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TECHNICAL REPORT

# Successful Field Capture Techniques for Free-ranging Argali Sheep (*Ovis ammon*) in Mongolia

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Argali sheep (*Ovis ammon*) are the world's largest wild sheep and are threatened throughout their range in Mongolia. Little is known about the ecology of this highly cursorial species. This project was initiated to develop safe capture techniques in order to learn more about the ecology of argali in the Ikh Nartiin Chuluun Nature Reserve in southeastern Mongolia by using radiotelemetry. To our knowledge no one had ever successfully live-caught a free-ranging argali. We developed three techniques for capturing argali. From 2003 to 2007 we hand captured 65 argali lambs, losing one (our first capture) to maternal neglect because we stayed too long in the area and a second that was euthanized after being accidentally injured by a horse. Between 2000 and 2003 we captured six argali by darting, losing one ewe to an abdominal infection after a misplaced dart. Finally, between 2002 and 2007 we captured 32 argali by drive-netting. We lost one ewe to over-exertion after a long drive. The remaining 31 animals captured by drive-netting did not appear to suffer any immediate effects (still alive in 30 days). This report will discuss the strengths and weaknesses for each of these capture techniques. Zoo Biol 27:137–144, 2008. 

**Keywords: *Ovis ammon*; argali sheep; lamb capture; darting; drive-netting**

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## INTRODUCTION

Argali (*Ovis ammon*) inhabit the mountains, inter-mountain valleys, rolling hills, and rocky outcrops of Mongolia [Amgalanbaatar and Reading, 2000]. Little is known about the ecology of this highly cursorial giant sheep [Sukhbat, 1978; Amgalanbaatar, 1993; Luschekina, 1994; Mallon et al., 1997; Reading et al., 1997]. There are mounting pressures on wildlife in Mongolia from natural resources extraction activities, hunting, poaching, predation by domestic dogs, and grazing from rapidly increasing livestock herds [Mallon et al., 1997; Reading et al., 1998, 1999]. As a result, argali populations are declining throughout Mongolia, but especially in the western Altai Mountains [Shiirevdamba et al., 1997]. Currently, argali are listed as a threatened species by the Mongolian and the US governments, as well as by the World Conservation Union [Nowak, 1993; Shiirevdamba et al., 1997; IUCN, 2006].

The data in this report were collected at the Ikh Nartiin Chuluun Nature Reserve (Ikh Nart) located in southeastern Mongolia from 2000 through and including 2007. Ikh Nart was established in 1996 to protect 43,740 ha of open valleys and large maze-like rocky outcroppings in northwestern Dornogobi Aimag [Myagmarsuren, 2000]. The region is high upland (altitude ~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. The climate is strongly continental and arid, characterized by cold winters (low $-40^{\circ}$C), dry, windy springs, and relatively wet, hot summers (high $+35^{\circ}$C). Precipitation is low and seasonal, with most occurring in the summer.

Mongolian resource managers require data for argali life history, habitat utilization, movement patterns, population ecology, and nutritional requirements to develop sound conservation management programs for this species. However, argali are shy, elusive, and cursorial sheep that have never been successfully live-captured to our knowledge.

Staff from Zoological Gardens are becoming increasingly directly involved in field research and conservation projects. We utilized a multi-disciplinary approach by sending staff from three departments (Research & Conservation, Animal Health, and the Mammal Department) to Mongolia to evaluate the feasibility of safely capturing argali sheep for radio-collaring. Three techniques were evaluated; hand-capturing neonatal lambs and darting or drive-netting for juveniles and adults.

## MATERIALS AND METHODS

### Lamb Capture

We opportunistically and actively ground searched for neonatal lambs from 2003 to 2007 during lambing seasons (late March to early May). We utilized ground searching as described for guanaco [Franklin and Johnson, 1994] as opposed to helicopters as described for neonatal Dall lambs [Scotten and Pletscher, 1998] owing to the unavailability of helicopters in Mongolia. We identified newly post-parturient ewes that were reluctant to leave an area even after initially fleeing from us but would keep glancing back and quickly return to the site. This behavior usually signaled that the ewe had hidden a newborn lamb. We methodically combed the area for the cryptic lambs that, if ~2-days-old or less, would remain frozen, not even moving

when approached close enough to step on them. Slightly older lambs (>3-days-old) would bolt when we got within 2 m and were already too quick and agile to capture.

When located the best approach seemed to be to encircle or triangulate the lamb. Two team members would approach and then stand still at 45° angles in front of the lamb occupying its attention, whereas a third team member would sneak silently from the back. While the lamb watched the team members in front, the third team member made the rush and grab.

