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A TECHNIQUE FOR IMPLANTING HEART-RATE TRANSMITTERS IN BIGHORN SHEEP

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Abstract: We conducted laboratory experiments, using a domestic ewe, to determine the necessary input sensitivity and optimum location for implanting electrodes for heart rate telemetry of bighorn sheep. A 2-lead electrocardiograph was used to obtain strip-chart recordings of the QRS waveform at 3 superficial lead attachments. A cylindrical heart rate transmitter with fixed electrodes was experimentally implanted in the domestic ewe in a vector between the manubrium and xiphoid. The transmitter was implanted between the subcutaneous fat and muscle, superficial to the rib cage. The transmitter failed on the second day after surgery due to accumulating serosanguineous fluid in a pocket around the electrode(s). The transmitter was restored to operation by suturing through the skin and into the subcutaneous tissue near the electrode(s). Sutures also prevented migration of the implant. The transmitter functioned properly for 4 weeks before being passively expelled due to tissue necrosis caused by pressure at the cranial electrode. The wound healed with only localized infection and without other complications. The ewe was in the third trimester during the experiment and successfully lambed 1 month after the transmitter was expelled. We similarly implanted a heart rate transmitter in a free-ranging bighorn ewe and collected > 200 hours of data before the transmitter was expelled. Bighorn heart rates averaged 55, 78, and 168 beats per minute for resting, foraging and disturbed behavioral states, respectively.

During a 3 year study of a recently established population of bighorn sheep (Ovis canadensis) in north-eastern Wyoming we identified vehicular disturbance as a potential limiting factor (Coates and Schemnitz 1988). Harlow et al. (1987) demonstrated that cardiac frequency was an accurate predictor of adrenal responsiveness for bighorn sheep, thus demonstrating that heart rate telemetry could be

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used to quantitatively assess environmental stressors. Proposed highway upgrading through population core-use areas occupied during our study justified analysis of cardiac response of bighorn sheep to vehicular disturbance.

Follman et al. (1982) described a heart-rate transmitter (model EKG-1-2000, Stuart Enterprises, Oceanside, CA) suitable for use in large mammals that was durable, had long range, and was easily implanted under field conditions. However, there was insufficient information available in the literature to conduct a study of cardiac response of free-ranging bighorn to vehicular disturbance. We required additional information on properties of the QRS waveform, including required input sensitivity for the transmitter described by Follman et al. (1982), and optimum location for transmitter placement.

A pregnant, adult-domestic ewe (Ovis aries) was used to obtain the necessary information in a laboratory setting, followed by experiments in the field using a free-ranging bighorn ewe. This paper presents new information on electrocardiology of sheep and provides information necessary for implanting the heart-rate transmitter described by Follman et al. (1982) in bighorns.

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ELECTROCARDIOGRAPHY AND TRANSMITTER PLACEMENT

A 2-lead electrocardiograph (model EK-5A, Burdick Co., Milton, WI) was used to obtain strip chart recordings for the domestic ewe at 3 superficial lead attachments: manubrium to xiphoid, manubrium to right foreleg, and xiphoid to right foreleg. The first lead placement, manubrium to xiphoid, yielded the waveform of highest amplitude with a peak value of 0.4 mV.

We determined the input sensitivity necessary for heart-rate transmitters in sheep was 0.4 Mv. This input sensitivity is comparable to values reported by Cassirer (in-press) for elk (Cervus elaphus).

The transmitter described by Follman et al. (1982) was cylindrical with fixed, stainless-steel electrodes and overall dimensions of 30 X 160 mm. Considering the cardiological data for sheep, and dimensions of the transmitter, we concluded that the optimum location for implanting this transmitter in bighorn sheep was along the sternum in a vector between the manubrium and xiphoid.

SURGICAL PROCEDURES

Follman et al. (1982) referenced the surgical techniques of Philo et al. (1981) who reported 2 field procedures for implanting temperature-sensitive transmitters in grizzly bears (Ursus arctos). These procedures were rapid and relatively uncomplicated.

In the first procedure, the transmitter was implanted in the back of the neck, perpendicular to the spinal column. Two 5-cm incisions were made parallel to the spine, 8 cm to either side of the dorsal midline. The incisions were carried through the subcutaneous tissue, and a pocket was formed between the incisions by blunt dissection.

