Seasonal variations and sex differences in the interindividual distances in wild patas monkeys

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Abstract

Individual spatial positioning plays an important role in mediating the costs and benefits of group living and shapes various aspects of animal social systems, including cohesiveness. I analyzed the interindividual distances among females and among a male and females of a small troop of wild patas monkeys (*Erythrocebus patas*) to evaluate how infant births affected the individual spacing behavior among group members. I compared scan data from four distance categories (<1 m, <5 m, <10 m, and <20 m) among the nonbirth, early birth, and late birth seasons. The occurrences of female pairs in the <10 m and <20 m categories were lowest during the early birth season and highest during the late birth season, indicating that group cohesion varied across the 3 seasons. In contrast, the occurrence of male-female pairs did not vary across the 3 seasons, except in the <1 m category, in which a male and females were much less likely to be close during the early and late birth seasons. Thus, I conclude that infant births may have various influences on the spacing behavior of a male and females and that female cohesiveness is less likely to benefit predation avoidance just after the birth of infants.

Keywords：interindividual distance, sex differences, birth of infants, *Erythrocebus patas*

1 Introduction

Group cohesion is expected to vary both within and between species, and it depends on factors such as predation risk, the density and distribution of food resources, and feeding competition (Hamilton 1971；Isbell 1991；van Sckaik 1989；Wrangham 1980). Groups are likely to become more cohesive with increasing predation risk, as the presence of many close neighbors reduces the chance of being attacked (Janson and Goldsmith 1995). Smaller inter-individual distances, however, are likely to increase feeding interference, and foraging animals are thus likely to spread out to reduce

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feeding competition (Nishikawa et al. 2014 ; van Schaik and van Noordwijk 1988).

Due to the different costs and benefits associated with varying numbers of neighbors, animals have to balance a trade-off between feeding and avoiding predation (Lima and Dill 1990 ; Miller 2002). The outcome of this trade-off is affected by factors such as resource availability and predation risk. For instance, individuals who are more vulnerable to predation, such as juveniles or females with infants, are often found in the center of a group, where they are likely to be safer from predation (Busse 1984 ; Colling 1984 ; Heesen et al. 2015 ; Rhine et al. 1980).

Here, I report on seasonal variations and sex differences in interindividual distances among members in a small troop of wild patas monkeys (*Erythrocebus patas*) in northern Cameroon. Muroyama (2017) hypothesized that higher group cohesion, namely, a higher co-occurrence frequency of females, may reduce the predation risk among infants and indeed reported that the group cohesion of females was higher during the birth season than during the nonbirth season in this troop. In this study, I hypothesize that infants are more vulnerable to predation just after birth and that group cohesion is expected to be higher during the early birth season than during the late birth season. Moreover, male-female co-occurrence frequency is also expected to vary across seasons if the presence of males reduces predation risk among infants.

I investigated the seasonal variations in the co-occurrence frequency of each pair in the subject troop by comparing data from the nonbirth, early birth, and late birth seasons. To examine sex differences in co-occurrences, I analyzed data from pairs of a male and females and those from pairs of females separately, and compared the datasets. I examined data from 4 distance categories, namely, <1 m (0-1 m), <5 m (0-5 m), <10 m (0-10 m), and <20 m (0-20 m) ; the data in these categories are not exclusive or independent of each other.

2 Material and methods

Study site and subjects

This study involves a troop of patas monkeys (KK troop) that inhabits Kala Maloué National Park, Cameroon, West Africa. Kala Maloué National Park is situated in the far northern region of Cameroon, beside the Chari River (12°09'N, 15°53'E). The climate is characterized by two sharply defined seasons—a wet season that occurs from the latter half of May to September and a dry season encompassing the rest of the year. The mean annual rainfall and temperature during 1985-1988 were 497 mm and 28.9℃, respectively. For further details on the location, climate, vegetation, and life history parameters, see Nakagawa et al. (2003).

The KK troop was well habituated and observed from 1984 to 1997 (Nakagawa et al.

2003) ; thus, I was already familiar with the kin relationships among the members of the troop at the beginning of the study through previous observations by colleagues. Dominance relationships among adults were determined by approach-retreat interactions at the beginning of the study. A male was the most dominant member of the troop. When the study began, the troop (N = 9) consisted of 1 adult male, 6 adult females (>5 years old), 1 juvenile female (1.5 years old), and 5 infant (0.5 years old). One infant disappeared on 27 November 1988. Three high-ranking adult females gave birth during the birth season. Two pairs of adult females comprised a mother and her adult daughter (kin relationship). I selected all 6 adult females as the focal subjects. I collected data during the nonbirth (NB) season (October and November 1988), the early birth (EB) season (January 1989) and the late birth (LB) season (February 1989) (see Nakagawa et al. (2003) for more details).

