Mongolian Journal of Biological Sciences 2007 Vol. 5(1-2): 29-36

Siberian Ibex (*Capra sibirica*) Home Ranges in Ikh Nart Nature Reserve, Mongolia: Preliminary Findings

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Abstract

Siberian ibex (*Capra sibirica*) remain poorly understood, as little is known about their ecology. We began studying ibex in Ikh Nart Nature Reserve, Dornogobi Aimag, Mongolia to better understand the species' ecological needs and threats. In this paper we report on home range and core range sizes. We captured 27 ibex and fit them with radio telemetry collars using drive nets for adults and juveniles ($n = 22$) and hand captures for neonatal kids ($n = 5$). We collected 1,029 locations from September 2003 to February 2007. Throughout the study, 9 ibex with 40+ fixes used mean, annual home range sizes of 3,115.5 ± 504.2 ha using the Minimum Convex Polygon method. Home ranges calculated using the fixed kernel method were smaller: 475.9 ± 14.7 ha for 50% kernel and 1,808.0 ± 88.1 ha for 95% kernel. Ibex from different demographic groups (males vs. females and juveniles vs. adults) used remarkably similar home and core ranges; we found no significant differences among any demographic groups. Although not quantified, ibex mostly restricted their activities to areas with steep cliffs and rocky outcrops and home ranges overlapped extensively.

Key words: *Capra sibirica*, core range, home range, Mongolia, Siberian ibex.

Introduction

Siberian ibex (*Capra sibirica*) remain relatively poorly studied (Mallon *et al.*, 1997; Shackleton 1997). Few ecological studies of Siberian ibex outside of Russia (see Fedosenko and Blank 2001 for a review of the Russian literature) have been conducted even though they are relatively common in the mountain ranges they inhabit (but see Fox *et al.*, 1992). Despite descriptions of ibex habitat, to our knowledge, no study has examined home range size for Siberian ibex. Grignolio *et al.* (2004) briefly discuss several factors that could influence spatial behavior and home range size and use in ibex and other ungulates, including habitat features (e.g.., distribution of habitats, climate, human activities), population considerations (e.g., population density, social structure), and individual traits (e.g., gender, age, body condition, reproductive status).

Siberian ibex are sexually dimorphic in size and morphology, with males typically reaching about 90 kg and growing large, scimitar shaped horns that can extend to 140 cm (Schaller 1977; Fedosenko and Blank 2001). Females are approximately 50% as large as males, with smaller, dagger shaped horns (Schaller 1977; Fedosenko and Blank 2001). Such dimorphism could influence ibex ecology. Research on other large, sexually dimorphic ungulates (including other species of ibex) suggests that males and females should segregate themselves sexually, with females utilizing smaller home ranges than males (Main *et al.*, 1996; Villaret *et al.*, 1997; Ruckstuhl and Neuhaus 2000; Grignolio *et al.*, 2004). Theories to explain sexual segregation include the predation risk or reproductive strategy hypothesis, forage selection or sexual dimorphism-body size hypothesis, scramble-competition hypothesis, weather sensitivity hypothesis, social factor, social preference or behavioral incompatibility hypothesis, and activity budget hypothesis (for details, see reviews in Main *et al.*, 1996; Ruckhaus and Heuhaus 2000; and Bon *et al.*, 2001).

We began specifically studying ibex in Ikh Nart Nature Reserve, Dornogobi Aimag in 2005, although we acquired some data on the species while conducting argali research. We hope to better understand the ecological needs of ibex, as well as the threats facing them in Ikh Nart. In this paper we describe the home range and core range sizes of Siberian ibex. We briefly examine how the number of telemetry fixes influences home range and core use area estimation. We predicted that males would utilize larger home and core ranges than females and that the sexes would use different habitats, except during the rut. However, we also predicted that the lack of elevation change and limited escape terrain in Ikh Nart would reduce sexual separation of ibex relative to populations inhabiting mountainous areas. We further predicted that older animals would use larger home and core ranges.

Material and Methods

Study Area. We studied Siberian ibex in the northern portion of Ikh Nart Nature Reserve (hereafter we refer to the protected area as Ikh Nart). The reserve was established in 1996 to protect 66,600 ha of rocky outcrops in northwestern Dornogobi Aimag (Myagmarsuren, 2000; Reading *et al.*, 2006). The region is a high upland (~1,200 m) covered by semi-arid steppe vegetation. Permanent cold-water springs are available in some of the several, shallow valleys draining the reserve. Climate is strongly continental and arid, characterized by cold winters (to -40°C), dry, windy springs (to 25 mps), and relatively wet, hot summers (to 43°C). Humidity is extremely low. Precipitation is low and seasonal, with most precipitation falling in the summer (Reading *et al.*, 2006). The flora and fauna are representative of the semi-arid regions of Central Asia, with a mix of desert and steppe species (Reading *et al.*, 2006). Vegetation is sparse. Xerophytic and hyperxerophytic semi-shrubs, shrubs, scrub vegetation, and turfy grasses dominate, including *Haloxylon ammodendron*, *Sympegma ergelli, Anabasis brevifolia*, *Ephedra prjewaliskii*, *Ilynia regeli*, *Stipa glareosa*, *S. orientalis*, and *Reumuria songarica*. Different plant communities can be found around oases and streams, on rocky outcrops, and other localized areas.

