2005

Ecology of Argali in Ikh Nartiin Chuluu, Dornogobi Aymag

Richard P. Reading
Denver Zoological Foundation, rreading@denverzoo.org

Sukhiin Amgalanbaatar
Mongolian Academy of Sciences, monconcoal@magicnet.mn

Ganchimeg J. Wingard
Denver Zoological Foundation, ganichimeg_w@hotmail.com

Danny Kenny
Denver Zoological Garden, dkenny@denverzoo.org

Anthony DeNicola
White Buffalo, Inc., wbuffaloinc@aol.com

In: Proceedings of the symposium "Ecosystem Research in the Arid Environments of Central Asia: Results, Challenges, and Perspectives," Ulaanbaatar, Mongolia, June 23-24, 2004.
Erforschung biologischer Ressourcen der Mongolei (2005) 5.

Erforsch. biol. Ress. Mongolei (Halle/Saale) 2005 (9): 77–89

Ecology of Argali in Ikh Nartiin Chuluu, Dornogobi Aymag

R.P. Reading, S. Amgalanbaatar, G.J. Wingard, D. Kenny & A. DeNicola

Abstract

Argali sheep (*Ovis ammon*) are listed as threatened in both Mongolia and internationally. Yet, little is known about the biology and ecology of this species. Available data suggests that Argali in Mongolia are declining due to direct poaching and competition with domestic livestock. We initiated several research projects to better understand and conserve the species. In this report we discuss Argali ecology using radio telemetry.

We captured and radio-collared 36 Argali using drive-nets, lamb captures, and darting from 2000–2004. Fifteen collared animals have died: 2 due to capture techniques, 8 from predation, 1 from starvation and exposure, 1 from disease, 1 due to maternal neglect, and 2 of unknown causes. In addition, 1 collar ceased working and 4 others dropped off prematurely. We have collected more than 1,040 locations through mid-May 2004. The majority of the Argali were captured in the northern portion of Ikh Nart. Animals have primarily restricted their movements to that area and have not exhibited seasonal movement patterns. Mean home range size for 17 animals with sufficient data (> 45 days with locations) was $57 \pm 3.7\,km^2$ (range = 30–$80\,km^2$) using the 100 % minimum convex polygon method, with areas of predicted occurrence of $76 \pm 5.3\,km^2$ for 95 % kernel, $32 \pm 3.7\,km^2$ for 75 % kernel, $11 \pm 1.6\,km^2$ for 50 % kernel, and $3.8 \pm 0.5\,km^2$ for 25 % home ranges. Predation was the main cause (72.7 %) of mortality in the collared animals for which cause of death could be determined (non-study related).

Keywords Argali ecology, *Ovis ammon*, Mongolia, telemetry, home range

Introduction

Argali sheep (*Ovis ammon*) populations are declining and the species is considered threatened in Mongolia (Shiirevdamba et al. 1997; Wingard & Odgerel, 2001) and internationally (Nowak, 1993; IUCN, 1996). In Mongolia, Argali are distributed in the mountains and rocky outcrops of the southern, central, and western portions of the country, but their range is decreasing and becoming increasingly fragmented (Mallon et al., 1997; Amgalanbaatar & Reading, 2000, Reading et al., 2001). Outside of Mongolia, the range of Argali extends through adjacent regions of Russia, Kazakhstan, and China (Shackleton, 1997; Schaller, 1998).

Poaching continues to be an important source of mortality for Argali in Mongolia (Zhirnov & Ilyinsky, 1986; Mallon et al., 1997; Reading et al., 1997, 2001; Amgalanbaatar & Reading, 2000). Argali also suffer from livestock grazing, as herds of domestic sheep and goats displace Argali and likely compete with them for water and forage (Sukhbat & Gruzdev, 1986; Mallon et al., 1997, Reading et al., 1997, 1998, 1999, 2001; Amgalanbaatar & Reading, 2000). Other species of livestock likely also compete to a lesser extent with Argali. Finally, we also found that domestic guard dogs can pose a significant threat to Argali (see below).

We have been working on Argali conservation and management since 1996, focusing on determining the range of the species (Reading et al., 1997, 1998, 1999), a better understanding of Argali ecology (Amgalanbaatar & Reading, 2000; Onon et al., 2002; Reading et al., 2003), genetic analysis of putative subspecies (Tserenbataa, 2003; Tserenbataa et al., 2004), and an assessment of dietary overlap between Argali sheep and livestock (Reading et al., 2001).

Study area

We conducted field conservation and research in the Ikh Nartiin Chuluu Nature Reserve (hereafter Ikh Nart) in Dornogobi Aymag, Mongolia (figure 1). Ikh Nart was established in 1996 to protect 43,740 ha of rocky outcrops in northwestern Dornogobi Aymag (Myagmarsuren, 2000). 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 80 km/h), and relatively wet, hot summers (to 35 °C). Precipitation is low and seasonal, with most precipitation falling in the summer.

