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THE INFLUENCE OF PARENTAL EXPERIENCE ON PARENT-INFANT INTERACTIONS IN THE COMMON MARMOSET, CALLITHRIX JACCHUS

A Thesis

Presented for the

Master of Science

Degree

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Christine M. McGowan

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ABSTRACT

This study focused on the effect of parental experience on parent-infant interactions in the common marmoset, Callithrix jacchus. Three mated pairs each of experienced and inexperienced parents were observed at the Marmoset Research Center in Oak Ridge, Tn. Observations began when the infants were born and ended when they were 4 months old. The behaviors of interest included: nursing, carrying, rejection, retrieval, and grooming of infants. The results from this study indicated the following: 1) Experienced females nurse infants more often than inexperienced females one week postpartum; 2) Both inexperienced males and females tend to carry infants more often than experienced males and females during weeks 1-4 and 5-9; 3) Experienced males and females tend to reject reject and retrieve infants more frequently than inexperienced males and females during weeks 1-4. After week 5 inexperienced males and females tend to reject and retrieve infants more frequently than experienced parents; and 4) Both experienced and inexperienced parents rarely groom infants during weeks 1-4. Grooming increases slightly after week 5, but no significant differences were found in relation to parental experience. Possible influential variables and future problems are also discussed in relation to this study.

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Chapter 1

Introduction

Parental care in any organism involves protecting, nourishing, and, in some cases, transporting offspring until they are capable of surviving on their own. The degree to which each parent is involved in caring for the young varies a great deal within and among species. The variability in parent-infant relations may be due to a variety of factors including prior parental experience. The influence of parental experience on variation in parent-infant interactions in the common marmoset, Callithrix jacchus, will be the primary focus of this thesis.

In many primate species, previous caretaking experience has proven to be an especially important factor in determining how male and female parents will respond to their own infants (Epple, 1975; Snowdon and Suomi, 1982; Cleveland and Snowdon, 1984; Nicolson, 1986; Tanaka, 1989; Tardif, in prep). Other studies of mammals (Carlier and Noirot, 1965; Salo and French, 1989) and birds (Brown, 1987) have suggested that adequate parental skills can be aquired by helping to rear offspring of other group members. Studies by Epple (1978) and Cleveland and Snowdon (1986) showed that experience gained through helping to raise younger siblings in marmosets, Callithrix jacchus, and tamarins, Saguinus oedipus, respectively, enabled them to learn how to care for their own offspring. Some of the causal reasons for why inexperienced

parents behave differently from experienced parents have relied on untested hypotheses and anthropomorphic interpretations of behavior. For example, Hooley and Simpson (1981) described primiparous Japanese macaque, Macaca mulatta, mothers as being "less confident and less excitable" than multiparous mothers. Ingram (1977) claimed that primates with little or no experience behave in a "clumsy or awkward" manner when caring for infants.

More careful, detailed studies have shown that patterns of parental care may vary between experienced and inexperienced parents. Parental behavior such as nursing, carrying, rejection and grooming of infants are frequently observed in marmosets (Stevenson and Poole, 1976; Arruda and Yamamota, 1986; Tardif et al., 1986). Studies in other primates have examined the effect of experience on duration of nursing, carrying, grooming and frequency of rejection and retrieval of infants. The following hypotheses have been derived from results of these studies.

1) Duration of nursing. Various studies have revealed that duration of nursing is influenced by maternal experience (e.g. Nicolson, 1986; Tanaka, 1989). Snowdon and Suomi (1982) found that, in cotton top tamarins, Saguinus oedipus, inexperienced females were unable to orient infants toward the nipple. Infants were often seen riding sideways across the female's abdomen or with its head toward the mother's genital region. Hafez (1971) discovered that primiparous macaque, Macaca mulatta, mothers may prevent infants from nursing because they are inexperienced and

have not learned how to properly nurse infants. Observations of chimpanzees, Pan troglodyte, suggest that inexperienced mothers nurse infants less often than experienced mothers (Yerkes and Tomilin, 1935). From these studies the following hypothesis can be made: experienced females allow infants to nurse infants more often than inexperienced females.

2) Carrying behavior. Sex differences in carrying behavior resulting from experience may or may not occur depending on various factors. For example, Mendoza and Mason (1986) examined parental division of labor in titi monkeys, Callicebus moloch, and found that fathers with first infants carried infants substantially less often than did fathers with prior experience. The opposite was true for mothers; multiparous females tended to carry the infant less often than primiparous females. Mendoza and Mason (1986) proposed that this sex difference was due to preferential affiliation between infants and the father and intolerance of prolonged contact by the mother. The results from this study indicate that duration of carrying differs between males and females and that their behavior changes as they gain experience with subsequent litters. Thus, the following hypothesis can be made: inexperienced females carry infants more often than experienced females and inexperienced males carry infants less often than experienced males.

3) Rejection and retrieval of infants. Researchers have demonstrated that prior experience will affect the frequency of

rejection and retrieval of infants. Frequent rejection of infants has been observed as being characteristic of inexperienced parents (Epple, 1978). Causal reasons for why inexperienced parents reject infants more frequently than experienced parents have not been tested. The effect of parental experience on frequency of retrieval has also been examined. Mendoza and Mason (1986) found that experienced parents retrieved infants more frequently than inexperienced parents. Hence, the following hypothesis can be made: inexperienced parents reject infants more frequently than experienced parents and, conversely, experienced parents retrieve infants more frequently than inexperienced parents.

4) Grooming behavior. Observations of parent-infant interactions suggest that prior parental experience affects duration of caregiving, such as grooming (Epple and Katz, 1983). Studies of parental care in chimpanzees, Pan troglodyte, indicate that inexperienced females groom their infants more often than experienced females (Yerkes and Tomilin, 1935). Seay (1966) found that multiparous rhesus monkeys, Macaca mulatta, tend to groom infants more frequently than primiparae. These studies show conflicting results and suggest that there is some interspecific variation in how primates care for infants; however, the results do indicate that there are differences between experienced and inexperienced animals in the amount of time that they groom infants. Thus, the following general hypothesis can be made:

the amount of time that infants are groomed may differ between experienced and inexperienced parents.

In this thesis, behavioral observations of captive common marmosets, Callithrix jacchus, are used to test these hypotheses. Marmosets are one of several species in the family Callitrichidae. Very few field studies have been done on marmosets and tamarins because of their small size, rapid movements, and thick habitat. The majority of data on these primates are from studies of captive animals. In general, callitrichid species may be characterized as having: no significant sexual dimorphism in body size or pelage, with average body weight ranging from 250 to 700 grams, depending on the species (Hershkovitz, 1977); a high reproductive rate compared with other primates, with females typically giving birth to twins and often producing two litters a year (Leutenegger, 1979); slow infant development and relatively delayed sexual maturity at around 18 and 24 months (Goldizen, 1986).

Gestation length ranges from 128 to 150 days and the combined weight of the young at birth may exceed 10% of the mother's body weight. According to Eisenberg (1978) and Pook (1984) the increased energetic drain on a lactating mother of such a small species probably selected for increased parental care by males and older offspring. Studies done on the energy requirements of cotton top tamarins, Saguinus oedipus oedipus, support this idea by showing that lactation presents a much greater demand for energy than pregnancy (Kirkwood and Underwood, 1984). Thus, it is

argued, marmosets are usually found in extended family groups with a monogamous pair as the nucleus. The male as well as older offspring assist the female in caring for the newborn infants. Infant caretaking primarily consists of carrying the infants on the upper back and shoulder portion of the caregiver's body. The carriers actively retrieve or reject the infants until they are fully ambulatory. The effect of parental experience on carrying, nursing, rejection and retrieval, and grooming of infants is the primary focus of this thesis.

