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Vigilance behavior of the Tibetan argali *Ovis ammon hodgsoni* in the Indian Trans-Himalaya *

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Abstract An inverse relationship between individual vigilance level and group size is widely reported in many behavioral studies on animals across several taxa. It is generally held that such a relationship is due to a reduced probability of an individual being killed in larger groups. In the present investigation, I studied the vigilance behavior of the endangered Tibetan argali *Ovis ammon hodgsoni* in relation to group size and escape terrain. I hypothesized that an individual argali has a higher vigilance level in smaller groups and in habitats closer to cliffs than individuals living in larger groups and open areas (escape terrain). The results show that the vigilance of argali decreased with increasing group size, but there was no effect of escape terrain on its vigilance behavior. There were significant differences between age-sex groups: male, female and yearling in their time budgets. Females, compared to males and yearlings, spent more time being vigilant. They also foraged more and moved less than males. It is suggested that vigilance is an important anti-predator behavior amongst argali sheep [*Acta Zoologica Sinica* 53 (2): 195 – 200, 2007].
Key words Tibetan argali, *Ovis ammon*, vigilance, dilution effect, Ladakh, Trans-Himalaya

印度喜马拉雅山区西藏盘羊的警戒行为 *

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摘 要 在几个动物类群中开展的许多行为研究中发现，个体的警觉水平与群体大小存在着负相关关系。一般认为，这种关系是由于个体在一个较大的群体中被捕杀的概率小。在本研究中，我研究了濒危的印度喜马拉雅地区西藏盘羊（*Ovis ammon hodgsoni*）的警戒行为与群体大小和逃逸地形的关系。我假设小群体中的、位于悬崖旁的盘羊比那些大群体中的、开阔地带（逃逸地形）中的盘羊的警戒水平高。结果发现随着群体增大，盘羊的警戒水平下降，但是，逃逸地形与盘羊的警戒水平没有关系。盘羊的不同性别、年龄组之间的时间预算存在显著差异。与雄性和亚成年个体比较，雌性用于警觉的时间多，它们比雄性采食时间长，移动少。因此，警戒行为是是盘羊的一种重要反捕食行为 [动物学报 53 (2): 195 – 200, 2007]。
关键词 西藏盘羊 警觉 稀释效应 拉达克地区 喜马拉雅山区

Vigilance, an important anti-predator behavior in animals, is widely studied amongst wild ungulates (Underwood, 1982; Alados, 1985; Prins and Iason, 1989; Scheel, 1993; Illius and Fitzgibbon, 1994; Bednekoff and Ritter, 1994; Shorrocks and Cokayne, 2005). It entails a head lift above the animal's shoulder followed by scanning of the surroundings for potential predators, competitors and mates (Quenette, 1990). There is, however, a cost of such a behavior as the time spent being vigilant decreases the time that an animal can allocate to other vital activities such as foraging (Elgar and Catterall, 1981; Treves, 2000). For example, food intake rate of large mammalian herbivores decreases with increase in vigilance level (Fortin et al., 2004a). Therefore, herbivores tend to experience a trade-off between surveillance and foraging (Lima and Dill, 1990).

The vigilance level of an animal in response to predators decreases with increase in group size (see reviews by Barnard and Thompson, 1985; Lima and Dill, 1990). It also decreases with decrease in distance to escape terrain (Risenhoover and Bailey, 1985; see review

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by Elgar, 1989). The inverse relationship between group size and vigilance is related to the benefit of grouping, as the vigilance of animals in a group increases the probability of detecting a predator ('many eyes effect'; Powell, 1974) or a decrease in predation risk ('dilution effect'; Quenette, 1990). On the other hand, the positive relationship between the vigilance and distance to escape terrain is explained by the higher security of the animal as it gets closer to escape cover (Frid, 1997).

