CHAPTER 4

RESULTS

In this section, I report the results of my study according to the objectives mentioned. I converted all behaviors into percentage before analyzing the data and used appropriate statistics as required. I performed normality test for maternal behavior investment. Whereas data for paternal investment behaviors was not normally distributed, hence I used non-parametric test as required. I used chi-square to compare different ranks classes. The details of statistical test performed have been given next to the relevant analysis.

Group composition

The study group comprised total 62 animals at the beginning of the study and 48 animals at the end of study. In the first breeding season and before group split, adult male: adult female, adult: infants, adult males: infants and adult female: infants’ ratio was 1:2.83, 1:0.56, 1:2.16, and 1:0.76 respectively. Birth sex ratio of adult females: immature and adult male: infant was 1:0.88 and 1:2.5 respectively. Adult male: adult female, adult: infants, adult males: infants and adult female: infants’ ratio after group split in second breeding season was 1:2, 1:0.5, 1:1.5, and 1:0.75 respectively. The ratio among different age class did not vary a lot after group split. The birth rate of bonnet macaques from the data obtained during two successive breeding season was 0.30 infants/female/two successive breeding season. All births were observed between January and May. I observed 4 mortality cases. Two were sub-adult males and two of them were infants (two animals/year). Fourteen females gave consecutive birth, whereas one female did not reproduce in the second years and two did not reproduce in the first year of study period. During the study period, many
male dispersal activities were noted. Many sub-adult males dispersed and left the group. Following group split two adult males, nine adult females left the main group and a sub adult male took over the second group. Table 4.1 presents the group composition before and after the group split.

**Table 4.1: Group composition of the group before and after group split**

<table>
<thead>
<tr>
<th>Group composition</th>
<th>Before group split</th>
<th>After group split</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At the beginning</td>
<td>After birth of infants</td>
</tr>
<tr>
<td>Adult males</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Adult females</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Juveniles (male and female) and sub adult males</td>
<td>39</td>
<td>39</td>
</tr>
<tr>
<td>Infants / immature</td>
<td>-</td>
<td>15</td>
</tr>
<tr>
<td>Total number of animals</td>
<td>62</td>
<td>75</td>
</tr>
</tbody>
</table>
Maternal PI pattern in relation to dominance rank and sex of the offspring

To inspect the maternal PI patterns, the investigator analyzed data on the following objectives. (i) Dominance status of female in the group. (ii) Sex of the offspring born or sex ratio. (iii) Suckling frequency and duration, measured in nipple contact made by infants. (iv) Frequency and duration of weaning behaviors—this was measured in terms of punishment. (v) Socio positive—this is reported as grooming and body contact behavior because females often did not play with their infants except for one primiparous female, (vi) Socio negative (agonistic) behaviors—punishment and (vii) inter-birth interval. The *ad libitum* observation of behavioral pattern of the group member related to weaning is also mentioned at the end of analysis of maternal PI pattern. All the analysis are done on high-rank females, and middle-rank females due to constraints of group structure as mentioned above that low-rank females did not reproduce even a single son. However, details of investment on female infants by low-ranking females have been provided at the relevant places.

Dominance status of the female in the group

The ranks of females were established using a standardized method of Singh et al. (2003). Adult females were classified as high-rank female, middle-rank females, and low-rank females based on the proximity of scores on their interval scores obtained. Ranks were calculated for both before and after the group split. However, for the purpose of analysis ranks before group split has been used since group became relatively stable at the end of study period. Figure 4.1 represents the dominance ranks of adult females on interval scale before group split. And figure 4.2 represents the dominance rank of adult females on interval scores after the group split at the end of study period when the group was more or less stable.
Figure 4.1: Dominance ranks of adult females on interval scale before group split

Figure 4.2: Dominance ranks of adult females on interval scale after group split
Sex ratio and inter-birth interval

Total 25 infants were born during the study period covering two breeding seasons. High rank females produced 3 (12%) sons and 4 daughters (16%), middle rank females produced 8 (32%) females and 3 (12%) male infants, whereas low rank females gave birth to 7 (28%) daughters but did not reproduce even a single son (Figure 4.3). The number of male and female offspring born to females of the different rank class did not vary significantly ($\chi^2=3.64; \text{df}=2; p \geq 0.05$). The inter-birth interval for first male and female infant did not vary in case of same rank class females, whereas overall inter-birth interval of high-rank females irrespective of the sex of infant was (13.5 months) higher than the inter-birth interval of middle-rank females and low-rank females (11.6 months). Table 4.2 represents the IBI for all the 17 adult females in the study with their identities, dominance ranks, and sex of the first and second offspring.

