Social Behavior of a Captive Group of Golden Snub-Nosed Langur *Rhinopithecus roxellana*

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Ren-Mei Ren, Kang-Hui Yan, Yan-Jie Su, Shu-Zhong Xia, Hui-Yu Jin, Jin-Jun Qiu, and Teresa Romero (2010) Social behavior of a captive group of golden snub-nosed langur *Rhinopithecus roxellana*. *Zoological Studies* **49**(1): 1-8. Detailed accounts of social relationships in the golden snub-nosed langur *Rhinopithecus roxellana* are rare, and little is know about its social structure. The aim of this study was to contribute to the understanding of social relationships by analyzing patterns of affiliative and aggressive interactions in a captive group of this poorly known species. The 11 focal individuals were organized into a one-male unit, or OMU (i.e., a single adult male that associates with multiple adult females and their offspring), and an all-male unit, or AMU (i.e., a social unit formed only by males). One-minute instantaneous scans and ad libitum sampling techniques were used to record affiliative and agonistic behaviors, respectively. In general, OMU and AMU individuals displayed similar amounts of affiliative behaviors. However, affiliative interactions were more frequent within than between subunits. On the other hand, AMU members displayed more aggression towards members of their own subunit, and more often counterattacked any group member than did individuals of the OMU. Although OMU and AMU individuals did not interchange more agonistic behaviors with members of their own subunit than with members of the other subunit, they intervened more often on behalf of members of their own subunit, and against individuals of the other subunit. We discuss our results in the context of what is known regarding social behavior in captive and wild populations of this species and other primates with a multilevel social system. http://zoolstud.sinica.edu.tw/Journals/49.1/1.pdf

Key words: *Rhinopithecus roxellana*, One-male unit, All-male unit, Social interactions.

Primates show a strong tendency to live in cohesive groups, and compared to other mammalian orders, they exhibit a wide diversity of social systems (e.g., Smuts et al. 1989, Campbell et al. 2007). Socioecological models hypothesize that ecological factors, notably food distribution and predation, explain variations in spatiotemporal patterns observed among primate species and populations (Wrangham 1980, van Schaik 1989, Isbell 1991, Sterck et al. 1997). Despite discrepancies among various models, a common premise to all of them is that food distribution and abundance affect competitive regimes, which in turn affect the patterns of social relationships, and in particular the distribution of affiliative behaviors, the formation of alliances or the presence and strictness of dominance hierarchies (for a review see Isbell and Young 2002).

Among the different primate social systems, the nested or multilevel social system stands out for its complexity. In nested societies, several basic social units aggregate into larger higher-level sets of social organization. Several primate species, including hamadryas baboons *Papio*

hamadryas (Kummer 1968), gelada baboons *Theropithecus gelada* (Dunbar and Dunbar 1975), proboscis monkeys *Nasalis larvatus* (Yeager 1990), and snub-nosed langurs *Rhinopithecus* spp., (Kirkpatrick et al. 1999, Ren et al. 2000), live in multilevel societies. In all cases, the basic social unit is the one-male unit (OMU, i.e., a single adult male associates with multiple adult females and their offspring), and several OMUs group together to form a higher level of social organization. Although the social systems of the species listed seem to be similar, differences in their social organization were reported, e.g., the presence or absence of all-male units (AMUs), or the dynamics of male-female relationships (e.g., Grueter and Zinner 2004). However, the information available on the socioecology of primate species with multilevel social systems is unequally distributed among the different genera. Compared to gelada and hamadryas baboons, snub-nosed langurs have only recently been the focus of systematic studies (e.g., Ren et al. 1991 2000, Kirkpatrick et al. 1998, Zhang et al. 2003, Grueter 2009), and many questions concerning patterns of their behavior and ecology remain unanswered.