The flora and fauna are representative of the semi-arid regions of Central Asia, with a mix of desert and steppe species. Vegetation is sparse. Xerophytic and hyperxerophytic semi-shrubs, shrubs, scrub vegetation, and bunch grasses dominate, although different plant communities can be found around oases and streams, on rocky outcrops, and other extrazonal areas. Other globally significant species occurring in Ikh Nart include ibex (*Capra sibirica*), goitered gazelle (*Gazella subgutturosa*), Mongolian gazelle (*Procapra gutturosa*), cinereous vultures (*Aegypius monachus*), and saker falcons (*Falco cherrug*).

Methods

Animal capture and handling

We used drive nets, hand captures of lambs, and darting to capture animals for radio telemetry (figure 1). We only briefly describe each method here; for more detail see Kenny et al. (2001) and Reading et al. (2003). We placed parallel, overlapping drive nets approximately 3 m high by 30 m long in the bottom of a shallow, dry stream bed to create a barrier extending approximately 300 m. We employed 3–6 local herders on horseback and part of our field team on horses and motorized vehicles to locate and drive Argali toward the nets. Hidden people and riders near the nets re-directed animals that tried to avoid the barrier and were located to quickly reach and restrain netted animals. The total elapsed time from capture to release was 10–25 minutes.

Furthermore, we searched for newborn Argali lambs during early spring (late March until early May). Upon finding a lamb, we circled the animal, with one person approaching slowly from behind and grabbing the lamb. We processed animals in 7–10 minutes following capture. Additionally we darted Argali using Pneu-Dart® rifles with telescopic or red dot scopes and .50 caliber type C Pneu-Dart darts with barbed needles. For anesthesia, we used a mixture of carfentanil citrate, xylazine, and ketamine. Inconsistent ballistics forced us to approach to within < 35 m of target animals. We monitored darted animals closely and reversed carfentanil and xylazine with naltrexone hydrochloride and yohimbine hydrochloride, respectively. The entire process of darting to reversal took about 10–20 minutes.

We processed animals as quickly as possible. We repositioned darted and netted Argali from lateral to sternal recumbency as soon as possible to avoid bloating and respiratory compromise. We held lambs. We covered the eyes of captured animals with a hood and kept noise to a minimum. Processing included radio-collaring, ear tagging, recording morphometries measurements, collecting biological samples (hair, blood, feces, and parasites), and monitoring temperatures, pulses, and respiration. All radio-collars were equipped with mortality switches. Lamb collars were expandable and designed to drop-off after 6–9 months (Diefenbach et al., 2003).

Data collection

We tracked collared Argali throughout the year using a traditional receiver, antenna, and global positioning system (GPS) and binoculars or spotting scopes to sight animals at a distance and thus avoid influencing movements. We stopped collecting location data for that day on animals that responded to trackers. We collected location data as often as possible while in the field and tried to locate as many animals as possible each day.

We conducted focal animal tracking by tracking a single, randomly selected animal continuously for a full day (or as long as the observers went undetected) and collecting behavioral data for future analysis. Because lambs, especially newborns, remain near their mothers, our telemetry data on lambs also recorded locations for ewes for most of the first year.

Data analysis

We incorporated telemetry data into a geographic information system (GIS) to help facilitate analysis. For animals with multiple locations per day, we used only the first location to reduce possible bias. Since Argali could easily (and often did) cross their entire home ranges within 12 hours (longest straight line distance = 15.5km), we used 1 location per day as the maximum sampling interval for home range analysis (Swihart & Slade, 1985a, b). We used ArcView 3.2 © to determine 100 % minimum convex polygon (MCP) and 95 %, 75 %, 50 % and 25 % adaptive kernel home ranges for all animals with > 15 independent locations (i.e., 1 location/day) over 90 or more days.

We examined all variables for normality and homogeneity of group variance using Bartlett's test. We compared means using simply t-tests, with corrections for separate variances where appropriate, and analysis of variance (ANOA). Unless otherwise indicated, we present all means ± 1 S.E. We set significance at $p < 0.05$.

Results

We captured and radio-collared 36 Argali sheep between November 2000 and May 2004 using drive nets, lamb captures, and darting (table 1). The 9 animals captured using drive nets comprised 6 adult females, 1 adult male, 1 female lamb, and 1 male lamb. We hand captured 10 female and 12 male lambs (N = 22 total), including 1 set of twins. Finally, darting yielded 2 adult females, 1 yearling female, and 2 male lambs (N = 5 total). Therefore, overall we captured and collared 8 adult females, 1 adult male, 1 yearling female, 11 female lambs, and 15 male lambs.

Table 1: Argali sheep (*Ovis ammon*) tracked using radio telemetry in Ikh Nartiin Chuluu Nature Reserve, Mongolia 2000–2004: Animal name, study days (Sd), telemetry locations (Tloc) and days (Td), capture method (CM), status, gender, and age at capture. Capture methods are: DN = drive nets, HC = hand capture, DG = dart gun; Status abbreviations are: DC = dropped collar, CF = collar failed.

