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Relationship between ibex and snow leopard about food chain and population density in Tian Shan[2]

Daoning Wu[1,2], Roller MaMing[1] *, Guohua Xu[1,2], Xinsheng Zhu[1,2], Paul Buzzard[3]*
[1,] Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi 830011, China
[2,] University of the Chinese Academy of Sciences, Beijing 100039, China
[3,] Detroit Zoological Society, Detroit 48067, USA

Many studies have demonstrated that ibex (*Capra sibirica*) are the most frequently eaten prey of snow leopards (*Panthera uncia*) in Xinjiang, the west of China. Thus, an understanding of interactions between these species may have significant management and conservation of implications for both. In this study, we provide information on ibex grouping and density over a 24 month period in the Tian Shan of Xinjiang, China. We then use ibex density to estimate the density of snow leopards. We observed ibex primarily in ewe-lamb groups (N=880), but ibex sexual segregation and grouping changed seasonally with more mixed-sex groups during the winter rut. We observed the most ibex in April 2014 and 2015 with an average of (2422 ± 119 ibex). Over the 1643 km^2 study area we then estimated an ibex density of 154 ± 23 ibex /100 km^2 from which we estimated a density of 1.31~2.58 snow leopards/100 km^2.

Introduction

The snow leopard also known as the Ounce (or *Uncia uncia*) is distributed primarily in alpine areas across central Asia from Afghanistan across Western China and into Mongolia and Russia (McCarthy, 2000; Ma et al., 2005). In Xinjiang, China snow leopard status is still unknown in many areas, and there are many threats to its conservation such as poaching and habitat destruction (Ma et al., 2011-2015). In Xinjiang the future of snow leopards depends on establishing protected areas, protection from poaching and proper management of prey species (Schaller et al., 1988; Ma et al., 2006; Xu et al., 2014). The snow leopard is classified as a Class I in the list of the National Protect Wildlife Law in China and endangered in the International Union for the Conservation of Nature (IUCN) Red List since 1988 and is listed in Appendix I of the Convention on International Trade in Endangered Species (CITES) since 1975 (Wang, 1998).

Snow leopard is often regarded as indicator species and a flagship species in alpine mountain ecosystems, and snow leopard presence is indicative of a healthy ecosystem (Ma et al., 2013). The snow leopard is regarded as an indicator species, in part, because snow leopards rely on a wide variety of prey to maintain healthy populations. Ma et al. (2013), in fact, show that snow leopards in the central Tian Shan Mountains of Xinjiang can prey on a wide variety of species including medium to large wild and domestic ungulates up to three times heavier than themselves as well as small mammals, and a wide variety of birds (Table 1). An infrared camera even showed a snow leopard hunting in the nest of a Himalayan Vulture (*Gyps himalayensis*, Ma and Xu, 2015). Despite an ability to capture a wide variety of prey, ibex mostly consume ungulates (65% of prey items) and primarily ibex which account for 38% of prey items (Ma et al., 2013).

Methods

This study was conducted from October 2013 through September 2015 in the central Tian Shan, Urumqi, Xinjiang Uygur Autonomous Region in the west of China (N43°13′~N43°43′; E86°30′~87°29′). The study area covered 1643 km^2 (Zhu et al., 2015a).

We classified ibex group types as male, ewe-lamb, mixed-sex and singletons (Alados, 1986). To census ibex we used fixed-point observations and counts along transects. During fixed point observations we searched from two vantage points, which were selected in areas known to be used by ibex (McCarthy, 2000). Two well-trained teams used binocular telescopes (MINOX, 10×42) and high-powered spotting scopes to count every group of ibex. We conducted counts three times each month in the morning and evening and counts lasted at least two hours. We conducted line transect surveys three times each month with transects ranging from 8~10 km in length. The transects were in areas with limited human disturbance and relatively abundant wild population. Care was taken not to double count ibex groups. Data were analyzed by using Excel 2007 and Origin 9.0.

We calculated snow leopard population density with the following formula (Xu, 2006):

P= SW/150d

[2] * Corresponding authors, E-mails: maming@ms.xjb.ac.cn and pbuzzard@dzs.org

Where P= population density of the snow leopard (/100km^2), S= density of snow leopard prey (ibex) (/100km^2), W= ibex weight (50~60 kg, the upper range for female ibex, Smith and Xie, 2008), d=snow leopard average weight (30~40 kg).

Table 1. Diet composition of the snow leopard and relative estimated mass in Tian Shan Mts.