Methods. Each year we attempted to capture adult and kid ibex and fit them with radio telemetry collars using drive nets for adults and hand captures for kids (see Kenny *et al.* in press for details on capture methods). During drive netting, we used 2 sets of parallel, overlapping drive nets approximately 3 m x 30 m to create 2 net barriers extending approximately 400 m in the bottom of a shallow, dry stream bed or other suitable site. We employed 4-8 people on horseback, motorcycles, and 4 x 4 vehicles to locate and drive ibex toward the nets and a hidden ground crew to extend the net and restrain captured animals. Researchers located and captured newborn ibex kids during late April – early May. Ibex kids were approachable for 1-3 days after birth, at which time we slowly approached and grabbed them by hand.

For all animals captured, we placed hoods over their eyes, weighed them, took a variety of morphometric measurements, aged them using horn rings, collected biological samples (i.e., hair, blood, fecal, parasites), and monitored temperatures, pulses, respirations, put ear tags on each ear, and attached radio collars. For adults we attached traditional radio collars and the entire process lasted 7-15 minutes. For lambs we used expandable, drop-off radio collars (that stayed attached 9 – 15 months) and the entire process lasted 7-10 minutes. We took care to keep noise to a minimum during captures and avoided undue handling. We kept moisturizer for the eyes on hand. We used a pocket weather tracker to monitor some meteorological parameters during capture events.

We tracked radio-collared animals throughout the year using a traditional receiver; a yagi, hand-held, two- or three-element antenna; and a global positioning system (GPS). We searched for collared animals a minimum of two weeks each month, often the entire month. Although we attempted to get a fix on every collared animal for every day we were in the field, we generally obtained a fix only once every few days. We ensured that we did not bias our fixes by influencing animal movements. To do this we approached animals slowly from behind rocky outcrops and used binoculars and spotting scopes to locate and identify animals at a distance. Animals that responded to trackers were not tracked during that day. After the collared animal(s) moved from their position, we collected the GPS position.

We incorporated our telemetry data into a geographic information system (GIS) to help us understand habitat use, home range sizes, and movement patterns. We estimated home ranges using minimum convex polygon and the fixed kernels method (Worton, 1989) using ArcGIS 9.1 Geographic Information Systems software (Environmental Systems Research Institute, Redlands, CA) along with the Animal Movement (Hooge and Eichenlaub 1997), xTools (xTools Pro extension for ArcGIS Desktop Copyright C Data East, LLC), and Hawth's Tools (Beyer 2004) extensions. MCP home ranges were determined using 100% of daily fixes (i.e., 100% MCP). For fixed kernels, we used least squares cross validation to select the smoothing parameter because our data were clumped (Seaman & Powell, 1996; Gitzen *et al.*, 2006). We used 95% kernel home ranges to indicate typical use areas and 50% kernel home ranges to indicate core use areas. We estimated the minimum number of points used in range analyses by plotting number of locations against range size to determine the asymptote (Loveridge & Macdonald, 2003).

We examined all variables for normality and homogeneity of group variance using Bartlett's test and transformed data or excluded outliers to normalize data, where appropriate. We compared means using simple *t*-tests, with corrections for separate variances where appropriate. We ran least squares regressions to test for the effects of age on home range size and used multivariate analyses (specifically, analyses of variance and regressions) to examine variables that influence target variables, such as species habitat selection. We set significance at $P < 0.05$. We report means ± 1 standard error (SE).

Results

We captured 29 ibex in Ikh Nart from September 2003 – May 2007, of which 2 males were recaptures (Table 1). Since we captured several animals simultaneously, we simply re-released re-captured animals immediately after capture. Therefore, we radio collared a total of 27 ibex. Of this total, we hand captured and collared 5 ibex kids (2 males and 3 females) with expandable, drop-off collars, all in 2005 and 2007. We captured the other 24 ibex using drive nets, including 5 adult nannies 15 adult billies, 2 nanny yearling, 1 male kid, and 1 female kid. We collected 1,029 locations on radio collared Siberian ibex in Ikh Nart from September 2003 to February 2007. We collected data on most animals for < 1 year, although we obtained > 3.5

Table 1. Siberian ibex (*Capra [ibex] sibirica*) telemetry data in Ikh Nart Nature Reserve, Mongolia, Sept., 2003 - Feb., 2007. Home range analyses conducted through February 2007, thus days with fixes and days in study only include data up until then. MCP = 100% Minimum Convex Polygon home range. Kernel is the adaptive kernel core (50%) or home (95%) range. % MCP overlap is the percentage of MCP area that overlaps with the MCP home range of at least 1 other study animal.

