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Letter to the Editor

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Sexual interference and allomaternal behavior as predictors of rank recognition in female golden snub-nosed monkeys

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Rank recognition allows social animals to adapt to complex and changeable environments and to cope with hierarchical relationships within their societies (Crone 2017). Rank recognition can improve the distribution of advantageous resources, individual adaptation, and social cohesion among group-living animals (Marmolejo-Ramos and Angiulli 2014). Empirical evidence suggests that rank recognition is a basic behavioral manifestation of social cognition adopted by a wide range of insects, birds, and mammals, including nonhuman primates (Schmitt and Fischer 2011; Smith et al. 2017). Unlike most other vertebrates, primates have unusually large brains and form complex social groups. Individuals must repeatedly interact with group members to maintain social relationships in many different contexts, with strong cognitive demands arising from these social interactions (Freeberg et al. 2012). The golden snub-nosed monkey *Rhinopithecus roxellana* is an endangered species of Asian primate characterized by its multilevel social structure and hierarchical rankings. Individuals need to perform social behaviors to maintain stable and long-lasting social relationships with differently ranked individuals, which requires sophisticated recognition of social hierarchy (Zhao et al. 2020). However, how individuals benefit from revealing their internal states of rank recognition remains unknown. In reference to modern evolutionary theory that ultimate function is necessary for exploring the evolution of behavior. Rank recognition allows individuals to predict the likely actions of others to guide their own potential behavior and action, which could help to avoid conflict and increase social stability (Frijda 2006). Thus, further studies are required to facilitate our understanding of the importance of rank recognition in dealing with social interactions within a species.

In *R. roxellana*, sexual interference and allomaternal behavior affect social connections and have important implications for the cognitive skills required to manage social interactions (Qi et al. 2011). Thus, they can be applied as behavioral judgment indicators of rank recognition among females. Here, we analyzed sexual interference and allomaternal behavior for females to infer rank recognition within 6 one-male units (OMUs) of a wild *R. roxellana* troop (see Supplementary Materials for information on species and study methods). From September 2016 to July 2017, the rank status of the target females and other females in the OMUs remained stable. A total of 203 sexual interference episodes were recorded, including 142 among adult females. Of the 142 sexual interference bouts, 98 were initiated against the mating pair by a female with higher rank than the mating female, whereas the remaining 44 episodes were initiated by a lower-ranked female. Based on Mann–Whitney U analysis, the frequency of sexual interference initiated by females ranked higher than the mating female was significantly higher than that initiated by females ranked lower ($Z = -2.898$, $P = 0.004$). Thus, highly ranked females interfered with copulation more frequently than lowly ranked females. However, the relationship between the initiation frequency of sexual interference and female rank did not reach a significant level according to Spearman rank correlation analysis ($r_s = -0.378$, $P = 0.083$). We also observed a total of 1,136 allomaternal events, including 842 allomaternal nonsnatching and 294 allomaternal snatching events involving the 7 target females (i.e., MJ, HM, YD, DH1, WM, SM, and JT; Table 1). Based on Mann–Whitney U analysis, the initiation frequencies of allomaternal snatching between females ranked higher and lower

Table 1. Allomaternal behavior of target females.

Target female	Number of allomaternal bouts	Number of allomaternal snatches	Frequency of allomaternal snatching		Infant handling rate by allomaternal snatching	
			Higher ranked mother	Lower ranked mother	Higher ranked mother	Lower ranked mother
MJ	119	34	0.21	0.79	0.29	0.70
HM	136	45	0.24	0.76	0.36	0.76
YD	148	72	0.19	0.81	0.21	0.64
DH1	124	42	0.40	0.60	0.35	0.92
WM	153	51	0.10	0.90	0.20	0.83
SM	64	18	0.39	0.61	0.71	0.64
JT	98	49	0.22	0.78	0.27	0.58

than the mothers varied significantly, with females ranked higher than the mothers exhibiting greater initiation frequency than females ranked lower than the mothers ($Z = -2.366$, $P = 0.018$). In addition, compared with low-ranked females, high-ranked females exhibited greater infant handling by allomaternal snatching ($Z = -2.197$, $P = 0.028$). Thus, females ranked higher than the mother could directly take the infant without performing affiliative behavior, whereas females ranked lower adjusted their behavior to appease the mother and gain access to the infant. These results implied that females could recognize their own rank and that of others, and rank recognition in *R. roxellana* groups played an important role in sexual interference and allomaternal processes.

This study provides preliminary evidence and insight into social cognition in *R. roxellana*. Our findings imply that sexual interference and allomaternal behaviors are initiated differently, depending on whether the initiator views themselves as highly or lowly ranked. This further suggests that females adjust their behavior according to their hierarchical position and anticipate the way social interactions will progress. These results also indicate that rank recognition in monkeys may be indicative of potential action, that is, as a signal of "action readiness." Therefore, rank recognition may be a critical function with a predictive cue to the identity and actions of others, which is an important consequence of evolutionary development and critical in understanding primate evolutionary theory (Frijda 2006). Furthermore, we inferred that rank recognition in *R. roxellana* may function to solve disputes and reduce conflict, similar to the macaque signals and vocalizations that facilitate (or constrain) social bonding and group size (McComb and Semple 2005). Thus, given its importance, the function of rank recognition should be considered in future research. As no obvious correlations were found between the initiation frequency of sexual interference and female rank, females may consider the mating needs of others and the size of the OMU. Furthermore, highly ranked females do not control all mating opportunities, implying that they may recognize the hierarchical relationships among females within their OMU—with rank recognition likely playing a driving role in sexual interference, as reported in studies on cognition in capuchin monkeys (Tecwyn et al. 2017). However, further studies on emotional and motivational behaviors are required to confirm if such behaviors impact social cognition and to confirm whether *R. roxellana* monkeys are capable of intelligent reasoning to guide future actions, as observed in humans.

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Conflict of Interest

The authors declare that they have no competing interests.

Authors' Contributions

H.T.Z, J.X.L., and B.G.L. contributed to research design; H.T.Z., Y.W., N.L.L., X.W, C.L.W., Y.R., T.J., and W.L. contributed to project commitment and data collection; H.T.Z. contributed to manuscript draft writing; H.T.Z., R.L.P., and B.G.L. contributed to manuscript revision. All authors read and approved the final version of the manuscript.

Statement of Ethics

Our research adhered to the regulatory requirements of Guanyinshan National Nature Reserve, China. All applicable institutional, national, and international guidelines for the care and use of animals were followed.

Supplementary Material

Supplementary material can be found at https://academic.oup.com/cz.

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