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Behavioural Processes 78 (2008) 25–28
BEHAVIOURAL PROCESSES
www.elsevier.com/locate/behavproc

Group size effect on vigilance: Evidence from Tibetan gazelle in Upper Buha River, Qinghai-Tibet Plateau

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Received 30 April 2007; received in revised form 27 November 2007; accepted 30 November 2007

Abstract

Tibetan gazelle *Procapra picticaudata* is a threatened and endemic species to the Qinghai-Tibet Plateau. With the method of group scan sampling, we observed the behaviours of males and females of the gazelle in the two summers of 2005 and 2006, in order to test the group size effect on group vigilance. We found that male gazelles were significantly more vigilant than the females at both group scan level (percentage of individuals scanning during a session) and group scan frequency (percentage of intervals with at least one individual scanning). We also found a negative correlation between group scan level and group size and a positive correlation between group scan frequency and group size, showing the group size effect on vigilance was testified in Tibetan gazelle. The predation factor might be the main driving force for the group size effect.

Keywords: Herd size; Group vigilance; Ungulate; *Procapra picticaudata*

1. Introduction

One of the many advantages of living in groups is that each member of a group spends less time to be vigilant and more time for feeding and other important behaviours (Pulliam, 1973). The negative relationships between group size and vigilance, which is called "group size effect", have been reported in many birds and mammals (Elgar, 1989; Lima, 1995; Roberts, 1996; Dias, 2006). Three main hypotheses have been proposed to explain this inverse correlation: the 'many-eyes' hypothesis or the detection effect (Pulliam, 1973), the 'safety in numbers' hypothesis or the dilution effect (Cresswell, 1994), and the 'scramble competition' hypothesis (Beauchamp, 2003).

The 'many-eyes' hypothesis states that more eyes are easier to detect a predator, and thus individuals decrease their own vigilance and benefit from other group members (Pulliam, 1973). The 'safety in numbers' hypothesis proposes that the risk of being predated would be diluted in large groups because predators usually predate only on one prey during an attack (Whitfield, 2003). These two hypotheses consider that the vigilance serves the main function in detecting predators, and therefore they are classified as the predation effect (Beauchamp, 2003, 2007). Many studies have provided evidences for the predation effect (e.g. Lima, 1995; Roberts, 1996; Whitfield, 2003). The 'scramble competition' hypothesis focuses mainly on that group members that compete for the limited food resources, thus leading to a decrease in vigilance with the increasing group size. Some theoretical and field studies also supported this hypothesis (Beauchamp and Ruxton, 2003; Randler, 2005a,b).

Although the group size effects occur in many birds and mammals, they are not found in black howler monkeys *Alouatta pigra* and swan geese *Anser cygnoides* (Treves et al., 2001; Randler, 2003). Therefore, studies on group size effects should be conducted in more species to explore whether and how the effects take place.

Moreover, apart from group size, sex also affects vigilance levels. Many studies have shown that the vigilance levels are usually different between males and females, although which sex is more vigilant is not consistent (Elgar, 1989; Childress and Lung, 2003; Shorrocks and Cokayne, 2005; Cameron and du Toit, 2005). For example, in impala *Aepyceros melampus* males are more vigilant (Shorrocks and Cokayne, 2005), while in merino sheep *Ovis aries* females are more vigilant (Michelena et al., 2006). Other factors, such as the nearest neighbor distance (Fernandez-Juricic et al., 2004; Randler, 2005a), the age (Boukhriss et al., 2007), the coloration of animals (Gotmark and

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0376-6357/$ – see front matter © 2008 Published by Elsevier B.V.
doi:10.1016/j.beproc.2007.11.011

Hohlfalt, 1995), the time of daylight and season (Elgar, 1989), and the centre-edge position (Lazarus, 2003; Dias, 2006), may also play a part in the vigilance levels.

Here, we studied the vigilance behaviour of Tibetan gazelle *Procapra picticaudata* in Upper Buha River, Qinghai-Tibet Plateau during two summers of 2005 and 2006. Because of the life history traits of this endemic ungulate, we expect (1) male gazelles behave more vigilant than females and (2) vigilance level decreases with the increasing group size.

2. Materials and methods

2.1. Study areas and subjects

This study was conducted in the upper Buha River, Tianjun County, Qinghai Province, China (36°53′30″–48°39′12″N, 96°49′42″–99°41′48″E), which was located in northwest part of Qinghai Lake drainage area and south of the Qilian Mountains. Elevation ranges from 2850 m to 5826 m above sea level, with average elevation of 3800 m. The climate is characterized by dry, cold winters, strong winds, high levels of solar radiation and a short frost-free period. Mean annual temperature is −1.5 °C, extreme recorded low temperature is −40 °C. Annual precipitation varies from 330 mm to 412 mm, and most rain fall in between June and September. Alpine meadow is the main vegetation in the core study area of about 200 km^2. The dominant plants are *Kobresia* spp. and *Stipa* spp. The Buha River is the largest river flows into the Qinghai Lake, the largest semi-salty lake in China.

