1990).

The concept of dominance covers a large range, right from the ‘peck-order’ to “stress”, and “incentives and priorities”, “aggression” and “group control role” for different primates.

Dominance has been defined as a determinant drive of social behaviour in infrahuman primate (Maslow, 1935), since then studies relating to it have proliferated (e.g. Bernstein, 1970; Richard, 1974; Loy, 1975; Roonwal, 1976). Variably, the organization and behaviour of primate groups revolve around its dominance network, but the way it is expressed is so intricate that it seems to be erratic in measurement.

The term dominance can be used in several senses, it can mean numerical superiority, as when the most common tree dominates the landscape, or one person talks more than any one else in a conversation. It can mean the winner of a competition.

In animal behaviour, however, social dominance refers to a learned relationship between individuals such that in agonistic encounters, such as fleeing or other submissive signaling (Bernstein, 1981). Many people use dominance to mean “priority of access to incentives” because a dominant individual could theoretically use agonistic behaviour as an instrumental act to achieve this functional out come (Carpenter, 1950).

It is behavioural concept rather than a straight forward element or category of behaviour. Dominance relationship may reduce injuries during contest competition. Moreover, studies correlating dominance with paternity are not consistent (e.g. Shively and Smith, 1985; Stern and Smith, 1984). Factors other than dominance influence paternity and different species use different mechanisms (Gust et.al., 1996).

Primates are intelligent animal with good memories and anytime that they do fight over something the outcome of that fight may be remembered. The outcome of prior fights thus influences future contests with the same opponents- a dominant relationship. Mason (1993), however, used a transactional analysis of agonistic behaviour and failed to find any evidence that primates fight for dominance.

Dominance is a function of age and social context, which cannot be genetically encoded. The genetic benefits of dominance are not clear. For example, one study found that the causes of mortality differed for high and low ranking individuals and that no clear survival advantage could be demonstrated as a function of rank (Cheney et.al., 1981). In other studies the genetic consequences of dominance have been assumed on theoretical grounds alone or assumed based on high mating success of males during the time that they were dominant.

Dominance hierarchy is a social ranking system within a group in which some individuals give way to others, often conceding useful resources

to others without a fight (Alcock, 1989). The diffusion of dominance related concept, viz., group hierarchy (Carpenter, 1964), looped hierarchy (Kummer, 1968), basic/dependent rank (Kawai, 1958) and subsets of age-sex classes (Loy, 1975) has complicated the multitude ness of various competitive (e.g. Syme, 1974; Farres and Haude, 1976), as well as social measure (eg. Bernstein, 1970; Richards, 1974)

Although hierarchical relationships are nearly universal among social mammals, little is known about factors determining rank. Three known system of status determination:

(i)Rank determine by size (age),

(ii) Rank determine by genealogy and

(iii) Rank determined by reproductive value (in female).

Social ranking or dominance hierarchy has long been recognized as a conspicuous feature of the behaviour pattern of many primates. Variation in dominance expression by different primate species does exist, but in every nonhuman primate society now known there is some competition for rights to incentives, such as food, better place and estrous females. The displacement interactions of this kind result in establishing position of dominance and the rank order. Such rank orders among group members markedly affect social integration and group control (Carpenter, 1964).

The different behavioural repertoires maintaining dominance are essential aspects of group integration. The usual consequence of rank ordering is minimization of social disruption. A dominant animal acquires a resource that a subordinate has to relinquish.

It has widely accepted that hierarchical structures among socially living species including many primates regulate access to resources (Silk, 1987). The status determination among social animals include-hierarchy determined by size (body weight), as found in red deer (Clutton-Brock et.al., 1979), and by genealogy, as found in many species of Cercopithecidae [*Macaca mulatta* (Sade, 1967), *Macaca radiata* (Hausfater, 1975), *Papio cynocephalus* (Loy, 1975), *Papio anubis* (Dunbar,1984).

Many views about dominance in terms of its theoretical function and speculate that dominant individuals use their superiority to obtain whatever improves their genetic fitness mates, food, shelter and social services. Natural selection favors individuals that survive, reproduce more successfully and maximize the survival of their offsprings.

Dominance hierarchy is probably the most important component of social cohesion and social regulation in langurs as in all other nonhuman and human primates. The displacement interactions results in establishing position of dominance and rank order. Such rank orders among group members markedly affected social integration and group control (Carpenter, 1964).

In case of Cercopithacidae, daughters commonly rank just below their mothers. There are reports of dominance hierarchy and the determination ways in Colobinae (Jay, 1963; Sugiyama, 1967; Yoshiba, 1968; Bishop, 1975; Vogel, 1977; Hrdy and Hrdy, 1976; Dolhinow et al., 1979; Borries et al., 1991).

In Hanuman langurs around Jodhpur, the displacement hierarchy is linear and stable over short periods but fluctuated according to the age composition of the group, resulting in an age inversed status structure. Females occupy top ranks as soon as they enter menarche and gradually decline thereafter, with menopausal females being the lowest ranking individuals (Borries et al., 1991). The enough benefit from dominance relationship is that it may reduce injuries during contest competition.

There is likely to be some relation between well established dominance relationship and the tendency to reconcile after conflicts. The hypothetical link is that of “conditional reassurance”. According to this hypothesis, dominant individuals are prepared to reconcile only with subordinates who clearly and regularly demonstrate that they recognize their position. For example, Kummar (1975) found that fight between male gelada baboons stopped after reaching a decisive outcome. The winner approached to loser with appeasing gestures such as presenting and lip smacking the animal than proceeded to mounting and grooming and finally relaxed. Also Maxim (1976),

in experiments on rhesus monkeys, found a link between the establishment of dominance and the development of a more friendly relationship.

The word social dominance itself is used in a wide variety of context with definitions including information about competitive abilities (e.g.- priority of access) and traits that are related to an individual's status, and even going as far as using the terms "aggressive" and "dominant" as synonyms.

Dominance hierarchies are three major types-

(i) Despotism- in which one individual dominates all other members of his or her social group, with no rank distinctions among the subordinates most usually, hierarchies are referred to as being linear or non linear. In first case, an individual (usually called the alpha animal) dominates all other group members, another individual (Beta) dominates all group members but not alpha, and so on.

(ii) Linear hierarchy- in order for this hierarchy to exist, two conditions have to be fulfilled (a) the dominance relations must be asymmetric, that is for every paired interactions, one individual can be classified as being dominant and (b) dominance relations must be transitive, that is for any three animals if A dominates B and B dominates C, then A also dominates C.

(iii) Non linear hierarchies- in which there is at least one or more intransitive triads.

Dominance and social dispersion are related concept. Stability and organization of any primate group depends upon the delicate balance struck between group cohesion and social dispersion. Dominance, by assuming group stability through a system of formalized aggression, often acts as a social centrifuge; driving animals apart and keeping them separate (Harris and Strayer, 1975). When a dominant animal approaches a cohesive unit of a

few submissive animals, the latter would disperse on its approach even though it might not be its intention.

Hierarchies are formed in the course of the initial encounters between animals by means of repeated threats and fighting. Dominance behaviours the analog of territorial behaviour, differing in that the members of an aggressively organized group of animals coexist within one territory. The dominance order, some time also called dominance hierarchy or social hierarchy is the set of sustained aggressive-submissive relations among these animals.

The simplest possible version of a hierarchy is despotism: the rule of one individual over all other members of the group, with no rank distinction being made among the subordinates. More commonly, hierarchy contain multiple ranks in a more or less linear sequence: an alpha individual dominates all others, a beta individual dominates all other but the alpha, and so on down to omega individual at the bottom, whose existence may depend simply an staying out of the way of its superiors. The networks are some times complicated by triangular or other circular elements, but such arrangements seem a priori to be less stable than despotism or linear orders. The society of some species are organized into

(i) Absolute dominance hierarchies- in which the rank order is the same wherever the group goes and whatever the circumstance. An absolute hierarchy changes only when individuals move up or down the ranks through further interactions with their rivals.

(ii) Relative dominance hierarchies- in which even the highest ranking individuals yield to subordinates when the latter are close to their personal sleeping places. Relative hierarchies with a spatial bias are intermediate in character between absolute hierarchies and territoriality.

Dominance hierarchies, like territories, are distributed in a highly irregular fashion through the animal kingdom. Among the invertebrate, the hierarchies appear to be limited principally to evolutionarily more advanced forms characterized by large body size. Among the insects, hierarchies are

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most clearly developed in species that are fully social yet still primitively organized, such as the bumblebees and paper wasps. The following case histories demonstrate some of the extreme variations in dominance relations in different species.

Dominance behaviour mostly displays in form of aggression and finally as conflict. Natural selection has placed a favorable premium on certain aspects of aggressive behaviour for the individual. Animal often live in competitive status where aggressive individuals may here greater success in obtaining food, shelter and mating opportunities. It is more than coincidental that some of the world's most successful animals are characteristically aggressive and adaptable and become dominant among their group members. That is, they may be described as both behaviorally and ecologically aggressive.

The rhesus monkey and langurs in India, the baboon in Africa, the starling and house sparrow in the United State and man himself, have all achieved numerical success in competitive situations through both their behavioural and ecological aggressiveness and make themselves as dominant or leader.

There is likely to be some relation between well established dominance relationship and the tendency to reconcile after conflicts. The hypothetical link is that of "conditional reassurance". According to this hypothesis, dominant individuals are prepared to reconcile only with subordinates who clearly and regularly demonstrate that they recognize their position. For example, Kummar (1975) found that fight between male gelada baboons stopped after reaching a decisive outcome. The winner approached to loser with appeasing gestures such as presenting and lip smacking. The animal then proceeded to mounting and grooming and finally relaxed. Also Maxim (1976), in his experiments on rhesus monkeys, found a link between the establishment of dominance and the development of a more friendly relationship.

The availability of resources in a particular species environment constrainer permits opportunities for various social relationships to emerge.

One resource is much focused on food availability and distribution. Limited availability or clumped distribution of resources may result in increased competition for those resources. Under these circumstances dominance related behaviours may be expected increases several investigation discovered relationship between dominance status and access to limited resources in the form of preferred or restricted food sources. Hrdy found that displacement behaviour revealed a stable dominance hierarchy among langur females.

Defeat does not leave an animal with a hope less future. The behavioural ontogenies of species seem designed to give each loser a second chance, and in some of the more social forms the subordinate need only wait its turn to rise in the hierarchy. The most frequent recourse form itself to monkey, is emigration.

The socio-ecological model predicts that food distribution and predation risk shape the competitive regime and therefore the relationships formed among females of diurnal primate species (Sterck *et al.*, 1997; Van Schaik, 1989). Species facing scramble competition or no competition should have egalitarian dominance relationships, in which hierarchies are unclear and non-linear, if distinguishable at all.

In contrast, species facing contest competition should have despotic dominance relationships, in which dominance relationships are clearly established and form usually linear hierarchies. Such despotic females have often formalized dominance relationships, which are expressed in ritualized signals where in the direction is independent of the context (de Waal, 1986, 1989). Contest-type competition occurs when food distribution allows some individuals to exclude others from accessing the resource.

Therefore, contest competition should increase with the monopolizablity of the resource and with the number of competitors. A linear hierarchy should be adaptive when contest is so strong that the number of aggressive interactions needs to be reduced by clear dominance relationships among the competitors. Indeed, intra specific and inter specific comparisons have proved that females that face more contest competition have a more

linear and formalized hierarchy, e.g. *Saimiri oerstedi* versus *Saimiri sciureus,* sympatric *Presbytis thomasi* and *Macaca fascicularis* (Sterck and Steenbeek, 1997), and 3 neighboring groups of *Semnopithecus entellus.*

Dominance relationships develop from repeated contests within dyads (Bernstein, 1981). Many group-living animals use ritualized signals to avoid aggression (de Waal, 1986). Such formalized submissions are one of the last behaviors to indicate rank changes and therefore serve as an indicator for acceptance of the relationship (*Macaca fascicularis*: de Waal, 1977; *Macaca mulatta*: de Waal and Luttrell, 1985; *Papio cynocephalus*: Walters, 1980; *Pan troglodytes*: de Waal, 1982).

De Waal and Luttrell (1985) concluded that social integration is a condition for a formal hierarchy as it clarifies the social status of an individual in the group. Clear relationships among all individuals should lead to an interaction pattern, where in all individuals can be accepted as partners for affiliative interactions, though interaction frequencies and intensities among dyads differ due to the quality of the relationship.

A common principle running through out the vertebrates is that juveniles and young adults are the ones most likely to be excluded from territories, most likely to start at the bottom on the dominance orders, and therefore most likely to be found wandering as floaters and subordinates on the fringes of the group.

The present study

The Jodhpur langur population is being monitored since 1967 by Mohnot (1968-1987), Makwana (1979) followed by German scholars (1977-85) and then again Mohnot et al. (1994-2001) under Indo-US Primate Project.

Although scientific research in Jodhpur has been going on for over 35 years and an enormous amount of information has been published and recognized internationally (Mohnot, 1971; 1974; Mohnot et al 1981; Winkler, 1981; Sommer, 1985; Agoramoorthy, 1987,1989; Rajpurohit, 1987; Agoramoorthy et al., 1988; Rajpurohit & Mohnot, 1991; Rajpurohit et al.,

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1994; 1995; 2004; Mohnot et al., 1995; Srivastava, 1989; Borries, 1989; Rajpurohit and Chhangani, 1997; Chhangani, 2000; Schulke, 2001; Rajpurohit and Rajpurohit, 2003).

The present study covers dominance hierarchy or ranking order and its role in social organization in hanuman langurs around Jodhpur. The proposed study groups are already familiar with human observers. Data on dominance hierarchy obtained by ad libitum, scan and focal animal sampling (Altman, 1974). Before the protocol starts, I assured the individual identification of the group members through following these numbers for first 30-60 days from down to dusk.

The data collection during this study from scanning and focal animal sampling and given an order of dominancy among troop members. The contexts of the ranking order and other relevant data have been simultaneously recorded.

In order to representative sample of a given group has been observed from down to dusk for a maximum of six consecutive days and then replaced by another group. At irregular internals occasionally the study group has been visited during the night.

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Chapter 2

MATERIAL AND METHODS

CHAPTER-2

MATERIAL AND METHODS

A. Study area

(1) Topography

Jodhpur is a second largest city of State Rajasthan. It is a historic city having about a 1.11 million people today was founded about 1459 A.D. It lies at altitude about 241 m, latitude 26^0 18'N and longitude 73^0 08' E at the eastern fringe of the Great Indian Desert. The town was erected on a hilly sandstone plateau of approximately 150 km^2 surrounded by flat semi-desert. This diagonal plateau is inhabited by a geographically isolated population of 1850-1900 langurs (Mohnot *et al*. 2005; Rajpurohit et al., 2005. in press), which has been studied by various Indian and German researchers for more than 35 years now.

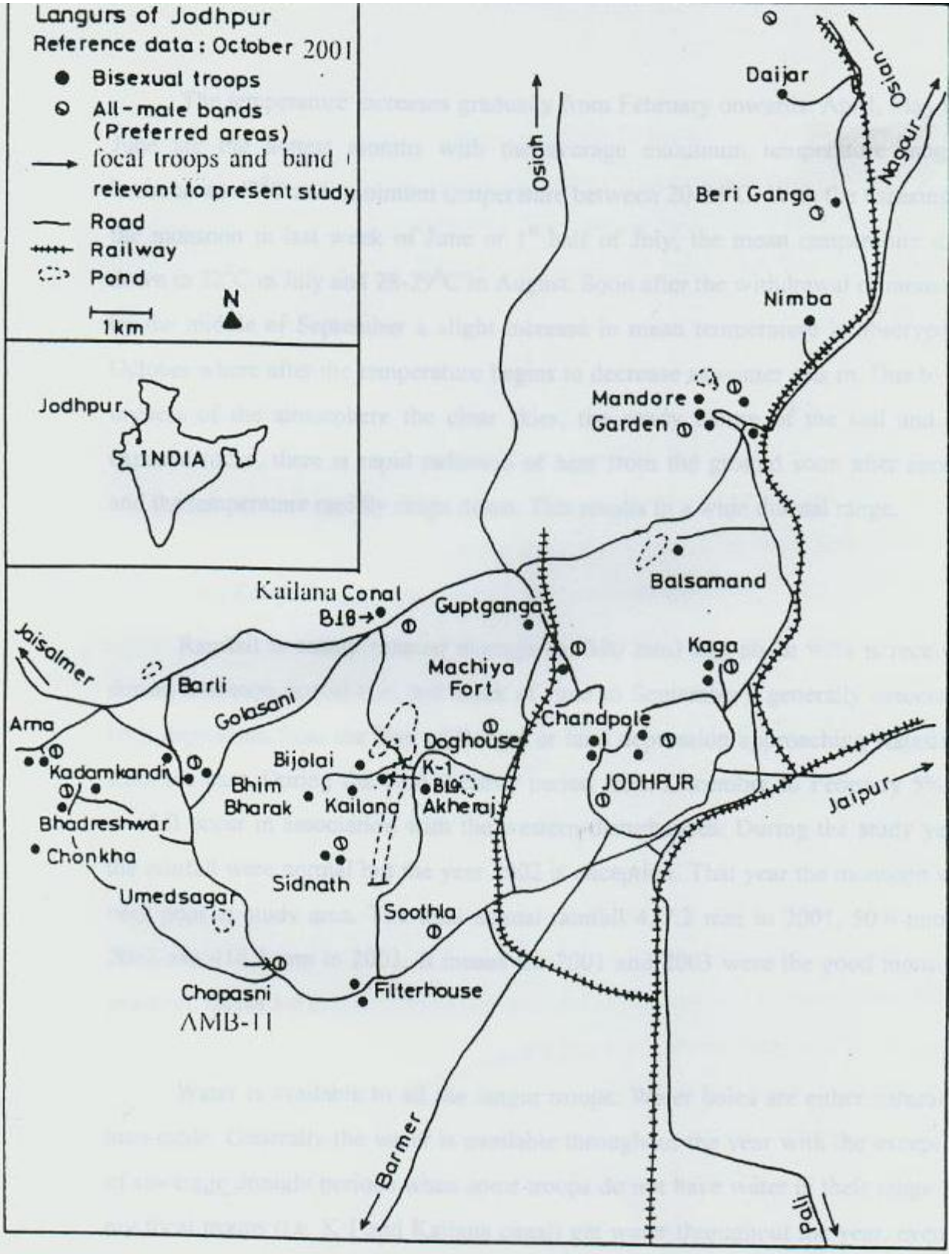
The presence of hillocks is the characteristic of this habitat, but there are some marked differences between the individual habitats. On the basis of habitat use by the langur troops, Mohnot (1974), Winkler (1981), Agoramoorthy (1987), Rajpurohit (1987), Borries (1989), Srivastava (1989), Sommer (1985, 1988), Chhangani (2000), Bhaker (2001), and Rajpurohit (2004) distinguished them into three different types, each one holding several langur troops. These are: -

(i) Open scrub habitat: Herb and shrub dominate, with an absence of large trees. A permanent water source is present, but water may not available round the year.

(ii) Garden and orchard habitat: Large trees are main characteristic, while grasses are common in this habitat. The trees are used by langur troops for feeding, resting, sleeping, etc. While water is usually available in this kind of habitat throughout the year (Plate 1).

(iii) Human habitation habitat: The presences of large and small trees and vegetable fields in between buildings. Deserted buildings are used frequently by langur troops for their roosting. This habitat type also includes some parts of the city. There are several natural and artificial water sources, which provide water round the year (see appendices 4a and 4b).

(iv) Hilly area: Most of the area is hilly of this 26 km. long diagonal ridge running from village Daijar in the northeast to Arna in the west. And majority of langur groups inhabit in this hilly area (see figure 2).


Langurs of Jodhpur
Reference data : October 2001
Bisexual troops
All-male bands (Preferred areas)
focal troops and band relevant to present study
Road
Railway
Pond
1km
N
Jodhpur
INDIA
Daijar
Osian
Nagaur
Beri Ganga
Nimba
Mandore Garden
Balsamand
Kailana Conal
B18
Guptganga
Jaisalmer
Barli
Machiya Fort
Kaga
Arna
Gokasani
Chandpole
Doghouse
Bijolai
K-1
B19
Kadamkandi
Bhim Bharak
Kailana
Akheraj
JODHPUR
Jaipur
Bhadreshwar
Chonkha
Sidnath
Umedsagar
Soothla
Chopasni
AMB-11
Filterhouse
Barmer
Pali

(2) Ecology

(a) Climate

The climate of Jodhpur and its vicinity is mainly arid and dry. Briefly it is characterized by uncertain and variable rains resulting in one lean year in three, produce drought condition, and one famine in eight (Mohnot, 1974). There are extremes of temperature, with much diurnal variation, dust storms in May and June, potential evaporation exceeding annual precipitation, bright sunshine with clear visibility.

(2a.1) Temperature

The extreme of temperature is a striking feature. The winter is swearing cold and the summer intensely hot scorching. January is the coldest month of the year, the mean monthly maximum temperature being 35.3^{0}C in 2002, 33.7^{0}C in 2003 while 35^{0}C in 2004. The lowest minimum as low as 9.9^{0}C in 2002, 11.20^{0}C in 2003, and 10.7^{0}C in 2004. And the highest maximum temperature 42.6^{0}C in 2002 and 41^{0}C in 2003, while 40.9^{0}C in 2004 (See tables 1-3).

The temperature increases gradually from February onwards. April, May and June are the hottest months with the average maximum temperature ranging between 40-43^{0}C and minimum temperature between 20-24^{0}C. With the ushering in the monsoon in last week of June or 1st half of July, the mean temperature drop down to 32^{0}C in July and 28-29^{0}C in August. Soon after the withdrawal of monsoon by the middle of September a slight increase in mean temperature is observed in October where after the temperature begins to decrease as winter sets in. Due to the dryness of the atmosphere the clear skies, the sandy nature of the soil and the exposed rocks, there is rapid radiation of heat from the ground soon after sunset, and the temperature rapidly drops down. This results in a wide diurnal range.

(2a.2) Rainfall

Rainfall is scanty (annual average ca. 380 mm) and about 90% is received during monsoon period (i.e. last week of June to September), generally associated with depression from the Bay of Bengal or land depression approaching Rajasthan from the east. During the cold weather

period from December to February 5% of rainfall occur in association with the western disturbances. During the study years the rainfall were normal in 2003 and medium in 2004 but the year 2002 is exception. That year the monsoon was very poor at study area. The total annual rainfall 42.9 mm in 2002, 418.7 mm in 2003 and 220.4 mm in 2004. It means the 2003 was good and 2004 was medium monsoon years (cf. tables 1-3).

Water is available to all the langur troops. Water holes are either natural or man-made. Generally the water is available throughout the year with the exception of sewerage drought periods when some troops do not have water in their range but my focal troops (i.e. K-I and Kailana canal) get water throughout the year, even in drought conditions, since these troops live at the bank of Kailana Lake.

(2a.3) Relative humidity

Relative humidity means the moisture present in the air. In general, the mean humidity ranges between 18-65%, percentage being high in the morning hours (30-80%) and low in the afternoons (05-55%). The relative humidity was as low as 12 percent during March 2002 and 12 percent during April 2003 and 8 percent during March 2004 (see table 1-3).

(2a.4) Evaporation

Evaporation closely follows the seasons when the winds are slight and temperatures are low, evaporation is also low. As temperatures rises and wind velocity increases, evaporation also increases. Evaporation rates reach their peak in the summer months. With the advent of the moisture laden monsoon winds and precipitation, there is a marked fall in evaporation rates. During the study period, the highest evaporation was observed 14.7 mm in May 2002, 13.9 mm in May 2003 and 13 mm in May 2004. And the lowest evaporation was 3.4 mm in January 2002, 3.4 mm in December 2003 and 3.3 mm in December 2004.

(2a.5) Winds

During the summer and monsoon months winds over Jodhpur blow mostly in the north-easterly and easterly direction and in winter in the north-easterly and westerly. They are strongest in June and weakest in November.

Hot and violent dust raising winds are experienced during the hot summer months (May and June). The annual mean wind speed is 5 km per hour (5 km/h). The maximum wind velocity that can be expected normally in the area is about 25-40 km per hour but, can occasionally reach as high as 100 km per hour during a severe dust storm period.

Dust storms: Dust storms are most frequent during the summer months, April-June, but maximum in mid May to mid June. After the rains have settled down the sand in the desert, there are practically no dust storms. Thus October-January is almost free from dust-storms.

(b) Biomes

(2b.1) Vegetation :- (Flora)

The essentially xerophytic vegetation is under the influence of several environmental factors in this habitat. Its main constituents are a few moderate sized trees and many shrubs, herbs and grasses. The entire vegetation of Jodhpur can be categorized into two types according to availability.

(i) Annual vegetation-Consisting mainly of those coming up during monsoon or after short rainy season.

(ii) Perennial vegetation- Occurring throughout the year and subsisting mainly on sub-terrainean water.

Several plant species of the annual vegetation are highly drought resistant and thrive well in extreme climate conditions chiefly due to several xerophytic adaptations (Mohnot, 1974; Bhandari, 1978; Agoramoorthy, 1987; Rajpurohit, 1987; Srivastava, 1989).

The main tree species are Kumbat, *Acacia Senegal*; Babul, *Acacia nilotica*; Dhok, *Anogeissus pendula*; Kankero, *Maytenus emarginate*; Angraji banwalia, *Prosopis juliflora*; Khejari, *Prosopis cineraria*; Black plum, *Eugenia jombolana*; Rohira, *Tecomella undulate*; Jal , *Salvadora persica*; Samel, *Bombex ceiba*; Neem, *Azadirachta indica*; Adusa, *Adhatoda zeylanica*; Shisham, *Dalbergia latifolia*; Ber (Bordi), *Ziziphs mauritiana*; Aam, *Mangifera indica*; Pipal, *Ficus religiosa*; Bargad, *Ficus benghalensis* and Kadam, *Mitragyna parrifolia*.

The main shrubby species are Ker, *Capparis deciduas*; Thor, *Euphobia caducifolia*; Bui, *Aerva persica*; Sinio, *Crotolaria burhia*; Kankera, *Grewia tenax*; Luni, *Indigofera oblongifolia*; Khimp, *Leptadenia pyrotechnica*; Biyani, *Tephrosia purpurea*; Jhar ber, *Zizyphus nummularia*; Akaro, *Calotropis procera*; Gugal, *Commiphora wightii* and Nagphani, *Opuntia dellenii*. Besides these some herbs like Satyanasi, *Argemone maxicana*; Dhatura, *Datura terox* and Dudhi, *Wrightia tinctoria* and grasses like Dub, *Dynodan dactylon* and Sevan, *Lasiurus sindicus* and among them some plants parts (natural and cultivated) are used by langurs (see Appendix 10).