In this study, I looked at the vigilance behavior of the endangered Tibetan argali *Ovis ammon hodgsoni* in relation to its group size and escape terrain in the proposed Gya-Miru Wildlife Sancturay, Ladakh, India. This mountain sheep is confined to the Tibetan Plateau and its marginal mountains, and is of global conservation importance (Schaller, 1998). Argali feed in a wide range of group sizes (Schaller, 1998); it has a cursorial strategy of out-running predators, and inhabits open areas away from cliffs (Namgail et al., 2004). The Tibetan wolf *Canis lupus* (courser) is the main predator followed by the snow leopard *Uncia uncia* (stalker) that prey on argali in the area (Namgail et al., 2006). Therefore, if vigilance is an important anti-predator behavior, its level should decrease with a) increase in group size and b) increase in distance to cliff.

1 Materials and methods

1.1 Study area

The study was carried out in the Tsabra catchment of the proposed Gya-Miru Wildlife Sanctuary (GMWS), Ladakh, India. It encompasses *c*. 60 km^2, and is located at 65 km southwest of Leh, the principal town of Ladakh. This prospective reserve has a unique assemblage of flora and fauna. The elevation in the area ranges between 4 200 to 5 400 m. The monsoon clouds hardly reach the area, which like rest of the Trans-Himalaya is situated in the rain-shadow of the Greater Himalaya. Thus the magnitude of precipitation is low and erratic, mostly in the form of snow in winter, which is associated with the extra-tropical disturbances of mid-latitudes known as "Western Disturbances" (Dhar and Mulye, 1987). The temperature during the study period ranged between −10℃ to −27℃ (Namgail, 2003). The vegetation is characterised by dry alpine steppe (Rawat and Adhikari, 2005), and the most common vegetation include *Caragana* spp., *Artemisia* spp. and *Eurotia* sp.

Besides Tibetan argali, there is a small population of blue sheep *Pseudois nayaur* in the study catchment, but I did not observe any interaction between the two during the study period, as the latter always grazed closer to the cliffs (Namgail et al.[①], also see Namgail et al., 2004). There is no other ungulate in the area, except for domestic sheep-goat and occasionally few horses accompanying the herders. The area is earmarked for winter grazing by domestic sheep-goat, and *c*. 2 000 of these livestock are taken into the catchment in the latter part of January each year for 2 − 3 months. Apart from the snow leopard and wolf, there are myriad smaller mammalian predators such as the Eurasian lynx *Lynx l. isabellina* and red fox *Vulpes v. montana*, which are threats to the growing lambs. Avian predators include the ubiquitous golden eagle *Aquila chrysaetos*, which occasionally lifts lambs (Namgail, 2005).

1.2 Sampling and statistical analyses

Data on argali's behavior were collected between Jan. − March 2003. Suitable trails and ridgelines were walked to locate argali herds. The slopes were scanned with 4 × 80 binoculars. Once a group located, its size and the distance to cliff from its location were recorded. A group is defined as a collection of animals within 30 m from one another and engaged in similar activities on a slope bounded by the same cliffs, while a cliff is defined as a very steep slope (> 45°) on an area more than 20 m diameter with vertical drops of more than 5 meters. Focal sampling was used to observe the animal's vigilance and other behavior such as feeding, moving and others (all other social activities). On an average, I observed the focal animal from 250 m. An active (non-lying) animal was picked up randomly from the group and observed through a spotting scope for 20 minutes on a stretch, using a stopwatch. For each observation, group size, distance to cliff and sex/age composition were recorded.

Individuals were not marked during the present investigation, and to avoid observing individuals more than once (Machlis et al., 1985), I observed different groups of argali on different days, and to avoid resampling of the same individual, I systematically shifted my focus to different individuals (the number of individuals observed in a focal group ranged between 1 − 5). Behavior of the focal animal was observed and called out by one person and recorded by another. An animal was scored foraging when it foraged on a plant species or moved with its head oriented towards it. When it stood still with its head above shoulder, it was considered to be vigilant, and when it moved with its head upright above shoulder, it was deemed to be moving. All other activities such as sniffing, fighting etc. were placed in a single category: 'others'.

