CAPTURING AND HANDLING OF WILDLIFE:

APPROACHES TO REDUCING STRESS

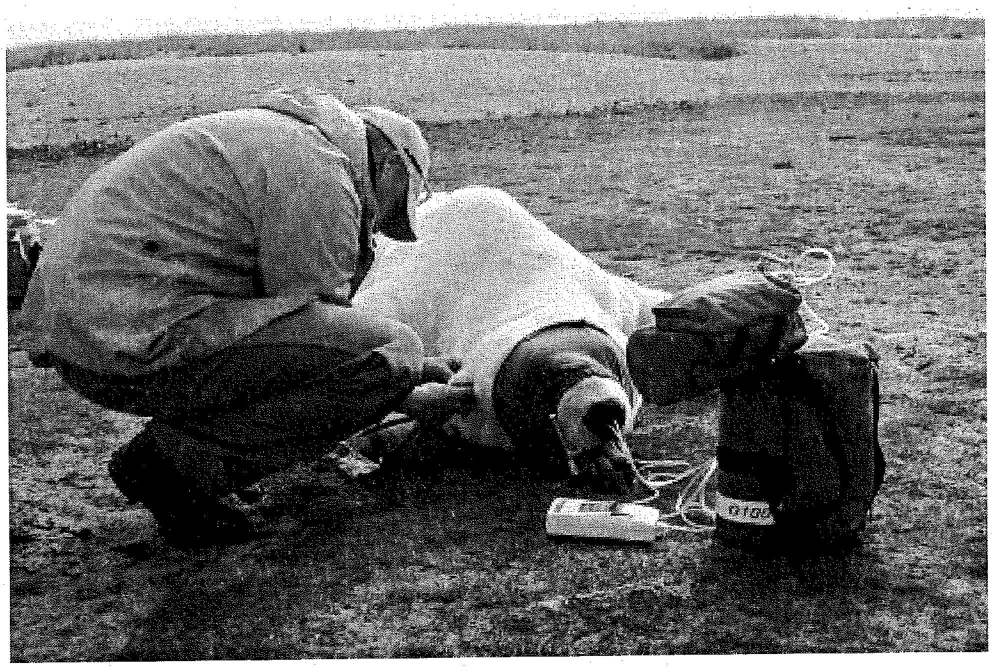

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Table of Contents

Capture and Handling of Wildlife

Approaches to Reducing Stress

Introduction: An Energetic Perspective on Stress and Distress

Marc Cattet

The biological response to stress requires energy. When stress is extreme or prolonged, energy is used at the expense of other biological functions, i.e., reproduction, immune response, etc. This is termed 'distress'. Without careful consideration and planning, the techniques used to capture and handle wildlife can result in altered biological function, or sometimes death.

STRESS AND DISTRESS

The purpose of this course is to examine different approaches to capture and handle wildlife with the goal of reducing stress. However, because the term 'stress' is used so broadly in our day-to-day lives, it is essential to first develop a common perspective on stress before exploring its significance to wildlife health. Although defining stress will provide a logical starting point, to further our understanding of how animals are affected by the stresses of capture and handling will require a simple conceptual model, one that provides an energetic perspective.

Definition: "Stress is the biological response elicited when an animal perceives a threat to its well-being."

An animal can be viewed as a combination of interdependent biological functions, all of which require energy to maintain (Fig. 1). The maintenance and growth of tissues, the immune response, and reproduction represent some of the many biological functions that draw energy from the food ingested by an animal, or from the energy stored in its body tissues, i.e., fat and muscle. Similarly, the stress response is also a normal biological function that is critical for survival and, like all other functions, draws on an animal's energy resources.

The stress response is activated when an animal perceives a threat to its well-being (Fig. 1). Although what defines a threat (also called a 'stressor') varies considerably from one animal to the next, few would disagree that capture and handling is perceived as threatening by many animals. In general, the stress response allows an animal to cope with a threat in an appropriate way – it might be to flee in the face of a predator, or to fight a conspecific, or to shiver when exposed to sudden cold temperatures, or to reduce metabolism when faced with food deprivation. Regardless of what the response is, it will not be without a cost in energy.

Stress is a part of life and all animals have evolved mechanisms to cope with the threats encountered during their lives. In general, the biological cost of these day-to-day threats is minimal because sufficient reserves of energy exist to cope with the cost of the threat. Yet, when threats are severe or prolonged, animals can suffer from the burden of stress – a state called 'distress' (Fig. 1). In this state, they may succumb to disease or fail to reproduce or develop properly.

Although the harmful effects of distress vary among individuals and are not easily predicted, a common thread is that the energy available for stress is insufficient to cope with the cost of the threat, and resources must be shifted away from other biological functions to meet the threat. For example, when stress shifts energy away from growth, a young animal no longer thrives and its growth is stunted. When energy is shifted from reproduction, reproductive success is diminished. In such cases, the period of distress lasts until the animal is able to replenish its energy reserves sufficiently to restore normal function.

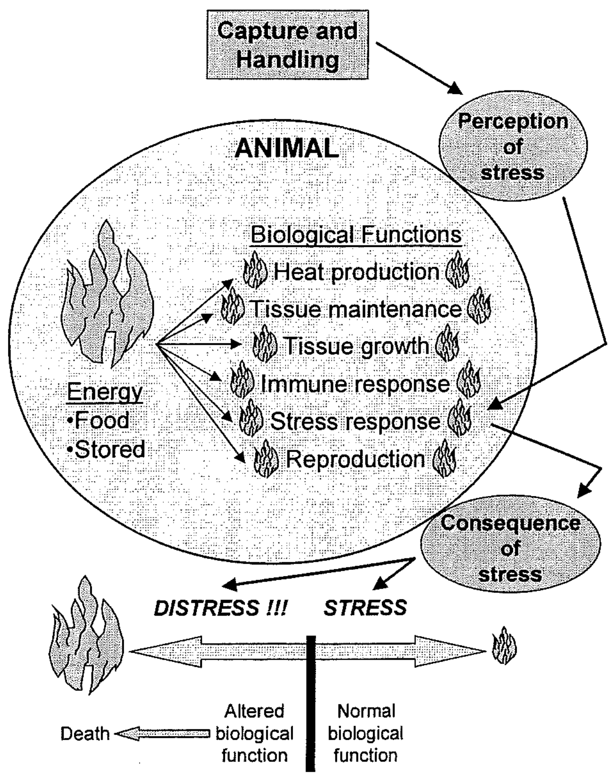

Figure 1. Using an energetic model of stress, an animal is viewed as a combination of interdependent biological functions, all of which require energy to maintain. The stress response is one of many normal biological functions drawing on an animal's energy resources. Because capture and handling is perceived as a threat by many animals, it elicits a stress response. If the stress of capture and handling is minimal, the biological cost is small because sufficient reserves of energy exist to cope with the cost of the threat. However, if the stress is severe or prolonged, available energy for stress is insufficient to cope with the cost of the threat, and resources are shifted away from other biological functions to attempt to meet the threat. This is termed distress.

CAPTURE AND HANDLING STRESS

The procedures used to capture and handle wildlife induce stress, but also have potential to cause distress, adversely affecting animals in many ways. Physical trauma, bloat, and convulsions are distresses that are readily observed. Other distresses are less visible, detected only through careful examination and frequent monitoring of captured animals. Nevertheless, even these unapparent complications such as capture myopathy, hypoxia, shock, and respiratory arrest are distressful and life-threatening. Unfortunately, many wildlife professionals have long tended to evaluate the safety of capture and handling procedures for target animals based solely on mortality rates. And yet, death simply represents the final common outcome for a large array of potential distresses – in general parlance, it is only the tip of the iceberg. Ultimately, our ability to reduce capture and handling stress in wildlife will be dependent on our ability to first recognize signs of stress and distress.

Effects of Capture and Handling Stress on Wildlife Health

Marc Cattet

An energetic model of stress provides a convenient mean to understand how capture and handling can distress wildlife. For example, in hyperthermia (or overheating) and capture myopathy, the demand for energy to meet perceived threats largely exceeds an animal's capability to maintain tissue function and integrity.

INTRODUCTION

The procedures used to capture and handle wildlife have potential to cause distress, adversely affecting animals in many ways. Some effects are short-lived, lasting hours or perhaps a day at most, e.g., hypothermia. Other effects are far more serious, resulting in long-term impairment of physical function, or sometimes death. In this talk, the energetic model of stress (Fig. 1 on page 2) will be used to explain the development two distressful conditions that can occur during the capture and handling of wildlife, hyperthermia and capture myopathy.

HYPERTHERMIA

Hyperthermia is excessive elevation of body temperature. It is one of the more commonly encountered capture-related emergencies, and a major cause of mortality in animals immobilized under high ambient temperatures. It is typically caused by a combination of increased heat production and inability to effectively dissipate body heat. It is reliably recognized by a critical rise in body temperature to above 41°C (106°F).

Using the energetic model of stress (Fig. 1 on page 2), hyperthermia can be viewed as resulting in distress when its demand for energy largely exceeds an animal's capability to maintain tissue function and integrity. The consequences of hyperthermic distress can also adversely affect reproductive function. The following outlines the threat, the stress response, and the consequences of distress:

1. The threat

The threat is one, or more often a combination, of the following factors:

- Pursuit, especially when prolonged;
- Restraint, especially when prolonged
- Chemical immobilization (increases heat production and/or inhibits heat dissipation); and
- High ambient temperatures and/or intense solar radiation.

The threat is exacerbated under a variety of conditions that include: (1) little wind exposure; (2) large surface-to-body mass ratio; (3) dense hair coat; (4) dark hair color; and (5) any underlying condition (infectious disease, trauma) associated with fever.