## Darting

We initially tried to capture juveniles and adults by stalking on foot and attempting to immobilize them from a hiding spot with a dart gun. Because we lacked access to helicopters or net guns, as is favored in North America for bighorn sheep (*O. canadensis*) we tried darting and then moved on to drive-netting [Andryk et al., 1983; Bates and Guymon, 1985; Beasom et al., 1980; Jessup et al., 1988; Krausman et al., 1985; Kock et al., 1987a; Clark et al., 1988]. We selected a 0.22 caliber delivery system (model 193SS, Pneu-Dart® Inc., Williamsport, Pennsylvania, USA) with a 2-ml type C Pneu-Dart® dart with a 1.9 cm barbed needle for this project. A red dot scope (Tasco® AccudotTM, Bushnell Corp., Overland Park, Kansas, USA) was determined to be the best sighting aid. Knowledge of distance to the target is critical; hence, we used a range finder to accurately determine distance (Leica LRF 800 & 1200, Leica Camera Inc., Northvale, New Jersey, USA).

Anesthetic darts and reversal agents were prepared in advance using the bighorn sheep (*O. canadensis*) as a model [Kreeger et al., 2002]. Lacking reliable weight data for a free-ranging argali ewe we used 90 kg as our initial estimate. The 2 ml dart was loaded with 4 mg carfentanil (Wildnil®, Wildlife Pharmaceuticals Inc., Fort Collins, Colorado, USA), 50 mg xylazine (Cervizine® 100 mg/ml, Wildlife Pharmaceuticals Inc.), and 100 mg of the dissociative anesthetic ketamine (200 mg/ml, Wildlife Pharmaceuticals Inc.) to fill the dart.

After radio-collaring, carfentanil was reversed with 100 mg of naltrexone hydrochloride (Trexonil®TM 50 mg/ml, Wildlife Pharmaceuticals Inc.) administered intravenously and 400 mg administered intramuscularly. Xylazine was reversed with 15 mg of yohimbine hydrochloride (AntagonilTM 5 mg/ml, Wildlife Pharmaceuticals Inc.) administered intravenously. There is no reversal for ketamine, but fortunately it is metabolized in about 20–30 min (personal experience).

We experimented with several darting strategies: (1) *Jump shooting*: While hiking we would occasionally surprise a potential target at close range. (2) *Blinds*: We sat behind natural blinds within range (≤50 m) of a water hole and used a spotter with a radio to transmit the location and direction of potential targets as they approached the blind. (3) *Driving*: We used team member/s to attempt to drive potential targets on foot or a vehicle toward a hidden shooter. (4) *Spotting*: A spotter hidden at a high location spotting targets directed shooter/s to the location by radio. In a variation we located grazing animals and tried to position shooter/s at a point that would intercept the slowly moving, grazing animals. (5). *Judas sheep*: We located radio-collared animals and then attempted to stalk an uncollared companion animal.

## Drive-netting

We conducted a successful drive-net feasibility study in September 2002 [Ramey et al., 2004]. Drive-netting argali requires topographical knowledge of the

area, a lot of human staff, two-way radios, horses, vehicles, and nets. The net we used was 27 m (90′) long, 2.7 m (9′) with a square mesh pattern of 12.7 × 12.7 cm (5 × 5″) made of twined nylon 0.5 cm (0.2″) in diameter (Memphis Net & Twine Co., Inc., Memphis, Tennessee, USA). Locally made lightweight wooden poles (245–305 cm in length, 96–120″) slightly notched at one end were used to raise and support the net. A typical setup consisted of two parallel sets of nets ~400 m (440 yd) in length and ~20 m (22 yd) apart with about 0.5 m (1.7′) draped on the ground to prevent animals from running under the net. Argali typically strike the net as a group; hence, the first animal will become entangled, collapsing that net section, allowing the rest of the animals to run through. The second net enabled us to catch additional animals.

In a typical drive, we would use motorcycles to locate sheep and slowly start driving them toward the net. English- and a Mongolian-speaking staff member would be located on a high vantage point to assist in locating and moving the animals. We made every effort not to drive the animals too hard initially. If the argali tried to turn back or angle away from the group the motorcycles would attempt to loop around them and redirect toward the net. Several horsemen, vehicles, and foot staff were strategically positioned near potential escape routes or hidden in the rocks to help direct sheep toward the center of the net as they got close. It is critical to have some horsemen close to the net to provide the final back pressure to successfully direct animals into the net. Additional ground staff were hidden along the net ready to jump out and redirect sheep trying to parallel it. It was imperative for all staff to be kept up to date with two-way radios.

