From the Field: Neck lesions in ungulates from collars incorporating satellite technology

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Investigators have used marking collars and telemetry collars to enhance knowledge about movements of ungulates for many decades. Technological advances have provided increasingly dependable and sophisticated equipment (Fancy et al. 1988; Mourão and Merdi 2002), and methods of collar attachment have evolved substantially, particularly with respect to juvenile ungulates (Smith et al. 1998, Bleich and Pierce 1999). Nevertheless, recent observations of mule deer (*Odocoileus hemionus*) and mountain sheep (*Ovis canadensis*) fitted with telemetry collars that incorporate Global Positioning Systems (GPS) and other satellite technology indicate those collars may cause injury to the study animal. The intent of investigators should be to minimize injuries and effects of marking on the behavior of animals (White and Garrott 1990), but our observations suggest lack of compliance in some cases with existing guidelines (Committee on Acceptable Field Methods 1987, Institutional Animal Use and Care Committee [Powell and Proulx 2003]).

We placed collars incorporating GPS receivers and very high frequency (VHF) transmitters (Telonics, Mesa, Ariz.; and Posrec, TVP Positioning AB, Lindesberg, Sweden) on mule deer and mountain sheep. We collared female deer in Round Valley, Inyo, and Mono counties, California during March (n=12) and November 2002 (n=1). Four of 6 deer recaptured in November 2002, 2 of 3 recaptured in January 2003, and 2 of 2 recaptured in March 2003 (1 of which was collared in November 2002) exhibited all stages of ulcer formation except bone involvement. Patchy alopecia, nonblanchable erythema, induration, and edema of the intact skin surrounding ulceration were present. In some deer there was only partial skin loss and the ulcers were superficial; others revealed skin loss to the subcutaneous layer resembling a deep abrasion. The most severely affected deer had skin loss with extensive destruction of muscle on the dorsal aspect of the neck (Figure 1). Affected areas varied from 4–100 cm^2 and extended from 4–8 cm distal of the occiput or jaw to the mid-cervical region on the dorsal and ventral surfaces of the neck, respectively; lateral surfaces were not involved.

We removed collars from the 6 deer that exhibited lesions in November 2002 and January 2003. Three of those animals were recaptured in March 2003, and all lesions had healed completely. As part of long-term ecological investigations (Pierce et al. 2000*a*,*b*), we placed VHF collars from 3 manufacturers on 113 juvenile (<1 year of age) and >500 adult mule deer of both sexes since 1992. We

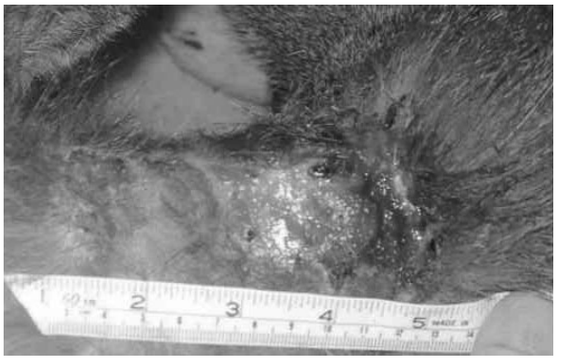

Figure 1. Lesion on neck of adult female mule deer collared with GPS receiver and VHF transmitter, Round Valley, California, USA. The collar was placed on the deer in March 2002 and removed 8 months later.

recaptured 152 of those deer 503 times and observed injuries similar to those reported herein on 4 occasions.

We placed telemetry collars incorporating GPS receivers, platform transmitter terminals, and VHF transmitters (Model TGW-200 and 3580, Telonics, Mesa, Ariz.) on 25 mountain sheep in the Cabeza Prieta National Wildlife Refuge, Pima and Yuma counties, and 10 mountain sheep in the Silver Bell Mountains, Pima County, Arizona during 2001–2003. In the Cabeza Prieta National Wildlife Refuge we retreived collars from 4 mountain sheep, and the neck of each exhibited dermal lesions. One female collared during March 2001 and recaptured in February 2002 exhibited a lesion 4 cm in diameter on the dorsum of the neck; that collar was removed and the animal released. Another female, collared in February 2002, was killed by a mountain lion (*Puma concolor*) in June 2002; that animal exhibited a dime-sized laceration on the dorsal surface of the neck that appeared to be healing. A third female, collared in February 2002, was in poor body condition (McCutchen 1990) in September, and was found dead in October 2002 of unknown causes; she had serious injuries similar to those described above. The fourth female, collared during January 2003 and recaptured in May of that year, exhibited a laceration (2 cm) that was in the process of healing. In the Silver Bell Mountains we examined the neck of 6 mountain sheep, and 5 exhibited dermal lesions similar to those described for mountain sheep in the Cabeza Prieta National Wildlife Refuge. Since 1978 we placed >110 VHF collars (Model 500, Telonics, Inc., Mesa, Ariz.) on mountain sheep of both sexes and observed lesions similar to those reported herein only once.

