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THE USE OF A TYMPANIC MEMBRANE THERMOMETER FOR ASSESSING HYPERTHERMIA IN BIGHORN SHEEP

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ABSTRACT: In November 1992, 45 desert bighorn sheep (*Ovis canadensis nelsoni*) were captured at Old Dad Peak and the Kelso Mountains of southern California (USA) using a netgun fired from a helicopter. Tympanic membrane temperature was compared to rectal temperature for 22 sheep to determine if tympanic membrane temperature was a reliable indicator of hyperthermia and capture stress. All animals captured had elevated rectal temperatures after capture and arrival to the processing area. The group of 22 sheep had a mean ± SD rectal temperature of 40.9 ± 0.7 C (range 39.5 to 42.1 C) at arrival. During processing of these sheep, mean ± SD rectal temperatures were 40.9 ± 0.29 C (range 40.0 to 41.7 C) with mean ± SD tympanic temperatures of 38.4 ± 0.5 C (range 35.7 to 40.5 C). Mean tympanic temperatures were significantly lower than mean rectal temperatures when comparing all measurements and paired tympanic and rectal temperature measurements. Three animals had rectal and tympanic temperatures greater than 41.0 C and 39.7 C, respectively, one of which died after capture. Tympanic membrane temperature measurement may provide a method for evaluation of hyperthermia and capture stress by separating retained body heat due to exertion from critical elevations in core body temperature which may affect post-capture survival.
Key words: Bighorn sheep, *Ovis canadensis*, temperature, hyperthermia, tympanic temperature, capture.

INTRODUCTION

The capture of wildlife, either by physical restraint or chemical immobilization, has become a relatively routine procedure for biologists. During capture by any method, animals are subjected to a variety of negative stimuli that can lead to prolonged exertion, exhaustion, stress, and hyperthermia. Collectively these factors can cause physiological derangements including lactic acidosis and initiate the development of myositis, muscle necrosis, depressed immune function, and possibly death (Spraker, 1982). This sequence of events and end result are referred to as capture stress, capture myopathy, or exertional myopathy.

Normal body functions in animals depend on a relatively constant body temperature. The core body temperature of healthy animals is dependent on the heat generated by muscle contraction, assimilation of food and metabolic processes (Lusk, 1989), with about 25% of the total heat production due to muscle contraction (Haskins, 1995). During exercise, the heat generated by muscle contraction increases 40 to 60 times (Carlson, 1982; Haskins, 1995).

Temperature measurement in mammals is usually done with a thermometer placed in the rectum. The accuracy of rectal temperature in relation to core body temperature, especially in hyperthermia, is poor in humans (M. Benzinger, 1969; T. H. Benzinger, 1969, 1977). Since significant heat production occurs during exercise and the heat loss mechanisms may not adequately compensate for the increased heat production, rectal temperature will increase due to retention of heat within the abdominal cavity. Due to blood flow dynamics, there can be a time lag of up to 1 hr before rectal temperature accurately reflects the true core temperature of humans (M. Benzinger, 1969; T. H. Benzinger, 1969).

Tympanic temperature was introduced as a means to accurately monitor core body temperature at the level of the hypothalamus (Benzinger, 1959). Although initially controversial, tympanic temperature measurements have become widely accepted in human medicine because tympanic temperature is more reflective of core temperature than temperatures obtained from other sites (Brinnel and Cabanac, 1989; Benzinger and Benzinger, 1972).

My objective was to compare temperatures measured with a standard rectal thermometer and a tympanic thermometer for the assessment of hyperthermia associated with capture of free-ranging bighorn sheep (*Ovis canadensis nelsoni*).

MATERIALS AND METHODS

On 3 to 5 November 1992, personnel from the California Department of Fish and Game captured and translocated 45 desert bighorn sheep at Old Dad Peak and the Kelso Mountains, San Bernardino County, California (USA)(35°06′N, 115°50′W). All animals were captured using a netgun fired from a helicopter. Sheep were hobbled, blindfolded, placed in a nylon mesh bag and airlifted to a central location. Processing of sheep included initial physical examination, weighing, ear-tagging, collection of various biological samples, and administration of prophylactic agents. All sheep were doused with water during processing. Based on evaluation of temperature, pulse and respiratory rate, length of chase time and a subjective assessment of clinical status, animals were classified as normal or stressed following Kock et al. (1987b). Individual animals were treated for hyperthermia and exertional myositis using intravenous fluids (Lactated Ringers Solution, Baxter Healthcare Corporation, Deerfield, Illinois, USA), flunixin meglumine (Banamine, Schering-Plough Animal Health Corporation, Kenilworth, New Jersey, USA), prednisolone (Solu-Delta-Cortef, The Upjohn Co., Kalamazoo, Michigan, USA) or dexamethasone (Dex-a-vet, Anthony Products Co., Arcadia, California, USA) and intraperitoneal sodium bicarbonate (Bicarboject, American Veterinary Products Co., Fort Collins, Colorado, USA). After processing, the hobbles and blindfold were removed and sheep were placed either in individual crates or covered horse trailers for transport to the release site.