Figure 4.3: Rank of mother and the number of male and female offspring born to high-rank females (HRF), middle-rank females (MRF) and low-rank females (LRF)
Table 4.2: Female ID, rank, sex of offspring and her inter-birth interval (IBI)

<table>
<thead>
<tr>
<th>Female ID</th>
<th>Rank</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; infant</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; infant</th>
<th>IBI (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>1</td>
<td>NB</td>
<td>F</td>
<td>-</td>
</tr>
<tr>
<td>F2</td>
<td>2</td>
<td>F</td>
<td>CNF</td>
<td>-</td>
</tr>
<tr>
<td>F3</td>
<td>3</td>
<td>M</td>
<td>M</td>
<td>14</td>
</tr>
<tr>
<td>F4</td>
<td>4</td>
<td>M</td>
<td>CNF</td>
<td>-</td>
</tr>
<tr>
<td>F5</td>
<td>5</td>
<td>F</td>
<td>F</td>
<td>13</td>
</tr>
<tr>
<td>F11</td>
<td>6</td>
<td>F</td>
<td>LG</td>
<td>-</td>
</tr>
<tr>
<td>F6</td>
<td>7</td>
<td>F</td>
<td>M</td>
<td>11</td>
</tr>
<tr>
<td>F12</td>
<td>8</td>
<td>F</td>
<td>LG</td>
<td>-</td>
</tr>
<tr>
<td>F13</td>
<td>9</td>
<td>M</td>
<td>LG</td>
<td>-</td>
</tr>
<tr>
<td>F7</td>
<td>10</td>
<td>NB</td>
<td>F(LG)</td>
<td>-</td>
</tr>
<tr>
<td>F8</td>
<td>11</td>
<td>F</td>
<td>F</td>
<td>13</td>
</tr>
<tr>
<td>F9</td>
<td>12</td>
<td>M</td>
<td>F</td>
<td>11</td>
</tr>
<tr>
<td>F10</td>
<td>13</td>
<td>F(died)</td>
<td>LG</td>
<td>-</td>
</tr>
<tr>
<td>F14</td>
<td>14</td>
<td>F</td>
<td>F(LG)</td>
<td>12</td>
</tr>
<tr>
<td>F15</td>
<td>15</td>
<td>F(died)</td>
<td>F(LG)</td>
<td>-</td>
</tr>
<tr>
<td>F16</td>
<td>16</td>
<td>F</td>
<td>LG</td>
<td>-</td>
</tr>
<tr>
<td>F17</td>
<td>17</td>
<td>F</td>
<td>F(LG)</td>
<td>13</td>
</tr>
</tbody>
</table>

Note: NB-no birth; CNF-could not follow; LG-left the group
Duration of nipple contact

The duration of nipple contact in the first fifteen days of infant’s age did not vary significantly for male (65.96±16.1) and female (61.11±4.37) offspring respectively in either of the rank class (t=.533; df=3; p >.05). However, irrespective of the sex of infant, the duration of nipple contact in the first fifteen days of age period of the infant was high for high-rank females (74.84%) than middle-rank females (56.68%) and low-rank females (56.70%) (Figure 4.4).

Figure 4.4: The duration of nipple contact in first 15 days of birth in high-rank females (HRF), middle-rank females (MRF), and low-rank females (LRF)

Further, the nipple contact continued until the birth of next infant irrespective of the sex of the first offspring born. Nevertheless, the entire duration of nipple contact for male infants (30.85%) was significantly higher (t=2.596; df=56; p<.05) than the total duration for female infants (18.18%) in high-rank females. In middle-rank females, the total duration of nipple contact also did not vary with respect to sex of the offspring (Figure 4.5).
Figure 4.5(a): Duration of nipple contact for male and female offspring measured at 15-days interval from birth in high-rank females (HRF)

Figure 4.5(b): Duration of nipple contact for male and female offspring measured at 15-days interval from birth in middle rank female (MRF)
Figure 4.5(c): Duration of nipple contact for female offspring measured at 15-days interval from birth in Low-rank females (LRF)

