



Bleats and Blats

Official Newsletter of the
Desert Bighorn Council



August 2010

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Hello DBC members and friends!

Our next biennial meeting will be held April 6-8, 2011, and the Meeting Committee has already started planning for a great meeting. So we hope you save the date, or better yet, start planning your trip today! Please read on for important information about the 52nd meeting of the Desert Bighorn Council, which will be hosted by Arizona.

This newsletter also includes a summary of recent literature related to bighorn sheep, and I'm sure you'll agree that it's an interesting mix of research papers. We hope that you'll plan to join us at our meeting in April, when we'll hear about additional valuable research and State updates, and we'll have an opportunity to share information about bighorn sheep research, biology, and management.

Typically, this newsletter is sent only to DBC members; however, we are sending this newsletter to a number of you who are either past members or may be new to the desert bighorn sheep world. We hope you consider attending the meeting in April, and renewing your membership or joining us as a new member at that time. Dues are only \$20, collected every other year (in April of odd-numbered years, when the DBC meeting is held), and include one copy of the most recent DBC Transactions. For more information, visit our website at www.desertbighorncouncil.org.

The next newsletter is scheduled for November so if you have updates or announcements to share, please send them to me by October 20th. Also, if you'd like to share your bighorn sheep stories, reports, and/or photos on our website, they would also be most welcome. We hope to hear from you!

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Save the Date!
for the DBC's 52nd meeting

The Desert Bighorn Council will hold its 52nd biennial meeting on April 6-8, 2011. The meeting, which will be hosted by Arizona, will be held at the Aquarius Casino Resort Hotel in Laughlin, Nevada (across the river from Arizona; <http://www.aquariuscasinoresort.com>). The meeting will feature:

- State status reports,
- technical paper sessions,
- a field trip to nearby desert bighorn sheep habitat,
- a social get-together in Bullhead City, Arizona, and
- opportunities for you to gather and/or share information about desert bighorn sheep biology, management, and conservation.

The Meeting Committee has already started to plan a great meeting, so we hope you'll join us! More information on registration, presenting a paper/poster, and accommodations will be included in our next newsletter and will soon be posted on our website (www.desertbighornCouncil.org), so stay tuned!

Note: it is not too early to submit an abstract for presentation at the meeting. Email your abstracts to Brian Wakeling (2011 Meeting Chair) at bwakeling@azgfd.gov.

DBC Transactions Update
from the editor, Brian Wakeling

The anticipated delivery date for the 2009 *Desert Bighorn Council Transactions* is January 1, 2011. Expect 4 peer-refereed technical papers, several status reports, abstracts from presented papers, and the latest update to the bylaws.

Hansen-Welles Scholarship Update

The Technical Staff recently approved a Hansen-Welles Scholarship application for Cerissa Hoglander, a Master's student at Northern Arizona University's School of Earth Sciences and Environmental Sustainability. Her project is titled "Landscape Models of Water Resource Availability for and Habitat Use by Desert Bighorn Sheep (*Ovis canadensis mexicana*) in Southwestern Arizona". The grant is for \$4,000.

Congratulations Cerissa!!

For more information on the Hansen-Welles Scholarship, including application instructions, please visit our website at <http://www.desertbighornCouncil.org/scholarship.html>

DBC Committee Update

Volunteering to serve on a committee is a great way to become more involved in DBC activities, and there are a number of committees that could use additional members. If you are interested in serving on any of the

following committees, please contact Brian Wakeling (BWakeling@azgfd.gov). Please note that you must be a DBC member to serve on a committee:

- Meeting Committee
- Feral Burro Committee
- Constitution and Resolutions Committee
- Transactions Committee
- Nominating Committee
- Awards Committee

...and speaking of awards, this is a great time to start thinking of nominations for awards. If you'd like to nominate someone for their dedication and work towards the betterment of desert bighorn sheep, please contact Rick Brigham (rickceil30@cableone.net). Awards will be presented at the April 2011 meeting.

Volunteer Opportunity

The Arizona Game and Fish Department is planning to capture bighorn sheep along US 93 in late November, as part of a highway overpass study. Volunteers are being sought to conduct ground-based scouting prior to the capture. If you are interested in assisting, please contact Scott Sprague, Wildlife Specialist, Arizona Game and Fish Department, at ssprague@azgfd.gov.