### Animal Handling

All captured sheep (neonates, juveniles, adults) were quickly hooded, regardless of capture method. We kept talking low and to a minimum. Hand-caught neonates were restrained on a lap, whereas darted or drive-net captured juvenile or adult animals were manually restrained by two or three people and positioned sternally to avoid bloating and aspiration of rumen contents. Lamb collars were expandable and designed to fall off in about 12 months. Some of the adult collars were permanent, whereas later versions were designed to fall off in about 2 years. We weighed lambs suspended in a sack with a digital fish scale (Cabela's®, Sidney, Nebraska, USA) and adults with a "Big Buck" scale (Cabela's®) while suspended from a soft-handled tarp. We also performed a physical exam and obtained several morphometric measurements. For all captures we attempted to record handling times, rectal temperatures, and heart and respiratory rates. Animals were checked (absence of a mortality signal) by radiotelemetry in 24–48 hr after capture.

## RESULTS

### Lamb Capture

Sixty-five 1- to 2-day-old neonatal lambs (33 males, 32 females) were successfully captured for radio-collaring from 2003 to 2007. One neonate died, our first capture, owing to maternal neglect because we lingered in the area too long,

**TABLE 1. Mean and standard error comparisons for argali sheep by capture technique for temperature, heart rate, respirations, handling time, and mortality**

| | Lambs | Darting | Drive-netting |
|---|---|---|---|
| Temp (°C and °F) | 39.1 SE ± 0.2 (102.4°F) $n = 49$ | 39.1 SE ± 0.2 (102.4°F) $n = 3$ | 40.8 SE ± 0.2 (105.4°F) $n = 30$ |
| Heart rate (beats/min) | 92.7 SE ± 3.8 $n = 45$ | 64.8 SE ± 16.7 $n = 5$ | 137.2 SE ± 6.0 $n = 30$ |
| Respiration (breaths/min) | 71.5 SE ± 4.0 $n = 43$ | 21.6 SE ± 2.7 $n = 5$ | 73.9 SE ± 7.2 $n = 30$ |
| Handling time (min) | 15.2 SE ± 0.7 $n = 52$ | 46.8 SE ± 5.5 $n = 5$ | 14.8 SE ± 1.0 $n = 29$ |
| Mortality | 2 of 65 (2%) | 1 of 6 (17%) | 1 of 32 (3%) |

and a second was euthanized for a fractured leg after being stepped on by a horse. The mean handling times, rectal temperatures, heart and respiratory rates, and mortality are reported in Table 1. Any manipulation appeared to stimulate the lambs' quickly changing heart and respiratory rates. The mean weight for 60 male and female lambs was 4.4 kg SE ± 0.1.

## Darting

We successfully darted six argali (four juveniles and two adult ewes) from 2000 to 2003. Sheep were darted at a mean distance of 28 m SE ± 3.7 ($n = 5$). The mean induction time for five animals was 2 min and 30 s SE ± 0.7. The mean reversal time (animal walked or jogged off) for five animals was 3 min 18 s SE ± 1.0. Darted argali traveled 0.25–1 km from the initial darting site before going down. The mean handling times, rectal temperatures, heart and respiratory rates, and mortality are reported in Table 1. As darted animals were usually immobilized in $< 3$ min, we believe the physiologic values recorded are probably close to baseline values. One adult ewe was struck by a dart in the left flank just behind the last rib. It was found down and moribund 5 days later. The ewe was euthanized. Necropsy showed the cause of death to be a fibrinous peritonitis caused by the dart needle penetrating the rumen. We were able to weigh 19 argali ewes (71.0 kg SE ± 1.5) and two adult rams (149.3 kg SE ± 0.5) captured by either darting or drive-netting giving us a more accurate model for drug calculations.

## Drive-netting

From 2002 to 2007 we captured 32 argali sheep (five lambs, six juveniles, 18 ewes, three rams) with drive-nets. We caught multiple animals (two or more) on nine occasions. The mean handling times, rectal temperatures, heart and respiratory rates, and mortality are reported in Table 1. Longer processing times were associated with multi-catch events. One ewe died in less then 24 hr, but unfortunately a necropsy was not performed. We believe the death was owing to acute capture myopathy from over-exertion after a long chase. After this event we called off several chases when animals appeared overly stressed.