Name	Sex	Age	Status	Date collared	MCP (ha)	% MCP overlap	Kernel (ha) 50%	Kernel (ha) 95%	Days w/ fixes	Days in study
Randy	M	Adult	Alive	9/20/05	2,668.9	100.0	439.5	1,672.9	71	510
Bold	M	Adult	Lost Collar	9/18/03	3,611.9	97.1	380.2	1,434.7	45	1,232
Dagii	M	Adult	Alive	9/9/06	5,338.8	98.4	425.5	1,556.4	42	158
Borkhuu	M	Kid	Alive	9/9/06	4,196.5	100.0	349.1	1,297.5	42	158
Tony	F	Adult	Alive	9/20/05	4,961.8	99.9	401.0	1,883.8	115	504
Gerda	F	Adult	Alive	9/21/05	3,690.5	96.0	442.7	1,876.7	104	506
Mary Jo	F	Adult	Dead	9/21/05	4,916.7	95.9	405.7	1,772.4	73	374
Chris	F	Adult	Dead	9/8/04	3,753.0	89.0	264.8	1,041.0	52	230
Tsomoo	F	Adult	Alive	9/9/06	3,615.6	100.0	360.4	1,356.2	43	158
Nasaa	M	Adult	Alive	9/9/06	4,231.3	98.0	382.4	1,469.4	39	156
Anand2	M	Adult	Alive	9/9/06	2,320.5	100.0	491.8	1,631.7	39	127
Baagii	M	Adult	Alive	9/9/06	3,406.2	100.0	386.3	1,429.6	37	158
Malcolm	M	Adult	Alive	9/21/06	4,069.4	100.0	253.3	1,167.5	37	142
Alison	M	Adult	Alive	9/21/06	3,284.0	97.9	246.3	1,175.4	36	145
Alex	M	Kid	Lost Collar	5/3/05	2,666.6	99.4	435.6	1,925.0	26	191
Ochoo	F	Adult	Alive	9/9/06	2,548.8	100.0	355.6	1,327.5	36	155
Saikhanaa	F	Yearling	Alive	9/9/06	3,162.0	95.0	345.3	1,206.8	38	156
Guy	M	Kid	Lost Collar	4/30/05	1,254.6	64.0	216.9	912.0	25	160
Hanson	M	Adult	Dead	9/20/05				13	36	
John	M	Adult	Dead	9/8/04				6	38	
James	M	Adult	Dead	9/21/06				2	2	
Taka	M	Adult	Dead	9/21/06				2	2	

Table 1. Continued.

Name	Sex	Age	Status	Date collared	MCP (ha)	% MCP overlap	Kernel (ha) 50%	Kernel (ha) 95%	Days w/ fixes	Days in study
Tomoroo	F	Adult	Dead	9/20/05					9	26
Debmaa	F	Adult	Dead	4/12/03					3	4
Anya	F	Kid	Dead	5/4/05					2	5
Barbara	F	Kid	Alive	4/28/07					0	0
Namkhai	F	Kid	Alive	4/22/07					0	0
Mean (25+ days with fixes)					3,538.9 ±241.6	96.1 ±2.8	361.0 ±16.6	1,439.7 ±69.550.1 ±5.9		
Mean (40+ days with fixes)					4,083.8 ±282.8	97.4 ±1.2	380.4 ±20.4	1,541.9 ±108.2	65.3 ±9.9	
% Change from 25+ to 40+ Fixes					86.7%	98.7%	94.9%	93.4%	76.7%	

years of data on one animal (Table 2).

We recorded sufficient data on 18 ibex through February 2007 for an initial evaluation of home range sizes and habitat use; we collected more than 25 days of telemetry data for these 18 animals and more than 40 days of data for 9 animals (Table 1, Figure 1). Throughout the study, the 9 ibex with 40+ fixes used mean home ranges of 4,083.8 ± 282.8 ha using the MCP method. Kernel home range sizes more accurately depict typical use, or home range, areas and core use areas, and for ibex mean kernel ranges were 380.4 ± 20.4 ha for 50% kernel (i.e., core use area) and 1,541.9 ± 108.2 ha for 95% kernel ranges (i.e., home range area) (Table 1). Thus, mean core use areas covered 24.7% of the area of mean home ranges. Using only 25 telemetry fixes (i.e., location data) underestimated the extent of home and core range sizes. Depending on the method used to calculate home and core range size (i.e., MCP or percent kernels), mean home and core ranges size for animals with 25+ telemetry fixes were 86.7 – 94.9% of the area of the mean home range size for animals with 40+ fixes (Table 1).

Because we tracked different ibex for different lengths of time and across different years, we also examined home and core range sizes for single years (Figure 2). Annual home and core range sizes covered less area using MCP, but more area using kernel methods, with annual means for all animals of 3,115.5 ± 504.2 ha for MCP; 475.9 ± 14.7 ha for 50% kernel; and 1,808.0 ± 88.1 for 95% kernel for animals with 40+ fixes. Ibex used significantly smaller MCP home range sizes during a single year than overall (t = 5.37, df = 13.7, P < 0.001 for animals with 40+ fixes). Alternatively, none of the differences in mean annual and overall kernel home range sizes for ibex were significant (t = 1.38, df = 10, P = 0.20 for 50% kernel core ranges and t = 0.47, df = 10, P = 0.65 for 95 kernel home ranges for animals with 40+ fixes for animals). We collected insufficient data for comparisons between years for animals with 40+ fixes, but we were able to compare home range sizes in 2005 and 2006 using animals with 25+ fixes. For these data, ibex used significantly larger core (i.e., 50% kernel) and home (i.e., 95% kernel) ranges in 2006 (t = -5.19, df = 8.5, P < 0.01 and t = -3.61, df = 9, P < 0.01, respectively), but not significantly different MCP home ranges (t= -1.70, df = 10, P = 0.12).

