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DIEL USE OF WATER BY REINTRODUCED BIGHORN SHEEP

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ABSTRACT.—Water sources are an important habitat component for populations of bighorn sheep (*Ovis canadensis*), and the technique of sampling at water sources has been used extensively to study behaviors and estimate parameters of bighorn populations. Little is known, however, concerning the time of day at which groups of bighorns visit water. Understanding when bighorns visit water sources will allow wildlife investigators to conduct sampling when bighorns are most likely to be present at this resource. We quantified use of 7 water sources by reintroduced bighorn sheep during summer 2005 and 2006 on Antelope Island State Park, Utah. Our purpose was to determine if female, male, or mixed-sex groups visited water at a particular time and if visits to this resource by all bighorns differed in time during drought conditions compared with nondrought conditions. The mean time that all bighorns visited water was 14:22 (s = 3:08 hours). No time differences existed among female, male, or mixed-sex groups or between drought and nondrought conditions. Our results provide wildlife investigators with a time frame for activating motion-sensor cameras or sampling at water sources, which will increase the likelihood of photographing or observing reintroduced Rocky Mountain bighorn sheep at water sources in portions of the Great Basin Desert.

Key words: bighorn sheep, Great Basin Desert, motion-sensor cameras, Ovis canadensis*, photograph, reintroduction, water.*

Water sources are a critical habitat component for the conservation and management of bighorn sheep (*Ovis canadensis*) populations inhabiting desert ecosystems (Buechner 1960, Turner 1970, Leslie and Douglas 1979, Epps et al. 2004, Bleich et al. 2006, Marshal et al. 2006); however, exceptions do exist (Alderman et al. 1989, Broyles and Cutler 1999). Movement and range use by bighorns can be influenced by the distribution of water sources (Leslie and Douglas 1979, 1980, Rubin et al. 2002, Oehler et al. 2003, Turner et al. 2004), and the lack of perennial water may increase the probability of population declines (Douglas 1988, Dolan 2006). Additionally, the location of water sources is an important consideration for reintroductions of Rocky Mountain bighorn sheep (*O. c. canadensis*). General guidelines indicate that these animals should be released in areas surrounded by escape terrain and within 3.2 km of perennial water sources (Smith et al. 1991, Smith and Flinders 1992, Singer et al. 2000a, 2000b). The literature is sparse, however, on the needs of Rocky Mountain bighorn for water (Shackleton et al. 1999) and how those needs for this critical resource vary by group composition and time of day.

Motion-sensor cameras deployed at water sources have been used extensively to study behaviors and population parameters of bighorn sheep. Our objective was to determine if reintroduced Rocky Mountain bighorn sheep visited sources of water at a particular time of day. Because cameras placed at water sources have been successfully used to test hypotheses regarding sexual segregation in this species (Bleich et al. 1997), we used this technique to test for differences in time when female, male, and mixed-sex groups of bighorns visited water. Furthermore, documenting use of water by bighorns during seasons of differing environmental conditions is critical to understanding their ecology in arid systems (Burkett and Thompson 1994, Payer and Coblentz 1997); therefore, we investigated whether time differences existed for visits by all bighorns to this resource between periods of drought and nondrought conditions. Our results indicate when bighorns visit water sources, and this information will allow wildlife investigators to conduct sampling when these animals are most likely to be present at this resource.

We conducted our research on Antelope Island State Park (40°57′N, 112°13′W) in the Great Basin desert of northern Utah. This

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island comprises 11,300 ha and is located in the southeast corner of the Great Salt Lake. Antelope Island is 24 km long and 8.3 km wide, with the highest peak at 2134 m elevation. From 1948 to 2007, the mean temperature in summer (July–September) for the island was 31 °C (s = 3.7) and average precipitation was 77 mm. During summer 2005, mean temperature was 23 °C (s = 4.3), whereas the average temperature in summer 2006 was 22 °C (s = 5.2). In summer 2005, 22 mm of rain fell, whereas in summer 2006, 122 mm of rain fell (Farmington Utah State University Field Station, Western Regional Climate Center, www.wrcc.dri.edu). Legal hunting of bighorn sheep is not permitted on the island, and human use of this area is restricted to hiking, biking, and horseback riding on limited, designated trails that traverse the fringes of areas used by bighorns (Fairbanks and Tullous 2002, Whiting et al. 2009). Human activity near some water sources may influence the time of day when bighorns use these sources (Jorgensen 1974). During our study, however, cameras only photographed 2 hikers at water sources; therefore, we assumed that human activity was a minimal influence on the time of day that bighorns visited these sources.