In the second procedure, the transmitter was placed free in the abdominal cavity. An 8 cm incision was made immediately posterior to the umbilicus, and the transmitter was implanted in the abdominal cavity.

We elected to use a modification of the first procedure due to possible complications with peritonitis from the second procedure. A domestic ewe was sedated using ketamine and xylazine hydrochloride (0.5-0.75 mg/kg body weight)and restrained in lateral recumbency. Tissue surrounding the surgical site was infiltrated with 15 cc lidocaine-hydrochloride (Vedco Distributing, St. Joseph, Missouri). Sites for the incision were shaved and cleaned with a bacteriostatic agent, betadine.

The 5-cm incision was made 10 cm caudal to the manubrium and a shallow pocket was formed using a minimum of blunt dissection. The cylindrical configuration of the transmitter, and conical shape of the front electrode-cap, helped to form a subcutaneous channel as the transmitter was pushed through the loose connective tissue. The incision was closed with #3 chromic cat-gut suture. A prophylactic injection (7 cc) of penicillin-G benzathine and penicillin-G procaine was administered to prevent infection.

The transmitter functioned well immediately after implantation but failed on the day after surgery due to accumulating serosanguineous fluid at the cranial end of the transmitter. However the transmitter was restored to operation by reducing the size of the pocket and draining the fluid. This was accomplished by suturing through the skin and into the subcutaneous tissue at the cranial end of the pocket. Sutures through the skin and into the subcutaneous tissue at several sites surrounding the transmitter prevented migration of the implant.

The transmitter functioned well for 30 days before being passively expelled due to tissue necrosis. There was only localized infection and the wound healed without complications. Post-surgical care was not necessary. The domestic ewe was in the third-trimester of pregnancy and successfully lambed 1 month after the transmitter was expelled.

A free-ranging bighorn ewe (yearling) was immobilized in April 1989 at Bighorn Canyon National Recreation Area, a National Park Service Unit in north-central Wyoming and south-eastern Montana, using 2 cc of ketamine/xylazine hydrochloride (400 mg/200 mg). Standard precautions were followed to prevent capture myopathy (Jessup et al. 1984). The bighorn ewe was restrained in lateral recumbency and hair was removed from the incision site by plucking and shaving. The site was disinfected using betadine and a prophylactic injection (7 cc) of penicillin-G benzathine and penicillin-G procaine was administered.

Surgery and insertion of the transmitter were as previously described, and collodion was used to cover the suture line and create a barrier for dirt at the incision. After recovery the ewe walked approximately 250 m and laid down, but remained alert.

HEART RATE RESPONSES

The transmitter had a range of up to 2 km depending on topography and juxtaposition of the ewe. For the purpose of data collection we remained as far away as possible while maintaining visual contact with the ewe. Cardiac activity was measured continuously for 60 sec at 5 min intervals in order to estimate mean heart rate associated with 3 behavioral states: resting, foraging and disturbed. Cardiac activity of the bighorn ewe was monitored for > 200 hours before the transmitter was expelled (14 days after surgery).

Resting heart rate averaged (mean of the means) 55 beats per minute (S = 0.7 b.p.m., N = 190). Resting heart rate was analyzed when the ewe was bedded or when it stood motionless (Fig. 1).

Foraging heart rates averaged 78 beats per minute (S = 4.5 b.p.m., N = 182). Foraging heart rates were recorded when the ewe foraged while standing motionless, when it walked across flat ground, or searched for food on a slope (Fig. 1).

Heart rates associated with disturbance averaged 168 beats per minute over a 2 hour period (range 135 - 200 b.p.m., N = 2, Fig. 1). Disturbances were elicited by approaching the ewe on foot and causing it to flee. After the initial flight response we remained as far away as possible while maintaining visual contact.

Disturbance analyses were conducted in this manner on 2 occasions. In both instances the ewe was alone and resting at the onset of disturbance (mean resting heart rate 55 b.p.m.), and heart rate elevated to 135+ beats per minute within 1 minute. Heart rate continued to rise for up to 1 hour after the initial disturbance, reaching peaks of 200 beats per minute. Heart rate remained elevated for 2 hours after onset of disturbances without overt indications of stress (e.g. animal not in alert posture or fleeing). Distance to the observer ranged 1 to 2 km during peak heart rates.

