© 2017 Journal compilation
http://mjbs.num.edu.mn
http://biotaxa.org./mjbs
Volume 15(1-2), 2017

Mongolian Journal of Biological Sciences

ISSN 1684-3908 (print edition)
MJBS
ISSN 2225-4994 (online edition)

http://dx.doi.org/10.22353/mjbs.2017.15.03

Original Article

Siberian Ibex (*Capra sibirica*) Neonatal Kid Survival and Morphometric Measurements in Ikh Nart Nature Reserve, Mongolia

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ABSTRACT

Key words: Siberian ibex, neonatal kid, Mongolia, *Capra sibirica*, survivorship, morphometrics.

Article information:
Received: 07 April 2017
Accepted: 26 May 2017
Published online:
30 May 2017

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Understanding the factors influencing survival of ungulate neonates facilitates successful management programs, particularly as they relate to population dynamics and adaptive species management. However, kid survival of near threatened Siberian ibex (*Capra sibirica*) remains poorly understood. During 2005-2013, we captured and collared 21 ibex kids in Ikh Nart Nature Reserve in southeastern Mongolia, to monitor their survival and cause-specific mortality. We found no differences in morphometric measurements between male and female kids, except body mass being males weighing more than females. A total of 11 mortalities were documented and predations by red foxes (n=5, *Vulpes vulpes*) and grey wolf (n=1, *Canis lupus*) was the leading cause of the mortalities. Known fate models indicate the monthly survival of kids best explained by body mass and first month of life (April-May + weight). Monthly survival estimates ranged from 0.077 (95% CI = 0.60-0.88) in April-May to 0.97 (95% CI = 0.90-0.99) in June-March, with an annual survival rate of 0.45 (95% CI = 0.24-0.68). We found little support for the hypotheses that body mass or birth date influenced survival; however, our small sample size limited the power of the analyses. Overall, our results indicated that predation and other factors led to high kid mortality during the period shortly after birth.

Cite this paper as: Otgonbayar, B., Buyandelger, S., Amgalanbaatar, S. & Reading, R. P. 2017. Siberian ibex (*Capra sibirica*) neonatal kid survival and morphometric measurements in Ikh Nart Nature Reserve, Mongolia. *Mong. J. Biol. Sci*., 15(1-2): 23-30.

Introduction

The Siberian ibex (*Capra sibirica* Pallas, 1776) is a sexually dimorphic, polygynous, and gregarious mountain ungulate inhabiting the mountains, mesas, canyons, areas of rocky outcrops and other rough terrain of Central Asia (Fedosenko & Blank 2001; Singh *et al*., 2010). The species remains poorly studied with little known about its ecology. The IUCN Red List of the Mongolian Mammal classified the species as Near Threatened (Clark *et al*., 2006). In Mongolia, ibex numbers have declined since peaking around (Clark *et al*., 2006), the trend could be related to over-exploitation, poaching, habitat degradation, competition with livestock for resources, and mining activity.

Ibex usually give birth in late April-early May. Most adult ibex females give birth each year, with a gestation lasting approximately 170-180 days (Fedosenko and Blank 2001). Segregation of sexes peaked during the lambing season (April-June) in ibex herds (Singh, 2010). Neonatal kids usually appear beginning of April to May in the semi-desert region of Mongolia, but as a rule, birth dates vary with elevation, with females descending to lower elevations, where spring begins earlier, for lambing (Savinov, 1962). Siberian ibexes usually produce one kid, but twinning is not uncommon, with the rate of twinning depending on age (Savinov, 1962), and year (i.e., environmental conditions) (Fedosenko & Blank, 2001). Female ibex remained near the neonatal kids through their first day of life and then began feeding a short distance (~ 100 to 500 m) away (Savinov, 1962).

Studying species' survival rates and factors influencing survival is essential to understanding life history patterns and population dynamics. Juvenile survival may drive ungulate population dynamics in some species due to its inherent variability compared with adult survival (Gaillard et al. 2000). The first two or three months of life is a critical time for ungulates (Nelson & Woolf, 1987), because their small body size and slower locomotion increase the chances of depredation. Therefore, females often leave their young for long periods of time during the first several days following birth (Savinov 1962; Fedosenko & Blank, 2001).