Twenty-six California bighorn sheep (*O. c. californiana*) were released on Antelope Island in March 1996. Recent morphometric evidence indicates that Rocky Mountain and California bighorns may not be separate subspecies (Wehausen and Ramey 2000). During our study, we considered all bighorn sheep on Antelope Island to be Rocky Mountain bighorns, and the average population size was 162 individuals (J.C. Whiting unpublished data). Other ungulates on Antelope Island were bison (*Bison bison*), mule deer (*Odocoileus hemionus*), and pronghorn (*Antilocapra americana*). The 2 mammalian predators occupying the island were coyote (*Canis latrans*) and bobcat (*Lynx rufus*). Vegetation types included Utah juniper (*Juniperus osteosperma*), mountain brush, big sagebrush (*Artemisia tridentata*)– grass complex, and forbs. Forage species used by bighorns were bluebunch wheatgrass (*Elymus spicatus*), spike fescue (*Luecopoa kingii*), and Sandberg's bluegrass (*Poa secunda*). Plant nomenclature follows Welsh et al. (1993).

We deployed motion-sensor cameras at 7 water sources. These digital cameras possessed an infrared illumination and motion-detection system (RECONYX, LLP, 3600 Hwy. 157, Suite 205, La Crosse, WI 54601). We set cameras from 19 July to 30 September 2005 and from 1 July to 30 September 2006. We determined these designated time periods for summer by precipitation and temperature patterns, as well as behaviors of bighorn sheep on Antelope Island (Whiting et al. 2009). Water sources were located in diverse habitats used by both sexes of bighorns (Bleich et al. 1997) and ranged in elevation from 1290 to 1680 m, with the average distance between springs at 1.2 km (s = 0.66). We selected locations at the head of each spring in areas obviously used by ungulates. We set cameras within 15 m of each water source and at the same general location throughout the study. When setting the field of view for cameras, we ensured that headwaters and convergences of game trails were visible and that cameras were oriented to optimize the correct classification of animals (Jaeger et al. 1991, Bleich et al. 1997).

We documented use of water sources during the summer months for 2005 and 2006 because bighorns on Antelope Island visited water almost twice as often in summer compared with other seasons (Whiting et al. 2009). Initially, we randomly assigned the placement of 5 cameras among 7 springs, but by July 2006, we had acquired 2 additional cameras and had deployed cameras at all 7 springs. We set cameras at any particular spring on average 64% (range 50%–74%) of the total number of days in which cameras could have been deployed. Cameras operated continuously at high sensitivity and took a picture when an object triggered the motion sensor, which had a sensitivity range of ≤30.5 m and a 40° field of view (RECONYX SILENT IMAGE, User Guide Recreational Edition). So long as animals were in the field of view of the sensor, a picture was taken every 20 seconds. Each picture recorded the date and time (Mountain Standard Time), and we used the first picture in a visit to gather data for our analyses.

We categorized groups of bighorns as female, male, or mixed sex. We subdivided males into size categories (Class I, II, III, and IV) as described in Geist (1968). Female groups consisted of at least one adult female but also included young, yearlings, and Class I males because these young males gradually transition from female groups to male groups at 2–4