Animal	Sd	Tloc	Td	CM	Status	Gender	Age
Jed	240	39	37	DN	Alive	Male	Adult
Baatar	2	2	2	HC	Dead	Male	Lamb
Ankhaa	3	3	2	HC	Dead	Male	Lamb
Gadas	29	4	4	HC	Dead	Male	Lamb
Dave	5	3	3	HC	Dead	Male	Lamb
Amgaa	127	21	18	DG	Dead	Male	Lamb
Bor	153	29	23	DN	Dead	Male	Lamb
Bayanaa	159	34	30	HC	Dead	Male	Lamb
Davaa	167	33	24	DG	Dead	Male	Lamb
Tsogoo	41	5	5	HC	Dead	Male	Lamb
Dave2	35	4	4	HC	Alive	Male	Lamb

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Table 1 continued ...

Animal	Sd	Tloc	Td	CM	Status	Gender	Age
Toogii	41	5	5	HC	Alive	Male	Lamb
Ambii	42	6	6	HC	Alive	Male	Lamb
Purev	40	8	8	HC	Alive	Male	Lamb
Namshir	395	62	53	HC	Alive	Male	Lamb
Batorshikh	401	50	48	HC	DC	Male	Lamb
Debmaa2	93	59	34	DG	CF	Female	Adult
Batbold	103	42	42	DN	DC	Female	Adult
Naraa	99	23	23	DN	DC	Female	Adult
Lauren	6	8	4	DG	Dead	Female	Adult
Choi	229	26	26	DN	Alive	Female	Adult
Otgoo	238	36	34	DN	Alive	Female	Adult
Mandakh	599	175	129	DN	Alive	Female	Adult
Tuya	603	144	122	DN	Alive	Female	Adult
Ganaa	17	22	9	DG	Dead	Female	Yearling
Dayan	7	2	2	DN	DC	Female	Lamb
Ankhaa2	3	2	2	HC	Dead	Female	Lamb
Noname	2	2	2	HC	Dead	Female	Lamb
Megmaa	4	3	3	HC	Dead	Female	Lamb
Tsetseg	7	2	2	HC	Alive	Female	Lamb
Jargal	33	6	6	HC	Alive	Female	Lamb
Baatarmaa	33	7	6	HC	Alive	Female	Lamb
Lauren2	45	5	5	HC	Alive	Female	Lamb
Zulaa	387	68	65	HC	Alive	Female	Lamb
Tonimaa	397	56	48	HC	Alive	Female	Lamb
Onon	399	55	48	HC	Alive	Female	Lamb

Home range & movement

As of mid-May 2004, we have collected 1042 locations on the 36 Argali collared since 2000 (figure 1). Collared animals restricted their movements primarily to the area of rocky outcrops within Ikh Nart's boundaries (figure 2). Several (N = 14) animals were captured only recently (September 2003 or April 2004) and therefore, we have little data on them. Some of these animals (N = 4) have lost their collars prematurely (i.e., collar failure). One animal's collar ceased functioning, although it remains on the Argali. Other animals died before we could accumulate much data (see above).

As a result, we report on analysis from telemetry data collected for 17 Argali: 9 lambs (6 male, 3 female) and 5 adults (1 male, 4 female) (table 2). We tracked these animals for an average of 281.71 ± 40.46 days and collected data for each animal on an average of 47.29 ± 7.77 days (i.e., telemetry days). Seven sheep have been part of the study for more than 375 days (mean = 454.43 ± 37.88 days) and we have locations for them on more than 45 days (mean = 73.29 ± 36.22 days) (table 2). Reading et al. (2004) noted that home range sizes increased little after acquired 45 days worth of locations.

Animals primarily restricted their movements to the northern portion of Ikh Nart (figures 2 and 3). Argali inhabited mean home ranges of $56.54 \pm 3.72\,km^2$ (Range = 29.96–80.30 km^2) using the 100 % minimum convex polygon (MCP) method. Kernel home range sizes (i.e., area of predicted occurrence) were larger for 95 % kernel ranges (mean = $75.85 \pm 5.32\,km^2$), but smaller for 75 % (mean = $31.77 \pm 3.69\,km^2$), 50 % (mean = $10.99 \pm 1.63\,km^2$), and 25 % (mean = $3.85 \pm 0.49\,km^2$) ranges (table 2). The 100 % MCPs were significantly (t = 4.47

