Foraging and Bedding Site Selection by Asiatic Ibex (*Capra sibirica*) During Summer in Central Tianshan Mountains

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Abstract.- The Asiatic ibex (*Capra sibirica*) is typically found in the mountains of central Asia, studies on the habitat selection of this animal are few at present. We investigated the bedding and foraging sites selection by line census in the GuRenGuoLeng areas of Central Tianshan Moutains during summer, and assess how environmental factors affect their habitat use. Our results showed that there is no significant difference between foraging and bedding sites of ibex in distance to human settlements, vegetation height in summer, while altitude, slope, distance to road, vegetation cover, distance to water resource, distance to livestock, distance to summit of mountain, distance to hidden objects, hiding cover level and number of plant species have very significant differences. Slope location has no significant difference and landscape types have no significant difference but slope direction show very significant difference. Compared with foraging sites, ibex's bedding sites prefer a higher altitude, smaller slope, closer to water resource and summit of mountain, further distance to road and livestock, higher hiding cover level and lower vegetation cover, habitat in the upper bare rock cliff and sunny slope. Stepwise discriminant analysis showed a series of seven ecological factors play important role on distinguish the bedding and foraging sites, in accordance with the order of its contribution value: distance away from livestock, vegetation cover, hiding cover level, distance to summit of mountain, distance from the settlements, altitude, distance from the hidden objects.

Key words: Asiatic Ibex (*Capra sibirica*), habitat selection, stepwise discriminant analysis.

INTRODUCTION

Habitat selection is the outcome of the trade-offs between the costs and benefits connected with each habitat (Sih, 1980; Lima and Dill, 1990). Individuals may experience these trade-offs differently over time and space. Habitat selection may vary in relation to short-term variations in factors such as activity, time of day and weather; medium-term variations in environmental conditions and physiological status (Ratikainen *et al.*, 2007). Animal habitat selection has close relationship with many factors, such as the need for forage and cover to avoid extreme weather and predators.

The Asiatic ibex (*Capra sibirica*) is distributed only in the mountains of central Asia, India and Mongolia (Schaller, 1977), and is a threatened species in China. It is classified as a Category I Protected Wild Animal Species under the Wild Animal Protection Law in China, and listed as "Endangered" in the China Red Data Book of

Endangered Animals (Wang, 1998; Smith and Xie, 2009). The Asiatic ibex are sexually dimorphic in size and morphology (Schaller, 1977; Fedosenko and Blank, 2001). The Asiatic ibex (*Capra sibirica*) remain relatively poorly studied on ecological studies (Shackleton, 1997; Reading *et al.*, 2007) even though they are relatively common in the mountain ranges they inhabit. Some work has been done on the Asiatic ibex in its southeastern distribution range in the northwestern Himalaya Mountains of India (Schaller, 1977; Fox *et al.,* 1992; Bagchi *et al.*, 2004), Russia (Fedosenko and Blank, 2001) and Mongolia (Reading *et al.*, 1999). Grignolio *et al.* (2004) briefly discuss several factors that could influence spatial behavior and home range size and use in ibex and other ungulates.

Except for some field surveys about its distribution and population density (Xu *et al.*, 2007), vigilance behavior (Xu *et al.*, 2010), daytime activity budgets (Xu *et al.*, 2006, 2012) and bed-habitat selection (Bian *et al.*, 2011), information of the Asiatic ibex in China is still very limited. Our knowledge on the habitat preferences of Asiatic ibex in central Tianshan Mountains remains unknown. The purpose of our study was to

investigate the habitat preferences of the Asiatic ibex in the central Tianshan Mountains in Northwest China. Our results can be used to develop a conversation and management strategy for Asiatic ibex in China.