The distribution of snub-nosed langurs is restricted to China and Vietnam, and three of the 4 species, golden (*R. roxellana*), Yunnan (*R. bieti*), and Guizhou (*R. brelichi*) snub-nosed langurs, are endemic to China. The golden snub-nosed langur exclusively inhabits temperate forests in the mountains of central and southwestern China (e.g., Hu et al. 1980, Ren et al. 1998). Over the last century, it suffered dramatic diminution of its distribution and population density (Li et al. 2002), and with an estimated population of 22,000-23,000 individuals, it is classified as a vulnerable species by the *IUCN Red List* (Eudey et al. 2000, Wang and Xie 2004, http://www.iucnredlist.org/). Band sizes range 100-300 individuals (Kirkpatrick et al. 1999, Li et al. 2000 2002, Ren et al. 2000, Tan et al. 2007), and OMUs usually cohesively associate in the band with rare fission-fusion (Ren et al. 2000, Zhang et al. 2006).

Previous studies suggested that the golden snub-nosed langur is a female-bonded species, and that its social system resembles that of geladas because female affiliative interactions are extended within OMUs and because females play an important role in maintaining long-term relationships with their unit females (Shi et al. 1982, Ren et al. 2000, Zhang et al. 2008a). However, kinship data are scarce or lacking in most cases, and precise information on male-female social interactions, or relationships among OMUs is still very preliminary (e.g., Ren et al. 1998, Grueter and Zinner 2004, Zhang et al. 2008b). Due to difficulties in observing this species in natural habitats, individual recognition has not been possible or has been limited to individuals of a 1-provisioned band (e.g., Krikpatrick et al. 1999, Li et al. 2000, Zhang et al. 2008a), and as a result, our understanding of their social organization is incomplete. Hence, detailed data on social interactions within and between OMUs are still needed to fully understand the social organization of golden snub-nosed langurs in particular and multilevel societies in general. In this regard, studies on captive populations, where individual recognition is feasible, may provide valuable insights into the behavioral patterns of this poorly known species. The aim of this study was to contribute to the understanding of golden snub-nosed langur social structure by analyzing the patterns of affiliative and aggressive interactions of zoo-living individuals. In contrast to previous studies on captive groups, the study colony included an AMU, which also allowed us to investigate OMU-AMU relationships.

MATERIALS AND METHODS

Subjects and housing

The study was carried out on a well-established group of golden snub-nosed langurs housed at the Shanghai Wild Animal Park (Shanghai, China). Animals had access to a 650 m^2 natural soil outdoor area and a 60 m^2 indoor enclosure. The outdoor enclosure contains big poles with platforms connected by chains, creating a 3-dimensional environment. Water was available ad libitum, and animals were fed twice a day with a mixture of vegetables, cornbread, fruit, and leaves. All observations were made in the outdoor area.

Since its founding in 1995, the group was organized into 2 subunits with all females, their offspring, and 1 adult male forming an OMU, and the rest of the adult and subadult males forming an AMU. The sizes of the 2 different subunits are within those observed in the wild, i.e., 5-52 individuals in OMUs (Ren et al. 2000, Zhang et al. 2006) and 3-7 individuals in AMUs (Ren et al. 2000, Tan et al. 2007). At the time of the study, the OMU consisted of 1 male leader (which was older than 7 yr), 3 adult females (older than 5 yr) and 3

juveniles (2 males and 1 female of 1-3 yr old); and the AMU consisted of 2 adult males, 1 subadult male (5-7 yr old), and 1 juvenile male. Information on sex, age-class, and kinship relationships is presented in table 1. All group members were individually recognized by body size, pelage color, and/or other distinguishable individual features (e.g., scars). In Nov. 2000, the leader of the OMU (M05) was temporarily removed due to veterinary reasons, and an adult male from the AMU (M22) took over the leadership of the OMU. When M05 was reintroduced in the colony 6 d later, he joined the AMU.

Observational procedures

In total, 260 observational hours were collected between Oct. 2000 and Jan. 2001 by KHY. One-minute group-scan sampling was used to record affiliative behaviors (including grooming, embracing, playing, and contact sitting; Table 2). Additionally, agonistic interactions (including staring, vocal threats, lunging, chasing, grasping, hitting, biting, crouching, retreating, and fleeing; Table 2), and agonistic interventions were recorded ad libitum. An agonistic intervention was defined as an aggressive interaction against an individual and in favor of another individual. By definition (de Waal 1978), every agonistic intervention was at the same time a pro-intervention (individual

Table 1. Composition of the colony during the study period. AMU, all-male unit; OMU, one-male unit. Offspring of females are indicated by a dash to the left of the subject's name (e.g., 23 is the son of 01)

Subject ID no.	Sex	Age class	Subunit
01	female	adult	OMU
-23	male	sub-adult	AMU
-71	male	juvenile	AMU
-91	male	juvenile	OMU
02	female	adult	OMU
-81	male	juvenile	OMU
03	female	adult	OMU
-82	female	juvenile	OMU
05	male	adult	OMU[a]
21	male	adult	AMU
22	male	adult	AMU[a]

[a]During the study period, no. 22 took over the OMU and became its new leader.