2. The stress response

- Increased respiratory ventilation by rapid, shallow breathing (panting).
- Increased heart rate and blood flow to superficial tissues coupled with increased dilation of superficial blood vessels, i.e., vasodilation.

3. The consequences of distress

- Dehydration – prolonged panting may result in a significant loss of body water.
- Fetal developmental anomalies or death.
- Reduced reproductive function in females (anestrus) and males (transient sterilization).
- Shock – caused by excessive and prolonged vasodilation.
- Cellular damage to critical organs including brain, kidney, and liver – caused by the oxygen demand of tissues exceeding the capability of the cardiovascular and respiratory systems. This leads to cellular damage as a result of hypoxia, hyperthermia, and intravascular clotting of blood.
- Death – shock and cellular damage can result in death.

CAPTURE MYOPATHY

Capture myopathy is a disease syndrome that has long been recognized to occur in wild mammals and birds, and also on occasion in domestic animals and humans. In wildlife, it is typically caused by prolonged physical exertion and stress associated with pursuit, restraint, handling, and transport. Capture myopathy is best described as a syndrome because of its many manifestations which, undoubtedly, help explain the numerous other names for the syndrome, including muscular dystrophy, white muscle disease, stress myopathy, and exertional rhabdomyolysis.

Using the energetic model of stress (Fig. 1 on page 2), capture myopathy can be viewed as a severe or prolonged stress response; its demand for energy largely exceeding an animal's capability to maintain tissue function and integrity. The following outlines the threat, the stress response, and the consequences of distress:

1. The threat

The threat is one, or more often a combination, of the following factors:

- Pursuit, especially when prolonged;
- Chemical immobilization;
- Excessive or prolonged stimulation (physical, visual, auditory); and/or
- Other animals, e.g., incompatible conspecifics.

In the face of these, the likelihood of an animal developing capture myopathy is increased under high ambient temperatures, or when the quality of nutrition is poor, e.g., deficient in vitamin E, selenium, and copper.

2. The stress response

- "Mass discharge" of the sympathetic nervous system – results in (1) increased arterial pressure; (2) increased blood flow to active muscles and decreased flow to organs that are not needed; (3) increased metabolism and availability of glucose; (4) increased muscle strength; and (5) increased mental activity.
- Intensive muscular activity to allow "fight or flight."

3. The consequences of distress

As indicated, capture myopathy is a syndrome with many possible outcomes including:

- Circulatory shock – caused by continuous stimulation of the sympathetic nervous system and results in inadequate delivery of nutrients (glucose and oxygen) and removal of cellular wastes (lactic acid) from tissues.
- Weakness and brown urine – caused by inadequate removal of cellular wastes (lactic acid) from muscle, intense heat production within muscle, and inadequate delivery of oxygen to the kidneys. Myoglobin, an oxygen-transporting pigment of muscle, is released into the circulation from degenerating muscle and excreted in the urine giving it a characteristic brown color.
- Muscle rupture – caused by extensive muscle damage (from acid accumulation and heat) preventing skeletal muscles carrying out normal function including bearing weight. The most common location for rupture is the proximal third of the gastrocnemius muscles.
- Cardiac arrest – this is a delayed effect that may occur days or weeks following the initial stress. It is generally initiated by a subsequent stressful event and is caused by electrolyte imbalances (resulting from previous muscle necrosis) resulting in functional abnormalities of the heart, i.e., ventricular fibrillation and cardiac arrest.
- Death – each of the above consequences can result in death.

Capture and Handling of Wild Birds: Effects of Stress on Research Results

Karen Machin

Many field and laboratory studies use various forms of manipulation (e.g. capture, handling, blood sampling, marking such as: banding, radio transmitter attachment, etc.) to gain more insight into animal ecology and behaviour. However, little attention is given to the ethical and conservation implications of such wildlife manipulations. Stress associated during capture, handling, and with instrumentation may have sublethal consequences, which may interfere with normal behaviour, reproduction or other biological functions. It is unrealistic to think that such manipulations will have "no effect" and survival should not be used as the only measure of success of a procedure.

Through a series of examples I hope to demonstrate the sublethal effects of capture and handling on wild birds.

1. Evaluation of Isoflurane and Propofol Anesthesia for Intra-abdominal Transmitter Placement in Nesting Female Canvasback Ducks

Studies of waterfowl rely frequently on radiotelemetry, and intra-abdominal radio transmitters are often used preferentially over externally mounted transmitters because they appear to have less impact on behavior, health, survival and reproduction in ducks. Anesthesia has therefore been employed to facilitate transmitter placement, reduce stress during handling and minimize disruption of normal behavior after release. Methoxyflurane has been used to decrease nest abandonment following handling but poor control of anesthetic depth and rough recoveries are experienced with its use. One hundred eighteen canvasbacks (Aythya valisineria), at 15 to 18 days of incubation, were assigned randomly to 3 treatments so that nest abandonment could be compared among treatments. Sterile dummy silicone implants were surgically placed while ducks were anesthetized with either propofol or isoflurane, or ducks were flushed from the nest but not captured (control). Isoflurane was delivered in oxygen and propofol was delivered through an intravenous catheter. Propofol provided smooth, rapid induction and recovery, whereas, ducks recovering from isoflurane tended to struggle. At the nest, ducks in the propofol group were given additional boluses until they were lightly anesthetized, whereas, birds that received isoflurane were released. All birds survived surgery. One mortality occurred prior to surgery in 1995 using propofol during a period without ventilation and monitoring. Adequate artificial ventilation is recommended to prevent complications. Nest abandonment occurred in all treatment groups in both years, but propofol (15.4%) and control groups (7.5%) had lower than expected abandonment compared to isoflurane (28.2%). Propofol offers several advantages over isoflurane for field use; equipment is easily portable, anesthetic cost is reduced, and ambient temperature does not alter physical characteristics of the drug. Advantages over isoflurane, combined with lower nest abandonment following intra-abdominal radio transmitter placement, make propofol a good anesthetic choice for field studies.

2. Nest Abandonment in relation to Stress

Stress includes a cardiovascular effect and a hormonal response associated with the sympathetic-adrenal medullary system and the hypothalamic-pituitary-adrenocortical axis. In birds, corticosterone is the major adrenal glucocorticoid hormone produced in response to a stressor. Birds show a rapid increase of circulating plasma corticosterone in response to a variety of stressful stimuli including capture and handling. Increased adrenocortical secretion may have marked deleterious effects on reproduction, behaviour, and immunocompetence, and may also alter metabolism. Chronically high levels of stress can have negative consequences on an individual. Thirty six canvasbacks (Aythya valisineria) trapped on the nest between 10 and 12 days of incubation were assigned randomly to 2 treatments so that nest abandonment and plasma corticosterone levels could be compared among treatments. Half of the ducks were anesthetized with intravenous propofol during the procedure (handling, and banding) while the remainder were not anesthetized (control). Blood samples were taken at the beginning and end of the 20 minute procedure. Initial blood samples were taken within 3 minutes of initial disturbance (approaching the trap). Propofol anesthetized ducks recovered on the nest without human disturbance while unanesthetized ducks were released at the nest. Corticosterone levels were determined using a DPC Coat-a-count radio immunoassay corticosterone kit. Corticosterone levels were significantly higher in the control group after handling compared to ducks that were anesthetized with propofol. However, nest abandonment in the control and anesthetized groups did not differ but power may be been low due to small sample size. Corticosterone levels reflected acute stress associated with handling but corticosterone may not predict post-release behaviour (nest abandonment). Nest abandonment is likely multifactorial in cause and changes in corticosterone responses in different situations may not be mirrored by changes in corticosterone.

3. Effects of Intra-abdominal Transmitter Implants in Mallard Ducks

Intra-abdominal radio transmitters are used to provide valuable information on reproduction, movement patterns, habitat use, and survival in a variety of wildlife species, including waterfowl. Pre-laying female mallard ducks (Anas platyrhynchos) were decoy trapped during April 1998 and randomly assigned to receive either 5mg (0.05ml) ketoprofen (Anafen, Rhône Mérieux Inc. Athens, Georgia) intramuscularly (IM) or 0.05 mL saline IM. Forty females from 3 sites, and thirty-nine females at a 4th were anesthetized with isoflurane and implanted with a 22 g transmitter. Time of ketoprofen delivery, surgeon and length of surgery were recorded. Ketoprofen or an equal volume of saline was injected shortly before surgery and observers were blind to treatments. Data collected from radio tracking were used to estimate various measures of reproductive effort for each marked female: nest initiation date, number of days from surgery to nesting, number of nesting attempts, number of days devoted to egg laying and incubation, and nesting success, where one or more eggs hatched. Hen survival, and distance hen moved within a day and average for 3 days post-operatively from trapping site were also determined. Average daily distance moved over 3 days, proportion of females that nested, and nested successfully did not differ between groups. No difference between ketoprofen- or saline-treated groups was found in number of nests initiated days from surgery to initiation of the first nest, initiation date, or days spent in laying and incubation. However, the likelihood of initiating a nest was positively related with length of surgery. Similarly, days from surgery to initiation of the first nest was longer (3.5 days) for saline-treated females than ketoprofen-treated females, although non-significant. Hen survival did not differ between treatments and survival was greater than 13 days in all cases. No difference between treatments was found in number of days surviving following surgery.

Using data from a similar study of 10 years of implanting decoy trapped female mallard ducks in the 3 provinces of Alberta, Manitoba, and Saskatchewan the nest initiation date were compared between ducks that were trapped and anesthetized with isoflurane to place an intra-abdominal transmitter and ducks not captured on the same study areas. Ducks that were not captured nested an average of 19 days earlier than those that were captured and implanted. Analgesia can improve recovery but cannot not eliminate effects of poor sterile technique and long surgery times. This data also suggests that implanting a radio transmitter has significant sublethal effects that would not be detected using survival alone.

