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RESEARCH ARTICLE

Cross-Genus Adoption of a Marmoset (*Callithrix jacchus*) by Wild Capuchin Monkeys (*Cebus libidinosus*): Case Report

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We report a case of interspecies adoption of an infant marmoset (*Callithrix jacchus*) by wild capuchin monkeys (*Cebus libidinosus*). The marmoset was an infant when it was first observed in the capuchin group on 3 March 2004. Since it first appeared it has been observed informally and frequently. In January 2005 systematic observations were made of the marmoset and a capuchin of similar age. Throughout its period of adoption the marmoset appeared to be socially integrated into the group, benefiting from nurturant behaviors exhibited by two successive adoptive ''mothers'' and pronounced tolerance from all members of the group. This case highlights the flexibility of both *Callithrix* and *Cebus* in accommodating variable social behaviors and other characteristics (including size) of social partners. Am. J. Primatol. 68:692–700, 2006.
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INTRODUCTION

The spontaneous adoption of an unrelated infant, which is described as the change in the role of primary caregiver from one individual (usually the mother) to another individual [Thierry & Anderson, 1986; Thierry & Herrenschmidt, 1985], is rather common in captive primates [Maestripieri, 2001], and several cases have been observed in tufted capuchin monkeys [Verderane et al., 2005]

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(Visalberghi and Fragaszy, personal observation). Although reports of adoption in the wild are rare, Maestripieri [2001] argued that the successful cases observed in the laboratory suggest that primate females have the potential to adopt unrelated infants. This challenges evolutionary theory because of the apparent extremely altruistic nature of the behavior [Avital et al., 1998]. Maestripieri [2001] proposed that adoption of an unrelated infant is an evolutionary maladaptive consequence of mechanisms selected to promote mother–infant bonding. Indeed, adoption has even been achieved between different species of primates in captivity (*Macaca mulatta* and *M. fuscata* [Owren & Dieter, 1989], and *Callithrix jacchus* and *C. penicillata* [Guerra et al., 1998]). In those cases it was pointed out that cross-fostering should be done between related species in order to avoid incompatibilities in milk composition and parental behavior [Guerra et al., 1998].

Here we report a case of intergenus adoption of an infant marmoset (Callitrichidae: *Callithrix jacchus*) by wild bearded capuchin monkeys (Cebidae: *Cebus libidinosus*). These two species differ substantially in size (adult weight = 3–4 kg for *C. libidinosus*, 0.350–0.450 kg for *C. jacchus*), ecology, and parental care [cf., Fragaszy et al., 2004a; Rylands & Faria, 1993]. Particularly relevant to this case is the fact that capuchins exhibit lengthy periods of maternal care, but do not coordinate feeding with infants by means of vocal signals as do callitrichids. Marmosets mature more quickly than capuchins, exhibit communal care, and show closer coordination of activities and spatial cohesion than do capuchins. The marmoset was first observed in the capuchin group on 3 March 2004 and was last observed on 3 May 2005, after it had lived with the capuchins for 14 months. We report informal behavioral data collected during the period of March 2004 to May 2005. To illustrate the extent to which the young marmoset and the capuchins interacted socially, and the extent to which the marmoset was integrated into the group, we present comparable systematic data on social partners and activities for the marmoset and for a young capuchin of similar age collected over a 1-week period in January 2005.

MATERIALS AND METHODS

Site and Subjects

The field site (9° South, 45° West) is a seasonally dry woodland (Cerrado) plain located near Gilbués, Piauí, Brazil. The plain is edged by sandstone and siltite ridges, and mesas rising approximately 20–100 m above the plain [Fragaszy et al., 2004b]. The study group's home range includes a biological reserve (Green Wing Valley-Serra da Água Branca) and private lands. The study group of 13 capuchins (two adult males, four adult females, four juveniles 1–4 years old, one infant 10 months old, and two infants born in January 2005) regularly visits a site where (primarily natural) foods are provisioned daily, as part of a program to develop ecotourism. The proportion of the group's diet obtained from provisioning is unknown, but foraging on these foods accounted for less than 5% of the monkeys' foraging activity in January 2005.

The adopted marmoset, a *Callithrix jacchus*, was first observed in the group on 3 March 2004. It was clinging to an adult female and behaved in a manner typical of a very young infant. Experts that viewed photos of the marmoset taken in January 2005 judged the individual to be less than 1 year old (A. Rylands and C.V. Santos, personal communication). Therefore, at the time of adoption in March 2004, the marmoset would have been no more than 2 months old. The marmoset (Fortunata, hereafter designated "F") and a juvenile capuchin (Piau, hereafter "P") were observed systematically in January 2005. P was first seen as

a neonate on the same day that F was first seen in the group, and thus P was 10 months old at the time systematic observations were conducted.