## DISCUSSION

We successfully hand captured 65 lambs in five seasons. The first lamb captured died, we believe, from maternal neglect when staff inadvertently stayed too close and too long by the lamb owing to concerns for its safety. We believe that this led to the ewe abandoning the neonate. Our policy after that event was to process neonates as quickly as possible and then immediately leave the area. Collared lambs would be checked a day or two later with radiotelemetry to determine whether it was still alive and moving with its mother. A second concealed lamb was euthanized after a horse stepped on and fractured its leg.

Six argali were successfully darted for radio-collaring. We noted that the easiest animals to dart were juveniles traveling without adults. They did not appear to possess the same level of alertness as adults. We fired three darts at one juvenile, before succeeding, without it moving very far between shots. Our major concern with darting was poor dart placement. Some animals moved extremely quickly at the sound of the rifle. This occurred with one animal, where the dart struck the left flank leading to its death from peritonitis 5 days later. Another concern is that the drugs are expensive; the approximate cost for a 2 ml dart, immobilization drugs, and reversal agents was ~$175.00 US. These drugs are also potentially dangerous and life threatening to the patient and to the staff handling them. We also worried that a darted or partially drugged sheep might disappear from sight and get lost. We decided that no animals should be darted within 30 min of sunset to minimize loosing the animal in darkness.

We noted that in a dart recovered from a 34.1 kg lamb the needle was imbedded in the sacrum and filled with cancellous bone. Aspiration of the dart recovered 1.2 ml of drug; therefore, the lamb received 0.8 ml at most. It was noted that toward the end of the procedure it was able to slowly move its legs indicating it was beginning to recover on its own from the anesthesia without the benefit of reversal, perhaps indicating that it was a perfect dose for this size individual. The lamb received approximately 1.6 mg carfentanil (carfentanil 0.047 mg/kg), 20 mg xylazine (xylazine 0.59 mg/kg), and 40 mg ketamine (ketamine 1.17 mg/kg), which approximates the recommended dose for bighorn, 0.45 mg/kg carfentanil and 0.2 mg/kg xylazine [Kreeger et al., 2002].

To date we have successfully captured 32 argali by drive-netting. It was critical for the horsemen and vehicles to drive and haze the animals hard the last 100–200 m toward the center of the net. If the horsemen pulled up early, the sheep had time to slow down, survey the situation, and could visually pick out the net causing them to turn and try to escape by paralleling the net. The last line of defense was ground staff hidden near the net who would jump up and yell trying to redirect the group into the net. This strategy was successful on several occasions.

The major concerns with driving–netting argali were hyperthermia and over-exertion. During the drive we noted sheep breathing open mouth with their tongues hanging out the side of the mouth, presumably to aid in cooling. Netted animals had physiologic parameters that were elevated when compared with darted animals (Table 1). Comparing netted with darted animals, mean temperatures were 1.7°C higher, mean heart rates were 2.1 times higher, and respiratory rates were 3.6 times higher. The same parameters for North American bighorn sheep do not show as much difference when comparing drive-netting (temp: 41.2°C SE $\pm$ 0.1, $n = 197$;

pulse: 130.0 bpm SE ± 2.9, $n = 130$; resp: 72.0 bpm SE ± 2.9, $n = 2.9$) with darting (temp: 41.5°C SE ± 0.2, $n = 43$; pulse: 125.0 bpm SE ± 5.6, $n = 38$; resp: 50.0 bpm SE ± 4.0, $n = 39$). The difference is probably owing to the fact that darted animals are chased and darted from a helicopter [Kock et al., 1987b]. Our darted animals were stalked so that there was no chase. Despite these changes only one argali was noted to suffer any obvious ill effects (mortality) from netting as determined by subsequent visual observations and radiotelemetry movements. We believe that because argali are more cursorial then North American bighorn sheep, they are adapted to handle higher heat loads [Koch et al., 1987b].

Lamb captures and drive-netting are low-tech methodologies we felt were easily transferable to our Mongolian colleagues. Darting with expensive and potentially dangerous drugs was not a technique we felt could be reasonably transferred to our colleagues in Mongolia and might better be reserved for capturing specific individuals.

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## REFERENCES

Amgalanbaatar S. 1993. Argali population inventory and conservation measures in selected areas of Mongolia. Research Papers Forest and Hunting Institute. 32 p (in Mongolian).

Amgalanbaatar S, Reading RP. 2000. Altai argali. In: Reading RP, Miller B, editors. Endangered animals: conflicting issues. Westport, CT: Greenwood Press. p 5–9.