4. Effects of Intra-abdominal Radiotransmitters with External Whip Antennas

Intra-abdominal radiotransmitters with external whip antennas were surgically implanted in 50 free-flying mallard hens during the fall of 2000 (9 months prior to nesting season) as part of a mallard nesting ecology project. During the following nesting season (spring 2001), the location of 25 of the 50 implanted mallards was known and of those only 1or 2 were showing nesting behaviour. In an attempt to determine the cause of this abnormal behaviour, 12 mallards were collected for necropsy: 7 controls and 5 implanted mallards. The histopathology results demonstrated a that a fibrous tissue sac surrounding the implanted transmitters in 4 submitted cases were fibronecrotic with evidence of bacterial contamination. These results demonstrate a sublethal effect on reproductive behaviour. In addition, external whip antennas which penetrate the body wall may be a source of chronic and sublethal infection.

Capture and Handling of Wild Mammals: Effects of Stress On Research Results

Gord Stenhouse – Wildlife Carnivore Biologist, Alberta Fish and Wildlife Division

We study, monitor, and track individual animals to increase our understanding of how a population behaves. However when we ignore, or group individual variation in behaviour, we often miss crucial information that will make us better researchers and stewards of the resource.

Introduction

As part of ongoing wildlife research and management activities those involved in gathering data necessary to make management decisions have been involved in the capture of a range of wildlife species in North America over numerous decades. Throughout the tens of thousands of animal captures which that have taken place, the focus has been on the safety of both researchers and the animal being handled. We all must wrestle with questions around whether the capture and handling of a species will provide the data needed for the research question that will ultimately benefit the conservation of populations. Although we all hope that the capture and handling of wildlife does not have a detrimental impact on the species under investigation, often we have little or no data with which to critical review this feeling. In recent times however, researchers have also tried to understand how the capture and handling of an animal affects the data that we use to make important decisions.

It is important to ask these questions not solely as it may affect research results but because an improved understanding of the effects of capture and handling, and the stresses this causes, will ultimately advance the techniques we now use to conduct research studies. From a management perspective we will have more confidence that we have used data where the impacts of animal capture have been reviewed and incorporated.

Researchers working in the field of wildlife management have made significant advances in the techniques and tools that we now use to capture, handle, and track wildlife. These advances have included new chemical immobilization drugs and reversal agents, remote injection equipment, physiological monitoring techniques, and of course significant electronic advances in radio telemetry equipment.

This presentation will focus on the advances in radio telemetry and what these advances have allowed us to learn not only about animal movements and habitat use, which are standard questions for researchers, but how captured animals respond to the whole capture and handling sequence.

A review of Bear Capture and Handling on Research Results

Today I will present an overview of typical bear capture and handling techniques as these relate to animal recovery after handling.

Biologists involved in the capture and handling of bears (polar, grizzly and black bears) face many challenges since these species occur at low densities, in remote habitats, and of course pose a risk to capture personal. In most capture operations of these species the capture team immobilizes the animal, takes measurements, collects samples, and attaches radio-tracking equipment.

Often due to circumstances related to field logistics the capture team departs the capture site after handling has been completed. In the past, where no reversal agent was administered, researchers would often be leaving a bear that was still partially immobilized and not fully recovered from the handling procedures. A common field protocol often involved revisiting the capture site and "checking" on the bear sometime later that same day or at a minimum the next day. This check would focus primarily on whether the bear was no longer seen at the capture site, and assuming the bear was not present, the capture team would conclude the recovery had been successful.

Since the advent of reversal agents, research teams are often able to witness the recovering bear move away from the capture site, which is a significant advancement. However often the bear moves into dense cover or into an area where visual contact is impossible and thus it is often still not possible to witness the full recovery sequence.

The advent of GPS radio collars for wildlife research has resulted in the collection of a wealth of new information on bear movements and behaviour. These new radio collars can be programmed to record the location of a bear every few hours or few minutes if you wish. The actual choice of the GPS location schedule programmed into a collar is a combination of choices related to the research question being asked and the battery life of the radio collar.

Over the course of the past 3 years we have collected over 25,000 GPS data points from grizzly bears which were captured and radio collared along the east slopes of Alberta in and to the east of Jasper National Park. The focus of this research effort is to look at the effects of human activity on grizzly bear habitat use and grizzly bear health.

To address the research questions before us we programmed the GPS collars on our study animals to collect a location once every 4 hours until denning occurs. In some cases collars collected a location every 2 hours. These data have also provided us a unique opportunity to determine how grizzly bears behave (move) following a capture and handling sequence.

Data will be presented which shows the range of movement patterns following capture and handling, among and between individuals, during this research program. These results should be considered when researchers are attempting to analyze bear movement data after the capture period. These data also are important for those involved in the problem bear management who often are concerned about bear movements at and around a relocation site.

CCAC guidelines on: the care and use of wildlife

A. PREFACE

1. The Canadian Council on Animal Care (CCAC) is responsible for overseeing the use of animals in research, teaching and testing. Participation in the CCAC program is mandatory for academic institutions. Failure to adhere to CCAC guidelines and policies may lead to suspension of funding for research programs and/or institutions (CCAC **guidelines on: responsibility for the care and use of animals in research, teaching and testing**).

2. The care and use of wildlife is regulated through provincial, territorial and federal legislation. Some agencies have adopted animal care guidelines, including those of the CCAC, and have established internal committees that oversee the care and use of wildlife for research, management and operational procedures. While CCAC has no authority over these agencies, many are keenly interested in and/or are participating in aspects of the overall CCAC program.

3. In addition to the CCAC *Guide to the Care and Use of Experimental Animals,* Vol. 1, 2nd Edn., 1993 and Vol. 2, 1984 which lay down general principles for the care and use of animals, the CCAC also publishes guidelines on issues of current and emerging concerns (**http://www.ccac.ca**). The CCAC guidelines on: the care and use of wildlife is the sixth of this series. This document replaces Chapter XXII, *Wild Vertebrates in the Field and in the Laboratory*, *Guide to the Care and Use of Experimental Animals*, Vol. 2, 1984.

4. The refinement of animal care and use guidelines is an evolving process. The **CCAC guidelines on: the care and use of wildlife** have drawn substantially from the work of the organizations listed in Appendix A. Permission kindly granted to CCAC to use sections of guidelines developed by their various committees is gratefully acknowledged. Relevant information not included in the listed guidelines is referenced separately.

5. The guidelines have been developed by the CCAC subcommittee on wildlife. A preliminary first draft was agreed on by the subcommittee in April 2001 and circulated to all federal/provincial wildlife directors to seek their early input. The first draft of the guidelines was circulated in August 2001 to 56 experts (including officials of the organizations listed in Appendix A). A second draft of the guidelines was circulated for widespread comment in January 2002. The development of the guidelines was facilitated by workshops held in Halifax NS, April 2001, in collaboration with the Atlantic Provinces Council on the Sciences and in Edmonton AB, November 2001, in conjunction with the University of Alberta.

B. INTRODUCTION

6. These guidelines are necessarily broad and are limited to basic principles that will assist investigators, wildlife managers, and animal care committees (ACC) in the development and review of protocols and standard operating procedures (SOP). Although CCAC's mandate extends to the use of animals in research, teaching and testing, for the purposes of this document this is interpreted broadly to include population management, problem animal control and other forms of wildlife management where the welfare of animals is at stake. These guidelines are expected to be of use to researchers and resource managers from universities and colleges, zoological parks, research institutions, natural resource agencies, resource industries, government and/or its agencies, non-government organizations, and consultants retained by public institutions and agencies. Additional recommendations for the various species groups of wildlife have been developed in conjunction with these more general guidelines and are published on the CCAC website (http://www.ccac.ca).

7. Studies on wildlife in the field and in captivity may include a wide range of invasiveness and involve species that vary greatly in their response to humans. This tremendous variation in animal body size, physiology and behavior needs to be considered to determine the most effective means of capture, restraint and handling. The controlled parameters of studying test subjects in a laboratory setting do not form a good model for conditions likely to be encountered in field studies; nevertheless, good welfare practice in the field is characterized by the same features as in laboratory based research. When evaluating protocols for studies that are to take place in the natural habitat of the animal, ACCs should recognize that conditions may require different approaches and procedures than those dictated in a laboratory environment.

1. Definition of Wildlife

Guideline: For the purposes of this document, wildlife refers to free ranging or captive wild vertebrates, including amphibians, reptiles, birds, and mammals (but excluding fish). This includes introduced or feral species.

8. Definitions of wildlife may be restricted to game birds and mammals or expanded to include all wild organisms and their habitats. Practical considerations; however, require a definition that limits the number of species and is acceptable to a wide spectrum of wildlife professionals. CCAC **guidelines on: the use of fish in research, teaching and testing** are published separately. Guidelines for research on domestic commercial wildlife (for example, bison and deer) are published within the CCAC **guidelines on: the use of farm animals in research, teaching and testing**. Other guidelines should be consulted for animals maintained in zoological institutions (Canadian Association of Zoos and Aquariums [CAZA]; Zoo and Aquarium Association [AZA]).

2. Rationale for Wildlife Guidelines

9. Investigations involving wildlife and their habitats are of profound importance to the understanding and appreciation of our relationship with the environment (ABS/ASAB, 1997). The knowledge gained from such endeavors can be vital for the well being of human societies, as well as for providing information for the conservation and ethical treatment of vertebrates both in the wild and in captivity. Although acquisition of scientific knowledge and understanding may justify wildlife research, often the effects of field research procedures on subject animals or their habitats cannot be predicted. Many field studies of wild vertebrates involve simple observations of the animals. Other research questions can only be answered by manipulating the animal to some degree, either

in the field or in captivity (ABS/ASAB, 1997). Studies may disrupt normal animal activities, especially if capture, marking, or other more invasive procedures are used. These guidelines aim to minimize stress while working with wildlife. When stressed, animals may behave abnormally and possibly be placed at greater risk due to increased susceptibility to predation or accidents. Stress also reduces survival, performance, and reproduction.