The remaining chapters are organized as follows: Chapter 2 describes the animals used for observation, methodology for data collection, and statistical analysis used in the thesis. Chapter 3 presents quantitative results, and Chapter 4 is a summary and discussion of conclusions based on the empirical results.

Chapter 2

Methods

All behavioral data were collected at the breeding facility of the Marmoset Research Center, Oak Ridge Associated Universities, Oak Ridge, Tennessee between June and October, 1989. A total of 12 Callithrix jacchus adults from 6 groups were chosen for this study. Each group was housed in a 1m X 1m X 1.5m cage. All groups were visually isolated from each other by means of solid partitions or opaque screens (Figure 1). Environmental conditions such as temperature was controlled by a cooling system and the animals were fed twice a day, once in the morning and once in the afternoon. Because the doors to the breeder were kept open, humidity inside fluctuated with the conditions outside. The potential effect of this variable on the animals' behavior will be discussed in Chapters 3 and 4. Each cage contained only a mated pair and their infants. An important variable in assesing the role of experience is age. An attempt was made to control for this variable by selecting animals which were relatively close in age. Clearly, this is a potentially confounding problem for interpreting the results of this study and will be discussed in Chapter 4.

Adult animals were initially categorized in terms of experience based on breeding records: experienced animals had at least one prior breeding and successfully weaned infants while



Figure 1. Design of the breeding facility in the Marmoset Center in Oak Ridge, TN.

inexperienced animals had not been previously bred. The available breeding records did not include information about whether or not the parents had experience in rearing younger siblings; therefore, classifications refer to whether or not the male and female have weaned previous offspring (Table 1).

Each group of marmosets was observed for 30 minutes three times a week between 0800 and 1700 hours, a time period when the animals were most active (Kleiman, 1978; Goldizen, 1986). Observations began when the infants were born and ended when they were 4 months old. At this age they are completely weaned and independent of the parents (Hoage, 1982), an observation concurred in this work. A total of one hundred and fourteen observation hours were accumulated over a period of 120 days (Appendix A lists total duration, in minutes, and frequencies of behaviors observed for weeks 1-4 and 5-9). Continuous data were collected, during the 5 months of study, for 3 of the 6 groups. One of the experienced groups (cage 17B) was eliminated from the study after the fourth week due to death of the infants. A second experienced group (cage1A) was eliminated after the eighth week of observation due to sickness of both parents, subsequently attributed to pneumonia. The female in an inexperienced group (9B) died from an intestinal virus ten weeks into the study. Observations for this group were discontinued after her death. The remaining 3 groups were observed until the infants were 4 months old.

Table 1. Surviorship of previous offspring, infants observed and ages of the males and females in the six groups of Callithrix jacchus used for observation.

Cage	Previous Offspring (survived / total delivered)	Infants Observed (born/died)	Age(yrs) M	F
17B	8/12	2/2	10	10
9A	none	2/2	5	8
9B	none	2/2	8	6
26A	none	2/1	7	5
7B	2/3	2/1	6	6
1A	4/12	2/2	4	9

Observations were made from behind a 2m X 1m X .5m wooden blind placed 1m in front of the cage. Data are listed and defined in Table 2: nursing, carrying, retrieving and rejecting, and grooming. During each 30 minute session behaviors of both the male and female were noted. Observations were recorded using either check sheets and a stopwatch or a Hewlett-Packard 71-B hand-held computer programmed to function as an event recorder.

Statistical analysis included Mann-Whitney U tests on frequencies of rejection and retrieval, and repeated measures design on durations of nursing, carrying, and grooming of infants. Mean values for behaviors, of both experienced and inexperienced parents, were plotted on a weekly basis. Statistical methods used were chosen according to the type of data collected. For example, repeated measures design was used in comparing two different groups at specific points in time, or in detecting changes that occur over time (Neter et al., 1985). Because changes are expected when studying the development of infants, this method was deemed most appropriate. Mann-Whitney U tests were used in analyzing data on frequencies of rejection and retrieval. This is a nonparametric method which is appropriate when comparing the medians of two independent groups (e.g. experienced and inexperienced) and the probability distributions are unknown (Brown and Downhower, 1988).

Table 2. Definitions of behaviors of the adult male and female, Callithrix jacchus (from Cleveland and Snowdon, 1984).

Behaviors	
Category	Definition
Carry	-infant clinging with both hands and feet to some portion of the parent's body.
Reject	-parent actively pulling or pushing infant off of its body.
Retrieve	-parent picking up infant and allowing it to climb onto parent's body.
Nurse	-infant clinging to back or ventrum of female with its head positioned beneath her arm pit.
Groom	-parent using its hands to comb, pick or lick the fur of infant.

Chapter 3

Results

Statistical and graphical results are given for nursing, carrying, rejection and retrieval, and grooming behaviors during weeks 1-4, 5-9, and 10-16. These three time periods were chosen because there was a decrease in sample size after weeks 4 and 9. Previous observations of other callitrichid species (Cleveland and Snowdon, 1984; Tardif, in prep), and observations of my own, have indicated that these are time periods when behaviors such as nursing and carrying begin to decrease.

Nursing

Data pertaining to nursing behavior were analyzed using a repeated measure design with a 0.05 level of significance. Three F and p-values are given for each behavior studied (Tables 3 and 4). The first values refer to an overall difference between experienced and inexperienced males and females. The second values refer to whether or not the behavior changed over time and the third values refer to the interaction terms. During weeks 1 through 4 there was a significant difference between experienced and inexperienced females in the amount of time they allowed infants to nurse ($df=1, 4$, $F=10.57$, $p<0.05$). This difference was especially apparent during

Table 3. Statistical results for nursing, carrying, and grooming of infants during weeks 1-4. Degrees of freedom, F-values, p-values, and mean square error values are given for each behavior of both male and female, Callithrix jacchus.

Category	Df	Error Df	F-value	P-value
Nursing				
Exp vs. Inexp	1	4	10.57	<0.05*
Weeks	3		3.56	<0.05*
Interaction	3		1.73	>0.10
Carry-Males				
Exp vs. Inexp	1	4	1.58	>0.10
Weeks	3		2.63	<0.10
Interaction	3		1.30	>0.10
Carry-Females				
Exp vs. Inexp	1	4	1.31	>0.10
Weeks	3		0.71	>0.10
Interaction	3		0.69	>0.10
Groom-Males				
Exp vs. Inexp	1	4	1.59	>0.10
Weeks	3		1.17	>0.10
Interaction	3		1.17	>0.10
Groom-Females				
Exp vs. Inexp	1	4	0.0	>0.10
Weeks	3		1.53	>0.10
Interaction	3		1.07	>0.10

* Significant using an alpha level of 0.05

Table 4. Statistical results for nursing, carrying, and grooming of infants during weeks 5-9. Degrees of freedom, F-values, p-values, and mean square error values are given for each behavior of both male and female, Callithrix jacchus.

Category	Df	Error Df	F-value	P-value
Nursing				
Exp vs. Inexp	1	3	1.59	>0.10
Weeks	4		2.10	>0.10
Interaction	4		0.96	>0.10
Carry-Males				
Exp vs. Inexp	1	3	5.72	<0.10**
Weeks	4		6.63	<0.05*
Interaction	4		0.46	>0.10
Carry-Females				
Exp vs. Inexp	1	3	2.60	>0.10
Weeks	4		1.59	>0.10
Interaction	4		1.26	>0.10
Groom-Males				
Exp vs. Inexp	1	3	0.03	>0.10
Weeks	4		0.79	>0.10
Interaction	4		0.73	>0.10
Groom-Females				
Exp vs.Inexp	1	3	0.89	>0.10
Weeks	4		1.61	>0.10
Interaction	4		0.45	>0.10

* Significant using an alpha level of 0.05.
** Significant using an alpha level of 0.10.

week 1 (Figure 2). After this point the mean duration of nursing for experienced females dramatically decreased. For weeks 2, 3 and 4 there was no noticeable difference between experienced and inexperienced mothers. Statistical results also indicate that there was a significant change in the behavior over time ($df=3, 4, F=3.56, p< 0.05$).

