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First wild evidence of neonate nipple preference and maternal cradling laterality in Old World monkeys: A preliminary study from *Rhinopithecus roxellana*

Dapeng Zhao [a], Xiang Gao [a], Baoguo Li [a,*], Kunio Watanabe [b]

[a] *College of Life Sciences, Northwest University, Xi'an 710069, China*
[b] *Primate Research Institute, Kyoto University, Inuyama, Aichi 484-8506, Japan*

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Abstract

Although captive or free-ranging settings offer a more controlled environment for assessing non-human primate laterality, research on wild populations provides evidence of how laterality is affected by natural environmental conditions and, thus may yield potential insights into the evolution of laterality. This study of Sichuan snub-nosed monkeys (*Rhinopithecus roxellana*) constitutes the first report on asymmetric patterns of early mother–infant interactions among Old World monkeys in the wild. It was found that neonate nipple preference and maternal cradling laterality are both evident on the individual level. Although there is no significant group-level preference direction, the group preference strength on both measures is evident. Moreover, neonate nipple preference is not significantly correlated with maternal cradling laterality on either LBI scores or the direction (LBI scores: $r = 0.174$, $p = 0.632$; direction: $r = 0.624$, $p = 0.054$). Taken together, it is possible to suggest that wild *R. roxellana* show independent orientation laterality from the first week of life.
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1. Introduction

Lateralized behavior has been studied as an observable measure of cerebral functional asymmetry for many years and interest in the evolutionary origins of lateralized behavior in humans has prompted recent research into laterality in non-human primates (Corballis, 1997; Papademetriou et al., 2005). For non-human primates, limb laterality is thought to be largely determined by environmental factors such as maternal cradling laterality (Hopkins, 2004). Asymmetry in the early mother–infant interaction (mainly focus on nipple preference and maternal cradling laterality) of non-human primates is evident based on current research results. Such kind of asymmetry may have a bearing on the development of handedness in their offspring (for a review, see Hopkins, 2004). There is a growing body of evidence for asymmetries in early mother–infant interactions in non-human primates as well as in humans: women, for example, show universal left-sided biases in cradling infants (Damerose and Vauclair, 2002). Current research shows a left-side bias in nipple preference and maternal cradling in great apes, notably in chimpanzees, gorillas and bonobos (Manning and Chamberlain, 1990, 1991; Hopkins et al., 1993; Nishida, 1993; Dienske et al., 1995; Hopkins, 2004; Hopkins and Lathouwers, 2006). Old World monkeys, New World monkeys and prosimians have been subject to less study as concerns population-level asymmetries in early mother–infant interactions, but left- or right-side individual biases are clearly apparent (Damerose and Vauclair, 2002).

Among Old World monkeys, research has been conducted in captive (e.g., Damerose and Hopkins, 2002) and free-ranging conditions (e.g., Jaffe et al., 2006), but almost entirely in Cercopithecinae (*Macaca fuscata*: Haraiwa, 1981; Nakamichi, 1983; Tanaka, 1989; Ôta et al., 1991; *Macaca mulatta*: Hinde et al., 1964; Deets and Harlow, 1970; Lindburg, 1971; Tomaszycki et al., 1998; Jaffe et al., 2006; *Macaca nemestrina*: Erwin et al., 1975; *Papio anubis*: Damerose and Hopkins, 2002; *Semnopithecus entellus*: Winkler and Prestel, 1989). Although

* Corresponding author.
E-mail address: baoguoli@nwu.edu.cn (B. Li).

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Table 1
Focal mother–infant dyads and LBI scores in this study

No.	Mother ID	Infant ID	Infant sex	Neonate nipple preference					Maternal cradling laterality				
				L	*R*	LBI	ABS-LBI	Preference	*L*	*R*	LBI	ABS-LBI	Preference
1	DaBangChui	YuChui	Female	19	6	−0.52	0.52	Left	14	11	−0.12	0.12	Left
2	BaiDian	YuDian	Male	2	7	0.56	0.56	Right	8	9	0.06	0.06	Right
3	HongHei	YuHei	Female	17	12	−0.17	0.17	Left	52	34	−0.21	0.21	Left
4	TaoHua	YuHua	Male	5	9	0.29	0.29	Right	21	30	0.18	0.18	Right
5	DanHuang	YuHuang	Female	1	1	0.00	0.00	Ambi	10	12	0.09	0.09	Right
6	HeiJin	YuJin	Male	4	8	0.33	0.33	Right	33	46	0.16	0.16	Right
7	YiZuoMao	YuMao	Female	13	3	−0.63	0.63	Left	39	66	0.26	0.26	Right
8	DiMei	YuMei	Male	0	13	1.00	1.00	Right	5	26	0.68	0.68	Right
9	HeiXian	YuXian	Female	5	0	−1.00	1.00	Left	6	29	0.66	0.66	Right
10	HeiZuan	YuZuan	Female	24	8	−0.50	0.50	Left	22	13	−0.26	0.26	Left

