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RESEARCH ARTICLE

A Preliminary Study of Food Transfer in Sichuan Snub-Nosed Monkeys (*Rhinopithecus roxellana*)

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Food transfer happens regularly in a few nonhuman primates species that are also characterized by remarkable social tolerance. Sichuan snub-nosed monkeys (*Rhinopithecus roxellana*), or golden monkeys, which exhibit high social tolerance in their social relationships are thus of interest to see whether tolerance would extend to food transfer. In this study, branch feeding activity was observed in a semi-captive group of Sichuan snub-nosed monkeys, which consisted of 10 subjects that included a one-male unit (OMU) and an all-male unit (AMU). We recorded 1,275 food interactions over 27 days, and 892 instances of food transfer. The most commonly observed types of food transfer behavior were co-feeding (62.1%) and relaxed claim (22.8%). Of 892 food transfers, 756 (84.8%) took place in the OMU, most of which were among adults (34.7%) and among juveniles (42.1%). The transfer success rate was high in both the cases (87.9% for adults and 78.9% for juveniles). Food transfer in the AMU took place less often than that among adults in the OMU though with similar high transfer success. Food transfer between the OMU and AMU was limited to juvenile males from the OMU and adults from the AMU. These results provide the first evidence of food transfer in golden monkeys and suggest that tolerant social relationships in golden monkeys make transfer possible. Am. J. Primatol. 70:148–152, 2008.

Key words: food transfer; social tolerance; Sichuan snub-nosed monkeys; *Rhinopithecus roxellana*

INTRODUCTION

Food transfer is particularly observed in nonhuman primates such as chimpanzees (*Pan troglodytes*), capuchins (*Cebus apella*), and Callitrichidae [e.g. Feistner & Price, 2000; Ruiz-Miranda et al., 1999; de Waal, 1989a, 1997], and all these species also exhibit remarkable social tolerance [Caine, 1993; de Waal, 1989b, 1997]. Social tolerance is important for highly social species to sustain stable long-term relationship. In species with high social tolerance, there is relaxed proximity and social rank accompanied by low intensity aggression. High tolerance also makes food sharing possible [Boesch C. 2003; de Waal, 1989b]. So the food-transfer primates are positioned at the extreme tolerant end of the despotism-tolerance continuum in primates' society.

Sichuan snub-nosed monkeys (*Rhinopithecus roxellana*), or golden monkeys, a species endemic to China, are of interest because of their extremely large groups with complex social organization. Golden monkeys live in groups of up to 341 individuals with a social system that usually consists of two basic units: the one-male unit (OMU) and the all-male unit (AMU) [Ren et al., 1998, 2000]. High social tolerance is indispensable to maintain stability in such a complex society. Ren et al. [1990] reported that affinitive behavior made up 86.4% of the social behavior in two OMUs in captivity, with aggression occurring at a low frequency of 7.3%. In the wild, aggressive behavior between OMUs mainly took the form of chasing and threatening, and biting was never observed [Li et al., 2006]. Staring at each other, a kind of bidirectional threatening behavior, was recognized as one part of the social behavioral repertoire of golden monkeys [Yan et al., 2006]. Therefore the high social tolerance of golden monkeys led us to explore whether their tolerance would extend to food transfer. The objective of our study is to give a preliminary description of the frequency

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and patterns of food transfer in captive golden monkeys.

METHODS

The subjects were a group of semi-captive golden monkeys housed at Shanghai Wild Animal Park located in the east of China. The sample consists of the same two basic units that are found in the wild, or an ''OMU'' and an AMU. This ensures that social interactions in the captive environment are similar to those that occur in golden monkey groups in the wild. In this study, the OMU included eight individuals: one adult male (labeled ♯5), two adult females (♯3 and her daughter ♯98-2), four juveniles, two of each sex (♯01-4, 4 years old, and ♯03-1, ♯03-2, and ♯03-3, each 2 years old), and a newborn infant that was ignored in the study. The AMU included three adult males (labeled DWB, ♯97-1, and ♯98-1, respectively) without kinship to the individuals in the OMU. All individuals could be recognized easily based on their size and appearance. The monkeys entered an outdoor enclosure of approximately 648 m^2 (24×27 m) at around 8:00 every morning, and at around 4:30 pm they returned to an indoor enclosure ($9.8 \times 5.8 \times 3.7$ m) until the next morning. The group was fed regularly at around 8:30 am, 1:00 pm, and 4:45 pm with freshly cut branches of privet. At around 10:00 am and 3:30 pm, chopped steamed bread, eggs, fruit, and eggplants were given to the monkeys. Water was available at all times.