Recent Literature Related to Bighorn Sheep

Bleich, V. C., J. P. Marshal, and N. G. Andrew. 2010. Habitat use by a desert ungulate: predicting effects of water availability on mountain sheep. *Journal of Arid Environments* 74(6):638-645.

Abstract: Provision of surface water has been a long-standing management strategy to enhance habitat for large mammals in southwestern North America. In this paper, we use a resource selection function (RSF) developed from telemetered mountain sheep (*Ovis canadensis*) in three occupied mountain ranges in the Sonoran Desert, California, USA, to examine the effects of water development on habitat quality within those ranges. Further, we apply that model to four nearby and similar mountain ranges, but for which telemetry data are not available, and again examine the effects of water development. When distance to water was decreased to 2,000 m from an average of 3033 m (+/- 522 [SD]) in three occupied mountain ranges, availability of high-quality habitat increased by as much as 92%. When distance to water was decreased to 2,000 m from an average of 3660 m (+/- 799 [SD]) in three mountain ranges not occupied permanently by mountain sheep, and one occupied range for which telemetry data were not available, the proportion of high-quality habitat resulting from application of our model indicated increases that varied from 116 to 508%. We conclude that development of additional sources of surface water can increase availability of high-quality habitat for mountain sheep inhabiting Sonoran Desert mountain ranges, and that the technique has implications for population persistence and conservation of those large, specialized ungulates.

Bleich, V. C., J. H. Davis, J. P. Marshal, S. G. Torres, and B. J. Gonzales. 2009. Mining activity and habitat use by mountain sheep (*Ovis canadensis*). *European Journal of Wildlife Research* 55(3):183-191.

Abstract: We studied mountain sheep in the vicinity of three high-wall limestone mines in San Bernardino County, CA, USA to evaluate factors that influenced habitat use and, specifically, to investigate the influence of mining activity on distribution of those specialized ungulates. We used aerial telemetry data to estimate a resource selection function by fitting a logistic regression model and then comparing environmental characteristics at observed sheep locations to those at random locations. Distribution of mountain sheep was

most influenced by a fire in 1999 that resulted in an area they avoided. Mountain sheep used steeper slopes, areas of lower terrain roughness, higher elevations, and areas closer to escape terrain than were random points. In contrast, sheep avoided areas near roads (federal and state highways, local roads, and off-road vehicle trails) but used areas near hiking trails and a railway. Water sources had the smallest effect of the factors considered, with sheep being associated with areas further from water points than were random locations. The disturbed area associated with the mines had a moderate influence on distribution, with sheep being associated with areas closer to the mine than were random points. Mining activities can alter terrain features and vegetation structure or composition in a way that promotes occupancy by sheep if they create steep slopes and rugged terrain (escape terrain) or reduce vegetation density or height (i.e., improve visibility). Whether increased occupancy reflects a benefit depends on the demographic responses of those sheep to the resources and conditions available on mine sites; information about those responses remains lacking.

Brown, N. A., K. E. Ruckstuhl, S. Donelon, and C. Corbett. 2010. Changes in vigilance, grazing behaviour and spatial distribution of bighorn sheep due to cattle presence in Sheep River Provincial Park, Alberta. *Agriculture Ecosystems & Environment* 135(3):226-231.

Abstract: The physical presence of livestock can influence the behaviour of native ungulates. Behavioural data on bite rates and vigilance of Rocky Mountain bighorn sheep were collected during the summer and fall of 2006 in Sheep River Provincial Park, Alberta. Spatial distributions of bighorn sheep and domestic cattle were recorded using daily censuses and GPS collar locations during the same time period. We hypothesized that the presence of cattle would induce a negative behavioural response in bighorn sheep and cause avoidance behaviour. As predicted, foraging bite rates decreased and vigilance rates increased when cattle were located nearby. Vigilance in females was higher than in males. The average distances between bighorn sheep and cows were found to be smaller than expected at random, and minimal distances were not affected by the presence of cows. The sheep were found in the same general areas used by cattle. The cattle presence was shown to influence distribution and behaviour of bighorn sheep, although not in the way we expected.

Clifford, D. L., B. A. Schumaker, T. R. Stephenson, V. C. Bleich, M. L. Cahn, B. J. Gonzales, W. M. Boyce, and J. A. K. Mazet. 2009. Assessing disease risk at the wildlife-livestock interface: A study of Sierra Nevada bighorn sheep. *Biological Conservation* 142(11):2559-2568.