Suckling frequency

To examine this variable, the investigator analyzed and compared the number of time male and female infants of different rank class initiated nipple contact. Male and female infants of high-rank female initiated nipple contact about 25.29% and 19.27% of times respectively. Male and female infants of middle-rank females initiated nipple contact 14.85% and 11.81% of times respectively. Infants of low-rank females initiated nipple contact about 17.67% of times. High rank females’ male infant (.000 ±.000) initiated nipple contact significantly higher than female infants (.06±.07) (t=4.078; df=28; p=.01). Likewise, male infants (.47±.19) of middle-rank females also initiated nipple contact significantly higher than female infants (1.40±.52) (t=7.837; df=27; p=.01). Figure 4.6 presents the frequencies in the percentage of initiating nipple contact by male and female offspring measured at 15 days interval from birth in different rank class.
Figure 4.6(a): Frequencies in percentage of initiating nipple contact by male and female offspring measured at 15-days interval from birth in high-rank females (HRF)

Figure 4.6(b): Frequencies in percentage of initiating nipple contact by male and female offspring measured at 15-days interval from birth in middle-rank females (MRF)
Punishment

The pattern and duration of punishment varied highly among the different rank classes (Figure 4.7). In the case of high-rank females, the behavior of punishment towards female offspring began at the age of 6 months whereas for the male infant it began at the age of 7.5 months that is with the difference of almost 1.5 months. The total duration of punishment for female offspring (0.30%) was also significantly higher ($t=1.747$; $df=56$; $p<0.05$) than the male (0.04%) offspring. In the case of middle-rank females, punishment for male infants began at 4.5 months. For female infants and except for some occurrence of punishment in the first month itself, it began with the completion of 3.5 months. However, the total duration of punishment for the male infant (0.48%) was significantly higher ($t=1.824$; $df=39$; $p<0.05$) than the total duration of punishment for female infants 0.17%. Low-rank females also started punishing their female infants at the age of 3.5 months (Figure 4.7).
Figure 4.7(a): Duration of punishment for male and female offspring measured at 15-days interval from birth in high-rank females (HRF)

Figure 4.7(b): Duration of punishment for male and female offspring measured at 15-day interval from birth in middle-rank females (MRF)
Number of times infant received punishment

To analyze this variable, I had taken frequencies of punishment received by infants. The results of frequencies are bit different from the results of total duration in case of middle-rank females. Male and female infants of high-rank females received punishment 0.37% and 3.03% of times respectively. Male and female infants of middle-rank females received punishment about 4.13% and 1.27% of times respectively. Infants of low-rank females received punishment 2.29% of times. High rank females’ female infant (.34 ±.53) received punishment significantly higher times than male infants (.000±.000)(t=3.485;df=28;p=.02). However, male infants (.19±.28) and female infants (.19±.37) of middle-rank females did not differ significantly in the number times it received punishment. But in terms of duration, male infants’ received higher duration of punishment as explained in the above paragraph. Figure 4.8 presents the frequencies in percentage of punishment received by male and female offspring measured at 15-day interval from birth in different rank class.
Figure 4.8(a): The frequencies in percentage of punishment received by male and female offspring measured at 15- days interval from birth in high-rank females (HRF)

Figure 4.8(b): The frequencies in percentage of punishment received by male and female offspring measured at 15-days interval from birth in middle-rank females (MRF)
Figure 4.8(c): The frequencies in percentage of punishment received by female offspring measured at 15-days interval from birth in low-rank females (LRF)

Total frequencies of punishment and number of times an infant initiated nipple contact (INC)

As presented in figure 4.9, male infants of high-rank female initiated nipple contact about 25.29% of time, whereas, it received punishment only about 0.37% of time. Female infant of high-rank females initiated nipple contact 19.27% of time and received 3.03% of times punishment. Male and female infants of middle-rank females initiated nipple contact 14.85% and 11.81% of times, whereas received punishment about 4.13 and 1.27% of times respectively. Infants of low-rank females received punishment 2.29% of times and initiated nipple contact about 17.67% of times.
To analyze grooming patterns across different rank class and sex of the infant, I analyzed the grooming patterns in first 15 days of birth and for the total duration of grooming. Irrespective of rank and sex of offspring, all adult females started grooming their infants from the first 15 days of birth. The high rank females \((t=.146; \text{df}=56; p>.05)\) and middle rank females \((t=.642; \text{df}=39; p >.05)\) did not show any significant difference in the total duration of grooming. High-rank females spent 2.41% of time grooming their male infants and 2.05% of the time on female infants. Middle-rank females spent 2.86% of time grooming their male infants whereas 2.17% on females infants. In low-rank females, overall 1.74% of time was spent on grooming female infants (Figure 4.10).
Figure 4.10(a): Duration of grooming for male and female offspring measured at 15-day interval from birth in high-rank females (HRF)

Figure 4.10(b): Duration of grooming for male and female offspring measured at 15 days interval from birth in middle-rank females (MRF)
Body Contact