I aggregated the set of focal observations and calculated the percent time allocated by argali to different behavioural activities. Data were arcsine transformed before analysis to meet the assumptions of normality. I regressed group size and distance to cliff against vigilance and fitted linear models to evaluate the relationship

① Namgail T, Fox JL, Bhatnagar YV, 2003. Argali and livestock: friends or foes? Nature of interaction between argali and domestic sheep-goats in a prospective Trans-Himalayan wildlife reserve. Report submitted to the International Snow Leopard Trust, Seattle.

between vigilance and the aforementioned predictors. Following Cote et al. (1997), I used principal component analysis (PCA) to evaluate the differences in time budgets of different age-sex classes: male, female and yearling. This statistical technique is useful in analyzing non-independent data such as time budget. Subsequently, I tested for significant differences between age-sex differences on the factor scores of the first two axes with a one-way ANOVA followed by *post hoc* Fisher's LSD test.

2 Results

I observed 152 focal argali individuals during the study period, but only those observed prior to the livestock arrival ($n = 83$) were used in the analysis of the effect of group size and distance to cliff on argali's vigilance level, while all the observations were used for evaluating the age-sex differences in time budget. There were about 50 argalis in the Tsabra catchment during the study period, and out of the 48 individuals counted, 15 (31%) were males, 20 (42%) females, 4 (8%) yearlings and 9 (19%) lambs. Argali's group size ranged between 1 and 25, and the mean ($\pm SD$) group size was 12.7 (± 5.9).

The effect of group size on the argali's vigilance level was explained by a linear model. Vigilance decreased with increase in group size ($F_{1, 81} = 36.05$, $P < 0.001$). Thirty percent of the variation in vigilance was explained by this predictor ($R^2 = 0.31$; Fig.1a). There was however no effect of distance to cliff on the vigilance behavior of argali ($R^2 = 0.03$, $F_{1, 81} = 2.69$, $P = 0.10$; Fig.1b). There was no relationship between the two predictors: group size and distance to cliff ($R = 0.12$).

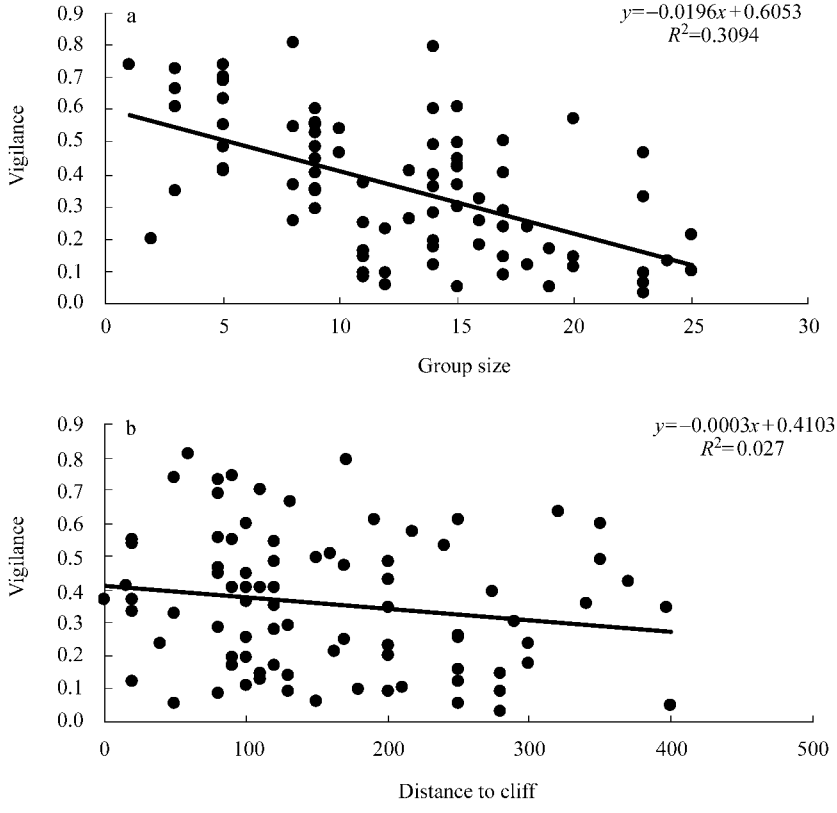

Fig.1 Relationship between vigilance level and (a) group size, (b) distance to cliff in the Tibetan argali in the Indian Trans-Himalaya