Abstract: Despite evidence that domestic sheep diseases threaten the persistence of bighorn sheep populations, the economic consequences of restricting domestic sheep grazing has polarized the debate, with some arguing that disease risk posed by domestic sheep has been exaggerated and grazing restrictions should be eased. We constructed a model to assess how different management strategies (grazing allotment closures, grazing time reductions, and reduced probability of stray domestic sheep) affect the risk of respiratory disease transmission from domestic sheep to endangered Sierra Nevada bighorn sheep, and to predict population-level impacts of an outbreak. Even when management strategies reduced risk of inter-species contact to less than 2% per year, our model predicted a 50% probability of a catastrophic respiratory disease outbreak during the next 10 bighorn sheep generations. If an outbreak occurs in the near future, the model predicts that the smallest Sierra Nevada bighorn sheep population would have a 33% probability of quasi-extinction. To eliminate all risk of contact and potential disease transmission, domestic sheep cannot be grazed on allotments that overlap with areas utilized by Sierra Nevada bighorn sheep. Where wildlife and domestic animal populations share limited habitat, and there is documented evidence of a substantial disease threat and extinction risk, stakeholders must recognize that the only way to eliminate contact and risk of disease transmission is to give priority to one species or the other. If conservation is the priority, difficult decisions will need to be made to balance trade-offs between economic livelihoods and species conservation.

Coburn, S., M. Salman, J. Rhyon, T. Keefe, and M. McCollum. 2010. Comparison of endocrine response to stress between captive-raised and wild-caught bighorn sheep. *Journal of Wildlife Management* 74(3):532-538.

Abstract: Stress hormones in Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*), produced in

response to environmental changes, road development, or high population density, may impact their immune systems to a threshold level that predisposes them to periodic, large-scale mortality. We compared the stress response to a novel environmental situation and repeated handling between bighorn sheep born and raised in captivity (CR) and bighorn sheep born in the wild (WC) and brought into captivity. We measured plasma epinephrine, norepinephrine, cortisol, and fecal glucocorticoid metabolites (FGM). Three weeks after each group's arrival we used a one-time drop-net event to elicit an acute stress response, and we collected blood samples from each sheep over 35 minutes, as well as one fecal sample. We collected blood and fecal samples from both groups on 7 other occasions over the subsequent 6 months. We also collected fecal samples from the pen at approximately 24-hour intervals for 3 days following every handling event to monitor the stress response to handling. We found that CR sheep had a stronger autonomic nervous system response than WC sheep, as measured by epinephrine and norepinephrine levels, but we found a very similar hypothalamic-pituitary-adrenal axis (HPA) response, measured by cortisol levels, to the acute stress event of a drop-net restraint. We also found that once the WC sheep had acclimated, as indicated by the return to the initial baseline FGM levels within 12 weeks, the CR and WC groups' HPA responses to sampling events were not significantly different from one another. Fecal samples can provide a noninvasive mechanism for managers to monitor baseline FGM for a given herd. Using long-term monitoring of FGM rather than values from a single point in time may allow managers to correlate these levels to outside influences on the herd and better understand the impacts of management changes, population density, or increased human developments on the health of the sheep population.

Clemenza, S. M., E. S. Rubin, C. K. Johnson, R. A. Botta, and W. Boyce. 2009. Puma predation on radiocollared and uncollared bighorn sheep. BMC Research Notes 2:230. Available online at: <http://www.biomedcentral.com/1756-0500/2/230>

Abstract: We used Global Positioning System (GPS) data from radiocollared pumas (*Puma concolor*) to identify kill sites of pumas preying upon an endangered population of bighorn sheep (*Ovis canadensis*) in southern California. Our aims were to test whether or not pumas selected radiocollared versus uncollared bighorn sheep, and to identify patterns of movement before, during, and after kills. Three pumas killed 23 bighorn sheep over the course of the study, but they did not preferentially prey on marked (radiocollared) versus unmarked bighorn sheep. Predation occurred primarily during crepuscular and nighttime hours, and 22 kill sites were identified by the occurrence of 2 or more consecutive puma GPS locations (a cluster) within 200 m of each other at 1900, 0000, and 0600 h. We tested the "conspicuous individual hypothesis" and found that there was no difference in puma predation upon radiocollared and uncollared bighorn sheep. Pumas tended to move long distances before and after kills, but their movement patterns immediately post-kill were much more restricted. Researchers can exploit this behaviour to identify puma kill sites and investigate prey selection by designing studies that detect puma locations that are spatially clustered between dusk and dawn.