Many of biotic and abiotic factors influence neonatal survival. Abiotic variables include temperature, wind, and precipitation (Escos & Alados, 1991; Reading *et al*., 2009; Egorov, 1955). Biotic factors include habitat use as it relates to predator avoidance (Fox *et al*., 1992), habitat quality (Singer *et al*., 1997), parasites, disease, maternal care (Gaillard *et al*., 2000; Dwyer, 2003), competition, timing of birth (Festa-Bianchet, 1988), plant growth, and predation (Linnell *et al*., 1995; Ricca *et al*., 2002, Vreeland *et al*., 2004). Moreover, birth weight, date of birth, gender and physiological correlates often influence neonatal survival (Nelson & Woolf, 1987, Sams *et al*., 1996; Bergman, 2013; Buuveibaatar *et al*., 2013).

Of the several abiotic and biotic factors that influence neonatal survival, we predicted that birth weight, gender and predation would be most important influences on kid survival at our study site. We expected that heavier kids would experience higher survival than smaller kids, and that female kids would survive longer than male kids, a trend documented for other species of dimorphic ungulates (Clutton-Brock *et al*., 1985). Furthermore, we considered other the effects of morphometric measurements and litter size (singleton vs. twin) on survival of ibex kids. Because twins must share maternal resources, we expected twin kids would display lower survival than singletons (Buuveibaatar *et al*., 2008).

Body size can influence survival (Kunkel & Mech, 1994), and therefore sex biased mortality is more likely in species with sexual size dimorphism. We therefore, hypothesized that kid mass and gender would influence survival of ibex kids in Ikh Nart Nature Reserve (hereafter Ikh Nart). We examined the influence of several monthly and morphological factors to explain ibex kid survival. However, other factors may impact of kid survival. For example, physiological factors (Sams *et al*., 1996), winter and spring precipitation and temperature (Portier *et al*., 1998).

The goal of this study was to better understand the factors affecting neonatal survival and relationship between different morphometric and physiological characteristics. To the best of our knowledge, this is the first large-scale analysis of lamb morphometrics and survivorship for this species.

Materials and methods

We conducted our research in Ikh Nart, located in southeastern Mongolia (45.723°N, 108.645°E) (Figure 1). Ikh Nart was established in 1996 to protect 66,760 ha of rocky outcrops and lies at the northern edge of the Gobi Desert, where dry steppe and semi-desert ecosystem meet (*Reading at al*., 2011). Ikh Nart's 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). The flora and fauna are representative of the arid regions of Central Asia, with a mix of desert and steppe species (Reading *et al*., 2011). Vegetation is sparse that xerophytic and hyperxerophytic