Most of the variation (73.3%) in the time budget of argali age-sex classes was explained by the first two axes of PCA. The first axis explained 40.1% and the second one explained 33.6% of the variability. The former distinguished foraging from movement, while the latter separated vigilance from other behaviours, as indicated by the eigenvectors (Table 1). There were significant differences between age-sex groups: male, female and yearling in their time allocation to different behavioral activities ($F_{2, 149} = 3.35$, $P < 0.05$, Fig.2). The *post hoc* Fisher's LSD tests revealed that females, compared to males and yearlings, spend more time being vigilant. Females also foraged more and moved less than males (Fig.3).

3 Discussion

There was an inverse relationship between argali vigilance level and group size. Such a relationship could be related to the increased predator detection (many eyes effect). An individual argali in a group may be taking

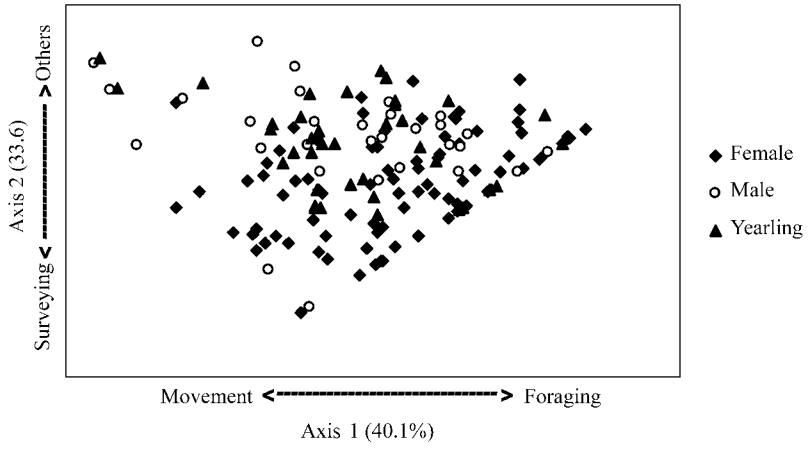

Fig.2 Principal component analysis (PCA) of the time budget of the different age-sex classes of the Tibetan argali in the Indian Trans-Himalaya

The figures in parentheses show the percent variance explained by the respective axis.

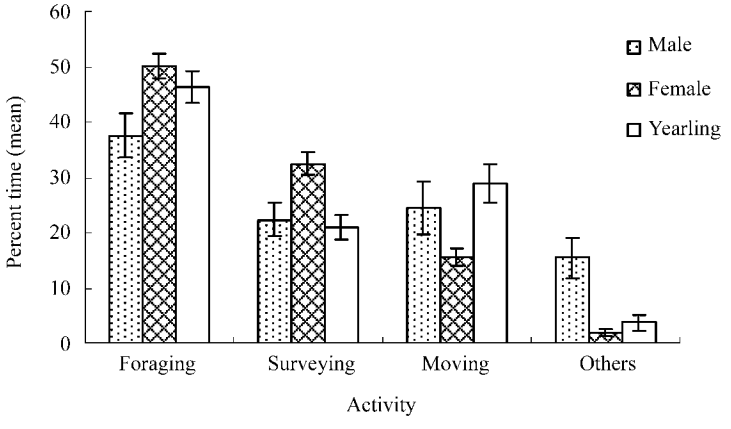

Fig.3 Percentages (Mean ± *SE*) of time allocated to different behavioral activities by different age-sex classes of the Tibetan argali in the Indian Trans-Himalaya

Table 1 Eigenvectors derived from principal component analysis of the Tibetan argali time budget in the Indian Trans-Himalaya

