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Group size and sex effects on vigilance: evidence from Asiatic ibex, *Capra sibirica* in Tianshan Mountains, China

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Abstract. The Asiatic ibex is a threatened endemic species that is distributed in the mountains of central and northern Asia. Using the method of group scan sampling, the behaviour of the Asiatic ibex was studied in the autumn of 2005. The effects of group size and sex on vigilance were tested. The results indicated that both group size and sex affected vigilance levels. Male ibex were significantly more vigilant than females at both the group scan level (percentage of individuals scanned during a session) and group scan frequency (percentage of intervals with at least one individual scanning). The group scan level was negatively correlated with group size, and group scan frequency was positively correlated with the group size in male, female, and overall groups. These results showed that group size and sex affected vigilance in Asiatic ibex.

Key words: sexual dimorphism, ungulate, group scan level, group scan frequency, Xinjiang

Introduction

Vigilance is commonly assumed to be a response to potential predation threats (Ratti & Habermehl 1977). A negative relationship between group size and vigilance, which is called the 'group size effect' on vigilance, has been shown in many species of birds and mammals (Elgar 1989, Lima 1995, Roberts 1996, Dias 2006, Lian et al. 2007, Li et al. 2008, Li & Jiang 2008). Three main hypotheses have been proposed to explain the group size effect: the 'scramble competition' hypothesis (Clark & Mangel 1986, Beauchamp & Ruxton 2003), the 'many-eyes' hypothesis or the detection effect (Pulliam 1973), and the 'safety in numbers' hypothesis or the dilution effect (Foster & Treherne 1981).

The scramble competition hypothesis proposes that, in groups, individuals will compete for limited food resources, which leads to a decrease in vigilance with increasing group size (Clark & Mangel 1986, Beauchamp & Ruxton 2003). The many-eyes hypothesis states that when more animals are in a group, there are more eyes to detect the predator and the individuals could thus decrease their own vigilance and benefit from other group members (Pulliam 1973). The safety in numbers hypothesis states that the risk of being predated should be diluted in large groups because the predator could only predate one prey during an attack (Foster & Treherne 1981). The scramble competition hypothesis emphasizes competition for resources, and other two hypotheses stress the role of predation risk in shaping vigilance levels (Beauchamp 2003, 2007). The three above hypotheses have all been supported in many studies on species such as dark-eyed juncos, *Junco hyemalis*; American tree sparrows, *Spizella arborea* (Lima 1995); coots, *Fulica atra* (Randler 2005a, 2005b); and in redshanks, *Tringa totanus* (Whitfield 2003).

Although the group size effect has been seen in many birds (Beauchamp 2008) and mammals (Elgar 1989, Quenette 1990), it was not observed in some animals

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such as in the Guatemalan howler monkey, *Alouatta pigra*, and the swan goose, *Anser cygnoides*, (Treves et al. 2001, Randler 2003). For these reasons, more studies should be conducted to test the group size effect on vigilance in additional species.

In addition to the group size effects, other factors have also been found to play a role in vigilance behaviour, including sex (Elgar 1989, Childress & Lung 2003, Shorrocks & Cokayne 2005), nearest neighbour distance (Randler 2005a, b, Fernandez-Juricic et al. 2007), age (Boukhriss et al. 2007), and colouration (Götmark & Hohlfält 1995). Especially in animals with size-related sexual dimorphism, sex plays an important role in shaping behaviour. The vigilance level is different between male and female groups, but the particular sex that is more vigilant is not consistent among different species (Ginnett & Demment 1997, Reboreda & Fernandez 1997). Thus, the effects of sex on vigilance level should also be studied in more species.

The Asiatic ibex is a threatened and endemic species in China and its range extends through central and northern Asia. It is classified as a Category I Protected Wild Animal Species under the Wild Animal Protection Law in China, and it is listed as "Endangered" in the China Red Data Book of Endangered Animals (Wang 1998). Except for some field surveys regarding its distribution and population density, the Asiatic ibex has only occasionally been studied in China (Wang 1983, Gu 1990, Feng et al. 2007a, b). The Asiatic ibex usually lives at high elevations and migrates down to lower slopes during the winter. It prefers rugged areas and avoids grasslands in favor of shrub and bare rock areas. Except during the rutting season, male and female ibex live in different groups. The ibex is abundant in nature reserves, which enables us to observe its behaviour (Feng et al. 2007a, b).