MATERIALS AND METHODS

Study area

The study area is located in the Khabir Ga Mountain (a range of central Tianshan Mountains), northwest Hejing County, Bayingolin Mongolian Autonomous Prefecture of Xinjiang Uygur Autonomous Region, China (N43°07′-43°27′, E86°01′-86°29′) (Fig. 1). The typical landscape is rugged ridges and narrow valleys, with an elevation of 2801-4537m. Its climate is cold and arid. The mean annual average temperature is -4.7°C and the mean annual precipitation is 280-350mm. The summer is short and cool. An average temperature of 20°C in July. The cold season is long and cold with an average temperature of -15°C in January. The main vegetation is Stipa purpurea (*Stipa purpurea*), Flower-subsessile Needlegrass (*Stipa subsessiliflora*), Edelweise (*Leontopodium leontopodioides*), Chinese Cinquefoil Herb (*Potentilla* spp.), Allium (*Allium* spp.) etc. There are also many protected animals such as argali sheep (*Ovis ammon),* snow leopards (*Uncia undo),* wolves (*Canis lupus*), ferrets (*Mustela erminea*), lynxes (*Lynx lynx*), vultures (*Aegypius monachus*) and golden eagles (*Aquila chrysaetos*).
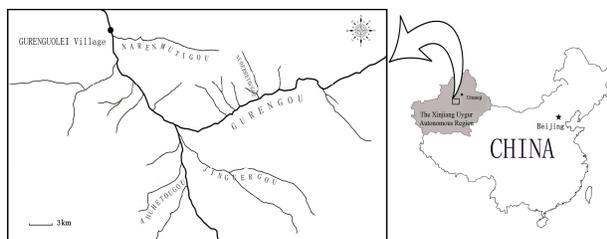

Fig. 1. Study area in GuRenGuoLeng of Central Tianshan Mountains, Northwest China.

Search and position

Nine line transects were used to search ibex in three ditches in June 2009 to December 2010. Line transect laid the way from the bottom to the ridge and covered all habitat types in this region. Due to the huge mountain and wide basin in the studied area, direct observation method can be used to study ibex's habitat. We observed foraging or bedding sites far away using a telescope until the ibex leave. Then one of colleagues is responsible for guiding another person to find the targeted area in the telescope. Part of bedding sites is determined by trace detection, according to the fresh bedding trace and fecal pellet, footprint, urine, hair, etc. surrounding it. We located all foraging and bedding sites by Garmin-72 GPS.

Observed parameters

We took 10×10m square quadrants with the ibex foraging or bedding traces as the center. In this quadrat we took five 1×1m small square quadrants in the center and four corners to a measure and record 15 ecological factors. The quadrants measured during the summer survey of ibex for foraging and bedding sites were 95 and 100 respectively. Ecological factor classification and measurement methods are based on Oil (1996), Zhang and Ma (2000), Liu *et al*. (2005) as follows:

Slope position (SP): This habitat is divided into three parts: the upper part 1/3 of the slope; the middle part 1/3 of the slope; the lower part 1/3 of the slope.

Slope (S): Slope is measured in five 1 m × 1m quadrats slope by declinator and the average value is used.

Slope direction (SD): Slope direction is divided into three kinds: sunny (S67.5°E ~ S22.5°W), a semi-shaded slope (N22.5°E ~ S67.5°E, S22.5°W ~ N67.5°W), north-facing slope (S67.5°W ~ N22.5°E).

Altitude (A): We record the altitude of quadrats by Garmin-72 GPS.

Landscape type (LT): Landscape types within the study area are divided into four kinds: gentle slopes with alpine meadows, gentle slopes with alpine pastures, steep gravel and bare rock cliff.

Distances to human settlements (DHS): settlements include locations of pastoralist's obo, mine sites ect. We measured the distance of the settlements from quadrats by Garmin-72 GPS.

Distances to roads (DR): We measured the vertical distance from quadrats to the road by meter

stick or Garmin-72 GPS.

Distance away from livestock (DL): We estimated the closest distance from quadrats to the nearest free grazing livestock.

Distance to water resource (DWR): It is measured by distance to the water source within the study area and vertical distance to water.

Vegetation height (VH): estimated five 1 m × 1 m quadrats vegetation height, and then calculated the average large plots of vegetation height data.

Vegetation cover (VC): estimated five 1 m × 1 m quadrats vegetation cover, followed by calculation of the average vegetation cover data as large quadrats.

Hiding cover level (HCL): in the five small quadrats center set a 1m high benchmark, benchmark 20m measured at four of its North and South, East and West direction from the center, that is, you can see the benchmark height total height percentage, then the average as large quadrats hiding cover values.

The number of plant species (NPS): Determination of the number of plant species within 5 m x 1m quadrats, and then calculated the average number of species of large plots.

Distance to summit of mountain (DSM): measured quadrats to the nearest hill at the top of the straight-line distance from the top of the hill.

Distance to hidden objects (DH): estimated quadrats to determine the distance away from the around the bare rock cliff, to the straight-line distance of the cliff.