Throughout weeks 5 through 9 there were no significant differences between experienced and inexperienced females. However, Figure 3 suggests that inexperienced females began to nurse infants more often than experienced females after week 5. This trend continued until week 7, when experienced females began to cease nursing. Inexperienced females dramatically decreased nursing between weeks 7 and 8. After this point they too ceased nursing. Nursing was not observed after week 9 for experienced or inexperienced females; therefore, statistical and graphical results are not presented for weeks 10-16.

Carrying

Repeated measures design was also used for analysis of data on carrying behavior of both males and females (see Tables 3 and 4). Males: There were no significant differences between experienced and inexperienced males in the amount of time they carried infants during weeks 1-4. Mean duration of carrying for inexperienced males fluctuated a great deal during this time period

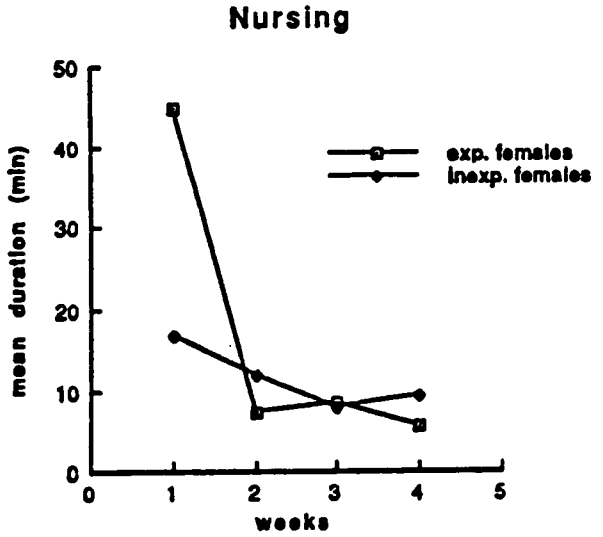


Figure 2. Mean duration of nursing for experienced and inexperienced female, Callithrix jacchus, during weeks 1-4. Mean duration per week is given in minutes.

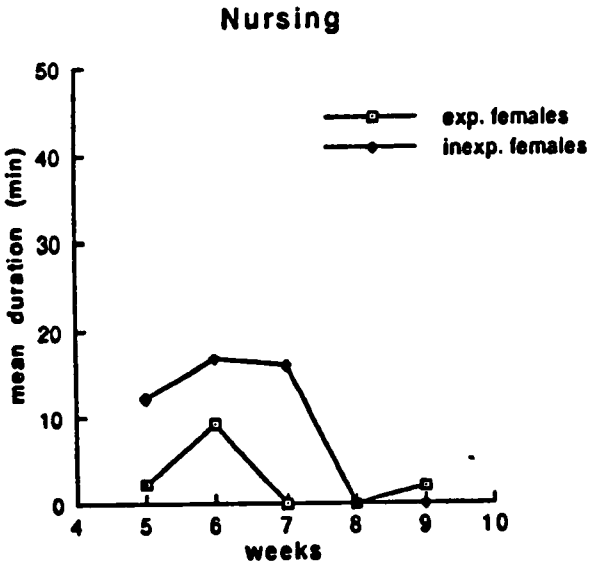


Figure 3. Mean duration of nursing for experienced and inexperienced female, Callithrix jacchus, during weeks 5-9. Mean duration per week is given in minutes.

(Figures 4 and 5 show mean duration of carrying for males during weeks 1-4 and 5-9). For experienced males, duration of carrying gradually increased until week 3, when it began to decrease. Overall, inexperienced males tended to carry infants more often than experienced males during weeks 1 through 4, though significance was only detected at the 0.10 level. This pattern continued throughout weeks 5 through 9. There was a significant change in carrying behavior during this time period for both experienced and inexperienced males ($df=4, 3, F=6.63, p<0.05$). Carrying began to decrease after week 5 (Figure 5). Experienced males stopped carrying infants after week 7, while inexperienced males carried infants beyond week 9. There were no significant differences detected at the 0.05 level during weeks 5 through 9; however significant differences were detected at the 0.10 level ($df=1, F=5.72, p<0.10$). Graphical results suggest that inexperienced males carry infants more often than experienced males.

Females: A similar pattern was observed for experienced and inexperienced females during weeks 1 through 4. There were no significant differences between experienced and inexperienced females; however, Figure 6 indicates that there was a tendency for inexperienced females to carry infants more often than experienced females (Figures 6 and 7 show mean duration of carrying during weeks 1-4 and 5-9). Mean duration of carrying decreased after week 2 for experienced females and after week 3 for inexperienced females. During weeks 5 through 9 there were no significant

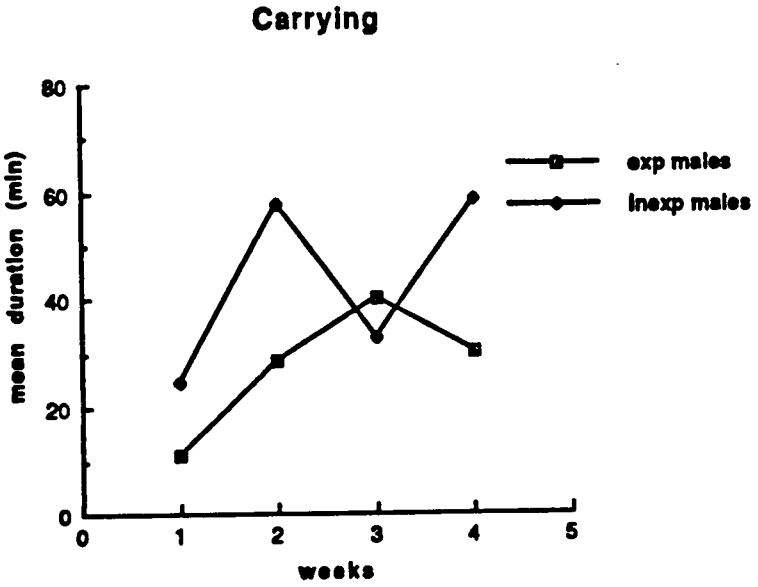


Figure 4. Mean duration of carrying for experienced and inexperienced male, Callithrix jacchus, during weeks 1-4. Mean duration per week is given in minutes.

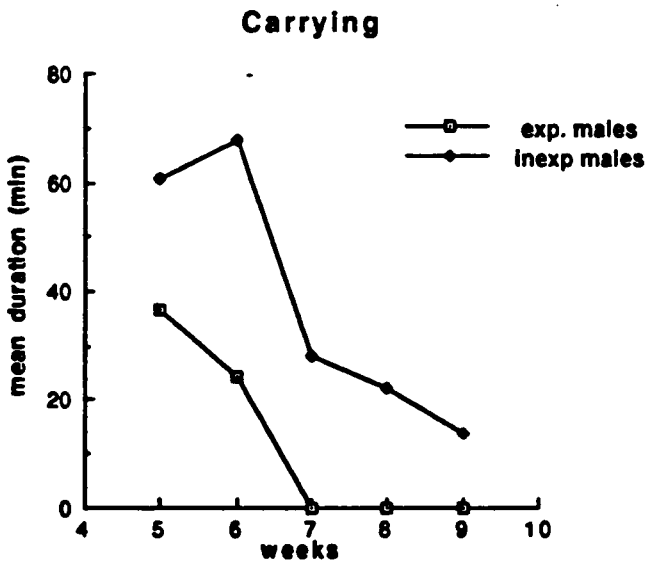


Figure 5. Mean duration of carrying for experienced and inexperienced male, Callithrix jacchus, during weeks 5-9. Mean duration per week is given in minutes.

