Quantification of the response of elk during velvet antler removal

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Thierman, J.L., Crowe, T.G., Stookey, J.M. and Valentine, B. 1999. **Quantification of the response of elk during velvet antler removal.** Can. Agric. Eng. **41**:233-237. A system was developed to physically measure the escape response of elk during velvet antler removal. This response was to be used as an indirect measure of the pain the animal may have experienced. Two load cells and a triaxial accelerometer were used in conjunction with data acquisition equipment to record the response of animals during different segments of the procedure. The load cells measured the tension in two ropes used to restrain the animal's head, and the accelerometer recorded any motion of the animal's head. Rope tension accurately indicated the elks' responses, but the accelerometer did not provide any additional information. Other potential improvements to the system were also noted.

Un système a été développé afin de mesurer les paramètres physiques de la réaction de fuite des wapitis durant l'enlèvement de la peau qui recouvre leurs bois. Cette réaction devait être utilisée comme un indicateur de la douleur que l'animal peut ressentir. Deux cellules dynamométriques et un accéléromètre triaxial furent utilisés, en plus d'équipements pour l'acquisition de données qui permettent d'enregistrer la réaction des animaux durant différents moments de la procédure. Les cellules dynamométriques mesuraient la tension dans deux cordes utilisées pour retenir la tête de l'animal, et l'accéléromètre enregistrait les mouvements de la tête de l'animal. La mesure de la tension était un bon indicateur de la réaction du wapiti, mais l'accéléromètre n'a pas fourni d'informations additionnelles. Les observations faites lors de ces expériences permettront d'apporter des améliorations au système.

INTRODUCTION

Harvesting velvet antler is a surgical procedure performed on male elk every year. This procedure is performed for both safety reasons and economic gain and has been found to have a painful effect on the animal (Matthews and Cook 1991; Pollard et al. 1992). The entire soft antler is cut off above the pedicle during a stage of growth when the antler is still being supplied with blood, innervated, growing, and not completely calcified. Various techniques have been used to harvest velvet antler, but the majority of producers have moved away from animal sedation and electro-immobilization, in favor of animal restraint combined with a local anesthetic. A technique capable of measuring the pain and stress experienced by the animals during the surgical procedure would help the elk industry identify optimal harvest techniques.

LITERATURE REVIEW

The quantification of pain in animals is a difficult task. Researchers have traditionally relied on a combination of behavioral and physiological indices (Broom and Johnson 1993). Behavioral observations such as vocalization, kicking, tail flicking, and changes in posture have been proven indicators of pain (Molony and Kent 1996; Molony et al. 1995; Broom and Johnson 1993). Matthews and Cook (1991) found that red deer stags showed little movement in response to velvet antler removal under local anesthesia, but the animals showed a moderate to strong response when no anesthetic was used. Rather than monitoring animal reaction during antler removal, Pollard et al. (1992) used post-treatment observations such as head shakes and ear flicks to examine the effect of antler removal on red deer stags. They found considerable differences in behavior between control stags and stags that had their antlers removed. It is unclear, however, whether the animals in this study responded to pain, the abrupt reduction in the weight of the head, or to a new or different sensation that may have been painless.

Assessing animal pain from physiological factors is another common technique used in animal welfare research. The change in characteristics such as heart rate, respiration rate, blood pressure, temperature, and various hormone levels can be used as an indication of pain (Association of Veterinary Teachers and Research Workers 1986; Wall 1992). Studies have shown a correlation between plasma cortisol concentrations and the pain an animal is experiencing (Robertson 1992; Molony and Kent 1996). However, many other factors, such as fear, hunger, handling, and restraint can have an effect on these hormone levels, and various studies have shown contradicting results when using adrenal activity as a measure of animal stress (Rushen 1991).

Matthews and Cook (1991) used plasma cortisol levels to examine the effects of velvet antler removal on red deer stags. Later, Matthews et al. (1994) expanded the study by examining post-treatment cortisol levels of red deer stags subject to control and antler removal procedures. In both cases, no difference was found between the two treatments. These studies showed that handling evokes a large amount of stress in the animal and the physiological response due to pain may be minimal relative to that of handling.