Ibex from different demographic groups (males vs. females and juveniles vs. adults) used remarkably similar home ranges (Table 2, Figure 2). We defined juveniles as ibex < 2 years of age. For example, looking at adult and juvenile ibex with 40+ fixes for all years, we found mean range sizes of 3,991.7 ± 402.0 ha and 4.556.6 ± 360.1 ha for MCP home ranges; 1,477.8 ± 143.2 ha and 1,534.9 ± 237.4 ha for 95% kernel home ranges; and 369.2 ± 29.2 ha and 377.4 ± 28.3 ha for 50% kernel core ranges, respectively (Figure 2). We found no significant differences (i.e., for all tests P > 0.10) between males and females or adults and juveniles whether we examined the total cumulative home range sizes or the mean home range sizes for a single year (all years averaged) (Table 2, Figure 2). This was true for both MCP and kernel home and core ranges, although for several analyses the lack of sufficient data precluded us from running tests on animals with 40+ fixes. We tried grouping juveniles with females to increase the power of our tests (we justified this because kids travel with their dams and both male and female yearling ibex behave as females), but the differences remained insignificant (Table 2, Figure 2). Mean female (+ juvenile) home ranges compared well with male home ranges: 4,189.0 ±

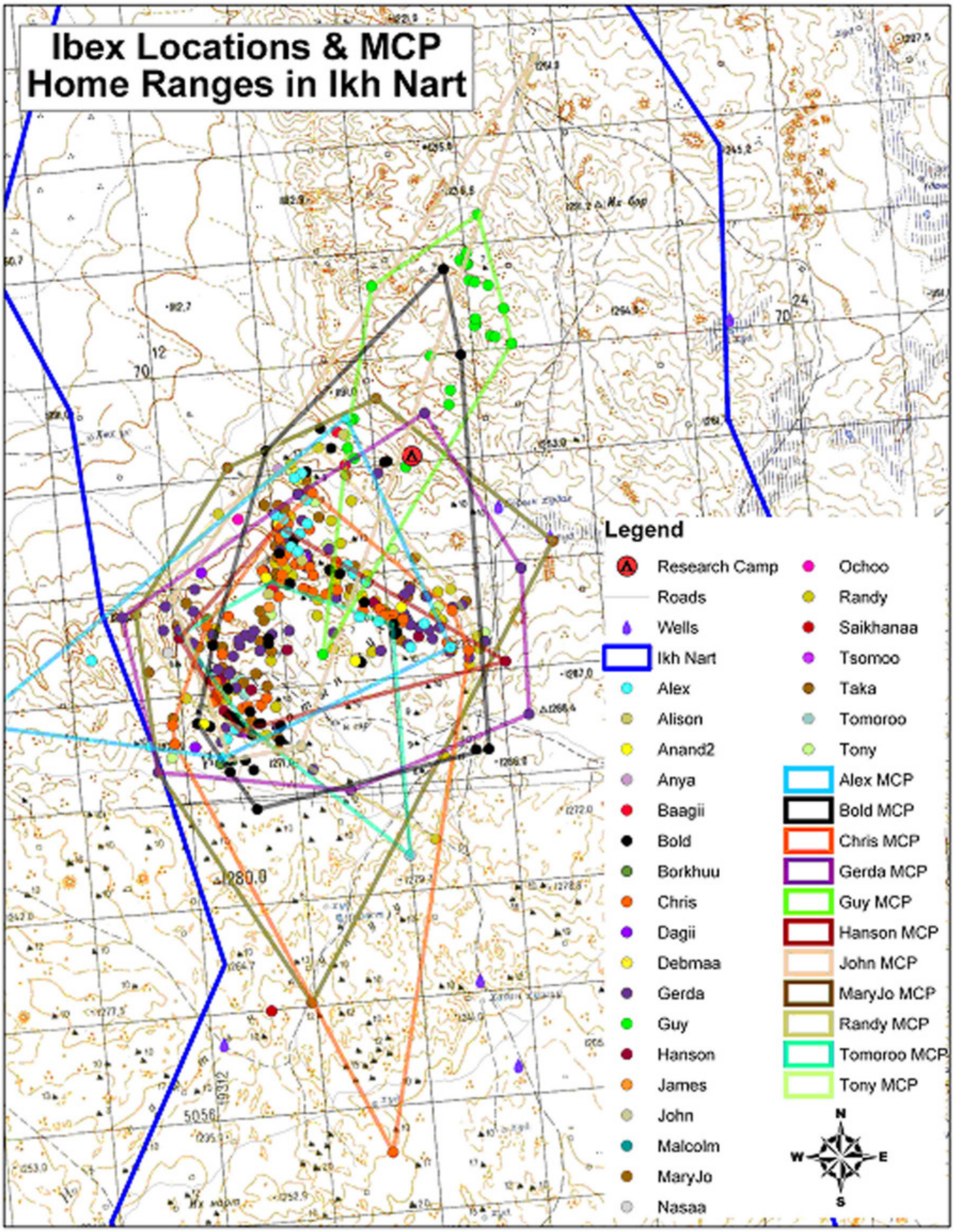

Figure 1. Siberian Ibex (*Capra [ibex] sibirica*) locations and Minimum Convex Polygon Home Ranges in Ikh Nart Nature Reserve, Mongolia.