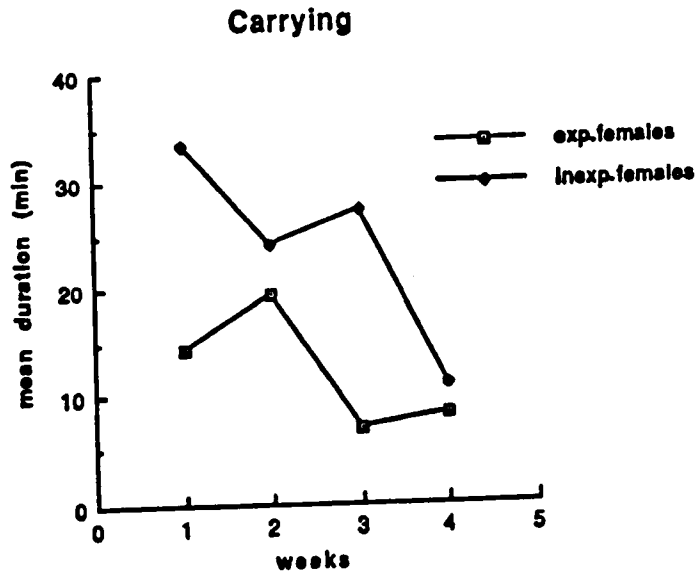


Figure 6. Mean duration of carrying for experienced and inexperienced female, Callithrix jacchus, during weeks 1-4. Mean duration per week is given in minutes.

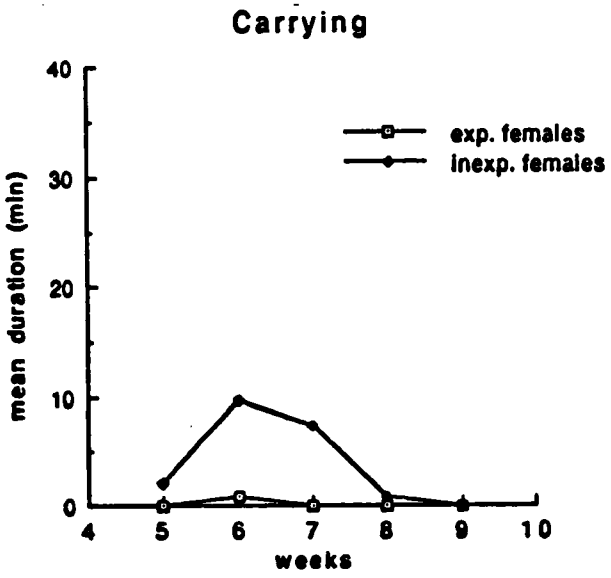


Figure 7. Mean duration of carrying for experienced and inexperienced female, Callithrix jacchus, during weeks 5-9. Mean duration per week is given in minutes.

differences between experienced and inexperienced females. Graphical results (Figure 7) reveal that inexperienced females continue to carry infants more often than experienced females. Infants of experienced mothers were rarely carried between weeks 5 and 7. After week 7 experienced females stopped carrying infants, whereas inexperienced females did not stop carrying infants until week 9.

Retrieval and Rejection

Frequencies of retrieval and rejection of infants, for both males and females, were analyzed with a Mann-Whitney U test ($p=0.05$). Statistical results for these behaviors are shown in Table 5.

Males: There were no significant differences between experienced and inexperienced males in frequency of retrieval of infants; however there was a tendency for experienced males to retrieve infants more frequently during weeks 1-4 (Figures 8 and 9 show mean frequencies of retrieval during weeks 1-4 and 5-9). Between weeks 2 and 4 the difference in mean frequencies of retrieval was very small. After week 5 inexperienced males began to retrieve infants more frequently than experienced males, but this difference was not significant. Statistical results indicate that experienced males were rejecting infants more frequently than inexperienced males during weeks 1-4 ($N=6$, $Z=1.85$, $p<0.10$).

Table 5. Statistical results for frequencies of retrieval and rejection of infants during weeks 1-4 and 5-9. Sample sizes (N), Z-values, and p-values are given for male and female Callithrix jacchus.

		Weeks 1-4	
Category	N	Z-value	P-value
Retreival			
Males	6	0.67	>0.10
Females	6	1.11	>0.10
Rejection			
Males	6	1.85	<0.10 *
Females	6	0.44	>0.10
		Weeks 5-9	
Retrieval	N	Z-value	P-value
Males	5	-1.48	>0.10
Females	5	-1.52	>0.10
Rejection			
Males	5	-0.29	>0.10
Females	5	-0.59	>0.10

* Significant using an alpha level of 0.10.

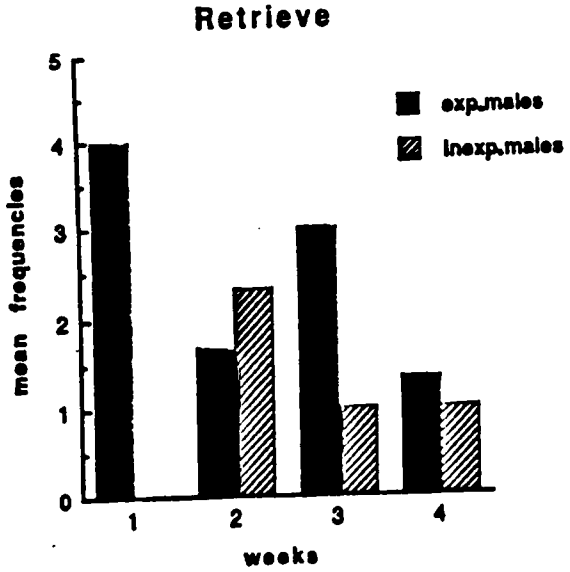


Figure 8. Mean frequencies of retrieval for experienced and inexperienced male, Callithrix jacchus, during weeks 1-4. The black bars represent experienced males and the striped bars refer to the inexperienced males.

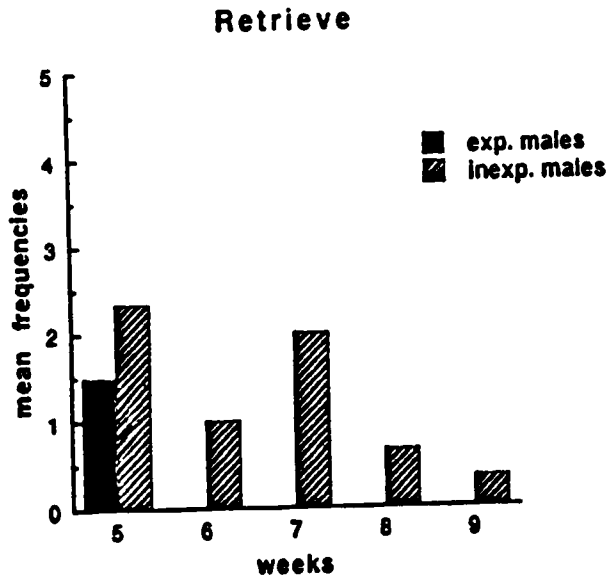


Figure 9. Mean frequencies of retrieval for experienced and inexperienced male, Callithrix jacchus, during weeks 5-9. The black bars represent the experienced males and the striped refer to the inexperienced males.

Inexperienced males were not seen rejecting infants during weeks 1 through 4 (Figures 10 and 11 show mean frequencies of rejection during weeks 1-4 and 5-9). This pattern changed after week 6, when inexperienced males began to reject infants more frequently; however there were no statistically significant differences between the two.