The heart rate of an animal is the other primary physiological indicator of pain or stress. However, as with

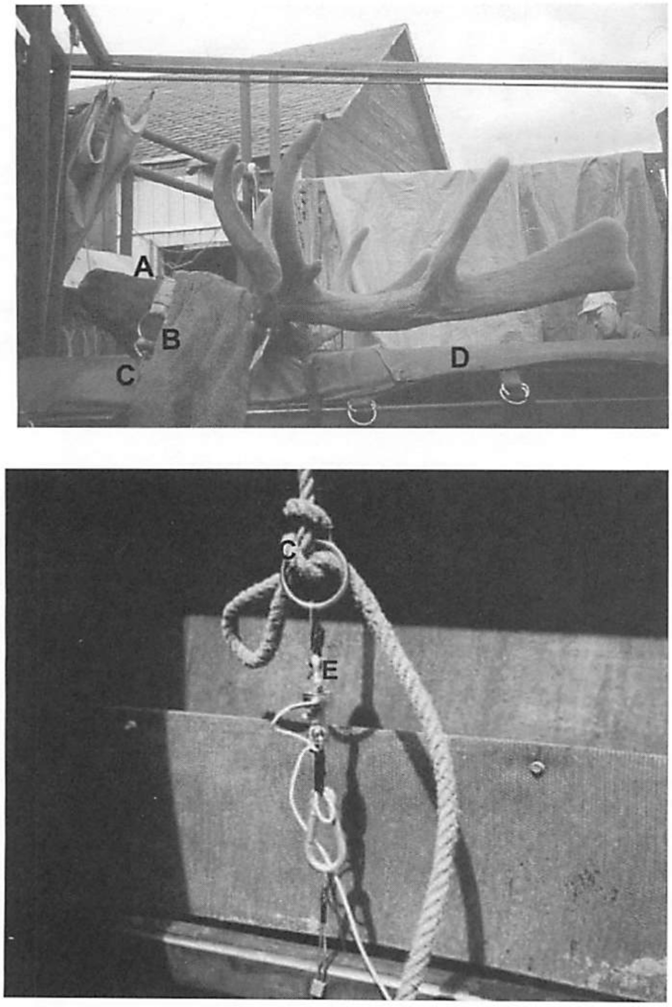

Fig. 1. Animal restraint and response sensors. a) Animal restrained in chute. b) close up of load cell in line with tie-down rope. A - accelerometer; B - halter; C - tie-down ropes; D - padded side panel; E - load cell.

hormone levels, there are other factors that can have an equally large or greater effect on the heart rate of an animal. For example, the heart rate of calves increased to 1.5 times the relaxed rate when an electric prodder was used on them and to 1.7 times the relaxed rate when they were forced to climb a ramp (Rushen 1991). This shows that physical activity can affect the heart rate more than a painful or stressful experience. Matthews et al. (1992) showed that the average heart rate tended to increase during velvet antler removal, but no differences were found in the post treatment period between control stags and stags with their antlers removed. Pollard et al. (1992) compared the heart rates of red deer stags on two consecutive days. The stags that had their antlers removed on the first day showed an increase in heart rate when handled on the second day. The control stags showed a decrease in heart rate when handled for the second consecutive day, suggesting that velvet antler removal was a stressful experience.

The extent to which an animal exhibits an escape reaction has also been associated with pain. This observation is usually scored subjectively, which may produce questionable consistency and accuracy (Schwartzkopf-Genswein et al. 1997). In a study performed on beef cattle, Schwartzkopf-Genswein et al. (1997) quantified the response of an animal being branded by measuring the force it exerted on the restraining device. The force data showed clear differences between two branding treatments, indicating the more painful procedure. In a related study, Schwartzkopf-Genswein et al. (1998) used image analysis to determine the animal's response to the branding procedure. The motion of each animal's head was videotaped, and image-processing software was used to calculate the distance and velocity with which the animal's head moved. The extracted data also showed differences in response between branding treatments. Although image analysis was found to be more sensitive than force measurements to quantify the escape response of cattle, restraining devices that hold the elk's head would eliminate this technique as an option for measuring animal discomfort.

The reviewed literature has revealed that researchers have attempted to measure animal discomfort in a variety of ways. Techniques used to measure discomfort have included post-treatment monitoring, plasma cortisol levels, and heart rate measurements. These parameters can be elevated by other environmental factors, including handling and restraint stresses. Recent attempts to correlate the struggle of a restrained animal with the pain experienced during a management procedure seem promising. However, differences in restraining devices would not allow techniques developed for cattle to be directly applicable to elk during antler removal.

OBJECTIVES

The objectives of this study were to:

(1) develop a system to physically measure the escape response of elk during velvet antler removal,

(2) evaluate the performance of the response-measurement system in a commercial setting, and

(3) suggest improvements for future developments.

MATERIALS AND METHODS

Animals

Sixty male elk, ranging in age from three to nine years, were used in this study. The animals were familiar with the handling facilities from their previous annual experiences. As is typical in an extensive commercial operation, all-terrain vehicles were used to herd the animals from pasture paddocks into the handling facility, where they waited before being individually moved into the chute. Figure 1a shows the side view of an animal being restrained. Each animal was captured by moving it into a chute and closing the end door. The side panels of the chute were padded and could be moved horizontally and vertically by hydraulic actuators. To restrain the animal, the side panels were contracted, holding the animal's neck below the jaw. The side panels were then raised slightly to lift the head of the animal, giving it less mobility. Further restraint was provided by a halter that fit over the animal's nose and behind its ears. Two ropes were fastened to the rings at the ends of the halter's nose strap and extended down along the outside of the side panels. Each rope was secured to one side of a force transducer that was connected to the bottom of each side frame.