10. The use of wildlife in research, as well as in teaching and testing, raises ethical questions that must be addressed prior to the initiation of the project. Adequate review of the protocol is critical to ensure that proposed field research procedures or techniques minimize adverse habitat conditions, distortion of the behavior of animals, or other risks to the animal(s). Wildlife management studies may have alteration of habitat or behavior as a goal, but this should be balanced against the risk for the animals. Humane treatment of wildlife held captive requires that conditions provide the necessities of normal existence, and ensures that they can be returned to the wild, if considered appropriate, with no impairment in their abilities to resume their normal activities, including reproduction.

11. Wildlife involved in studies must be treated humanely, not only for ethical and legal reasons, but also for scientific reasons (ASB/ASAB, 1997). In general, ethically acceptable procedures should minimize interference to individual study animals, populations, and their habitats, and thereby increase the validity of the experimental data.

3. Ethics on the Use of Wildlife

Guideline: The use of wildlife for research, teaching and testing is acceptable only if it contributes to the understanding of fundamental biological principles, or to knowledge that can be expected to benefit humans, animals or ecosystems. Expert evaluation of proposals must attest to the potential value of studies involving wildlife.

12. The CCAC *Ethics of Animal Investigation* (1989) applies equally to wildlife used for research, teaching and testing as it does to laboratory animals. The underlying ethical basis of CCAC guidelines and policies requires adherence to the three principles of humane experimental technique outlined by Russell & Burch: Replacement, Refinement and Reduction (Russell & Burch, 1959). According to the CCAC, adherence to the Three Rs means:

- Animals may be used only if the researcher's best efforts to find a replacement by which to obtain the required information have failed. Replacement of a rare or threatened species with a more common species is more desirable in terms of conservation impacts. However, it will not affect the welfare implications of the work, as the replacement species is likely to be closely related and of a similar sentience. It is recognized that where the aim of field studies is to understand the ecology, ecophysiology, or behavior of wildlife, replacement by a non-animal method, or even replacement of one species with a less sentient species may not be an option.
- The most humane, least invasive techniques should be used; pain and/or distress should be minimized. The animal's physical and psychological well being must take precedence over considerations of cost and convenience. In addition, refinement should aim for the use of techniques which have less potential to impede normal behaviors, and investigators should use opportunities to publish refinement techniques to improve welfare outcomes for study animals.
- The fewest animals appropriate to provide valid information and statistical significance should be used. Good study design is the primary means of minimizing the number of animals required to demonstrate experimental outcomes in field studies, as in laboratory-based animal studies. However, field studies often require larger samples than laboratory studies to overcome

environmental variation and intrinsic host variability that cannot be controlled in the study. Prior statistical evaluation of sample size is useful, even when sources of variation can only be roughly estimated. Familiarity with the literature on similar studies regarding sample size and study design is equally important. Animal use can also be minimized by better sharing of data, and publication of results in generally accessible formats.

- If possible, studies should be designed so that specimens are used for multiple purposes, or so they can be combined with samples from additional field seasons to maximize the use of specimens. This also includes the collection of biological and genetic samples for archiving whenever possible.
- All studies should undergo an evaluation for scientific merit or potential value prior to ethical review by ACCs. Where this has not been done as a part of the application for research funding, the ACC may arrange for an independent review of scientific merit (CCAC *guidelines on: protocol review*, 1997).

13. Results from wildlife studies should be formally reported (e.g., scientific paper, accessible database, formal report). Surveys, or inventory-type studies where the aim is to determine the type of species present in an area, can contribute to conservation science.

14. Investigators should take into account traditional/local knowledge and community values, and where appropriate, return knowledge and understanding of the species studied to the local community.

3.1 Responsibilities

15. More detailed information is given throughout these guidelines to assist both investigators and members of ACC to ensure that the following responsibilities are met.

3.1.1 Responsibilities of investigators

3.1.1.1 *Protocols involving the use of wildlife*

Guideline: All projects involving the use of animals for research, teaching and/or testing should be described within a protocol and should be approved by an ACC prior to commencement of the work.

(references outlining the requirements: CCAC *guidelines on: animal use protocol review*, 1997 and the CCAC *Terms of Reference for Animal Care Committees*, 2000)

16. Investigators are responsible for obtaining approval of their studies by their home institution. They are also responsible for providing notification of the approved protocol to the local ACC in the jurisdiction where the studies are to be conducted.

17. An example of a protocol for wildlife studies is given in Appendix D. Due to unpredictable conditions in the field, ACCs should be aware that some of the procedures described within a protocol may have to be adapted depending on the prevailing conditions. Nonetheless, the protocol form developed by the local ACC should be completed fully and accurately.

18. In preparation of a protocol, investigators should:

- first and foremost, articulate the goal of the study from academic or practical standpoints, put the work in a broad perspective, and explain how the study contributes to the general state of knowledge;
- ascertain the conservation status of the animal to be studied and ensure that the animals chosen are best suited to provide the information sought;

• avail themselves of relevant expertise to ensure that protocols and SOPs are comprehensive and represent best practices. Suggestions of appropriate organizations to contact are listed in Appendix E. If similar procedures will be used on several protocols, such as capture and/or marking techniques, it is recommended that the procedures be written up as SOPs. SOPs must be approved by the ACC and reviewed regularly. Approved SOPs need only be referred to by their assigned number and title in the procedures section of the protocol form;
• describe all the animal-based procedures accurately;
• alert ACCs to potential changes in the protocol, in particular where there might be better welfare outcomes. No major changes should be undertaken until review and approval by the ACC.

19. A **complete protocol** on any proposed studies involving the use of wildlife should be submitted for review by the local ACC at least once every three years. If the protocol is similar to a previous submission it should include a progress report (see below under renewal form).

20. In the interim years a **renewal form** is required that includes any minor changes to the original protocol, the number of animals required in the upcoming year and a progress report for the past year. The **progress report** should include a basic summary of progress to date and a list of species and numbers of each used, including animals used unintentionally (e.g., by catch). It should also include information on all animals injured or killed unintentionally, any treatments given and precautions or recommendations to reduce such incidences in the future. Details on the disposal of carcasses and copies of related correspondence to the permit agencies should be included. Additionally, it is extremely useful to the local ACC to include recommendations that may improve the well being of the animals and/or the outcome of the study (e.g., handling times, chase times, vital signs). The progress report will be used by the ACC to report annual animal use to the CCAC and to evaluate future protocols. In particular, this exercise provides feedback to the ACC to assist in further development and understanding of good welfare practices in field-based research. The progress report is a means of educating the ACC and improving standards of future protocols.

21. An **addendum** to a complete protocol can be used to submit minor changes during the course of a year. These changes may include such things as personnel changes and refinement of procedures without altering the level of invasiveness. All major changes in protocol, such as the use of an alternative capture technique require submission of a complete new protocol.

22. A protocol must be reviewed and approved by the local ACC prior to the commencement of a study. Similarly, renewals and/or addendums must be reviewed and approved by the ACC before continuing with a study. In some cases interim approval may be granted until the whole ACC has an opportunity to review the protocol or proposed changes.

23. In carrying out the approved protocol, investigators should:
• be responsible for adherence to the protocol, unless permission is given by an ACC to deviate from, or to amend the protocol;
• obtain all applicable permits prior to initiation of research and understand and comply with all regulations relative to the species to be studied;
• avoid or minimize the intensity and duration of an animal's pain, suffering and distress, and ensure that an animal experiencing severe unrelievable pain and/or distress is humanely killed as soon as possible;
• be knowledgeable of and provide appropriate husbandry, to ensure humane treatment and daily maintenance of animals used in captivity;
• understand and attempt to minimize any negative demographic and behavioral effects on the

species population;
• take precautions to minimize the capture of non-target animals and be prepared to deal with them. In particular, plans for handling non-target species should include a mechanism to deal with unplanned captures and accidental killing. The plans should include reporting to ACCs and the relevant permit agency, as well as details for disposing of any carcasses;
• be prepared to deal appropriately with accidental injury to animals during capture or handling;
• ensure appropriate disposition of the animal(s) at the conclusion of the study if animals are not to be released (e.g., investigators should attempt to donate carcasses to museums, to researchers investigating contaminants in the area, or to other suitable research programs);
• for animals released back to the wild, take care to maximize each individual's ability to resume normal behavior and to minimize effects on existing populations;
• ensure that animals released do not represent a risk to the public, other animals, or the environment.

Guideline: Investigators are responsible for their own conduct, as well as for the conduct of all other personnel involved in the investigator's studies.

24. In particular investigators should:
• ensure that all individuals involved with capture, handling, identification, maintenance, monitoring, and/or euthanasia of animal(s) are appropriately trained;
• ensure that all cooperators of their projects, whether volunteers, institution staff or contractors involved in any aspect of the study, comply with the procedures specified in the approved protocol;
• ensure that all personnel assisting with the project take sufficient precautions to reduce the risk of transmitting diseases.

3.1.2 Responsibilities of the ACC
Guideline: The ACC is responsible for reviewing all studies that are conducted by investigators belonging to their institution or agency, regardless of whether that project will be conducted within their jurisdiction or in the jurisdiction of another ACC.

25. ACCs may enter into working relationships with other ACCs regarding the review and approval of protocols that fall in one or more jurisdictions. For example, one ACC may accept the review and approval of another ACC; however, the home institution or agency should be aware of all projects being conducted by its investigators and ensure that the procedures to be used are ethically acceptable.