We removed dried material from the neck of one bighorn sheep for culture of necrotic skin debris (Diagnostic Laboratory, Arizona Health Sciences Center, University of Arizona, Tucson, Ariz.). Samples were placed in tryptic Soy Broth to rehydrate and then transferred to Blood Agar plates and MacConkey Agar plates; growth from the latter subsequently was transferred to an Enterotube. We identified 2 colonies of diphtheroid organisms and 2 colonies of *Staphylococcus aureus* from the Blood Agar plates, and the MacConkey plate yielded *Salmonella arizonae*.

Salmonella arizonae occurs widely and can cause fatal infections. Because the route of infection usually is oral, it generally results in an enteric infection (Carter et al. 1995). Asymptomatic carrier states frequently exist, and it is possible that the organism was transferred to the neck from a hoof contaminated with fecal material while scratching due to an irritation. The diphtheroids are principally *Corynebacterium* spp. that frequently are recovered from clinical specimens; thus, minimal significance is placed on the occurrence of these organisms. *Staphylococcus aureus* occurs as a commensal in the skin and mucous membranes and is involved in a variety of wound and skin infections, including abscesses. *S. aureus* infections frequently are opportunistic.

To examine how the GPS-satellite collars irritated the neck, we placed collars on 2 healthy captive mule deer at the University of Arizona, Tucson. We obtained blood samples from each animal for complete blood cell counts and serum chemistry (i.e., alkaline phosphatase, glucose, alanine aminotransferase, total protein, albumin, globulin, calcium, anylase, choleseterol, blood urea nitrogen, phosphorus, creatinine, total bilirubin). We placed collars on the animals on 7 and 21 May 2003 and removed them 30 days later so we could examine the neck. The neck of the male appeared normal, while the female showed an abrasion on the dorsum of the neck (Figure 2). We obtained a bacterial culture from the abraded area and a second set of blood samples when we removed the collars.

There were no remarkable differences between the first and second complete blood cell counts and serum chemistries; all values were within the normal ranges for mule deer. *Proteus mirabilis* was cultured from the neck lesion of the female. *Proteus mirabilis* is a fecal contaminant and has

Figure 2: Lesion on neck of captive adult female mule deer collared with a GPS receiver, a platform transmitter terminal, and VHF transmitter, University of Arizona, Tucson, Arizona, USA. The collar was placed on the deer in May 2003 and removed 30 days later.

been implicated in urinary tract, external ear, skin infections, and diarrhea. It is part of the normal flora of the large intestine (Carter and Cole 1990).

We suspect that lesions exhibited by deer are a function of the circular shape and lack of flexibility of the collar, which incorporates the GPS receiver, associated wiring, and the VHF antenna. We brought the problems described herein to the attention of the manufacturer; upon receiving diagrams and neck measurements of deer, the manufacturer constructed subsequent GPS collars in an oval shape. Examination of 19 animals that wore these newly designed collars for 5–17 months indicates substantially less irritation to the dorsal ridge of the neck, and no open sores were evident. Lesions exhibited by mountain sheep also may be related to collar design. The satellite-GPS collars have satellite and GPS components situated dorsally and attached by rivets that extend beyond the collar material; the rivets in combination with the increased weight of the GPS receiver, platform transmitter terminal, and required battery may cause irritation that develops into dermal lacerations. This potential problem also has been brought to the attention of the manufacturer and has been corrected. However, since December 2003 we placed 25 redesigned collars on mountain sheep and have been able to examine the neck of 5 animals. Three had open sores 25, 36, and 80 days after collar placement. Two of the sores have healed.

We call attention to these problems in the interest of avoiding future debilitating injuries to study animals and because those subjects should be treated humanely (Schmidt and Bruner 1981). Further, such injuries could bias results in investigations of animal behavior and foraging ecology (Bleich et al. 1980), energetic costs (Godfrey et al. 2003) and resultant body condition, cause-specific mortality and survivorship (Schaefer et al. 2000), and reproductive success (Bleich et al. 2003). White and Garrott (1990) emphasized the importance that such marking devices not influence study animals.

Research methods should always be refined to decrease influences they may have on research animals. Injuries reported herein can influence animal behavior that may affect results (Powell and Proulx 2003). Ill-fitting collars and problems associated with them clearly influence research results (Bleich et al. 1980, 1994) and have implications for ethics within the wildlife profession. We encourage investigators to be cautious when deploying collars of new designs or incorporating novel technologies. Further, we urge investigators and manufacturers to work together to ensure that collars comply with recommendations of the Committee on Acceptable Field Methods (1987).