Epps, C. W., J. D. Wehausen, P. J. Palsboll, and D. R. McCullough. 2010. Using genetic tools to track desert bighorn sheep colonizations. Journal of Wildlife Management 74(3):522-531.

Abstract: Understanding colonization is vital for managing fragmented populations. We employed mitochondrial DNA haplotypes and 14 microsatellite (nuclear DNA) markers to infer the origins of newly established populations of desert bighorn sheep (*Ovis canadensis nelsoni*) and to assess loss of genetic diversity during natural colonizations. We used haplotype distribution, F-statistics, Bayesian population clustering, and assignment tests to infer source populations for 3 recent colonies and identified a previously undetected colonization from multiple source populations. Allelic richness declined in 3 of 4 colonies in comparison to the primary source populations, but not as much as has been reported for translocated populations. Heterozygosity declined in only one colony. We also demonstrated that both native and translocated desert bighorn sheep have naturally recolonized empty habitats and suggest that colonization may partially offset population extinction in the region as long as connectivity is maintained. Genetic techniques and mitochondrial DNA haplotypes we described will allow managers to determine the origins of future colonizations by bighorn sheep in California, USA, and prioritize protection of linkages between known sources and colonies.

Dassanayake, R. P., D. R. Call, A. A. Sawant, N. C. Casavant, G. C. Weiser, D. P. Knowles, and S.

Srikumaran. 2010. *Bibersteinia trehalosi* inhibits the growth of *Mannheimia haemolytica* by a proximity-dependent mechanism. *Applied and Environmental Microbiology* 76(4):1008-1013.

Abstract: *Mannheimia (Pasteurella) haemolytica* is the only pathogen that consistently causes severe bronchopneumonia and rapid death of bighorn sheep (BHS; *Ovis canadensis*) under experimental conditions. Paradoxically, *Bibersteinia (Pasteurella) trehalosi* and *Pasteurella multocida* have been isolated from BHS pneumonic lungs much more frequently than *M. haemolytica*. These observations suggest that there may be an interaction between these bacteria, and we hypothesized that *B. trehalosi* overgrows or otherwise inhibits the growth of *M. haemolytica*. Growth curves (monoculture) demonstrated that *B. trehalosi* has a shorter doubling time (similar to 10 min versus similar to 27 min) and consistently achieves 3-log higher cell density (CFU/ml) compared to *M. haemolytica*. During coculture *M. haemolytica* growth was inhibited when *B. trehalosi* entered stationary phase (6 h) resulting in a final cell density for *M. haemolytica* that was 6 to 9 logs lower than expected with growth in the absence of *B. trehalosi*. Coculture supernatant failed to inhibit *M. haemolytica* growth on agar or in broth, indicating no obvious involvement of lytic phages, bacteriocins, or quorum-sensing systems. This observation was confirmed by limited growth inhibition of *M. haemolytica* when both pathogens were cultured in the same media but separated by a filter (0.4- μ m pore size) that limited contact between the two bacterial populations. There was significant growth inhibition of *M. haemolytica* when the populations were separated by membranes with a pore size of 8 μ m that allowed free contact. These observations demonstrate that *B. trehalosi* can both outgrow and inhibit *M. haemolytica* growth with the latter related to a proximity-or contact-dependent mechanism.

Flesch, A. D., C. W. Epps, J. W. Cain III, M. Clark, P. R. Krausman, and J. R. Morgart. 2010. Potential effects of the United States-Mexico border fence on wildlife. *Conservation Biology* 24(1):171-181.