251.3 ha and 3,873.2 ± 781.7 ha for MCP home ranges; 1,553.8 ± 119.1 ha and 1,537.9 ± 144.6 ha for 95% kernel home ranges; and 370.6 ± 25.2 ha and 409.8 ± 30.0 ha for 50% kernel core ranges, respectively (Figure 2). We found no relationship between age and home range size using any home or core range measure over any time period (i.e., for all tests $P > 0.20$).

Although not quantified, ibex mostly restricted their activities to areas with steep cliffs and rocky

Table 2. Comparison of home range means between different demographic groups of Siberian ibex (*Capra [ibex] sibirica*) in Ikh Nart Nature Reserve, Mongolia.

Analysis Fixes	Time period	Parameter	Males vs. females (adults only)	Males vs. female & juveniles	Adults vs. juveniles
Minimum Convex Polgyon					
25+ fixes	All years	*t*-score (*df*)	0.18 (10)	0.29 (15.9)	0.60 (5.5)
		P-value	0.86	0.78	0.57
	1 year	*t*-score (*df*)	0.22 (4.5)	-0.28 (4.1)	0.49 (3)
		P-value	0.83	0.80	0.66
40+ fixes	All years	*t*-score (*df*)	-1.05 (3.8)	-0.39 (2.4)	0.27 (3.1)
		P-value	0.36	0.73	0.81
50% Kernel Core Range					
25+ fixes	All years	*t*-score (*df*)	0.19 (6.2)	0.22 (16)	-0.47 (10)
		P-value	0.85	0.83	0.65
	1 year	*t*-score (*df*)	0.83 (2.9)	1.26 (1.4)	-1.18 (1)
		P-value	0.47	0.38	0.45
40+ fixes	All years	*t*-score (*df*)	-0.20 (3.3)	1.01 (2.7)	-1.35 (3)
		P-value	0.85	0.40	0.27
95% Kernel Home Range					
25+ fixes	All years	*t*-score (*df*)	-0.06 (5)	-0.34 (13.2)	-0.07 (3.7)
		P-value	0.95	0.74	0.95
	1 year	*t*-score (*df*)	0.27 (3)	0.87 (1.3)	-0.99 (1.1)
		P-value	0.81	0.52	0.50
40+ fixes	All years	*t*-score (*df*)	-0.21 (5)	0.09 (4.3)	-0.46 (2.7)
		P-value	0.84	0.94	0.68

outcrops on the edges of 2 drainages (Khukh Us and Ulaan Khad) (Figure 1). Home ranges overlapped extensively. Looking at individual home ranges, mean overlap between each animal's MCP home range and the MCP of other animals in the study was 96.1 ± 2.8% using the 18 animals with 25+ fixes and was 97.4 ± 1.2% using the 9 animals with 40+ fixes. We found no segregation by gender. The cumulative MCP home ranges of male ibex overlapped with the cumulative MCP home ranges of females + juveniles by 86.6% and 78.5% for animals with 25+ and 40+ fixes, respectively. Similarly, 79.4% and 83.0% of the cumulative home ranges of females and juveniles overlapped with the cumulative home ranges of males for animals with 25+ and 40+ fixes, respectively. We found no significant differences (i.e., for all tests $P < 0.10$) among demographic groups with respect to home range overlap.

Discussion

Home range use remains poorly studied among Siberian ibex. In their recent summary of the biology and ecology of the species, Fedosenko and Blank (2001) do not even mention the sizes of home ranges, although they do note strong fidelity to home ranges and seasonal migrations.

Research on other ibex species report much smaller home range sizes than we found for Siberian ibex and, unlike studies of other ibex species, we did not find differences in home range size among animals of different genders or ages. For example, Grignolio *et al.* (2004) found that annual home ranges sizes for female alpine ibex (*Capra ibex ibex*) in Italy covered 186.2 ± 71.2 SD ha to 182.2 ± 70.0 SD ha using 95% MCP and 316.3 ± 111.0 SD ha to 304.8 ± 101.1 SD ha using 95% kernel methods. They also reported significantly smaller home range sizes for females compared to males (Grignolio *et al.*, 2004). Adult male alpine ibex in Italy used home ranges of 430 ± 52.4 SD ha to 486 ± 78.7 SD ha using the 95% kernel method (Grignolio *et al.*, 2003). Similarly, Escos and Alados (1992) found mean annual home ranges of 524 ± 33 SD ha for male and 88 ± 28 SD ha for female Spanish ibex (*Capra pyrenaica*) using 100% MCP. In contrast to Siberian ibexes in Ikh Nart, alpine ibexes in Italy showed an inverse relationship between age and home range size