Food types	Categories	Estimated mass /kg
Larger ungulates	Ibex (*Capra ibex*)	40-60
	Argali (*Ovis ammon*)	65-185
	Wild Boar (*Sus scrofa*)	90-200
	Red Deer (*Cervus elaphus*)	80-150
	Roe Deer (*Capreolus capreolus*)	15-30
Small mammals	Marmots (*Marmota bobak*)	3-5
	Pikas (*Ochotona* spp.)	0.09-0.2
	Cape Hare (*Lepus capensis*)	1.0-3.5
	Hamsters (*Criceulus* spp.)	0.08-0.16
	Gerbil (*Gerbillinae*)	0.06-0.15
	Various Rodents (spp.)	0.04-0.17
Aves	Common Pheasant (*Phasianus colchicus*)	0.8-1.6
	Chukar Partridge (*Alectoris chukar*)	0.4-0. 6
	Quail (*Coturnix coturnix*)	0.2-0.5
	Snowcocks (*Tetraogallus*)	1.0-2.6
	Wild Ducks	1.0-1.9
	Wild Geese	5.0-6.5
	Whooper Swan (*Cygnus cygnus*)	8.0-12
	Wild Crane	3.0-5.5
	Himalayan Vulture (*Gyps himalayensis*)(egg or young)	5.0-12.0
	Unidentified birds	0.2-1.4
Domestic livestock	Poultries（domestic chickens, ducks and geese)	2.0-3.5
	Domestic Cattle	100-300
	Domestic Yak	150-500
	Domestic Goat	25-30
	Domestic Camel	100-300
	Domestic sheep	15-30
	Dog and mastiff	13-30
Plants	Carex Hirta (*Carex* spp.)	
	Bog Sedges (*Kobresia* spp.)	
	Kali Collina (*Salsola collina*)	
	Branches, Leaves, Fruits and so on	

Results

We counted a total of 1637 ibex groupings and 19891 ibex individuals over the study period with an average group size of 12.15. We most commonly observed ewe-lamb groups, counting 9926 individuals in 880 groups. There were 448 mixed-sex groups of 7634 individuals, and 183 all male groups of 2215 individuals. We rarely observed solitary ibex. Usually only 3-7 were seen per month with the most (25) being observed in December and January (25 and 20 singletons, respectively, Fig. 1).

Ewe-lamb groups were most common during May and June with totals of 1525 and 1541 individuals in 123 and 88 groups, respectively (Fig. 1). Ewe lamb groups were relatively rare in the winter (November-February) when mixed sex groups were more common. There were 1160 and 1170 individuals in mixed-sex groups in January and February, belonging to 80 and 90 groups, respectively. Mixed-sex groups were rare in the summer with only two groups seen in June consisting of 51 individuals. All male groups were most common in

May, June, August and September (Fig. 1) with May having the largest number of males in all male groups (400 males in 33 groups).

The largest numbers of ibex were recorded in April (2422 ±119) and May (2399 ±95), and the fewest ibex were seen in July and November (943±47). In most other months we saw from 1543 to 2002 ibex (Fig 1).

To estimate ibex population density we used the largest monthly count (2422 ± 119) to calculate an ibex density of 154 ± 23 ibex /100 km^2. Then, using the formula from McCarthy (2000) we estimated 1.31-2.58 snow leopards/100 km^2 in the study area.

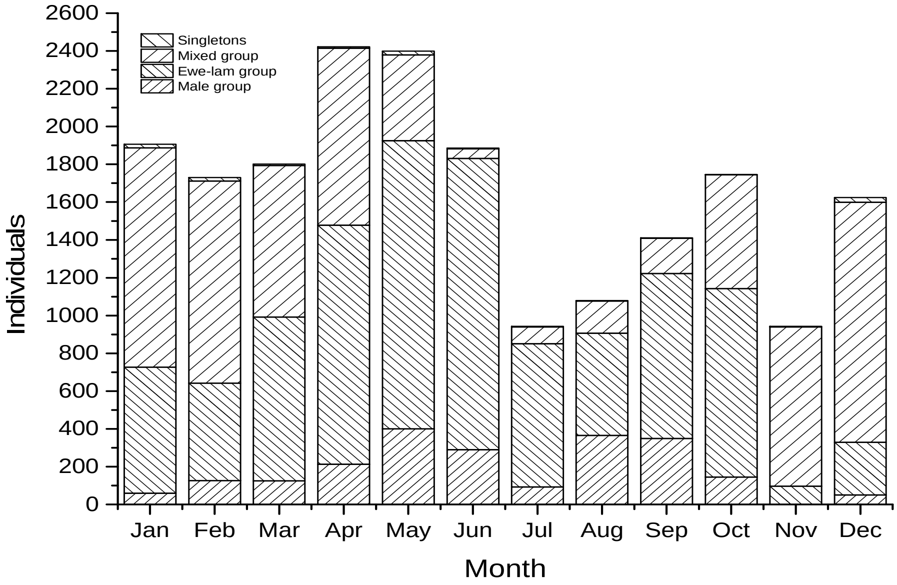

Fig1. Monthly of relative ibex group type individuals and population numbers in our study region