Abstract: Security infrastructure along international boundaries threatens to degrade connectivity for wildlife. To explore potential effects of a fence under construction along the U.S.-Mexico border on wildlife, we assessed movement behavior of two species with different life histories whose regional persistence may depend on transboundary movements. We used radiotelemetry to assess how vegetation and landscape structure affect flight and natal dispersal behaviors of Ferruginous Pygmy-Owls (*Glaucidium brasilianum*), and satellite telemetry, gene-flow estimates, and least-cost path models to assess movement behavior and interpopulation connectivity of desert bighorn sheep (*Ovis canadensis mexicana*). Flight height of Pygmy-Owls averaged only 1.4 m (SE 0.1) above ground, and only 23% of flights exceeded 4 m. Juvenile Pygmy-Owls dispersed at slower speeds, changed direction more, and had lower colonization success in landscapes with larger vegetation openings or higher levels of disturbance ($p \leq 0.047$), which suggests large vegetation gaps coupled with tall fences may limit transboundary movements. Female bighorn sheep crossed valleys up to 4.9 km wide, and microsatellite analyses indicated relatively high levels of gene flow and migration (95% CI for F-ST = 0.010-0.115, Nm = 1.9-24.8, M = 10.4-15.4) between populations divided by an 11-km valley. Models of gene flow based on regional topography and movement barriers suggested that nine populations of bighorn sheep in northwestern Sonora are linked by dispersal with those in neighboring Arizona. Disruption of transboundary movement corridors by impermeable fencing would isolate some populations on the Arizona side. Connectivity for other species with similar movement abilities and spatial distributions may be affected by border development, yet mitigation strategies could address needs of wildlife and humans.

Garfinkel, A. P., D. A. Young, and R. M. Yohe III. 2010. Bighorn hunting, resource depression, and rock art in the Coso Range, eastern California: a computer simulation model. *Journal of Archaeological Science* 37(1):42-51.

Abstract: The extraordinary record of prehistoric rock art depicting tens of thousands of animal images in the Coso Range of eastern California provides an opportunity to study the relationship between aboriginal hunting, forager ecology, bighorn prey population levels, and the production of rock art. We review archaeofaunal evidence that the Coso desert bighorn sheep population was strongly depleted during the Newberry era after 1500 B.C. We discuss the dating of the rock art and show a correlation between bighorn depletion and increased rock art production. These data are consistent with the arrival of Numic foragers ca A.D. 600 who competed

with the Coso Pre-Numics and eventually terminated the Coso rock art tradition. An ecological predator-prey computer simulation of the human populations (Numic and Pre-Numics), the sheep population, and the rock art "population", demonstrates these proposed interconnections and gives a reasonable fit to the observed rock art production rate.

Jansen, B. D., P. R. Krausman, K. D. Bristow, J. R. Heffelfinger, and J. C. DeVos Jr. 2009. Surface mining and ecology of desert bighorn sheep. *Southwestern Naturalist* 54(4):430-438.

Abstract: Understanding how mining operations influence use of habitat and movements by bighorn sheep (*Ovis canadensis*) is critical to long-term management of populations that inhabit areas in and around mining operations. We studied responses of a population of desert bighorn sheep to a surface-mining operation in the Silver Bell Mountains, Pima County, Arizona. We incorporated two study periods with different levels of activity at the mine: closure (1993-1995) and operation (2003-2005). We captured and radiocollared ≥ 22 bighorn sheep in each period and monitored size of home ranges, size of core areas, and use of the mine. Home ranges and core areas of adult males during the breeding season were larger during closure than during operation. During the non-breeding season, there was evidence that home ranges of adult males were larger during closure compared to when the mine was in operation. Core areas of adult males were similar in size during the non-breeding season of both periods. During the breeding season, adult males used the mine more while the mine was in operation than during closure. During the non-breeding season, however, adult males did not use the mine more during either period. Home ranges and core areas of females were not different in size during both seasons and periods of closure and operation of the mine. During both seasons, females used the mine more during operation than during closure. Overall, the population of desert bighorn sheep used an active mine more than it did when the mine was closed.

Moquin, P., B. Curry, F. Pelletier, and K. E. Ruckstuhl. 2010. Plasticity in the rumination behaviour of bighorn sheep: contrasting strategies between the sexes? *Animal Behaviour* 79(5):1047-1053.