Females: There were no significant differences between experienced and inexperienced females in frequency of rejection or retrieval of infants. Figures 12 and 14 suggest that experienced females tend to retrieve and reject infants more frequently than inexperienced females during weeks 1, 3 and 4. During week 2, inexperienced females began to reject and retrieve infants slightly more than experienced females. This pattern was very similar to that seen with the inexperienced and experienced males.

Between weeks 5 and 9 there also were no significant differences between experienced and inexperienced females. Figures 13 and 15 indicate that inexperienced mothers began to retrieve and reject infants slightly more than experienced females after week 5. This continued until week 8, when both experienced and inexperienced females stopped retrieving infants. Rejection of infants continued until week 9, when experienced females began to reject infants slightly more than inexperienced females.

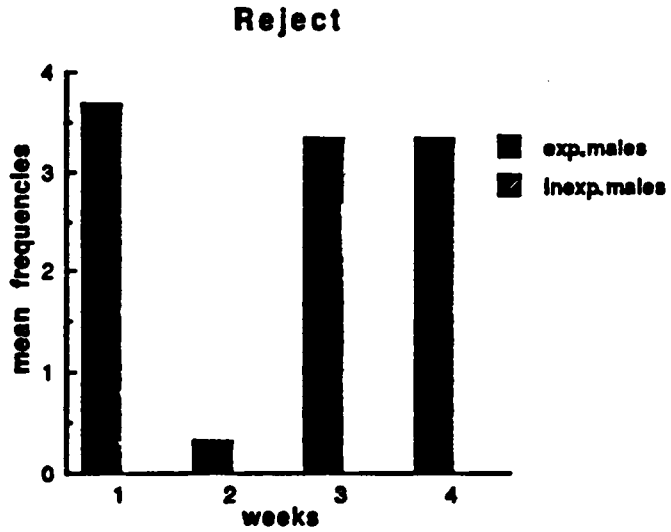


Figure 10. Mean frequencies of rejection for experienced and inexperienced male, Callithrix jacchus, during weeks 1-4. The black bars represent the experienced males and the striped bars refer to the inexperienced males.

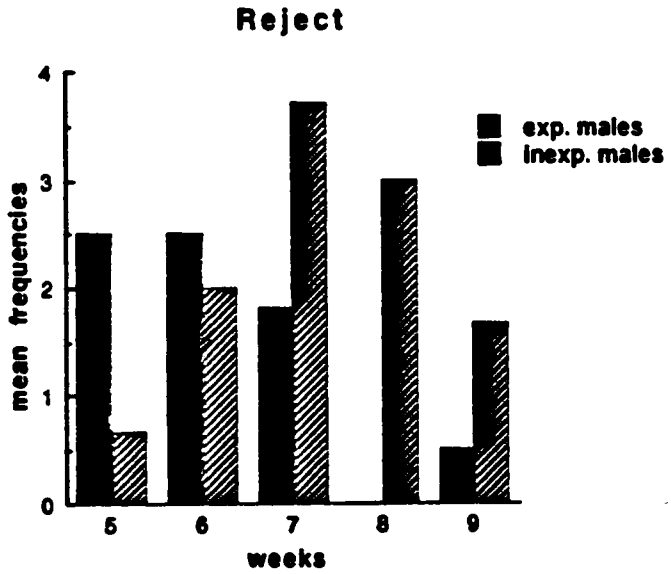


Figure 11. Mean frequencies of rejection for experienced and inexperienced male, Callithrix jacchus, during weeks 5-9. The black bars represent the experienced males and the inexperienced males.

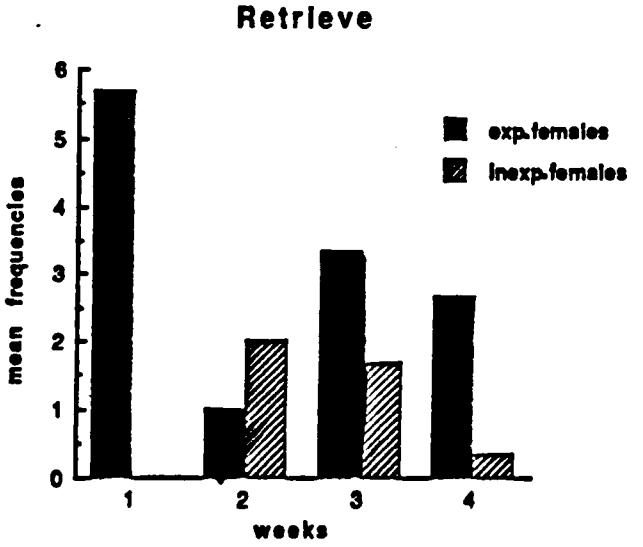


Figure 12. Mean frequencies of retrieval for experienced and inexperienced female, Callithrix jacchus, during weeks 1-4. The black bars represent the experienced females and the striped bars refer to the inexperienced females.

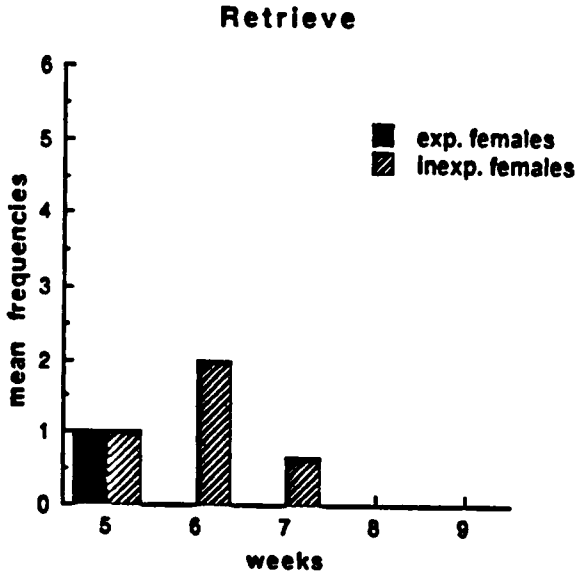


Figure 13. Mean frequencies of retrieval for experienced and inexperienced female, Callithrix jacchus, during weeks 5-9. The black bars represent the experienced females and the striped bars refer to the inexperienced females.

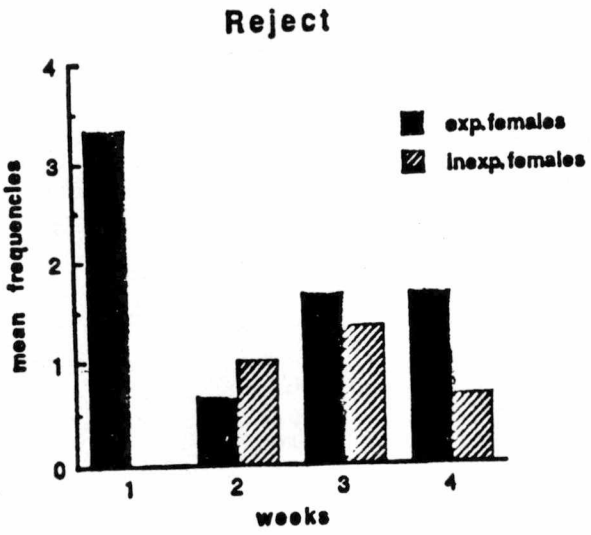


Figure 14. Mean frequencies of rejection for experienced and inexperienced female, Callithrix jacchus, during weeks 1-4. The black bars represent the experienced females and the striped bars refer to the inexperienced females.