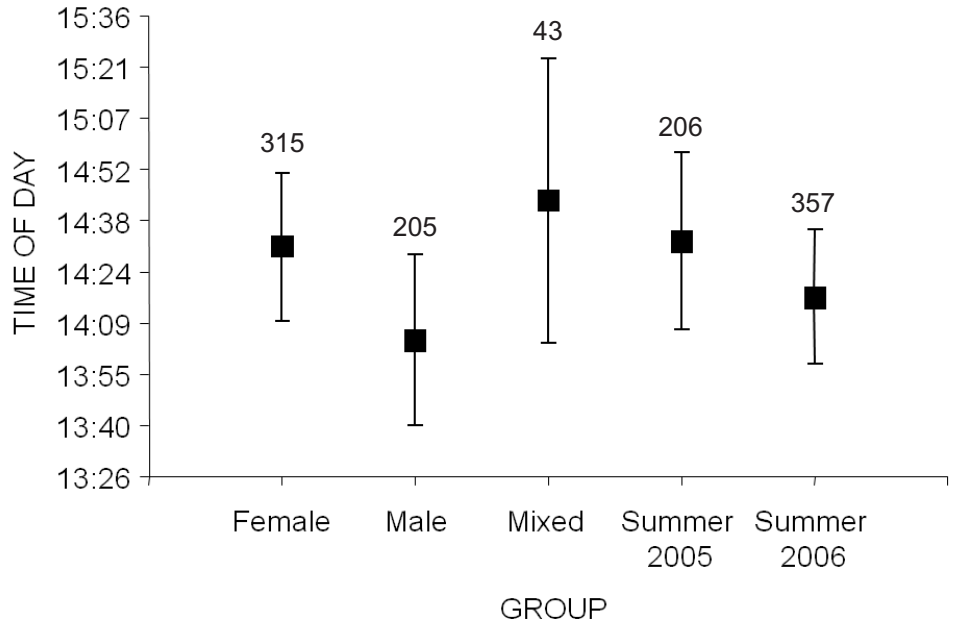

Fig. 1. Means (squares), 95% confidence intervals (bars), and sample sizes (numbers) for time of day (Mountain Standard Time) that reintroduced female, male, and mixed-sex groups of bighorn sheep visited water sources and a comparison of time of day that all bighorns visited water sources during drought (summer 2005) and nondrought conditions (summer 2006) on Antelope Island State Park, Utah.

years of age (Festa-Bianchet 1991, Ruckstuhl 1998, 1999). Male groups included at least one individual from Class I, II, III, or IV. Mixed-sex groups were composed of at least one adult female with young, yearlings, and Class I males and at least one Class II, III, or IV male (Bleich et al. 1997).

We had difficulty determining whether a continuous stream of pictures represented one bighorn activating the camera numerous times or multiple animals activating the camera (Cutler and Swann 1999). To help alleviate this problem, we arbitrarily considered a lapse of 25 minutes between any bighorn activating a camera as an indicator of a new visit. With this criterion, the median number of hours between visits was 4 (range 25 minutes to 540 hours). We tested for differences in the time of day that bighorns visited water sources among group types and between summer 2005 and 2006 by calculating means and associated 95% confidence intervals (Zar 1999).

The average time of day that all bighorn sheep visited water was 14:22 (s = 3:08 hours, n = 563, median = 14:34). The average time of day that groups of females visited water sources was 14:31 (s = 3:18 hours, median = 14:43), whereas the average time of day that groups of males visited this resource was 14:05 (s = 3:00 hours, median = 14:13). Finally, the average time of day that mixed-sex groups of bighorns visited water sources was 14:44 (s = 2:16 hours, median = 14:49). Group composition did not influence when bighorns visited water (Fig. 1). Moreover, all bighorns visited water sources at similar times during 2005 ($\bar{x}$ = 14:32, s = 3:05 hours, median = 14:49) compared with 2006 ($\bar{x}$ = 14:17, s = 3:10 hours, median = 14:21; Fig. 1).

In our study, Rocky Mountain bighorns visited water sources at the same time of day regardless of group composition and drought conditions. In comparison, female desert bighorn sheep (*O. c. mexicana*) are active mostly during morning and evening hours (Alderman et al. 1989). In one study, desert bighorns visited water sources most often during morning (6:00–8:00) and evening (16:00–18:00; Campbell and Remington 1979). In that study, however, bighorns were observed intermittently at one water source for 61 days from June until October 1978. In another study, the average time that desert bighorns visited water was 13:00. In that study, animals were observed at

one water source for 12 days between 2 June and 26 June 1973 (Jorgensen 1974). The differences in outcomes reported by Campbell and Remington (1979) and Jorgensen (1974) may be the result of insufficient sampling of water sources across years and in different areas. Ostermann-Kelm et al. (2008) reported that during 55 days of observation from June to September 2003, 64 of 82 groups of desert bighorns visited sources of water from 11:00 to 15:00, similar to our results. We sampled 7 water sources during 2 summers, and our data indicated that bighorns visited this resource in the afternoon and early evening, possibly prior to foraging during evening (Alderman et al. 1989). We hypothesize that this intake of water allowed bighorns to maintain forage consumption (Lautier et al. 1988, Robbins 2001) and likely aided in rumination and digestion during nocturnal hours (Robbins 2001, Cain et al. 2006).