Observation Procedures

F was observed since it first appeared several times a week by the two individuals who provisioned the monkeys. These individuals noted who carried F, and general features of its behavior (e.g., occurrences of play or feeding). From 16 to 23 January 2005 the group was followed from morning until dusk, or until the group passed out of sight. A total of 42 hr of contact time with the group were achieved (mean = 5 hr per day, range = 3–8 hr). Instantaneous focal samples of each subject were collected at 30-sec intervals for 20 consecutive samples (a 10-min period, if no interruptions occurred), using an audible interval timer. We scored standard categories of behavior (see Table I). All neighbors within 2 m and the substrate used were recorded using the same interval sampling method. If the subject moved out of sight for one to five intervals, the observer resumed sampling when the individual reappeared. There was a 30-min interval between observation periods for the same infant. F and P were observed in alternation within each day. The order in which the infants were observed was alternated across days. Twenty-three and 22 sampling periods were collected for F and P, respectively. M. Verderane collected the data. The data were compared using Kruskal-Wallis (multivariable contrasts) and Mann-Whitney (pairwise comparisons) tests. Alpha was set at $P < .05$, two-tailed.

RESULTS

When F was first observed, it was clinging to an adult female capuchin (Chiquinha; see Fig. 1). Since that time F was always seen with the group when it arrived at the provisioning site, until 3 May 2005. No information is known about

TABLE I. Behaviors Observed in Similar-Aged Capuchin (P) and Marmoset (F) Subjects

	F		P	
Behaviors	♯ Intervals	%	♯ Intervals	%
Resting; stationary (includes autogrooming and scratching)	179	38.1	43	9.6
Locomotion	59	12.6	77	17.1
Feeding	131	27.9	250	55.7
Vocalize (outside of play or fighting)	33	7.0	2	0.4
Cling to a carrier	30	6.3	14	3.1
Suckling	0	0	3	0.7
Grooming	0	0	0	0
Social play	17	3.6	21	4.7
Solitary play	0	0	5	1.1
Observe another individual at close range	4	0.9	5	1.1
Explore the physical environment	0	0.0	0	0
Fight (includes threaten and chase)	0	0.0	0	0
Other behaviors	5	1.1	4	0.9
Out of view	12	2.6	25	5.6
Total	470	100.0	449	100.0

Fig. 1. A capuchin female carries an infant marmoset on her back. This picture (taken in May 2004) shows the first female observed nursing and carrying the marmoset. Photo by Pedro Lima (Fundação BioBrasil).

F's provenance, but wild marmosets are present in the home range of the capuchin group. The marmoset was observed to cling ventrally, dorsally, and transversely across the neck and shoulders of the carrier, as do young infant capuchins (Fig. 1), and in a ventral position (Fig. 2).

Chiquinha remained F's primary carrier and caregiver (see Fig. 3) from March until July 2004, when Dendê was observed carrying F. Chiquinha delivered an infant on 16 January 2005. Given that pregnancy lasts an average of 155–160 days in capuchins [Fragaszy et al., 2004b], she would have conceived a few weeks before she stopped carrying F. In any case, Dendê took on the role of primary caregiver for F in July 2004, and retained that role through January 2005. To our knowledge, Dendê did not lactate during this period because her youngest living offspring was approximately 3 years old, but in January 2005 F was observed in a nursing position with Dendê (0.2 events/10 hr of observation).

During ad libitum observations of F while we systematically followed the group in January, we observed that F occasionally clung to Dendê but more often traveled independently (see Table I). Dendê monitored F's movements and retrieved the marmoset (1.4 events/10 hr of observation) when alarm calls were given by capuchins, or when F lagged behind the group and vocalized insistently. Her success in retaining F was usually short-lived, since F would descend after a few seconds to travel independently.

F was clearly socially integrated into the group in some ways: it traveled and fed with the group, responded to alarm vocalizations given by members of the

Fig. 2. An adult female capuchin holds an infant marmoset in the nursing position. Photo taken by Jeanne Shirley in June 2004.

group (0.5 events/10 hr of observation), including participating in mobbing a snake, and played with various members (1.0 event/10 hr of observation). During bouts of social play with juveniles, the capuchins (which vastly outweigh the marmoset) adjusted the force of their movements to accommodate the marmoset's lesser weight and strength. This group of capuchins frequently cracks open palm nuts on anvils with stones at the study site [Fragaszy et al., 2004b]. F was

Fig. 3. A young marmoset taking food (cracked palm nut) from its adoptive mother's hand. Photo taken by Jeanne Shirley in June 2004. See also Shirley, 2005.

uniformly tolerated by the capuchins at close proximity as they cracked nuts, and often scrounged leftovers from other animals (0.25 events/10 hr of observation), including the dominant male (see Fig. 4). This situation fully resembles the common capuchin pattern of scrounging infants and tolerant adults [Ottoni et al., 2005].