During the processing of these sheep, temperatures were obtained using a glass rectal thermometer (Veterinary Ring-top Thermometer, Cornell-Eisele Thermometer Division, Popper and Sons, Inc. New Hyde Park, New York, USA) and a tympanic thermometer (Ototemp Veterinary Infrared Tympanic Temperature Scanner, Exergen Corporation, Newton, Massachusetts, USA). Rectal temperatures were taken, beginning at arrival to the processing area, using a thermometer inserted into the rectum for a distance of 4 to 5 cm for 1 min. Tympanic temperatures were taken, starting 2 to 4 min after arrival, by inserting the tympanic thermometer into the external ear canal and directing the optical system towards the tympanic membrane. Tympanic temperature measurements were completed in 7 to 10 sec. Rectal and tympanic temperatures were taken at 1- to 5-min intervals for up to 30 min, but not all measurements were paired on all animals. A total of 121 rectal and 68 tympanic temperatures were recorded with 52 paired readings.

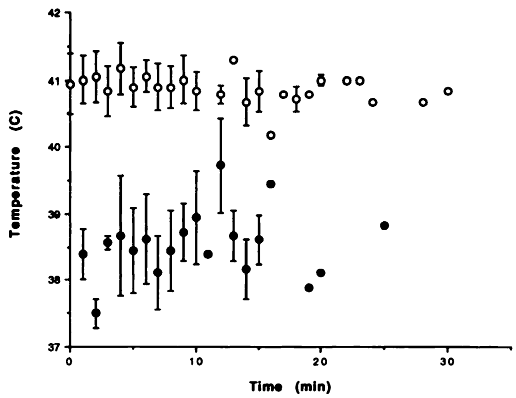

FIGURE 1. Mean rectal (○) and mean tympanic (●) temperature for 22 bighorn sheep. Error bars indicate standard deviation. Each point with an error bar, except at 0 min, represents two to 10 animals.

The body temperature of normal, healthy, unrestrained bighorn sheep is unknown. Bighorn sheep were assumed to be thermodynamically similar to domestic sheep and goats and a rectal temperature of 38.5 C was considered normothermic. Hyperthermia was defined as a rectal temperature >41.0 C or a tympanic temperature >39.7 C. The parameters suggested by Kock et al. (1987b) were used as a basis for determining stress in captured sheep.

Statistical analysis followed methods of Snedecor and Cochran (1980) and were done using EZSTAT (Trinity Software, Campton, New Hampshire, USA).

RESULTS

Measurements of rectal and tympanic temperatures were done on 22 animals (Fig. 1). In these sheep, mean ± SD rectal temperature at arrival to the processing area was 40.9 ± 0.7 C (range 39.5 to 42.1

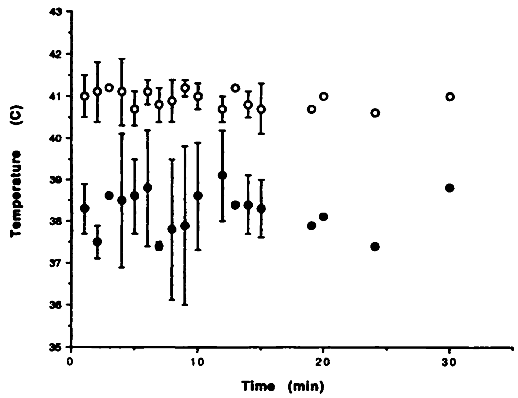

FIGURE 2. Mean rectal (○) and tympanic (●) temperature from paired readings from 21 bighorn sheep. Error bars indicate standard deviation. Each point with an error bar represents two to seven animals.

C). During processing, mean ± SD rectal temperatures were 40.9 ± 0.29 C (range 40.0 to 41.7 C) and mean ± SD tympanic temperatures were 38.4 ± 0.5 C (range 35.7 to 40.5 C). Mean tympanic temperature was significantly lower than mean rectal temperature (Student t-test; $t = 43.1$, $P < 0.001$).

Fifty-two paired measurements were done on 21 sheep during processing (Fig. 2). Mean ± SD rectal temperatures were 40.9 ± 0.4 C and mean ± SD tympanic temperatures were 38.4 ± 1.1 C. Mean tympanic temperature was significantly lower than mean rectal temperature (Wilcoxon signed rank test; $T = 0$, $P < 0.001$). No correlation was found between the paired measurements ($r = 0.16$).