Statistical analyses

We entered field data in Microsoft Excel 2003 and used SPSS 19 for Windows to deal with statistical analysis. All 14 numeric ecological data was tested for normality (Kolmogorov - Smirnov Test). We used Mann-Whitey U test (P <0.05) and T test (P > 0.05) to determine the differences between foraging and bedding habitat. Throughout this paper, values are presented as mean ± standard error, and the significance level is set at α = 0.05. The chi-square test is used to determine the differences of non-numeric ecological factors data. We also performed stepwise discriminant analysis (SDA) to determine the key decisive factor of habitat selection. Wilk's K value is selected as discriminant

index of foraging and bedding habitats of ibex, the smaller the value the stronger discriminant ability.

RESULTS

There is significant difference in altitude, slope, distance to road, vegetation cover (P <0.01) between foraging and bedding sites (Table I). Two independent samples Mann-Whitey U test showed significant difference in distance to water, distance from the nearest livestock, distance from the nearest hidden object, distance from the top of the hill, hidden level (P <0.01) between foraging and bedding sites of ibex. There is no significant difference in vegetation height, and distance from the nearest human settlement (P > 0.05) (Table I)

There is significant difference in slope position ($\chi^2 = 8.364$, df = 2, P = 0.015 <0.05), very significant difference in slope direction ($\chi^2 = 16.665$, df = 2, P = 0.000 <0.01) and no significant difference in choice of landform types ($\chi^2 = 4.701$, df = 3, P = 0.195> 0.05) between foraging and bedding site of ibex in summer.

Compared with foraging sites, Ibex prefer to bed at a higher altitude, smaller slope, closer distance to water and peak, closer distance from the road and the nearest livestock, higher hidden level, sunny slopes with lower vegetation cover in upper position of bare rock cliff.

Results of stepwise discriminant analysis (SDA) on foraging and bedding sites selection showed an eigenvalues of 3.644, canonical correlation coefficient of 0.886, which contains all of the variance (100%). There is a higher degree of separation between foraging and bedding sites in the canonical coefficient histogram.

Value of Wilks' K also suggested a very significant difference between foraging and bedding sites selection (Wilks' K = 0.215, $\chi^2 = 169.673$, df = 15, P = 0.000 <0.001). Stepwise discriminant analysis showed a series of seven ecological factors play a role on distinguish the foraging and bedding habitat, in accordance with the order of its contribution value: distance away from livestock, vegetation cover, hiding cover, distance from the top of the hill, distance from the settlements, altitude and distance from the hidden objects (Table II). Based on the above ecological factor variables, the

Table I.-   **Differences between environmental parameters recorded at foraging and bedding sites of Ibex during summer (Mean ± SE, abbreviations see text).**

Ecological factors	Foraging site	Bedding site	Mann-Whitey U test Z	T test	Significance
DH(m)	55.93±72.01	10.51±17.93	-6.067		**
DL(m)	657.67±114.50	841.50±132.36	-6.697		**
Altitude (m)	3376.00±138.73	3468.87±140.08		-3.649	**
Slope (°)	28.00±10.47	20.90±7.24		4.322	**
DWR (m)	1476.83±217.71	1415.87±153.00	-3.114		**
DR (m)	1477.08±286.94	1681.42±457.21		-2.932	**
DHS (m)	1881.50±257.93	1914.67±180.27	-1.123		NS
DSM （m）	84.50±82.10	28.08±28.32	-4.345		**
VH(cm)	13.86±3.26	14.77±4.19	-1.308		NS
HCL	7.63±1.81	12.33±5.56	-5.946		**
VC (%)	55.53±18.79	29.62±19.98		7.321	**
NPS	8.28±2.76	7.65±2.61	-1.128		**

Note: (**) Significant different (P<0.01), (NS) No significant different (P>0.05)

Table II.-   **Regression Discriminant analysis of foraging and bedding sites of Asiatic Ibex during summer (abbreviations see text).**

Variable No	Variables	Discriminant coefficient	Wilks'λ	F	Significance
1	DL (m)	-0.778	0.641	66.204	**
2	VC (%)	0.377	0.510	56.218	**
3	HCL	-0.207	0.435	50.206	**
4	DSM (m)	0.752	0.347	43.000	**
5	DHS (m)	0.429	0.300	43.912	**
6	Altitude (m)	-0.910	0.285	40.143	**
7	DH (m)	0.319	0.226	41.798	**

Note: (**) Significant different (P<0.01)

correct distinguish rate on foraging and bedding sites reached 95.8%.