captive and free-ranging settings could offer a more controlled environment for assessing limb preferences, studies of wild or naturalistic populations can potentially provide important insights into how limb laterality is affected by natural environmental conditions and so into the evolution of laterality. To date several hypotheses have been proposed to explain maternal cradling laterality: that the fetus becomes imprinted to the heartbeat of its mother, and left-side cradling has a soothing effect on the infant because it allows the infant to be close to the heart (Salk, 1973); that the cradling bias may be determined by the head-turning preferences of the infant (Ginsburg et al., 1979), which in turn may result from neural asymmetries related to handedness (Michel, 1981) or the different tactile sensitivities of the right and left female breast (Kaplan-Solms and Saling, 1988; Saling and Cooke, 1984); that left-side cradling had to do with the hemispheric specialization of emotions, and the mother could better monitor her infant's emotional state when holding on the left side rather than on the right (Manning and Chamberlain, 1991; Vauclair and Donnot, 2005).

In this study, our aim is to assess whether wild Sichuan snub-nosed monkeys (*Rhinopithecus roxellana*) show any evidence of neonate nipple preference and maternal cradling laterality, and to investigate the effect of maternal cradling on neonate nipple preference in this Colobine monkey.

2. Methods

2.1. Study site and species

The study site is located in Yuhuangmiao area, Zhouzhi National Nature Reserve, in the Qinling Mountains of China (Li et al., 2000; Zhao et al., 2005, 2008). Two polygynous troops of Sichuan snub-nosed monkey (*R. roxellana*), the east ridge troop (ERT) and the west ridge troop (WRT), are present at the study site (Li and Zhao, 2007). The WRT includes one all-male group as well as the focal group which consists of one-male units (OMU) (Zhang et al., 2006). The subjects of the study were 10 *R. roxellana* mother–infant dyads (Table 1) in the focal group. Of the infants observed in this study, six were females and four males.

2.2. Food provisioning

Provisioning of the study group was started on October 24, 2001. A 15 m × 30 m provisioning site is established at Sanchakou (1646 m above sea level) in Gongnigou valley (33°48′68″N, 108°16′18″E). The monkeys were herded towards provisioning sites at approximately 9:00 h every day where the research was conducted (Zhang et al., 2006; Zhao et al., 2008). Approximately 200 g of feed were provided per monkey per day on three occasions. To reduce any effect of provisioning on behavioral data collection, observations began only when the monkeys moved into the adjacent trees and resumed their normal activities after feeding at the provisioned area. A distance of 5–50 m was kept between the observer and the focal animals during the observation. All individuals could be identified by individual physical peculiarities (Zhang et al., 2006; Li and Zhao, 2007).

2.3. Data collection

The study was conducted from March to April 2007. Throughout the first week of the infant's life, each mother–infant pair was observed twice (on the 2nd day and the 6th day respectively) in a 1-h observation session. During the observation sessions, two observers, D.P. Zhao and X. Gao, watched each focal dyad simultaneously and collected the data using a check sheet.

The data on neonate nipple preference and maternal cradling laterality were collected by a scan-sampling technique with 60-s intervals (Altmann, 1974; Martin and Bateson, 1993). Any or all contact with the nipple by the infant was considered as suckling behavior because it was difficult to discern the difference between non-feeding nipple contact and actual suckling because of the constraints presented by the natural environment (e.g., Tanaka, 1997). As a result, neonate nipple preference was defined as contact between neonate's mouth and mother's nipple. Nipple side was recorded with from the mother's perspective (i.e., the mother's left or the mother's right). Maternal cradling laterality was defined as the mother holding the offspring with either her left or her right hand. It was recorded only when the infant was held ventrally by the mother when she was in a sitting posture (e.g., Tomaszycki et al., 1998).

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