Our study subject was Tibetan gazelle, a threatened and endemic species to the Qinghai-Tibet Plateau (Jiang, 2004). The populations of Tibetan gazelle are decreasing sharply and their ranges are fragmented and rapidly shrinking (Schaller, 1998; Zhang and Jiang, 2006). Accordingly, it is now classified as a Category II Protected Wild Animal Species in China and is listed as Low Risk in the IUCN Red List of Threatened Species (Zhang and Jiang, 2006). Tibetan gazelle is sexually dimorphic. Body length of the gazelle is short than 1 m, body weights are less than 20 kg (Zheng, 1994). The mixed-sex groups are mainly found during the rutting season from late December to early January and after then they separate and aggregate in single sex groups (Lian et al., 2004). The lambing period of Tibetan gazelle is about 2 weeks, from late July to early August (Li and Jiang, 2006). Tibetan gazelle is a common wild ungulate in the study area. The focal population at the south of Buha River consists of about 100 individuals. Main predator is wolf, there were about 10 wolves in this area.

2.2. Behavioural observation

Behaviours of Tibetan gazelle were observed with group scan sampling method (Martin and Bateson, 1993) from June to September 2005, and from June to July 2006. As Tibetan gazelle is inactive during night, observations were usually recorded during the daylight between 07:00 and 20:00. Because it was difficult to identify the individuals in the wild, we observed randomly selected groups with a binoculars (8 × 42) and a (20–60 × 63) telescope.

The activities (feeding, bedding, moving, standing and others) of all the group members were instantaneously recorded with scan sampling method at 5-min intervals. Behaviours were classified into five categories: feeding and searching ("feeding" in the following text), bedding and ruminating ("bedding" in the following text), moving, standing and other behaviours. Feeding was defined as a gazelle grazing on the pasture or moving during a grazing bout with its head below its vertebral column. Bedding referred to a gazelle sitting on the ground for rest and rumination. Moving consisted in a gazelle walking or running with its head above its vertebral column. Scanning referred to a gazelle standing and scanning its surroundings or being motionless with its head up, and sometimes the gazelle regurgitates and masticates a cud. Other behaviours included grooming, defecating, lactating and nursing a lamb.

We used "scanning" behaviour as our estimate of vigilance because (1) the head-up posture brings all the sensory organs to a position that should increase the detection range, (2) it costs time that could be used in other activities, and (3) it is the observed state of alertness when a predator is detected (Childress and Lung, 2003). Group vigilance was estimated with group scan level and frequency. Group scan level was calculated as the percentage of individuals in the group engaged in scanning during the session. Group scan frequency was estimated as the percentage of intervals where at least one gazelle was scanning.

One session was defined as an observation started when a male/female group of Tibetan gazelle was found until the group size changed. The observation time ranged from 20 min to 275 min with a median of 70 min. We attempted to observe the gazelle over all daylight hours equally, in order to minimize the effect of daytime hours on vigilance. The nearest neighbor distance in the gazelle groups was usually stable, ranging from 3 m to 5 m. The observed groups ranged from 1 to 15 individuals. Sessions shorter than 30 min were discarded. Because only six mixed-sex groups were found and they usually separated before the observations reached 60 min, these sessions were also discarded. All behaviours were observed by the same person. A total of 155 behavioural sessions were observed, of them, 72 (5085 min) on female groups, 73 (4980 min) on male groups.

2.3. Data analysis

Data were analyzed with SPSS 13.0 statistical package. The data of the group scan level (defined as the percentage of individuals scanning during a session) and the group scan frequency (defined as the percentage of intervals with at least one individual scanning) were firstly arcsine square-root transformed and then were tested with one-sample Kolmogorov–Smirnov test for normality. All data were normally distributed, and then the General Linear Model was used to test the sexual difference and group size effect. All significant differences were set at $P = 0.05$. In the analysis, we entered sex, group size and their interaction as explanatory variables, but found the interaction was not significant. So we removed the interaction of sex and group size and reanalyzed the data.

Table 1
Estimated marginal means of group scan level (proportion of individuals scanning during a session) and group scan frequency (proportion of intervals with at least one individual scanning) of female and male Tibetan gazelles

	Group scan level		Group scan frequency		*N*
	Mean	S.D.	Mean	S.D.	
Female	0.218	0.124	0.458	0.281	72
Male	0.286	0.189	0.529	0.282	73
Total	0.253	0.163	0.494	0.283	145

3. Results and discussion

Male gazelles were significantly more vigilant than females in group scan level ($F_{1,142} = 6.597$, $P = 0.011$; Table 1). They also showed a difference in group scan frequency between sexes, although the difference was not significant ($F_{1,142} = 3.244$, $P = 0.074$; Table 1). In some ungulates, females performed a higher level of group vigilance than males (e.g. Rocky Mountain elk *Cervus elaphus*, Childress and Lung, 2003; merino sheep, Michelena et al., 2006), because they were more vulnerable to predators, especially when they had lambs to nurse. The higher vigilance would favor them an early detection or warning of a predator. However, in our study, males behaved more vigilantly. Similar results appeared in impala (Shorrocks and Cokayne, 2005) and Asiatic wild ass *Eqqus hemionus hemionus* (Bi et al., 2007). That's because males usually behaved more aggressively, thus they scanned for not only predators but also group fellows (Bon and Campan, 1996). During our field observation, we found that chasing or fighting between males was much more than that between females. In such cases, males had to spend extra scanning on their group members.