A intervenes on behalf of individual B) and a contra-intervention (individual A intervenes against individual C). If a polyadic agonistic interaction occurred while scan sampling was being performed, the scan was cancelled, and information related to the identity of the original opponents, the supporters, and the behaviors exchanged was recorded.

Analysis

All analyses were done at the individual level using non-parametric statistical procedures. As a change in OMU leadership occurred during the study period, we divided the data into 2 different datasets: period 1 (from the beginning of the study to the removal of the original leader (M05) of the OMU) and period 2 (from the reintroduction of M05 into the AMU to the end of the study). For all statistical analyses, each observation period was examined as a separate dataset. Since no significant differences were found in the data from the 2 periods and the trends were quite similar, we present the results based on analyses of the combined dataset.

We used the Mann-Whitney *U*-test to examine behavioral patterns between the 2 social units, Wilcoxon signed-rank test to compare the distribution of affiliative and aggressive interactions interchanged with members of their own vs. a different social unit, and the goodness-of-fit test to compare observed vs. expected values. For agonistic interventions, the number of pro and contra interventions was corrected by the number of opportunities an individual had to intervene. For example, A's opportunity to intervene on behalf of B equaled the number of aggressive interactions involving B with individuals other than A (cf. Hemelrijk and Ek 1991). All statistical tests were 2-tailed with a significance level of $p < 0.05$.
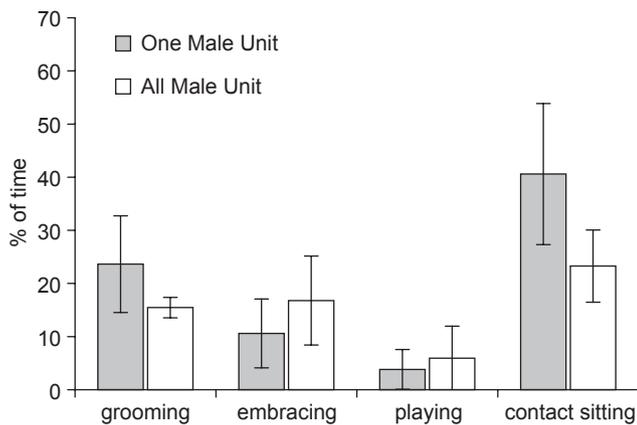
RESULTS

Affiliative interactions

Table 3 summarizes the statistical results of comparisons of affiliative interaction patterns with any group member, with members of the same subunit, and with members of the other subunit. In general, there was no significant difference in the proportions of instantaneous scans spent in any of the studied affiliative behaviors between the 2 subunits. However, individuals from the OMU

spent more time in contact sitting with individuals of their own subunit (mean ± S.E., 37.6 ± 16.7) than did individuals from the AMU with individuals of their own subunit (18.1 ± 4.0; see Fig. 1 for interactions with any group member).
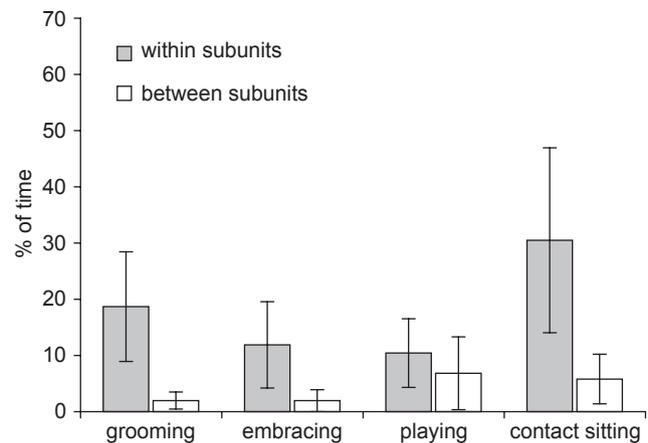
Affiliative interactions occurred more frequently within than between subunits (Fig. 2). Golden snub-nosed langurs spent more time grooming members of their same subunit than members of different subunits (Wilcoxon signed rank test: $n = 11$, $T = 0$, $p = 0.004$), and a similar pattern was found for embracing ($n = 11$, $T = 3$, $p = 0.009$), playing ($n = 11$; $T = 0$; $p = 0.007$), and contact sitting ($n = 11$; $T = 0$; $p = 0.004$).