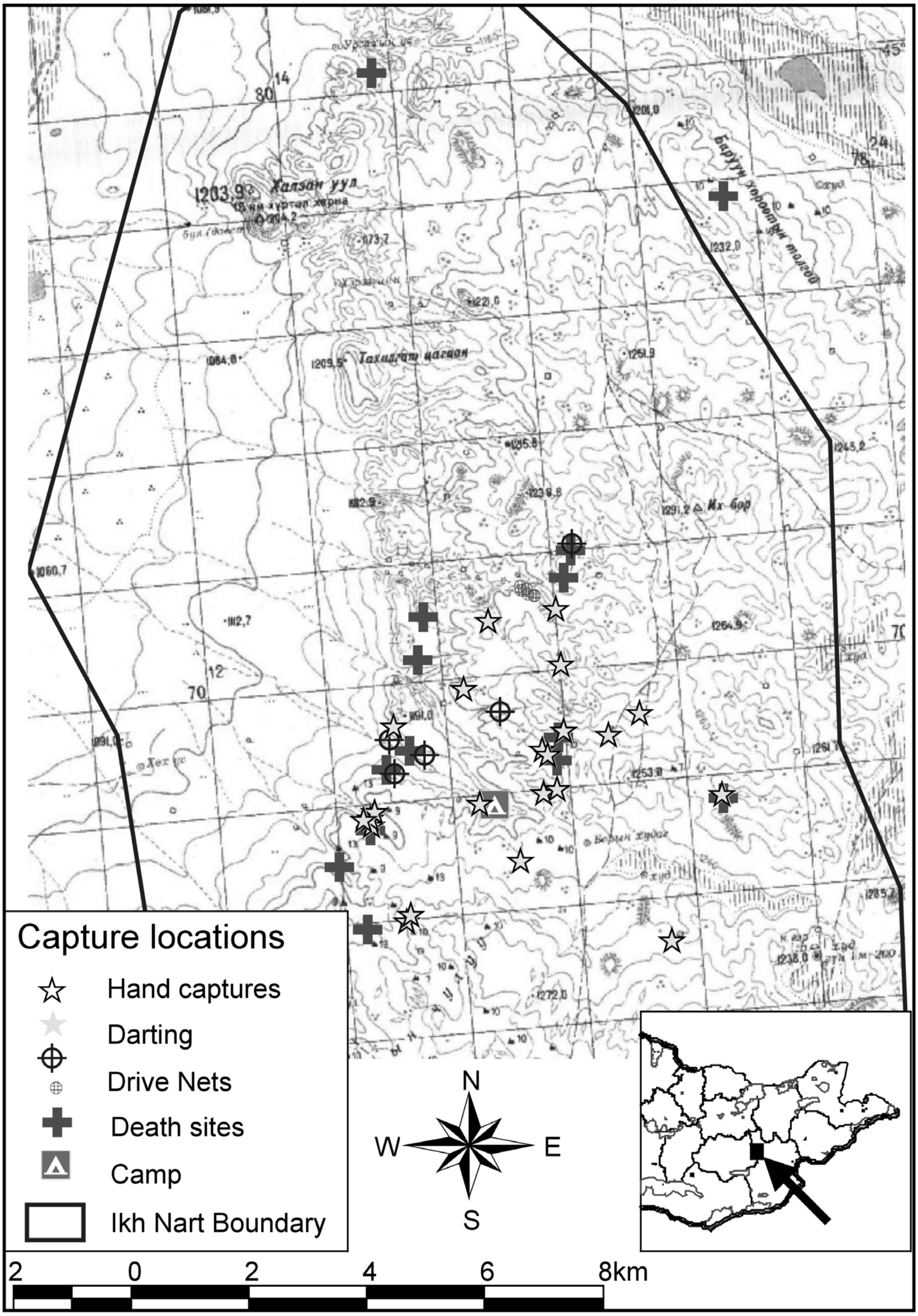

Figure 1: Locations of Argali (*Ovis ammon*) capture and death sites, Ikh Nartiin Chuluu Nature Reserve, Mongolia.