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Literature cited

Bleich, V. C., R. T. Bowyer, A. M. Pauli, M. C. Nicholson, and R. W. Anthes. 1994. Mountain sheep *Ovis canadensis* and helicopter surveys: ramifications for the conservation of large mammals. Biological Conservation 70: 1–7.

Bleich, V. C., and B. M. Pierce. 1999. Expandable and economical long-term collars for juvenile mule deer. California Fish and Game 85: 56–62.

Bleich, V. C., T. R. Stephenson, N. J. Holste, I. C. Snyder, J. P. Marshal, P. W. McGrath, and B. M. Pierce. 2003. Effects of tooth extraction on selected biological parameters of female mule deer. Wildlife Society Bulletin 31: 233–236.

BLEICH, V. C., J. D. WEHAUSEN, J. A. KEAY, AND J. G. STAHMANN. 1980. Radio telemetry collars and mountain sheep: a cautionary note. Desert Bighorn Council Transactions 34:6–8.

CARTER, G. R., M. M. CHENGAPPA, A. W. ROBERTS, G. W. CLAUS, AND Y. RIKIHISA. 1995. Essentials of veterinary microbiology. Fifth edition. Williams and Wilkins, Baltimore, Maryland, USA.

CARTER, G. R., AND J. R. COLE, JR. 1990. Diagnostic procedures in veterinary bacteriology and mycology. Fifth edition. Academic Press, New York, New York, USA.

COMMITTEE ON ACCEPTABLE FIELD METHODS. 1987. Acceptable field methods in mammalogy. Journal of Mammalogy 68 (supplement): 1–18.

FANCY, S. T., L. F. PANK, D. C. DOUGLAS, C. H. CURBY, G. W. GARNER, S. C. AMSTRUP, AND W. L. REGELIN. 1988. Satellite telemetry: a new tool for wildlife research and management. United States Department of Interior, Fish and Wildlife Service Resource Publication 172.

GODFREY, J. D., D. M. BRYANT, AND M. J. WILLIAMS. 2003. Radiotelemetry increases free-living energy costs in the endangered Takahe *Porphyrio mantelli*. Biological Conservation 114:35–38.

MCCUTCHEN, H. E. 1990. A technique to visually assess physical condition of bighorn sheep. Desert Bighorn Council Transactions 29:27–28.

MOURÃO, G., AND Í. M. MERDI. 2002. A new way of using inexpensive large-scale assembled GPS to monitor giant anteaters in short time intervals. Wildlife Society Bulletin 30:1029–1032.

PIERCE, B. M., V. C. BLEICH, AND R. T. BOWYER. 2000*a*. Social organization of mountain lions: does a land-tenure system regulate population size? Ecology 81:1533–1543.

PIERCE, B. M., V. C. BLEICH, AND R. T. BOWYER. 2000*b*. Selection of mule deer by mountain lions and coyotes: effects of hunting style, body size, and reproductive status. Journal of Mammalogy 81:462–472.

POWELL, R. A., AND G. PROULX. 2003. Trapping and marking terrestrial mammals for research: integrating ethics, performance criteria, techniques, and common sense. Institute for Laboratory Animal Research Journal 44:259–276.

SCHAEFER, R. J., S. G. TORRES, AND V. C. BLEICH. 2000. Survivorship and cause-specific mortality in sympatric populations of mountain sheep and mule deer. California Fish and Game 86: 127–135.

SCHMIDT, R. H., AND J. G. BRUNER. 1981. A professional attitude toward humaneness. Wildlife Society Bulletin 9:289–291.

SMITH, B. L., W. P. BURGER, AND F. J. SINGER. 1998. An expandable radiocollar for elk calves. Wildlife Society Bulletin 26: 113–117.

WHITE, G. C., AND R. A. GARROTT. 1990. Analysis of wildlife radiotracking data. Academic Press, New York, New York, USA

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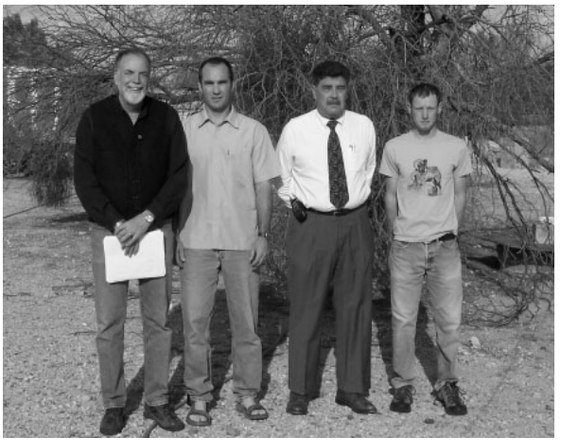

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