A combined measure of grooming, embracing, playing, and contact sitting was used to construct a sociogram of the affiliative network within the OMU (Fig. 3). None of the animals played a central role, and none of them was isolated, that is, all individuals were connected to someone else in the group. Even though the leader male was the focus of many affiliative interactions, he also directed affiliative behaviors to other adult members of the unit. When only adult-adult interactions were considered, adult females did not groom the leader male more than expected (goodness-of-fit test; $\chi^2 = 1.302$, *d.f.* = 1, $p = 0.253$), and the leader male groomed the adult females as frequently as they groomed him ($n = 3$; $T = 0$; $p = 0.250$).

Fig. 1. Mean percent (± S.E.) of affiliative behaviors of the 2 different subunits toward any group member.

Fig. 2. Mean percent (± S.E.) of affiliative behaviors exchanged between and within subunits.

Table 2. Affiliative and agonistic behaviors in *Rhinopithecus roxellana*

Behavior	Comments
Affiliative behaviors	
Grooming	Manipulation of the hair of another monkey with the hands, mouth, and/or teeth
Embracing	Encompassing another individual with both arms
Playing	Chasing each other with frequent change of roles or slapping each other without threatening facial expressions or vocalizations
Contact sitting	Resting in physical contact with another individual
Agonistic behaviors	
Staring	Looking directly and fixedly at another monkey, often with a wide-eyed gaze
Vocal threat	Directing threat vocalizations, including 'gu-gu', to another individual
Lunging	Briskly briefly moving in the direction of another monkey, often accompanied by a threat display or vocalization
Chasing	Running after another individual
Grasping/Hitting	Grabbing/slapping another monkey with the hands
Biting	Biting any body part of another individual
Crouching	Bending the head and/or limbs low
Retreating/Fleeing	Running away from another individual
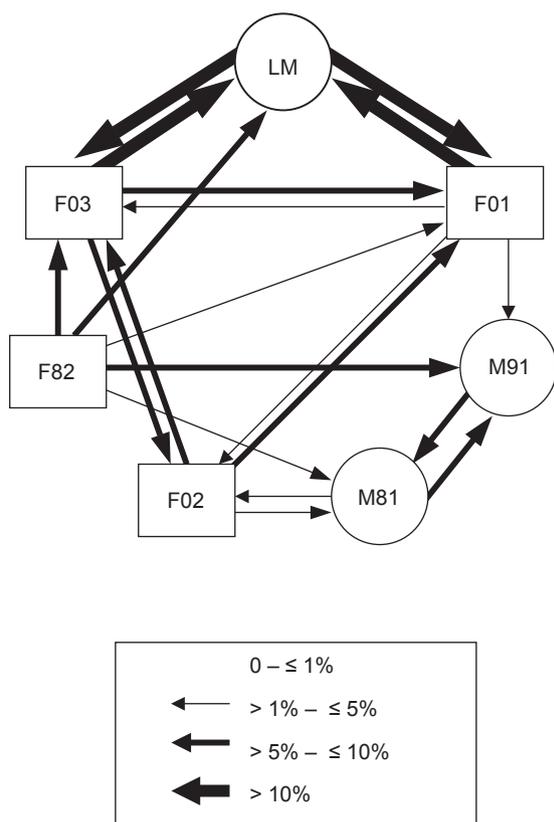
Fig. 3. Sociogram for the combined measure of affiliative behaviors that occurred within the one-male unit (OMU). The arrows are directed from the emitter to the receiver of the behavior, and the thickness reflects the percentage of scan samples spent by each dyad in affiliative behaviors. LM, leader male; □, female; ○, male.