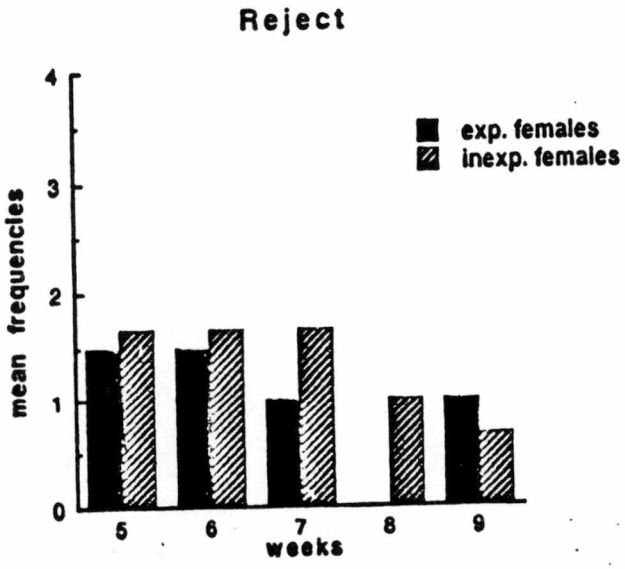


Figure 15. Mean frequencies of rejection for experienced and inexperienced female, Callithrix jacchus, during weeks 5-9. The black bars represent the experienced females and the striped bars refer to the inexperienced females.

Grooming

repeated measures design was again used for analysis of data on grooming behavior of both males and females (see Tables 3 and 4).

Males: There were no significant differences between experienced and inexperienced males in the amount of time that they groomed infants during weeks 1 through 4. Grooming of infants by experienced and inexperienced fathers was not observed very often within this time period. For this reason, grooming was not graphed for weeks 1 to 4. Duration of grooming increased after week 5, but there were still no significant differences between experienced and inexperienced males. Figure 16 indicates that inexperienced males groomed infants more often than inexperienced males between weeks 5 and 6. Grooming decreased after this point and there was not a noticeable difference between experienced and inexperienced males until week 8. At this time experienced males began to groom infants more often than inexperienced males.

Females: Similar results for grooming behavior were seen with females. No significant differences were found between experienced and inexperienced females during weeks 1 to 4. Because very little, if any, grooming was observed within this time period, graphical results are not presented. For weeks 5 through 9, some grooming of infants was observed, but there were no significant differences between experienced and inexperienced females. Figure 17 shows that inexperienced females groomed

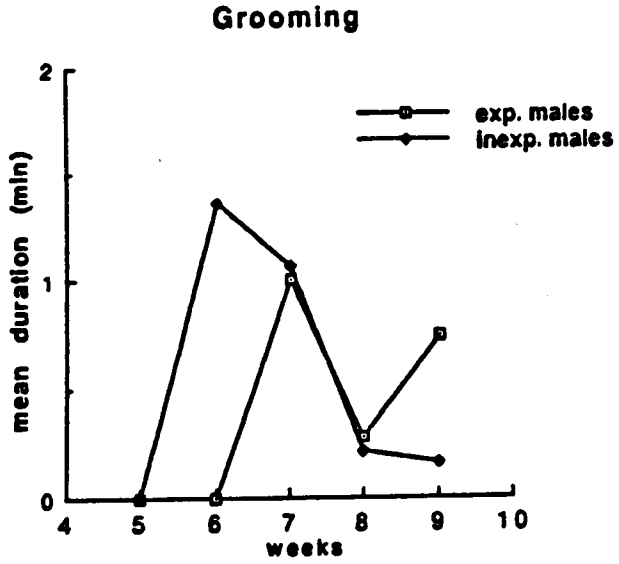


Figure 16. Mean duration of grooming for experienced and inexperienced male, Callithrix jacchus, during weeks 5-9. Mean duration per week is given in minutes.

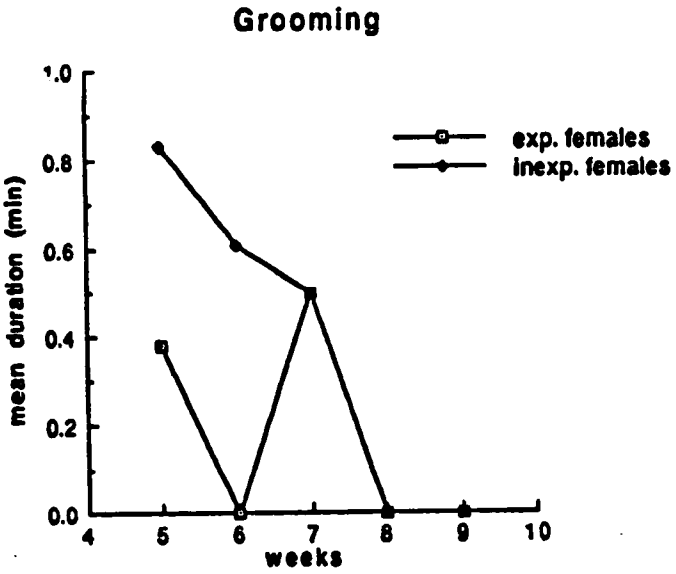


Figure 17. Mean duration of grooming for experienced and inexperienced female, Callithrix jacchus, during weeks 5-9. Mean duration per week is given in minutes.

infants more often than experienced females from weeks 5 to 7. A decrease in grooming was observed after week 7 and both experienced and inexperienced females ceased grooming infants after week 8.

Durations and frequencies of all behaviors decreased dramatically after week 10. The infants spent more time on their own and carrying, grooming, and retrieval of infants was rarely seen. Observations of rejection of infants were made, but they too were infrequent. Sample sizes for weeks 10 through 16 included one experienced group and two inexperienced groups. Due to such a small sample size and infrequent parent-infant interactions, analyses of data for weeks 10 to 16 are not given. Standard errors and median values for all behaviors suggest that there was a great deal of variability within and between groups of experienced and inexperienced animals (see Table 6).

Interactions Between Variables

Further analyses were made to determine possible correlations between duration of nursing, carrying, grooming and frequencies of rejection and retrieval. Because very little grooming was observed throughout this study, it seemed feasible that the animals were spending less time grooming infants and more time carrying, rejecting and retrieving infants. For females there were no significant correlations between grooming, carrying, rejection, retrieval, and nursing during weeks 1-4; however there

Table 6. Standard errors, means, and median values of nursing, carrying, grooming and retrieval, and rejection behaviors of experienced and inexperienced male and female, Callithrix jacchus.

	Weeks 1-4		
Category	Mean	Standard Error	Median*
Nursing			
Exp females	68.3	6.67	70
Inexp females	46.0	6.52	47
Carrying			
Exp males	108.8	13.06	135
Inexp males	194.5	8.53	193
Exp females	44.8	7.20	37
Inexp females	95.5	8.37	101.5
Retrieval			
Exp males	10	1.53	15
Inexp males	4.3	0.72	6
Exp females	12.7	1.20	9
Inexp females	4.0	0.97	3
Rejection			
Exp males	10.7	2.50	2
Inexp males	0.0	0.00	0
Exp females	7.3	1.50	3
Inexp females	3.0	1.06	2

Table 6 (Continued)

Category	Mean	Weeks 5-9 Standard Error	Median*
Nursing			
Exp females	13.9	1.56	13.5
Inexp females	43.1	3.83	36.3
Carrying			
Exp males	61.2	13.55	60.5
Inexp males	192.5	6.72	172.8
Exp females	0.75	0.50	.75
Inexp females	20.35	1.76	14.25
Grooming			
Exp males	2.0	0.45	2.03
Inexp males	2.8	0.86	0.5
Exp females	0.88	0.20	0.88
Inexp females	1.93	0.25	1.83
Retrieval			
Exp males	1.5	0.21	1.5
Inexp males	6.3	0.56	8
Exp females	1.0	0.00	1
Inexp females	4.0	0.62	3
Rejection			
Exp males	7.0	0.35	7
Inexp males	9.3	0.82	8
Exp females	5.0	0.54	5
Inexp females	6.7	0.43	8

* Median values for nursing, carrying, and grooming behaviors are given in minutes. Medians for retrieval and rejection are listed as frequencies.

was a positive correlation between rejection and retrieval of infants ($r=0.70$, $p<0.05$). During weeks 5-9, all behaviors except rejection and retrieval were positively correlated with one another (carry vs. rejection: $r=0.42$, $p<0.05$; carry vs. retrieval: $r=0.68$, $p<0.05$; carry vs. nurse: $r=0.72$, $p<0.05$; carry vs. groom: $r=0.48$, $p<0.05$; rejection vs. groom: $r=0.47$, $p<0.05$; rejection vs. nurse: $r=0.58$, $p<0.05$; retrieval vs. groom: $r=0.64$, $p<0.05$; retrieval vs. nurse: $r=0.68$, $p<0.05$; nurse vs. groom: $r=0.53$, $p<0.05$).