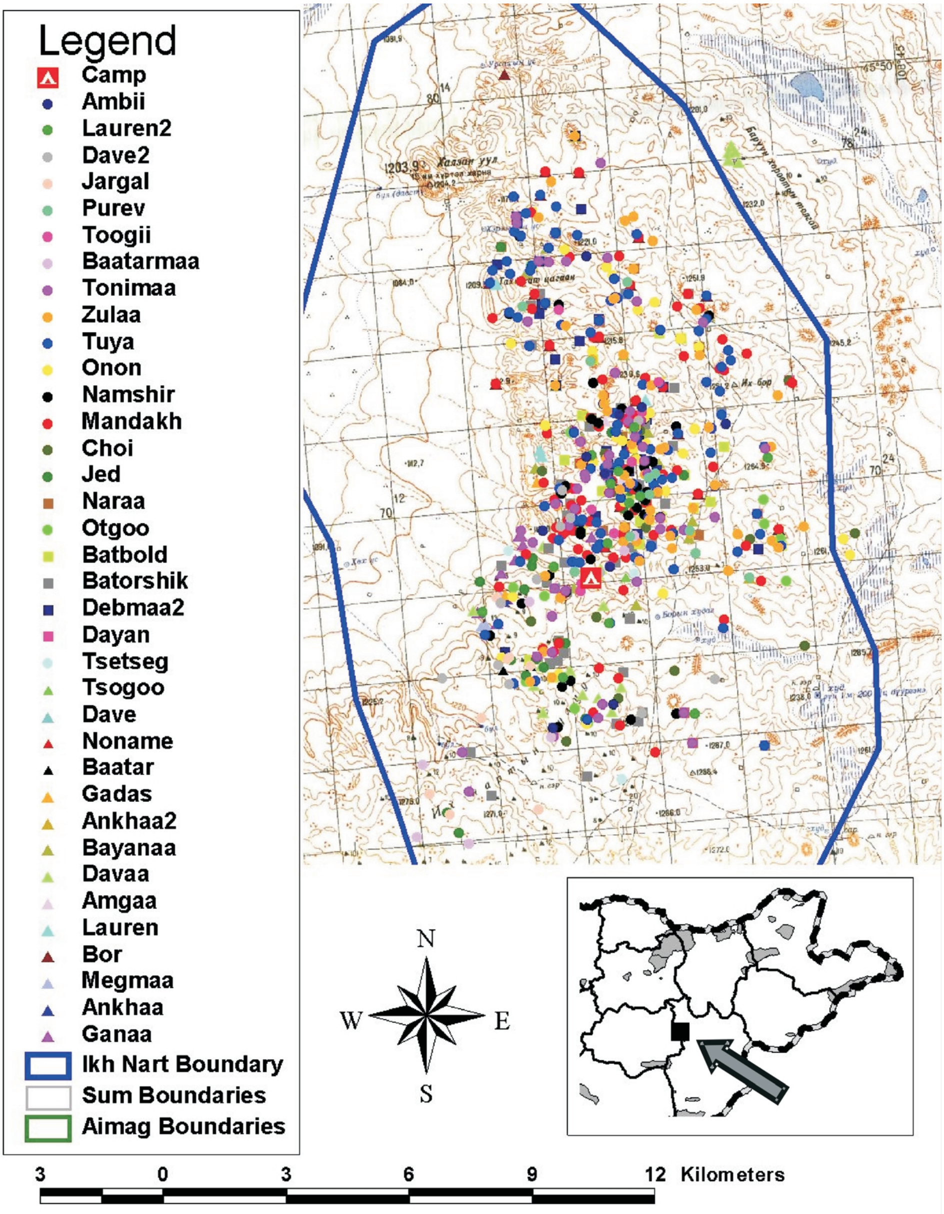

Figure 2: Locations recorded for radio-collared Argali (*Ovis ammon*) in Ikh Nartiin Chuluu Nature Reserve, Mongolia 2000–2004. Only 1 location/day shown. Circles represent animals still alive, triangles represent animals that have died, and squares represent animals whose collars have failed or dropped off.

df $= 14.9$, $p < 0.001$) larger for the 7 Argali with more data (mean $= 69.49 \pm 2.93\,km^2$), but kernel home range sizes were similar (all $p > 0.05$, table 2). A particularly important habitat area appears to extend from the drainage in which our research camp is located to the north-northeast some 5 km and covers about 20–25 km^2 (figure 3).

We examined seasonality by looking at home ranges during spring (March–May), summer

