CHAPTER 3
RESEARCH DESIGN AND METHODOLOGY

Distribution of Primates in India

India harbors 17 species of primates. Northeastern Himalayas and the Western Ghats of south India have highest evolutionary diversity and primate ecology (Choudhury, 2001; Karanth et al., 2010; Mazumder, 2014). These two areas alone provide shelter to 70% Primates of India (Choudhury, 2001; Kumara & Singh, 2004). These evergreen, semi-evergreen and moist deciduous forests are the “Hot Spots” area of biological diversity (Myers, 1988; Myers et al., 2000). India shelters Hoolock Gibbons \( (Hylobates hoolock) \) and Cercopithecidae with two subfamilies- Cercopithecinae and Colobinae (macaques and the langurs) and Lorisidae, Subfamily Lorisinae (“Primates-SG-Primates of India”, n.d.). Some species of primates such as Golden langurs \( (Trachypithecus geei) \), Phayre’s leaf monkey \( (Trachypithecus phayrei) \) are range-restricted or rare (Lion-tailed macaque, Hoolock gibbon and Slender Loris), whereas few species continue to co-exist within human habitats such as rhesus macaque \( (Macaca mulatta) \), bonnet macaque \( (Macaca radiate) \) and Hanuman langurs \( (Semnopithecus entellus) \) (Choudhury, 2001; Groves, 2001; Karanth et al., 2010; Mazumder, 2014; Singh et al., 2001). The Southern part of India shelters four old world species of primates belonging to family Cercopithecinae and Colobinae (Bonnet macaques, Lion tailed macaques, Hanuman langurs, and Nilgiri langurs). Of these, Hanuman langurs (OCCURRENCE: >20,000 Sq. Km; OCCUPANCY>2,000 Sq. Km) are found all over India, whereas, Nilgiri langurs OCCURRENCE:<20,000 Sq. Km; OCCUPANCY: 2500 Sq. Km) are endemic to Western Ghats of India from the coorg region to Cape Comorin. Lion-tailed macaques
(OCCURRENCE:<20,000 Sq. Km; OCCUPANCY: 2500 Sq. Km) are also endemic to Western Ghats of India from Northern Karnataka till Kerala and in some area of Tamil Nadu. Bonnet macaques (OCCURRENCE: 630,000 Sq. Km; OCCUPANCY: >2000 Sq. Km) are likewise endemic to the Southern part of India. This species of macaque is a habitat generalist and can be seen in the rain forest as well as human landscapes. They feed on fruits, berries, tender leaves, insects, etc. Bonnet macaques’ lives in well-defined ranges and are relatively more socially active (“Species of India-APES FAMILY OF INDIA”, 2016). In the current study, I selected Bonnet macaque (Macaca radiate) as my study species.

**Study Site**

Behavioral data for the present study was obtained from the large group of bonnet macaques inhabiting the roadside of Utaranhalli at the outskirts of Mysuru city in South India (12°14'53.22"N; 76°40'51.95"E). Mysuru lies in the Southern plateau of Karnataka state and is a part of Kaveri basin. It is situated at an altitude of 820m above sea level and covers 16,916 Sq. Km of the area. The highest peaks of the areas are Bettadpora hill (1338m), Narayana Durga (1088m) and Chamundi Hill (1074m). Geographically, Mysore includes *maidan* (plains), partly *semi-malnad* (hilly) and cultivated area. It is an angular area surrounded by forest viz. Nagarahole, Bandipur, BR hills and MM hills and where Eastern and Western Ghats range join into Nilgiri hills. The Vegetation of Mysore is thorn Scrub (Tao & Razi, 1981) and is a non-forest habitat. Mysore houses about 26% species of Indian avifaunal diversity (Zafar-ul-Islam & Rahmani, 2004). It also shelters Leopard (*Panthera pardus*), Jungle cat (*Felis chaus*), Rusty-spotted cat (*Felis rubiginosa*), Indian Fox (*Vulpes bengalensis*), Small Indian Civet (*Vivericula indica*), Common palm civet (*Paradoxurus hermophroditus*), Common mongoose (*Herpestes edwardsi*), Black buck (*Antelope vervicarpa*), Wild
Figure 3.1: Map of study site (Mysore Area) in India

pig (*Sus scrofa*), Porcupine (*Hystrix indica*), Pangolin (*Manis crassicaudata*) and Black-naped hare (*Lepus nigricollis*), Smooth Indian Otter (*Lutra perspicillata*), Indian Flying Fox (*Pteropus giganteus*), Fulvous Fruit Bat (*Rousettus leschenaultia*), and Indian (Pipistrelle *Pipistrelus coromandra*), Palm Squirrel (*Funambulus palmarum*) and Bonnet macaque (*Macaca radiate*). Scrub jungles & fields around Nagamangala (Mandya) houses Jackal (*Canis aureus*) and indirect evidence (pug marks & droppings.) have shown the presence of Wolf (*Canis lupus*) in Melkote Temple Sanctuary (Mandya). Elephant (*Elephas maximus*) occasionally are seen in remnant forest patches attached to National parks bordering Mysore area (“Mysore Nature-Mysore Nature”, 2016). Figure 2.1 shows the map of Mysore district in India.