Data collection

I collected data on a male and all females by following one target adult female for a day and conducting group scans ('scan sampling', Martin & Bateson (2007)). I scanned and identified the adults (1 male and 6 females) within a radius of 1 m, 5 m, 10 m, or 20 m from the target female at 10 min intervals. During the NB season, I followed each target female for a total of approximately 20 h (N = 6 ; mean : 18 h 31 min ; range : 15 h 50 min to 21 h 13 min). The mean number ± standard error (SE) of scans for the 6 females in the NB season was 110.5 ± 11.7. During the EB season, I followed each target female for a total of approximately 10 h (N = 6 ; mean : 9 h 18 min ; range : 6 h 14 min to 11 h 30 min). The mean number ± SE of scans for the 6 females in the EB season was 56.2 ± 9.1. During the LB season, I followed each target female for a total of approximately 10 h (N = 6 ; mean : 10 h 46 min ; range : 10 h 10 min to 11 h 41 min). The mean number ± SE of scans for the 6 females in the LB season was 64.5 ± 3.0. Two females gave birth at the start of the EB season, and one female gave birth at the end of the EB season. Consequently, 3 high-ranking females became the mothers of infants. During the LB season, I followed each mother on a given day approximately 1 month after she gave birth (26–34 days). Visibility was stable during the study period.

Focal animal following lasted all day when possible. Whenever a session was interrupted, I resumed at approximately the same time on another day. I scheduled observation hours such that they were almost evenly distributed between 0630 and 1730.

Analyses

I calculated the observed frequencies of 15 female-female pairs and those of 6 male-female pairs during each of the 3 seasons in each individual distance category, namely, <1 m, <5 m, <10 m, and <20 m. I performed all statistical analyses with R (version

3.6.2). First, I used the Friedman rank sum test for comparison among the NB, EB, and LB seasons for each sex. For post hoc comparison between the two seasons, I performed pairwise comparisons using the Nemenyi-Wilcoxon-Wilcox all-pairs test for a two-way balanced complete block design. Next, I compared the observed frequencies of male-female pairs and those of female-female pairs during each of the 3 seasons in each individual distance category by using the Mann-Whitney U test.

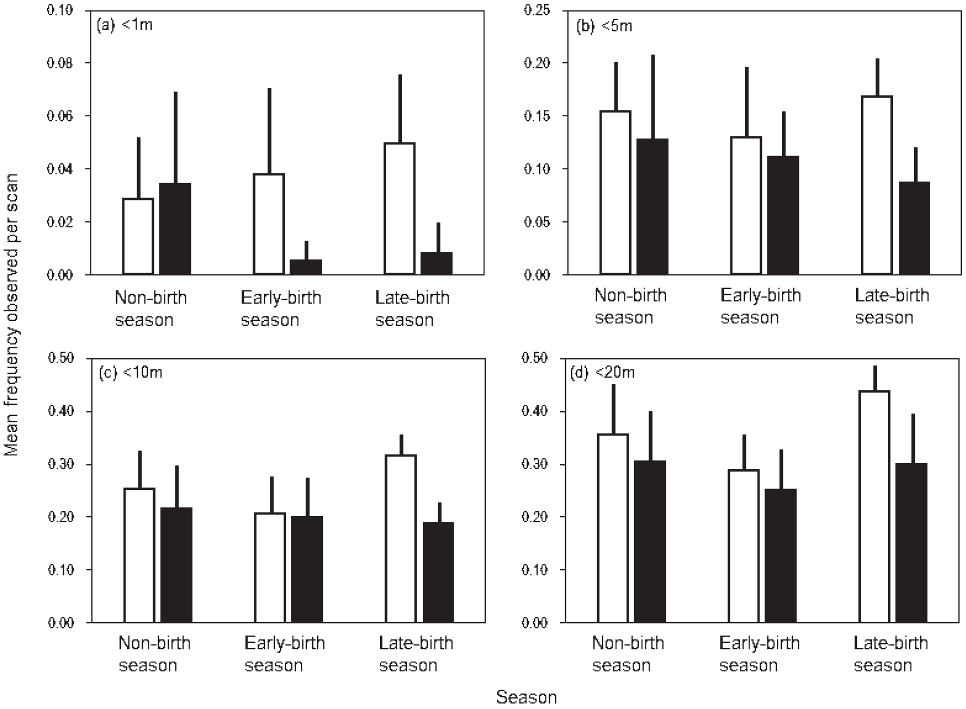

Figure 1. Average observed frequencies of female-female pairs and those of male-female pairs in each distance category : (a) <1 m, (b) <5 m, (c) <10 m, and (d) <20 m. The open bars indicate female-female pairs, and the closed bars indicate male-female pairs. The error bars show the standard deviation.