This study was approved by the Peking University Institutional Animal Care Committee and the State Forestry Administration of China. All the observations were made by an observer (Z.Z). Branch feeding was chosen for the observation of food interactions from April 18 to May 16, 2005. The feeding process was recorded with a digital video camera (Panasonic NV-DS30EN, Matsushita Electric Industrial Co., Ltd., Osaka, Japan) by the observer, starting from the time when the attendant came into the outdoor enclosure and dropped the privet branches into four separate piles (one big pile for the OMU and three small piles for each adult male in the AMU). At the same time, the interactions that took place out of view of the camera were narrated by the observer onto the video tape. These observations were conducted approximately three times a day. The sessions that took place in the morning and in the early afternoon lasted from the time when the food was dropped into the enclosure to the time when the branches were almost eaten up or until food interactions were no longer happening, which took from 20 to 50 min. The session in the late afternoon lasted for approximately 5 min after the monkeys were fed because of the closing time of the Wild Animal Park. In total, 69 observation sessions were recorded over 27 days.

Data collection outside the food sessions was conducted with the scan sampling technique. Before and after the food sessions, the observer scanned the behavior of the ten subjects each minute and wrote down each individual's behavior in the following form: date/time/behavior type/behavior state/receptor/site. Each individual had 3,494 min of recorded behavior from April 18 to May 17, 2005, registered over 27 days. This information was used to determine the affinitive relationships and the order of social dominance in the group.

Food interactions were coded from the video records according to de Waal's (1989a) definition. In brief, food interaction was defined as an approach by a nonpossessor to a position that is within reach of a possessor, regardless of the duration of the subsequent association. A random sample of 457 (32.6%) of the food interactions was independently coded by another coder to assess interrater reliability. The κ coefficients of agreement for the behavior type of the claimer, behavior type of the possessor, and the different transfer results were 0.70, 0.71, and 0.65, respectively.

RESULTS

General Description of the Food Interactions

Overall, 1,275 food interactions were analyzed, after excluding 126 interactions either because of an unclear claimer/possessor relationship, or because the purpose of claiming was not food related. Specifically, 1,068 interactions took place in the OMU, 67 interactions in the AMU, and 140 interactions between the OMU and AMU. Food interactions were triggered by the claimer in six ways, which correspond to five states of food transfer (Table I).

TABLE I. Frequency of Food Interactions Initiated by Different Behaviors Corresponding to Different Food Transfer States

	States of transfer					
Claimer's behavior	y	yn	yuna	n	ny	Total
Food interest	0	0	0	5	54	59
Steal food	31	29	36	14	0	110
Collect near	77	4	5	8	0	94
Co-feed	554	13	10	38	0	615
Relaxed claim	203	29	0	67	0	299
Forced claim	27	56	0	15	0	98
Total	892	131	51	147[a]	54	1275

''y'', food transfer happens, possessor allows claimer's attempt; ''yn,'' food transfer happens, but results from the force used by the claimer despite the possessor's refusal; ''yuna'', food transfer happens, but the possessor is not aware of the claimer's behavior; ''n'', food transfer does not happen because of possessor's refusal; ''ny'', food transfer does not happen but possessor allows claimer's behavior, it happens when claimer just shows food interest without attempting to take it.

[a]In one instance, food transfer did not happen, but not because of the refusal from the possessor (♯03-3 relaxed claim food from ♯97-1, ♯97-1 hold ♯03-3, so there was no food transfer observed).

We defined food transfer as the claimer's collection or receipt of food, without resistance, from a possessor (corresponding to the ''y'' state of food transfer).

Food interactions that excluded those types of behavior in which the claimer simply showed interest and those in which the possessor was unaware of the claimer's behavior were defined as food–claim interactions. Food transfer behavior happened in 892 (76.6%) out of a total of 1,165 food–claim interactions. An individual's claims that resulted in food transfer signified transfer success. Co-feeding and relaxed claim were the two most common ways the monkeys used to obtain food from each other, representing 62.1 and 22.8% of 892 food–transfer interactions, respectively. Also, the transfer success was high when claimers used these two methods (90.1 and 67.9%, respectively) or the collect near method (81.9%). When claimers used stealing or forced claim, the transfer success dropped accordingly (28.1 and 27.6%, respectively).