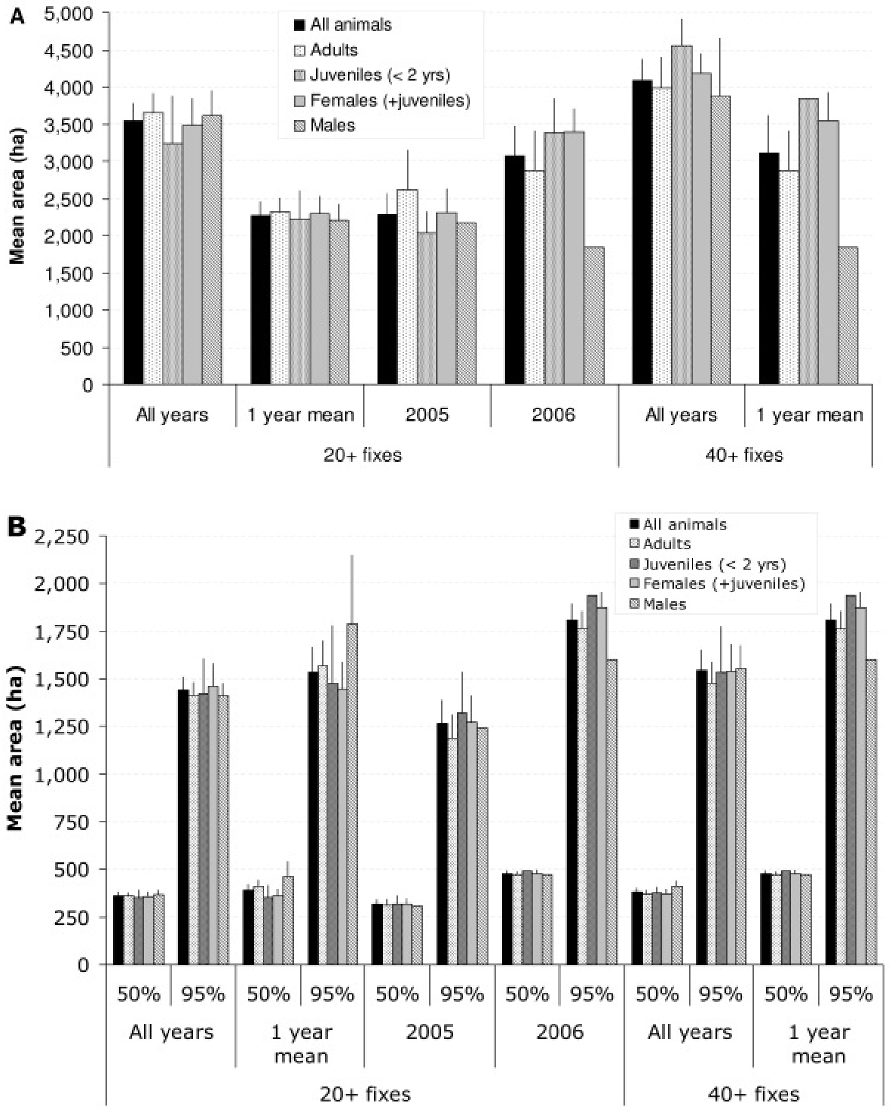

Figure 2. Comparison of male and female Siberian ibex (*Capra sibirica*) home range sizes using all data, mean single year data, and data from 2005 and 2006 only. A: Minimum convex polygon home ranges. B: 50% kernel core range and 95% kernel home ranges using 20 or more fixes and 40 or more fixes.

(Grignolio *et al.*, 2004), although we had very few age classes for a rigorous analysis and so were forced to lump our data into adults and juveniles. Male Spanish ibex showed distinct seasonal home ranges, but females did not (Escos and Alados 1992). Finally, lactating female Alpine ibex used smaller home ranges in summer only than non-lactating females (Grignolio *et al.*, 2007). We collected insufficient data for a comparison of home range use by season, but, as we found with argali in Ikh Nart (Reading *et al.*, 2003, 2005), we observed little, if any, seasonal differences among Siberian ibex from different demographic groups, probably because of the limited relief in Ikh Nart (generally < 100 m).