The habitat bears 75.5% dicotyledon plants, 24.3% monocotyledon and 0.2% gymnosperm (Winkler, 1981). Plant parts of more than 208 species occurring in the wild state or in gardens, orchards, vegetable fields have been observed to be eaten by Hanuman langurs. Besides this natural feeding, for religious reasons local people feed most of the langur groups with vegetables, fruits, nuts, sweets and other cooked and uncooked food, wheat preparation like roti, sogra, etc. (see Appendix 9).

(2b.2). Fauna

A large number of fauna belonging to different taxa are found interacting in diverse habitats around Jodhpur. The detailed list of such animals was provided by Mohnot (1974). Some frequent interactors with langurs and more precisely resource competitors are herds of cattle i.e. cows (*Bos indicas*), sheep (*Ovis orienes*) and goats (*Capra hitcus*). Other common mammals are Desert gerbil (*Meriones hurrianae*), the five stripped squirrel (*Funambulus pennanti*), the Indian gerbil (*Tatera indica*) and the Indian crested porcupine (*Hystrix indica*).

The nocturnal lagomorph (*Lepus nigicollis*) is widespread. Among the insectivores mammals are the little shrew (*Suncus stolickzkanus*) and the Indian hedgehog (*Paraechinus micropus micropus*). The pariach dog (*Canis familiaris*) and the Indian grey mangroose (*Herpestes edwardsi ferrigineus*) are the most common carnivores. Other carnivores, e.g. the fox (*Vulpes bengalensis*), the jackal (*Canis aureas*), the wolf (*Canis lupus pallipes*), the Hyaena (*Hyaena hyaena*) and the Jungal cat (*Felis chauplateri*) are also

found. The Nilgai (*Boselaphus tragocamelus*) are the large herbivore found in study area (see Appendix 11).

Several birds and reptiles were also recorded most frequently interaction with langurs. Few invertebrates were also found associated with them.

(B) Study Animal

The Hanuman langur (*Semnopithecus entellus entellus*) is a well known old world monkey (Primates: Cercopithecidae: Colobinae). Its taxonomy is still debated. *Presbytis entellus* and *Semnopithecus entellus entellus* is represented by 16 subspecies (Roonwal and Mohnot, 1977; Rowe, 1996) (see appendix 3). Some taxonomists consider genus *Semnopithecus* to be a subgenus of *Presbytis* (Groves, 1993). Other includes all species of the genus *Trachypithecus* in *Semnopithecus* (Brundon Jones, 1995).

Irrespective of taxonomic status we know that the Hanuman langur, *Semnopithecus entellus entellus* live from sea level to up in the Himalayan Mountains to 4000 meters. This is the highest altitude for any primate species other than humans (Roonwal & Mohnot, 1977; Wolfheim, 1983). Its populations range from the Himalayas in northern India to the southern most tip of the Indian peninsula, extending into Sri Lanka and other land masses on either side of the Indian subcontinent. The epithet “Hanuman” comes from the name of the monkey god who helped to retrieve Ram’s wife, Seeta, from the clutches of Ravana, the king of Lanka, in the Hindu epic Ramayana.

The langurs are primarily frugivorous and leaf-eating. In Jodhpur study area, they only have xerophytes to live upon and the bulk of their food comprises different edible xerophytic plant parts. They often consume a variety of cooked and uncooked vegetarian food stuffs, either procured by them or offered to them by people. They also invade crops, orchards and artificial feeding (Mohnot, 1971).

The colouration in Hanuman langur varies across its subspecies from grey to dark brown to golden, with varying amount of dark black colour (Roonwal and Mohnot, 1977; Napier, 1985). In Jodhpur study area, the Hanuman langur is a large, grey bodied with black-faced, black palm and

black feet. The body color of adults is grey with long limbs and long tail which is longer than the head and body. The subspecies from the northern parts of its distribution range have large body than those from the south.

The subspecies from Sri Lanka is the smallest (Napier, 1985). Head and body length of females range between 40.6-68.0 cm and males 51.0-78.0 cm. Tail length of females is 69.3-101.6 cm and males 76.1-97.8 cm (Napier, 1985). Body weight of adult female is 11.2 kg (range 6.7-15.6) and that of adult males is 18.3 kg (range 10.6-19.8) (Roonwal and Mohnot, 1977; Oates, *et al*., 1994; Rajpurohit, 1987; Chhangani, 2000). Jodhpur langurs have no breeding season, though there is a birth peak in March and a minimum in November (Sommer & Rajpurohit, 1989).

Menstruations are almost visible. The mean reproductive parameters are the following: Age of menarche, 2.4 years; cycle lengths, 24.1 days; gestation lengths, 200 days, inter birth interval 16.7 months (Sommer *et al*., 1990). Langur normally gives a single birth, but at the study area in Hanuman langurs' twins and three births also recorded (Mohnot, 1974; Rajpurohit, 1987). Even a case of quadruped birth was also recorded in 1997 (Chhangani, pre. comm.).

B.1. Distribution of troops in study area

The whole Jodhpur langur population is dispersed over a 26 km. long diagonal ridge running from the village Daijar in the north-east to Arna in the west, passing through Jodhpur fort. This Daijar-Arna plateau which comprises following points. Daijar – Mandalnath – Beriganga – Nimba - Mandore – Balsamand - Kaga – Fort - Old city – Chandpole – Guptganga - Dog house - Kailana canal - Machia Safari Park – Kailana – Bijolai – Sidhnath – Soothla - Filter house – Chopasani –Bhadreshwar - Kadam kandi - Barli and Arna covers almost the entire langur habitat around Jodhpur (see figure 2).

B.2. Definitions-group, troop and band

In this dissertation, these three words have been frequently used. The "Groups" is used as general term while referring the whole population. The 'Troop' refers to the bisexual groups and 'Band' refers to the unisexual groups or all-male parties (Bachelor's).

The entire langur population of Jodhpur region is organized in 35 bisexual troops and 14 all male bands. Some 150 sq. km. of the total area is used by these animals. Each troop is comprised of an adult male-resident (unimale bisexual) and occasionally of more than one adult male (multimale bisexual), several adult females and their immature off springs (plate 2 and 3).

A male band is composed of only males of different age classes but not includes breast feeders. In Jodhpur study area the unimale bisexual troops are more frequent. There are no other langur troops found in a radius of about 100 km around. Although some solitary males have been observed occasionally in the distant areas as far as 65 kms from Jodhpur for example in Osian (Rajpurohit, *et al*., 2004).

B.3. Age-Sex-Classification

For this study, I have adopted the age-sex-classification in *Semnopithecus entellus* by Jay (1963) which was the first systematic field study on langur as well as the extensive studies conducted by Mohnot (1974) and Roonwal and Mohnot (1977). In the present study the same classification was adopted with little modification.

Considered new born from birth to 3 months which is also known as black-coat (BC) when its fur colour is black. Between 3 to 5 months, it is called changing coat (CC) when fur colour changes from black to brown and then to white. Infants above 5 months are called white coat (WC) and goes up to 7 months and are also designated as infant-I.

Infants between 7-12 months are considered as infant-II. This phase may continue till the infants are weaned which may very from individual to individual and male to female i.e. between 12 to 16 months. Weaned infants above 16 months and up to 96 months are considered as Juveniles. Females in cycle and till they deliver their first infant around the age of 48 months were considered as young adults. Females beyond 48 months are classified as adults (plate 4).

For males, Mohnot (1974), Roonwal & Mohnot (1977), Rajpurohit (1987) and Rajpurohit and Sommer (1993) described ages of males based on their physical growths and development of genitalia as the major criteria of identification and standardization of the age on the basis of their physical characteristics. The same classification has been followed in this study- Infants, 0-15 months; weaning infants, 13-20 months; Juvenile-I, 20-30 months; Juvenile-II; 30-40 months; sub adults, 48-66 months; young adults, 66-84 months; adults, 84 to 156 months; old males, 156-420 months and above (see appendix 5).

B.4. Focal Groups

The present field study was carried out during a 2.5 years between May, 2002 to December, 2004. It is concentrated mainly on two bisexual troops and one all male band viz. troop Kailana-I (B-19), Kailana canal (B-18) and Chopasani (AMB-11): Filter house. The first two bisexual troops are located 8 to 10 kms. West of Jodhpur city while Chopasani band is generally found at Chopasani temple, 8 kms. South- West to city.

B.4.a. Troop-Kailana-I (B-19)

The study group Kailana-I (also shown by K-I or B-19) roosts at the bank of Kailana Lake (an artificial reservoir used for the Jodhpur city drinking water) on the *Prosopis* trees. This troop B-19 has been under investigation since 1967 when it was denoted as B-25 (Mohnot, 1974).

In 1978 when Paul Winkler followed this study group, has splited into two sub groups (due to course of the invasion of all male band between October-December 1977).Which were later designated as Kailana-I (K-I or B-19) living at original site and Kailana-II (K-II or B-20) started living at Bijolai palace near Bijolai bisexual group, which was displaced afterward towards Bhimbharak (Winkler, 1981 and Pers. Obser.).

Since than one or the another observer has been studying this troop (i.e. Kailana-I) due to easy approach and an average sized troop i.e. about 20 animals the majority of the researchers worked on this troop Winkler, 1981; Agoramoorthy, 1987; Sommer, 1985; Rajpurohit, 1987; Borries,

1989; Srivastava, 1989; Mohnot, *et al*., 1987 and Mohnot & Rajpurohit, 2001 with Indo-US Primate Project, 1995-2001.

My interest to select this focal troop because this group members had individually identified since 1977, and besides that it contains some very old females. Some females are more than 30 year's of age. This troop comprising 14 individuals at present but when I began my study in May 2002 the troop composition was 17 individuals (cf. tables 4-6).

B.4.b. Troop-Kailana canal (B-18)

The Kailana canal troop (B-18) roosts near Hathi canal bridge on Soorsagar way. This site is located 10 kms. West of Jodhpur city. It is a unimale bisexual troop comprising 20-25 individuals. I began my study in May, 2002 when the troop composition was 20 members (cf. tables 7-9).

This focal troop used to range in Machiya Safari Park in the south and raid the crop fields in the north to the roosting site. And the troop has been selected as focal troop since it is easily approachable and second the troop size is also not too large. All the adult females and the resident male were individually identifiable before the focal sampling started.

B.4.c. All male band (AMB-11)

For the present study, I have selected this Chopasani male band (AMB-11). This band is located about 8 km southwest of Jodhpur city. This all male (AMB-11) was comprised of 16 individuals in May, 2002. This male band frequently seen near Chopasani temple or at filter house, comprising adult males, sub adults and Juveniles-I and Juveniles-II (see table 10).

The group size of this all-male band ranged between 11 and 16 members during this three years study period. The Chopasani male band was observed visiting and inter-acting the different bisexual troops in its range area they are Filter house, Sidhnath, Kadamkandi, Bhadreshwar, Chonkha village and Chonkha stone mine troops.

All the adult males and several non-adult males were individually known. The resident males of focal troops B-18 and B-19 were also individually known during the whole study period.

5. Identification

Individuals of two focal troops and an all-male band were identified with the help of identification mark, such as cuts, scars, tail carriage, deformity if any, facial features, pastures, gestures, etc. and also by pedigree records. Support was also received from the earlier photographic records available from previous observers. For example, the resident males and adult females of troops Kailana-I and Kailana canal were identified as per the identifications given in table 11 and 12. Similarly males of Chopasani male band (AMB-11) were regularly followed and individually identified as per the identification given in table 13.

Table11: Identification marks of focal troop B-19 (Kailana-I)

Animal		Identification mark
Resident male		Left ear cut (plate 5)
Females No. (Adults)		
F1	-	right ear half cut upper side
F2	-	head upper side some area is no hair, body fur white and healthy body.
F3	-	chest (Front) hair black
F4	-	upper side lip cut (left side) and teeth visible out side in normal posture.
F5	-	right ear long cut
F6	-	body thin and healthy, hair light black
F7	-	tail end brush like.
F8	-	old and fatty, forehead out growth

Table12: Identification marks of focal troop B-18 (Kailana-canal)

Animal		Identification mark
Resident male		Healthy and aggressive and left ear cut (plate 5)
Female No. (adults)		
F1	-	Comparatively small face and eye lick is black
F2	-	body fur black and tail end band
F3	-	black spots on bally
F4	-	small and brown eyes
F5	-	left nipple longer than right
F6	-	bunching of tail tip hairs
F7	-	tail end brush like
F8	-	tail middle part band
F9	-	right ear upper side, there is a small hole
F10	-	body thin and healthy, hair light black
F11	-	chest hair black

Table13: Identification marks of focal troop All Male Band, AMB11 (Chopasani)

Animal (adults)	Identification mark
M1	Curved tail and bulky body
M2	Left ear tern, scar on right thigh
M3	Cut on left nose
M4	Half tail
M5	Scar on back and face
M6	Right ear long cut
M7	Figure of left hand missing

C. Study methods

The present study on socio-behavioural aspects and particularly on 'The study on Dominance hierarchy in Hanuman langurs, *Semnopithecus entellus entellus* is carried out for over 2.5 years around Jodhpur, Rajasthan, India. The study was initiated in May, 2002 and terminated in December 2004. Some 1570 hrs in this field work was devoted to this study. The data were collected by *ad libitum* basis as well as by *scan* and focal animal sampling methods of Altmann (1974).

C.1. All Count Method

The basic information of habitat type, group location and roosting site of bisexual troops and all male bands of Jodhpur are known from the available literature. Dr. S.M. Mohnot and his co-workers carried out first intensive census during July-August 1983 (Mohnot, *et al*., 1987). Regular surveys after six months were carried out to study the population trends.

During Indo-US Primate Project (i.e. 1994-2001) this langur population was censuses annually.

During counts, efforts were made to identify sexes of all the age categories, follow of individual troop site and social behaviour, especially dominance hierarchy among bisexual troops and all male bands were noticed. The large sized troops were counted two to three times so as to minimize the error in counts.

Focal groups were followed periodically which were visited 4-days a week to records birth, missing, emigration and other demographic changes.

C.2. *Ad-libitum* sampling

There is long hand notes in which all details were recorded. Sampling of events such as multimale situation in troops, male-male tolerance, oestrous female sharing, group splitting, and interaction with neighbouring troops and band members and among themselves, interaction with other animal, which frequently share their home range.

The process of acquiring residency and the process of multimale to unimale troop formation are recorded as a part of ad libitum sampling. With the help of this kind of sampling all components of intertroop interaction, intratroop interaction, resident male change process, male strategies, daily activity pattern, reproductive profiles and such other behaviours were recorded.

C.3. Scan sampling

In this type of sampling method, the all bisexual troops and male bands were scanned. Besides this the troop and band situation, composition, social change, disappearances from group, new birth, etc. were recorded. Scanning of individual langur for its movement, activity, invasion of bisexual troop and its location were followed. Subgrouping, interaction with other wild and domestic animals and any other important events relevant to this study were also recorded. The whole area was scanned from time to time for langur groups.

C.4. Focal animal sampling

This type of sampling method used to record daily activity cycle of individual langurs and the detailed behavioural observation were made from down to dusk (5.30 to 18.30) on selected focal troops and band (Altmann, 1974). Observation on status, daily activity and interaction with other individuals were recorded. Individual behaviour, e.g. resting, feeding, moving, sleeping, grooming, jumping, clamping, mating, whooping, barking, grunting and drinking were recorded by this sampling method.

Stopwatch was used for the purpose of sample period. A canon camera (with zoom of 210 mm) used for photography of different gestures and pastures of different age and sex individuals. And a binocular of 10 × 40 power was also used as and when required.

The social behaviour of Hanuman langurs with special reference to Dominance behaviour (ranking order) was recorded by using all these sampling method. To facilitate quick data recording some 40-50 behaviours and gestures were abbreviated. Some abbreviations were followed from Dolhinow (1978) and some are self made (see appendix 7).

On few occasions, night observation was also made during full moon lights. The observation schedules were evenly distributed over the daytime and month so as to achieve statistical compatibility of data.

To facilitate data collection, 30 minutes focal sampling unit was followed with five minutes sample interval during this time. The inter-troop encounters, social interactions, troop location, home range, etc. were recorded on each protocol sheet (see appendix 8). Activities of each focal animal were observed in 30 seconds sample time for 30 minutes.

For the behavioural study initially 10 and later 08 groups (6 were bisexual and 2 were all-male bands) of Hanuman langurs were studies during these 2.5 years. Out of 8 study groups 3 groups were selected as focal groups living in different areas of Jodhpur for long-term behavioural study. By and large the environment and ecological conditions are uniform so far as climate, rainfall, topography, altitude vegetation, etc are concerned.

But, there are variations in biotic factors like artificial feeding, agricultural activity, and human interference. These bisexual troops are Kailana Canal (B-18) located near Hathi canal (on Jaisalmer highway), Kailana-I or K-I (B-19) located near Kailana lake, while the Chopasani all male band (AMB-11) generally found around Chopasani temple or near filter house (see figure 2).

In the initial stage, observation were made on focal troops from a distance of 4-5 meters and the Chopasani male band from a distance of 10-15 meters without diverting their attention as far as possible. After identification and habituation following them collected the different social behaviours and specially dominance hierarchy data.

The information regarding feeding, movement, home range, roosting, social behaviour, inter and intra troop interaction, troop band interaction and individual behaviour patterns were recorded from time to time.

Composition of focal troops and band during study period

(Table 4-10)

For better understanding of group structure, the compositions of all the three focal groups were noted during the study period 2002 to 2004. Details of these study group structure and the demographic and social changes including births, expulsion, deaths, disappearances, emigration, immigration and male change were recorded regularly.

1. Bisexual Troop-K-I (B 19)

Bisexual troop B 19 or K-1 home range adjoins the Kailana lake, an artificial reservoir for the drinking water. Earlier this troop lived on the big Eucalyptus trees at the Guest house, but after establishment of a restaurant at guest house, their roosting site was disturbed and displaced to rocky ground nearby (Plate 6).

It's a highly disturbed troop due to this picnic spot (i.e. Kailana Lake) and highway road near to roosting site. Artificial feeding is common in this troop. All members of this troop were individually identified before the commencement of study. The troop size, age and sex composition of this troop as found during study period is given table (tables 4-6).

2. Kailana canal troop (B 18)

This troop lives near Kailana canal also known as Hathi canal, on the way of Jaisalmer-Soorsagar highway. Its' home range is also designated as disturbed habitat. Langur visits frequently in the interior of the agricultural farms near the site (plate 7).

This troop depends mainly on natural plants for feeding. Here, the artificial feeding is not so common. This troop also interacts with other wild animal like blue bull, wild boar, jackals, jungle halves, dogs, etc. The troop composition, age and sex observed during study period are given in tables 7,9.

3. Chopasani male band (AMB 11)

Chopasani male band's (AMB 11) preferred roosting site is Chopasani temple (langurs roost on a big tree behind temple), which is about 8 km southwest to Jodhpur city. In general male band has larger, home range and two or even more preferred sites for night stay.

This male band also has its home range about 10-12 sq. km. and observed visiting/interacting to the bisexual troops in this area viz. Filter house (B 25), Sidhnath (B 23 and B 24), Beheembharak, Kailana, Kadam kandi, Bhadreshwar and Chonkha stone mines. This male band was selected as a focal male band because of its small size and easily accessibility. During the study period the band size ranged between 11 and 16 male langurs of different age groups (see table 10).

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Table 1: Climatic data of study area-Jodhpur, Year 2002

S. No.	Months	Maximum Temperature (^{0}C)	Minimum Temperature (^{0}C)	Relative Humidity (%) RH – I	RH - II	Evaporation (mm)	Rainfall (mm)	Wind Speed (km/h)
1	January	24.7	9.9	58	22	3.4	000.0	02.9
2	February	27.9	11.7	52	14	4.9	000.7	03.6
3	March	35.0	18.4	40	12	7.7	000.0	03.7
4	April	40.2	24.1	35	12	11.4	004.7	05.5
5	May	42.5	28.1	54	22	14.7	000.6	11.1
6	June	42.6	39.3	61	29	12.6	000.0	09.8
7	July	37.5	27.4	68	38	11.3	000.0	13.5
8	August	36.6	27.0	69	41	8.8	013.8	09.4
9	September	37.8	25.4	66	29	8.9	011.0	07.2
10	October	38.8	21.5	40	13	7.3	000.0	02.5
11	November	32.3	17.3	45	18	5.2	000.6	03.3
12	December	28.1	13.5	56	23	3.9	011.5	03.1

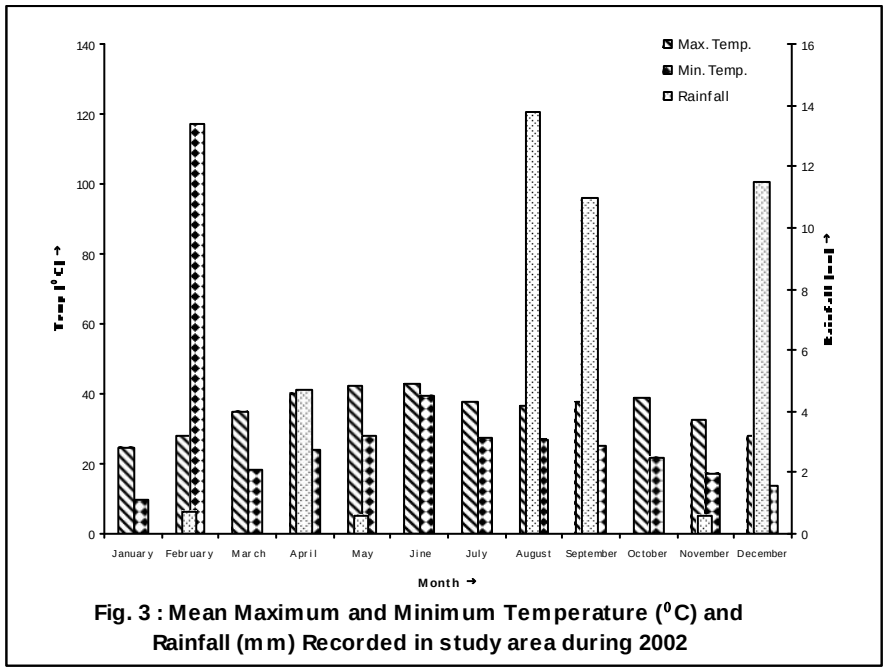

Fig. 3 : Mean Maximum and Minimum Temperature (^{0}C) and Rainfall (mm) Recorded in study area during 2002

Table 2: Climatic data of study area-Jodhpur, Year 2003

S. No.	Months	Maximum Temperature (^{0}C)	Minimum Temperature (^{0}C)	Relative Humidity (%) RH – I	RH - II	Evaporation (mm)	Rainfall (mm)	Wind Speed (km/h)
1	January	25.4	11.2	60	26	3.8	000.7	04.1
2	February	27.2	13.8	57	22	4.6	023.1	04.6
3	March	33.6	18.1	38	12	7.5	002.7	04.5
4	April	39.6	24.3	34	13	10.9	000.0	05.3
5	May	41.0	27.0	42	16	13.9	000.4	09.3
6	June	39.4	28.7	69	36	10.8	064.6	12.5
7	July	34.3	26.0	88	66	5.6	260.3	06.4
8	August	33.7	26.0	91	68	5.6	065.3	05.7
9	September	35.2	24.5	81	48	6.1	001.6	04.7
10	October	37.0	18.3	43	14	6.0	000.0	02.0
11	November	31.6	15.4	44	18	5.1	000.0	03.0
12	December	26.6	11.7	63	23	3.4	000.0	03.1

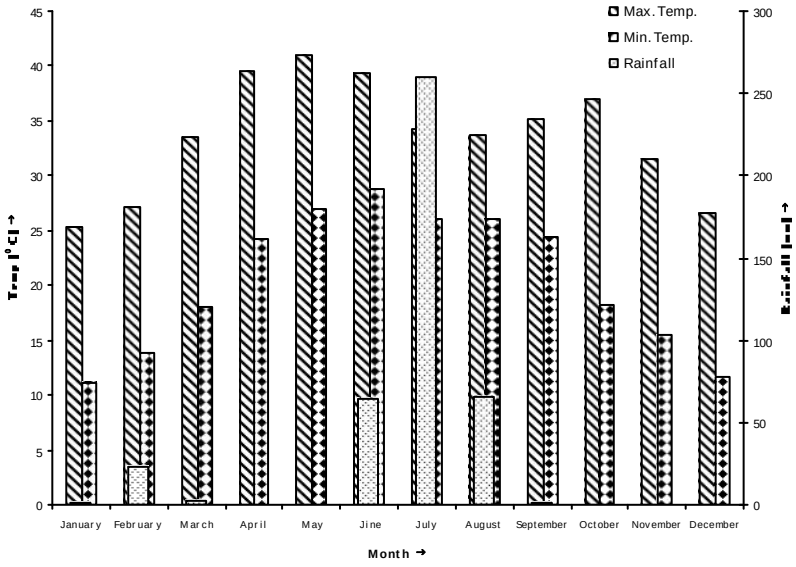

Fig. 4 : Mean Maximum and Minimum Temperature (^{0}C) and Rainfall (mm) Recorded in study area during 2003

Table 3: Climatic data of study area-Jodhpur, Year 2004

S. No.	Months	Maximum Temperature (^{0}C)	Minimum Temperature (^{0}C)	Relative Humidity (%) RH – I	RH - II	Evaporation (mm)	Rainfall (mm)	Wind Speed (km/h)
1	January	25.8	10.7	70	27	03.6	000.0	03.3
2	February	29.7	12.6	57	17	05.3	000.0	03.3
3	March	37.8	17.6	35	08	08.5	000.0	02.9
4	April	40.9	24.6	42	13	12.3	000.2	06.1
5	May	40.7	27.9	50	20	13.0	000.0	09.5
6	June	39.7	27.8	65	33	11.6	031.5	10.8
7	July	38.2	27.6	68	37	09.7	035.1	04.0
8	August	34.0	25.2	86	54	04.7	139.5	06.3
9	September	37.1	25.4	66	35	06.1	011.1	04.7
10	October	35.0	20.1	58	27	05.2	002.8	03.4
11	November	33.1	16.0	50	17	04.1	000.0	02.7
12	December	28.1	13.4	54	23	03.3	000.2	03.1

