

Female multiple copulations among wild Sichuan snub-nosed monkeys (*Rhinopithecus roxellana*) in Qinling, China

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Mating strategies are the key to understanding both reproduction and evolution. The majority of the previous work on the mating strategies of the Sichuan snub-nosed monkey (*Rhinopithecus roxellana*), a polygynous species, has concentrated on the character of sexual behavior between heterosexual individuals, mating patterns, and the seasonality of mating and births in captivity^[1-7] and in wild^[8,9]. The importance of multiple copulations of them, both wild and captivity, has so far been neglected.

In this study we present some preliminary data on female multiple copulations among wild Sichuan snub-nosed monkeys in the Qinling Mountains, attempting to explain the significance of this phenomenon.

This study was carried out in the Yuhuangmiao region, located in Zhouzhi Nature Reserve on the northern slope of the Qinling Mountains^[10], intermittently, from March 8, 2003 to May 22, 2004.

Monkey groups were provisioned using apples, radishes, and corns at a stable feeding site three times per day (10:00 AM, 12:00 PM and 2:00 PM) during the observation. This manipulation was to coax the animals from a distance of 0.5–50 m. One male unit (OMU), such as the BaZiTou unit and LuoPan unit, as well as individual animals within each unit could be distinguished^[11-12]. We collected the sexual behavior data with the focal animal sampling^[13] and behavior sampling^[14]. During the observation period, there were 38 females and 6 males in our group. For each male unit, the total number of adult females and the sub-adult female fluctuates from 4 to 10.

Only one male was traced as long as possible every day from dawn till dusk. Besides the focal male, we noted other males' copulations as more as possible.

The mating season was between late September and December in accordance with previous authors^[3,7].

A total of 733 hours of observations were conducted from March 2003 to May 2004. During this period a total of 399 copulations (Table 1), including 22 multiple copulations (Table 2), were observed.

Table 2 shows that: (i) female multiple copulations occurred throughout the year but were more frequent during the mating season than the non-mating season; (ii) the number of female multiple copulations per hour ranged from two to five; (iii) the mean duration of female multiple copulations per hour were greater in the mating season (19.67 ± 1.29 s, $n=17$) than in the non-mating season (9.8 ± 2.46 s, $n=5$); the difference in the mean duration of female multiple copulations between mating season and non-mating season was very significant ($t=3.62$, $p=0.0008 < 0.01$, t -test); and (iv) during the mating season both adult and sub-adult females were the main initiators to display the typical sexual behavior of multiple copulations, whereas during the non-mating season males become the primary initiators.

Sperm competition is less important since usually only a single adult male is present in the polygynous mating system. In these cases, sperm might be a "limiting resource" for females within the one-male group, and female-female competition for conceptions might occur consequentially.

As for the Sichuan snub-nosed monkey (*Rhinopithecus roxellana*), we suggest that multiple copulations initiated by females support the Small's viewpoint^[15] that females might compete for the limited sperm reserves available, while behaviours of male Sichuan snub-nosed monkeys show their attitude about sperm allocations to some extent.

In the present study, all adult females involved in multiple copulations during the mating season of 2003 gave birth between March and April of the next year 2004 while those not involved in multiple copulations did not give birth. This suggests that by increasing the incidence of multiple copulations in the mating seasons female monkeys aim to increase the possibility of impregnations. These results are consistent with those of Andreas^[16]. Andreas pointed out that females benefited from multiple copulations via the assurance of fertility.