Abstract: Although activity budgets have been studied extensively in ruminants, information on the plasticity of rumination among individuals is rare. Generally, time spent bedded is considered a proxy for time spent ruminating. Researchers rarely include measures of interindividual differences in the intensity and time spent ruminating. We explored individual variation in rumination behaviour in Rocky mountain bighorn sheep, *Ovis canadensis*. We expected rumination to be a plastic behaviour affected by various intrinsic and extrinsic factors such as body mass, age, sex, reproductive status and environmental conditions. We investigated rumination behaviour based on (1) mean number of chews per bolus of food (chews/bolus), (2) mean number of chews per second per bolus (chewing rate) and (3) mean time spent chewing per bolus (bolus processing time) for sheep of known age, sex, body mass and reproductive status. Our results show that both intrinsic and extrinsic factors affected rumination behaviour. Females tended to spend less time processing each bolus than males of similar body mass, resulting in a significantly higher chewing rate for females. There was no difference in chews/bolus between sexes. Environmental factors and group size also affected rumination behaviour: cold temperatures were associated with fewer chews/bolus; wind was associated with more chews/bolus. Sheep in larger groups had a slower rate of rumination than those in smaller groups. We conclude that rumination behaviour is very plastic and, therefore, that assumptions of uniform rumination rates across individuals may be misleading and may miss an important piece of ruminants' foraging ecology.

Tomassini, L., B. Gonzales, G. C. Weiser, and W. Sisco. 2009. An ecologic study comparing distribution of *Pasteurella trehalosi* and *Mannheimia haemolytica* between Sierra Nevada bighorn sheep, White Mountain bighorn sheep, and domestic sheep. *Journal of Wildlife Diseases* 45(4):930-940.

Abstract: The prevalence and phenotypic variability of *Pasteurella* and *Mannheimia* isolates from Sierra Nevada bighorn sheep (*Ovis canadensis sierrae*), White Mountain bighorn sheep (*Ovis canadensis nelsoni*), and domestic sheep (*Ovis aries*) from California, USA, were compared. The White Mountain bighorn sheep population had a recent history of pneumonia-associated mortality, whereas the Sierra Nevada bighorn sheep population had no recent history of pneumonia-associated mortality. The domestic sheep flocks were pastured in

areas geographically near both populations but were not known to have direct contact with either bighorn sheep population. Oropharyngeal swab samples were collected from healthy, domestic and bighorn sheep and cultured to characterize bacterial species, hemolysis, biogroups, and biovariants. *Pasteurella trehalosi* and *Mannheimia haemolytica* were detected in all of the study populations, but the relative proportion of each bacterial species differed among sheep populations. *Pasteurella trehalosi* was more common than *M. haemolytica* in the bighorn sheep populations, whereas the opposite was true in domestic sheep. *Mannheimia haemolytica* was separated into 11 biogroups, and *P. trehalosi* was characterized into two biogroups. Biogroup distributions for *M. haemolytica* and *P. trehalosi* differed among the three populations; however, no difference was detected for the distribution of *P. trehalosi* biogroups between the Sierra Nevada bighorn sheep and domestic sheep. The prevalence odds ratios (pOR) for the distribution of *M. haemolytica* biogroups suggested little difference between White Mountain bighorn sheep and domestic sheep compared with Sierra Nevada bighorn sheep and domestic sheep, although these comparisons had relatively large confidence intervals for the point estimates. Hemolytic activity of the isolates was not different among the sheep populations for *M. haemolytica* but was different for *P. trehalosi*. No clear evidence of association was found in the Pasteurellaceae distribution between the White Mountains bighorn sheep and domestic sheep.

Whiting, J. C., K. M. Stewart, R. T. Bowyer, and J. T. Flinders. 2010. Reintroduced bighorn sheep: do females adjust maternal care to compensate for late-born young? *European Journal of Wildlife Research* 56(3):349-357.

Abstract: Little is known regarding the potential adjustment of maternal care towards late-born young by reintroduced female ungulates, which may be adapted to environments quite different than those at their release site. We compared nursing behaviors of young to investigate whether females would adjust maternal care toward late-born young between two populations of reintroduced bighorn sheep (*Ovis canadensis*) in Utah, USA. Neonates on Mount Timpanogos were born on average 28 days later in 2002 and 13 days later in 2003 than neonates in Rock Canyon. Suckling and weaning behaviors, however, were similar in 2002 and 2003 between those populations, except for the number of unsuccessful suckles, which was greater for young in Rock Canyon than for young on Mount Timpanogos during the middle of lactation in 2002. Our results provide preliminary evidence that females did not adjust maternal care to compensate for late-born young within the first 3 years following reintroduction, which possibly influenced survivorship of young.

Whiting, J. C., R. T. Bowyer, and J. T. Flinders. 2009. Diel use of water by reintroduced bighorn sheep. *Western North American Naturalist* 69(3):407-412.

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.