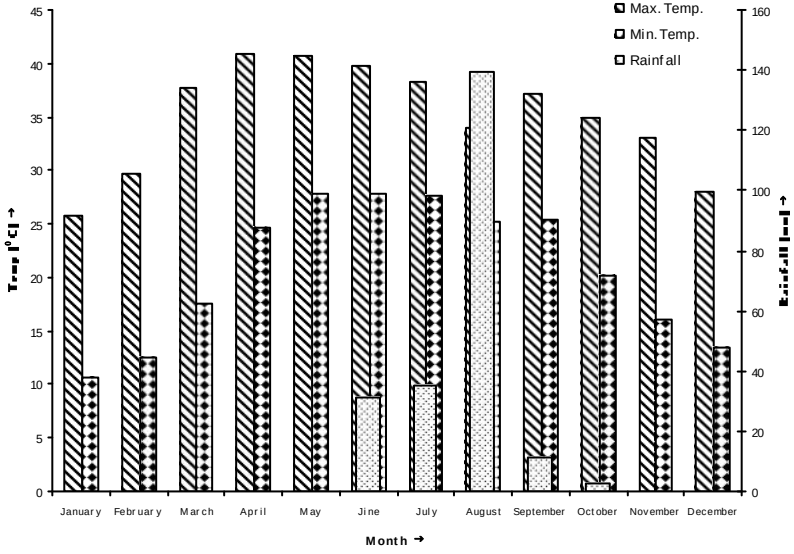

Fig. 5 : Mean Maximum and Minimum Temperature (^{0}C) and Rainfall (mm) Recorded in study area during 2004

Table 4: Group composition of focal bisexual troop Kailana-I (B 19) during 2002

S. No.	Months	Adults		Subadults		Juveniles		WC Infants		CC Infants		BC Infants		Total	Remarks
		M	F	M	F	M	F	M	F	M	F	M	F		
1.	May	1	8	0	1	0	1	0	1	1	0	2	2	17	-
2.	June	1	8	0	1	0	0	0	1	1	0	2	2	16	1 J female missing
3.	July	1	8	0	1	0	1	1	0	0	1	2	1	16	
4.	August	1	8	0	1	0	1	1	0	1	2	1	0	16	-
5.	September	1	9	0	0	0	1	1	0	2	2	0	0	16	1 SA female changed to adult
6.	October	1	9	0	0	0	1	0	1	1	1	0	1	15	1 CC male death, 1 BC female new born, 1 WC male missing
7.	November	1	9	0	0	0	1	0	1	0	0	0	1	13	1 CC female death (observed) 1 CC male missing
8.	December	1	9	0	0	0	1	0	1	0	0	0	1	13	-

(M= male; F= female; WC= white coat; CC= changing coat; BC= black coat infants)

Table 5: - Group composition of focal bisexual troop Kailana-I (B 19) during 2003

S. No.	Months	Adults		Subadults		Juveniles		WC Infants		CC Infants		BC Infants		Total	Remarks
		M	F	M	F	M	F	M	F	M	F	M	F		
1.	January	1	9	0	0	0	2	0	0	0	0	1	1	14	1 BC male new born
2.	February	1	9	0	0	0	2	0	0	0	1	1	1	15	1 BC female new born
3.	March	1	9	0	1	0	1	0	0	0	1	2	2	17	1 male and 1 female BC new born
4.	April	1	9	0	1	0	1	0	1	0	0	2	2	17	-
5.	May	1	9	0	1	0	1	0	1	1	1	1	1	17	-
6.	June	1	9	0	1	0	1	0	1	1	2	1	0	17	-
7.	July	1	8	0	1	0	1	1	2	1	1	0	0	16	1 adult female disappeared.
8.	August	1	8	0	1	0	1	1	2	1	0	0	0	15	1 CC female died (pers. cam).
9.	September	1	8	0	1	0	1	2	2	0	0	0	0	15	-
10.	October	1	8	0	1	0	1	2	2	0	0	0	1	16	1 BC female new born.
11.	November	1	8	0	0	0	2	2	1	0	0	0	1	15	1 SA female missing
12.	December	1	8	0	0	0	2	1	1	0	0	0	1	14	1 WC male death by accident

(M= male; F= female; WC= white coat; CC= changing coat; BC= black coat infants)

Table 6: Group composition of focal bisexual troop Kailana – I (B – 19) during 2004.

S. No.	Months	Adults		Sub adults		Juveniles		WC Infants		CC Infants		BC Infants		Total	Remarks
		M	F	M	F	M	F	M	F	M	F	M	F		
1	January	1	7	0	0	0	2	1	1	0	0	0	1	13	
2	February	1	7	0	0	0	2	1	1	0	1	0	0	13	
3	March	1	7	0	0	0	2	1	1	0	1	1	0	14	1 male born
4	April	1	7	0	2	1	0	0	2	1	0	0	0	14	
5	May	1	7	0	2	1	0	0	2	1	0	0	0	14	
6	June	1	7	0	2	1	0	0	2	1	0	0	1	15	1 new BC
7	July	1	7	0	2	1	0	1	2	0	0	1	1	16	
8	August	1	9	0	1	1	0	1	2	0	0	1	1	17	
9	September	1	8	0	0	1	2	1	0	0	1	1	0	15	1 AF lost
10	October	1	7	1	0	0	2	0	0	1	1	0	0	13	1 AF lost
11	November	1	7	1	0	0	1	0	0	1	2	0	1	14	
12	December	1	7	1	0	0	2	0	0	1	1	0	1	14	

(M = male; F = female; WC = white coat; CC = changing coat; BC = black coat infants)

Table 7: - Group composition of focal bisexual troop Kailana Canal (B 18) during 2002

S. No.	Months	Adults		Subadults		Juveniles		WC Infants		CC Infants		BC Infants		Total	Remarks
		M	F	M	F	M	F	M	F	M	F	M	F		
1.	May	1	10	0	1	1	1	0	1	0	2	2	1	20	1 SA male disappeared
2.	June	1	10	0	1	1	1	0	2	1	1	1	1	20	-
3.	July	1	10	0	1	0	1	0	1	2	2	0	0	18	1 WC female killed by dog 1 J male missing
4.	August	1	10	1	1	0	1	1	2	1	1	0	1	20	1 SA male reappeared 1 BC female new born
5.	September	1	10	1	0	0	2	2	1	0	1	0	1	19	1 SA female disappeared
6.	October	1	10	1	1	0	1	2	2	0	0	0	0	18	1 BC female death
7.	November	1	10	1	1	0	1	1	2	0	0	0	1	18	1 BC female new born 1 WC male missing
8.	December	1	10	1	1	0	1	1	1	0	0	0	1	17	1 WC female disappeared

(M= male; F= female; WC= white coat; CC= changing coat; BC= black coat infants; SA=sub adult; J=Juvenile)

Table 8: - Group composition of focal bisexual troop Kailana Canal (B 18) during 2003

S. No.	Months	Adults		Subadults		Juveniles		WC Infants		CC Infants		BC Infants		Total	Remarks
		M	F	M	F	M	F	M	F	M	F	M	F		
1.	January	1	10	1	1	0	1	1	1	0	0	2	1	19	2 BC males new born
2.	February	1	10	1	2	0	0	1	1	0	0	2	1	19	-
3.	March	1	10	1	2	0	1	1	0	0	1	2	2	21	2 BC females new born
4.	April	1	10	1	2	0	1	1	0	0	1	1	2	20	1 BC male disappeared
5.	May	1	10	1	2	0	1	1	1	0	0	1	2	20	-
6.	June	1	10	1	2	1	1	0	1	1	1	0	1	20	-
7.	July	1	10	1	2	0	2	0	0	1	2	0	0	19	1 J male missing
8.	August	1	10	1	2	0	2	1	1	0	1	0	0	19	-
9.	September	1	10	1	2	0	1	1	1	0	0	0	0	17	1 J female disappeared 1 CC female death
10.	October	1	10	1	2	0	1	1	1	0	0	0	0	17	-
11.	November	1	11	1	1	0	1	1	1	0	0	0	1	18	1 SA female considered AF 1 BC female new born
12.	December	1	11	1	1	0	1	1	1	0	0	0	1	18	-

(M= male; F= female; WC= white coat; CC= changing coat; BC= black coat infants; SA=sub adult; J=Juvenile)

Table 9: Group composition of focal bisexual troop Kailana Canal (B – 18) during 2004

S. No.	Months	Adults		Subadults		Juveniles		WC Infants		CC Infants		BC Infants		Total	Remarks
		M	F	M	F	M	F	M	F	M	F	M	F		
1	January	1	11	0	0	0	0	0	0	0	1	0	0	13	
2	February	1	11	0	0	0	0	0	0	0	1	0	0	13	
3	March	1	11	0	0	0	0	0	0	0	1	0	0	13	
4	April	1	10	0	0	0	0	0	1	0	0	0	1	13	1 new bcf
5	May	1	9	0	0	0	0	0	1	0	0	0	1	12	
6	June	2	10	0	0	0	0	0	1	0	0	0	1	14	1 outer AM joined
7	July	2	10	0	0	0	1	0	0	0	1	0	0	14	
8	August	1	10	0	0	0	1	0	0	0	1	0	0	13	1 male discarded
9	September	1	10	0	0	0	1	0	0	0	1	0	0	13	
10	October	1	11	0	1	0	0	0	1	0	0	0	1	15	1 AF joined
11	November	1	10	0	1	0	0	0	1	0	0	0	1	14	1 AF missed
12	December	1	10	0	1	0	0	0	1	0	0	0	1	14	

(M = male; F = female; WC = white coat; CC = changing coat; BC = black coat infants)

Table – 10: Group composition of an All Male Band (AMB – 11) during 2.5 years study period (i. e. May, 2002 to December, 2004)

S. No.	Months/ Year	Adults			Sub adult	Juveniles		Total	Remarks
		Old	Adult	Young		J - II	J - I		
1	May, 2002	1	6	3	1	2	3	16	
2	August, 2002	1	5	3	1	2	2	14	1 adult male and 1 juvenile missing
3	November, 2002	1	6	3	1	2	2	15	1 adult male reappeared
4	February, 2003	0	5	2	1	2	1	11	1 OA, 1AM, 1YA and 1 JM missing
5	May, 2003	0	5	2	1	2	1	11	
6	August, 2003	1	5	2	2	2	0	12	An old male reappeared
7	November, 2003	1	5	2	2	2	0	12	
8	February, 2004	1	4	2	2	2	0	11	1 adult male missing
9	May, 2004	2	5	2	2	0	0	11	
10	August, 2004	2	6	1	1	0	1	11	1 juvenile joined
11	November, 2004	2	6	1	1	1	0	11	
12	December, 2004	1	6	1	1	1	0	10	1 OM missed

(OA= Old Adult; YA= Young Adult; SA= Sub Adult; J= Juvenile)

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Chapter 3

OBSERVATIONS AND RESULTS

CHAPTER-3

OBSERVATION AND RESULTS

The entire langur population of Jodhpur region is organized in 35 bisexual troops and 14 all male bands (see appendices 4a and 4b). Each troop is comprised of an adult male (unimale bisexual) and occasionally of more than one adult male (multimale bisexual), several adult females and their immature offspring. A male band is composed of only males of different age classes but not including breast feeders. For observation point of view I have selected-two bisexual troops and all male band (I.e. B-18; B-19 and AMB-11 respectively). The observation on dominance hierarchy is mainly focused on these three focal groups; but some other troops also occasionally visited around Jodhpur study site for comparative study.

The present study comprises about 1570 hours of observation on two bisexual troops and one all male band living under varying ecological conditions. The focal troop B18 and B19 members were known individually. Observations were approximately equally distributed throughout the day. The observation were based on a dominance determination on basis of various determinants by using focal animal sampling while ad libitum on other behaviour was carried out simultaneously. By observation point of view, in these focal troops, the different determinants are responsible for rank determination.

3A. Ranging Behaviour

Home range use by Hanuman langurs in different habitats have been studied by various researchers for last 34 years, the data, however, do carry detailed information on the ecological constituents of the habitats and their biological significance. They use their home range very enormously. Group of the same species may differ in their ranging pattern temporarily or permanently during the different times of the day or in season or year or spatially across different habitats.

The Hanuman langur's home ranges often overlap to some extent which may be quite extensive at time. In bisexual troops the home range varies from 0.07 km^2 to 1.5 km^2; in all male bands they are more extensive, 4.3 to 22 km^2.

In the present study, I have observed home range of the two focal troops (K-I or B-19 and B-18) and one all male band have dealt with factors such as the troop size, food availability, natural predator, weather conditions, human interference, such as provisioning etc. I have also tried to elucidate the role of troop members, in particular that of the resident male and old females in protecting the troop range.

3A.1. Troop size and home range

The observational data of troop size and home range of B-19 and B-18 suggest a positive correlation between these two parameters (troop size and home range). In this study the home range of focal troops was measured by total distance in meters traveled by these troops from down to dusk.

Hanuman langurs tend to travel as a cohesive group, it is easy to record distance along travel routes and to obtain approximation of range length. These ranges were measured for all the three focal groups and were recorded for a minimum of 6 consecutive days (range 6-8days).

If I compare earlier investigations of home range and troop size which show the smaller troop size encompasses smaller home range, the findings correspond to these. During the last 24 years, the size of focal troop B-19 showed an up downward trend from 28-13 individuals. In present study the troop size varied between 13-16 individuals and home range estimated 0.6 sq. km. These figures are comparable to earlier investigation data of this troop i.e. Kailana – I (see table 14).

Table 14: Jodhpur langurs troop size and home range of a focal bisexual troop Kailana-I (B-19) during last 24 years

Study period	Troop size	Home range	Source
1981-82	22	0.9 sq. km.	Sommer, 1985
1984-86	24	1.0 sq. km.	Rajpurohit, 1987; Borries, 1989
1986-87	28	1.5 sq. km.	Srivastava, 1989
1999-2000	20	0.8 sq. km.	Bhaker, 2001
2001-2005	13-16	0.6 sq. km.	Rajpurohit, 2004 and Present study

The observer found that in 1982 with 22 individuals the home range of B-19 was worked out as 0.9 sq. km; it became 1.0 sq. km. when troop size reached 24 individuals in 1984 and 1.5 sq. km. when troop size increased up to 28 individuals in 1986, which further decreased to 0.8 sq. km. when troop size decreased to 20 in year, 2000. During the present study the troop size being 13-16 individuals the home range has decreased 0.8 sq. km. to 0.6 sq. km.

3A.2. Food and weather conditions in home range

Survival and reproduction of individuals depend on their ability to locate and harvest sufficient food to meet their nutritional need. Timing and selection of food plants are synchronized to meet the requirements of proteins, fats, vitamins, water, minerals, trace elements, etc.

All primate species have the same general need to acquired energy and interact with a variety of food distributed in their home range and is within their reach. Most dietary studies of colobiane monkeys have involved species that line in small one-male-group (bisexual troop) occupy small home ranges and feed largely on leaves.

The Hanuman langurs (*Semnopithecus entellus*) is a territorial and folivorous. The food resource of langurs at Jodhpur is highly seasonal in their availability and leaves are the major portion of diet. Although langurs show

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seasonal preference for other food and plant items as they become available. In adverse conditions they fed on bark of the available trees.

The availability of food and weather also affect the home range of troops. If the food is available in plenty in its home range then their range is decreased because they get enough natural food near by and they need not to travel a lot in search of food. On the contrary if the weather condition is not good and the food available is minimum then langurs travel more in search of food and thus the home range may increase.

In the present study I have tried to investigate the food availability in relation to climatological data such as rainfall, relative humidity and temperature which play major role in the growth of plants that constitute major foods of langurs in nature.

The availability of food influenced the troop ranging pattern in the focal troop form one study period to the next. Home range tends to grow when food become less. A possible explanation for this situation is the increased competition in between langurs to exploit langur areas per individual.

The home range is also affected by provisioning. The provisioned food has become an important part of langur diet in this habitat. It ranges maximum in Jan-March to minimum in May (see figure-10). Local people are providing more than 50 food items to langurs during provisioning.

The spectrum of provisioned item is highly variable from month to month. Certain items are provisioned in all months, like groundnuts (*Arachis hypogaea*) and potatoes (*Solanum tuberosum*) while others are seasonal and are fed if they are available, for example, carrots (*Daucus carota*) are fed during October-April and mango (*Mangifera indica*) in April-June only. Besides this some flat backed cakes of pearl millet locally known as “sogra” and of wheat floor “chapattis” are fed consistently all the months (see Appendix 9).

Due to this artificial feeding langurs get more food within the home range. So they do not travel more for food or natural food. Thus their home range also decreased. As per observation, B-19 and B-18 troops live near a picnic spot, thus local people usually feed them with different kinds of food stuff. By and large these focal troops (i.e. B-18 and B-19) get more provisioned food round the year,

thus their home ranges are also less in comparison to the other adjoining and interior troops.

3A.3 Home range shift and encounter with neighbouring troops

The home range of the study group (K-1) increased from 0.9 sq. km. in 1981-82 to 1.0 sq. km. in 1985 and 1.5 sq. km. in 1986-87 but it has decreased to 0.8 sq. km. in 1991-2000 and further reduced to 0.6 sq. km. during this study period (i.e. 2002-2004).

The reduction in home range is directly related to decrease in troop size, dwindling food resources, lack of resistance. But water has not affected home range of this troop. Because its have plenty of water (Kailana lake) in its home range. Langurs have relatively smaller home range in general than do other folivorours primates. However, they often aggressively defend against incursion by other troops or even by all male bands.

During the study period about 21 instances of inter troop contact were recorded in overlapping home range of B-19 and B-20 troops (the neighbouring troop of K-1). The data suggest one inter troop contact per 20 hours of observation. Most of these contacts occurred between 8.30 -11.30 hours.

Spotting a troop at the border of its home range, adult females (particularly old females) usually give a warning vocalization (barks), alerting other troop members about approaching by neighbouring troop. At this time the resident male may jump and whoop call under excitement and becomes aggressive and uneasy. An exception to this situation may be seen when two or more bisexual troops meet at their overlapping ranges, when the neighbouring troop often meets without antagonism.

While the infants and juveniles of both the troops freely play for different lengths of time. However, at the time of encountering neighbouring troops may indulge in agonistic interactions. This kind of situation is very common when all male bands encroach upon a troop's home range, this leads to aggressive encounters in which the resident male of the troop almost always resist the invaders.

Occasionally I observed that the adult female and juveniles support the resident male in intercepting invaders. They may line up against the invading

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males and the resident male run after the males and chase them away. Sometimes the invaders resist by hitting and biting giving severe injuries. The males are always the victims inflicting serious injuries. These encounters may last for about a few minutes to one hour or sometime even longer.

The use of overlapping home range by neighbouring troop members is usually peaceful. The leaders of the troops mostly sit and watch the interacting members of their troop quietly. However, on 6-7 occasions the resident male of troop B-19 (Kailana -I) and neighbouring troop B-20 (Kailana-II) were observed to be involved in chasing and wrestling.

On one occasion the resident male of troop B-19 inflicted a serious wound on the left upper arms of the resident male of troop B-20 in inter troop resident interaction. During such cases serious fight also observed with troop females who came in defense of their range and resources. Resident males were very rarely observed injuring females and immature during this kind of practice of resource competition.

3A.4. Defense home range

The vigilance of resident male is associated with home range defense and intertroop encounters. In langurs, resident males and old past menopausal females are extremely vigilant. The vigilance starts from early morning and is always initiated by the resident male with morning whoops, which continue until the troops members return to the roosting site, or when the day's activity comes to an end in the evening.

Except for the very hot periods of day (during summer) when all members hide in the cooler shady locations the vigil is undertaken in turn by old and experienced females. Sometime 2 or more individuals were participates in this activity at the same time, watching in different directions.

The resident male or the old females often climb to a tree or on the top of the hillock from where they can keep watch of the troop's range and its surroundings. They scan the whole region rather carefully and meticulously.

In the langurs the defense of a potentially limiting resource is often determined by means of vigilance behaviour. The inter troop encounters concern not only access to specific food resource, but defense of the entire range. Since

large ranges are difficult and uneconomical to patrol every day, they mostly watch the range. In langurs, however, the resident males are always aggressive towards potential migrant males.

3A.5. Daily schedule and activity pattern

The ecology and behaviour of langurs have received considerable attention in the last three and half decades. The flexibility of langur's behavioural responses to fluctuation in resource availability is an essential component of the adaptive strategy. The analysis of the nature and causes of variability in activity proportion can contribute to our understanding of the nature of that adaptive strategy. Playing behaviour is also a part of daily activity patterns in hanuman langur (plate 8 and 9)

3A.5.a. Feeding

Feeding began when an animal made first contact with any part of a food plant, excluding contacts with the plant as a locomotors substrate.

Feeding bouts were considered terminated when the focal animal either (i) moved more than one full stride or (ii) stopped eating a food plant. According to this definition a switch to a new food type in the absence of either of these conditions was not sufficient for the bout to be considered. For breast feeders suckling is infant feeding (getting milk of mother).

3A.5.b. Dozing

This category includes solitary behaviour during which focal animals slept, rested or were motionless with eyes closed, but slight body movements did occur.

3A.5.c. Locomotion

This category includes all locomotive activities, e.g. walking, running, climbing, leaping and jumping between arboreal supports, but excluded short movements during feedings (less than one full stride) and locomotion during social interactions.

3A.5.d. Monitoring

This category includes solitary behaviours during which an animal was neither feeding nor sleeping nor engaged in social behaviour. But it was looking around, watching and remains vigilant. Normally the resident male and sometime adult females showed this solitary behaviour in a troop.

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3A.5.e. Grooming

In grooming, the focal animal developed contact with any other troop member with grooming intention. This was terminated when grooming stopped for movement. It includes all kinds of grooming for example allogrooming and auto grooming or self grooming. Allogrooming may be in between female-female, female-male or adult female-juvenile female.

3A.5.f. Sexual and others

This category included all activities during when the focal animal's attention and behaviour was clearly directed towards another individual, other than the five categories mentioned above. It includes copulation, chasing, displacement, aggression, play, etc.

3A.6. Annual distribution of activity

After descending from their roosting sites and before moving to foraging ground the langurs usually stay in the vicinity of their roosting sites for a while and then undertake social activities such as grooming, huddling, allogrooming, etc. for short duration. It spends a good deal of time on the ground (almost 80 percent) and is, thus, much more terrestrial than several other species of the genus *Semnopithecus*.

Estimates of the proportions of time spent in different activities for all months in study troop B19 suggest that of the total activity budget, langurs spend one third of the active period in monitoring i.e. 32.11% followed by dozing 25.29%, feeding 21.11%, locomotion 9.0%, grooming, 10.19% and sexual and other social activities 2.30% (see figure 6 and table 15).

Table15. Annual distribution of main activities in the bisexual study troop (B19) of Hanuman langur during 2002-2004.

Activities	Percentage of total activity (%)
Feeding	21.11
Dozing	25.29
Monitoring	32.11
Grooming	10.19
Locomotion	9.0
Sexual and Others	2.30

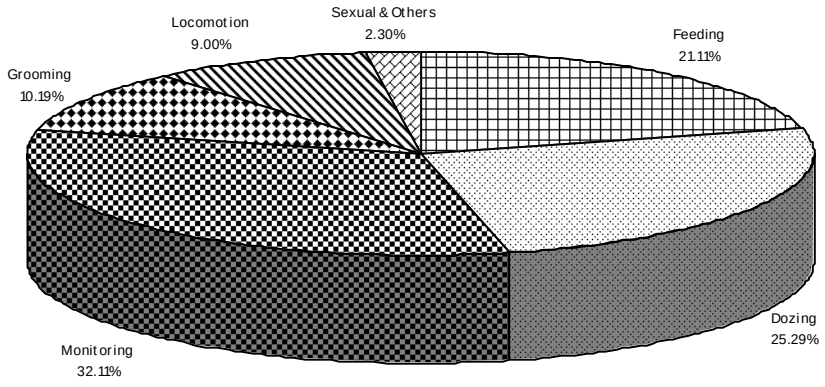

Fig 6 : Annual distribution of main activities in study troop B19 (Kailana I)

Such as B19 troops' individuals, B18 members also estimated for proportion of time spent in different activities for all months suggest that the total activity budget, langur spend 22.10% on feeding, 23.29% for Dozing, 34.11% monitoring, 9.19% grooming, 9.01% for locomotion and 2.3% on sexual and others. (See table 16 and figure 7).

Table16. Annual distribution of main activities in the bisexual study troop (B18) of Hanuman langur during 2002-2004.

Activities	Percentage of total activity (%)
Feeding	22.10
Dozing	23.29
Monitoring	34.11
Grooming	09.19
Locomotion	09.01
Sexual and Others	02.30

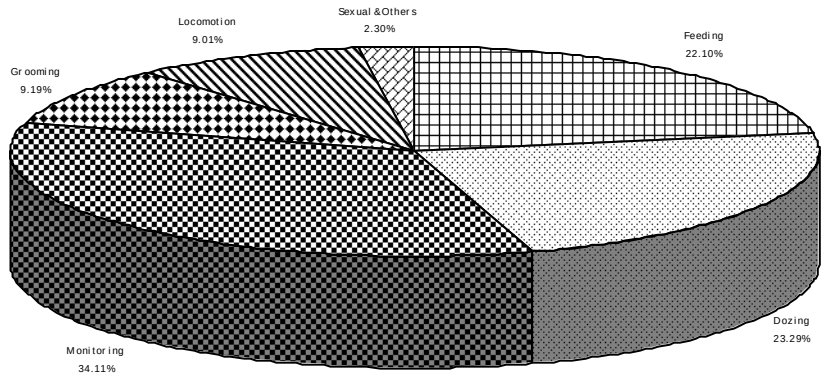

Fig 7 : Annual distribution of main activities in study troop B18 (Kailana Canal)

Seasonal variation

Langurs are usually more active in the morning and evening and less so at midday and in the afternoon (especially during hot months). There is generally about an hour's siesta at mid day or in the afternoon, during which it is extremely relaxed.