Agonistic interactions

The statistical results of comparisons of agonistic interaction patterns with any group member, with members of the same subunit, and with members of the other subunit are shown in table 3. Members of the AMU directed more aggression to members of their own subunit (67.7 ± 25.8) than OMU members did to individuals of their own subunit (34.4 ± 15.6). Furthermore, the 2 subunits also differed in the amount of counter aggression directed to any group members, with AMU members directing more counter aggression than OMU members (AMU: 71.25 ± 26.6; OMU: 24.86 ± 5.6).

Statistically significant differences were not found when agonistic interactions within and between subunits were compared. Frequencies of aggression and counter aggression were similar between members of different subunits and between members of the same subunit (aggression: $n = 11$, $T = 31.5$, $p = 0.457$; counter aggression: $n = 11$, $T = 20$, $p = 0.135$; Fig. 2). However, golden snub-nosed langurs did intervene more frequently on behalf of members of their own subunit than on behalf of members of the other subunit (pro-intervention: $n = 11$, $T = 5$, $p = 0.039$). Moreover, they intervened against members of the other subunit more often than against members of their own subunit (contra-intervention: $n = 11$, $T = 1$,

Table 3. Mann-Whitney *U*-test results for comparisons of affiliative and agonistic patterns between the one-male unit (OMU) ($n = 7$) and all-male unit (AMU) ($n = 4$) with any group member (overall), with members of the same subunit (same subunit), and with members of the other subunit (different unit)

		Overall	Same subunit	Different subunit
Grooming	*U*	4.0	7.0	8.0
	p	0.073	0.230	0.315
Embracing	*U*	6.0	6.0	5.0
	p	0.164	0.164	0.109
Playing	*U*	7.0	11.0	12.0
	p	0.230	0.648	0.788
Contact sitting	*U*	4.0	**3.0**	8.0
	p	0.073	**0.042**	0.315
Aggression	*U*	8.0	**2.0**	10.0
	p	0.315	**0.024**	0.527
Counter aggression	*U*	**2.0**	5.5	7.0
	p	**0.024**	0.109	0.230

Values in bold are significant at $p < 0.05$.

p = 0.008).

DISCUSSION

In this study, we investigated the distribution of the affiliative and agonistic interactions among members of a captive group of golden snub-nosed langurs, a poorly known species. The group was formed 2 different subunits, an OMU and an AMU. Although the age/sex composition of the 2 subunits greatly differed (Table 1), overall they displayed similar amounts of affiliative behaviors. However, langurs from the OMU spent more time in contact sitting with members of their own subunit than did individuals of the AMU with members of their own subunit, suggesting an overall stronger spatial association among OMU members than among AMU members.

When we compared affiliative interactions within and between subunits, we found that the distribution clearly reflected patterns of spatial association. All affiliative behaviors were more frequent among members of the same subunit than between members of different subunits. Among multilevel primate societies with OMUs and AMUs, patterns of spatial association generally determine the strength of social bonds between group members. For instance, in both gelada and hamadryas baboons, affiliative interactions do not usually occur among members of different subunits (Kummer 1968, Dunbar and Dunbar 1975). A similar pattern of affiliative interactions was previously described for provisioned free-range golden snub-nosed females, which also exhibited more social interactions with unit members than with non-unit individuals (Zhang et al. 2008a). Our results confirm this general pattern and extend previous studies on affiliative interactions of golden snub-nosed langurs to individuals other than adult females (i.e., the leader male and juveniles from the OMU, and adult and subadult males from the AMU).

Although several mother-son dyads were present in the study colony, adult individuals from different subunits did not interchange any affiliative behaviors. Thus, affiliation between subunits was limited to interactions among OMU juveniles and AMU individuals. The absence of inter-unit affiliation between adult individuals of different sexes resembles what was described for provisioned free-ranging populations. According to Zhang et al. (2008a), when adult females groomed non-unit members, they groomed females not

males. Since our study colony was formed by only 1 OMU, it was not possible to study relationships among adult females of different OMUs. Multilevel societies are characterized by the presence of several OMUs, and thus knowledge of the social interactions between and within OMUs is essential to fully understand the structure and dynamics of these societies. Future studies should focus on social interactions between and within OMU members, especially in wild populations.