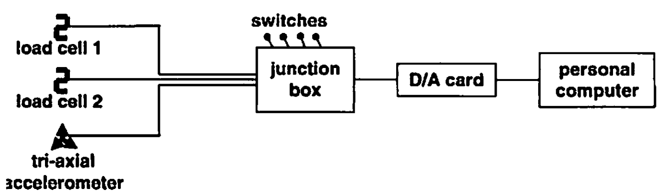

Fig. 2. Schematic of instrumentation and data acquisition system.

Data acquisition intervals

To quantify the response of the animals, it was necessary to know each animal's "normal reaction" while in the chute. A baseline measurement prior to any operation allowed subsequent data to be adjusted for the animal's response while in the chute, making the comparison of different animals possible. It was expected that the noise from the saw would also induce a response in the animal. Therefore, a second baseline was collected for a period with the saw running near the base of the antler prior to cutting. Our primary objective was to record the animal's response during the cutting and it was important to be able to discriminate between the cutting periods of each antler. Finally, it was thought that animal response during the time immediately following the cutting may also be indicative of the severity of the procedure. Therefore, the animal's post-operative response was also recorded.

Animal response instrumentation

Included as part of the animal restraining devices was equipment capable of measuring the animal's response during the procedure. Two 2200-N load cells (LCFD-500, Omegadyne, Inc., Laval, QC) were connected to the steel bars running lengthwise along the bottom of each side frame (Fig. 1b). The load cells were connected in line with the restraining ropes to sense tension variations produced by the animal. A movement or force exerted by the animal changed the tension in the ropes and allowed the animal's response to be quantified.

A triaxial accelerometer (ADXL05 EM-3, Analog Devices, Inc., Norwood, MA) was mounted on the nose strap of the halter as shown in Fig. 1a. This allowed the acceleration of the animal's nose to be measured in three directions. The exact orientation of these directions was dependent upon the position of the animal's head when restrained. Generally, the top surface of the animal's nose was level, or at a slight angle, when it was restrained. The accelerometer was situated such that the positive x-axis was directed down the length of the nose, picking up any forward and backward head movement. The positive y-axis pointed horizontally to the right side of the animal's head and recorded the left to right motion of the head. The positive z-axis pointed upward, normal to the animal's nose, and it recorded the vertical motion of the head.

Figure 2 shows a schematic of the instrumentation and data acquisition system. A junction box supplied the load cells and accelerometer with power and assembled the output signals from the instruments. The junction box also contained four switches that governed the voltage level of a marker channel. The marker channel was used to identify noteworthy points during data collection and to start and stop data acquisition sequences. Each switch produced a different voltage output, allowing a range of trigger/marker levels. The junction box was supplied with 12 V at 250 mA by a transformer receiving a 60 Hz 120 V a/c power supply. The box contained voltage regulators that supplied 5 V to the accelerometer and ± 5 V to each load cell.

The junction box had six analog output channels: two load cell signals, three accelerometer signals, and a trigger/marker signal. From the junction box, the six signals were transmitted to an external data acquisition card (OMB – TempBook/66, Omega Engineering Inc., Stamford, CT). The signals were then digitized and sent to a personal computer (Satellite Pro 470 CDT, Toshiba Corporation, Tokyo, Japan) by a parallel port connection.

Data acquisition procedure

The data acquisition process was controlled by programs compiled in data acquisition software (Labtech Notebook, Laboratory Technologies Corporation, Wilmington, MA). The software was able to record input signals from up to nine channels, one being a trigger channel used to control the data acquisition program. At the completion of a program, the data were automatically logged to a data file.

The data acquisition program used during the cutting procedure had a sampling frequency of 20 Hz. The program was triggered by toggling a switch on the junction box, causing data to be collected for a five-second baseline. This was used to represent the animal's response while being restrained in the chute, as well as to measure the initial tension in the ropes. The same switch was toggled again, resuming data collection for a second five-second interval while the saw was running. The switch was turned on a third time to restart data acquisition and indicate when cutting of the first antler began. The switch was turned off to mark when cutting of the first antler was complete. A second switch was turned on to mark the instant that the second antler removal started. When the cut was complete, the second switch was turned off and the program ran for ten more seconds before ending. This sequence of triggers and markers allowed all portions of the procedure to be clearly identified in the data file.