Both on the ground and in trees a favorite resting position is to sit on its sub caudal pods, with the tail hanging limp or stretched on the ground behind, the hind legs stretched out in front and raised, resting on some support. In winter, however, they are comparatively more active at midday and in the afternoon. Their activities generally slow down during rain and dust storm irrespective of the time of the day.

The three most prominent diurnal activities are feeding, monitoring and dozing. Altogether these activities account for about 79% of the total diurnal activities. Monitoring takes little more time (34.80%) in hot months compared to cold months (33.8%). Likewise, more time spend in dozing during hot months (28.9%) comparison to cold month (21.2%). A reverse situation exists with regards to the feeding in hot months (17.7%) compared to cold months (20.7%). These differences are statistically significant. Sexual activity does not fluctuate in different seasons. But activities such as play, aggression and social interaction do fluctuate. During cold months, it is 1.2% of the total activity and 1.1% in hot months. The grooming activity is slightly more during hot months (10.5%) compared to cold months (9.9%) given in table 17 and figure 8.

Table17. Seasonal variation of activities in the focal bisexual troop (B18) of Hanuman langur

Activity	During hot days (March-Sept.) 32°C	During cold days (Oct.-Feb.) 20°C
Feeding	17.70	20.70
Dozing	28.90	21.20
Monitoring	34.80	33.80
Grooming	10.50	09.90
Locomotion	05.40	11.60
Sexual	Not fluctuate (01.60)	
Others	01.10	01.20

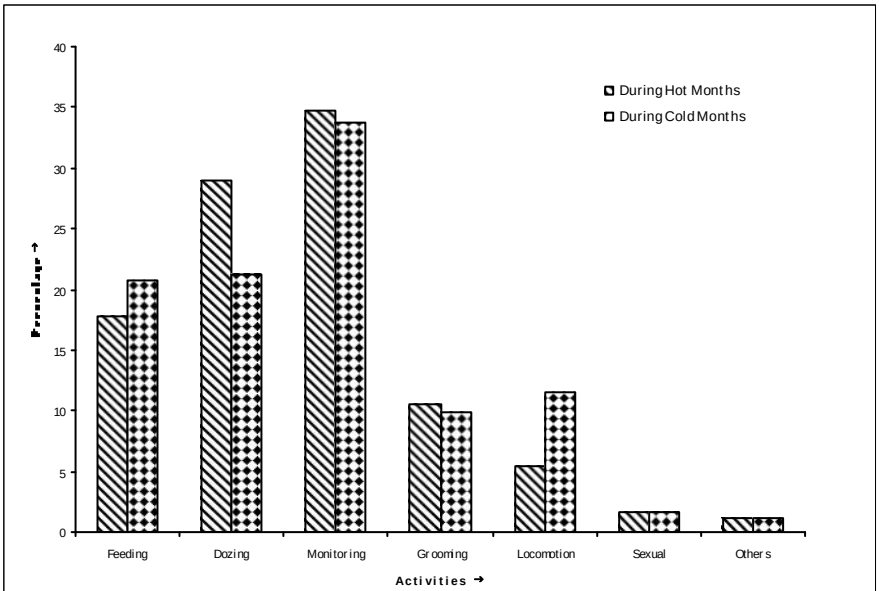

Fig. 8 : Percentage of main activities in B19 during cold months (Oct.-Feb.) and Hot months (March-Sept.)

3A.7. Diurnal distribution

The diurnal distribution of main activities in cold months (October-February) and hot months (March-September) in this species has been observed as follow.

3A.7.a. Monitoring

Monitoring as the most common activity (35%) of langur, further reveals that during hot months it is the highest (46.10%) at 07.30 hours and the lowest (24%) at 11.30 hours. Likewise, during cold months, the highest (42.3%) is at 09.30 and the lowest (27.3%) at 12.30 mid-day. This further suggests peaks in early morning and late afternoon and valleys during midday in monitoring activity.

3A.7.b. Dozing

The langurs of B-19 troop spend 24.2% of their diurnal activity time in dozing. By and large, the pattern of dozing is almost same in hot and cold months. In hot months the dozing peak is reached at 11.30 hours and in cold months at 12.30 mid-day.

During late afternoon the dozing decreased considerably. The inter-seasonal difference in overall activities is statistically significant. The positive deviation from expectation (x^2-test) during the day hours is also significant for cold months at

06.30 and 11.30 to 13.30 hours and at 10.30 to 12.30 hours for hot months. The significant negative deviation is seen at 08.30 to 10.30 hours and 15.30 to 17.30 hours in cold months and at 07.30 hours and 15.30 to 17.30 hours in the hot months.

3A.7.c. Feeding

For the entire observation period the feeding in B-19 troop was low during early morning and midday, but increased a little in late morning and in late afternoon. And the similar observation found in troop B-18 (Kailana canal).

The two peaks of feeding activity can be observed; one between 07:30 hours and 08:30 hours for the entire period. The significant positive deviation from expectation can be determined at 14:30 to 17:30 hours during cold months and at 07:30 and 15:30 to 17:30 hours during hot months. The negative deviation from expectation of 09:30 to 13:30 hours during hot months is significant on the contrary, for cold months it is statistically non-significant.

A negative correlation between temperature and feeding activity is thus evident from the present study.

3A.7.d. Locomotion

Of the total activity time langur devote to locomotion each day averaged about 6.9% during hot months and 12% during cold months. The seasonal and diurnal variation indicates that the peak for locomotion activities are closely coincides with peak of feeding activity and a strong correlation among these two activities thus exists.

The inter-seasonal difference in locomotion activities is statistically significant. The significance positive deviation from expectation is seen at 15:30 30 to 16:30 hours during cold months and at 15:30 to 17:30 hours during hot months. A significant negative deviation is also evident at 06:30 and 11:30 hours during cold months and at 10:30 to 12:30 hours during hot months.

3A.7.e. Grooming

Langurs spend 9% of their activity time on grooming. The diurnal and seasonal grooming distribution is almost equal; the significant negative deviation from expectation is evident only at 06:30 hours during cold months. The grooming

activity is slightly high or at 12:30 to 15:30 hours during hot months but the variation is non-significant.

3A.7.f. Huddling

This activity has been seen in cold months especially when there are cold waves. During winter, the langurs sit close and rest in a typical pattern. This type of close sitting pattern is known as 'huddling'. In this pattern langurs sit and rest with closely to each other or even tight contact to each individuals of troop to keep warm themselves by such body contacts (plate 10).

This is a precise method for winter months. By this mutual contact they can get warm to each other. Huddling observed highest in early morning and late night during cold months while in hot months such type of sitting pattern has not been observed rather it has not significance during summer.

3A.8. Monthly distributed of activities

Variation in monthly activity pattern in two focal bisexual troops B-19 and B-18 was studied. Overall monitoring activity for B-19 and B-18 remained uniform. Here, the monitoring showed the lowest score during December and highest during March.

The scores for dozing activity of the troop B-19 showed stability from October to March and then increased abruptly in month of April and remain stable until July. It went down a little in August and increased again in September and the same observation found with B-18 troop.

The feeding activity of troop B-19 showed a definite pattern, feeding increasing from October onwards and reached its optimum in December. From January onwards decline in feeding was recorded with lowest score in April. This followed another peak in August and from September feeding declined.

The locomotion and feeding activities went on in conjecture, with some what similar patterns. The first peak, during December and valley in May with further increases until August and decrease in September.

Grooming profiles of B-19 indicate a gradual increase from November (which has the lowest score) to April when it reaches a maximum and then decreases gradually until August. It increases abruptly during September. The grooming went down in October.

3B. RESOURCE UTILIZATION

The study of feeding behaviour is essential to the understanding of a species' ecological adaptation to the environment, and it is also an important factor to be considerers when examining the relationship between ecology and socio-biological problems. Since animals must get food if they are to maintain themselves and reproduce, the search for food is a crucial part of primates' lives and affects almost everything else they do.

3B.1. Drinking

Drinking has been a relatively neglected subject in the field studies of nonhuman primates. Many of the forest primates never descent to drink but obtain all they need from dew and the water that is caught in leaf axils or tree hollows. The drinking behaviour of *P. entellus* at different study sites has been described by Mohnot (1974), Sugiyama (1964), Ripley (1970), Oppenhimer (1977), Vogel (1977), and Moore (1985).

However, the monthly and diurnal variation, probability of drinking and its relationship with climatic factors have not been investigated. In these studies I have also attempted to investigate some aspects of drinking in Jodhpur Langur population.

Source of Water: - In this habitat the sources of free water are available to langurs. The permanent water holes and temporary water holes like, ponds, ditches, rivulets, etc. that come into existence immediately following rains in Manson months.

The permanent waterholes of Kailana area where the study troop is located contain the city's largest lake (Kailana) where the langurs drink water for most of the year. Between July-September the troop members were observed using many rainfed pools.

Use of water holes: - When a troop goes to a water hole, all of them do not drink at the same time, but they drink in batches. Whilst one batch drinks, others keep watch and are very vigilant. After the first batch has finished drinking the second batch drinks and the process is repeated (plate 11).

All members of a troop never drink all together, thus reducing the risk of being predated (whilst drinking) when animals are at water hole drinking. There was no strict time schedule followed by langurs for drinking.

Seasonal difference in drinking: - The relationship between relative humidity and monthly distribution of drinking episodes are shown in fig.9. The maximum number of drinking episodes were recorded in April and the minimum in July-August. The seasonal variation of drinking seems to compensate for any prevailing relative humidity and temperature in the habitat. In April the relative humidity was lowest and highest during July-August when monsoon is usually very active.

Competition for access to water holes: - it appears that the females are very conscious of their water holes and when necessary defend them I observed during my study that a young adult female of B-18 rushed to its water hole boundary and intercepted approaching females and did not allow the former to get to the water hole. After some time the young adult female was replaced by another young adult female, who tool position and resisted the entry of the invading females into the water. This was further prevented by another female who indulged in slapping and threat gestures (plate 12).

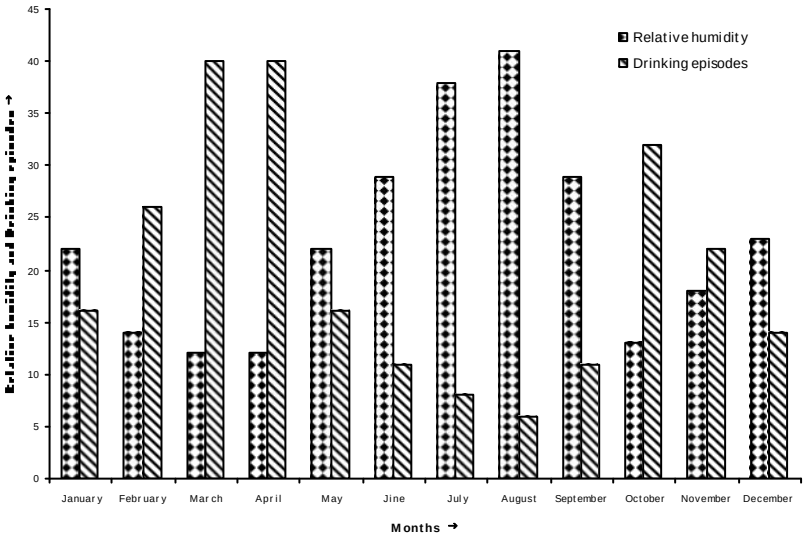

Fig. 9 : Montly distribution of drinking episodes in relation to relative humidity in B19 (Kailana - I)

3B.2. Food and Feeding

An array of some 170 primate species interacting with a great variety of complicated food distribution patterns gives a picture of primate feeding behaviour that is extremely complex. The complexity is further increased by the surrounding in which feeding takes place one in which predators must be avoided, competitors and weather coped with, social relationship maintained, and reproduction pursued (Oates, 1986).

Primates are therefore faces with frequent decisions between conflicting pressures on their allocation of time. However, since food is such a crucial resource, the actions needed to find and gather it are usually the major determinates of patterns of primate activity in space and time.

Among nonhuman primates, differences in social structure, behaviour, and size and use of home range have been attributed to characteristics of food resources (Clutton-Brock and Harvey, 1977).

The Present Study: - The great majority of species eat a combination of fruits, leaves and flowers and most also eat some animals at least occasionally. Roots bark seeds and gum also feature in many diets. These foods are taken from a wide variety of sources.

Food Selection: - Langurs of study troop B-19 were observed to subsist on plant parts of 122 species in this habitat of these, 87 species occur in nature and remaining 35 species, are obtained during their raids on cultivated fields, gardens and orchards and also during provisioning by the local people.

In addition to the above, some of items of prepared food like, "sogra', flat cakes of millet 'chapatis', 'Puris', 'Jalebis' and Bread of wheat flour and 'laddus' of gram flour are frequently fed by people. During the monsoon months, July-September laddus' of gram flour are frequently fed by people, they were also observed consuming insect larvae during these months.

Langurs fed on natural food the most, which are available in their home, range the year round. The maximum provisioned food is eaten during December-March and minimum in May. Some episodes of inter-species interactions noted

during study with various animals (plate 13). The monthly distribution of feeding from dawn to dusk for study period is represented in Fig. 10.

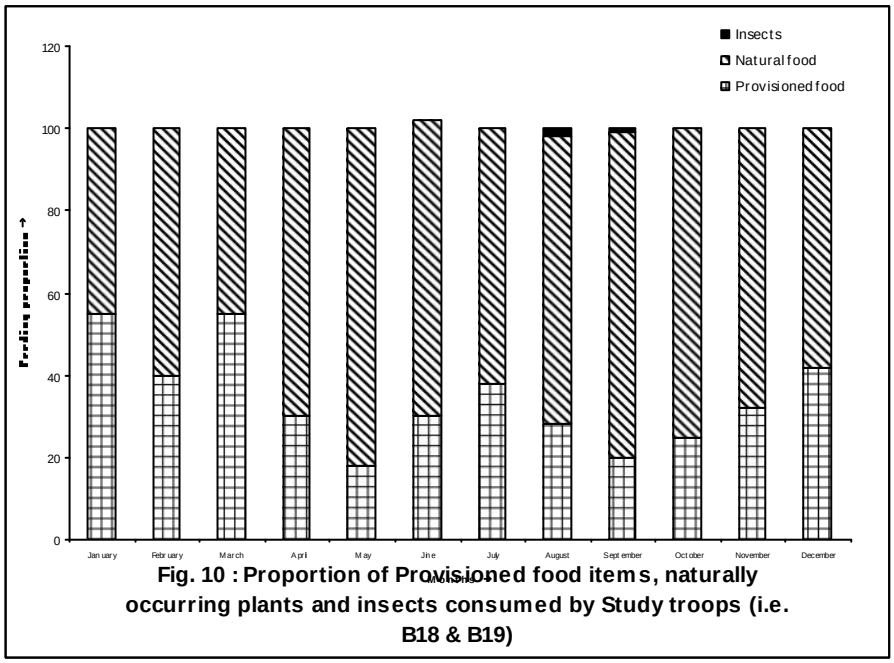

Fig. 10 : Proportion of Provisioned food items, naturally occurring plants and insects consumed by Study troops (i.e. B18 & B19)

Provisioned Food: - The provisioned food has become a important part of langur diet in this habitat. It ranges from 55% in December to 18.7% in May. Some 35-food items are given to langurs during provisioning.

The spectrum of provisioned items is highly variable from month to month, certain items are provisioned in all month, like groundnuts (*Arachis hypogaea*) and potatoes (*Solanum tuberosum*) while others are seasonal and are fed if they are available, for example, carrot (*Daucus carota*) are fed during October-April and Mangos *(Mangifera indica*) in April June only.

The annual distribution of provisioned food varies considerably. If we take into account various kinds of artificial foodstuffs given to langurs round the year, the flat backed cakes of pearl millet locally known as "Sogra" are fed rather consistently in all months.

Langurs devote upto 23.5% their total feeding time on "Sogra" if we consider all kinds of artificial food into account. "Chapatis" of wheat flour come next with 15.4% of feeding followed by a variety of cooked food items, which all together constitute about 28.8%.

Likewise, on the yearly basis fruits and vegetables also represent a fairly good amount of provisioned food. The commonly fed fruits and vegetables in a year are carrot 8.1%, groundnut 8.1%, banana 7.6. % and brinjal 6.6% the remaining 28.7% of food is comprised of several other fruits and vegetables in different proportions. These details are given in Fig. 11

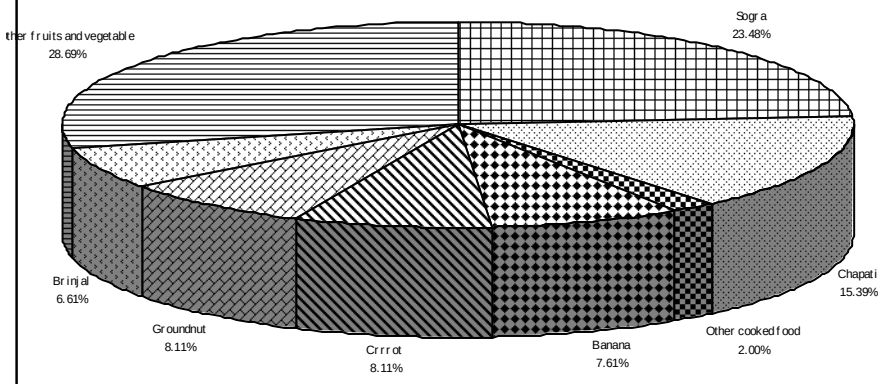

Fig 11 : Annual distribution of provisioned food items in study troops of langurs

Monthly distribution of provisioned food: Like the variation found in the annual distribution of provisioned food, the monthly distribution of provisioned food also varies from month to month. For example maximum amount of cooked food is eaten in October and Minimum in February. Conversely, the maximum of fruits and vegetables together are consumed in February and minimum in October. The monthly feeding on cooked food and fruits and vegetables is given in fig.12.

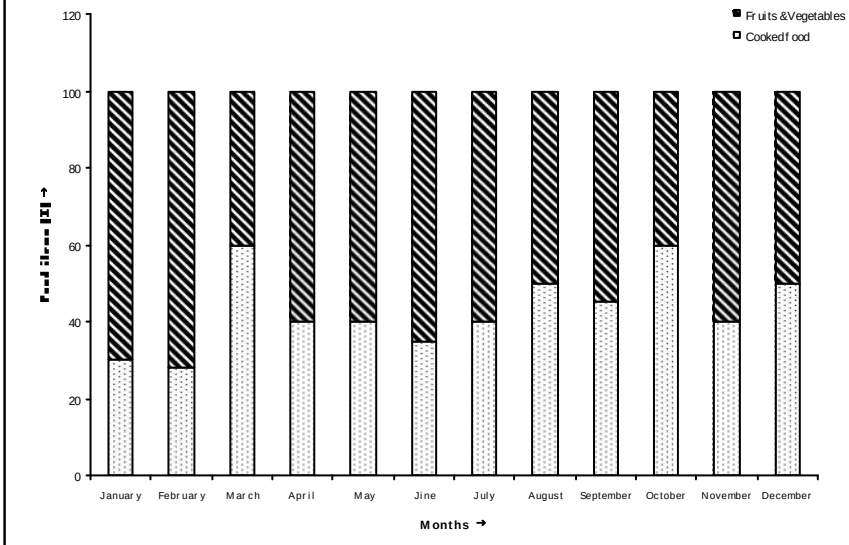

Fig. 12 : Monthly distribution of provisioned food items in Study Troops

Feeding spectrum of Provisioned Food: - Some provisioned food items have become the staple food of langurs, as they constitute 2% of the diet on a yearly basis with some fluctuation from month to month. Most of these items are seasonal and are consumed in quantities only during certain months. The "sogra", a pearl millet preparation contributes substantially to langur diet (23.5%) out of total provisioned foods. Amount fruits and vegetable items, banana, carrots and mangoes did show seasonal variation. Carrots were consumed only during winter months from October- April, bananas during June to February and mangoes during April – July (figure 11).

Natural Food: - This habitat represents some 320-plant species in nature. Of these, 208 are eaten by langurs. The members of study troop B-19 were observed consuming over 87 plant species belonging to 38 families. Five of them like *Prosopis juliflora, Acacia senegal, Diptercanthus petulus, Acacia nilotica*, and *Indigofera oblongifolia* find prominent place in the langur diet round the year.

The total number of plant species consumed in different months varies considerably. Month of August in the monsoon season provide large range of plant species and June the least.

The monthly distribution of the number of plant species consumed by langurs of the study troop and its correlation with rainfall shows that during the

dry season the number of species constituting langur food go down and with the onset of rains the plant texa increase manifolds reaching to a maximum during August.

During October, November and December the flora remains constant which slowly shrink water the dry spell and become minimum in June, with some exception in May. In general, the availability of plant species is directly related to the quantum of rain during the monsoon months. The spectrum of flora increases with good rain and decreases with poor rain. Consequently the dependence of langurs on food plants also varies accordingly.

Staple Food: - All plants on which langurs were observed to spend 5% of their feeding time either in a year as a whole or in any month or months thereof have been considered as staple. The staple food includes 4 trees, a shrub and an herb. The annual distribution of six natural plant species which constitute staple food of langur diet and percentages of total feeding time per month is given in Fig.13

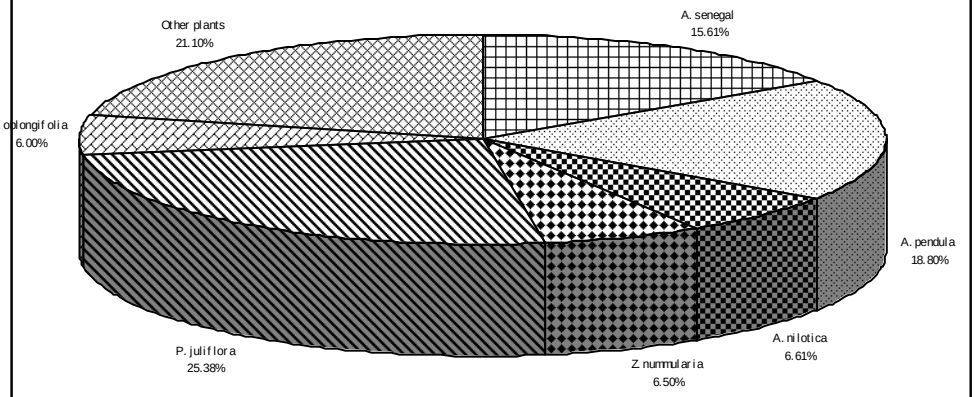

Fig 13 : Annual Feeding percentage of natural plant species in Study Troops of langur

The three plant species viz. *P. juliflora*, *A. senegal* and *A. nilotica* constitute the major share of langurs diet on yearly basis. These species together account for about 60% of total time which langurs spend on feeding. The remains 3 staple plant species account for about 6 to 7% of feeding.

These six staple plant species account for about 79% of their total yearly diet. Among staple food, *prosopis juliflora* receives the highest score and

Indigofera oblonifolia lowest. Plant parts of *P. juliflora* were consumed heavily during dry months of April and least during the monsoon month of August.

The staple food plant *Z. nummularia* which is infrequently eaten showed strong seasonal variation. It is consumed only during cold months from October to March. Other staple food plants showed remarkable seasonal variation not only in their availability but also in their consumption.

The annual distributions of plant parts utilized by langurs in nature are given in Fig 14. This illustrates percentages of total feeding time that langurs spent on major food types viz. mature leaves, young leaves, fruits (generally unripe but occasionally ripe) flowers (both buds and open), stem, gum and bark.

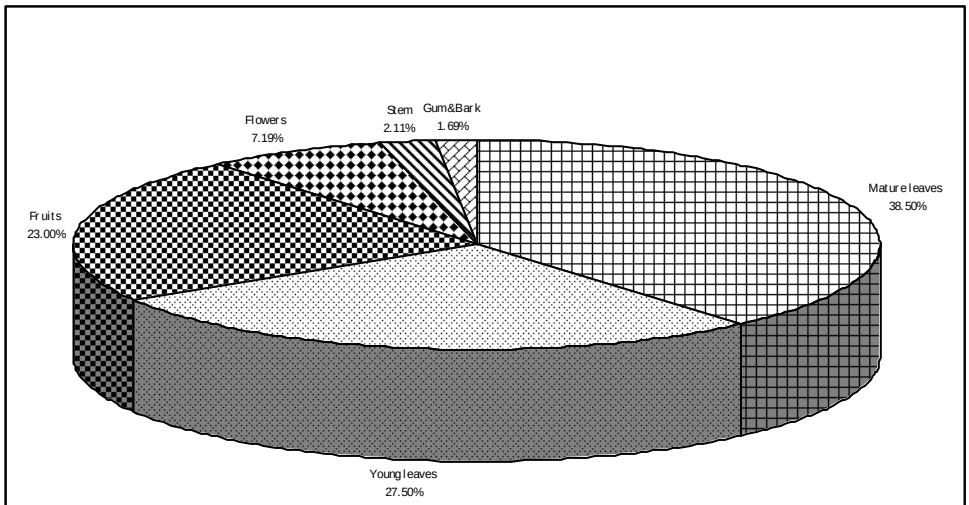

Fig 14 : Annual distribution of natural plant parts utilized in study troops

Langurs devoted and overwhelming proportion (66%) of their total feeding time in consuming leaves of the time spent eating leaves, more time is devoted to mature leaves 38.5% as compared to young leaves 27.5% Fruit eating accounts for 23% of the total feeding time. Consumption of flowers accounts for about 7% and remaining items such as stem, gum, and bark totaling about 3%

3B.3. Resource allocation

Feeding time: - The competition for food resources occurs in an indirect or 'passive' form whenever animals aggregate into groups since an individual requires a minimum food patch size and food density of a certain level.

The resources dwindle as a result of troop members feeding simultaneously or sequentially from the same food patch or even in the same general area (Post

et al. 1980). As a result, there must be some differences in the foraging behaviour of adults and nonadults, males and females, high ranking and low ranking and among females of different reproductive status, and so on.

The competition for food usually involves one individual using threat or physical attack to supplant some other individual from a food patch or to prevent access of another individual to a food patch that is suitable for exploitation.

The precise relationship between age, dominance rank, reproductive status and various quantitative measures of food intake, quality of food and feeding efficiency, found in this study. The feeding is linked with age, sex dominance and reproductive status of an individual langur.