We examined the effect of herd size on vigilance with group scan level and scan frequency. Group scan level, defined as the average percentage of individuals scanning during a session, decreased significantly with increasing group size ($F_{14,129} = 1.827$, $P = 0.041$; Fig. 1). This means as group size increased, a smaller proportion of individuals scanned around for potential hazards. Meantime, the group scan frequency, defined as the percentage of intervals with at least one individual scanning, increased significantly with increasing group size ($F_{14,129} = 4.405$, $P < 0.001$; Fig. 2). This tells us despite individuals spent less time on vigilance within larger groups, the overall group vigilance level did not decrease but elevated.

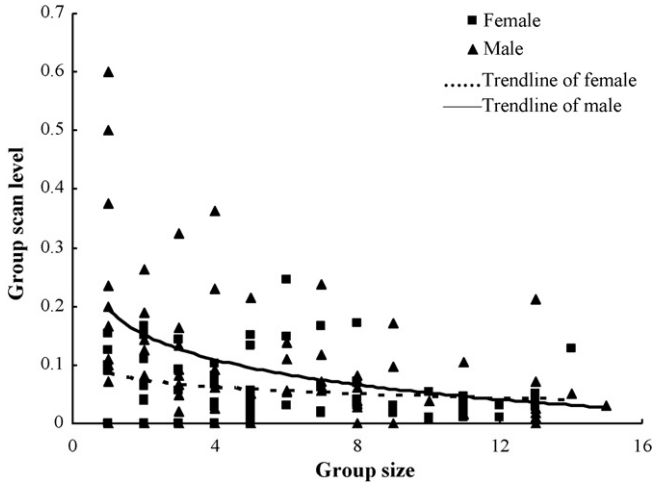

Fig. 1. Influence of group size on the group scan level (proportion of individuals scanning during a session).

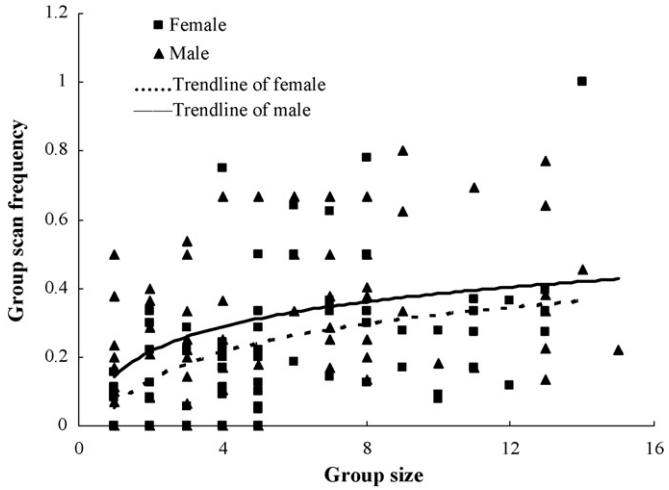

Fig. 2. Influence of group size on the group scan frequency (proportion of intervals with at least one individual scanning).

Our study showed that the group size actually had a significant effect on vigilance of Tibetan gazelle. Although some studies supported that the scramble competition played an important role in the group size effects (Beauchamp, 2003; Beauchamp and Ruxton, 2003; Randler, 2005a,b), we considered the predation effects (the 'many-eyes' hypothesis and the 'safety in numbers' hypothesis) might be the main reason in Tibetan gazelle. That's because scramble competition effects are based on that resources are limited and that foragers jostle to obtain a greater share of resources (Beauchamp, 2003). Thus an increase in the scramble intensity and a decrease in vigilance are expected with the increasing group size. However, vegetations throughout most of the study areas are homogeneous alpine meadows and the food resources are rich for herbivores during summer; therefore the scramble competition might be slight. The intra-specific agonistic effect is another non-predation effect which we used to explain sexual vigilant difference. However, this intra-specific agonistic behaviour might be less related to the group size but more to the determination of social rank (Bon and Campan, 1996). In that case, predation pressure might be the main driving force for the group size effects. Wolves are common in the study areas and they prey on the gazelles (Liu and Jiang, 2003). Living in large groups is no doubt beneficial for each group member because of increased detection ability and dilution of predation risk.

In conclusion, we found that group size had a negative effect on the group scan level and a positive effect on the group scan frequency in Tibetan gazelle. The predation factors of detection and dilution might play the main role on the group size effect on vigilance.

Acknowledgements

We thank the Knowledge Innovation Project of Chinese Academy of Sciences (No. CXTDS2005-4), National Foundation for Nature Sciences (No. 30670267), Whitley Foundation and Sir. Peter Scott Fund for financial supports. We thank Ang Zhihe, Ang Danjia, La Maoji, Cui Qinghu and Lu Xing for help in field work.

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