When the program was complete, the data were stored in a file that could be accessed by a computer spreadsheet (Microsoft Excel, Microsoft Corporation, Redmond, WA). Each file contained seven columns: time, trigger/marker, load cell 1, load cell 2, and x, y, and z accelerations. The elapsed time was recorded in seconds and the acceleration and trigger/marker values were in volts. The signals from the load cells were converted into force values (newtons) by a calibration equation in the data acquisition program.

RESULTS and DISCUSSION

The accelerometer data provided a time history of the accelerations resulting from the motion of the animal's head. Figure 3 shows harmonic vibrations sensed by the accelerometer while the saw was in contact with the antlers (intervals C and D). By comparing signals of force history in the same figure with accelerometer output, it is clear that the accelerometer was responding to something other than animal-induced movement. Because the saw vibration obscured the accelerations from the animal's motion, the data were used solely to confirm the periods in which cutting occurred.

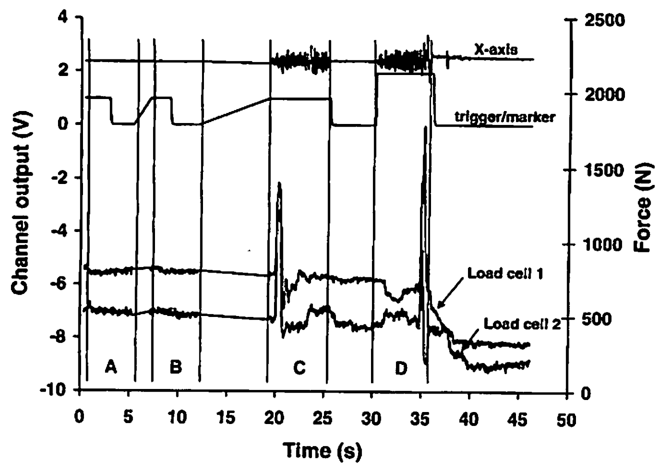

Fig. 3. Typical output from the x-axis of the accelerometer and trigger/marker channel (voltage) with force histories from the 2 load cells. Interval A represents the initial 5-second baseline, interval B is the 5-second baseline with the saw on, and intervals C and D represent the cutting of the first and second antlers, respectively.

The force histories from the load cells, seen in Fig. 3, showed an excellent representation of the animal's response to the procedure. The large spike at the beginning of the first cut (interval C) is a strong indication that the animal was experiencing some discomfort. A similar spike is present at the end of the second cut. The spikes were a common reaction for many of the animals tested.

One problem with the system, as illustrated in Fig. 3, was that the baseline value tended to change with the shifting of the animal. The initial intent was to subtract the baseline measurement from the forces measured during the two cutting periods to determine a relative response due to the procedure. Often this was possible for the first antler, but between the two cutting periods the animal readjusted itself to a new steady value. Thus, subtracting the initial baseline average value from the force histories would not result in meaningful results.

Other problems resulted from the methods used to restrain the animal. As previously mentioned, the squeeze could be adjusted both vertically and horizontally. Because of this, different animals had more or less leverage against the ground, affecting their ability to struggle. Also, the initial tension in the ropes varied by a large amount among animals. This was due to the way each animal was restrained within the squeeze chute. A larger initial force restraining the elk's head via the halter may have caused the animal to "submit" more readily than an animal tied less securely. Also, the orientation of the ropes was not consistent among the animals due to their forward or backward movement. This made it impossible to determine a force vector and the scalar values could only be compared.

The data acquisition system worked flawlessly. The junction box was essential to organize the output signals and supply power to the instruments. The data acquisition software made programming easy and the method of data logging provided a great deal of convenience.

CONCLUSIONS and RECOMMENDATIONS

The system, incorporating load cells inline with the halter tie-down ropes, was able to sense the escape response of elk. The tensions in the tie down ropes did not accurately represent the forces exerted by the animals. However, the values did represent the relative response of each animal, allowing different animals to be compared. However, a better comparison would be possible if the system-induced errors such as friction were eliminated. For a more accurate representation of the force exerted by an animal, a different arrangement would be required. An optimum design would enable the force from the animal to be measured in three directions, without any system interference. If a system such as the present one was to be utilized, it would be important to maintain a consistent baseline rope tension for all animals throughout the entire procedure. This would eliminate the possibility of the animal submitting because it was tied down too securely and allow baseline readings to be extracted from the raw data.

The implementation of the accelerometer was not beneficial in capturing the response of the animal. The vibrations caused by the saw obscured the data and made it difficult to discern movement initiated by the animal. However, the accelerometer data clearly indicated the time during which the saw was in contact with the antler. This made the accelerometer signal useful as a marker to confirm the duration during which an antler was removed.

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