Age-sex characteristics and Dominance relations: - One can expect both food intake rates and inter-individual dominance relations to the relative body size of various age-sex classes. Generally, at about 3-4 years of age males are larger and heavier to females, and indeed, the adult male langur weigh nearly twice as much as their female counterparts (Male 18.5 vs. Female 11.5 kg., Mohnot et al., 1987).

Likewise, from within both sexes individuals of older age classes are typically larger and heavier than individuals from younger age classes.

Feeding in relation to Rank: - Females were grouped by descending order of their dominance into three groups High ranking females devote more time in feeding then expected and low ranking females devote less time to feeding than expected and the middle ranking females stand in between these two ranks, though this middle rank consumes a little more time in feeding then expected.

3C. Dominance behaviour and rank order

By observation point of view, in these focal troops, the different determinants are responsible for rank determination.

DETERMINANTS FOR ACCESS DOMINANCE ORDER

Dominance hierarchy has long been recognized as a stereotyped behaviour of many primates varies from genera to genera and from species to species. But

in every primate society there is some competition for rights to incentives, such as food, estrous females and shelter.

Dominance determinants are the major source by which we can determine a ranking status in a particular group. Some major determinants, which I used in my observation of ranking system, are followings-

FOR BISEXUAL TROOPS

In a bisexual troop, only a single resident male occurs, so he gets top rank in his group and plays major role to determine rank system in females by various aspects.

3C.1. Resource competition: -

Most nonhuman primates live in groups. These are numerous potential benefits to sociality, including increased protection from predators, cooperative defense of food resources and collective rearing of offsprings. Group life also provides an opportunity for long term cooperative relationships. At the same time, however, sociality entails number of cost.

In group living animals must compete with one another for scare resources such as food, water and mates (Walters and Seyfarth, 1987). Life within primate groups thus delicately balanced between competition and cooperation (Crook and Gartlan, 1966; Crook, 1970).

The most obvious manifestation of competition within primate group is aggressive behaviour which often taken the form of display, signals exchanged between two or more animals that rarely lead to physical contact but usually result in one animal gaining a particular resources (Janson, 1985; Walters and Seyfarth, 1987).

Although aggressive behaviour usually reflects competition between two or more individuals, competition is not always overly aggressive. Perhaps the most common competitive interactions among primates is what Rowell (1960) called as “approach retreat interaction”. The more subtle manifestation of competition has been termed “competitive-exclusion”. Approach retreat and competitive exclusion interactions are common in species having well established dominance relations.

During study period, I have observed that the food resource is one of the main factors which are responsible to some extents for competition and dominancy. The focal bisexual troops (B18 and B19) are located at open shrubs habitat. So these troops have natural plants and scrubs for feeding (plate 14 and 15). Beside this, these troops are well provisioned by local people. During observation study, I have noted lot's of dominant rank status episodes during feeding (plate 16 and 17).

The observation was taken by focal animal sampling methods. The food seems to be the basic resource because half of the dominancy occurred and determined over food. During natural feeding the dominant behaviour was less because at study site the natural plants and scrubs are in plenty and the troop size is small, so they get enough nutrients from natural course. But when the weather conditions was not favorable and there is scarcity of natural food, the competition has increased in the focal troops

The langurs of focal troop spend about one third of their total feeding time over provisioned food and about half of the dominance behaviour occur over the provisioned food is much higher competition.

For provisioned food there is much higher than for natural food. Thus competitions for feeding are mainly due to artificial feeding in B-18 and B-19 troops. In langurs during artificial feeding (provisioning) the high rank females get food first, but some, time parallel rank female also tries to get food simultaneously and that time conflict occur between these adult females. Although this is not a serious aggressive behaviour towards agonistic partner(s), such as threatening fence (A prevents B from approaching further or acquiring food), hit, pull or push, jump at chase, bite, etc.

Such type of food competition also occurs in different members of troops. Likewise in between juvenile and females and among juveniles, but I observed dominance episodes only in adult females in bisexual troops. It clearly observed that dominant or high ranker always get food first and they suppress to other to getting food. But parallel ranker always show some aggressive and conflict behaviour for food competition.

3C.2. Competition for good place (Shelter)

Dominant or high ranker always tries to get a good place for their rest or sitting from where they can control their group members. But in female-female create a competition for good place. It became more competitive when the group home range is small, B19 (Kailana-I) troop has small home range. Within this home range every troop member tries to get good place for shelter during rest time.

The focal troops have fixed home ranges and within that home range they have some preferred area for roosting. This place is always used by high ranking females and the resident male. But some how that place is occupied by their members like low ranking females or juveniles. Then adult higher ranker female shows some aggressive and dominant behaviour towards individuals which have occupied that place.

3C.3. Allomothering as dominance indicator

Infant transfer or allomothering by troop's members or other than the mother appears to be a peculiar character of colobine social behaviour. Allomothering has been extensively observed by many scientists studying the common Indian Langur (*Semnopithecus entellus*). I also observed such kind of behaviour in my focal troops (B-18 and B-19).

In study troop (B-19) there were 7 to 8 females having 4-5 infants during the course of this study. The remaining group females (Who have no infants) always trying to get and carry the infant of troop, but there are several mothers who resist, reject or avoid allomothering of their babies with respect to all or particular troop members.

Sometimes during allomothering the infant screams were heard due to inadequate handling or of deserting by allomothering.

Thus the real mother tries to retrieve her baby from allomother. I observed most episodes like that in my study period. Most episodes show that high ranker female almost not interest in infant carrying but on their choice, they takes infants against baby's mother choice. So due to low rank, mother cannot refuse or object for allomothering.

So it observed that infant carrying mother always tries to sit at silence place where nobody can disturb to her. It has also been observed that infant of high

ranker female get more allomothering by their low rankers' females. This shows that high ranker female's infant always get good carrying by their aunt who gets low rank or submissive against infant's mothers.

In many situations, mother is not interested in allomothering and tries to snatch, threaten and hitting the allomother. Many of the times when there was only new born/black coat infant in while troop, due to attraction for all the troop members the allomother observed behaving agonistically for getting/playing this young one.

My observation completely shows that high ranker female's infant always pass their time with the aunt who get low status against high rankers. And high ranker female take/carrying babies of low ranking females only on their choice, although mother babies tries to object it. Therefore dominancy determined by these episodes of allomothering behaviour of females.

3C.4. Mating behaviour as dominancy indicator

A bisexual troop comprises of an adult male, several adult and subadult females and their offsprings. Whole all male band comprises of different aged males only, however multimale bisexual troops is uncommon at study area.

At Jodhpur study area bisexual and all male bands are predominant social structures in this species. In a bisexual troop containing only one resident male, that has to mate with all the adult females of troops as and when they are in estrous.

In bisexual troop B-19 there were 7-8 adult females. While in troop B-18 having 10-12 adult female during this study period, I noted that some times more than one or two females were observed in estrous at the same time. This situation leads to female-female competition for mating with resident male.

In general, only high ranker or top most female mates with resident male when more than one female are in estrous and present to male. She always tries to get near most position to resident male and shows dominancy on low ranking female who also tries to mate with resident mate. Infect I observed that high ranking female mates only till she become pregnant, in this pregnancy situation male mate with other females (plate 18).

Male have choice to mate more females but females maintain a regulatory system, that high ranker mate first with resident upto fulfill their choice. She opposes and shows aggression towards such females who tries to get their position. My observation clear that dominance hierarchy maintain a regulatory system, although competition leads in their life, but it have limit because they get a ranking status system.

3C.5. Displacement as result of dominancy

(As indicator of dominancy)

In the process of displacement, a female approach another female with some threat gesture and may contact her visually or physically and then the other animal often moves away or relinquishes her position. Displacements occurred in all possible combinations involving non adult and partners of both sexes.

In this study, I determined the dominance hierarchy of focal troop females (B-18 & B-19) on the basis of several determinants, but the most important being displacement.

Displacement observed on food procurement, for possession of resident male and for better sites to feeding (natural as well as artificial), resting, grooming etc.

In summer the troop members show dominancy for the places bit cooler such as building or tree shades. The natural food is very limited at study site. *Prosopis juliflora* and *Anogeissus peridula* are the main natural food plants over which troop members fed. Some high ranking females have been observed that they did not allowed other females to feed upon those plants simultaneously.

Displacement takes place in three clear phases.

(1) mode of enforcements - this includes approaching, slapping, baring teeth, threatening, pulling fur, mounting, jumping into belly, chasing and teeth grinding.

(2) Reaction of recipient - mostly in 'classical displacement' the recipient avoids the actor (A approaches B and B moves away) here A showing high ranking status than B, some time the recipient rechase and may also vocalize.

(3) Context - includes acquisition of natural food, provisioned food, water, sleeping or resting sites (or better position) and others. Age sex class distribution of displacement behaviour of study troops members are given in table 18

Table18:-Age-sex class distributation of displacement behaviour in langur troop B18

Actor	Receptor	Displacement	Episodes %
Adult female	Adult female	290	87.34
Adult female	Non Adult female/male	7	2.10
Adult male	Adult female	28	8.43
Adult female	Adult male	3	0.9
Non Adult females	Adult female	4	1.2
Total		332	100

Table19: - Context in which adult langur females of focal bisexual troop (B-18) displaced one another

Context	Episodes		
	(n)	%	%
Feeding			
(1) Natural food	75	22.3	47.5
(2) Provisioned	85	25.2	
Position			
shade	14	04.2	
unknown	55	16.3	20.5
Grooming	21	06.2	06.2
Others			
(1) Sexual contact	10	03.0	
(2) Redirected aggression	22	06.5	16.6
(3) Nepotism	01	00.3	
(4) RAIb	16	4.7	
(5) Looser support	3	0.9	
(6) Winner support	04	01.2	
Unknown	31	09.2	09.2
TOTAL	337	100	100

(RAIb= Redirected aggression for Infants)

Table20: - Context in which adult langur females of focal bisexual troop (B-19) displaced one another

Context	Episodes		
	(n)	%	%
Feeding			
(1) Natural food	70	19.83	43.90
(2) Provisioned	85	24.07	
Position			
(3) Shade	19	05.38	
(4) Unknown	51	14.44	19.82
Grooming	23	06.51	06.51
Others	13	03.68	
(1) Sexual contact			
(2) Redirected aggression	28	07.93	
(3) Nepotism	08	02.26	18.95
(4) RAIb	11	03.11	
(5) Looser support	03	00.84	
(6) Winner support	04	01.13	
Unknown	28	07.93	07.93
Total	353		

(RAIb= Redirected aggression for Infants)

It has been observed that adult females act as both actors and receptors and are the most frequent participant in all displacements. The context in which study troop females displace one another is given in table-19 and Table-20 for focal bisexual troops B-18 and B-19 respectively

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The displacement behaviour is directly linked to the acquisition of resources. It is found that most (3/4) of the total displacement are directly related to resource competition and remaining appears to be the indirect form of resource competition (plate 19).

During the present study in B-18 troop an average of about half (47.50%) of all displacements occurred over access to food, this however, included both natural (22.3%) and provisioned (25.2%) food. The remaining (52.5%) displacement observed were over access to position or better place (20.5), social interactions (16.2%) and over grooming (6.2%) which may directly influence the resource competition (see table 19 and 20). The remaining displacements were circumstantial where the cause was not apparent.

In this study displacements are worked out from daily records of all those events in which both actor and receptor females were known and their ranks were accordingly determined. Displacement events of total records, about 3/4 came into being in the natural course. While the remaining 1/4 took place during provisioning.

On the basis of the frequency of displacement the displacement matrices for the study to (B-18 & B-19) were placed into blocks viz Sept. 02 to Dec. 02, Jan 03 to April 03, May 03 to Aug. 03, Sept 03 to Dec.03, Jan 04 to April 04, May 04 to Aug 04 and Sept 04 to Dec 04.

These matrices exhibit the established dominance hierarchies found among focal troop females. On the basis of these matrices, the ability of one female to displace another is predictable. Although the low scare of rank reversal supports the hypothesis that a stable hierarchy exist among langurs for a short duration, it is not constant over months.

From the matrices, it appears that there is general tendency of young females to be on the top and old females (including post menopause females) to be at the bottom of the rank axes.

The functional explanation can only be derived on long term basis high rank means access to more food and more food gives rise to earlier maturation, greater fertility, more mild and thus a greater number offsprings.

The greater ability of the resident male to displace adult female may be the effect of its dominance, except for rare occasions he cannot displaced by any of the troop members. Food seems to be the basic resource because half of the displacement occurred over food. If total feeding time is compared with total episodes of displacement over the provision food, the langurs of Jodhpur spent about 1/3 of their feeding time over provisioned food and about half of the displacements occur over the provision food. Thus provisioning increases competition. Aggression and chasing actions noted during resource competition (plate 20).

Thus competition for provisioned food is much higher than for natural food. This distribution of provisioned and natural might be the cause of this difference, since provisioned food always distributed in patches and much more limited than the natural food. Some inter-troop encounters also noted during study when food placed in partnership between two troops (plate 21).

3c.6. Grooming as dominance indicator

Langur spends 9-11% of their activity time on grooming. This diurnal and seasonal grooming distribution is almost equal; the significant negative deviation from expectation is evident only at 6.30 hrs during cold moths. The grooming activity is slightly high at 12.30 to 15.30 hrs during hot months but the variation is non significant.

In present study, it has been observed that grooming play an important part of dominance indication. It is observed in most of the grooming episode that high ranker females are always groomed by low ranker females. Such type of observation also noticed in male band. Resident male mostly groomed by top ranker females (plate 22 and 23). Percentage of various dominance measures found in focal bisexual troop (B19 and B18) are given in table-21 and 22 respectively.

3D. Dominance hierarchy in AMB-11

AMB-11 (Chopasani) preferred site is Chopasani temple for roosting which is about 8 km. south west to Jodhpur city. In general male band has large home range and two or more preferred sites for night stay. This male band (AMB11) also

has its home range about 10-12 sq. kms. And observed visiting or interacting to the bisexual troops in this area viz. filter house (B-25), Sidhnath (B-23 and B-24), Beheembhark (B22, B21), Kailana (B19, B20), Kadam Kandi (B26, B27), Bhardreswar and Chonkha (B28, B28a, B28b).

This male band was selected as focal male band for this study because of its small size and easily accessibility. During the study period the band size ranged between 8-16 male langurs of different age group. Different kinds of inter individual interactions formed the criteria of determining ranks of individuals.

Dominance hierarchy in males of band is well marked, particularly among the adult males, which can be determined under the conditions of stress as well as during the normal situations.

The main determinant of the hierarchy in the male bands is displacement, when a ranking individual displaces a sub ordinate repeatedly. It can be for the food procurement, for the estrous females while interacting with troops or to occupy the places they like most for sitting and watching.

Other determinants were chasings, fights, success or failures in copulations and harassment to subordinates during interactions with the troop members (table 26). The dominance status has also been worked out on the basis of Whoop calls, Warning signals and other vocalizations, which are usually emitted by the resident males followed by the low ranking males.

The alpha and beta males are the established males, which are most successful and are challenged only rarely by other males. To ascertain the hierarchy of the adult males in this particular male band (AMB-11) which was selected for the dominance study, each adult male was identified individual by body marks, fascial features and physique (See table-13). Which vary from individual to individual was carefully recorded. This identification facilitated recording of the dominance interactions during different interactions.

This study male band regard 8-18 males during the study of these except 3-4 juvenile males, the rest were adults, which studied for determination of dominance hierarchy.

Dominancy in all male band (AMB11) determined on the basis of displacement episodes in this group. It is clear by this study that most dominant

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always withdrawal others more time than subordinate male. The table 23 and 24 shows about AMB11 dominancy. About 6 male chosen as subject for this study. Table 23 data shows that during Sept. 2002 to Dec. 2003, m1 maintained his rank on top most. M1 displaced more times than others and lost zero. During study period from Jan. 2004 to Dec. 2004, M2 become dominant and maintained his rank with winning episodes more than others (table 23 and 24).

Some 931 episode concerning dominance interaction were recorded from among these 6 adults males and their dominance ascertained. The maximum episode i.e. 692 (74.3%) relate to the displacement in these 185 (26.7%) were on food procurement, 325 (48.4%) for the possession of estrous females during interband interactions and 172 (24.9%) were meant for other behaviour.

In 94 episodes dominant chasing and giving threats to subordinates were recorded during troop's interactions or when ranks disturbed former's sexual acts low. Harassment during copulation was quite common. Of 107 copulation episodes, dominant males were successful in 40 while 67 copulation were disturbed harassed.

Besides these dominance interactions, 38 (4.1%) episode of whoop calls by dominant were recorded as an additional support to determine hierarchy. There were 49 (5.2%) reversals and most of them 45 were observed when male either resting or not engaged in any apparent activity. The remaining for reversal was observed for food (three) and procurement of estrous females (one) given in table-25.

Table 23: - Dominance hierarchy in all male band AMB-11(Chopasani) (September 2002 to December 2003)

	M1	M2	M3	M4	M5	M6	Total
M1	-	0	0	0	0	0	0
M2	14	-	1	0	0	0	15
M3	4	1	-	1	0	0	6
M4	6	7	2	-	0	1	16
M5	1	0	0	1	-	1	3
M6	2	1	1	5	3	-	12
Total	27	9	4	7	3	2	52

Total episodes (n) =52 Reversals=4(7.6%)

Table 24:- Dominance hierarchy in all male band AMB-11(Chopasani) (January 2004 to December 2004)

	M2	M1	M3	M4	M5	M6	M7 Juvenile	Total
M2	-	2	1	0	0	0	0	3
M1	18	-	0	0	0	0	0	18
M3	7	3	-	2	0	0	0	12
M4	10	5	2	-	0	1	0	18
M5	2	1	1	4	-	1	0	9
M6	1	2	4	2	3	-	0	12
M7 Juvenile	0	0	0	1	0	2	-	3
Total	38	13	8	9	3	4	0	75

Total episodes (n) = 75

Reversals=7(9.3%)

Table 25:- Determinants of dominance hierarchy observed in AMB-11

S. No.	Dominance interaction	Determination		No. of observation	Percentage
		Dominant	Submissive		
	Displacement 1.for food	Always Succeed	Displaced	185	74.3
	2.for estrous females	Succeed Mostly	Harassed	335	
	3.while resting	Displaced	Displaced	172/692	
	Chasing and fights(while interacting with troop)	Winning	Loosing (moved away)	94	10.1
	Sexual acts 1.copulation	Succeed always	Succeed rarely	40	11.5
	2.sexual harassment	Occasionally	Frequently	67/407	
	Whoop calls and warning signals	Mostly (initiate)	Frequently (followed)	38	

Shift of Rank

In focal troop of all male band

Shifts in ranks from low to higher and higher to lower in different situations is of common occurrences among males of the band. There were two males in the band whose rank remained static during the study period and old male observed

lowest in the rank during this study period. On the other band, male emerged out highest in rank in 2003 from his fourth rank in 2002. It failed down again to fourth rank in 2004.

In focal bisexual troops

In focal bisexual troops (B18 and B19) female-female competition maintained every time. Therefore, there are no fixed ranks of any members for long duration. Dominant always tries to get and maintained their top rank in troop, for it they must keep more potential and much more aggression toward others. But competition is the fact of life and never all time resulted in one sided. Thus one, who is subdominant, can be top dominant in next future/ time.

In my study period, I have been observed that female could not maintained their rank in troop for long duration. In B19 focal troop where I studied seven females as a subject of dominance determination. During 2002 to 2004, it observed that F1 was top most dominant in 2002 and 2003 but she lost one step in rank order in 2004. As such F3 was on third rank in 2002 and fourth in 2003 but she become gained first rank in 2004 (see table 27).

In focal troop B18, I have been studied 10 individuals adult females as a subject for dominance determination. In this troop F1 also lost her rank from first in 2002 to second in 2003 and 2004. And F3 who was at third rank in order in 2002 but got second rank in 2003 and maintained same in 2004 (see table 28). All these shifting of rank shows that dominancy in langurs are flexible.

Table 27:- Shifting of dominance hierarchy in Focal bisexual troop B-19 during study period

S.No.	Subject (females)	Rank status in		
		2002	2003	2004
1	F1	1	1	2
2	F2	2	3	2
3	F3	3	4	1
4	F4	4	2	3
5	F5	5	5	4
6	F6	6	6	5
7	F7	7	7	6

Table 28:- Shifting of dominance hierarchy in Focal bisexual troop B-18 during study period

S.no.	Subject (females)	Rank status in		
		2002	2003	2004
1	F1	1	2	2
2	F2	2	1	2
3	F3	3	3	1
4	F4	4	4	3
5	F5	5	6	5
6	F6	6	5	4
7	F7	7	7	6
8	F8	8	9	8
9	F9	9	8	7
10	F10	10	10	9

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Table 21:- Percent occurrence of dominance measures (indicator) in focal bisexual troop (B-19)

Subject code (females)	Competitive feeding (loosing)	Grooming to others	Groomed by others	Withdrawal on others' approach	Withdrawal by others on approaching	Aggression to others	Aggression by others	Submission to others	Submission by others
F1	20	10	25	1	5	16	0	3	20
F2	22	12	21	3	4	15	1	7	15
F3	26	16	20	5	3	14	2	7	9
F4	27	17	17	7	2	13	3	7	7
F5	30	20	16	9	1	12	4	4	4
F6	31	21	12	11	0	11	5	4	5
F7	35	25	10	13	0	0	6	6	7

Table 22:- Percent occurrence of dominance measures (indicator) in focal bisexual troop (B-18)

Subject code (females)	Competitive feeding (loosing)	Grooming to others	Groomed by others	Withdrawal on others' approach	Withdrawal by others on approaching	Aggression to others	Aggression by others	Submission to others	Submission by others
F1	20	10	25	1	5	16	0	3	20
F2	22	12	21	3	4	15	1	7	15
F3	26	16	20	5	3	14	2	7	9
F4	27	17	17	7	2	13	3	7	7
F5	30	20	16	9	1	12	4	4	4
F6	31	21	12	11	0	11	5	4	5
F7	35	25	10	13	0	0	6	6	7
F8	36	26	7	14	1	1	6	5	4
F9	37	27	5	15	0	2	6	4	4
F10	40	28	0	15	0	0	6	3	8

Table 26:- DOMINANCE INDICATIVE ACTIVITY OF ALL MALE BAND(AMB-11)

1.	Dominance indicator		Female rank-1	Female Rank-2	Gama(rank-3)	Rank-4	Rank-5A	Rank-5B	Rank-6
	Identification		Curved tail & bulky body	Left ear tern scar on right thigh	Cut on left nose	Half tail	Scar on back & face		Figure of left hand missing
A	WHOOP CALL	Morning	Regular	Only during attack on bisexual group	During running and chasing	During running and chasing	occasional	Rarely during sexual excitement and fight	During □ight
		Evening	regular	occasional	rarely	rare	never	never	never
B	WARNING SIGNAL		Mostly	occasional	occasional	occasional	No record	No record	No record
C	FOOD PRODURING SUCCESS		always	mostly	occasional	occasional	Rarely in presence of first 4 rank	Rarely in presence of first 4 rank	No successNo attain in presence of Alfa
D	SEXUAL ACTS	CONSORTING	Succeeded in majority of attempts	Succeeded frequently	occasionally	occasionally	No success	nosuccess	
		COPULATION	Succeeded in majority of attempts	Succeeded frequently	Often	often	occasionally	occasionally	
E	FIGHT	INITIATION	Occasionally	Often	Occasionally	Occasionally	rare	rare	Occasionally
		TERMINATION	Mostly	Mostly	Occasionally	frquently	often	often	Occasionally
		WINNING	Always	Won in absence of alpha only	Only with rank 4-6	Only with rank 5A,5B,6	Usually 5A, 5B fights jointly and to be rescue of one another when attacked by alpha, beta		Never
		LOOSING	No record	Only to alpha male	Avoid fight to alpha & beta	No decision			frequently

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Chapter 4
DISCUSSION AND CONCLUSION

CHAPTER-4

DISCUSSION AND CONCLUSION

A. Ranging behaviour

A.1. Home range, territory and core area

Traditionally the home range has been considered as the animals' feeding, resting and sleeping site (Burt, 1943; Bourliere, 1964 and Jolly, 1985). Within the home range, lies the frequently used area variedly called as "territory", core area, preferred area, etc. Likewise, sleeping sites and overlapping ranges qualify animal activities and the part of overlapping home range used by individuals of two or more neighbouring troops.

Waser (1986) has used the term 'activity field' to describe 'the distribution of individuals time as a function of location'. Primates like most mammals, usually show a strong attachment to one particular area (known as 'Philopatric') and hence the term 'home range' is often applied to their long term activity field. The focal troops (B18 and B19) members showed philopatric specially B19 troop females are strongly 'philopatric' to their home range.

The reviews by Clutton-Brock and Harvey (1977), Jolly (1985) and Oates (1986) indicate that home range size is an environmentally labile behavioural system and varies greatly both within and between the species of primates. The home ranges of bonnet monkeys (Rahman and Parthasarthy, 1969), rhesus monkey (Pirta and Singh, 1982), Chacma baboons (Davidge, 1978), leaf monkeys (Gurmaya, 1986), hamadryas baboons (Altmann and Altmann, 1970), lion tail macaque (Sugiyama, 1968), chimpanzees (Goodhall, 1986) and orangutans (Galdikas, 1988) have been studied in various ecozones.

Langurs of Jodhpur show a well marked home range with certain degree of defense mechanism. However, langurs here are not strictly territorial but exhibit definite preferences for certain areas within the home range. My focal troops, especially B19 and neighboring troop B-20 also represent this typical situation.

A.2. Relationship between troop size and home range size

The present data of troop size and home range of focal troops suggest a positive correlation between these two parameters. The smaller troop size encompasses smaller home range. In 1982, with 22 individuals the home range of B19 was worked out as 0.9 sq. km (Sommer, 1985), it became 1.0 sq. km. when troop size reached to 24 individuals in 1984 (Rajpurohit, 1987 and Borries, 1989), it became 1.5 sq. km. with troop size 28 in 1986 (Srivastava, 1989), which further decreased to 0.8 sq. km. with 20 individuals in 2000 (Bhaker, 2001; Rajpurohit, 2004) and during present study it has been decreased to 0.6 sq. km. with 16-13 individuals.

This clearly suggests that as troop size increases the home range increases and troop size decreases the home range decreases accordingly.

Similar relationship have been demonstrated by several comparative studies for instance, Waser (1977) found that the distance moved per day by Grey-checked manabeys (*Opercocebus albiqena*) in the Kibala forest increased with increased group size, but apparently not in a linear fashion.