The sociogram for the combined measure of affiliative behaviors reflected the strength of bonds between OMU individuals. The strongest bonds seemed to occur between the leader male and two of the adult females. In hamadryas baboons, the strongest social bonds are also between OMU leader males and their females (Kummer 1968, Sigg 1980, Abegglen 1984). The shape of the sociograms of the golden snub-nosed langurs and hamadryas baboons differ, however. In hamadryas baboons, females groom the leader male more often than they are groomed by him (e.g., Abegglen 1984). The leader male is the focus of affiliation, and affiliative relationships among females are weak or absent (Sigg 1980, Kummer 1995). Thus, hamadryas baboon OMU sociograms are described as star-shaped (Kummer 1968, but see Swedell 2002). In golden snub-nosed langurs, however, the leader male groomed as much as he was groomed by the adult females, and affiliative relationships among adult females were extended. Thus, the affiliative sociogram was less centripetal than that of hamdryas baboons. Previous studies on captive and wild groups of golden snub-nosed langurs also suggested that females place a high priority on maintaining long-term relationships within subunits (Ren et al. 2000, Zhang et al. 2008a).

Clear-cut differences were found when we compared the agonistic patterns of the 2 subunits. Individuals of the AMU displayed more aggression towards members of their own subunit than did individuals of the OMU to members of their own subunit. Furthermore, AMU members also counterattacked more often when they received aggression from any group member than did members of the OMU. Male mammals primarily compete for potential mating opportunities (Emlen and Oring 1977). When fertile females are concentrated in time or space, or when females are easily monopolized, males are expected to compete for access to females via contest competition (Clutton-Brock 1989, for a review see van Hooff 2000). In this scenario,

male-male rates of aggression are expected to be high, and dominance relationships are important. Higher AMU rates of aggression might reflect male competition for access to females. However, in gelada baboons, AMU males maintain strong social bonds, and aggression among AMU members is rare, suggesting that male-male competition does not always have to be aggressive. Unfortunately, there is no available information in the literature on social relationships among AMU members in golden snub-nosed langurs, and our sample size was too small to carry out further analyses. Therefore, more-detailed studies on social relationships among AMU members are certainly necessary.

Golden snub-nosed langurs did not interchange more agonistic behaviors with members of their own subunit than with members of the other subunit. However, they intervened more often on behalf of members of their own subunit, and against individuals of the other subunit. A study carried out on a provisioned band of golden snub-nosed langurs described that OMU members frequently supported each other in inter-unit agonistic interactions (Zhang et al. 2006 2008b). Zhang et al. (2008b) also reported that although females and juveniles actively engaged in inter-unit conflicts, adult males were the most active participants, intervening in more than 1/2 of the inter-unit agonistic interactions. Similarly, in our study population, the leader male supported his OMU members in 69.6% of agonistic conflicts that occurred between subunits. The protective role of adult males was also described for other primate species with social systems based on OMUs, e.g., hamadryas baboons (Kummer 1968) and gelada baboons (Dunbar 1983). Sexual dimorphism in body and canine sizes is found in all of those species, and the male's support against aggressors could be particularly critical, not only to gain access to food resources (e.g., Colmenares et al. 2006, Zhang et al. 2008b), but also to protect females' infants against possible infanticidal males (e.g., Swedell and Tesfaye 2003, Xiang and Grueter 2007). However, no data are available on the target, frequency, or effectiveness of langur male interventions, and thus, future studies focusing on patterns of male intervention in this species are needed before drawing further conclusions.

The present study also provides evidence that AMU members intervened on behalf of their subunit partners. Little information on the golden snub-nosed langur social structure is available, and

most studies examining their social relationships focused on inter- or intra-OMU interactions (e.g., Ren et al. 2000, Qi et al. 2004, Zhang et al. 2008a). This research shows that AMUs are closely bonded units, that is, their members maintain strong affiliative bonds and defend each other during agonistic conflicts. However, we also found high levels of aggression among members of the AMU, suggesting that components of intense competition might also be present.

Our study contributes to the understanding of golden snub-nosed langur's social life, since data about inter-individual relationships are largely lacking for this primate species. However, due to our small sample size, the present results should be examined with caution, and further studies, especially on wild populations, are needed to confirm our findings on the interactions between and within subunits.

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