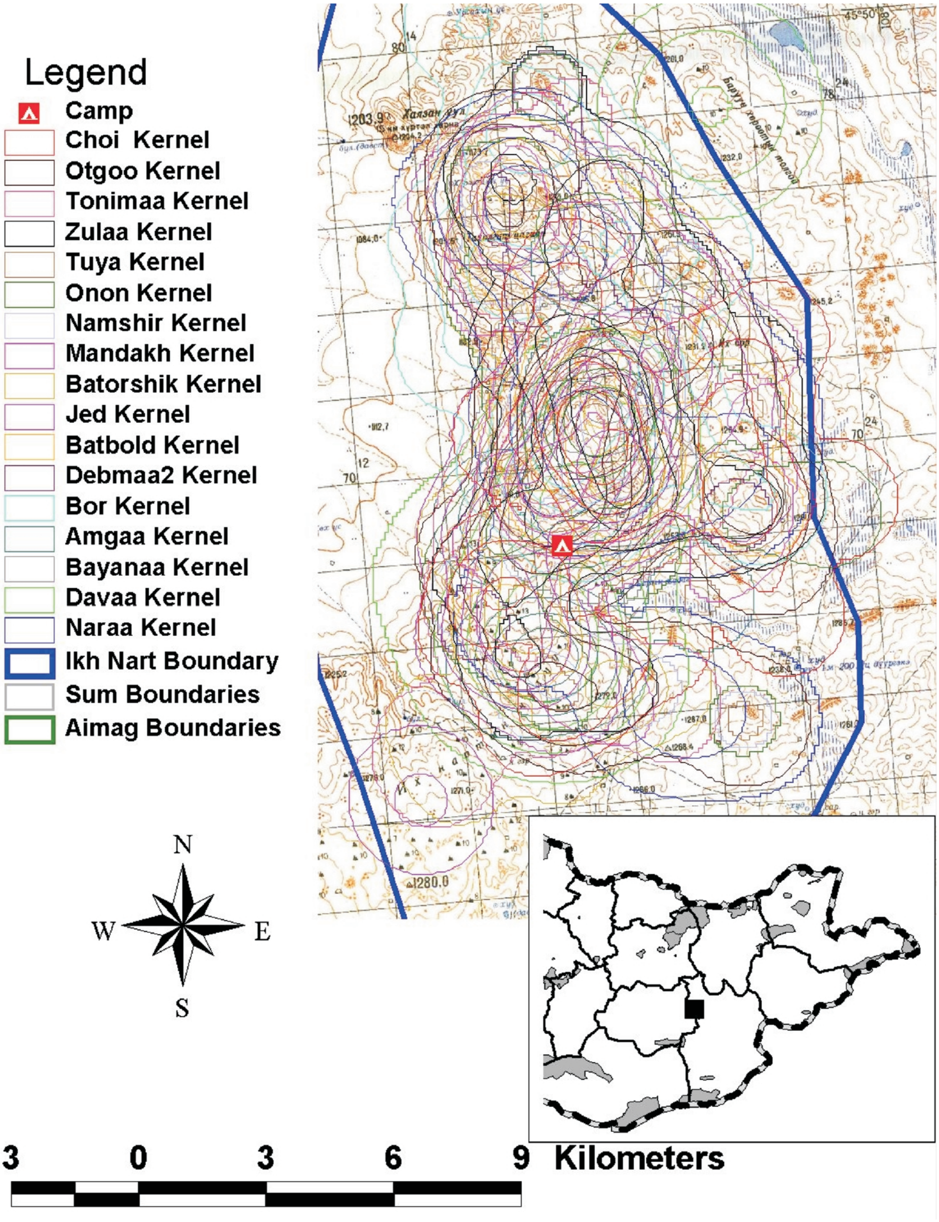

Figure 3: Kernel home ranges (95 %, 75 %, 50 %, and 25 %) for 17 radio-collared Argali (*Ovis ammon*) in Ikh Nartiin Chuluu Nature Reserve, Mongolia 2000–2004. Data are based on 1 location/day only.

(June–August), autumn (September–November), and winter (December–February). Mean home ranges for animals with at least 10 locations per season were 25.81 ± 4.86 in spring, 29.42 ± 1.57 in summer, 38.73 ± 6.73 in autumn, and 36.29 ± 7.00 in winter (table 3). Seasonal differences were not statistically significant ($F = 1.40$, $df = 3.21$, $p = 0.27$) and ranges overlapped significantly (table 4).

Table 2: Home range sizes (km^2) of argali sheep (*Ovis ammon*) in Ikh Nartiin Chuluu Nature Reserve, Mongolia 2001–2004. Study days refer to the number of the days from animal capture until death or last telemetry location. Telemetry days refer to the number of days for which we received at least one location on an animal.

			Kernel Home Ranges				
Animal	**Sd**	**Td**	**100 %**	**95 %**	**75 %**	**50 %**	**25 %**
Debmaa2	93	34	46.52	43.59	12.03	4.07	1.65
Naraa	99	23	55.50	108.02	47.62	15.06	3.91
Batbold	103	42	48.51	60.75	27.35	8.87	2.20
Amgaa	127	18	26.95	45.35	16.70	4.00	1.70
Bor	153	23	46.41	89.45	51.40	20.64	5.58
Bayanaa	159	30	36.97	36.64	7.15	3.16	1.34
Davaa	167	24	31.48	83.10	42.37	16.41	5.77
Choi	229	26	57.85	93.98	45.79	15.41	4.08
Otgoo	238	34	60.82	108.00	60.52	22.02	7.01
Jed	240	37	63.81	91.50	43.36	22.57	5.91
Zulaa	387	65	61.68	80.86	28.38	10.04	3.91
Namshir	395	53	65.28	48.18	15.59	6.66	2.01
Tonimaa	397	48	74.07	84.28	23.00	7.55	2.97
Onon	399	48	65.40	69.96	20.47	5.96	1.97
Batorshikh	401	48	61.92	87.24	39.02	2.048	8.10
Mandakh	599	129	77.79	83.46	26.26	8.78	3.26
Tuya	603	122	80.30	75.16	33.01	13.53	4.00
All data							
Mean	281.7	47.3	56.54	75.85	31.77	10.99	3.85
S.E.	40.5	7.8	3.72	5.32	3.69	1.63	0.49
Animals with > 375 study days and > 45 telemetry days							
Mean	459.4	73.3	69.49	75.59	26.53	7.80	3.75
S.E.	37.9	36.2	2.93	5.08	2.97	2.97	0.79

While we collected data on male and female Argali, we only obtained data from 1 ram. Data from lambs likely reflect the movements of their mothers (i.e., lamb data can be used as indicative of ewe movements) regardless of their gender, thus we did not analyze these data separately.