Contrary to our expectations, the locations of male and female ibex home ranges in Ikh Nart overlapped substantially. These findings contrast with past studies of other species of dimorphic ungulates, including other ibex species (Main *et al.*, 1996; Villaret *et al.*, 1997; Ruckstahl & Neuhaus, 2000; Bon *et al.*, 2001; Grignolio *et al.*, 2004). Our findings suggest that male and female Siberian ibex do not use different habitats, although they still may segregate by sex within the same habitat. Our findings suggest that predation risk, scramble-competition, sexual dimorphism-body size, and weather sensitivity hypotheses do not hold for Siberian ibex, at least in Ikh Nart (see reviews of these hypotheses in Main *et al.*, 1996; Ruckstuhl and Neuhaus 2000; Bon *et al.*, 2001). We require more data to determine if ibex segregate socially within the same habitat and, if so, which of the remaining hypotheses (social factor, behavioral incompatibility hypothesis, or activity budget hypothesis) might explain any such separation (Main *et al.*, 1996; Ruckhaus & Heuhaus, 2000; Bon *et al.*, 2001). The reason(s) for high overlap and lack of difference in areas used remains unclear, but may be related to the relatively small amount of escape terrain in the region or limited, clumped food patches (Ruckstahl & Neuhaus, 2000). Fox *et al.* (1992) also found little segregation of habitat use by sexes for Siberian ibex in Ladakh, India. As expected, ibex primarily utilized habitat near the rugged terrain that does exist, including steep cliffs and rocky outcrops. Ibex rely upon steep, escape terrain to avoid predation (as opposed to argali that are able to outrun predators) (Fox *et al.*, 1992; Fedosenko and Blank, 2001). Since Ikh Nart contains a relatively small amount of very rugged habitat, overlap in home ranges among ibex was high.

More research on Siberian ibex is need to better elucidate factors influencing home and core range sizes and spatial distribution, including studies in different habitats, particularly mountainous areas. Such work would contribute to our understanding of spatial behavior among ungulates in general and Siberian ibex ecology specifically. Additional research should include larger sample sizes (both individuals and amount of data per individual) of a greater range of sex and age classes over a longer time period as well as seasonally (this work is underway); studies of foraging behavior (e.g., Neuhaus & Ruckstuhl, 2002); and habitat associations.

Acknowledgments

Several people helped make this work possible. Special thanks go to D. Batbayar, S. Batdorj, N. Batdorj, L. Surmaa, S. Monkhdalai, N. Ankhtsetseg, T. Batbold, D. Dandar, G. Bat-Orshikh, S. Buyandelger, C. Craig, D. Enkhtuvshin, Ch. Ganzorig, M. Munkhbaatar, Ts. Munkhzul, J. Murdoch, G. Otgonbayar, Dr. B. Rosenbaum, T. Selenge, G.Tsogtjargal, T. Tuya, G. Volooj, G. Wingard, and all of our Earthwatch volunteers. W. Hodges calculated most of the home ranges. Funding was provided by the Denver Zoological Foundation, Earthwatch Institute, the Trust for Mutual Understanding, the Mongolian Academy of Sciences, ESRI, and the Argali Wildlife Research Center. S. Grignolio and an anonymous reviewer provided valuable comments to strengthen the manuscript.

References

Beyer, H. L. 2004. *Hawth's analysis tools for ArcGIS*. http://www.spatialecology.com/htools.

Bon, R., Rideau, C., Villaret, J. C., and Joachim, J. 2001. Segregation is not only a matter of sex in Alpine ibex, *Capra ibex ibex*. *Animal Behaviour* 62:495-504.

Escos, J. and Alados, C. L. 1992. The home-range of the Spanish ibex in spring and fall. *Mammalia* 56:57-63.

Fedosenko, A. K. and Blank, D. A. 2001. *Capra sibirica*. *Mammalian Species* 675:1-13.

Fox, J. L., Sinha, S. P., and Chundawat, R. S. 1992. Activity patterns and habitat use of ibex in the Himalaya Mountains of India. *Journal of Mammalogy* 73:527-534.

Gitzen, R. A., Millspaugh, J. J., and Kernohan, B. J. 2006. Bandwidth selection for fixed-kernel analysis of animal utilization distributions. *Journal of Wildlife Management* 70(5):1334-1344.

Grignolio, S., Parrini, F., Bassano, B., Luccarini, S., and Apollonio, M. 2003. Habitat selection in adult male Alpine ibex, *Capra ibex ibex*. *Folia Zoologica* 52:113-120.

Grignolio, S., Rossi, I., Bassano, B., Parrini, F., and Apollonio, M. 2004. Seasonal variations of spatial behaviour in female Alpine ibex (*Capra ibex ibex*) in relation to climatic conditions and age. *Ethology, Ecology and Evolution* 16:255-264.

Grignolio, S., Rossi, I., Bertolotto, E., Bassano, B., and Apollonio, M. 2007. Influence of the kid on space use and habitat selection of female alpine ibex. *Journal of Wildlife Management* 71(3): 713-719.

Hooge, P. N. and Eichenlaub, B. 1997. *Animal movement extension to ArcView*. Ver 2.0. Alaska Science Center – Biological Science Office, U.S. Geological Survey, Anchorage.

Kenny, D. E., DeNicola, A. J., Amgalanbaatar, S., Namshir, Z., Wingard, G., Tuya, T. and Reading, R. P. 2008 (in press). Three field capture techniques for free-ranging argali sheep (*Ovis ammon*) in Mongolia. *Zoo Biology*.

Loveridge, A. J. and Macdonald, D. W. 2003.

Niche separation in sympatric jackals (*Canis mesomelas* and *Canis adustus*). *Journal of Zoology* 259:143-153.