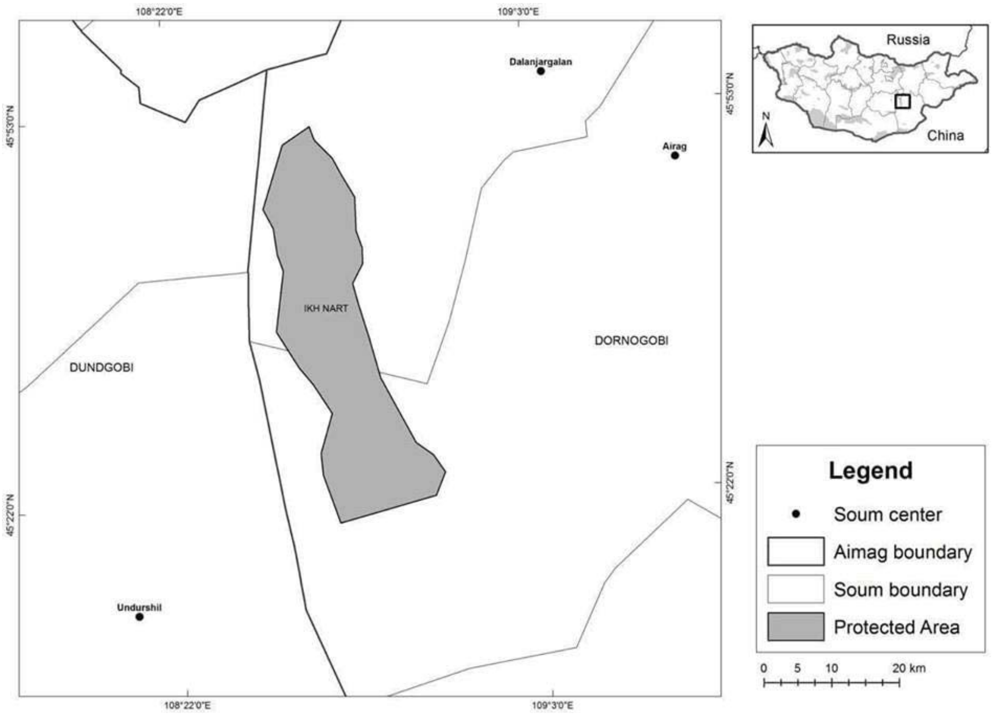

Figure 1. Location of Ikh Nart Nature Reserve, Mongolia relative to county (thin line), province (solid line) and country borders (inset below).

semi-shrub, shrub, scrub vegetation and turfy grasses dominate, including *Haloxylon ammodendron, Sympegma ergelli, Anabasis bervifolia, Ephedra prjewaliskii, Ilynia regeli, Stipa glareosa, S. orientalis,* and *Reumuria songarica* (*Reading et al*., 2007). Argali sheep (*Ovis ammon*) also occur in Ikh Nart, as do gray wolves (*Canis lupus*), red fox (*Vulpes vulpes*), corsac fox (*V. corsac*), and raptors, such as golden eagles (*Aquila chrysaetos*) and Cinereous vultures (*Aegypius monachus*).

Details of capture methods outlined in Reading *at al*. (2009) and approved by the Mongolian Academy of Sciences. We observed female ibexes using binoculars from beginning of April to end of May to see if she had a neonatal kid. A female ibex with a neonatal kid typically grazes a short distance away and circles the kid's hiding place, but moves away if she detects something suspicious. Once a neonatal kid was detected, one team member remained at the observation site while directing the other members toward kid using 2-way radios. The team then surrounded the kid, while one individual silently and slowly moved forward from behind the kid to grab it (Reading *et al*., 2009). Kids older than ~ 5 day typically fled once we reached ≥ 10 meters and were too fast and agile to capture.

We blindfolded captured kids during handling processes to minimize stress. We aged kids based on our observation of when mothers gave birth. We placed ear tags and expandable, drop-off radio telemetry collars on captured kids and recorded temperature (C°), pulse rate, respiration rate, total body length (TBL: tip of nose to base of tail), height (top of shoulder to foot placed flat), girth (chest circumference just behind front legs), foreleg (point of elbow to tip of foot), hind leg (point of hock to tip of foot), neck (circumference here radio-collar attached), tail (base to tip), and ear (tip through middle to base). Mean handling time was 5.4 min (*SD* = 0.10 min). Kids were fitted with Advanced Telemetry Systems (ATS, Inc., Isanti, MN) radio transmitters (65-100 g) fastened to expandable neck-collars, and then released. We used an AVM model LA12 portable receiver (AVM Instrument Company, Dublin, CA) and three-element hand held Yagi antenna (AVM Instrument Company, Dublin, CA) to locate kids.

We monitored radio-collared kids starting 2 days after the captured day. We regularly collected data from the collared animals, but usually only obtained locations for a few days each month. We equipped collars with a mortality switch. When we detected a mortality signal, we recovered the carcass as quickly as possible and tried to determine the cause of death. Where possible, we determined cause of death by animal spoor, method of killing (for predation events), and necropsies of complete or mostly complete carcasses. We examined stomach, intestinal tracks, and the marrow of lone bones whenever possible.

Data analysis

Differences in body mass and morphometric measurements between sexes were tested using t-tests assuming equal variances (based on Levene-s test; Sokal & Rohlf, 2000).

We used the known-fate model in program MARK version 8.1 (White & Burnham, 1999), with the logit link function to evaluate effects of body mass and birth date on kid survival. We used the Akaike information criterion corrected for small sample size (AICc) and (AIC weight) for model selection. We considered the model with the smallest AICc value to be the best model to fit the data (Burnham & Anderson, 2002).