Food possessors responded negatively to the claimers in 272 (23.3%) of the 1,165 food–claim interactions. However, claimers still received food in 131 (48.2%) of these interactions despite the possessors' resistance. Aggressive behavior, including driving the claimer away as well as grasping and hitting the claimer, occurred in only 47 (17.3%) of the 272 negative interactions. Fierce aggression, such as wrestling or biting, was not observed at all.

Food Transfer in the One-Male Unit

The details of 892 food–transfer interactions are shown in Table II, 756 (84.8%) of which took place in the OMU. Specifically, in the OMU, adults and juveniles usually received food from their peers (262 [34.7%]) and 318 [42.1%] of all transfer interactions in the OMU, respectively) and transfer success was high in both the cases (87.9 and 78.9%, respectively). Food transfers were less frequent between adults and juveniles (176 [23.3%] of all food transfers in the OMU) than transfers among adults and among juveniles. In addition, adults received food from juveniles more frequently than did juveniles from adults (Wilcoxon signed rank tests, $Z = -2.137$, $n = 12$, $P = 0.033$) and proportionally (Wilcoxon signed rank tests, $Z = -2.395$, $n = 12$, $P = 0.017$).

Co-feeding was common in all age categories, especially among adults and among juveniles in the OMU (Fig. 1). Relaxed claim was the predominant method by which adults obtained food from juveniles, though this method was also used by individuals in other age categories. Stealing was observed mostly in juvenile claimers, and was as common a method for them to get food from adults as co-feeding. Collect near and forced claim were less common than the other methods: collect near was approximately equally frequent in all categories; and forced claim was used (1) by adults who claimed food from juveniles, and (2) in transfers among juveniles.

Food Transfer in the All-Male Unit

Fifty-three food transfers were observed in the AMU, which was a much lower number of transfers than the number among adults in the OMU (Mann–Whitney U-tests, $U = 0$, $n_1 = 3$, $n_2 = 3$, $P = 0.05$), but transfer success in the AMU was as high as in the OMU (Mann–Whitney U-tests, $U = 2$, $n_1 = 3$, $n_2 = 3$, ns). Relaxed claim and co-feeding were the two most common transfer methods observed in AMU (Fig. 1). In contrast, in food transfer that was observed among adults in the OMU, co-feeding was the typical method.

Food Transfer Between the OMU and AMU

Seventy-six (91.6%) of the 83 food transfers between the OMU and AMU were observed between juvenile males in the OMU and adults in the AMU. Adults obtained food from juvenile males in 34 cases

TABLE II. Matrix of Food Transfer/Food–Claim Interactions Between Golden Monkeys

	Claimers										
Possessors	♯3	♯5	♯98-2	♯01-4	♯03-1	♯03-2	♯03-3	DWB	♯97-1	♯98-1	SUM
♯3	—	46/54	0/1	1/2	9/31	6/17	0/5	0/0	0/0	0/0	65/115
♯5	62/66	—	48/54	1/1	5/16	8/12	3/5	0/0	0/0	0/0	131/165
♯98-2	36/49	70/74	—	4/5	4/17	21/29	2/3	0/0	0/0	0/0	138/178
♯01-4	11/14	3/3	21/22	—	44/56	28/39	15/20	3/3	0/0	0/0	126/158
♯03-1	8/17	8/9	11/11	14/18	—	39/51	23/32	14/15	4/4	0/0	122/158
♯03-2	12/17	4/5	20/24	18/19	35/44	—	8/9	1/1	0/0	0/0	98/119
♯03-3	6/6	3/5	5/10	22/27	54/60	18/28	—	9/11	6/6	1/1	124/154
DWB	0/0	0/0	1/1	0/0	9/14	2/2	16/29	—	9/13	7/9	46/70
♯97-1	0/0	0/0	0/0	0/0	4/5	0/0	10/17	11/13	—	2/2	27/37
♯98-1	0/0	0/0	0/0	0/0	0/0	0/0	3/6	13/14	11/12	—	29/35
SUM	135/169	134/150	106/123	60/72	164/243	122/178	80/126	51/57	30/35	10/12	892/1165