In general, Mysore receives an average rainfall of 761.9 mm and monsoon season last for about 5-6 months from May end to September end. Most of the rainfall in Mysore area occurs between April to November and October is the rainiest month. The summer season lasts for about three months from March to May end, and the dry spell is from December to February. Mysore climate is often moderate, and the mean monthly temperature ranged between 11 °C and 38 °C. However, the average rainfall during the study period was 782 mm in 2011-12 and 491 mm in 2013. The study area mostly comprised coconut, chiku, litchi, mango farms & ragi & rice fields, varying according to seasons (“Mysore Nature-Mysore Nature”, 2016). Figure 2.2 shows the range of study group in Utaranhalli, Mysore.
Figure 3.2: Range of study group in Utaranhalli, Mysore
Research design and study period

This study entitled “PI patterns in relation to dominance status in bonnet macaque (Macaca radiata)” is an observational field study. The study was conducted for the period of 18 months between November 2011 and April 2013 covering two breeding seasons. The habituation and identification of animals took around two months; hence, the actual period of study was 16 months from January 2012 to April 2013. I collected total 2,102.6 hours of data out which only 1,995 hours of data is used for the purpose of analysis. My group was mainly a provisioned group. An individual household in the area used to provision the group three times a day: Morning, afternoon and evening. I surveyed the groups inhabiting the roadsides around the city of Mysore and collected data on demography and group composition of bonnet macaques. Afterward, the Bonnet macaque group inhabiting Utaranhalli, Mysore was selected for collecting data. I selected this particular group because the central part of my observations was infant, both in mother-infant pair and in adult male-infant pair. The group was provisioned and was well habituated to humans already, the proximity provided by the group started almost from zero distance after the group was habituated. However, I maintained a distance of minimum 1m for taking data on their behavior, since the group itself was well habituated to humans, usually juveniles and sub-adults use to come very close to explore, but I did not play, feed, touch or responded to animals.

Procedure and observational methods

To start, I habituated my study group for my presence and identified each of them individually with the help of natural marking such as relative body size, nipple color and size, facial structure and marks (scars, shape and face color). It took almost two months to habituate the group. Initially, all the animals were named based on the
identification mark. Later, the adult males were named as M followed by the numbers, such as M1, M2, M3, etc. Likewise, the adult females were named as F followed by the numbers. Infants were named after adding ‘I’ next to their mother’s name. I did not take data on juveniles and sub-adult males. The study group comprised 62 animals at the beginning of the study including six adult males, seventeen adult females, ten sub-adult males, fifteen juvenile females, and fourteen juvenile males (all the infants of the previous breeding season were included in juvenile groups). I recorded birth of 25 infants during the study period but due to split in the group and infant death/disappearance, the original group was downsized to 48 consisting of four adult males, eight adult females, twelve juvenile females, nine juvenile males, and fifteen infants by the end of April 2013. Adult males were defined as an animal \( \geq 5 \), adult females as \( \geq 3 \), sub-adult males as 3-5 years and juveniles as 1-3 years (Singh et al., 2011). The infants were defined as the animal less than 15 months of age for the present study. The infant was considered dead when no longer seen.

I constructed a specialized ethogram of behaviors specific to my research question. An ethogram is a detailed and complete description of the behavior or action patterns of a species (Tinbergen, 1963). I observed and recorded all the behavior or activities performed by the animals of my study group. I specifically recorded the details of all the behaviors of mother-infant pairs and male-infants pair of previous season infant to construct the catalog of behaviors from my initial observation. I listed all the behaviors performed, then categorized, and defined these behaviors to observe objectively. Further, I kept adding behaviors to the ethogram as new behavior came to my observation during infants’ interaction with mother and adult males. I did this part of my study together with the habituation and identification of the group in the initial
two months. I categorized behavioral activities into three major categories: General behaviors, maternal investment behaviors, and paternal investment behaviors.

General behavior: It included feeding, drinking, foraging (the time spent on cleaning and removing food coverings, searching and catching of insects, which included scratching, breaking and removal of bark etc.), passivity (resting and sitting), locomotion (travel), self-groom and social behaviors (including grooming, play, agonistic interactions, sexual interactions, etc.).