For males, there was a significant correlation between rejection and retrieval of infants during weeks 1-4 ($r=0.53$, $p<0.05$). No correlations were found between grooming, carrying, rejection and retrieval. During weeks 5-9, only carrying and retrieval of infants was positively correlated ($r=0.46$, $p<0.05$). The remaining variables were not significantly correlated. The results for these tests are listed in Appendix B.

Correlation tests between male behaviors and female behaviors were made to determine if there was division of labor in caring for infants. These tests showed that carrying behavior of males was negatively correlated with carrying behavior of females during weeks 1-4 ($r=-0.78$, $p<0.05$) and 5-9 (-0.73, $p<0.05$). No correlation was found between the remaining behaviors.

In order to determine the effect of humidity level on parental behaviors, correlation tests were made between this variable and carrying, rejection, retrieval, and grooming behaviors of both males and females. For females, no correlation was found

between humidity level and carrying ($r=-0.47$, $p<0.05$), rejection ($r=-0.20$, $p<0.05$), retrieval ($r=-0.22$, $p<0.05$), and grooming ($r=-0.24$, $p<0.05$). The same results were found for males.

Chapter 4

Discussion

The results for nursing, carrying, grooming, and rejection and retrieval of infants support of some of my original hypotheses and are in agreement with some of the conclusions made by Hafez (1971), Yerkes and Tomilin (1935), Epple (1978) and Mendoza and Mason (1986). The primary empirical results from this study may be summarized as follows:

1. Nursing: Experienced females nurse infants significantly more often than inexperienced females, one week postpartum. After week 5 inexperienced females begin to nurse infants more often. Infants of both experienced and inexperienced mothers are weaned by week 9.

2. Carrying: Both inexperienced males and females tend to carry infants more often than experienced males and females. Experienced males and females stop carrying infants after week 7 while inexperienced males and females continue to carry infants until week 9.

3. Rejection and retrieval: Between weeks 1 through 4 experienced males and females reject and retrieve infants more frequently than inexperienced males and females. After week 5 inexperienced males and females reject and retrieve infants more frequently than experienced males and females. Both experienced

and inexperienced parents decrease retrieval and rejection of infants after week 8.

4. Grooming: Both experienced and inexperienced males and females rarely groom infants during weeks 1 through 4. Grooming increases slightly after week 5, when inexperienced males and females groom infants more often than experienced males and females. In general, experienced and inexperienced parents spend little time grooming infants and more time carrying, rejecting and retrieving infants.

In general, patterns observed in weeks 1 through 4 changed during weeks 5 to 9. For example, experienced females nursed infants more often one week postpartum, but after week 5 inexperienced females began to nurse more often. This change indicates that inexperienced females may have been learning how to properly care for their infants, as found in studies of cotton top tamarins, Saguinus oedipus (Snowdon and Suomi, 1982; Cleveland and Snowdon, 1984). Adequate care of infants is especially important one week postpartum, when sick or weak infants usually die (Tardif, personal communication). The infants' chances of survival may be greatly influenced by the amount of time that the female allows the infant to nurse. Current records of the infants observed show that 1 of the infants in cage 9B and both infants in cages 9A, 17B and 1A died at ages of 1, 4, 4, and 3 months, respectively. It is unclear as to whether inadequate care contributed to the death of these infants.

Positive correlations between duration of nursing, carrying, rejection, retrieval and grooming, during weeks 5-9, suggest that nursing increases and decreases in direct proportions to other behaviors.

Similar changes in parenting were seen in frequencies of rejection and retrieval of infants. There was a general trend for experienced males and females to retrieve and reject infants more frequently than inexperienced males and females during weeks 1 through 4. As mentioned in Chapter 3, positive correlations were found between rejection and retrieval for both males and females during weeks 1-4. This indicates that frequencies of retrieval are directly related to frequencies of rejections. After week 5 both inexperienced males and females began to reject and retrieve infants slightly more than experienced males and females. Inexperienced males, in particular, did not begin to reject infants until week 5. During weeks 1 through 4 they may have been developing adequate parental skills. This change in behavior suggests that inexperienced parents may be learning how to interact with infants more effectively. Other studies of titi monkeys, Callicebus moloch, have indicated that with increased reproductive experience, parents become more effective in responding to infants (Mendoza and Mason, 1986).

The tendency for inexperienced males and females to carry infants more often than experienced males and females continued from week 1 through week 9. Experienced males and females

stopped carrying infants at week 7 while inexperienced males and females continued to carry infants until week 9. This indicates that experienced parents promote independence of infants at an earlier age than inexperienced parents. Prior studies (Tardif, 1986) have revealed that frequent rejection of C. jacchus infants promotes early independence. However, an insignificant correlation between frequency of rejection with duration of carrying indicates that this was not observed in this study. Lack of significance may have been due to the effect of a small sample size. Positive correlations were found between frequencies of retrieval for both males and females during weeks 5-9. This suggests that duration of carrying is directly related to frequencies of retrieval. Evidence of division of labor was also found from correlation tests between paternal and maternal behaviors. Duration of carrying by females was negatively correlated with duration of carrrying by males, which indicates that males and females compensate for the time that the other parent is not carrying the infants.

Grooming of infants by experienced and inexperienced parents was rarely seen during weeks 1 through 4 and only slightly increased after week 5. As mentioned in Chapter 3, no correlations were found between duration of grooming, amount of time spent carrying, and frequencies of rejection and retrieval by males; however positive correlations were found between duration of grooming, carrying, nursing, rejection and retrieval by females during weeks 5-9. This again indicates that grooming by females

varies according to durations and frequencies of carrying, nursing, rejection and retrieval.

Even though data were not collected on infant behavior one must consider that the infants' behavior directly affects the amount and kind of parental care received. Locke-Haydon and Chalmers (1983) claim that if we are to understand the development of caregiver-infant relationships we must discover the rules by which infants assess the amount of care they perceive themselves to have received and caregivers assess the amount of care they perceive to have given. Clearly this is an important idea that must be considered when studying parent-infant interactions.

Possible Influential Variables

A variety of variables, many of which could not be directly measured or controlled for given the duration of this study, may have influenced the patterns observed here. These variables include environmental conditions, age of the animal, presence of the observer, sample sizes, and duration and season of study. Each of these variables are discussed in relation to the results of this study. Environmental conditions such as temperature and humidity level were accounted for. Temperature in the research facility was controlled by an internal cooling system and did not rise above 88 ± 1 F. Thus, temperature was kept relatively constant during observation periods and consequently was not a salient variable, as found in previous studies (Tardif, 1986). During the months of

July, August, and September doors to the breeding facility were kept open; thus, humidity inside the facility did fluctuate with the humidity outside. As mentioned in Chapter 3, no correlation was found between humidity level and carrying, rejection, and retrieval.