Results

We captured 21 ibex kids including 10 females and 11 males (Table 2) between March 28 to May 5, with most captures (52.3%) occurring during April 10-12 (Figure 2). Average age of kid at capture was 3.2 days (range = 1-9 days). We found no differences in morphometric measurements between male and female kids, except body mass being males were heavier than females (Table 2).

We documented a total of 12 mortalities, of which 9 (52%) occurred in first month since the birth during April-May, but thereafter their mortality rate decreased substantially (Figure 3, Table 1). Predation was the leading cause of death; 6 of 11 mortalities caused predation. Predation prior to 14 days of age included three kids (3, 3 and 5 days old) killed by a red fox (*Vulpes vulpes*) and gray wolf (*Canis lupus*) (Table 1). Two kids survived at least close to or until the time of radio failure or harness breakage (until when? Be explicit!!!), and had unknown fates after that time. Starvation was

Table 1. Sources of mortality for ibex kids (*Capra sibirica*) during their first year of life in Ikh Nart Nature Reserve, Mongolia, 2005-2013.

Mortality source	Detail	Number	Age (day old)				
			≤3	≤5	≤15	≤30	≤160
Predation	Fox	5	2	1		1	
	Wolf	2			1		1
Starvation		3	3				
Sickness		2	1				1

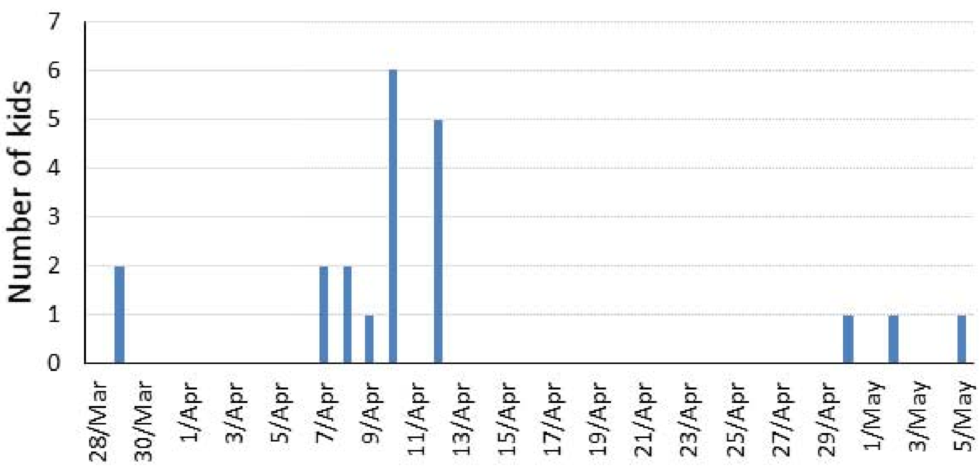

Figure 2. Number of captured ibex kids (*Capra sibirica*) on each calendar date from 2005 to 2013 in Ikh Nart Nature Reserve, Mongolia.

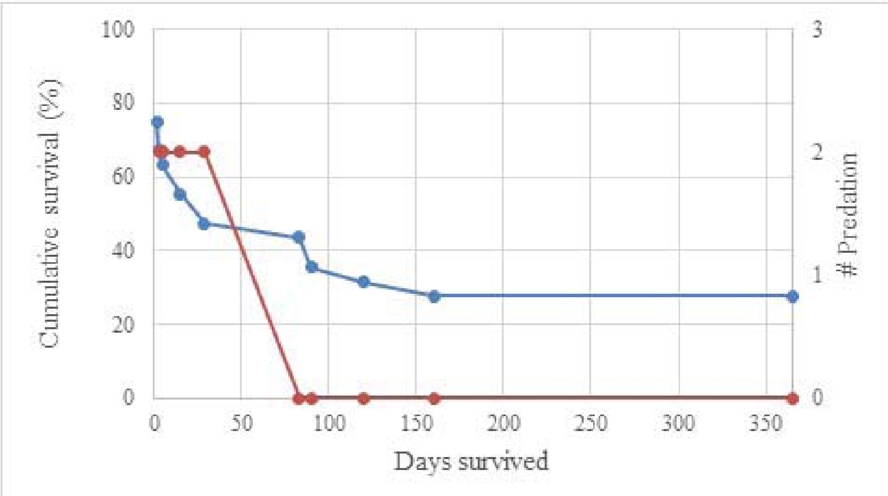

Figure 3. Cumulative survival rates for radio-collared neonatal Siberian ibex (*Capra sibirica*) kids (blue line) and number of predations per day alive (red line) in Ikh Nart Nature Reserve from 2005 to 2013.