In this paper, we tested the effects of group size and sex on vigilance in Asiatic ibex from the Tianshan Mountains of China. Given the aforementioned hypotheses and life span features of the Asiatic ibex, we predict that (1) the vigilance level decreases with group size and (2) the vigilance level between male and female groups is different.

Study Area

This study was conducted on the Tomur National Nature Reserve in the Tianshan Mountains of Xinjiang, China (80°07' – 80°52' E, 41°40' – 42°02' N). The nature reserve is located in the southern flank of the Tianshan Mountains and encompasses approximately 3000 km^2 of rugged ridges and narrow valleys with an elevation of 2000–7000 m above sea level. Its climate is cold and arid, and the mean annual precipitation varies from 600 to 700 mm. The area is inhabited by various other protected animals such as argali sheep, *Ovis ammon*; the snow leopard, *Uncia uncia*; the wolf, *Canis lupus*; the red fox, *Vulpes vulpes*; the snowcock, *Tetragallus altaicus*; and the chukar partridge, *Alectoris chukar* (Sun 1985).

Material and Methods

The behavioural observation was conducted according to the group scan sampling method (Bateson & Martin 2005) during the autumn, from September to December 2005, and between 07:00 to 19:30 h. We randomly selected groups, and we observed their behaviour using binoculars. The ibex's activities were recorded by scanning animal groups at 10-min intervals; all of the observations were recorded by the same person.

The activities were classified into five categories: feeding, standing, moving, bedding, and other behaviours. Feeding was defined as biting, chewing, browsing, grazing, or swallowing food. Standing was defined as standing still, alert, and ruminating. Bedding was defined as sternal recumbence, with or without rumination, and includes sleeping with eyes closed. Moving was defined as traveling and walking. Other behaviour was defined as all other activities not included in the above categories such as grooming, defecating and lactating (Shi et al. 2003, Li & Jiang 2008).

Scanning refers to an ibex standing and scanning its surroundings. Instances where it was motionless with its head up were further regarded as vigilance according to Childress & Lung (2003). Group vigilance was estimated using group scan level and frequency. The group scan level was calculated as the percentage of individuals in the group that were engaged in scanning during the observation session. The group scan frequency was measured as the percentage of intervals during which at least one ibex was scanning (Li & Jiang 2008).

Each observation session began when a group of ibex was found and lasted until they disappeared or the group size changed. Observation sessions with fewer than six scans were discarded. All of the observed groups were composed of adult individuals; mixed groups were discarded due to low sample size (three groups). All of the observed mixed groups were large groups with at least 14 individuals that included adult males, females, and lambs. The group size in mixed groups often changed, making it difficult to define the

start and end of the observation session. Therefore, we compared only adult male and female groups with at least six behaviour observation scans. In total, we observed 34 male group behavioural sessions and 39 female group sessions.

The data for group scan level and group scan frequency were arcsine square-root transformed and then tested for normality with the one-sample Kolmogorov-Smirnov test. Because all of the data showed a normal distribution, we used the General Linear Model to test the effect of the group size, sex, and their interaction on vigilant behaviour. Vigilance level differences between male and female groups were compared using the t-test. We used linear regression to test the effect of group size on vigilance separately for male and female groups. All of the significant differences were indicated by $P \leq 0.05$, and all of the data were analyzed using the SPSS 13.0 statistical package.

Table 1. *Effects of group size, sex, and their interaction on the group scan level and the group scan frequency of Asiatic ibex.*

Factors	Group scan level	Group scan frequency
Group size	$F = 6.780$, $P \leq 0.001$	$F = 2.107$, $P = 0.023$
Sex	$F = 4.334$, $P = 0.044$	$F = 9.436$, $P = 0.004$
Interaction of group size and sex	$F = 0.884$, $P = 0.563$	$F = 0.761$, $P = 0.675$

Table 2. *Comparison of group scan level and the group scan frequency of female and male Asiatic ibex.*

	Group scan level		Group scan frequency		N
	Mean	SD	Mean	SD	
Female groups	0.323	0.136	0.386	0.127	34
Male groups	0.373	0.124	0.449	0.106	39
Total	0.350	0.131	0.420	0.120	73

Results and Discussion

We tested the effects of group size, sex, and their interaction on vigilance using group scan level and frequency. Group size and sex had significant effects on both the group scan level and frequency, but the individuals' interaction did not affect the vigilance level (Table 1).