26. When multiple research partners are involved in a project, the ACC of the principal investigator should normally take the lead in providing an ethical review of the protocol. Co-operating investigators should be responsible for provision of the reviewed protocol to their home institution. Any questions concerning the reviewed procedures from the home ACC's of the co-operators should be directed to the lead ACC for resolution.

27. Where more than one ACC is involved in the review of a protocol, a well-defined arrangement between the ACC of the home institution and the host organization, for monitoring the proposed project and the welfare of the animals, should be agreed upon before the project begins (CCAC proposed Policy Statement on *Animal-Based Projects Involving Two or More Organizations*). ACCs need to be aware of the protocols and progress of projects which are being carried out locally. The local ACC is often the point of contact for the public and should be able to answer questions concerning wildlife studies in their area.

28. ACCs must ensure that all protocols are properly evaluated. In reviewing a protocol involving wildlife, ACCs are responsible for ensuring that:
- all animals to be used in a study will be treated in a manner which provides for their physical and psychological well being for the duration of the study;
- adequate physical and personnel resources will be available for the duration of the study;
- pain and/or distress concomitant to the study will be minimized both in intensity and duration;
- any animal experiencing severe, unrelievable pain and/or distress inflicted as a result of the study will be humanely killed as soon as possible;
- the project has merit, either by evidence of peer review for scientific merit (research projects); for pedagogical merit (teaching projects); or by evaluation of the goals (e.g., responsible sustained management, reduction of human hazards).

29. Protocol forms at Categories A and B levels of invasiveness (see Appendix B) and minor changes submitted on an addendum may be approved on an interim basis by a subcommittee of the ACC consisting of the ACC chair, a veterinarian, and a community representative. The subcommittee should consult a wildlife professional with the appropriate expertise where needed. Final approval should take place at a formal ACC meeting.

Guideline: The local ACCs should include persons with relevant expertise with wildlife in field or captive situations OR should seek advice from independent experts who can provide an understanding of the nature and impact of the proposed field investigation.

30. ACCs that regularly deal with field-based projects should have two or more field biologists on the committee. Committees that rarely review wildlife studies (less than five per year) may need to rely on *ad hoc* advice. However, given the wide range of species and methodologies employed, even the most experienced committees with field biologists will have to periodically seek outside reviews from other field biologists or wildlife veterinarians.

31. ACCs that deal with applications for field-based wildlife projects and which have insufficient expertise in the area of field-based research, should seek expert advice from experienced field researchers about the potential welfare implications of proposed techniques on the individual animals and the potential impacts on populations. It should also be noted that ACCs are in a position to pass on acquired knowledge on the welfare implications of field-based practices.

3.1.3 Role of the veterinarian

Guideline: Consultation and/or participation of wildlife veterinarians should be sought in projects involving immobilization or translocation of animals, medical or surgical procedures, and/or potential disease concerns.

32. The *Veterinary Act* of most provinces requires that a veterinarian have an established "veterinarian-client relationship" before dispensing pharmaceuticals or medical advice. Veterinarians remain liable for the use of pharmaceuticals dispensed and for veterinary care. This means that a veterinarian should be an integral part of research involving the use of pharmaceuticals or medical and surgical procedures. Researchers should be encouraged to develop veterinary-client relationships with veterinarians experienced or knowledgeable about the species in question and the logistics of field research. Additionally, veterinarians are also involved through the Canadian Association of Zoo and Wildlife Veterinarians in teaching a nationally recognized course in the Chemical Immobilization of Wildlife which is the national standard for training wildlife biologists and officers, conservation officers, park wardens, and researchers from provincial/territorial and federal wildlife agencies.

33. In many circumstances, combining the expertise and experience of wildlife biologists and technicians with that of veterinarians, maximizes the likelihood of safe, humane and efficient use of wild animals.

4. Wildlife Regulations

34. Anyone proposing to conduct research on, study, capture, hold or release wildlife should be familiar with, and comply with, the relevant legislation governing their use.

35. In most cases, licenses or permits are required to import or export wildlife or parts thereof, to capture or kill wildlife, to band or otherwise mark wildlife, and to hold in captivity or release wildlife. It is the investigator's responsibility to ensure that all the licenses/permits and approvals are in place before proceeding with any wildlife project (see Appendix C).

36. A wildlife study that involves native communities may require permission from the First Nations Government and, if it involves interviews or other surveys, requires review by the Human Ethics Review process. Depending on the community, region or land claim area involved, there may be established protocols for appropriate consultation, project approval and/or community participation. There may also be regional organizations that must be consulted in addition to the local community. Depending on the community involved, appropriate local contact could be a band office, Métis Local, designate Inuit organization, Hunter's and Trapper's organization, a local environmental committee, or a renewable resource council. Researchers should be aware that traditional knowledge may be considered intellectual property and must follow the same guidelines (Tri-Council Policy Statement: *Ethical Conduct for Research Involving Humans*, 1998). Aboriginal views on wildlife research are discussed in Byers (1999).

4.1 International

37. The Convention on International Trade in Endangered Species (CITES) of Wild Fauna and Flora, in force since 1975, has 154 member countries including Canada (2001). These countries ban commercial trade in endangered species, and regulate and monitor trade in other species that might become endangered. The import or export of any animals on the CITES list requires a permit from the Canadian Wildlife Service (CWS) and/or the provincial or territorial agency responsible for wildlife.

38. Investigators should be aware of the International Union for Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species (http://www.iucn.org/redlist/redbook). As the US and Canada share many species and populations of species, investigators should also determine if the species/population to be studied is on the US Endangered Species List.

4.2 Federal

39. The CWS oversees the following Acts and Regulations:

- Canada Wildlife Act (http://laws.justice.gc.ca/en/W-9/index.html);
- National Wildlife Areas Regulations;
- Migratory Birds Convention Act (http://laws.justice.gc.ca/en/M-7.01/index.html);
- Migratory Birds Sanctuary Regulations;
- Migratory Birds Hunting Regulations (http://www.cws-scf.ec.gc.ca/publications/reg/index_e.cfm);
- Wild Animal and Plant Protection and Regulation of International and Interprovincial Trade Act (WAPPRIITA) (http://www.cites.ec.gc.ca/wappa/homepg.htm);
- Wild Animal and Plant Trade Regulations;
- Species at Risk Act - to be enacted (http://www.speciesatrisk.gc.ca/species/sar/strategy/index.htm).

40. The CWS promotes the conservation of Canadian and international wildlife and biological diversity by managing migratory birds and nationally significant habitat and by providing leadership on other issues such as recovery of endangered species.

41. WAPPRIITA is the enabling legislation for the CITES in Canada. CITES is an international agreement that protects species of animals and plants that are or may be threatened with extinction by regulating their international trade through an import/export permit system. WAPPRIITA also provides the authority to protect Canadian ecosystems from the introduction of listed harmful invasive species by requiring permits and makes it an offence to transport from one province or territory to another or export from a province or territory an animal or plant without the required provincial or territorial permits.

42. In addition, permits are required to carry on such activities as wildlife research in National Wildlife Areas and Migratory Birds Sanctuaries.

43. The Committee on the Status of Endangered Wildlife in Canada maintains a national listing of wildlife species at risk (http://www.cosewic.gc.ca).

44. Many birds migrate across international borders, and hence their use and survival may be of interest to several countries. The CWS regulates the hunting of migratory birds and also requires that special permits be obtained for the collection, banding and/or holding of these birds.

4.3 Provincial/territorial

45. All provinces and territories in Canada have legislation governing the use of wildlife. The legislation is administered by the provincial or territorial agency responsible for wildlife. Licenses or permits are required for the killing, capture, holding, marking, transport, trade, and sometimes release of most wildlife. This includes wildlife held for research, interpretive purposes, rehabilitation, and farming. Permits are also required for the movement of wildlife, or parts thereof, across borders, and such movement may necessitate obtaining permits in more than one province/territory. Provinces and territories may also have endangered species legislation. Investigators should note that several species fall solely within provincial/territorial jurisdiction. In addition, there may be requirements for special permits to work in certain areas. For instance, permits are needed to conduct wildlife research in provincial wildlife areas, refuges, and provincial or territorial parks.

46. Investigators should also be aware that provinces have animal protection legislation that may apply to the use of certain vertebrate animals. Provincial regulations also exist for the types of traps permitted and for the use of firearms in specific areas. Therefore, it is imperative that investigators consult with the appropriate provincial or territorial agency when planning a project involving wildlife.

4.4 Municipal

47. Many municipal governments have regulations governing the holding of wildlife within municipal boundaries. There are usually restrictions on the use of firearms and other weapons. Investigators must consult the appropriate municipal bylaws.

4.5 Private property

48. Although wildlife is a public resource, wild animals may occupy private and communal lands and certain rights of access are extended to lease holders. Therefore written permission must be obtained from the owner to access private property regardless of the permits held. It is also prudent to inform local residents of any studies being conducted, whether on private or public land. In addition, government agencies likely to receive calls from the public should be notified prior to the activity, e.g., provincial wildlife and local conservation officers, the Coast Guard, Harbor Commission, CWS, RCMP or local police.

4.6 Professional associations

49. Many professional associations have produced guidelines for the capture, handling and care of wildlife (see Appendix A). In addition, some scientific journals have developed guidelines that must be followed in order to publish in their journals. For Canadian researchers, many journals specifically ask for demonstration of ACC review and approval before reviewing a paper that involves animals.

Methods of Capture and Restraint Without Using Drugs

Marc Cattet

INTRODUCTION

There are a variety of methods employed to capture wildlife without the use of drugs. The choice of which method to use is often dictated by a number of factors, including species, purpose of capture, number of animals to be captured, and the characteristics of the animals' environment. Few, if any, methods can be regarded as "stress-free", but certain measures can be applied, including the adjunctive use of drugs, to reduce stress during capture and restraint.