Table 2. Morphometric measurements and statistical comparison of mean body measurements between male and female Siberian ibex kid (*Capra sibirica*) in Ikh Nart Nature Reserve, Mongolia, 2005-2013.

	Males			Females			All animals			Student t-test results		
Measurement	Mean	SE	n	Mean	SE	n	Mean	SE	n	t	df	*P*
Weight	3.44	0.20	11	2.71	0.24	9	3.11	0.17	20	0.34	18	0.01
Ear	7.45	0.16	11	7.08	0.32	10	7.27	0.17	21	1.04	19	0.15
Tail	6.75	0.37	11	6.25	0.52	10	6.51	0.31	21	0.79	19	0.21
Neck	17.73	0.65	11	17.36	0.81	10	17.55	0.50	21	0.36	19	0.36
Foreleg	14.95	0.35	11	14.55	0.39	10	14.76	0.26	21	0.75	19	0.22
Shoulder	40.50	1.70	11	38.92	1.36	10	39.75	1.09	21	0.71	19	0.24
Hind leg	18.19	0.44	11	17.85	0.55	10	18.02	0.34	21	0.48	19	0.31
Girth	38.50	1.84	11	35.32	1.73	10	36.98	1.29	21	1.24	19	0.11
TBL	55.00	2.55	11	56.83	1.99	10	55.87	1.61	21	-0.55	19	0.29
Front Hoof L	3.08	0.16	11	2.89	0.14	10	2.99	0.11	21	0.85	19	0.2
Front Hoof W	2.28	0.15	11	2.03	0.16	10	2.16	0.11	21	1.13	19	0.13
Hind Hoof L	3.06	0.07	6	2.83	0.08	6	2.95	0.06	12	2.17	10	0.02
Hind Hoof W	2.06	0.06	6	1.81	0.08	6	1.94	0.06	12	2.34	10	0.02

Mean – average body measurements, SE – standard error, n – number of kids and weights in kg, all other measurements in cm and differences examined with Student's t-test: t-test statistic, df – degrees of freedom and p – probability.

second leading cause of mortality (n=3 or 27.3%) and mostly occurred during the dry spring season (Table 1). Two kids were perished due to sickness or diseases (at 2 and 160 days old) (Table 1). At least seven (19.0%; 1 female and 3 males) and possibly 9 (30.0%; if the kids with a radio failure and harness breakage survived) of 21 kids remained alive after one year.

Our post-hoc modeling of kid survival found that model SApril-May + weight was the best approximating model (Table 3). This model accounted for 80% of the AICc weight among competing models, with no competing model < 3 AICc. Exclusion of weight from the best model produced the 2nd ranked model (AICc weight = 14%), followed by exclusion of April-May (Table 3; AICc weight = 4%). Remaining models were ≥ 8 Δ AICc from the best model. The weight of evidence supporting this best model was ≥ 5.6 times greater than the next model and April-May model was ≥ 9.6 times better than all other models (Table 3). Monthly survival estimates for April-May were 0.77 (95% CI = 0.60-0.88) compared to 0.97 (95% CI = 0.90-0.99) for the remaining months of the year; overall probability of surviving 12 months was 0.45 (95% CI = 0.24-0.68).

Table 3. Candidate model set and model selection criteria for the Kaplan-Meier known-fate survival analysis used to model Siberian ibex (*Capra sibirica*) kids survivorship in Ikh Nart Nature Reserve, Mongolia, 2005-2013.