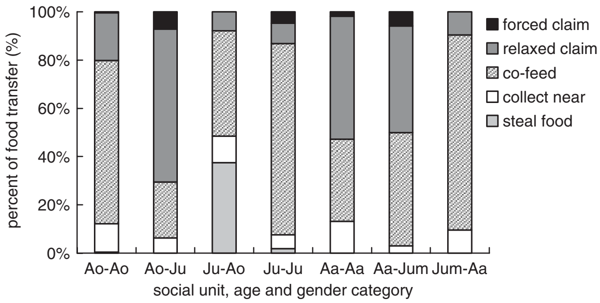

Fig. 1. Relative frequency of five kinds of food transfer in seven social units, age and gender dyads in this study. Ao–Ao, food transfer among adults in the one-male unit; Ao–Ju, an adult in the one-male unit obtains food from a juvenile; Ju–Ao, a juvenile obtains food from an adult in the one-male unit; Ju–Ju, food transfer among juveniles; Aa–Aa, food transfer among adults in the all-male unit; Aa–Jum, an adult in the all-male unit obtains food from a juvenile male; Jum–Aa, a juvenile male obtains food from an adult in the all-male unit.

and juvenile males obtained food from adults in 42 cases, however, transfer success from juvenile males to adults was higher than the reverse (Wilcoxon signed rank tests, $Z = -2.023$, $n = 6$, $P = 0.043$). Co-feeding and relaxed claim were the equally main methods adults used to take food from juvenile males; co-feeding was the predominant way for juvenile males to obtain food from adults (Fig. 1).

DISCUSSION

These preliminary findings suggest that there is high food-related tolerance in golden monkeys: transfer success in golden monkeys is higher than that which is reported in chimpanzees [de Waal, 1989a] and in capuchins [de Waal et al., 1993], in similar contexts. Golden monkeys used methods that are similar to those which are used by chimpanzees and capuchins to get food from a possessor and, as is the case for chimpanzees, two peaceful methods (co-feeding and relaxed claim) were the most common ways to get food from others [de Waal, 1989a]. Active giving was not observed among golden monkeys in this study, whereas it was reported in chimpanzees and capuchins [de Waal, 1989a, 1997] as well as in Callitrichidae [Feistner & Price, 2000; Price & Feistner, 2001]. Because active giving was observed typically from adults to infants in the other food-transfer species, further research should focus on infant golden monkeys to verify its existence in *Rhinopithecus roxellan*.

The high frequency and transfer success among adults in the OMU are coincident with the reported highly relaxed social relationships in OMU (see Introduction) and with our own behavioral observations of these study animals. In our observational study [Zhang et al., unpublished], affinitive behavior was the most commonly observed social interaction in the OMU, and the observed social rank among adults in the OMU was in a relaxed format. For example, though ♯5 was the adult male in OMU and an attack of the OMU on the AMU was mainly initiated by ♯5, his social rank was lower than ♯3. Twice ♯3 stared at ♯5 and uttered ''gugu'' [a kind of threat vocalization; see Yan et al., 2006] when ♯5 claimed food from ♯3 in a relaxed manner. But once, when ♯3 unintentionally made the infant cry, ♯5 chased ♯3 away. These interactions shed light on the high frequency and success of food transfer among adults in the OMU. Similarly, transfer success among adults in AMU was as high as in OMU, but happened less frequently. The difference in frequency may be partly because the AMU was fed differently from the OMU and the different gender composition of adults in these two units; however, the main reason might be owing to the fact that though adults in the AMU are tolerant of each other, their social rank was more rigid than in the OMU, which was reflected in more agonistic and submissive behavior during the observation period in the AMU (53 cases) compared with the OMU (eight cases).

Unlike other food-transfer primates where transfer is mostly limited to exchanges between adults and immatures [Fragaszy et al., 1997; Ruiz-Miranda et al., 1999], adult golden monkeys tolerated their peers more than they did juveniles. This was probably because juveniles in this study had all been weaned for at least half a year and could feed independently. It is expected that infant golden monkeys approaching weaning would get more food from adults than after weaning. Another difference from chimpanzees [de Waal, 1989a] was that there was high frequency of food transfers among juveniles in this study; it is likely that food transfer itself may be a kind of play among juvenile golden monkeys [Orgeldinger, 1994; see Nettelbeck, 1998]. Further studies with a larger sample size and longer observation period should be conducted to verify the food transfer pattern and further explore its functions in different social units and age categories in golden monkeys.

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