The methods used to capture and restrain wildlife without drugs can be arbitrarily divided into those that are used to capture single animals at a time, and those that are used to catch two or more animals at a time. The following describes many of these methods, and for each provides a brief description of potential stressors and measures that can be applied to alleviate stress.

METHODS USED TO CAPTURE ONE ANIMAL AT A TIME

1. Leg-hold snares

There are many variations of snares employed to capture wild species, but in general restraint involves complete encirclement of a limb by a loop of cable attached by an anchor line to a stationary object. The stresses associated with snaring include:

- Relatively non-specific for target species;
- Can cause significant injury to skin, muscle, and joints; and
- Must be watched constantly or, at least, visited regularly and frequently to reduce injury and avoid predation.

Measures that can be applied to reduce stress include:

- Trap transmitters;
- Short anchor lines;
- Padded snare cables; and
- Tranquillizer tabs.

2. Leg-hold traps

Leg-hold traps are usually a double-jaw, spring-operated steel trap that snaps shut to clasp the limb of an animal when the foot, placed in the center of the trap, depresses the trigger plate and releases the trigger mechanism. The stresses associated with leg-hold traps are similar to those of leg-hold snares, except there is greater potential to cause significant trauma, e.g., fracture, dislocation. Some of the measures that can be applied to reduce stress include padding the jaws with rubber and weakening the springs.

3. Purse-jawed traps

These are large coin-purse shaped traps that are used to trap aquatic mammals or large birds e.g., vultures, raptors, and cranes. Because a powerful spring is often used to snap these traps shut, there is significant potential for injury to target animal, as well to the person setting the trap.

4. Box traps

As the name implies, these are box-shaped traps covered either with wire mesh or aluminum or steel plate. An open spring-activated door at each end, with bait placed in the middle of the trap on a trigger plate, induces an animal to enter and take the bait. These traps are generally employed for small to medium-sized mammals, e.g., mice to foxes. The stresses associated with box traps include:

- Relatively non-specific for target species; and
- Must be visited regularly and frequently to reduce stress due to hyperthermia or hypothermia.

Measures that can be applied to reduce stress include:

- Place in sheltered areas away from direct sun exposure; and
- Provide bedding to reduce hypothermia in small mammals.

5. Barrel (or culvert) traps

These are typically solid barrel-shaped traps with a single door at one end. A cable attached to the open door is hooked into a trigger mechanism near the opposite end of the trap. A wire continues from the trip lever into the trap and is attached to the bait. These traps are generally employed for medium- to large-sized mammals, e.g., wolverines to bears. The stresses associated with barrel traps include:

- Relatively non-specific for target species;
- Guillotine-type doors can cause serious injury or death; and
- Must be visited regularly and frequently to reduce stress due to hyperthermia or hypothermia.

Measures that can be applied to reduce stress include:

- Place in sheltered areas away from direct sun exposure; and
- Use spring-activated swinging doors.

6. Clover traps

This trap is primarily for deer and consists of a metal pipe frame covered by heavy nylon mesh. There is a drop gate at one end held up by a hook or dowel attached to a mouse-trap trigger mechanism. The stresses associated with Clover traps include:

- Relatively non-specific for target species; and
- Trapped deer can clearly see approaching handlers are likely to injure themselves if not restrained quickly.

Measures that can be applied to reduce stress include:

- Use of "collapsible" Clover traps.

7. Panel traps

These are similar to Clover traps; the bait is placed inside and a trip wire drops a gate. The sides of the trap are wooden fence panels. Limited space within the trap limits the ability of deer to jump out and the side panel can be detached to press the deer against the other wall. Like Clover traps, panel traps are also relatively non-specific for target species. However, panel traps tend to cause less trauma to deer and handlers than do Clover traps.

8. Net-gun

A gun that shoots a canister-held net was originally developed for red deer capture in New Zealand, and has since been employed to capture a wide variety of wild species in North America. When fired over and in front of an animal from a helicopter, the net effectively immobilizes the animal by entanglement. Net-guns can also be used successfully from the ground. Relative to other methods used to capture one animal at a time, net-guns have lower rates of injury and death, while enabling the selection of specific target animals. Net-guns can also be employed in some situations to capture more than one animal. In general, the stresses associated with net-guns are reduced significantly if pursuit, capture, and handling times are kept to a minimum.

MASS CAPTURE TECHNIQUES

There are a variety of techniques available for capturing two or more animals at a time. Some rely on passive means (e.g., bait) to draw animals into the trap. These include drop-nets, jump-nets, and corral traps. With nets, there is considerable risk of injury from thrashing about while entangled. Blindfolding and hobbling of animals is strongly recommended, and tranquilization of some individuals may be required. Relative to net-type traps, corral traps are less likely to cause trauma.

Other mass capture techniques rely on actively driving target animals into it. These include linear drive-nets, funnel or drive traps, and chutes and squeezes. There is considerable risk of physical injury during the chase, and entrapped animals are generally in a high state of excitement as a result of being chased. All effort should be made to reduce handling time and stress. This includes blindfolding, hobbling, and tranquilization or sedation. Further, if prolonged handling is anticipated, chemical immobilization may be required.

Methods of Capture and Restraint With Drugs

Nigel Caulkett

When to use drugs:

There is no simple answer to determine when drugs, particularly chemical restraint, should be used during wildlife capture and restraint. Many factors can enter into this decision.

1. Species: Some species, such as pronghorns, do not tolerate physical restraint. Excessive or prolonged restraint can result in injury or death to the animal. Some species might be extremely difficult to physically restrain, i.e., physical restraint of an adult male grizzly bear could result in injury or death to the handler.
2. Length of restraint: In general, physical restraint is suitable for short procedures, procedures longer than 5-10 minutes generally require additional sedation or anesthesia
3. Prevention of injury and capture myopathy: Some species are at high risk of injury or capture myopathy. Prolonged or intense physical restraint can increase the risk of these physical injury or capture myopathy.
4. Painful procedures: Painful procedures, such as tooth extraction, should not be performed under physical restraint alone.
5. Terrain: the environment may help to determine which technique is most suitable.

It is important to remember that physical and chemical restraint are not mutually exclusive of each other. Sedation or tranquilization may be used to supplement physical restraint, and physical means can be used in addition to light anesthesia or deep sedation.

How to use drugs:

Drugs can be used to produce anxiolysis, sedation, anesthesia, and analgesia.

Anxiolytic agents:

These agents are tranquilizers, they will decrease stress during manipulation and some agents can be used to decrease the stress of transport and translocation.

Benzodiazepines:

Valium, and midazolam may be useful during handling of ungulates. These drugs work particularly well in fawns. They can be administered IV immediately prior to manipulation.

Short or intermediate duration of action:

Phenothiazines, such as acepromazine, or butyrophenones, such as azaperone, can be used to decrease stress for minor procedures, such as short transport < 6 hours. They may be administered to animals recovering from anesthesia if immediate translocation is anticipated.

Long acting tranquilizers:

Long acting tranquilizers such as clopixol accuphase or trilafon LA may be used to decrease anxiety for up to a week. These drugs can be administered in advance of an anticipated stressor, such as prolonged transport or holdling. They will have a prolonged effect and can potentially reduce the incidence of stress-induced trauma or capture myopathy.

Sedative agents:

Sedatives can be used to produce a sleep-like effect. They have a rapid onset, and may be given in addition to physical restraint to make the animal tractable. The alpha-2 agonist drugs will come close to producing general anesthesia, and are often combined with other drugs for this effect. Xylazine (rompun) has been used for many years. It can be administered IV or IM and is readily antagonized with an appropriate alpha-2 agonist drug.

Cervizine 300^R is a concentrated for of xylazine, it is useful for wildlife work, as it can be administered in small volumes.

Medetomidine is approximately 20 times as potent as xylazine. It can be administered in small volumes, and is reliably antagonized with atipamezole.

Anesthetic mixtures:

There are a variety of anesthetic mixtures available for wildlife restraint. Some of these mixtures such as xylazine-ketamine, telazol^R, and carfentanil-xylazine, have been around for several years and still have great utility.

The following section will focus on 3 combinations that are more recently developed and have the potential to be useful in a range of species.

Medetomidine-ketamine:

Medetomidine is an extremely potent alpha-2 agonist drug. It has the advantage that it can be delivered at a much lower volume than xylazine. Xylazine is typically combined with ketamine to produce anesthesia. Typically a relatively high dose of ketamine is required (often 4-6 mg/kg, depending on the species). In general, ketamine requirements are reduced by 50% if it is combined with medetomidine, rather than xylazine. The major advantages of this are reduced volume requirements, and increased "reversability' and decreased ketamine-induced side effects, when the alpha-2 agonist is antagonized. Medetomidine is rapidly antagonized by atipamezole at 3-5 times the medetomidine dose. Major side effects of this combination are hypertension (high blood pressure), bradycardia (slow heart rate) and hypoxemia (low blood oxygen). Like xylazine-ketamine, this mixture is useful in most species. Like xylazine-ketamine, it should be avoided in bears as sudden recoveries can be encountered when this mixture is used.

Medetomidine-telazol (MZT): This mixture was developed for use in bears. The major drive was to develop a reliable, reversible combination, when medetomidine-ketamine failed to be reliable in bears. MZT can be mixed in a very small volume, this greatly increases its utility in large ungulates and large bears. This mixture could potentially be useful in all large North American land mammals. It produces superior analgesia to telazol alone, and has been used for minor surgical procedures. The mixture is readily reversible with atipamezole. The major side effects of MZT are hypertension, bradycardia and hypoxemia. This mixture is potentially useful in any land mammal

Xylazine-telazol (XZT): This mixture is probably the next best thing to MZT. The lack of availability of medetomidine necessitated the use of an alternate alpha-2 agonist drug. XZT has much the same clinical effect as MZT. It also has the same side effects. The major difference between XZT and MZT is that the volume of XZT is greater, and since a higher dose of telazol is required, the mixture is less "reversible". An appropriate alpha-2 antagonist should be chosen for the target species. This mixture has the potential to be useful in most North American land mammals. Large volume requirements decrease its utility in adult male bison.