Behaviour	Eigenvector 1	Eigenvector 2
Foraging	0.752462	0.145476
Surveying	-0.187681	-0.825594
Moving	-0.631285	0.414628
Others	-0.007527	0.353998

advantage of the vigilance of group members to reduce its own vigilance level, thereby allocating more time to other vital activities such as foraging. Nevertheless, there are other benefits of group living in gregarious animals (Roberts, 1996). For example, the predation risk decreases with the increase in group size, as the probability of an individual being killed in a group of two is half that of being alone (dilution effect, Quenette, 1990). If vigilance level of an individual depends on predation risk (probability of being killed, in case the group is attacked), and if that risk declines with increasing group size, vigilance should also decline with increasing group size (see review by Roberts, 1996). Thus, the observed negative relationship between argali vigilance level and group size could also be related to a reduced predation risk (dilution effect).

There are however several other confounding factors that might affect the relationship between vigilance level of individual animals and the group size. For example, the perceived level of predation risk may decline with time at a particular site while group may build up through that time (see Roberts, 1995, 1996). This however is of concern in species in which individuals change membership within a day. The argalis are less fluid vis-à-vis their group size in the study area (Namgail et al., 2007) as well as in other parts of Ladakh (Namgail et al., 2004). For instance, during the study period, some groups remained static for up to ten days. Therefore, the decrease in argali's vigilance level with increase in group size could largely be attributed to the decreased risk of predation in larger groups.

Furthermore, foraging constraints also lead to a

decline in herbivore vigilance with increasing group size due to density dependent effects on spare time (the time available for vigilance while chewing food), which tend to have a negative relationship with the number of herbivores in a food patch (Fortin et al., 2004b). Although, predation risk is thought to be the most important factor influencing the vigilance level in herbivores, there are other potential factors that can influence their scanning rates. For example, Fortin et al. (2004b) have shown that an individual's vigilance level increases in more productive patches, where food intake is constrained by forage processing rather than by forage encounter rate. This is largely because the animals can be vigilant while processing their food (chewing) in patches with high vegetation biomass. However, the spatial pattern in forage biomass could not have influenced the behavioral patterns observed in the present study, as the plants (small herbs and shrubs) were sparsely and evenly distributed across the study area (Namgail et al.[①]).

Contrary to my expectation, argali's vigilance level did not increase with the decrease in distance to cliff. This could be related to less predation pressure from cliff-based predators such as the snow leopard, which stalks at the edge of the cliffs (Jackson and Ahlborn, 1989). During the three-month study period, I sighted wolf almost every week, whilst I did not see any snow leopard, although I found the cat's signs such as scraps, but only at two locations. Thus, since wolf is the major predator, which hunts in the open, heightening vigilance level near cliffs is perhaps less beneficial, especially when the views are obstructed by the cliffs (see Arenz and Leger, 1999). Contrastingly, the cliffs may prevent an argali from being detected by wolf, thereby leading to a lower level of perceived threat in habitats close to cliffs. Such observations were made in the African savannas, where ungulate species became less vigilant in areas with more visual obstructions (Scheel, 1993).

During the present investigation, the time budget of females differed significantly from those of males as well as yearlings, as the former spent more time being vigilant, which could be attributed to their concern about the threat of predation on the growing lambs, as females increase their reproductive fitness by avoiding predation on their young (Elgar, 1989). Nevertheless, since both quality and quantity of plant species decline in winter due to the senescence of plants (Namgail et al., 2003), females spending more time than necessary in vigilance may have a less forage intake rate, leading to a lower reproductive performance (see Bleich et al., 1997).

To conclude, vigilance appears to be an important anti-predator behavior in the Tibetan argali. The vigilance level of argali decreases with the increase in group size, but there was no effect of proximity to escape terrain on the vigilance behavior. Females were more vigilant than males and yearlings, which could be related to the former's strategy of reducing predation on the growing lambs.

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① See the footnote on the page 196.

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