Table 1. Observation hours and copulation times

	Observation hours/h	No. of Copulations
March 8th to Mar 30th 2003	79	24
Jul 9th to Aug 1st 2003	107	25
Sep 24th to Dec 31st 2003	266	276
Jan.2nd to May 22nd 2004	281	74
Total	733	399

Table 2. Female multiple copulations per hour

Case	Date	Initiator	Male Name	Female name	Copulation times	Mean duration
1	03.03.25	male	BaZiTou	ErXuan ^{a)}	2	10.5 s
2	03.03.26	male	JingZiTou	LiuLiu	2	12 s
3	03.07.20	male	JiaBan	YuanLian	2	5 s
4	03.07.30	male	LuoPan	HongGuan	2	4 s
5	03.09.25	male	JiaBan	YuanLian	2	14 s
6	03.09.25	female	LuoPan	SiKong ^{a)}	2	15 s
7	03.09.26	female	LuoPan	HeiXian	2	22.5 s
8	03.10.08	female	BaZiTou	HongTouPa	2	20.05 s
9	03.10.18	female	LuoPan	HeiXian	2	9.5 s
10	03.11.03	female	BaZiTou	NaiZui ^{a)}	2	18 s
11 ^{b)}	03.11.03	female	JiaBan	BeiTou	2	10 s
12	03.11.12	female	LuoPan	HeiXian	2	26.5 s
13	03.11.21	female	LuoPan	HeiXian	3	20.3 s
14	03.11.23	female	BaZiTou	ErXuan ^{a)}	2	19 s
15	03.11.23	female	KuangGong	SaAnFa ^{a)}	5	22.5 s
16	03.11.27	female	KuangGong	SaAnFa ^{a)}	3	28 s
17	03.12.02	female	LuoPan	HeiXian	2	24 s
18	03.12.03	female	LuoPan	HeiXian	2	23.5 s
19	03.12.03	female	LuoPan	HeiXian	3	24.3 s
20	03.12.08	female	LuoPan	SiKong ^{a)}	3	20.7 s
21	03.12.09	female	LuoPan	SiKong ^{a)}	2	16.5 s
22	04.01.07	male	JingZiTou	LiuLiu	2	17.5 s

a) sub-adult female

b) inter-unit copulations

The Sichuan snub-nosed monkey (*Rhinopithecus roxellana*) is a seasonal breeder both in captivity^[5] and in the wild^[8]. This study has shown that female multiple copulations occur within both the mating and the non-mating season, suggesting that the purpose of this behavior is not limited to the ultimate function of reproduction. This is supported by research of other species. For example, in almost all primate species females engage in polyandrous mating, which suggests that fertilization is not the sole function of copulation^[17].

That males employed multiple copulation behavior might help establish or cement reproductive relationships, as such behavior was only displayed in non-mating peaks by the males in this monkey. This supposition was verified by the result of this study. During the observation, for example, there were two adult females, YuanLian and XiaoKeng, in HeiTou's OMU. JiaBan, a new comer, immigrated into a group from the AMU (all male unit) and, replaced the dominant male HeiTou and monopolized the mating rights of the HeiTou's OMU in May 2003^[18]. On joining into the OMU, JiaBan was observed twice to multiply copulate with female YuanLian who was no baby monkey to be nursed at that time. This might be the only

reason that the takeover male JiaBan did not choose XiaoKeng as the consorting object due to the fact that XiaoKeng gave birth in April 2003 and had a baby infant to lactate with her lactation sterilization^[4]. This suggests that male Sichuan snub-nosed monkeys seem to know that the lactating female is not able to be pregnant.

JiaBan's data of uncontinuously frequent copulations with YuanLian in the mating season and the birth data of YuanLian in 2004 tells us that this behavior is one of the new resident male's strategies to establish a good reproductive relationship with the optimum female to allow him to make a positive impact on future propagation.

During this study one case of inter-unit female multiple copulations was observed, too. A possible explanation for this behavior might be the reduction of the possibility of inbreeding. Within the social structure of the Sichuan snub-nosed monkey, there are strong possibilities of incest, the male copulating with his offsprings. Inter-unit sexual interactions during the mating season may be a mechanism to improve this bad action^[9].

On the whole, the results of this short-term study provided preliminary data on female multiple copulations among wild Sichuan snub-nosed monkeys (*Rhinopithecus*

roxellana). The results suggested that the function of this behavior serves not only to reproduce but also promote social interaction for the affiliation between bisexual individuals. There might be a very different aim for the male and female monkeys to adopt such behavior. More data is required in order to further evaluate the generality and possible significance of female multiple copulations in this polygynous species.

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