The vigilance level differed between male and female groups (Table 2). Male ibex were significantly more vigilant than females in both the group scan level ($F_{1,72} = 4.334$, $P = 0.044$) and frequency ($F_{1,72} = 9.436$, $P = 0.004$; Table 2). These results are consistent with studies on the Tibet gazelle, *Procapra picticaudata* (Li & Jiang 2008); impala, *Aepyceros melampus* (Shorrocks & Cokayne 2005); and Asiatic wild ass, *Equus hemionus hemionus* (Bi et al. 2007). Many studies have reported differences in the vigilance level between males and females, but their results are not consistent (Elgar 1989, Childress & Lung 2003, Cameron & Dutoit 2005, Shorrocks & Cokayne 2005). Females may be more vigilant because they are more vulnerable to predators. Increased vigilance can enable them to detect a predator earlier. Males may be more vigilant because they are more aggressive, and they scan for both predators and competitors (Bon & Campan 1996).

Group size had a significant effect on the vigilance level. For all groups, the group scan level decreased significantly with increasing group size ($F_{1,72} = 6.780$, $P \leq 0.001$), whereas the group scan frequency increased with increasing group size ($F_{1,72} = 2.107$, $P = 0.023$). For male groups and female groups, similar results were obtained for the group scan level (Fig. 1) and frequency (Fig. 2). The results indicated that each individual spent less time on vigilance with increasing group size, but the vigilance level of the whole group increased. Explanations for this group size effect on vigilance level could be based on the scramble competition hypothesis, the many-eyes hypothesis, or the safety in numbers hypothesis. The scramble competition hypothesis emphasizes the role of competition for resources, noting that group members will compete for the limited food resources, which leads to a decrease in vigilance with increasing group size (Clark & Mangel 1986, Beauchamp 2007). The many-eyes and safety in numbers hypotheses

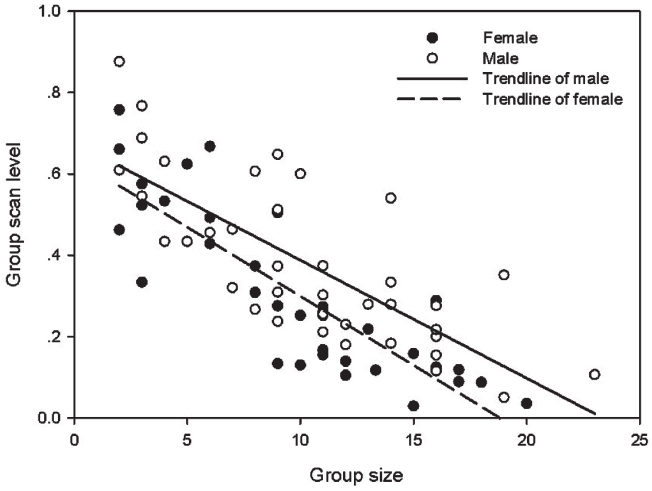

Fig. 1. *Influence of group size on the group scan level.*

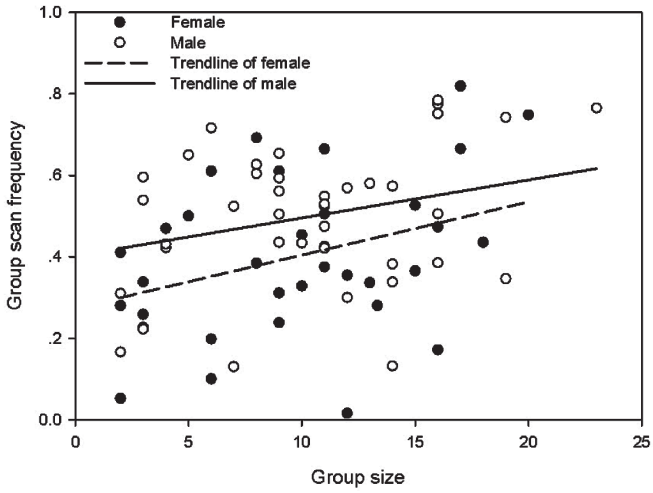

Fig. 2. *Influence of group size on the group scan frequency.*

emphasize the role of predation risk in shaping vigilance levels (Beauchamp 2003, 2007). All of these hypotheses could explain the Asiatic ibex's vigilance behaviour.

In conclusion, we found that both the group size and sex affected the vigilance level in the Asiatic ibex. Group size had a negative effect on the group scan level and a positive effect on the group scan frequency. The vigilance level was different between male and female groups. Males were more vigilant according to both group scan level and frequency.

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