Mortality

As of May 2004, 15 collared animals have died (table 1). These mortalities included 10 male lambs, 3 female lambs, 1 yearling female, and 1 adult ewe (table 4). Two animals (1 male lamb and 1 ewe; 13.3 % of mortalities) likely died as a direct result of capture techniques (see Reading et al., 2003). Of the 13 Argali that died of non-study related causes, 8 animals (53.3 % of total mortalities) died due to predation. Of these, canids killed 6 lambs; a red fox (*Vulpes vulpes*) killed 1 neonate; a Pallas' cat (*Octocolobus manul*) killed 1 lamb; and an unidentified felid killed 1 neonate. The canid predations included 2 animals 9–10 months old killed by domestic guard dogs (*Canis familiaris*); 1 fox kill of a neonate already compromised by 'joint ill' disease; and 3 other lambs (2 neonates and 1 9-month-old) killed by unidentified canids, but probably domestic dogs or possibly wolves (*Canis lupus*).

Of the remaining 5 deaths, 1 yearling (6.7 %) died of starvation and exposure during a harsh winter; 1 lamb (6.7 %) died of maternal neglect; 1 lamb (6.7 %) died of unknown disease; and 2 lambs (13.3 %) died of unknown causes. The lamb that died of maternal neglect appeared to

Table 3: Seasonal home range sizes (km^2) of argali sheep (*Ovis ammon*) in Ikh Nartiin Chuluu Nature Reserve, Mongolia 2001–2004. Home ranges determined using 100 % minimum convex polygon method. Means exclude animals with less than 10 points/season.

Animal	Spring	Summer	Autumn	Winter
Batorshikh	19.16 (12)	28.02 (18)	12.40 (10)	22.68 (8)
Jed	12.35 (10)	– (0)	56.45 (17)	23.05 (10)
Mandakh	51.55 (34)	33.88 (28)	59.46 (29)	46.83 (38)
Namshir	12.14 (16)	22.67 (20)	27.10 (14)	4.11 (3)
Onon	22.12 (13)	27.16 (21)	28.20 (8)	12.20 (6)
Tonimaa	25.84 (19)	27.90 (18)	44.55 (10)	– (1)
Tuya	40.71 (32)	32.78 (25)	47.32 (32)	38.98 (33)
Zulaa	22.61 (12)	33.56 (31)	23.84 (15)	16.30 (7)
Mean ± S.E.	25.81 ± 4.86	29.42 ± 1.57	38.73 ± 6.73	36.29 ± 7.00

be a twin, rare for our study site, and the mother seemed to simply abandon 1 of the 2 lambs (she was observed with both lambs and then departed with one). The second twin apparently died a few weeks later, but all we found was his collar. The neonate that died of a suspected disease was attended by his dam, but she was unable to get him to rise. He was found with white foam in his mouth. The second lamb that died of an unknown cause did not appear to die from predation or maternal neglect (it was 5 months old).

Discussion

Our interdisciplinary study of Argali sheep is beginning to yield results with important implications to the conservation management of the species in Mongolia and likely throughout its range (Amgalanbaatar et al., 2002; Reading et al., 2003; Tserenbataa et al., 2004). Additional findings presented here continue to refine our understanding of Argali ecology and our continued research promises to further enhance our understanding of the species in the future.

Home range & movement

Given their cursorial nature and larger mass, we expected and found larger home range sizes for Argali than for bighorn sheep (*O. canadensis*; Geist, 1999; Reading et al., 2003), especially when we compare data from Argali studied for more than 1 year and with more than 45 days of telemetry data. Home ranges for bighorn sheep vary from 3.2–44.1 km^2 for ewes and 9.8–54.7 km^2 for rams using 95 % MCP (Krausman et al., 1989, 1999; Singer et al., 2001). Although much of our data comes from lambs, the movements of these animals likely reflect the movements of their mothers, with whom they are closely associated for most of their first year.

We found no changes in habitat use, movement patterns, or home range sizes by season among Argali in Ikh Nart, despite such changes despite such changes being reported for Argali in Russia (Heptner et al., 1988) and bighorn sheep in North America (Shackleton et al., 1999; Krausman et al., 1999). Alternatively, Dall's sheep (*O. dalli*) expand their home ranges in summer and contract them in winter, but like Argali in Ikh Nart show no seasonal movements (Nichols & Bunnell, 1999). As we gather more data on more animals, we will continue to explore movement patterns and habitat use, and attempt to relate these to vegetation and other habitat parameters like escape terrain.

All of our collared Argali remained in the region of rocky outcrops, primarily within the park's boundaries. No animal ventured into the open habitat to the west. The kernel home ranges indicate the most important habitat and future research will explore the reasons for this,

Table 4: Sources of mortality for Argali sheep in Ikh Nartiin Chuluu Nature Reserve, Mongolia 2001–2004.