Andryk TA, Irby L, Hook DL, McCarthy JJ, Olsen G. 1983. Comparison of mountain sheep capture techniques: helicopter versus net-gunning. Wildl Soc Bull 11:184–187.

Bates JW, Guymon JG. 1985. Comparison of drive nets and darting for capture of desert bighorn sheep. Wildl Soc Bull. 13:73–76.

Beasom SL, Evans W, Temple L. 1980. The drive net for capturing western big game. J Wildl Manage 44:478–480.

Clark RK, Jessup DA, Weaver RA. 1988. Relocation of bighorn sheep within California. Joint Proceedings of the American Association of Zoo Veterinarians and American Association of Wildlife Veterinarians, Toronto, Ontario, Canada. p 121–129.

Franklin WL, Johnson WE. 1994. Hand capture of newborn open-habitat ungulates: the South American guanaco. Wildl Soc Bull 22: 253–259.

IUCN 2006. 2006 Red List of Threatened Species. www.iucnredlist.org. Downloaded on 29 September 2006.

Jessup DA, Clark RK, Weaver RA, Kock MD. 1988. The safety and cost-effectiveness of net-gun capture of desert bighorn sheep (*Ovis canadensis nelsoni*). J Zoo Anim Med 19:208–213.

Kock MD, Jessup DA, Clark RK, Franti CE, Weaver RA. 1987a. Capture methods in five subspecies of free-ranging bighorn sheep: an evaluation of drop-net, drive-net, chemical immobilization and the net-gun. J Wildl Dis 23:634–640.

Koch MD, Jessup DA, Clark RK, Franti CE, Weaver RA. 1987b. Effects of capture on biological parameters in free-ranging bighorn sheep (*Ovis canadensis*): evaluation of drop-net, chemical immobilization and the net-gun. J Wildl Dis 23:641–645.

Krausman PR, Hervert JJ, Ordway LL. 1985. Capturing deer and mountain sheep with a net-gun. Wildl Soc Bull 13:71–73.

Kreeger TJ, Arnemo JM, Raath JP, editors. 2002. Sheep, bighorn, *Ovis canadensis*. Handbook of wildlife chemical immobilization. International ed. Fort Collins, CO: Wildlife Pharmaceuticals, Inc. 254p.

Luschekina A. 1994. The status of argali in Kirgizstan, Tadjikistan and Mongolia. Unpublished report. Arlington, VA: Office of Scientific Authority, US Fish & Wildlife Service. 41p.

Mallon DP, Bold A, Dulamtseren S, Reading RP, Amgalanbaatar S. 1997. Status survey and action plan for caprinae. In: Shackleton D,

The IUCN. SSC Caprinae (Specialist Group editors). Wild sheep and goats and their relatives. Gland, Switzerland. p 193–201.

Myagmarsuren D, editor. 2000. Special protected areas of Mongolia. Ulaanbaatar, Mongolia: Mongolian Environmental Protection Agency and GTZ (The German Technical Advisory Agency. 102p.

Nowak R. 1993. Court upholds controls on imports of argali trophies. Endangered Species Tech Bull 18:11–12.

Ramey RR, Tserenbataa T, Amgalanbaatar S, Namshir Z. 2004. A new method of argali (*Ovis ammon*) capture using horsemen and drive-nets. Mongolian J Biol Sci 2:19–21.

Reading RP, Amgalanbaatar S, Mix H, Lhagvasuren B. 1997. Argali *Ovis ammon* surveys in Mongolia's South Gobi. Oryx 31:285–294.

Reading RP, Amgalanbaatar S, Mix H. 1998. Recent conservation activities for argali (*Ovis ammon*) in Mongolia—Part 1. Caprinae August: 1–3.

Reading RP, Amgalanbaatar S, Mix H. 1999. Recent conservation activities for argali (*Ovis ammon*) in Mongolia—Part 2. Caprinae January: 1–4.

Scotten BD, Pletscher DH. 1998. Evaluation of a capture technique for neonatal Dall sheep. Wildl Soc Bull 26:578–583.

Shiirevdamba TS, Shagdarsuren O, Erdenjav G, Amgalan Ts, Tsetsegma Ts, editors. 1997. Mongolian Red Book. Ulaanbaatar, Mongolia: Ministry for Nature and the Environment of Mongolia. 388 p (in Mongolian, with English summaries).

Sukhbat Kh. 1978. Distribution of Mongolian argali. Res Mongolian Acad Sci Inst Gen Exp Biol 13:81–86 (in Mongolian).