Volatile anesthetics:

Sevoflurane is basically an improved version of isoflurane. It is less pungent than isoflurane, and is better tolerated by animals that are mask-induced with the drug. It has a quicker onset and offset than isoflurane. This property increases its utility in small wildlife. It has similar cardiopulmonary side effects to isoflurane.

Analgesic agents:

Analgesics are agents that are used to decrease pain. If painful procedures are performed analgesics must be used. There are several choices for wildlife.

Local anesthetics: short acting agents, such as lidocaine, or long acting agents, such as bupivicaine can be administered at the surgical site to provide post operative pain control.

Narcotics: narcotics, that produce minimal sedation, can be useful for post operative pain control in wildlife, particularly if the animal is held after surgery. Butorphanol and buprenorphine are the most useful of these agents.

Alpha-2 agonists: medetomidine and xylazine will produce profound analgesia, until they are antagonized.

Nonsteroidal antiinflammatory drugs: These are asprin-like drugs that have no sedative effect. Modern agents such as ketoprofen or meloxicam are potentially useful in wildlife.

Equipment for Drug Administration: Factors to Consider for Reduction of Stress

Nigel Caulkett

A variety of drug delivery equipment is available on the market. Darts can induce significant injury or death. It is important to carefully consider delivery equipment for each situation.

The major factors to consider are the size of the animal, and the range at which the drug can be delivered. Darts can produce significant injury or death if they are not used appropriately. The energy of impact is equal to the mass of the dart multiplied by the velocity squared. It is important to use the lightest possible dart, delivered at the lowest velocity possible, while maintaining an accurate trajectory. Rapid injection, from explosive charge powered plungers, can also induce significant trauma. As a rule of thumb, metal darts should be reserved for large, well muscled animals, when the dart must be delivered at a distance of > 20 meters. Low velocity equipment should be used whenever possible.

A variety of techniques can be used to deliver anesthetic agents to free-ranging animals. Pole syringes can be used to deliver drugs up to about 2 meters. Lung-powered blow pipes are effective to about 10 meters. Blow pipes, powered with compressed air or CO2, and CO2 or air pistols can be used up to 15-20 meters. CO2 rifles or cartridge rifles can be used to propel darts 30 meters and beyond. Use the lowest velocity equipment possible for the capture event.
A variety of darts are available. Low velocity darts (Dan-inject, telinject) are generally manufactured from plastic, and injection of contents is powered by compressed gas. High velocity darts are usually metal (cap-chur[R], pneu-dart[R]) and injection of contents is powered by an explosive charge. Paxarms[R] manufactures a high velocity plastic dart that injects its contents using compressed air. Use small, light darts and compressed air powered injection, whenever possible.

Monitoring and Supportive Care - Birds

Karen Machin

1. Anesthesia and Surgery

Differencess in response to anesthesia between birds and mammals are related to differences in physiological, anatomical and metabolic characteristics. Wide species variation can make anesthesia challenging in the avian patient. Excitement and stress associated with handling, particularly of wild birds, can increase circulating epinephrine, which may sensitize the myocardium to catecholamine induced arrhythmias during inhalant anesthesia. Heart rate should be monitored during anesthesia. Monitoring can be accomplished most easily with an esophageal stethoscope. Heart rate ranges from 100 - 300 beats/minute, depending on species.

Respiratory function in birds is more susceptible to the effects of anesthetics than it is in mammals. General anesthesia causes skeletal muscle relaxation. The degree of relaxation depends on the type of anesthetic, depth of anesthesia and physical condition of the bird. Since respiration is an active process and dependent on the movement of skeletal muscles in birds, any depression of muscle activity will affect ventilation efficiency. Also birds in dorsal recumbency have reduced ventilation due to visceral weight compressing abdominal air sacs and reduction in effective volume. When birds are placed on their back during anesthesia they should be intubated and artificially ventilated to ensure adequate gas exchange.

Anesthesia and handling can cause ventilatory depression and apnea (lack of breathing) in birds. During induction of anesthesia in birds, especially waterfowl, apnea and bradycardia (lowered heart rate) can occur by placing pressure or a mask over the beak. These actions mimic the diving response and are mediated by stimulation of receptors in the beak. In mammals, the functional residual volume (air that remains in the lungs after exhalation) can provide oxygen for a limited amount of time during periods of apnea. In birds, apnea coupled with a high metabolic rate can lead to rapid decompensation as birds lack significant functional residual volume. Reduction of ventilatory responses to hypoxia (low oxygen) and hypercarbia (high carbon dioxide) through direct effects of anesthetics on the central nervous system and peripheral chemoreceptors are similar in mammals and birds. However, in birds, anesthetic gases delivered in 100 % oxygen can also cause ventilatory depression through suppression of intrapulmonary CO_2 receptors and stimulation of O_2 sensitive chemoreceptors. Therefore, placement of endotracheal tubes and artificial ventilation of birds during anesthesia ensures that proper ventilation is maintained.

Doses of anesthetics are often higher in birds than in mammals, probably because of higher metabolic rates. Differences in metabolic rate may also be responsible for varying responses to anesthetics between species. Before anesthetizing a bird in a field situation it is strongly recommended that practice sessions be done to determine dosages and response to anesthesia with the same or a similar species. Hypothermia can affect metabolic rate. In most avian patients, hypothermia is common because of the large surface area to body volume ratio. Thermoregulation is compromised by the central effects of anesthetics and heat lost can also occur through the respiratory tract or surgical sites. Body temperature should be monitored and artificial heat should be provided to prevent hyperthermia.

Monitoring Anesthetic Depth

In comparison to mammals, monitoring depth of anesthesia is much more difficult. During inhalation anesthesia (isoflurane is the anesthetic of choice in birds), concentration should be adjusted to maintain (1) spontaneous respiration, (2) sluggish to absent nictitating membrane movement in response to opening and closing the eyelids, and (3) no voluntary movement or obvious change in heart and/or respiratory rate in response to wing and leg extension or surgical stimulation. Birds that do not have spontaneous respiration should be ventilated artificially. During injectable anesthesia, increases in respiratory rate, heart rate, increasing strength of nicitating membrane movements or spontaneous movements may indicate additional anesthetic is needed.

Fluids: at 10mg/kg/hr should be given if surgical procedures are more than 15 - 20 minute or if blood loss is expected or occurs.

Emergency Supportive Care - CPR

i. Respiratory support: supply oxygen.

Airway: Place an endotracheal tube (if not already intubated) or place a tube in the abdominal airsac (in an extreme emergency).

Breathing: use IPPV (intermittent positive pressure ventilation) to ensure that adequate oxygen is supplied to the tissues (especially the brain). Breathing should be approximately 1 breath per 5 seconds (faster in small birds). Doxapram (Dopram) at 5 - 10 mg/kg can be given to help stimulate respiration.

ii. Cardiac support: if a bird goes into respiratory arrest while handling or during anesthesia, cardiac arrest may follow if respiration does not resume within 1 minute. Resuscitation of birds may be possible but attempts are often unrewarding. Resuscitation is most successful if the bird is already intubated and IPPV is initiated.

Circulation: cardiac massage can be done by compressing the chest. The bird is placed in dorsal recumbency and the sternum is compressed down and upwards toward the head.

2. Holding Wild Birds

Stress from capture and handling of wild birds can alter normal behaviour. The removal of fear and anxiety can be partially accomplished with appropriate environmental modification that provides appropriate choice and location of perches, bedding, food and water. A quiet, darkened environment is essential to decreasing stress of wild birds in captivity. Wild birds may not eat or drink in captivity, either in response to stress or because the food or water offered is not recognized as being such. Every effort should be made to make the normal diet of the bird available, however, this may not always be possible. Some birds (especially small birds with high metabolism) may require supportive care such as force feeding. The effects of handling to provide supportive care must be weighed against the benefits of providing needed food and fluids.

Force Feeding: is very beneficial to meet nutritional demands of the body until the bird has regained a normal appetite

Nutritional Requirements: If prolonged nutritional support is expected BMR should be calculated. Basal metabolic rate is the minimum amount of energy necessary for daily maintenance.

$$BMR = K\ (\text{Body Weight}^{0.75})$$

K passerine birds = 129

K non-passerine birds = 78

Maintenance Energy Requirement (MER) is the BMR plus the additional energy needed for normal physical activity, digestion and absorption. The MER for stressed birds should be estimated at approximately 25 % above BMR.

Fluid Therapy: Birds that are not eating may also require fluid therapy. Use either an isotonic saline solution or lactated ringers.

Fluid deficit: BWt x % dehydration (estimate)
Maintenance: BWt x 40 - 60 ml/kg/day
Plan: replace 50% of deficit within the first 6 to 12 hours plus appropriate amount of the maintenance and replace the remainder over the next 24 to 36 hours. Don't forget to add in the appropriate amount of maintenance fluids to each 24 hour block.
Route: 1) **By mouth** (per os) can be used in birds that are not eating or drinking adequately. A soft or metal feeding tube is used. However, birds that are severely dehydrated will often experience nausea and will likely regurgitate until some of the deficit has been replaced.
2) **Subcutaneous** placement of fluids is best achieved in the inguinal and axial regions. This route should not be used in an emergency situation.
3) **Intravenous** (IV) via the medial tarsal-metatarsal or brachial veins if dehydration is severe and fluid replacement is required immediately or if blood loss has occurred. Similarly, IV catheters can be placed in the above veins for longer term treatment.
IV boluses: can be given fluids up to 1 - 3 % of body weight (10 - 30% of blood volume) at a time, but must be given slowly.
4) **Interosseous** delivery can be used if fluid loss requires immediate treatment and veins are not available. Care must be taken to avoid penetrating joints when placing interosseous catheters.