However, in other aspects F was not perfectly adjusted to the capuchins' behavior. Three times, F was observed eating gum from trees–a common form of

Fig. 4. A marmoset is tolerated in close proximity by the dominant male of the capuchin group as he eats. Photo taken by Eduardo Darvin Ramos da Silva in January 2005.

feeding in marmosets [Rylands & Faria, 1993] that is not observed in capuchins. Capuchins can easily leap several meters from tree to tree. F could not leap such long distances and thus sometimes did not keep up with the group. Once, in January 2005, F was apparently left alone for 5 hr. F gave distinctive vocalizations for periods of many minutes while the capuchins cracked nuts, but the capuchins did not respond overtly to these vocalizations. In the end of April 2005, F was observed arriving at the provisioning site alone for 3 days, and after 3 May it was not seen again. F's age by the time of its disappearance was at least 14 months old (almost adult).

Compared to P, F maintained a different activity budget ($H = 99.74$, $df = 7$, $P < 0.001$). F rested proportionally more often than P (F = 37%; P = 10%; Dunn's test, $P < 0.001$), and P foraged more for natural foods than F (P = 54.6; F = 21.5; Dunn's test, $P < 0.01$). Both used trees more than ground or anvil surfaces (use of trees: F = 94%, P = 99%, $H = 47.65$, $df = 2$, $P < 0.001$). F vocalized during proportionally more samples than P (F = 7%; $P < 1\%$, $z = 2.28$, $P < 0.05$). P and F received equivalent amounts of maternal care ($H = 0.99$, $df = 3$, $P > 0.05$). P and F behaved similarly in terms of the proportion of samples spent in social or solitary play, or observing others at close range (Table I).

P was observed with nine different neighbors (including F) within 2 m on 118 samples. F was observed with nine different neighbors (including P) on 95 samples. Overall, P's neighbors were more evenly distributed across members of the group. For example, P's most frequent neighbors were the dominant male, its mother, and a juvenile male, and together these three individuals accounted for 60% of its neighbors. P's mother was its neighbor 23 times, and another group member was its neighbor 99 times. F's second adoptive mother, Dendê, was its neighbor 55 times, and other group members were its neighbor 40 times.

These distributions differed significantly from each other ($\chi^2 = 35.36$, df = 1, $P < 0.0001$).

DISCUSSION

This case of intergenus adoption by wild primates is unique. Given the enormous difference between these two genera in size, behavioral ecology, social organization, developmental trajectories, and patterns of infant care [c.f., Fragaszy et al., 2004a; Rylands & Faria, 1993], it is extraordinary that the marmoset was adopted by two successive females in the same group, and that the amount of maternal care received by the marmoset and a capuchin infant close to it in age did not differ. This suggests that the nurturant tendency supporting an adoption is present in wild adult female capuchins, as suggested by Maestripieri [2001] for female primates. This case of adoption also emphasizes the behavioral flexibility of the marmoset, because it behaved like an infant for a longer period than is the pattern in this species. *C. jacchus* are almost completely independent of all caregivers in their social group by 9–12 weeks of age [Santos et al., 1997].

Several proximate factors probably promoted successful adoption in this case. On the part of adult capuchins, general attraction to infants and strong tolerance toward infants are probably necessary preconditions. In capuchin groups, as in primates in general, young infants are the focus of strong filial interest on the part of others besides the mother, especially young females [Fragaszy et al., 2004a]. Attraction on the part of capuchins toward infants of other primate species (*Brachyteles* and *Alouatta*) has also been observed in the wild (Izar, personal observation). Food-sharing, an important component of parental care in marmosets [e.g., Ferrari, 1987; Santos & Martins, 2000], is also common in capuchins in the form of tolerated scrounging [Ottoni et al., 2005; Verderane, 2005]. Finally, the carrier of the infant probably incurred a minimal cost, given the small size of the marmoset relative to the capuchins, and the food provided for the animals. In addition, there must be a sufficient similarity between the behaviors of the infant marmoset and infant capuchins to permit adoptive behavior on the part of the adult capuchin to succeed. In this case the infant marmoset clung without support from the carrier, eventually was able to travel independently with the capuchin group most of the time, and nourished itself adequately while it remained with the capuchin group. Indeed, the comparison between the behaviors of the marmoset and the capuchin of similar age revealed differences in foraging behavior and ability to follow the group that could be related to the marmoset's disappearance from the group.

We recognize that other elements in this situation, and more generally in natural settings, may work against interspecies adoptions. In this study region capuchins spend most of their time in hilly forest, while marmosets usually frequent forest fragments in the plain and wetland areas, so there are few opportunities for interspecies interactions to occur. Moreover, in other regions capuchins prey on smaller primate species (e.g., *Callithrix penicilatta* (W.P. Martins, personal communication) and *Callicebus moloch* [Sampaio & Ferrari, 2005]). However, behavior toward another species as prey or a potential social companion is highly variable among mammals in general, and depends on a variety of local and experiential conditions [Kuo, 1930, 1938; Resende et al., 2004]. In the current situation, we know of nothing in the immediate ecological context or experience of this capuchin group that would make cross-species adoption likely, except that the group is provisioned. Provisioning may make the monkeys less sensitive to the energetic costs of adoption, and may also have

enhanced the chances of survival for the marmoset, since it foraged less often from natural foods than the capuchin of similar age. Because there are no other comparable cases to examine, we can draw no strong conclusions from this case.

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