Susceptibility of bighorn sheep to predation could also influence the time of day when groups of bighorns visited water. In our study area, the number of coyotes was not controlled, and these canids are effective predators of young bighorns (Dekker 1986, Hass 1989, Bleich 1996). Female bighorn sheep with neonates use different habitat than males to decrease potential predation of young (Bleich et al. 1997). On Antelope Island, most females were lactating during our study (Whiting unpublished data); therefore, susceptibility of bighorns to predation may have influenced the time at which these animals visited water. Our results indicated, however, that bighorns visited water sources at similar times regardless of sex or group composition. Therefore, either predation likely did not influence the time at which bighorns visited this resource or both sexes of bighorn were equally willing to take large risks to acquire this critical resource. Males and females did use water sources that were located in different areas on Antelope Island, likely because of the susceptibility of females with young to predation (Bleich et al. 1997).

Displacement by sympatric ungulates is another possible influence on the timing of visits to water sources by bighorn sheep in our study area (Ostermann-Kelm et al. 2008). Bighorns are poor competitors; for example, burros (*Equus asinus*) and feral horses (*Equus caballus*) can outcompete bighorns at limited water sources (Weaver 1973, Andrew et al. 1997, Bleich 2005, Ostermann-Kelm et al. 2008). On Antelope Island, bison, mule deer, and pronghorn share water sources with bighorns. Our results, however, were not influenced substantially by these ungulates displacing bighorns, because we set cameras at water sources in areas used by bighorns (Rogerson et al. 2008, Whiting et al. 2009). Indeed, 3 of our cameras were deployed at water sources that were located at high elevations, on steep slopes, or near rocky outcrops, which likely precluded the consistent use of these areas by other ungulates. Furthermore, 75 perennial springs exist on Antelope Island (S. Bates personal communication), with most occurring at low elevations in habitats used by the other ungulates. Future studies should focus on potential competition and displacement around water in habitats used by multiple ungulates, especially in desert systems (Krausman and Leopold 1986, Ostermann-Kelm et al. 2008).

Technological advances in motion-sensor photography have allowed researchers to study wildlife activities that are rare and difficult to observe and quantify (Cutler and Swann 1999). Cameras deployed at water sources have been used extensively to study behaviors of bighorn sheep, especially in desert ecosystems. For example, this technology has been used to document use of natural (Douglas 1988, Bleich et al. 1997) and artificial water sources (Campbell and Remington 1979, Leslie and Douglas 1979, 1980), to determine extent and shifts of range use by bighorns in response to human disturbance (Campbell and Remington 1979, Leslie and Douglas 1979, 1980), to estimate population parameters and ratios of young to adult females (Jaeger et al. 1991), and to identify intraspecific associations and grouping patterns of these aridland animals (Leslie and Douglas 1979). Recently, motion-sensor cameras have also been used to quantify number and duration of visits of reintroduced Rocky Mountain bighorns to water sources and their surrounding riparian areas (Whiting et al. 2009), because overuse of these areas can perpetuate the passage of parasitic lungworms (*Protostrongylus* spp.) to bighorns (Rogerson et al. 2008). Motion-sensor photography that records the activities of bighorn sheep at water sources is an important research tool for understanding the ecology of this unique

ungulate. Our results provide wildlife investigators with a time frame for activating cameras or sampling at water sources, increasing the likelihood of photographing or observing reintroduced Rocky Mountain bighorn sheep at water sources in portions of the Great Basin Desert.

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LITERATURE CITED

ALDERMAN, J.A., P.R. KRAUSMAN, AND B.D. LEOPOLD. 1989. Diel activity of female desert bighorn sheep in western Arizona. Journal of Wildlife Management 53:264–271.

ANDREW, N.G., V.C. BLEICH, P.V. AUGUST, AND S.G. TORRES. 1997. Demography of mountain sheep in the East Chocolate Mountains, California. California Fish and Game 83:68–77.

BLEICH, V.C. 1996. Interactions between coyotes (*Canis latrans*) and mountain sheep (*Ovis canadensis*). Southwestern Naturalist 41:81–82.