As mentioned earlier, attempts were made to select animals that were relatively close in age. Because ages of the animals ranged from 4 to 10 years, parental behaviors of animals in age groups 3-4, 5-6, 7-8, and 9-10 were compared with each other. Due to small sample sizes statistical tests were not possible. Histograms of percent of time spent carrying indicated that there were no noticeable differences between the age groups. There was however one male in cage 1A which exhibited aberrant behavior by frequently rejecting infants and rarely carrying them. Originally, it was thought that this was a result of nervousness resulting from the blind. Observations made 1 year after this study was completed revealed that this was not a result of the blind because the male treated its next litter in the same manner when the blind was removed. My presence, as an observer, initially disturbed the animals for approximately 10 minutes at the outset of observations. In order to compensate for the time that the animals were attentive to the blind, observations continued for an extra 10 minutes. After the first week or two the animals became accustomed to my presence and less disturbed with the blind. The time in which it took the animals to become adjusted gradually diminished.

The sample size (three experienced and three inexperienced groups) used for this study decreased after weeks 4, 9, and 10 due to problems mentioned in Chapter Two. This was probably one of the main factors which may have affected the statistical results. Attempts were made to find other groups in the breeder that had newborn infants, but most of the animals had stopped giving birth midway through my study. In spite of this problem, results of the study still provide useful information.

Future Problems

This study has provided some pertinent information regarding the effect of parental experience on parent-infant interactions in the common marmoset; however, if the following changes or additions were made when designing a new study a clearer understanding of parental behavior in Callithrix jacchus might be obtained.

1. Increase in sample size. An increase in the actual number of animals used for observation and more frequent observations of each animal may provide more extensive data to obtain statistically significant results. Having a videocamera placed ouside each cage, 24 hours a day, may also be helpful in determining the exact times at which the animals are most active, as well as provide longer sample periods.

2. Select animals that have known history on experience in helping to rear younger siblings. As mentioned in Chapter Two, the

breeding records did not include information on the animals' experience or exposure to other infants. This information could be used to predict how the animals will respond to their own infants.

3. Include cages that contain not only the parents and infants, but also house related juveniles. Other studies (Box, 1975; Ingram, 1977; Locke-Haydon and Chalmers, 1983) have indicated that the presence of juvenile helpers affects the amount of time that the parents spend caring for infants. Comparisons between groups with and without helpers may give new insight as to how experienced and inexperienced parents respond to infants when others are present.

4. Cross species comparisons between common marmosets, Callithrix jacchus, and cotton top tamarins, Saguinus oedipus, both housed at the Marmoset Center, could be used to further investigate the effects of size, physiology, ecology, and communal care on different modes of parental care (sensu Tardif, 1986).

Most of these goals, if achieved, would add to the existing knowledge of parental behavior in callitrichids and provide a better understanding of the variables which influence parent-infant interactions. This study has offered some conclusions about the effect of parental experience on parental behavior in the common marmoset, Callithrix jacchus. These conclusions may be speculative, but can provide some basis for generating new hypotheses.

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APPENDICES

Appendix A. Data set collected for nursing, carrying, grooming, rejection and retrieval behaviors of all six groups of Callithrix jacchus used for observation. Total durations and frequencies are given for weeks 1-4 and 5-9.

Cage	Sex	Nurse (min)	Carry (min)	Reject	Retrieve	Groom (min)
			Weeks 1-4			
1A	M	___	16.5	29	15	0.0
	F	73.0	89.0	18	25	2.83
7B	M	___	175	1	1	0.0
	F	70.0	8.38	3	4	0.0
9A	M	___	183.0	0	1	1.0
	F	47.0	101.5	0	4	1.0
9B	M	___	207.5	0	6	0.0
	F	51.0	23.0	7	5	4.0
17B	M	___	135	2	14	0.0
	F	56.0	37.0	1	9	1.0
26A	M	___	193	0	6	8.0
	F	40.0	162	2	3	1.67
			Weeks 5-9			
1A	M	___	1.33	9	2	0.33
	F	5.0	0.0	3	1	0.76
7B	M	___	121	5	1	3.83
	F	22.8	1.5	7	1	1.0
9A	M	___	162.8	8	3	0.5
	F	15.0	8.0	3	3	0.5
9B	M	___	172.8	12	8	0.0
	F	36.3	38.8	9	6	3.5
26A	M	___	241.7	8	8	8.0
	F	78.0	14.2	8	3	1.8

Appendix B. Results from correlation tests for all behaviors of both male and female, Callithrix jacchus. Correlation coefficients and p-values are given for weeks 1-4 and 5-9.

Weeks 1-4 (males)

Category	Nurse	Carry	Reject	Retrieve	Groom
Nurse	-	-	-	-	-
Carry	-	1.0 0.0	-0.40 >0.05	-0.14 >0.05	0.27 >0.05
Reject	-	-0.40 >0.05	1.0 0.0	0.53* <0.05	-0.32 >0.05
Retrieve	-	-0.14 >0.05	0.53* <0.05	1.0 0.0	0.13 >0.05
Groom	-	0.27 >0.05	-0.32 >0.05	0.13 >0.05	1.0 0.0

Weeks 1-4 (females)

Nurse	1.0 0.0	0.01 >0.05	0.19 >0.05	0.29 >0.05	0.12 >0.05
Carry	0.01 >0.05	1.0 0.0	0.12 >0.05	0.21 >0.05	-0.17 >0.05
Reject	0.19 >0.05	0.12 >0.05	1.0 0.0	0.70* <0.05	0.05 >0.05
Retrieve	0.29 >0.05	0.21 >0.05	0.70* <0.05	1.0 0.0	0.08 >0.05
Groom	0.12 >0.05	-0.17 >0.05	0.05 >0.05	0.08 >0.05	1.0 0.0

Appendix B (Continued)

Category	Nurse	Carry	Reject	Retrieve	Groom
		Weeks 5-9 (males)			
Nurse	-	-	-	-	-
Carry	-	1.0 0.0	0.18 >0.05	0.46* <0.05	-0.21 >0.05
Reject	-	0.18 >0.05	1.0 0.0	0.06 >0.05	-0.35 >0.05
Retrieve	-	0.46* <0.05	O.06 >0.05	1.0 0.0	-0.16 >0.05
Groom	-	-0.21 >0.05	-0.35 >0.05	-0.16 >0.05	1.0 0.0
		Weeks 5-9 (females)			
Nurse	1.0 0.0	0.72* <0.05	0.58* <0.05	0.67* <0.05	0.52* <0.05
Carry	0.72* <0.05	1.0 0.0	0.42* <0.05	0.68* <0.05	0.48* <0.05
Reject	0.58* <0.05	0.42* <0.05	1.0 0.0	0.37 >0.05	0.47* <0.05
Retrieve	0.67* <0.05	0.68* <0.05	0.37 >0.05	1.0 0.0	0.63* <0.05

Appendix B (Continued)

Category	Nurse	Carry	Reject	Retrieve	Groom
Groom	0.52*	0.48*	0.47*	0.63*	1.0
	<0.05	<0.05	<0.05	<0.05	0.0

* Significant using an alpha level of 0.05.

VITA

Christine M. McGowan was born in Philadelphia, Pennsylvania on March 10, 1965. She attended elementary school in Lansdowne, Pennsylvania and graduated from Friends' Central High School, in Philadelphia, in June 1983. The following August she entered Guilford College in Greensboro, North Carolina, and in May 1987 she received a Bachelor of Science degree in Biology. In the summer of 1987 she began working for Ciba Geigy Co. as a technical analyst. One year later she accepted a teaching assistantship at the University of Tennessee, Knoxville, and received her Master of Science degree in Life Sciences in August 1990.