I examined body contact between mother-infant pair at two stages. First, I examined the duration of body contact in first 15 days of birth with respect to rank of the mother and sex of the infant. Irrespective of sex and rank of females, all male and female infants were in body contact with the mother for more than 90% cases throughout first 15 days age period of the infant. The total duration of body contact did not vary significantly within high rank females (t=.452; df=56; p>.05) and middle rank females (t=.929; df=39; p>.05) with respect to sex of offspring (Figure 4.11). However, after analyzing graphs two peaks in body contact of male infants in high-rank females was seen at 7 months and 9.5 months almost for 100% to 90% time spent in body contact respectively. This is probably the time nearing group split. Although there are not enough evidence but probably high-rank females provided selective protection to male infants during the fights of group split. Enough data is required to support this hypothesis.
Figure 4.11(a): Duration of body contact for male and female offspring measured at 15-days interval from birth in high-rank females (HRF)

Figure 4.11(b): Duration of body contact for male and female offspring measured at 15-days interval from birth in middle-rank females (MRF)
From the above analysis, it can be summarized that mothers do show bias in allocating direct maternal resource. High-rank females have invested differentially on the parameters, which were defined as the measure of direct investment in Chapter 3 and did not show any differential investment pattern in indirect measures of PI. Whereas our group structure did not let us predict the allocation of maternal resources in low-rank females, however, secondary sex ratio did not vary significantly, but high-rank females showed differential investment in direct measure of investment such as nipple contact and punishment. High-rank females did not differentiate in indirect measures such as grooming and body contact.

Except what I had hypothesized, the study also revealed some other information about investment patterns of middle-rank females. Middle-rank females also show differential investment on direct measures of parameters in male and female infants. However, the investment patterns of middle-rank female are not very clear. The present study could not examine the investment patterns of low-rank females, as the low-rank females did not reproduce even a single son during the study.
period. One important point came out as a subjective observation while following the group about the weaning strategy of the female bonnet macaque. However, it was not occupied by all the females almost 45% of females in the group occupied the same strategy to wean their infants. Rather than punishing the infants, females use to stay away from their infant for whole day on everyday basis for almost about few days to a week.

**Male PI pattern in relation to the dominance status of the mother and the sex of the offspring**

To examine male PI pattern, the investigator analyzed data on the following objectives. (i) Togetherness of adult male-infant-togetherness was measured in terms of body contact, proximity, and tolerance. (ii) Duration of grooming – here duration of grooming directed toward infants by adult males was taken as a measure. (iii) Duration of play-play was not taken as an independent variable rather after collecting data it was realized that play itself does not comprise a significant portion. Hence, play was taken as one of the components of affiliative behavior. Affiliative behavior included all the caring behaviors like patting, huddling, etc. directed towards infant and play with infant, and (iv) agonistic behavior. All the four factors were analyzed in context of sex of infants (male or female), female rank and male rank.

**Sex of Infant and male PI patterns**

M1 did not show any difference in the different behaviors of male care with respect to sex of the infants while M2 spent more time on grooming (Mann-Whitney U=487.500, p=.004), proximity (Mann-Whitney U=398.5, p=.01), showed higher tolerance (Mann-Whitney U=439.5, p =.04) and affiliation (Mann-Whitney U=503, p=.03) towards male infants than female infants. M3 also spent significantly more time in body contact (Mann-Whitney U=492, p=.02) and proximity (Mann-Whitney
U=306, p=.00) of male infants as compared to female infants. Unlike M2 and M3, M4 did not show any difference in various male care behaviors. However, the M1 spent more time in the proximity (Mann-Whitney U=399, p=.01) of male infant’s mother and M4 spent more time with the mothers of female infants (Mann-Whitney U=388, p=.007). Figure 4.12 shows the percentage of time spent by males with respect to sex of infant on different behaviors.

**Figure 4.12: Percentage of time spent by males with respect to sex of the infant on various behaviors of paternal investment**

![Percentage of time spent by males with respect to sex of the infant on various behaviors of paternal investment](image)

**Female rank and male PI patterns**

Figure 4.13 shows the percentage of time spent by males in male care behaviors on the infants of females of different ranks. Males spent more time in proximity with the infants of high rank female (7.78%) and middle rank female (7.90%) as compared to the infants of low rank female (0.98%) (Kruskal-Wallis \( \chi^2=10.59, df = 2, p =.005 \)). Males also showed more tolerance for infants of high rank female (7.88%) and middle rank female (7.67%) than low rank female (1.11%)
Males showed more affiliative behaviors towards the infants of high rank female (14.75%) as compared to the infants of middle rank female and low rank female (Kruskal-Wallis $\chi^2 = 6.719$, df = 2, p=.03). However, agonistic behaviors were more towards infant of low rank female (9.66%) and middle rank female (7.00%) as compared to high rank female (Kruskal-Wallis $\chi^2=10.201$, df = 2, p =.006). For grooming and body contact there was no significant difference with respect to the rank of the mother. In males, except M2, none of the males showed grooming which was largely directed towards male infant. Individual males also showed the different pattern of male care with respect to the rank of the mothers. The patterns of male care differed for high-rank female and middle-rank female, but it did not differ with respect to the infant of low rank female.