_____. 2005. In my opinion: politics, promises, and illogical legislation confound wildlife conservation. Wildlife Society Bulletin 33:66–73.

BLEICH, V.C., N.G. ANDREW, M.J. MARTIN, G.P. MULCAHY, A.M. PAULI, AND S.S. ROSENSTOCK. 2006. Quality of water available to wildlife in desert environments: comparisons among anthropogenic and natural sources. Wildlife Society Bulletin 34:627–632.

BLEICH, V.C., R.T. BOWYER, AND J.D. WEHAUSEN. 1997. Sexual segregation in mountain sheep: resources or predation? Wildlife Monographs 134:1–50.

BROYLES, B., AND T.L. CUTLER. 1999. Effect of surface water on desert bighorn sheep in the Cabeza Prieta National Wildlife Refuge, southwestern Arizona. Wildlife Society Bulletin 27:1082–1088.

BUECHNER, H.K. 1960. The bighorn sheep in the United States, its past, present, and future. Wildlife Monographs 4:1–174.

BURKETT, D.W., AND B.C. THOMPSON. 1994. Wildlife association with human-altered water sources in semiarid vegetation communities. Conservation Biology 8:682–690.

CAIN, J.W., P.R. KRAUSMAN, S.S. ROSENSTOCK, AND J.C. TURNER. 2006. Mechanisms of thermoregulation and water balance in desert ungulates. Wildlife Society Bulletin 34:570–581.

CAMPBELL, B.H., AND R. REMINGTON. 1979. Bighorn use of artificial water sources in the Buckskin Mountains, Arizona. Desert Bighorn Council Transactions 23:50–56.

CUTLER, T.L., AND D.E. SWANN. 1999. Using remote photography in wildlife ecology: a review. Wildlife Society Bulletin 27:571–581.

DEKKER, D. 1986. Coyote, *Canis latrans,* preys on two bighorn lambs, *Ovis canadensis,* in Jasper National Park, Alberta. Canadian Field-Naturalist 100:272–273.

DOLAN, B.F. 2006. Water developments and desert bighorn sheep: implications for conservation. Wildlife Society Bulletin 34:642–646.

DOUGLAS, C.L. 1988. Decline of desert bighorn sheep in the Black Mountains of Death Valley. Desert Bighorn Council Transactions 32:26–30.

EPPS, C.W., D.R. MCCULLOUGH, J.D. WEHAUSEN, V.C. BLEICH, AND J.L. RECHEL. 2004. Effects of climate change on population persistence of desert-dwelling mountain sheep in California. Conservation Biology 18:102–113.

FAIRBANKS, W.S., AND R. TULLOUS. 2002. Distribution of pronghorn (*Antilocapra americana* Ord) on Antelope Island State Park, Utah, USA, before and after establishment of recreational trails. Natural Areas Journal 22:277–282.

FESTA-BIANCHET, M. 1991. The social system of bighorn sheep: grouping patterns, kinship and female dominance rank. Animal Behaviour 42:71–82.

GEIST, V. 1968. On delayed social and physical maturation in mountain sheep. Canadian Journal of Zoology 46:899–904.

HASS, C.C. 1989. Bighorn lamb mortality: predation, inbreeding, and population effects. Canadian Journal of Zoology 67:699–705.

JAEGER, J.R., J.D. WEHAUSEN, AND V.C. BLEICH. 1991. Evaluation of time-lapse photography to estimate population parameters. Desert Bighorn Council Transactions 35:5–8.

JORGENSEN, P. 1974. Vehicle use at a desert bighorn watering area. Desert Bighorn Council Transactions 18:18–24.

KRAUSMAN, P.R., AND B.D. LEOPOLD. 1986. The importance of small populations of desert bighorn sheep. Transactions of the North American Wildlife and Natural Resources Conference 51:52–61.

LAUTIER, J.K., T.V. DAILEY, AND R.D. BROWN. 1988. Effect of water restriction on feed-intake of white-tailed deer. Journal of Wildlife Management 52:602–606.

LESLIE, D.M., AND C.L. DOUGLAS. 1979. Desert bighorn sheep of the River Mountains, Nevada. Wildlife Monographs 66:1–56.