During processing, 16 sheep were identified as stressed during clinical assessment. Eleven sheep were treated for clinical signs associated with hyperthermia and capture stress. All treated animals responded to treatment as indicated by decreased body temperature within 10 to 12 min after initiation of treatment and improvement in heart and respiratory rates.

Three of the 11 sheep treated for hyperthermia and stress developed tympanic hyperthermia. These three ewes had rectal temperatures greater than 41.0 C and tympanic temperatures greater than 39.7 C during processing. Two of these ewes were captured in mid- to late afternoon when ambient temperatures were around 21 C, had prolonged chase times (>10 min), and required multiple attempts at netting before being captured. The third ewe was captured early in the morning when ambient temperature was approximately 7 C and had a 4 min chase time.

One of the three ewes with elevated tympanic temperature was hyperthermic at arrival to the processing area; her rectal temperature was 41.5 C. This animal had tympanic temperatures of 40.3 and 40.5 C at 10 and 12 min, respectively, after arrival with rectal temperatures of 41.0 and 40.7 C at 10 and 12 min, respectively. This ewe had visible musculo-skeletal deficits at release including muscle cramping, weakness, and reluctance to walk. She was found dead 10 days after capture in the vicinity of the release site, but no necropsy was conducted.

The other two ewes became hyperthermia after arrival to the processing area. One ewe became hyperthermic 4 min after arrival (rectal temperature 41.4, 41.2, and 40.8 C; tympanic temperature 40.3, 40.2, and 40.0 at 4, 5, and 6 min after arrival, respectively). The other ewe had rectal temperatures that decreased from 41.7 C at 2 min to 41.2 C at 10 min after arrival to the processing area, but tympanic temperatures did not rise above 40 C until 12 min after arrival and then remained elevated for only 1 min.

One animal had persistently elevated rectal temperature during processing (range 40.8 to 41.6 C) but did not have an elevated tympanic temperature. The carcass of this sheep was found 9 wk postcapture approximately 5 km from the release site, but a necropsy to determine the cause of death was not conducted.

DISCUSSION

Normal body temperatures for free-ranging, unrestrained animals are not available for most ungulate species, including bighorn sheep. Franzmann and Thorne (1970) captured bighorn sheep using chemical immobilization with minimal disturbance and measured rectal temperatures of approximately 38.6 C. After physical restraint, and presumably some exertion, rectal temperatures of these sheep increased to approximately 40.3 C. Krausman et al. (1985) found rectal temperatures of 40 to 41 C in three ewes captured by netgun, although pursuit times were not provided. Kock et al. (1987a) found rectal temperature to be dependent on capture technique with rectal temperatures ranging from 38.3 to 43.8 C. A normal range of rectal temperature for captured bighorn sheep of 39.1 to 41.2 C was suggested by Kock et al. (1987b).

Strenuous activity or exertion creates heat that is additive to the heat generated by basal metabolic activity (Carlson, 1982). Rectal temperature is generally considered to be reflective of homeothermy, not minute by minute alterations in heat generation (Benzinger, 1977). Detailed studies of body temperature in relation to activity are lacking in large ungulates, although Rogers et al. (1987) reported increased rectal temperature in a white-tailed deer after exertion.

Rectal temperature can increase 4 to 5 C after strenuous exercise in humans (Eckert et al., 1988), and in racing greyhounds and thoroughbreds (Carlson, 1982). The upper threshold of body temperature at which severe metabolic derangements occur is unknown, but body temperatures of 5.5 C above core body temperature are associated with heat prostration or heat stroke in humans. Hyperthermia is one of the primary indications for the development of capture myopathy (Spraker, 1982). Mortality of free-ranging ungulates after capture has been documented in many species and situations (Spraker, 1982), but correlations of mortality with rectal temperature are uncommon (Kock et al., 1987a, b).

The elevations in tympanic temperature in three sheep in this study is evidence that a significant increase in core body temperature occurred during capture or processing that was not readily apparent using rectal temperatures. The increase in rectal temperature was probably associated with heat generated during exertion and retained within the abdomen and the large muscle mass of the rear legs as well as the inability of these animals to dissipate this heat rapidly. Similar discrepancies between tympanic and rectal temperatures have been documented in human athletes (Eckert et al., 1988).

Tympanic temperature appears to be superior to rectal temperature as an indicator of pathologic hyperthermia associated with exertion and capture. Tympanic temperature measurements can separate retained heat due to exertion from critical elevations in core body temperature that may influence the prognosis for survival of an animal. Tympanic thermometers provide a safe, non-invasive, and fast temperature measurement that is more responsive to dynamic, immediate physiologic processes than the measurement of rectal temperature.

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