Discussion

Our results supported by the earlier work of Zhu et al. (2015a) with ibex at the same study site. We also encountered ewe-lamb groups most frequently and demonstrated that group types changed with the seasons. Specifically, mixed sex groups were most common in winter rut, and at other times ewe-lamb groups were most common.

Our population density estimate for ibex in the central Tian Shan (154 ± 23 ibex /100 km^2) falls within the range of reported ibex densities (13-270 ibex/100 km^2) from China and Kyrgyzstan (Schaller et al., 1988; Xu et al., 2007; McCarthy et al., 2008; Zhu et al., 2015b). The estimate from our study came from a much larger area (1643 km^2 compared to the 50-475 km^2 surveyed in previous studies) and from multiple years of study. Our study demonstrates the importance of long term studies because ibex counts varied widely from month to month and using the lower counts would have resulted in much lower density estimates.

The population density estimate for snow leopards in the study area (1.31-2.58 snow leopards /100 km^2) is more than what had been reported in other parts of Xinjiang (Schaller et al., 1988; Ma et al., 2011; Xu et al., 2014), but it is similar to potential snow leopard densities calculated from ungulate biomass in SaryChat and Jangart, Kyrgyzstan as well as Tomur, Xinjiang (8.7, 1.0, and 1.1 and 8.7 snow leopards/100 km^2, respectively, McCarthy et al., 2008). The ungulate biomass indices used by McCarthy et al. (2008), however, did not agree with other indices of abundance.

Using only ibex population density as a predictor of leopard density has several potential sources of error (McCarthy et al., 2008). For example, predator/prey rations may be complicated because of competition with sympatric mammalian predators including gray wolf (*Canis lupus*), red fox, brown bear, wild cat and Eurasian lynx (*Lynx lynx*). In addition, considering only ibex does not account for other potential snow leopard prey such as red deer, roe deer, small mammals and birds (Ma and Xu, 2015). Ibex use is justified, though, because Ma et al. (2013) found that ibex were the most common prey and Schaller et al. (1988) analyzed 19 snow leopard droppings from Tomur in the western Tian Shan and found that ibex were the only animal remains in all of the droppings.

However, if limitations are recognized and addressed, estimation of snow leopard abundance from ibex and other ungulate densities may provide the best available and easily applied method for assessing snow leopard population density with more accurate information about the diet of snow leopard and the densities of other ungulates. For a better understanding of the conservation status of snow leopards future work should strive for more accurate estimates of snow leopard densities, and comparisons can be made among abundance estimates using the formula from McCarthy (2000), the formula of Carbone and Gittleman (2002) which also uses ungulate abundance to estimate carnivore abundance as well as camera trap evidence (Buzzard et al., unpublished data).

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Резюме

Множество исследований доказывает, что сибирский горный козел является наиболее частой добычей снежного барса в Синьцзяне, Западный Китай. Поэтому, понимание взаимодействия между этими видами может быть подспорьем для сохранения обоих видов. В данной работе мы приводим материалы по группировкам горных козлов и их плотности в течение более чем 24 месяцев в Тянь-Шане (Синьцьзянь, Китай). Затем, мы использовали данные по численности горных козлов для оценки численности снежного леопарда. Первоначально мы наблюдали их в группах самки-молодые (N=880), но отделение особей по возрасту, а также другие перемещения зверей, приводят к тому, что группировки претерпевают сезонные изменения, образуя более смешанные в половом отношении группы в течение зимнего периода. Большинство горных козлов наблюдалось в апреле 2014 и 2015 гг., в среднем по (2422 ± 119 ibex). На территории наблюдения более 1643 km^2 мы вычислили среднюю плотность 154 ± 23 горных козлов на 100 km^2, а затем, с помощью вычислений, определили плотность снежного барса в 1.31~2.58 особей на 100 km^2.

Методы полевого исследования включали в себя круглогодичные стационарные и маршрутные наблюдения с помощью мощной оптики, а также использование инфракрасных фото-ловушек. Было получено более 600 снимков снежного барса и более 10 тысяч снимков горных козлов. Подробности проведения работы и последующих вычислений можно найти в предлагаемой статье.