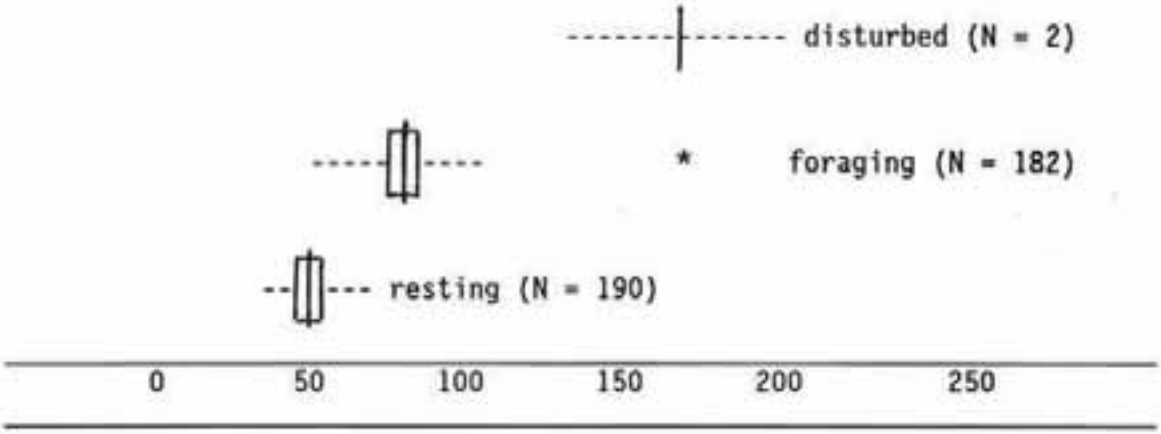

Fig. 1 Heart rates of a free ranging bighorn ewe associated with resting, foraging, and disturbance. Plots show means (center vertical lines), 95% confidence limits (boxes) and ranges (horizontal lines). The asterisk is an outlying data point. No confidence limit is shown for disturbed heart rate since N = 2.

DISCUSSION

Heart rate responses to disturbance were only analyzed on 2 occasions, but this represents the best data of this type currently available for free ranging bighorns. The technique can be performed rapidly in the field but the transmitter described by Follman et al. (1982) is bulky and causes tissue necrosis. Expulsion of the transmitter does result in localized infection, but no complications were involved with either the domestic ewe or free ranging bighorn.

We recommend using an alternate transmitter packaging system, or free electrodes implanted along the sternum as described, where long term data and transmitter retention are desired. Data of this type are needed by managers to correlate heart rate with stress (Harlow et al. 1982) in order to maintain and(or) maximize bighorn populations in sub-optimal habitats.

LITERATURE CITED

Cassirer, E. F., V. B. Kuechle and T. J. Kreeger. (in-press) Optimum placement of electrodes for heart rate telemetry. Tenth International Symposium on Biotelemetry, Fayetteville, AR.

Coates, K. P., and S. D. Schemnitz. 1988. Habitat utilization, interspecific interactions and status of a recolonized population of bighorn sheep at a wild-horse range. Contract completion report for Bighorn Canyon National Recreation Area, Montana and Wyoming. 79 pp.

Follman. E. H., A. E. Manning and J. L. Stuart. 1982. A long-range implantable heart rate transmitter for free ranging animals. Biotelemetry Patient Monitoring 9:205-212.

Harlow, H. J., E. T. Thorne, E. S. Williams, E. L. Belden and W. A. Gern. 1987. Adrenal responsiveness in domestic sheep (Ovis aires) to acute and chronic stressors as predicted by remote monitoring of cardiac frequency. Can. J. Zool. 65:2021-2027.

Jessup, D. A., W. E. Clark, and R. G. Mohr. 1984. Capture of bighorn sheep: management recommendations. California Dept. of Fish and Game, Wildl. Manage. Branch. Administrative report 84-1. 33pp.

Philo, L. M., E. H. Follman and H. V. Reynolds. 1981, Field surgical techniques for implanting temperature sensitive transmitters in grizzly bears. J. Wildl. manage. 45:772-775.