3 Results

Figure 1 illustrates the average observed frequencies of female-female pairs and those of male-female pairs during the 3 seasons in each distance category. The observed frequencies of the female-female pairs were lowest during the EB season and highest during the LB season for both the <10 m and <20 m categories, and the observed frequencies differed significantly among the 3 seasons (<10 m : Freedman test, df = 2, 28, chi-square = 17.73, $p < 0.0002$; <20 m : Freedman test, df = 2, 28, chi-square = 19.60, $p < 0.0001$). The post hoc pairwise comparisons revealed significant differences between the NB and LB ($p < 0.046$) seasons and between the EB and LB ($p < 0.0001$) seasons for the <10 m category and between the NB and EB ($p < 0.017$) seasons and between the EB and LB ($p < 0.0001$) seasons for the <20 m category.

In contrast to the female-female pairs, the observed frequency of the male-female pairs did not differ significantly among the 3 seasons in any of the distance categories, except for the <1 m category, in which it differed significantly among the 3 seasons (Freedman test, df = 2, 10, chi-square = 7.14, $p < 0.028$). The male-female co-occurrence frequency was much lower during the EB and LB seasons than during the NB season.

The observed frequencies of the female-female pairs were higher than those of the male-female pairs during the LB season for all the individual distance categories (<1 m : Mann-Whitney test, $U = 85$, $p = 0.0020$; <5 m : Mann-Whitney test, $U = 84$, $p = 0.0026$; <10 m : Mann-Whitney test, $U = 90$, $p = 0.0005$; <20 m : Mann-Whitney test, $U = 84$, $p = 0.0011$) and during the EB season for the <1 m category (Mann-Whitney test, $U = 80$, $p = 0.0065$).

4 Discussion

In this study, the occurrence of female-female pairs in the <10 m and < 20 m categories was lowest during the early birth season and highest during the late birth season, indicating that group cohesion varied across the 3 seasons. In contrast, the occurrence of male-female pairs did not vary across the 3 seasons, except in the <1 m category, in which males and females were much less likely to be close during the early and late birth seasons. These findings indicate that co-occurrences of females were relatively high during the late birth season but not during the early birth season, as predicted. This suggests that female cohesiveness is less likely to benefit predation avoidance just after the birth of infants. It is possible that female cohesiveness is a byproduct of natal attraction, which lasts for the first two months post-birth in baboons (Silk et al. 2003).

An adult males was less likely to exhibit spacing behavior than females, whereas the male and/or females appear to have avoided co-occurrence in close proximity such as <1 m. The adult male does not appear to have protected newborn infants who may be their own offspring. Adult patas males have been reported to spend much time solitarily in captive environments (Rowell and Olson 1983) and in the wild (Nakagawa 1992). The results are consistent with these previous studies.

The limitations of the data set should be kept in mind. This study was conducted for only four months for one troop, and thus, neither annual variations nor variations among troops in interindividual differences were examined. Moreover, no ecological factors were incorporated into the analysis of the data. Further studies are needed to make conclusive statements on the findings.

Acknowledgments

I wish to express my thanks to Ministère de l'Enseignement Supérieure et de l'Informatique et de la Recherche Scienctifique (MESIRES), Institut des Recherches Zootechniques (IRZ), and the Secrétariat d'Etat au Tourism for permitting the research activities in Kala Maloué National Park in Cameroon. All of the protocols used in this research complied with relevant regulations in Cameroon and the Primate Research Institute, Kyoto University, Japan. I also thank Y. Sugiyama for his constant encouragement, M. Kawai for providing the opportunity for this study, and H. Ohsawa and N. Nakagawa for various kinds of help and for valuable information. This study was supported by the Ministry of Education, Science and Culture, Japan (grant no. 63041140 to M. Kawai ; 03-0918 to the author).

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