Model	AICc	Delta AICc	AICc Weights	# Parameters	Deviance
{SApril-May+weight}	56.8674	0.0000	0.80336	3	50.6472
{SApril-May}	60.3397	3.4723	0.14155	2	56.2306
{Sweight}	62.8914	6.0240	0.03952	2	58.7823
{SApril}	65.5603	8.6929	0.01041	2	61.4513
{Sbirth date}	69.0472	12.1798	0.00182	2	64.9381
{Slitter size}	69.5556	12.6882	0.00141	2	65.4465
{SConstant}	69.6198	12.7524	0.00137	1	67.5838
{Sgender}	71.4976	14.6302	0.00053	2	67.3886
{St}	77.5379	20.6705	0.00003	12	50.4179

AICc – Akaike's Information Criterion corrected for small sample size, ΔAICc – difference in AICc relative to min AICc, AICc weight – Akaike weight, *k* – number of parameter

Discussion

Despite the overall sample size was low, we believe our study provides some insights with regards to survival and cause-specific mortality of the Siberian ibex kids in Mongolia.

We collared more kids in 2011-2013, because by then in the study we better understood the behavior of female ibex that recently gave birth to kids. For example, female ibex with a neonatal kid typically grazed short distances from hiding place of their kid and they continued this behavior until the kid could run independently.

Our results indicated predators are main reason of mortality on neonate kids at Ikh Nart. A study of red fox diet found an increase in ungulate hair occurrence in April to May, when both foxes and ibex give birth and rear their young (Buyandelger, 2008; Murdoch *et al*., 2010). Other studies found lower annual survival rate (> 37.5%) in the face of fox and wolf predation in the Tian Shan Mountains (Egorov, 1955). Reading *et al*. (2009) reported that the greatest source of mortality for argali neonatal lamb was predation (44.6%) and starvation (21.4%), with wolves representing the main predators of lambs. Similar to Reading *et al*. (2009) our result showed that predation was main reason of mortality; however, foxes, rather than wolves, represent the main predators for kids. Because neonatal survival influences population trajectories, it is critical for wildlife managers to obtain reliable information before initiating management actions (Barber-Meyer *et al*., 2008).

While body mass did enter the model, sex of kid was not an important explanatory variable in known-fate survival models in this study, probably because mass accounted for gender differences. Mean birth mass of kids at Ikh Nart (3.11, range = 1.2-4.5 kg) was greater than that reported in Kazakhstan (2.9, range = 2.6-3.5) (Savinov, 1962). We captured two pairs of twins that weighed 1.2-2.7 kg; three of these individuals died within ≤ 15 days of life, but one (weight = 2.3kg) grew to adulthood.

Timing of mortality in our study followed a trend in which nine kids were under two months old when they died. All seven kids that survived in our study were born after April 10 (peak of birth). Timing of lambing strongly influences reproductive success of ungulates (Festa-Banchet, 1988). Birth date may also effect survivorship because predation pressure – individuals born outside the peak of parturition – would face greater predation pressure due to predation saturation during peak parturition (Egorov, 1955). Early birth dates would potentially subject kids to harsher weather conditions and lower quality forage for the mothers, whereas later birth dates may not give kids sufficient time to grow and put on condition before winter (Festa-Bianchet, 1988).

Neonatal survival models generally require large amounts of data on the species that we were unable to obtain for this study. Additional research include larger sample sizes of a greater range of morphological, physiological, and sex classes should be conducted over a long time period (Reading *et al*., 2007). A larger sample size will enable us to accurately assess survival and cause-specific mortalities of kids, in relation extrinsic and intrinsic factors.

Acknowledgements

We thank M. Zulbayar, S. Batzorig, D. Munkhbaatar, D. Altangerel, R. Ulziiduuren, Ts. Otgonbayar, D. Batbayar, L. Batdorj, S. Batdorj, S. Munkhdalai, G. Munkhchuluun, and S. Dandarbaatar for assistance with capture and monitoring, and Karin Holser for helpful comments on our manuscript. Also we thank Joshua B. Smith and Gary C. White at Smithsonian Mason Conservation Institution for advice with data analysis. Funding was provided by the Denver Zoological Foundation, Earthwatch Institute, Mongolian Academy of Sciences and Argali Wildlife Research Center.

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