Maternal investment behavior: A set of behaviors including nipple contact, body contact (duration of time mother carrying infant on back or ventrally and infant playing on the body of mother), punishment (weaning: mother threatening or biting infant, turning away when infant makes nipple contact) and grooming (mother cleaning and manipulating infants fur) were considered as maternal investment behavior. Under maternal investment, the behaviors were divided into direct and indirect investment. The duration of nipple contact, punishment and inter-birth interval (number of months elapsed between two successive birth) were the criteria considered under direct investment, whereas grooming and body contact were indicators of indirect investment. I had also recorded the distance between mother and infant from 1m to 5m. However, it was an effective measure in case of males, but with respect to their mother, it did not come as an effective measure because most of the time infants were either in body contact or were at a distance more than 5m. Thus, I exclude this behavior from the analysis.

Paternal investment behaviors: Adult male directed behaviors towards infant such as body contact (males ventrally carrying infants or in body contact), proximity (male and infant in less than one meter distance), grooming (male cleaning and manipulating infants fur), tolerance (male and infant in distance more than one meter
to less than five meters), affiliation (males showing any kind of caring behaviors such as patting; holding, huddling) and agonistic behaviors (it included behaviors such as male chasing, biting or threatening infant) as paternal investment behaviors. The investigator also considered male-female proximity (male and female sitting in less than 1 meter) as one of the parameters to see if it affects male-infant proximity or interaction anyway. Moreover, to see whether male-infant interactions is merely a proxy of male-female proximity or they are independent of it.

I used two sampling methods to collect the data on the behaviors mentioned above: Focal animal sampling, and *ab libitum* sampling. I collected major part of my data using focal animal sampling (Altmann, 1974). This technique includes recording all occurrence of the activities/interactions or behavior performed by an animal for specific time period, which is called as sample period. The duration of sample period differs from species to species and habitat to habitat. In the present study, each animal was followed for the duration of 10 min, and during the observation sessions, occurrences and duration of all the general behaviors (such as locomotion, foraging, passivity, etc.) and behaviors specific to my study were recorded. The time spent in observing each animal was equalized by a matrix of observations taken on each individual. The matrix was maintained every fifteen days in case of maternal investment, whereas for paternal investment I maintained it every month. The sampling was done for adult females, adult males and all newborn infants. Juveniles and sub-adults were excluded from focal observations.

The data on male-infant and mother-infant distances were collected using scan sampling. In this sampling method, the observer records behavior of visible group members within a very short period of time at a predefined interval. It is a simultaneous sampling of all individuals in view (Altmann, 1974).
I collected data for establishing dominance hierarchy using opportunistic and *ad libitum* sampling (Altmann, 1974). In this method, behaviors and interactions are recorded as and when they occur without adhering to any specific method. I recorded total 1024 occurrence of dyadic agonistic interactions among group animals with their individual identities. Group interactions were not considered for establishing dominance hierarchy. The ranks of males and females were established using standardized method of Singh et al. (2003).

\[ h = \frac{12}{(n^3-n)} \sum_{a=1}^{n} [d_a - (n-1)/2]^2 \]

In which \(d_a = \sum_{a=1}^{n} P_a\)

\(h\) is the strength of hierarchy that ranges between 0 and 1.

\(P_a\) refers to the proportion of encounters won by an animal against another in a pair-wise encounter.

\(D_a\) is a product of a summation process based on the proportion of encounters won rather than merely the number of animals dominated by an animal.

According to the research question adult females are classified as high-rank females ‘HRF’, middle-rank females ‘MRF’ and Low-rank females ‘LRF’ (Bercovitch et al., 2000; Symington, 1987). This classification is based on the proximity of dominance rank on interval scale derived from the standardized method of (Singh et al., 2003). I did not categorize adult males as the number adult males were restricted to only four. Adult males were categorized as M1 (dominant and 1st rank), M2 (rank 2), M3 (rank 3) and M4 (rank 4).

The present study has followed all the ethical guidelines put forward by the Government of India and University of Mysore, Mysore.
Life-History Traits and group composition

The data on life history traits and group composition were obtained by collecting information on the following parameters: number of animals, number of male, female, juvenile and infants, birth rate, mortality rate, number of young born in a litter, inter-birth interval, male-female ratio, male-infant ratio, female-infant ratio and birth sex ratio of bonnet macaque.

Ranging

Bonnet macaques occupy smaller home ranges and often do not show seasonal variation in their ranging behavior. Hence, I kept a record of all the locations where the group was feeding and was frequently seen over the period of time. The group use to visit similar areas showing some variations on weekly basis and monthly basis. I recorded GPS points of the group locations where the group uses to visit at the finishing stage of study using Garmin etrex 20 GPS unit. I connected these GPS points of the group locations at the edges to calculate home range and its area by Q GIS software. The total area which the study group was ranging is 0.39 Sq. Km.

Statistical analysis

The data was analyzed using Microsoft Excel and SPSS 20. For most of the behaviors, we calculated percentage to equalize the data and compared different rank classes. To test whether the difference between the groups on the specified behaviors, was real or due to chance a normality test was performed. The alpha level for all statistics performed was kept 0.05.