Animal	♀/♂	Age	Details
Predation (53.3%)			
Bor	♂	Lamb	Predation: by domestic dog (*Canis familiaris*) witnessed by research team.
Davaa	♂	Lamb	Predation: by domestic dog witnessed by research team.
Amgaa	♂	Lamb	Predation: by a canid; probably a dog or wolf
Noname	♀	Lamb	Predation: by a canid; probably a dog or wolf
Dave	♂	Lamb	Predation: by a canid; probably a dog or wolf
Megmaa	♀	Lamb	Predation: by red fox (*Vulpes vulpes*), complicated by 'joint ill'
Tseteg	♂	Lamb	Predation by Pallas' cat (*Felis manul*); scat, tooth, and claw marks found
Tsogoo	♂	Lamb	Predation: by a felid
Capture Related (13.3%)			
Ankhaa	♂	Lamb	Maternal neglect: presence of capture team precluded care
Lauren	♀	Adult	Peritonitis: immobilizing dart penetrated rumen during capture
Maternal Neglect (6.7%)			
Ankhaa2	♀	Lamb	Maternal neglect: found under snow (possible an abandoned twin; ewe departed with other twin, Gadas - see below).
Disease (6.7%)			
Baatar	♂	Lamb	Disease: unknown illness (foam in mouth)
Starvation (6.7%)			
Ganaa	♀	Yearling	Starvation: during severe winter
Unknown (13.3%)			
Bayanaa	♂	Lamb	Unknown: not predation or maternal neglect
Gadas	♂	Lamb	Only collar found (twin of Anakhaa2 - see above).

including linking our vegetative analysis to our habitat use data. Finally, because we know Argali inhabit Ikh Nart well south of our research camp, our data suggest that the park may support more than one subpopulation. We hope to collar more animals from the south to test this hypothesis.

Mortality

As reported earlier (Reading et al., 2003), domestic guard dogs appear to be an important source of mortality for Argali sheep in Ikh Nart, especially for lambs. While wolves and even foxes may have been responsibly for some of the lambs killed by canids, the relatively rarity of wolves compared with domestic dogs, the only partial consumption of the carcass, and the difficulty a fox would likely experience trying to kill a large, healthy lamb suggest that dogs were responsible for most canid predations. We have already begun working on mitigating this source of mortality in Ikh Nart by working with local authorities and pastoralists. As this problem likely exists throughout the range of Argali, we are also trying to inform managers, biologists, and conservationists throughout Mongolia and other range countries.

We noticed, for the first time, a few Argali with apparent twins in the spring of 2004 (an alternative, but we believe less likely explanation, is that ewes adopted orphaned lambs). Despite seeing lambs early in the birthing season, by mid-June, we observed only 2 ewes with surviving twins. This suggests that ewes in Ikh Nart have difficulty rearing 2 lambs and may therefore abandon one. More data are obviously required to better explore and understand this situation.

We believe that we have successfully mitigated most deaths due to our research methods. For example, after losing our first collared lamb to human error, we enforced strict protocols on remaining far from newly collared lambs and have lost no other lambs due to our actions since (N = 21 animals). Similarly, because chemical immobilization is inherently dangerous, we shifted away from this method and toward the exclusive use of drive nets and breakaway collars. We have yet to lose an Argali due to physical constraint and collaring using drive nets. Of course, there are always risks associated with capturing and collaring wild animals, but our goal is minimize these and continually improve our techniques.

Future conservation & research

We hope to continue our research into Argali biology and ecology as a long-term study, and possibly expand to other study sites in Mongolia. Future work will strive to integrate our work from different disciplines to provide a more complete picture of Argali ecology upon which we can develop sound conservation management plans for the species, something already begun (MNE & WWF-Mongolia, 2000).

Acknowledgements
Several people helped make this work possible. Special thanks go to Ya. Adiya, Yad. Adiya, Dr. B. Mandakh, T. Batbold, Battaa, Batorshikh, Bogoo, Bold, T. Choibalsan, Dayan, Dr. S. Dulamtseren, Dr. T. Galbaatar, Javkhlan, B. Lhagvasuren, Dr. B. Miller, M. Monkhbaatar, Ts. Monkhzul, Z. Namshir, Naranbaatar, Naranchuluun, Yo. Onon, Orvchaa, Otgonbayar, D. Pletscher, Renchinsenge, E. Togoldor, Toomoo, Volooj, J. Wingard, and Zorig. Funding was provided by the Denver Zoological Foundation, Earthwatch Institute, the Trust for Mutual Understanding, the Mongolian Academy of Sciences, and the Argali Wildlife Research Center.

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Richard P. Reading
Denver Zoological Foundation
2900 East 23rd Ave.
Denver, CO 80205, USA
rreading@denverzoo.org

Sukhiin Amgalanbaatar
Argali Wildlife Research Center &
Institute of Biology
Mongolian Academy of Sciences
Ulaanbaatar 51, Mongolia
monconcoal@magicnet.mn

Ganchimeg J. Wingard
Wildlife Program
University of Montana
Missoula, M 59802, USA
ganchimeg_w@hotmail.com

Denny Kenny
Denver Zoological Garden
2300 Steele St.
Denver, CO 80205, USA
dkenny@denverzoo.org

Anthony DeNicola
White Buffalo, Inc.
26 Davison Road
Moodus, CT 06469, USA
wbuffaloinc@aol.com