DISCUSSION

Habitat selection

The habitat factors descriptive statistics and test results show that there is significant differences on selection between foraging and bedding sites of ibex in summer, mainly in: distance from the livestock, vegetation cover, hiding cover, slope direction, distance from the top of the hill, distance from the settlements, altitude, landscape type, distance to the nearest hidden object. Compared with foraging site, Ibex prefer to bed at a higher altitude, smaller slope, closer distance to water and peak, closer distance from the road and the nearest livestock, higher hidden level, sunny slopes with lower vegetation cover in upper position of bare rock cliff. The stepwise discriminant analysis results also showed that the contribution rate of ecological factors on foraging and bedding sites choice is different in summer. Ibex's differences in the choice of foraging and bedding sites can be due to predators and food resources. Optimal foraging theory suggests that an animal should forage in areas where its intake rate is highest and predation risk lowest (Houtman and Dill, 1998). Although the ibex may be safer in the cliffs (bedding sites), there is less forage available in them. Therefore, they move out of such bedding sites for foraging and need to strike a balance between food acquisition and predator avoidance, while foraging outside the bedding sites.

Anti-predator

The high preference for bedding sites close to cliff is consistent with the result obtained in other studies on ibex in India, Mazong and Tuomuer Mountain (Fox *et al*., 1992; Xu *et al*., 2007; Bian *et al*., 2011) and blue sheep (Namgail *et al.*, 2004), which have similar ecological niche with ibex. Such preferences reflect the importance of cliffs as escape terrain, and perhaps a high predation pressure in the area. We saw wolves for several times during field investigation. It suggests there is a high density of large carnivores in Central Tianshan Mountain. Bare rock cliffs become an important escape terrain in an area with high predation risk (Namgail, 2006). In addition, the cliffs and other hidden objects can block the wind and favor incubation in the night (Liu *et al*., 2005). The body structure of the ibex is more suitable for bare rock cliff habitat, especially their relatively short and stout limbs to ensure their flexibility of movement and evasion from predators in steep and rugged terrain (Bleich, 1999). Steep terrain is ideal place for mountainous ungulates to escape predators (Oil, 1994). Ibex select rest in the upper mountains and has enough time to discover predators (Bian *et al*., 2011).

Food

Food availability is the most important factors of habitat selection (Frankin *et al*., 1975). High plant cover means high availability of food resources in some extent and, therefore, ibex prefer to forage in the area with higher plant cover, compared with bedding sites. The European goats (*Capra ibex*) stay in the high altitude areas above the treeline and prefer alpine pastures and stone canyons in summer. In the hottest time of the day the goat alternately rest in canyon and forage in grassland, which provide high-quality forage (Grignolio *et al.*, 2003). Our findings show that there is a very significant difference on altitude between foraging and bedding sites and suggest that the local ibex migration mainly in the daytime activities. The ibex move regularly between foraging and bedding sites to meet the demand for food and refuge during summer.

Impact of human activities

Stepwise discriminant analysis can distinguish the foraging and bedding sites of ibex more effectively. Obviously, the key factors affecting ibex selection of foraging and bedding sites are disturbances and predators. Until now, there are a lot of controversies on the influence of livestock grazing on wildlife (Mishra and Rawat, 1998). Livestock grazing are mainly concentrated in the lower position of the mountains in the studied area. The high affinity of these ungulates toward cliffs may also make them relatively less vulnerable to disturbance associated with livestock grazing, as such terrain types are used less frequently by livestock herders. The high preference for bedding site far away to road are consistent with the result obtained in other studies (Chu *et al*., 2009; Bian *et al*., 2011) and suggest anthropogenic interference is important factors on habitat selection of ibex. Iron mining industry developed rapidly in recent years and caused some damage on the original habitat of ibex in the studied area. Mine production operations, especially large transport vehicles, made ibex more sensitive to human disturbance. Ibex prefer for resting in the places farther away from the road to avoid human disturbance.

As ibexes are the common species of alpine ungulates in study area, its survival conditions become a good indicator when evaluating the conservation conditions of the area. Such results will be helpful in understanding the conditions needed for ibex survival in the study area. The results are valuable for the conservation and management strategy.

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