These observation can be interpreted further to suggest that up to a troop size of 20 to 25 individuals, the energetic loss of adding a new member is relatively small because of the size of typical food patches the habitat can described as patchy allows several individuals to feed together in one patch without undue competition.

When the troop size increased to about 25 individuals all of them may have to move a long way to find sufficient resources. Similar results on group size have been suggested for black and white colobus by Oates (1977), mantled howler by Milton (1980) and rhesus monkeys by Makwana (1979) and Pirta and Singh (1982).

On the contrary, Horwich (1972) stated that use of territory does not depend on the size of the troop in the case of Nilgiri langur, *Presbytis johnii*. However, these authors have further mentioned that these troops of bigger sizes and smaller home ranges have comparatively rich environment.

A.3. Relationship between food availability and troop's home range

In the present study, it has been tried to investigate the food availability in relation to weather conditions, such as rainfall, temperature, humidity which play major role in the growth of plants that constitute major feeds of langurs in nature.

The availability of food influenced the troop range size in the focal troops from one study period to the next. Home range tends to grow when food became less. A possible explanation for this situation is the increased competition probably forces langurs to exploit larger areas per individuals.

Jay (1965) has stated that the core area of *Presbytis entellus* seems to change seasonally depending upon the availability of preferred food. Altmann and Altmann (1970) reported seasonal changes in baboons home rage size. Lindburg (1971), Southwick et al (1976) and Pirta and Singh (1982) have also reported similar differences for rhesus monkeys (*Macaca mulatta*).

A.4 Intertroop relations

In the langurs, the defense of a potentially limiting resource is often determined by means of vigilance behaviour. This is not to say, however, that the boundaries (excluding overlapping ranges) of home ranges are immutable. Violations of boundaries often cause the langur to become aggressive, which result in intertroop encounters.

The inter-troop encounters concern not only access to specific food resource, but defense of the entire range. Since larger ranges are difficult and uneconomical to patrol every day. When groups defend whole or part of their home ranges, most intertroop interactions are characterized by aggression rather than mutual avoidance.

Cheney (1986) reported similar results for macaques, red howlers and capuchins. On the contrary, however, Sugiyama (1968) for bonnet macaques reported a relative lack of intertroop aggression, even when groups were in close proximity to each other.

In langur, however, the resident males are always aggressive towards potential migrant males. The former mostly injure and sometime even kill the potential immigrants (Mohnot, 1974; Hrdy, 1977; Sommer and Mohnot, 1985;

Agoramoorthy, 1987). Vogel (1975) summarized the existence of considerable regional differences in intertroop relations and intertroop aggression within the area of distribution of *Presbytis entellus*.

Among langurs of different study sites, Cheney (1986) has found a correlation between population density and range size, as well as between the rates of intertroop encounters and frequency of aggressive encounters. These encounters are also influenced by other complex factors, such as the distribution and availability of food, demographic composition and individuals in the troop.

An analysis of how different species distribute their time among various activities is essential to characterize their lifestyles and lays the foundation for interrelating their ecology and behaviour (Struhsaker and Leland, 1979).

Activity profiles are one way to approach the problem of how animal budget their time and may be useful in suggesting how a species utilize resources and adapts to its environment. Inter-specific variability in activity budget among primate species is quite marked.

Researches have suggested that some of these differences at least may be attributable to body size and dietary variability within the order (Clutton-Brock and Harvey, 1977). Although inter-specific variability in activity budget has been documented in many species and may be reflect fluctuation in resources availability or other environmental variables (Post, 1981).

Langurs are diurnal in habit, being active in the day and inactive at night. Around Jodhpur they start their activity before dawn and descent to the ground from sleeping sites (mostly trees) before sunrise. Troop members follow a strict daily schedule. They spent the day on well organized activity budget plans.

However, at any time, activity pattern may be interrupted, disturbed, delayed or even changed altogether due to human interference (usually during provisioning), the presence of predator (feral dogs) and other animal (with whom they are possibly competing for resources) and weather condition, such as rains, dust storms and extremes of temperature (Mohnot, 1974; Rajpurohit, 1994).

A.5. Annual activity proportion

A comparison of the results obtained in this study with other studies of *Semnopithecus entellus* is difficult because of differences in sampling techniques

employed by different workers. But, it does appear that langurs inhabiting relatively rich environment spend more time about 57.40% resting (including monitoring 32.11% + dozing 25.29%) as found in the present study. Winkler (1981) found this activity to 48% (24% + 24%).

Langurs in the forested environments spend 30 to 60% of their activity in feeding (Yoshiba, 1967). Of the total daily activity, feeding at Simla was 40% (Sugiyama, 1976) and at Singer 30% (Oppenhimer, 1973; 1977).

In *Macaca radiata* the general pattern appears to be the same as in *Macaca mulatta*. Rahman and Parthasarthy (1969) observed in this species about 50% of the time being spent in sleeping and grooming, 40% in feeding and 10% in locomotion. While daily activity budget of *Presbytis thomasi* of north Sumatra showed that resting in the most common activity (54 to 66%) followed by feeding (24 to 40%) and movement (6 to 9%). Similar results were obtained by Post (1981) for yellow baboons, by Harding (1976) and Rose (1977) for *Papio anubis*.

These results suggest that langurs systematically arrange their activity budget depending upon availability of food in the habitat. They spend more time feeding in habitats with rich food then resting. In habitats with poor food availability they spend more time resting then feeding to maintain the balance between energy demand and energy supply for different activities.

B. RESOURCE UTILIZATION

Drinking Water

The influence of food supply and physiology is highly questionable in determining need of water. Some leaf eaters may be able to absorb water released by urea recycling, as found in some non-primate ruminates or by their moisture form food (Jolly, 1985). This does not diminish the importance of water supply.

In most places, the langurs have been reported as drinking water from various water sources. However, in Dharwar, where all sources of water dry up in summer, the langurs were observed by Sugiyama (1964) to live without water for 4 to 5 months and a similar condition was observed in Polonnaruwa, Sri Lanka

(Ripley, 1970). Langurs around Jodhpur were observed going without drinking for 12 days (Mohnot, 1974) and 60 days (Srivastava, 1989).

Around Jodhpur, all bisexual troops and some all male bands have one or more permanent water holes (natural or man made) in their home range, but most of them dry up during summer. The displacement for water resource and intertroop interaction concerning water hole (territorial behaviour) also suggest that water is limiting factor-affecting activities such as feeding and ranging of langurs.

The seasonal variation of rainfall and temperature is high at Jodhpur and there is a negative correlation between drinking episodes and relative humidity (RH). They consume more water during hot months when RH is very low. Similar results were reported by Mohnot (1974) for Jodhpur and Moore (1985) for Ranthambore.

It is quit likely that they probably needed more water to maintain their water balance, due to water loss through sweating or thermoregulation during summer months and also to detoxify the poisonous secondary compounds of nature. Two studies have suggested water as a limiting factor and create competition for it so dominancy shown in their resource utilization.

Diurnal distribution of drinking suggests that langurs drink water when they leave the roosting site during late morning and during late afternoon when they return to the roosting site. These drinking peaks consider with active feeding periods of the day.

These finding do not support the hypothesis of most drinking during the hottest part of the day proposed by Altmann and Altmann (1970). These observations suggest that low ranking females were displaced over water more frequently then other females but not prevented. Rank related access to water source has not been reported previously from wild primates but it has been described in captive studies (Clark and Dillon, 1973).

Food and Feeding

Food Selection: - According to their diet primates are commonly labelled as frugivorous, folivorous, insectivorous, omnivorous and so forth. These categories are related to evolutionary trends in functional morphology and ethology.

However, there is not only a great interspecific variety but amongst the highly adaptable species of hanuman langurs' considerable intraspecific variation from habitat to habitat and even within the same general area (such as Jodhpur) exists.

Like other Colobines, langurs are usually classified as folivorous, but study of the Jodhpur langurs suggest that this be too a narrow concept. Till date, Jodhpur langurs have been found eating 208 different plant species. Besides leaves they utilize fruits, flowers, bark, gum, insect larvae and sand.

More over, most of the Jodhpur langurs are provisioned by local people. These people distribute a variety of fruits, vegetables and baked wheat and millet cakes to the langurs. The amount of feeding time on provisioned food varies greatly from troop to troop (range 0-90 percent). The natural staple food (8-15 species) likewise, varies considerably from troop to troop.

Surprisingly, in this extremely arid environment the langurs utilize the maximum number of plant species ever reported for colobine monkeys. Langurs at Gir forest consume 36-41 species (Rahaman, 1973, Starin, 1973) at Singur 68 species (Oppenheimer, 1977), at Dharwar 37 plant species (Yoshiba, 1967) and at Polonnaruwa 43-57 species (Ripley, 1970; Hladik and Hladik, 1972).

Mohnot (1974) reported 84 plant species consumed by Jodhpur langurs. These large numbers of plant species suggest that langurs are not very selective in their diet and consume whatever plant material is available to them. It is also possible that this arid environment has different productivity levels in different months, so that some plant species are available in one month and some in others.

Consequently the langurs consume more plant species in the year as a whole. It can be shown that the number of plant species consumed every month does not exceed 40 in a given month.

The provisioned food: - The study troop belongs to the category of troops in this population which are moderately fed by local people. Many feeders attract the langur's attention by loud calling. Sometimes, the langurs run for more than 100 m to come to the feeding calling site. However, on other occasions, they do not move at all, even if they are very close by.

On comparing the feeding rates for the natural diet with that of provisioning, a close correspondence between feeding on *P. juliflora* and artificial feeding appears. The maxima of *P. juliflora* feeding correspond to the minima in feeding on provisioned food. Likewise, the maximum provisioned food and feeding for January negatively correlated with the minima feeding rate for *P. julflora*. These findings are very close of Winkler (1981) and Srivastava (1989) obtained from the same habitat.

Provisioning by local people was also found to be reflected by the behaviour of feeder that is people observations on red colobus, at Gombe National Park (Clutton-Brock, 1974) may be ecologically similar to those found for grey langurs: nine species accounted for 70% of Clutton-Brock's records. A very similar dietary diversity was found by Struhsaker (1975). Studies on Japanese monkeys by Maruhashi (1980) suggest that they plant species, with 69.7 of their total feeding time feeding on the top 10 plant species.

On the contrary banded langurs (*P. melalophos*) and dusky langurs (*P. obscurus*) spent only 27% and 37% of their respective total feeding times on the top 10 plant species. After comparing about 22 primate species Jolly (1985) concluded that, the majority of primates take half their food from 10 or less species of plants, although for more foods are sampled in small quantity.

It is now possible to identify langurs as specialist feeders in this arid habitat as they mostly relay on only six plant species round the year, but consume as many as 87 naturally occurring species altogether.

Langurs have sacculated stomachs specialized for the digestion of leaves (Amerasinghe et al, 1971; Bauchop and Mauthuci, 1968). The time spent in food ingestion during one year includes an average of 6% leaves, 23% fruits and 7% flowers. Among the leaves, about two thirds (38.5% of total feeding time) were devoted to mature leaves and about 27.5% on young leaves.

Likewise, the average yearly diet of langurs at Gir forest ranges 85.4% leaves (Rahaman, 1973; Starin 1973). At Singur the diet includes 77.9% of leaves; 15.3% of fruits and 5.8% of flowers. Yoshiba (1967) at Dharwar found langurs devoting 94.6% of their feeding time on leaves, 1.7% on fruits and 1.2% on flowers, studied at Polonnaurwa by Ripley (1970) and Hladik and Hladik (1972) revealed that the diet of langurs is composed of 71.9-83.7% of leaves 7.9-12.5% of fruits and 7.9-6.8% of flowers.

Taking data from all the study sites it is clearly seen that langurs spend on an average 80% of their feeding time consuming leaves. Thus, they can be considered as specialized folivores. Leaf-eating involves specialization of teeth, gut and behaviour.

Several physiological and behavioural adaptations allow langurs to eat large amounts of leaves. This helps them to survive on their relatively unnutritional through most of the day and gain energy by steady foraging for long periods of time that involves little movement.

Langurs make flowers a particularly important source of food at seasons when a plant species is flowering in abundance. Flower feeding may also aid animals through a vulnerable stage of life (Daubenmire, 1971).

Soft *Acacia* flowers are ideal weaning food for young langurs lucky enough to mature in the proper season. Likewise, Altmann (1980) reported a similar situation for baboons (*Papio cynocephalus*).

Langurs eat a fairly high proportion of fruits since they are easy to eat, at least when ripe. Fruits are concentrated energy source. Langurs select those fruit bearing trees, which need seed disperser so as to ensure necessary tree cover in nature. Similar finding were reported in mountain gorilla by Watts (1987) and Srivastava (1989).

Resource allocation

It is difficult to access the food requirement langurs of either sex in nature. But, it is quite likely that adult males need less food as compared to adult females, as females must support the high cost of reproduction.

The quantitative analysis of the date suggest that the resident adult male often monopolize food, especially the provisioned food, as he is able to displace all

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other troop members without any difficulties. In this study it was found that nonadults spend more time feeding compared to adults.

To explain the differences in nonadult and adult feeding duration I propose the following functional explanations Nonadult members need more food for growth. The adult members do monopolize food and secure more food in less time to meet their requirement. Non-adult can not obtain food during provision as efficiently as do adults. Non-adults need more time to search, find and select the food whereas adult members become experienced need less time.

Several authors (Clutton-Brock, 1975, 1977, Demment, 1978; Post et al. 1980) have suggested that adult male spend less time feeding compared to adult females, probable because male do not incur the additional metabolism requirements of pregnancy, lactation and cycling.

Present study is consistent with those suggestions the additional metabolic costs of reproduction is increased feeding in cycling females compared to in other reproductive conditions. These results close to the finding of Dittus (1974) for Toque macaque of Sri Lanka and of Post et. al. (1980) for yellow baboon in Amboseli and Srivastava (1989) for Hanuman Langur in Jodhpur.

However, there were differences in feeding time among the members of various dominance ranks. The high ranking individuals within the group generally have longer feeding durations than their low ranking counters parts. These dereferences are of statistical significance.

I propose the following hypothesis to explain feeding variation: The high ranking females require more food, firstly because they are mostly young adult females and need more food for growth and second to maintain their reproductive status efficiently.

The lower ranking females require less food, since these are post menopausal females (50%) who do not need more food because they do not have to maintain pregnancy, lactation, etc. The feeding frequency of middle ranking females is low because these are mostly the multiparous females who have longer interbirth interval (IBI) with low reproductive performance and thus need less food.

Differences in nutritional costs and requirements of reproduction may influence the feeding patterns of male and female nonhuman primates (Garber, 1987). In most mammalian lineages including primates the reproductive effort in adult females is substantial (McNab, 1980).

The fertile females are the potential breeders and are mostly high ranking, young in age, heavier and are more active. Therefore, these females need more food to maintain their status as compared to post menopausal females who are comparatively low ranking, old with poor physique, less active and are non-breeders. Hence, they obviously need less food and thus spend less time feeding.

More generally, it seems likely that, low ranking individuals, younger members and weak individuals have recourse to a variety and alternative behavioural strategies for minimizing interference from higher ranking individuals and at the same time ensuring adequate food intake. Such strategies probably involve inter-individual differences in choice of feeding site and choice of food quality.

Additionally, the particular strategy used by an individual at any moment would be expected to depend upon its sex, age, rank and reproductive states, the last three may change continually throughout life in langurs and thus patterns and strategies of food acquisition might profitably be considered as an integral part of any individual's life history.

C. Dominance Hierarchy and Social Organization:

Most non human primates live in groups; there are numerous potential benefits to sociality, including increased protection from predators, cooperative defence of food resources and collective rearing of off- springs. Group life also provides an opportunity for long term cooperative relationships. At the same time however, sociality entails number of costs. In group living animals must complete with one another for scarce resources such as food, water, and mates (Walters and Seyfarth, 1987). Life with in primate group is thus delicately balanced between competition and cooperation (Crook and Gartlan, 1966; Crook, 1970).

The most obvious manifestation of competition within primate group is dominance and aggressive behaviour which often takes the form of displays,

signals exchanged between two or more animals that rarely lead to physical contact but usually result in one animal gaining a particular resource (Janson, 1985).

Although aggressive behaviour usually reflects competition between two or more individuals which is not always overtly aggressive. Perhaps the most common competitive interaction among primates is what Rowell (1960) called as “approach- retreat-interaction”. One more subtle manifestation of competitions has been termed “competitive-exclusion” (Hardin, 1960).

In long tailed macaques sons from high ranking mothers were found to have a higher probability of achieving top dominance rank in any (non natal) group than those of low ranking mothers achieve. For Rhesus macaques high born sons have been reported to have a much higher survival rate than low born sons which automatically give the former better chances to achieve high rank and reproduction (Vessey and Meikle, 1987; Meikle and Vessey, 1988). High born Rhesus macaque sons also reach sexual maturity at an earlier age, giving them another reproductive advantage (Bercovitch, 1993). A similar effect of maternal rank on maturation was found for baboons (Albert and Altmann, 1995a).

The fact that approach and withdrawal measures have high loadings on dominance as well as spacing factors, suggests that social dispersion and dominance are related concepts stability and organization of any primate group depends upon the delicate balance struck between group cohesion and social dispersion. Dominance, by ensuring group stability through a system of formalized aggression, often acts as a social centrifuge; driving animals apart and keeping them separate (Harries and Strayer, 1975).

Bernstein (1976) suggested that in Assamese macaques, dominance hierarchy did not correlate with directionality of grooming. Neither dominance ranks nor dyadic dominance relationships seemed adequate to account for the observed directionality of the mounting and grooming.

He found that females did groom more in pigtailed macaques, geladas, green monkeys and in one of two groups of Sooty mangabeys. On other hand mater have been reported to groom their females’ partners more often in *Lemur*

coronatus (Kappeler, 1989) and grooming was reported to go down the hierarchy in *Cebas paella*.

Study suggested that clumped distribution of the food resource resulted in increased competition, reflected in increased competition levels of aggressive behaviours. This increased competition in response to the clumped distribution of food is also reflected in the highest ranking females and their infants, had priority a access at feeding.

These findings directly parallel those reported by other field investigators to be result of seasonally, or otherwise induced, changes in food availability and distribution: that is increased competition and aggression (Jones, 1980; Lee, 1983; Southwick et al., 1976, Bernstein and Mason, 1963). This suggests that ecological parameters such as food availability and distribution, which can have profound effects on the behaviour and social relations of socially living primates.

Approach-retreat and competitive-exclusion interactions are common in species having well established dominance relations. However, langurs are known to have established dominance hierarchy.

Dominance hierarchy has long been recognized as a stereotyped behaviour of many primates. Field studies and laboratory investigations suggest that dominance hierarchy is probably the most important component of social cohesion and social regulation in nonhuman primate society (Jay, 1965).

The expression of dominance by different primates varies from genera to genera and species to species, but in every primate society there is some competition for rights to incentives, such as food, estrous females and shelter. Carpenter (1964, p351) quoted “these dominance order among adults and among the young markedly affect social integration and group control”.

In hanuman langurs around Jodhpur there is a clear cut dominance hierarchy in all the male bands and bisexual troop’s females (particularly among adults), which appears to be a functional rank order.

<u>In male band:</u>

It has been investigated on the basis of several dominance interactions within a band, like displacements during the food procurements, to possess estrous females or to show the dominance when resting, chasing and in emitting

whoops etc. Each individual realize its status and follow the social hierarchy, most of these status and follow the social hierarchy, most of these status interactions are non-violent and the male dominance hierarchy is maintained without serious fights.

Mohnot (1984a and b) investigated functional rank order among adult males even though he considered a band as a loose gathering. According to Sugiyama(1967) and Sugiyama et al. (1965) also mentioned that the male bands are less rigid organizations and are without any functional rank order as observed by them at Dharwar (south India). All the observed old males of AMB-11 and some other all male bands were at the lowest rank among adults.

Likewise, there is always a fall in the rank when an ousted resident join or rejoin male band even after a very brief tenure out side the band. The fall in the rank appears to by psycho-physical (Rajpurohit, 1987). It is an important as well as significant aspect that has been observed in Rajpurohit (1987) and my present study, where all the ousted residents failed to regain residency of any bisexual troop and even fall in rank in their band from where they originally comes.

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).

Koyama (1970) observed in wild Japanese monkey troop at Arashiyama that fall in rank due to ageing. Age was the only factor applicable in rank order to both sexes in a captive group of pigtailed monkey also (Tokunda and Jonsen, 1969).

Dominance hierarchy in Nilgiri langur was worked out by Poirier (1970). Mode of tail carriage connected with dominance and rank have been studied by Ojha (1974), Roonwal (1976) and Roonwal and Tak (1982) in two sub species of *Rhesus mecacues*.

Roonwal and Makwana (1981) do not suggest any correlation between tail carriage and dominance in hanuman langurs, this supports the present investigation. Hausfater (1977) also do not see relationship between tail carriage and dominance status in Baboons (*Papio cynocephalus)*.

The correlation between kinship and dominance could not be worked out during this study. However, rank and kinship of a wild Japanese monkey troop living in Arashiyama, and stated that the ranking exists among consanguineous relatives, and their dominance relation has a great affect of individual infant, the influence of which remains after they have grown. Bernstein (1969) also reverted the group dominance in *Macaca nemastrins.*

From the present study and from other field studies it is now clear that behavioral patters that maintain dominance are the essential components of the group organization. Top dominant males never gave up their rank without serious fights, with conflicts often dragging on for several months. A defeated top dominant male not only lost future reproductive opportunities but could also loose some of his existing offsprings.

It is also seems that the dominance status may also be related to the individual differences in the social responsiveness and to the individual performance which may have significance for themselves and for the social system itself.

Kaufmann (1967) speculated from the evolutionary point of view on two types of natural selection in which social rank may be involved and he identified them a- Selection of those monkeys best adapted physically and behaviourally to survive in their general physical and biological environment, and Selection and maintenance of the intraband rank system.

In Bisexual Troop:

The age sex class distribution indicates that there is most competition among adult females and the resident male displaces adult females several times more often than the reverse.

These results are close to those obtained by Sommer (1985) and Srivastava (1989), with adult females as an actor and receptor contributing 77.5% and resident male as an actor 5.3% and receptor 4.0%. It is also close to those of Mohnot (1974) and Hrdy (1977). It is not clear whether or not females' high aggression is related to sexual cycling but presumably to maintain their

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reproductive status (pregnancy, lactation etc.) they need comparatively more food and when food is limited, obviously they have to compete for it.

Hrdy (1977) found high score of displacement over food (84.9%) of which 88.0% were provoked artificially. The displacements during feeding on natural food plant *Zizyphus numularia* were much higher than expected on the basis of total feeding time spent over this plant and displacements that took place. It was most probably because of ripe *Zizyphus* fruits. On the contrary, the competition over the other natural food plants, *Prosopis juliflora* and *Anogeissus pendula* is almost as expected.

This strongly suggests that the langurs are highly competitive for the finite food commodities which are scarcely distributed in their home range. The computation of plant species and their abundance also support the above observation. Similarly Hrdy (1977) reported that when langurs are confronted with decreased food resources they appear to resort to increased competition.

The present finding of contexts of displacement behaviour or dominance behaviour strongly suggests that it is directly or indirectly related to the acquisition of resources.

Similar results were obtained by Poirier (1970) for Nilgiri langurs, Lindburg (1971) for *Rhesus macaque*; Poirier and Smith (1974) for crab eating Macaques, Seyfarth (1976) for Chacma baboons, Deag (1977) for Barberry macaques and Shopland (1987) for yellow Baboons, Rajpurohit (1987) for male hanuman langurs and Srivastava (1989) for female hanuman langurs.

The rank change can be well understood on the basis of age. Young females tend to rise in hierarchy at the expense of elder ones. Reproductive status of female also influences their ranks. Long term studies do support the above strategies.

The present findings are in total agreement with those of for langurs of Mt. Abu but not with langurs of Polonnaruwa, Srilanka. Although there was no consistent female hierarchy at Kaukori, Jay (1963) noticed that old females almost never displace other females in the troop.

Hrdy's observations suggest that langurs with physical handicaps always have low rank positions. It is convincing that females with high reproductive

potential have high rank whereas the females with low reproductive potentials are low in rank. The existing hypothesis that the high ranking mothers always have high ranking daughters cannot be supported from this study.

The present study strongly suggests that the prime adult females as well as males enjoy the top ranks till the next younger emerges out as the prime one. This study further suggests that the ousted resident males failed to regain residency of any bisexual troop and even fall in rank in their band on rejoining. The most dominant male or rarely the beta male became resident wherever band invasion is successful.

The vacant position of alpha or beta male in male band is filled/occupied by the next ranking male and this pattern of filling and elevating of ranks goes on (also see Rajpurohit and Mohnot, 1988; Rajpurohit et al, 2003).

Sugiyama (1984) suggested that the high ranking female langurs produce many more offsprings than those of low ranking females; of course those studies were done mainly in the artificially fed troops. Loy and Harnois (1988) argued and concluded in their review paper that dominance probably is not a reliable structural variable for captive patas monkeys.

From the present study and from other field studies it is now clear that is behavioural patterns to maintain dominance are the essential components of the groups' organization.

It also seems that the dominance status may also be related to the individual differences in the social responsiveness and to the individual performances, which may have significances for them and for the social system itself.

The young females rose to the top of the hierarchy as soon as they became sexually mature and gradually declined with increasing age (Hrdy and Hrdy, 1976). This is not to reject that old or upper- middle-aged females may also attain high ranks if the troop does not contain young adult females.

However, the model predicts that young adult female should never occupy low ranks, which is confirmed by the long-term Jodhpur data (Borries et al., 1991) and the present short-term study. At Jodhpur, females of all reproductive status (i.e. cycling, pregnant, lactating) were observed to occupy different ranks.

In general influence of reproductive status was much smaller than the influence of age. The reports available for other primates suggest that births have nil or only minor and temporary effect on dominance hierarchy (*Gorilla gorilla*-Bingham and Hahn, 1974; *Macaca arctoides*-Weisbard and Goy, 1976).

In langurs of Jodhpur, the reproductive success of high- ranking females was significantly higher than that of low- ranking females (Borries et al., 1991). Such relation found in many primate species (Dittus, 1979; Silk et al., 1981; Paul and Kuster, 1988; Dunbar, 1989).