_____. 1980. Human disturbance at water sources of desert bighorn sheep. Wildlife Society Bulletin 8:284–290.

MARSHAL, J.P., V.C. BLEICH, P.R. KRAUSMAN, M.L. REED, AND N.G. ANDREW. 2006. Factors affecting habitat use and distribution of desert mule deer in an arid environment. Wildlife Society Bulletin 34:609–619.

OEHLER, M.W., R.T. BOWYER, AND V.C. BLEICH. 2003. Home ranges of female mountain sheep, *Ovis canadensis nelsoni:* effects of precipitation in a desert ecosystem. Mammalia 67:385–401.

OSTERMANN-KELM, S., E.R. ATWILL, E.S. RUBIN, M.C. JORGENSEN, AND W.M. BOYCE. 2008. Interactions

between feral horses and desert bighorn sheep at water. Journal of Mammalogy 89:459–466.

PAYER, D.C., AND B.E. COBLENTZ. 1997. Seasonal variation in California bighorn ram (*Ovis canadensis californiana*) habitat use and group size. Northwestern Science 71:281–288.

ROBBINS, C.T. 2001. Wildlife feeding and nutrition. Academic Press, San Diego.

ROGERSON, J.D., W.S. FAIRBANKS, AND L. CORNICELLI. 2008. Ecology of gastropod and bighorn sheep hosts of lungworm on isolated, semi-arid mountain ranges in Utah, USA. Journal of Wildlife Diseases 44:28–44.

RUBIN, E.S., W.M. BOYCE, C.J. STERMER, AND S.G. TORRES. 2002. Bighorn sheep habitat use and selection near an urban environment. Biological Conservation 104:251–263.

RUCKSTUHL, K.E. 1998. Foraging behaviour and sexual segregation in bighorn sheep. Animal Behaviour 56:99–106.

_____. 1999. To synchronise or not to synchronise: a dilemma for young bighorn males? Behaviour 136:805–818.

SHACKLETON, D.M., C.C. SHANK, AND B.M. WIKEEM. 1999. Natural history of Rocky Mountain and California bighorn sheep. Pages 78–138 *in* R. Valdez, and P.R. Krausman, editors, Mountain sheep of North America. University of Arizona Press, Tucson.

SINGER, F.J., V.C. BLEICH, AND M.A. GUDORF. 2000a. Restoration of bighorn sheep metapopulations in and near western national parks. Restoration Ecology 8:14–24.

SINGER, F.J., C.M. PAPOUCHIS, AND K.K. SYMONDS. 2000b. Translocations as a tool for restoring populations of bighorn sheep. Restoration Ecology 8:6–13.

SMITH, T.S., AND J.T. FLINDERS. 1992. Evaluation of mountain sheep habitat in Zion National Park, Utah. Desert Bighorn Council Transactions 36:4–9.

SMITH, T.S., J.T. FLINDERS, AND D.S. WINN. 1991. A habitat evaluation procedure for Rocky Mountain bighorn sheep in the Intermountain West. Great Basin Naturalist 51:205–225.

TURNER, J.C. 1970. Water consumption by desert bighorn sheep. Desert Bighorn Council Transactions 14: 189–197.

TURNER, J.C., C.L. DOUGLAS, C.R. HALLAM, P.R. KRAUSMAN, AND R.R. RAMEY. 2004. Determination of critical habitat for the endangered Nelson's bighorn sheep in southern California. Wildlife Society Bulletin 32:427–448.

WEAVER, R.A. 1973. Burro versus bighorn. Desert Bighorn Council Transactions 17:90–94.

WEHAUSEN, J.D., AND R.R. RAMEY. 2000. Cranial morphometric and evolutionary relationships in the northern range of *Ovis canadensis.* Journal of Mammalogy 81:145–161.

WELSH, S.L., N.D. ATWOOD, S. GOODRICH, AND L.C. HIGGINS. 1993. A Utah flora. 2nd edition. Brigham Young University, Provo, UT.

WHITING, J.C., R.T. BOWYER, AND J.T. FLINDERS. 2009. Annual use of water sources by reintroduced bighorn sheep *Ovis canadensis.* Acta Theriologica 54:127–136.

ZAR, J.H. 1999. Biostatistical analysis. 4th edition. Prentice-Hall, Upper Saddle River, NJ.

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