**Figure 4.13: Comparison of time in percentage spent by males on infants of high rank (HRF), middle rank (MRF) and low-rank females (LRF)**
High-rank female and individual male care patterns

M2 spent more time (1.38%) on grooming infants of high-rank female followed by M1 (0.08%), whereas, M3 and M4 did not spend any time on grooming infants of high rank female (Kruskal-Wallis $\chi^2 = 9.061$, df = 3, p = .02). M2 also spent more time (3.76%) in body contact with the infants of high-rank female, but M1, M3 and M4 did not show any such difference (Kruskal-Wallis $\chi^2 = 15.606$, df = 3, p = .001). M1 spent more time in proximity to the infants of high rank female (28.86%) followed by M2 (15.36%), whereas M2 and M3 did not differ significantly (Kruskal-Wallis $\chi^2 = 37.972$, df = 3, p = .00). M1 (22.03%) also showed higher tolerance than M2, M3 and M4 (Kruskal-Wallis $\chi^2 = 27.457$, df = 3, p = .00). M2 (1.22%) showed more affiliative behaviors as compared to M1, M2, and M3 (Kruskal-Wallis $\chi^2 = 10.089$, df = 3, p = .01). However, none of the males showed any significant difference in agonistic behavior towards infants of high rank female.

Middle-rank female and individual male care patterns

Individual males did not show any significant difference for grooming, body contact, and affiliative behaviors. However, M1 (25.74%) spent significantly more time in proximity to infants of middle-rank female too followed by M2 (14.85%), whereas M3 and M4 did not show any difference (Kruskal-Wallis $\chi^2 = 27.355$, df = 3, p = .00). M1 also showed higher tolerance (17.50%) for infants than M2, M3 and M4 (Kruskal-Wallis $\chi^2 = 19.343$, df = 3, p = .00). However, there was no significant pattern of affiliative behaviors, but M1 (0.16%) showed significantly higher agonistic behavior towards infants of middle rank female as compared to M2, M3 and M4 (Kruskal-Wallis $\chi^2 = 11.336$, df = 3, p = .01).
Male rank and male PI patterns

M2 spent significantly more time on grooming infants (16%) as compared to M1, M3, and M4 (Kruskal-Wallis $\chi^2 = 9.675$, df = 3, $p = .02$). M2 (11%) was also found to be in significantly more body contact with the infants as compared to M1, M3 and M4 (Kruskal-Wallis $\chi^2 = 12.675$, df = 3, $p = .005$). M1 showed more proximity with infants (8%) followed by M2 (5%), M4 (2%), and M3 (1%) (Kruskal-Wallis $\chi^2 = 65.051$, df = 3, $p = .00$). M1 (8%) also showed higher tolerance for infants followed by M2 (4%); M3 (3%) and M4 (1%) (Kruskal-Wallis $\chi^2 = 42.321$, df = 3, $p = .00$). For affiliative behaviors, M2 spent significantly higher time (14%) as compared to M1, M3 and M4 (Kruskal-Wallis $\chi^2 = 12.530$, df = 3, $p = .006$). However, males did not show any significant difference in patterns of agonistic behaviors. Figure 4.14 shows the percentage of time spent by different males on infants.

**Figure 4.14: Percentage of time spent by Individual males on Infants**
It can be summarized from the above analysis that adult males do invest in infant. Nevertheless, adult males differ a lot on the patterns of investment according to their rank and sex of the infant and even on the rank of females. Alpha males showed bias towards the infants of high-rank female but did not show any differential investment concerning sex of the infants. Second and third rank males showed bias with respect to sex of the infant. Beta male showed differential investment in all the parameters (grooming, affiliative behavior, proximity, tolerance) of paternal PI and invested significantly higher in male infants than female infants. Third rank male also spent more time with male infants and showed more tolerance but did not invested in grooming and did not show any differential affiliative behavioral pattern with respect to sex or rank of females. Omega male did not show any specific pattern of investment; rather, it spent significant time in the proximity of low-rank females.