On the basis of this study of Hanuman langurs I hypothesize that in the formation of adult female dominance hierarchy, the hierarchy is stable, linear and depends primarily upon individual factor such as food, good place for resting, reproductive status, grooming and allomothering. Establishment of dominance hierarchy among adult and young animals of a group depends upon social factors.

Dominance hierarchy

In other animals:

David M Powell (2003) - studied ranking system in Feral Horses and his observation suggested that high ranking females had more surviving offsprings than low ranking females, which is similar to my finding. Aspects of male and female sexual behaviour, elimination behaviour and special relationship were co related with several indices of social dominance by him.

Tiago Falotico et al. (2003) worked on semi free ranging, capuchin monkey for rank reversal in female's hierarchy. He suggested that benefits and costs of group living may not be equally distributed among all group members when they are organized in dominance hierarchies.

In capuchin monkeys, higher ranking individuals often have privileged access to food sources and reproductive partners. Other group members, particularly females, can benefit from proximity with the alpha male, gaining privileged access to the recourses and also protection in the case of conflicts. Data were analyzed through minimum spanning trees of inter-individuals distance and shortest directed trees of grooming and agonistic behaviour.

Dominance hierarchy in capuchin is generally considered stable, without reversions. However, they observed hierarchic reservedly and suggested that reversal was probably caused by transition to adulthood by one female and low grooming rates directed to the alpha male and adult females by the former alpha female.

M.J. Hotzel et al. (2003) - Tested hypothesis that social rank would affect the water ingestion and behaviour of water restricted Holstein cows and observation suggested that there was no effect of social rank or treatment on frequency of standing / laying, eating, grazing, ruminating, inactive or agonistic interactions. And concluded that when access to water is restricted, there is a great variation among individuals on water ingestion, which may negatively influence welfare of some individual and milk production of the group their study suggested that both social rank and milk production influence water ingestion when water is restricted.

Eliance Goncalves-de-freitas et al. (2003) Studied female dominance in fish (Nile Tilapia). Dominant females have priority for mating and are the biggest females in the group, size being an important feature in male mate choice in fishes. Infant handling is very common behaviour in group living primates. Data revealed that infant handling rate decreases with infant age and increases with the mother's dominance rank. Infant sex and birth order do not affected this rate.

Infants of the more dominant females receive handling behaviour from a larger number of donors. Young nulliparous females were the most frequent handlers and tended to direct their behaviour to close kin. Dominance females and their offspring received larger share of these benefits. The present study also supports this.

Advantage of bands as a social unit

The traditional concept of a band as a loose gathering of males is now no more valid. There is a definite kind of association or organized living among males and this association known as 'band'. Although bands apparently do not give an impression of a firm organization as do bisexual troops.

The male associations functional are an assertive unit with rank 'respect' among the members. Rajpurohit (1987) observation and my observation suggest this hypothesis. According to some workers males' bands are separate social units (Boggess, 1980; Hrdy, 1977 and Laws and Laws, 1984).

But on other hand Sugiyama et al. (1988) explained the lack of firm organization in male groups. Moore (1982, 1985) support kin relation as the basis of male band organization and believe that the band stability depends on the kin relation and in absence of that males may move from one band to another. The male band organization was first reported in 1836, in the Bengal Magazine as reported by Blyth (1843).

Similar accounts were published by Hughes (1884) and J.P.G. (1902). Prakash (1962) reported on all male band of 14 one year old males. However, this has not been confirmed from this study or any other study site the presence of only 1 year old male in a male band, such males stay in their natal troops and still dependant on mothers.

Evidences to support band hypothesis (Rajpurohit, 1987 and present study):-

Male Association: - It is well documented that the males of a particular male band will continue to stay together using same habitat and its resources. Structural changes in a band is often the result of ranking males living the band to become resident elsewhere and displaced residence coming back to the band after enjoying period tenures as residents.

Movement and invasion on bisexual troops: - In local movements, any adult male may lead the movement but for distant and/ or invading movements, experienced males shall move first. During such movements, the leading males after every 10-30 minute will stop for a while, look back, watch the situation and the following members and then move further. Although it is not very well organized but there is some pattern which is followed by them.

At the time of invasion on the bisexual troops, there is a definite mode in which Juveniles move first followed by sub adults and young males. The adult moves at the last of all. During the repulsive attacks by the resident males of the

bisexual troops, the Juveniles run back and withdraw first followed by sub adults. The adult males withdraw last of all.

Strong males becoming new residents: When a resident of the bisexual troop is defeated by the invading male band, the former has to withdraw, leaving troop at the mercy of the invading males. It is amongst these males that the most potent male emerge out as the leader, who takes over as resident male of the troop after chasing away rest of the males.

Low ranking males of the band usually accept the dominance of the most potent male (Who may or may not be alpha) and leave the troop. This pattern of male changes and acceptance of dominance by low ranks keep the bands organized decides favoring one male strategy.

Ousted resident Joining male bands - In most cases ousted resident joint their original male band from where they came but in some other cases, their origin not known and they forms separate male gangs by sweeping away male juvenile with them on their ousting from the troop.

Protection of Juvenile and others: - Usually the adult males have not been observed to care or protect the subadult and juvenile males from predators or from male attacks of troop residents and other band males. However, in this study dominant males of the band were observed protecting juveniles and subadult from resident male attacks.

Rejoining after temporary splitting into sub groups :- In all the observed cases the process of sub grouping eventually end up in regrouping when all the males of the band folk together suggesting a strong tendency to live together as a result of affinity, association and strong social band (Rajpurohit, 1995).

Dominance relationship may reduce injuries during contest competition. This may be benefit enough when resources are scares, competition is expected, but scramble competition. (First come, first served) is a clear alternative to contest competition.

Agonistic dominance does not guarantee success in scramble competition but wining contest competitions might motivate individual to strive for high status. A series of dyadic dominance relationship can often be summarized into a near

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linear hierarchy. The some attributes that allow A to Win over B and B to win over C may be expected to allow A to also win over C.

The hierarchy of female ranks is best conceptualized a layered ranking system in which there are cluster of females of the some dominance rank forming layers within the structure. For several decades the social behavior old world monkeys and apes has been scrutinized by investigators from several disciplines, many seeking models of human evolution and illustrations of natural selection including kin and sexual selection.

It has been known for many years that rank among males is important for reproductive success and, hence for evolution. Yet it has only been in the last few years that investigators have called attention to the possible importance of social rank for the reproductive success of females.

Earlier stages of primate research on baboons and macaques, and particularly on the conspicuous males of some species, produced a pre mature and over simplified picture not only of female behavior but also of primate behaviour in general (Bernstein, 1970, 1976). Social structure was conceptualized as rather uniform and to a large extent dependent upon social hierarchies which in turn promote the fitness of only the highest ranking individual (Rowell, 1972).

The influence of dominance on feeding has been of major interest in the sociological study of primates. In most primates' species, dominant individuals have priority of access to food (e.g. Kawai, 1965b; Chalmers, 1968; Fossay, 1972; Iwamoto, 1974; Sussman, 1977; Post Hausfater & McCuskey, 1980).

In some species, however, dominance has little influence on the amount of food obtained because competitive interaction over food is infrequent (eg. Fossay & Harcourt, 1977 and Bygott, 1979).

In many species of cercopithecines female rank is inherited matrilineal so that maternal occupy adjacent ranks. A female is said to have acquired her matrilineal rank in relation to a given sub ordinate female when the submission she receives from that female and the aggression she directs to her are both unidirectional.

Dominance relationships were determined on the basis of the direction of submissive behaviours (Displacement, fear grimaces and flights). Grooming is passively the most commonly studied primate social behaviour.

It is very common, at least among old world monkeys, and is generally regarded as a good index of facilitative relations among female primate (Oki & Maeda, 1973). The study of the factors affecting the distribution of grooming within a social group is therefore potentially able to illuminate the principle governing primate social structures.

Seyfarth (1977) proposed a model social grooming among female monkeys. The model explains several aspects of the distribution of grooming and among female monkeys on the basis of simple organizing principles, two basic once being an attraction to high ranking individuals and an attraction to kin

Aggression and dominance behaviour co relate by each other (Rajpurohit et al., 2005). The aggressive behaviour is very wide spread among animals and it is remarkable how rarely it leads to serious injury or death. This is emphasized by Matthews (1964) in review of fighting in mammals.

As in many birds and non primate mammals, aggression often takes in form of displays: conspicuous signals exchanged between two or more animals that rarely lead to physical contact but usually result in one animal gaining a particular resource, therefore they always show dominancy by their aggression.

The submissive or other members of ranking order always try to fight and show aggression to complete with parallel rank member and high ranker. Aggressive display among primates is extremely varied. Male ring tailed lemurs (*Lemur catta*) smear a pheromone on their tails and wave them in the air when competing over access to females (Jolly, 1972) a common squirrel monkey (*Saimiri sciureus*) make threatens other by displaying his erect penis (Ploog, 1967); baboons (*Papio cynocephalus*) "flash" their eye lids, revealing a patch of white skin (Devore & Hall, 1965); Gorillas (*Gorilla gorilla*) stand bipedally, beat their chest and charge (Schaller, 1963).

Virtually all primates species accompany such threats with vocalizations in Hanuman langur male (dominant) always make warning signals and whoop calls (Bhaker, 2001) in addition to display, primate aggressive behaviour also includes

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actions such as staring, jerking the head, chasing, lunging, shaking branches and slapping the ground.

These may be followed by physical contract in the form of hitting, grappling, holding down and biting. Such aggression results in injury, but rarely death. This dominance hierarchy maintains or regulates this injury and role in make up a well established family system.

Dominancy form of aggressive behaviour and conflicts are also pointed out in different animals by different scientists like social insect, Lizards (Mathews, 1964), Muskrats (Errington, 1963), elephants (carrington, 1958), tigers (Sehaller, 1963) langur monkeys (Suggiyama, 1967 and Rajpurohit, 2004)

CONCLUSION

The study of non-human primates has contributed to the understanding of basic biological phenomena, social behaviour and life style of human societies. Nonhuman primates are the only appropriate animal models in many basic and applied studies because other species are not susceptible to the disease or disorder under study. They are invaluable for biomedical researches because of their marked similarities to humans in almost all aspects of their anatomy, physiology, neurology, endocrinology, immunology and behaviours.

Primates like most mammals, usually show a strong attachment to one particular area (i.e. philopatric) and hence the term “home range” is often applied to their long term activity field.

Langur of Jodhpur shows a well marked home range with certain degree of defense mechanism. However, langurs here are not strictly territorial but exhibit definite preferences for certain ares within the home range. The present study suggests that as the troop size increases the home range decreases accordingly.

The core area of langurs seems to change seasonally depending upon the availability of preferred food. Home range tends to grove when food became less. A possible explanation for this situation is the increased competition probably forces langurs to exploit larger areas. The defence of a potentially limiting resource is often determined by means of vigilance behaviour.

The langurs systematically arrange their activity budget depending upon availability of food in the habitat. They spend more time in feeding in the habitats with rich food then resting. In habitats with poor food availability they spend more time resting then feeding to maintain the balance between energy demand and supply.

Langurs are usually classified as folivorous, but studies of Jodhpur suggest that Jodhpur langurs have been found eating 208 different plant species. In this extremely arid environment the langurs utilize the maximum number of plant species ever reported for Colobine monkeys. On comparing the feeding rates for the natural diet with that of provisioning, a close correspondence between feeding on natural plants and artificial feeding appears. The maximum provisioned food

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and feeding negatively correlated with the minimum feeding rate for *Prosopis juliflora*.

There were differences in feeding time among the members of various dominance ranks. The high ranking individuals within the group generally have longer feeding durations than their low ranking counter parts. The feeding variation can be explained as the high ranking females require more food, firstly because they are mostly young adult females and need more food for growth and second to maintain their reproductive status. On the other hand the lower ranking females require less food, since these are post menopausal females who do not need much more food because they do not have to maintain pregnancy, lactation etc.

The particular strategy used by an individual at any moment would be expected to depend upon the sex, age, rank and reproductive states, the last three changes continuously throughout life in langurs and thus patterns and strategies of food acquisition might profitably be considered as an integral part of any individual's life history.

The ecological parameters such as food availability and distribution, which can have profound effects on the behaviour and social relations of socially living primates. Dominance hierarchy has long been recognized as a stereotyped behaviour of many primate species. The field and laboratory investigations suggest that dominance hierarchy is probably the most important component of social cohesion and social regulation in nonhuman primate society.

The dominance status may also be related to the individual differences in the social responsiveness and to the individual performance which may have significance for themselves and for the social system itself. Selections of those monkeys whose best adapted physically and behaviourally to survive in their general environment in which social rank may be involved.

The present study revealed that the prime adult females as well as males enjoy the top ranks till the next younger emerges out as the prime one. The ousted resident males failed to regain residency of any bisexual troop and even fall in rank on joining their band again.

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The reproductive success of high-ranking females was significantly higher than that of low-ranking females of Jodhpur langurs. Such relation found in many primate species. Similarly, in many other mammals, the different studies suggest that high ranking females had more surviving offsprings than low ranking females.

Social structure has been conceptualized as rather uniform and to a large extent dependent upon social hierarchies which in turn promote the fitness of only the highest ranking individual.

It is concluded that dominance hierarchies do occur in nature, but their measurement must include more than one valid measure. The competitive feeding measure may be helpful in revealing the hierarchy provided motivations of animals are systematically controlled and pairings are not influenced by group members. In free-ranging situations, it is essential to provide preferred food item in comparison to naturally occurring ones.

Three must be few of dominance behaviours where food is not concentrated in a small area. Thus we can say that dominance hierarchy affects little the food taking of each animal and the reproductive success in natural selection.

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Chapter 5

SUMMARY

CHAPTER-5

SUMMARY

There are 6 chapters in this Ph.D. thesis entitled “Study the Dominance Hierarchy and its Role in Social Organization in Hanuman langur, *Semnopithecus entellus entellus* (Dufersne, 1797)” supported by 14 text figures, 28 tables, 23 plates and 10 appendices. The chapters 1-6 incorporated here are Introduction, Material and Methods, Observations and Results, Discussion and Conclusion, Summary and References (p.1-188) followed by appendices 1-10. At last the copies of reprints of published research papers and or abstracts of paper presented in the conferences/ congress or symposiums are enclosed along with some certificates of participation and fellowship award.

Nonhuman primates comprised monkeys, langurs, baboons, apes, lemurs, Lories, etc. inhabits most parts of the biodiversity rich 4 major biogeographically tropical and subtropical regions of the world. There are 63 genera and about 600 species and subspecies in about 92 countries. A total of 25 species are recorded from the Indian subcontinent.

The study of nonhuman primates has contributed to the understanding of basic biological phenomena, social behaviour and life style of human societies. Nonhuman primates are the only appropriate animal models in many basic and applied studies because other species are not susceptible to the disease or disorder under study. They are invaluable for biomedical researches because of their marked similarities to humans in almost all aspects of their anatomy, physiology, neurology, endocrinology, immunology and behaviours.

The Hanuman langur, *Semnopithecus entellus* a member of family Colobinae of old world monkeys is a highly adaptive leaf eating monkey. It is widely distributed in India, Sri Lanka, Nepal and Bangladesh and can survive in all kinds of environments from the snow-clad peaks of the Himalayas (up to 4000m)

in the north to deciduous forests in the south and in parts of the great Indian desert in the west (example Jodhpur) to rain forests in the east.

A genetically isolated population of about 1800-1850 langurs in and around Jodhpur, Rajasthan (India) has been studied by various Indian and foreign researchers on ecology, sociobiology and other aspects for more than 35 years now.

The present study on Dominance hierarchy in Hanuman langur is carried out during last 2.5 years (i.e. May 2002 to December 2004). And it is concentrated mainly on three focal groups (two bisexual troops-B18 and B19 and an all male band-AMB11). The study comprises about 1570 hours of observation on these 3 focal groups living under varying ecological conditions.

The observation suggest that in langurs, the different factors such as food, shelter, mate, displacement, grooming, etc. are responsible for dominance rank order determination among group members.

Ranging behaviour: -The Hanuman langur's home ranges often overlaps to some extent which may be some time quite extensive. In bisexual troops the home range varies from 0.07 Km^2 to 1.5 Km^2; in all male bands they are more extensive (i.e. from 4.3 to 22 $km^{2)}$.

During this study, I observed home range of the two focal troops (B18 & 19) and one all male band, concluded that home range effected by some factors such as the troop size, food availability, natural predator, weather conditions, human interference and provisioning etc. which elucidated the role of troop members in particularly that of the resident male and old females in protecting the troop range.

The data of troop size and home range of focal troops suggests a positive correlation between these two parameters. It is concluded that smaller troop size encompasses smaller home range. Troop size of B-19 during last 24 years showed up and downward trend from 28-13 individuals. It found that in 1982 with 22 individuals, the home range of B19 was worked out as 0.9 sq.km, but it decreased to 13-16 individuals with 0.6 km^2 home range in present study.

Study further concluded that food and weather also affect the home range of troop. It found that when weather condition was not good and the food

availability was minimum then langurs traveled more in search of food then home range increased.

In this study it has been investigated that the food availability in relation to climatological data such as rain fall, relative humidity and temperature which played major role in the growth of plants that constitute major foods of langurs in nature. The home range was also affected by provisioning. It is concluded that reduction in home range was directly related to decrease in troop size, dwindling food resources and lack of resistance.

Activity pattern: - the flexibility of langur's behavioural responses to fluctuation in resource availability. Daily schedule of activities includes mainly feeding, Dozing, Monitoring, Grooming, Sexual and others. Data of annual distribution of main activities in bisexual focal troop (B18 & 19) concluded that main activity was monitoring (32-34%), then feeding (21-22%) and dozing (23-26%) in their schedule. Grooming found between 9-10% of total activity budget. Data of seasonal relation concluded that feeding and locomotion increased during cold months but sexual activities remain constants.

Resource utilization and competition:- Displacement occurred in all possible combinations including non adult and adult partners of both sexes. Data suggest that adult females act as both actors and receptors and are frequent participants (89.2%) in all displacements observed in this study. The adult females displace the resident male very rarely. It was found that 72% of the total displacements are directly related to resource competition and remaining also appears to be the indirect form of resource competition. An average of about half of displacements occurred over access of food.

This however, included both natural and provisioned food. The remaining displacements were over access to position, social interactions and grooming which may directly influenced the resource competition. This study revealed that *Prosopis juliflora* and *Anogeissus pendula* are the main natural food plants over which displacements took place; this is correlated from the fact that for feeding purposes langurs spent maximum time over these plants.

Langurs drink regularly in batches. All members of a troop never drank all together, thus reduced the risk of being predated. The maximum number of

drinking episodes were recorded in April and the minimum in July-August. The seasonal variation of drinking seemed to compensate for any prevailing relative humidity and ambient temperature. Probability of drinking was found high between 08.30 to 09.30 hrs and 16.30 to 18 hrs. it was quite likely that Jodhpur langurs probably need more water to maintain their water balance due to water loss through sweating or thermoregulation during summer months. Defend of water holes from neighbouring troop members and displacement over water holes were also observed during present study.

Resource in the Kailana habitat represents some 320 plant species in nature. Of these, 208 were eaten by langurs. Langurs of study troop were observed to subsist of plant parts of 122 species in the habitat, of these 87 belonging to 38 families occur in nature. They spent upto most of their feeding time over natural food and about one third on provisioned foods.

The provisioned food has become an important part of langur diet in this habitat. Langurs spent upto 23.5% of their total feeding time on flat cakes of millet “sogra”.

The three plant species viz*. Prosopis juliflora*, *Acacia Senegal* and *A. nilotica* constitute the major share of langur diet on a yearly basis. The six staple plant species account for about 79% of their total yearly diet. Langurs devoted 66% of their total feeding time in consuming leaves, of which 58% to mature leaves and 42% to young leaves. Fruit eating accounts for 2-3% and flowers to about 7%. The remaining items such as stem, gum and bark comes to about 3%. It is clearly evident from this study that langurs on an average spend 70% of their feeding time consuming leaves, thus they can be considered as specialized folivorous.

Dominance hierarchy: - In Hanuman langurs around Jodhpur, study found clear-cut dominance hierarchy in all the male bands and bisexual troops females (particularly among adults), which appears to be a functional rank order.

Present study concluded some determinants for bisexual troop as well as for all male band to determine the ranking order or system in Hanuman langurs.

In bisexual troops- study of dominance hierarchy in bisexual troop was based upon resource competition, competition for good place(shelter), allomothring, grooming, mating behaviour and displacement pattern.

Resource competition included drinking spot and feeding materials. Study was mainly based on feeding resources natural as well as provisioned food. Competition displayed in aggression and rarely as conflict. It concluded that food resource was one of the main factors which were responsible to some extents for competition and dominancy.

It showed that female- female created a competition for good place. It became large competition when the group home range was small especially in B19 troop. Preferred area for roosting always used by high ranking females and the resident male. But some times these places occupied by other parallel ranked females, then high ranker showed aggression and conflict in term of competition for that place.

Allomothering suggested as dominance indicator and concluded that high ranker female almost not interested in infant carrying but on their choice they took infants against baby's mother choice. So due to low rank mother couldn't refuse for allomothring. study further concluded that high ranker female's infants always got good carrying by their aunt who got low rank or submissive against infant's mothers

Mating behaviour means access to mate with resident male was determined rank orders in females of focal bisexual troop. It concluded that only high ranker or top most female mated with resident male and always tried to get near position to resident male. It has been found that high ranking female mated only till she became pregnant and in that pregnancy situation male mated with other females which maintained top status in rank order.

Study further suggested that male have choice to mate more females but females maintained a regularly system, that high ranker first mated with resident upto fulfilled their choice. She opposed and showed aggression towards such females who tried to get their position. So it is cleared by this study that dominance hierarchy maintained a regulatory system, although competition leaded in their life, but it had limited because they got a ranking status system.

Displacement was main determinant in this study. Displacement observed on food procurement, for possession of resident male and for better sites to feeding, resting and grooming etc. Study observed various episodes for

displacement and concluded that top ranker always got first and more food in troop. But some reversal episodes also observed and found that parallel ranker always competed for food, shelter etc and displaced each other. In summer the troop members showed displacement for place bit cooler.

Displacement took place in three clear phases respectively mode of enforcements (including approaching, slaping, baring teeth, threating, mounting, jumping and chasing etc), reaction of recipient and context (including acquisition of natural food, provisioned food, water, sleeping or resting sites and others).

So in bisexual troop dominance determined by percentage occurrence of some dominance measures like competitive feeding, Grooming to others, groomed by others, withdrawal on others' approach, withdrawal by others on approaching, Aggression by others, aggression to others, submission to others and submission by others.

In male band:- the main determinant of the hierarchy in the male band was displacement. It was for food procurement, for estrous females while interacting with troops or to occupy the better places. Other determinant were chasing, fights, success or failures in copulation and harassment to subordinates during interactions with the troop members.

In male bands especially to focal band AMB11, dominance hierarchy determined on the basis of several dominance interactions like displacement during the food procurements, to possess estrous females or to show the dominance when resting, chasing and in emitting whoops etc. It has been found that each individual realizes its status and followed the social hierarchy, most of these status interactions were nonviolent and the male dominance hierarchy is maintained without serious fights.

Study further concluded that there was always fall in the rank when an ousted resident joined or rejoined male band even after a very brief tenure outside the band. Study observed that all the ousted residents failed to regain residency of any bisexual troop and even failed in rank in their band from where they came.

It has also been concluded that most dominant male or rarely the beta male became resident when it was required. The vacant position of alpha or beta male

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was occupied by the next ranking male and that pattern of filling and elevating of ranks goes on.

It is concluded that alpha make whoop call regularly and warning signal mostly, food procurement successes always, fights occasionally and never loosing fight. Rank ordered in alpha-beta-gamma and so on. Gamma male has become always dominant only in absence of alpha and beta male. In male band rank shifted during this study.

Lastly it is concluded that determination of dominance hierarchy in social animal is necessary part of their life. It maintained a regulatory system in langur society. It also reduces competition and unnecessary injuries during living together.

If we compared the human life social system, it seemed that our society also has a well maintained hierarchy system. But when some body tries to oppose this hierarchy, it results loss of social benefits.

So in summary of this study, that without a well maintained hierarchical system, society cannot maintain as a good and well organized system. This hierarchical system evolved from invertebrate like insects to nonhuman primate and human beings.

In langur society one can get top most rank in their hierarchy who has more potential and adult with high power. Means power maintain ranks here, when they lose their power, they shifts toward low status. But in humans, here is opposite to langur hierarchical system. In human society the grant old person with high experienced gets top rank in their society. But exceptionally some persons try to use their power and try to get top most rank. It shows some similar characters to our original primate's behaviour.

Stability and organization of any primate group depends upon the delicate balance struck between group cohesion and social dispersion. Dominance, by ensuring group stability through a system of formalized aggression, often acts as a social centrifuge, driving animals apart and keeping them separate. Further, it can be explained at the operational level, viz. that as a dominant approaches a cohesive unit of a few submissive animals, the latter would disperse on its approach even though it might not be its intension.