Main, M. B., Coblentz, B. E., Weckerly, F. W. and Bleich, V. C. 1996. Sexual segregation in ungulates: new directions for research. *Journal of Mammalogy* 77:449-461.

Mallon, D. P., Bold, A., Dulamtseren, S., Reading, R. P. and Amgalanbaatar, S. 1997. Mongolia. In D.Shackleton and IUCN SSC Caprinae Specialist Group (eds.): W*ild sheep and goats and their relatives: status survey and action plan for Caprinae*. IUCN, Gland, pp 193-201.

Myagmarsuren, D. 2000. *Special protected areas of Mongolia*. Mongolian Environmental Protection Agency and the German Technical Advisory Cooperation (GTZ), Ulaanbaatar.

Neuhaus, P. and Ruckstuhl, K.. 2002. Foraging behavior in Alpine ibex (*Capra ibex*): Consequences of reproductive status, body size, age, and sex. *Ethology, Ecology and Evolution* 14(4):373-381.

Reading, R.P., Amgalanbaatar, S., Kenny, D., Onon, Yo., Namshir, Z. and DeNicola, A. 2003. Argali ecology in Ikh Nartiin Chuluu Nature Reserve: preliminary findings. *Mongolian Journal of Biological Science* 1(2): -14.

Reading, R. P., Amgalanbaatar, S., Wingard, G., Kenny, D., and DeNicola, A. 2005. Ecology of argali in Ikh Nartiin Chuluu, Dornogobi Aimag. *Erforschung Biologischer Ressourcen der Mongolei (Halle/Saale)* 9:77-89.

Reading, R. P., Kenny, D., Wingard, G., Mandakh, B., and Steinhauer-Burkart, B. 2006. *Ikh Nartiin Chuluu Nature Reserve guidebook*. Nature-guide No. 4, Mongolia. ECO Nature Edition Steinhauer-Burkart OHG, Oberaula, Germany.

Ruckstuhl, K. E. and Neuhaus, P. 2000. Sexual segregation in ungulates: a new approach. *Behaviour* 137:361-377.

Schaller, G. B. 1977. *Mountain monarchs: wild sheep and goats of the Himalaya*. University of Chicago Press, Chicago.

Seaman, D. E. and Powell, R. A. 1996. An evaluation of the accuracy of kernel density estimators for home range analysis. *Ecology* 77: 2075-2085.

Shackleton, D. ed. 1997. *Wild sheep and goats and their relatives: status survey and conservation action plan for Caprinae*. IUCN, Gland.

Villaret, J. C., Bon, R., and Rivet, A. 1997. Sexual segregation of habitat by the Alpine ibex in the French Alps. *Journal of Mammalogy* 78: 1273-1281.

Worton, B. J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. *Ecology* 70: 164-168.

Хураангуй

Янгир (*Capra sibirica*) бол харьцангуй бага судлагдсан зүйлийн нэг бөгөөд бид Дорноговь аймгийн нутагт байрлах Их Нартын Байгалийн Цогцолбор Газарт энэхүү зүйлийн экологи, түүнийг ховордоход нөлөөлж буй хүчин зүйлсийг судалсан болно. Энэхүү өгүүлэлд янгирын байршил нутаг болон цөм нутгийг судлан тогтоов. Судалгааны явцад нийт 27 янгирыг тороор (бие гүйцсэн ба төл бодгалиудад, *n* = 22) болон гараар (шинээр төрсөн бодгалиудад *n* = 5) барьж радио дохиолол дамжуулагч зүүж, 2003 оны 9-р сараас 2007 оны 2-р сарын хооронд нийт 1029 байрлалын мэдээг цуглуулав. Судалгааг хийсэн хугацаанд 9 бодгалийн байршил нутгийн жилийн хэмжээг (40+ удаагийн мэдээг ашиглан) дундаж үзүүлэлт болгон янгирын байршил нутгийн жилийн хэмжээ 3,115.5 ± 504.2 га болохыг минимум гүдгэр полигоны аргаар тогтоов. Кернелийн аргаар янгирын байршил нутгийг тооцоолоход харьцангуй бага буюу цөм нутгийн хэмжээ (50%-ийн кернел) 475.9 ± 14.7 га, нийт байршил нутгийн хэмжээ (95%-ийн кернел) 1,808.0 ± 88.1 га болох нь тогтоогдов. Янз бүрийн насны янгирын (эр ба эм хүйсийн бие гүйцсэн бодгалиуд; өсвөр ба бие гүйцсэн бодгалиуд) байршил нутаг болон цөм нутгийн хэмжээ үндсэндээ ижил болох нь илэрсэн бөгөөд тэдгээрийн хооронд байршил ба цөм нутгийн ялгаа илрээгүй болно. Хэдийгээр нарийвчлан тооцоолоогүй боловч янгирын байршил нутаг үндсэндээ эгц налуу бүхий хадан хясаа, хад чулуу бүхий уулын өндөрлөг хэсэгт байрлах бөгөөд бүх насны бодгалиудын хувьд тэдгээрийн байршил нутаг нь давхцаж байна.

Received: 11 April 2008
Accepted: 10 March 2009