Chapter 6

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CHAPTER-6

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APPENDICES

Appendix-1

List of non-human primates of Indian subcontinent

S. No.	Zoological name	Common name	First taxonmist with years
Tupaiidae (Tree shrews)			
1.	*Anthona ellioti*	Madras tree shrew	Water house, 1850
2.	*Tupaia glis*	Common tree shrew	Diard, 1820
3.	*Tupaia nicobarica*	Nicobar tre shrew	Zelebor, 1869
Lorisidae (Lorises and Galagos)			
4.	*Loris tardigradus*	Slender loris	Linnaeus, 1758
5.	*Nycticebus coucang*	Slow loris	Boddaert, 1785
Cercopithecidae (Macaques, langurs or leaf monkeys, Baboons)			
6.	*Macaca arctoides*	Stump tailed macaque	I. Geoffroy, 1831
7.	*Macaca assamensis*	Assames macaque	McClelland, 1840
8.	*Macaca fascicularis*	Long-tailed macaque	Raffles, 1821
9.	*Macaca mulatta*	Rhesus macaque	Zimmerman, 1780
10.	*Macaca nemestrina*	Pit-tailed macaque	Linnaeus, 1766
11.	*Macaca radiate*	Bonnet macaque	E. Geoffroy, 1812
12.	*Macaca silenus*	Lion-tailed macaque	Linnaeus, 1758
13.	*Macaca sinica*	Toque macaque	Linnaeus, 1771
14.	*Trachypithecus cristatus*	Silvered leaf monkey	Raffles, 1821
15.	*Semnopithecus entellus*	Hanuman langur	Dufresne, 1797
16.	*Trachypithecus geei*	Golden langur	Khajuria, 1955
17.	*Trachypithecus johnii*	Nilgiri langur	Fischer, 1829
18.	*Presbytis malalophos*	Banded leaf monkey	Fattles, 1821
19.	*Trachypithecus obscurus*	Spectaeled leaf monkey	Reid, 1837
20.	*Trachypithecus phayrei*	Phayre's leaf monkey	Blyth, 1847
21.	*Trachypithecus pileatus*	Capped langur	Blyth, 1843
22.	*Trachypithecus vetulus*	Purple faced langur	Erxleben, 1777
23.	*Pygathrix roxellana*	Snu faced langur	Milne-Edwands, 1870
Hylobatidae (Gibbons and Siamangs)			
24.	*Hylobates hoolock*	Hoolock gibbon	Harlan, 1834
25.	*Hylobates lar*	Lar gibbon	Linnaeus, 1772

Appendix-2

Indian primates with political distribution

S. No.	Common name	Scientific name (after Groves, 2001)	Distribution
	Endemic to India		
1.	Lion-tailed macaque	*Macaca silenus*	Western Ghats, Kerala, Karnataka, Tamil Nadu
2.	Nilgiri langur	*Trachypithecus johnii*	Western Ghats, Kerala, Tamil Nadu, Karnataka up to 21^0 N
3.	Bonnet macaque	*Macaca radiata*	Peninsular India up to 21^{s0} N
	Endemic to South Asia		
4.	Hoolock gibbon	*Hylobates hoolock*	India (Assam, Arunachal Pradesh, Meghalaya, Tripura, Mizoram), Myanmar and Bangladesh
5.	Golden langur	*Trachypithecus geei*	India (Assam) and Bhutan
6.	Common langur	*Semnopithecus entellus*	India (Throughout except western parts of Rajasthan and Gujarat), Pakistan, Sri Lanka and Nepal.
7.	Slender loris	*Loris tardigradus*	India and Sri Lanka
8.	Capped langur	*Trachypithecus pileatus*	India (Assam, Meghalaya, Nagaland, Arunachal Pradesh), Bangladesh and Myanmar
	Endemic to Asia		
9.	Crab-eating macaque	*Macaca fascicularis*	India (Andaman and Nicobar Islands), Myanmar, Sumatra, Borneo, Philippines, Vietnam to Malaysia.
10.	Pig-tailed macaque	*Macaca nemestrina*	India (Meghalaya, Nagaland, Tripura), southeast Asia up to Borneo
11.	Phayre's langur	*Trachypithecus phayrei*	India (northeast), Bangladesh, Myanmar, southeast Asia, China
12.	Rhesus macaque	*Macaca mulatta*	India (whole of northern India-north of Godawari to Assam), Myanmar, Indochina

13.	Stump-tailed macaque	*Macaca arctoides*	India (Nagaland, Arunachal Pradesh, Meghalaya, parts of Assam, Tripura), China, Tibet, Myanmar, Thailand.
14.	Assamese macaque	*Macaca assamensis*	Northeast India (Himalayas from Mussori eatward to hills of Assam and forests of A.P.), Myanmar, Banladesh, southeast Asia.
15.	Slow loris	*Nycticebus coucang*	India (northeast), Myanmar, Bangladesh, southeast Asia

Source: Envis Bulletin: Wildlife and Protected Areas (2001) 1: 138-151

Appendix-3

Subspecies of Hanuman langurs, *Semnopithecus entellus*
(Endemic to south Asia)

S. No.	Subspecies	Reference	Distribution
1.	*S.e. entellus*	Dufresne, 1797	Northern India, Bengal to Gujarat and Rajasthan
2.	*S.e. achilles*	Pocock, 1928	Sikkim and Nepal, at high altitudes; probably Kashmir
3.	*S.e. ajax*	Pocock, 1928	Himachal Pradesh and probably Kashmir-high altitude
4.	*S.e. schistaceus*	Hodgson, 1840	Uttar Pradesh and Nepal
5.	*S.e. shanicus*	Wroughton, 1917	Northern states
6.	*S.e. anchises*	Blyth, 1844	Madhya Pradesh and the Eastern Ghats
7.	*S.e. lania*	Elliot, 1909	Southern Tibet
8.	*S.e. elissa*	Pocock, 1928	Southern India: Coorg
9.	*S.e. dussumieri*	I. Geoffrey, 1843	Southern India: Malabar
10.	*S.e. iulus*	Pocock, 1928	Southern India: Karnataka
11.	*S.e. priam*	Blyth, 1844	Southern India: Tamil Nadu
12.	*S.e. hypoleucos*	Blyth, 1841	Southern India: Kerala
13.	*S.e. priamellus*	Pocock, 1928	Southern India
14.	*S.e. achates*	Pocock, 1928	Southern India: Dharwar, Bellary
15.	*S.e. aeneas*	Pocock, 1928	Southern India
16.	*S.e. thersites*	Blyth, 1847	Southern India and Sri Lanka

Source: Roonwal and Mohnot (1977) Primates of South Asia, Harvard University Press, Cambridge Massac. (P. 234-270).

Appendix-4a

Jodhpur langur: bisexual troops' number and locations

S. No.	Gr. No.	Location	Habitat
1.	B1	Daijar Temple	Open scrub hilly
2.	B2	Daijar Dam	Open scrub hilly
3.	B3	Beriganga	Hilly and temples
4.	B4	Nimba	Hilly and open scrub
5.	B4a	GSK Nimba	Garden and open scrub
6.	B5	Nimbri	Hilly and temples
7.	B6	Mandore Devel	Garden habitat
8.	B7	Mandore Fort	Garden habitat
9.	B7a	Mandore OS	Garden habitat
10.	B8	Mandore Temple	Garden habitat
11.	B9	Mandore Ns.	Garden habitat
12.	B10	Balsamand	Human habitat
13.	B11	Kaga North	Human habitat
14.	B12	Kaga South	Human habitat
15.	B13	City (JM)	Human habitat
16.	B14	City (Ranisar)	Human habitations
17.	B14a	City Pachatia	Hills and buildings
18.	B15	Chandpole Ck	Human habituation
19.	B16	Chandpole Ds	Human habituation
20.	B17	Guptganga	Hillock and open
21.	B17a	Soorsagar Bg	Open scrub
22.	B18	Kailana Canal	Open scrub
23.	B19	Kailana I	Open scrub
24.	B20	Kailana II/AS	Open scrub
25.	B21	Bijolai	Hilly-open scrub
26.	B22	Bheembharak	Open scrub with hilly
27.	B23	Sidhnath East	Hilly
28.	B24	Sidhnath West	Hilly-Temples
29.	B25a	Filter House-S	Garden and Orchards
30.	B26	Kadamkandi E	Open scrub and human habitat
31.	B26a	Kadamkandi SE	Hilly-open scrub
32.	B27	Kadamkandi W	Hilly-open scrub
33.	B28	Bhadreshwar	Hilly-open scrub
34.	B28a	Chonkha Klgt	Open scrub hilly
35.	B28b	Chonkha-S M	Hilly and mines
36.	B29	Arna	Open scrub habitat

OS= Outside, Ns= Nahar Sagar, JM= Juni Mandi, GM= Gundi Mohall, Ck= Chonka, Ds= Dispensary, Bg= Bagechi, AS= Air force sheds, SM= Stone Mines, B2 merged in B3 since 1987

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Appendix-4b

Jodhpur langur: All male bands' (AMB) number and preferred locations

S. No.	Gr. No.	Location	Habitat
1.	AMB1	Daijar FCI Godown	Open scrub + Farms
2.	AMB2	Beriganga	Hilly & open scrub
3.	AMB3	Mandore North	Garden
4.	AMB4	Mandore South	Garden Hilly + Garden
5.	AMB5	Kaga-Balsamand	Hilly, open scrub
6.	AMB6	City-Gaddi	Hilly-buildings
7.	AMB7	Chandpole, Soorsagar	Human habituation
8.	AMB8	Machiya Park-K. Canal	Open scrub
9.	AMB9	Suthla (Akharajji ka talab)	Open scrub hilly
10.	AMB10	Sidhnath	Hilly
11.	AMB11	Chopasani	Hilly, farms & temples
12.	AMB12	KK-Golasani Chonkha	Open scrubs
13.	AMB13	Arna/Barli	Hilly & open scrub
14.	AMB5a	Maha Mandir 3rd Pole	Human habitation

FCI= Food Corporation of India; KK= Kadam Kandi, K= Kailana

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Appendix-5

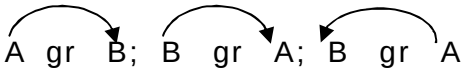
Age-sex classification of Hanuman langurs of Jodhpur

Age class	Females	Males
Infant I/Black coat infant (BCI)	Fur colour black: to coat colour change-birth to 3 month	Birth to 3 months.
Infant changing/changing coat colour infant (CCI)	Fur colour changing from black to brown and than white between 3 to 5 months of age, till fur colour changes fully.	Fur colour canging from black to brown and than white between 3 to 5 months of age, till fur colour changes fully.
Infant II/white coat infant (WCI)	Fur colour white: fur colour changes. Infant aged 5 to 14 month.	Fur colour white: fur colour changes. Infant aged 5 to 14 months.
Juvenile	15 months to about 2.5 years	15 months to about 4.0 years. Testes internal and glens of penis seen covered by prepuce in Juvenile I and testes descend glans of penis visible in Juvenile II. Sex skin not visible clearly.
Subadult/young adult	Above 2.5 years of age nipples visible; regular start around 3.3 to 3.8 years. Not older that 4 years.	About 4-6 years of age, glans visible, ischial pads still under developed. Canine teeth not yet fully erupted, capable of copulatory behaviour. Sex skin visible young adult. About 6-7/8 years of age, glans always visible, ischial pads small and usually pale, canine teeth fully erupted, teeth unworm, not yet full size. Sex skin clearly visible.
Adult	From birth of first infant, but from 4 years onwards.	About 7/8 years onwards; full size; ischial pads well developed with sex skin often puffy and pink in colour.

Jodhpur langurs: Behavioural Repertoires

Units of Behaviour (abbreviated and simplified list)

I. Focal-Animal

fe	=	feeding or foraging
mo	=	monitoring, resting with eyes open
mo	=	vigilance from tree top or hilltop etc.
do	=	dosing, eyes closed
gr	=	allogrooming 
sgr	=	self-grooming
lo	=	Locomotion; travel over distance> 25m, usually change of a transact; can be interrupted by monitoring < 1 min; (Note: foraging is not locomotion)
~	=	moving, change of place< 25m, mostly during foraging
~>	=	approaching actively; A~> B = A approaches B
~ ~	=	leaving actively A ~ B = A moves away from B
co	=	being in body contact (or arms reach) with another individual; A co B = A in contact with B
cli	=	climbing up (on tee, building) above ground
des	=	descending on ground
T	=	above ground on Tree
B	=	above ground on building (wall, roof, electric pole)

Contd...

II. Ad libitum (to be noted whether focal target or not)

dp	=	displacement; A dp B = A displaces B
grugri	=	grunt-and-grimace, “tense” behaviour

em = embracing; A em B = A embraces B

wh = whoop call; (wh, wh wh)

judis = jumping display (not necessarily combined with wh)

tg = teeth grinding

>>>< = mobbing (convulsive barks, e, e-i-e)

peer = penile erection

LS = leadership during group movement

IN = initiator of group movement (change of transact)

SI = something important (other group, dogs) in sight

⊢⊣ = distance sign; 200= 200 m apart; 2 2m apart

* or * = Disturbance; human or natural; give source (man pases by, throws stone, feeds, dog is barking, chasing langurs, aircraft, truck horns), give likewise reaction: minimal, orient moderate, major

III. Nearest Neighbour (of focal target, every five min.)

Individual/Distance/Activity; or any of them, if not all possible to recognize.

IV. Scan Sampling

Number of individuals engaging in main activities (fe, mo, do, gr, sgr, lo, others). Examples for group of 15 individuals: 5 fe, 4 mo, 3 do = 5 indi. are feeding, 4 are monitoring, 3 are dozing; remaining 3 not visible.

Contd…

V. Diet Specification

Example: a) M125T fe Ax ind YoLe= individual male M125 on tree feeds on Neem (*Azardica indica*) Young leaves.

Exmaple: b) M76 fe Ca dec Fr=M76 on ground feds on fruits of *Capparis deciduas*

F1 = flower, Ba = Bark Gu = Gum

MaLe = Mature leaves YoLe = Young leave LeBu = Leaf Buds

F1Bu = Flover Buds F = Fruits Se = Seeds

YoFr = Young Fruits Sand = sand/earth

PRO = Provisioning (ad lib., i.e. also to be noted, if focal individual is not feeding on provisioned food)

Chapa = Chapati Soga = Sogara Chana = Chana (roasted gram)

PRO = Provisioning (ab lib., i.e. also to be notes, if focal individual is not feeding on provisioned food)

Le 40 + F1 60 = Mixture 40% leaves, 60% flovers (or accordingly)

Appendix-7

Protocol sheet for focal, *scan* and *ad-libitum* sampling

Durg Singh Rajpurohit, Research Scholar
Department of Zoology, Jai Narain Vyas University, Jodhpur

Focal animal sampling (half an hour)			Protocol No.
Group:	Focal animal:		
Date:	Location:		Observer: DSR
Time:	Remarks (Weather, etc.)		
Min.	Behavioural observations in abbreviated forms		*Ad libitum*
	First 30 seconds	Next 30 seconds	
1			
2			
3			
4			
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Scan & Remarks:

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_____

Appendix-8

Hanuman langur-Provisioned food items in the study troops

S. No.	Local name/ Common name	Botanical name	Food form	Consumption months
Vegetables				
1.	Momphali	*Arachis hypogaea*	Raw/Cooked	12 months
2.	Alu	*Solanum tuberosum*	Raw	12 months
3.	Mirchi	*Capasicum annuum*	Raw	1 months
4.	Shakarkand	*Ipomoea batatas*	Raw	4 months
5.	Mooli	*Raphanus sativus*	Raw	7 months
6.	Makki	*Zea mays*	Raw	2 months
7.	Baingan	*Solanum melongena*	Raw	3 months
8.	Gawarphali	*Cyamopsis tetragonaloba*	Raw	3 months
9.	Band Gobi	*Brassica oleracea l. var. capitatal*	Raw	3 months
10.	Ful gobi	*Brassica oleracea l. var. Botrytis*	Raw	4 months
11.	Kanda	*Allium cepa*	Raw	4 months
12.	Palak	*Rumex vesicarium*	Raw	4 months
Fruits				
13.	Kaila	*Musa paradisiacal*	Raw	6 months
14.	Amrood	*Picidium guajava*	Raw	6 months
15.	Sitaphal	*Annona squamosa*	Raw	6 months
16.	Gajar	*Daucas carota*	Raw	6 months
17.	Anar	*Punica granatum*	Raw	2 months
18.	Aam	*Mangifera indica*	Raw	4 months
19.	Ganna	*Saecharum officinarum*	Raw	3 months
Flowers				
20.	Hajara	*Tagetes ereeta*	Raw	3 months
21.	Gulab	*Rosa indica*	Raw	5 months
Others				
22.	Chapati		Cooked	12 months
23.	Bread		Cooked	12 months
24.	Biscuits		Cooked	12 months
25.	Makhana		Cooked	12 months
26.	Kachori		Cooked	12 months
27.	Potato Chips		Cooked	12 months
28.	Laddu		Cooked	12 months
29.	Bhujiya/Pakore		Cooked	12 months
30.	Sogra		Cooked	12 months

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Appendix-9

Plant species with their scientific names used by Hanuman langur in Jodhpur area
(N=Nature, T=Tree, S=shrub, H=Herb, G=Grass)

S. No.	Local Name	Botanical Name	Natural (N)/ Cultivated (C)	Nature
1.	Kankera	*Maytenus emergineta*	N	T
2.	Gugal	*Commiphora wightii*	N	S
3.	Amal tash	*Cassia fistula*	C	T
4.	Jal	*Salvadora persica*	N	T
5.	Safed siris	*Albizzia procera*	C	T
6.	Ker	*Capparis deciduas*	N	S
7.	Aak	*Calotropis procera*	N	S
8.	Rohira	*Tecomella undulata*	N	T
9.	Karonda	*Carissa opaca*	C	S
10.	Samel	*Bombex ceiba*	C	T
11.	Neem	*Azadirachta indica*	N/C	T
12.	Dhawra	*Anogeissus pendula*	N	T
13.	Safed Dhaw	*Anogeissus latifolia*	N	T
14.	Sitaphal	*Annona squamosa*	C	T
15.	Safad-saras	*Albizia procera*	C	T
16.	Arru	*Atlanthus excelsa*	N	T
17.	Adusa	*Adhatoda zeylanica*	C	T
18.	Kumbhat	*Acacia Senegal*	N	T
19.	Babool	*Acacia nilotica*	N	T
20.	Shisham	*Dalbergia latifolia*	C	T
21.	Gunda	*Cordial dichotoma*	C	T
22.	Gundi	*Cordial gharaf*	N	S
23.	Jhar Ber	*Ziziphus nummularia*	N	S
24.	Ber (Bordi)	*Ziziphus mauritiana*	N	T
25.	Bui	*Aerva persica*	N	S
26.	Sinia	*Leptodenia pyratechnia*	N	S
27.	Arjun	*Terminalia arjuna*	C	T
28.	Imli	*Tamarindus indica*	N	T
29.	Jamun	*Syzygium cumini*	C	T
30.	Hingwal	*Spermadictyon suaveolens*	N	T
31.	Vilayti babul	*Prosopis juliflora*	N	T
32.	Karanj	*Pongamia pinnata*	C	T
33.	Kadam	*Mitragyna parvifolia*	N	T
34.	Umbia	*Miliusa tomenfosa*	C	T
35.	Aam	*Mangifera indica*	C	T
36.	Pipal	*Ficus religiosa*	N	T
37.	Makki	*Kirganelia reticulate*	C	S
38.	Nagphani	*Opuntia dellenii*	N	S

39.	Dudhi	*Wrightia tinctoria*	N	H
40.	Gular	*Ficus racemosa*	N	T
41.	Bargad	*Ficus benghalensis*	N	T
42.	Thor	*Euphorbia caducifolia*	N	S
43.	Deshi babul	*Acacia nilotica*	N	T
44.	Israeli babul	*Acacia tortilis*	C	T
45.	Gher ghani	*Grewia tenax*	N	S
46.	Dhatura	*Datura terox*	N	H
47.	Matira	*Citrullus lanatus*	C	Twiner
48.	Tumba	*Citrullus colocynthis*	N	Twiner
49.	Pilwan	*Cocculus pendulus*	N	T
50.	Kachri	*Cucumis callosus*	C	Twiner
51.	Dub	*Dynodan dactylon*	C	G
52.	Moth	*Cyperus arenarius*	C	H
53.	Moong	*Vigna radiafa*	C	H
54.	Ghantiya	*Dactyloctenium sindicum*	N	H
55.	Bhekar	*Indigofera cordifolia*	N	H
56.	Lutya-Bhekar	*Indiofera linifolia*	N	H
57.	Khemp	*Leptadenia pyrotechnica*	N	S
58.	Jinjanio	*Miemosa hamata*	N	S
59.	Khejari	*Prosopis cineraria*	N	T
60.	Khari jal	*Salvadora oleoides*	N	T
61.	Mitha jal	*Salvadora persica*	N	T
62.	Til	*Sesamum indicum*	C	H
63.	Bisoni	*Tephrosia purpuria*	N	H
64.	Sata	*Trianthema portulacastrum*	N	H
65.	Kanti	*Tribulus terrestris*	N	H
66.	Sunavri	*Zaleya redimita*	N	H
67.	Vad-Ber	*Ziziphus jujube*	N	S
68.	Sevan	*Lasiurus sindicus*	N	G
69.	Satyanasi	*Argemone maxicana*	N	H
70.	Dhok	*Anogeissus pendula*	N	T

Appendix 10

Common taxa: lizards, snakes, birds and mammals found in the study area (i.e. Jodhpur)

S. No.	Common Name	Zoological Name
Lizards		
1.	Garden lizard cameleon	*Calotes versicolor*
2.	Bark gecko	*Hemidactylus leschesnaulti*
3.	Golden striped lizard	*Ophisops jerdoni*
4.	Indian fringe toed sand lizard	*Acanthadactylus cantoris*
5.	Indian sand skink	*Ophiomours tridactylus*
6.	Indian spiny tailed lizard	*Uromastix hardwicki*
7.	Monitor lizard	*Varanus griseus*
8.	Spotted Indian house gecko	*Hemidactylus brooki*
9.	Yellow bellied house gecko	*Hemidactylus flaviviridis*
Snakes		
1.	Indian cobra	*Naja naja*
2.	Dhaman	*Ptyas mucosus*
3.	Indian krait	*Bungurus caeruleus*
4.	Russell's viper	*Vipera russelli russelli*
5.	Viper or pit viper	*Echis carinatus*
6.	Rajat bansi	*Sphalerosophis diadema diadema*
7.	Indian sand boa	*Eryx johni johni*
8.	Beaked thread snake	*Leptotyphlops macrorhynchus*
9.	Blind snake	*Ramphotyphlops bramina*
Birds		
1.	Cormorant	*Phalacrocorax carbo*
2.	Little cormorant	*P. niger*
3.	Darter	*Anhinga rufa*
4.	Gray heron	*Ardea cinerea*
5.	Large egret	*A. alba*
6.	Pond heron	*Ardeola grayii*
7.	Cattle egret	*Bubulcus ibis*
8.	Painted stork	*Mycleria leucocephata*
9.	White stork	*C. ciconia*
10.	Black stork	*C. nigra*
11.	White ibis	*Threskiornis aethipica*
12.	Spoonbill	*Platelea leucorodia*
13.	Greyleg goose	*Anser anser*
14.	Barheaded goose	*Anser indicus*
15.	Brahminy duck	*Tadorma ferruginea*
16.	Pintail	*Anas acuta*
17.	Common teal	*A. crecca*

18.	Spotbilled duck	*A. poecilorhyncha*
19.	Cotton teal	*Nettapus coromandelianus*
20.	Pariah kite	*Milvus migrans govinda*
21.	Shikra	*Accipiter badius*
22.	Crested hawk eagle	*Spizetus cirrhatus*
23.	King vulture	*Sarcogyps calvus*
24.	Indian longbilled vulture	*Gyps indicus*
25.	Indian whitebecked vulture	*Gupy bengalensis*
26.	Seavenger vulture	*Neophron percnopterus*
27.	Grey partridge	*Francolinus pondicerianus*
28.	Greh jungle fowl	*Gallus sonneratii*
29.	Indian peafowl	*Pavo cristatus*
30.	Sarus crane	*Grus antigone*
31.	Coot	*Fulica atra*
32.	Redwattled lapwing	*Vanellus indicus*
33.	Yellow wattled lapwing	*V. malabaricus*
34.	Green pigeon	*Treron pompadora*
35.	Blue rock pigeon	*Columba livia*
36.	Indian ring dove	*Streptopelia decaocto*
37.	Red turtle dove	*S. tranquebarica*
38.	Spotted dove	*S. chinensis*
39.	Alaxandrine parakeet	*Psittacula eupatria*
40.	Roseringed parakeet	*P. krameri*
41.	Indian cuckoo	*C. microplerus*
42.	Koel	*Eudynanys scolopacea*
43.	Great horned or eagle owl	*Bubo bubo*
44.	Spotted owlet	*Alhene brama*
45.	Common Indian nightjar	*Caprimulgus asiaticus*
46.	White breasted kingfisher	*Halcyon smymensis*
47.	Green bee-eater	*Merops orientalis*
48.	Indian roller	*Coracias benghalensis*
49.	Hoopoe	*Upupa epops*
50.	Grey hornbill	*Tockus birostris*
51.	Crusted lark	*Galerida cristata*
52.	Black drongo	*Dicrurus adsimilis*
53.	Brahminy myna	*Sturnus pagodarum*
54.	Common myna	Acridotheres tristis
55.	Pied myna	*S. contra*
56.	House crow	*Carvus splendens*
57.	Jungle crow	*C. macrorphynchus*
58.	Redvented bulbul	*Pycnonotus cafer*
59.	Common babbler	*Turdoides caudatus*
60.	Jungle babbler	*Turdoides striatus*
61.	Tailor bird	*Orthotomus sutorius*
62.	Indian house sparrow	*Passer domisticus indicus*

Mammals		
1.	Rhesus macaque	*Macaca mulatta*
2.	Bonnet macaque	*Macaca radiata*
3.	Nilgai-Roj	*Boselaphus tragocamelus*
4.	Jackal	*Canis aureus aureus*
5.	Wolf	*Canis lupus pallipes*
6.	Desert cat	*Felis libyca*
7.	Neula mongoose	*Herpestes edwardsi*
8.	Hedgehog	*Paraechinus micropus*
9.	Long eared hedgehog	*Hemiechinus auritus callaris*
10.	Hyaena	*Hyaena hyaena*
11.	Porcupine	*Hystrix indica*
12.	Desert hare	*Lepus nigricollis*
13.	Common bat	*Rhinopoma sp.*
14.	Fruit bat	*Pteropus gigantesus*
15.	Wild boar	*Sus scrofa*
16.	Desert fox	*Vulpes vulpes pusilla*
17.	Squirrel	*Funambulus pennanti*
18.	Gerbil	*Gerbillus nanus*
19.	Common small rat	*Tatera indica*
20.	Mouse	*Mus musculus*
21.	Chuchunder-mole rat	*Bandicota bendicota*
22.	Common house rat	*Rattus rattus*
Other domestic mammals		
1.	Cat	*Felis domesticus*
2.	Cow	*Bos Indicus*
3.	Buffalo	*Bos bubalus*
4.	Goat	*Capra hitcus*
5.	Sheep	*Ovis orienes*
6.	Horse	*Equus caballus*
7.	Donkey	*Equus hemionus*
8.	Camel	*Camelus dromedorius*
9.	Dog	*Canis familiaris*
10.	Rabbit	*Oryctolagus cuniculus, Lepus sp.*

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