**Note: for body weight you may want to estimate normal weight of the bird, especially if the bird is extremely stressed or emaciated.

Monitoring Anesthesia in Large Wild Mammals

Nigel Caulkett

Ungulates

Hypoxemia is not uncommon during anesthesia of ruminants. Hypoxemia, in the face of hyperthermia, is a particularly serious situation, as hyperthermia increases tissue oxygen demand. This can increase the risk of capture myopathy or result in acute mortality. Hypoxemia can be prevented or treated in the field. Animals should be positioned in sternal recumbency. The head and neck should be extended to maintain a patent airway. The animal should be monitored for hypoxemia, ideally with a pulse oximeter. A multi site sensor applied to the tongue generally provides a good signal. Normal hemoglobin saturation should be 95-98%, below 85% is considered hypoxemic. If a pulse oximeter is not available the mucous membranes should be monitored for cyanosis. Severely hypoxemic animals are often tachycardic. Heart rates above 150 in large ungulates may result from a stress response due to hypoxemia, hypercarbia, pain or hypotension. Tachycardia, followed by severe bradycardia (HR<30) is often a warning sign that hypoxemia is very severe and the heart may fail. Supplemental inspired oxygen should be considered in hypoxemic animals. Portable equipment is available to facilitate oxygen delivery. An ambulance type regulator (Easy Reg^R Precision Medical, Inc. 300 Held Drive, Northampton, PA 18067) and aluminum D-cylinder is light weight, portable and sturdy. It can provide a 10 l/min flow for up to 30 minutes. An E-cylinder will provide this flow for an hour or more. A nasal catheter can be used in deer and bison. The catheter should be threaded as far as the medial canthus of the eye. A flow rate of 6-8 l/min is generally sufficient for white-tailed deer. A flow rate of 8-10 l/min is required in larger wapiti or bison.

Heart rate and pulse quality should be monitored every 5 minutes. The auricular artery is easily palpated in deer. If the auricular artery cannot be palpated a femoral pulse can be used. The auricular pulse is difficult to palpate in bison. The facial artery may be used or the femoral artery.

Maintenance in sternal recumbeny will help to prevent the development of rumenal tympany. If rumenal tympany is a problem the animal may be rocked gently to stimulate eructation. A rumen tube can be used, but may predispose to regurgitation and aspiration. Generally, if rumenal tympany is severe, it is advisable to finish the procedure quickly and antagonize the anesthetic agents. If alpha-2 agonists have been used, the administration of tolazoline, yohimbine, or atipamezole will stimulate rumenal activity and relieve rumenal tympany.

Rectal temperature should be monitored every 5-10 minutes. Deer and bison are prone to hyperthermia[1,3], especially following a long chase. Rectal temperature greater than 40^0C are cause for concern, and attempts should be made to cool the animal, cold water sprayed on the animal or snow packed into the inguinal and axillary regions may help. Rectal temperature in excess of 41^0C is an emergency and should be treated aggressively. It is difficult to actively cool large animals and often the best option with severe hyperthermia is to antagonize the immobilizing agents and allow the animal to recover. Hyperthermia greatly increases metabolic oxygen demand. Hyperthermia, in the face of hypoxemia, is a particularly serious complication. Hyperthermic animals should receive supplemental inspired oxygen to offset hypoxemia.

Bears

It goes without saying that depth of anesthesia should be closely monitored. Some drug combinations have proven to be unreliable in bears. Xylazine-ketamine and medetomidine-ketamine are unreliable, and sudden recoveries may be encountered. These combinations are best avoided in most situations. Factors that increase the risk of sudden arousal include: loud noise, distress vocalization of cubs is particularly dangerous. Other factors that can induce arousal include: movement of the bear i.e. changing the body position or location of the anesthetized animal, or painful stimuli, such as tooth extraction.

Techniques for monitoring depth of anesthesia will depend on the agent used. Tiletamine-zolazepam {telazol^R^, Zoletil^R^ (ZT)} will produce reliable anesthesia with predictable signs of recovery. As anesthesia lightens spontaneous blinking will occur, bears will show chewing movements and paw movement. They will start to lift their head, and may attempt to raise themselves with their forelimbs. Animals with significant head movement generally require a "top-up" of tiletamine-zolazepam or ketamine, unless they are to be left to recover.

With xylazine-ketamine or medetomidine-ketamine, head lifting or limb movement signal that the bear is extremely light and should not be approached or manipulated. Increased intensity of the palpebral reflex or nystagmus are earlier indicators that the bear is light.

With xylazine-zolazepam-tiletamine (XZT) or medetomidine-zolazepam-tiletamine (MZT), head lifting should be absent before the bear is approached. The palpebral reflex can be used to determine depth of anesthesia. Lightly anesthetized bears will begin to breath deeply, and may sigh. They may start to lick, and will develop a spontaneous palpebral. Head lifting or paw movement should be a sign to be extremely cautious, as the bear may soon rouse.

The eyes should always be lubricated, and caution must be exercised to avoid corneal abrasions or ulceration. A blindfold should be placed to protect the eyes and decrease visual stimuli.

Bears are not particularly prone to hypoxemia. Oxygenation under tiletamine-zolazepam is generally good. The addition of an alpha-2 agonist can result in hypoxemia.

Oxygenation can be monitored by visualization of the mucous membranes or with a pulse oximeter. The pulse oximeter probe can be placed on the tongue. This may be difficult in bears lightly anesthetized with ZT, as they tend to chew. A hemoglobin saturation of <85% is indicative of hypoxemia. We generally supply these animals with supplemental inspired oxygen (Figure 3). Portable equipment is available to facilitate oxygen deliver. An ambulance type regulator (Easy Reg^R^ Precision Medical, Inc. 300 Held Drive, Northampton, PA 18067) and aluminum D-cylinder is light weight, portable and sturdy. It can provide a 10 l/min flow for up to 30 minutes. An E-cylinder will provide this flow for an hour or more. A nasal catheter is a simple method to provide supplemental inspired oxygen. The catheter should be threaded as far as the medial canthus of the eye. A flow rate of 5-10l/min is required in most bears. Efficacy of oxygen therapy can be monitored with a pulse oximeter.

Bears are best positioned in sternal recumbency, but can be positioned in dorsal or lateral recumbency, with few adverse effects.

The cardiovascular system should be closely monitored. Polar bears, black bears, and brown bears anesthetized with ZT commonly have heart rates of 70-90 beats/min. Heart rate is slightly lower with XZT and MZT , 50-70 beats/min. Bradycardia is common with medetomidine-ketamine, heart rates of 30-40 beats/min. are not uncommon in polar bears. The femoral artery is the best location to palpate a pulse, the brachial artery can also be used. Blood can be sampled from the jugular or medial saphenous vein. IV catheters may be placed in the jugular or cephalic vein (Figure 4).

Blood pressure can be measured directly, via the femoral artery. In smaller bears oscillometric monitors can be used. The cuff width should be approximately 0.4 times the limb circumference. Mean arterial pressure in polar bears anesthetized with TZ was approximately 150 mmHg (1). Polar bears anesthetized with MZT are hypertensive (MAP>200mmHg) (1). Black bears are also hypertensive with this combination (2).

Rectal temperature should be closely monitored. Rectal temperature tends to decrease over time with TZ. It tends to increase with XZT and MZT. In hot ambient temperatures body temperature can increase to dangerous levels (>41^{O}C). In these situations the alpha-2 agonist should be antagonized as quickly as possible.

When possible, anesthesia should be reversed in free-ranging animals. This is particularly important for sows with cubs, and in areas where high concentrations of bears are present.

Bears may be translocated as part of management procedures. Translocation of bears in cargo nets, by helicopter can result in mortality. Slinging in a cargo net can induce hypertension and hypoxemia. Ideally, these bears should be transported or weighed with their head and neck extended and their body extended in sternal or dorsal recumbency. We have used a stretcher-type sling to facilitate this positioning. If bears are to be relocated in culvert traps they should be awake before transport. Anesthetized bear can gravitate towards the door of the trap. If the neck is flexed they can loose their airway and suffocate.

Considerations During Invasive Procedures: Surgical Implants, Tissue Biopsies, and Tooth Extractions

Karen Machin

Do animals experience pain?

Current knowledge of animal pain suggests that procedures known to be painful when applied to human subjects are also likely to be painful when applied to other animals. Mammals, birds and amphibians have been shown to possess the neurological components to respond appropriately to a painful stimulus, have endogenous antinociceptive mechanisms to modulate pain, and treatment with pharmacological agents used in humans modulates pain pathways and behavioral responses to painful stimuli. Studies also suggest similar processes exist in reptiles and fish. The existence of pain perception in animals can be supported by the fact that the ability to detect noxious stimuli, signaling danger to life and well-being, represents a major selection pressure for the survival of any organism. Pain perception allows an animal to minimize its exposure to potentially harmful stimuli.

Pain can be difficult to define and can describe a wide variety of sensations as described by: uncomfortable, unpleasant, irritating, disturbing, severe, intense, distressing, intolerable or disabling. Pain sensation involves more than a single neural mechanism. Pain can be classified as two distinct types: physiological pain, which is elicited when an intense noxious stimuli threatens to damage normal tissue (nociceptive pain), and pathological pain, which is the consequence of an "abnormal" state and is associated with tissue damage. Pain that arises from the threat of tissue damage has different behavioral implications compared to pain that is incurred from existing traumatic damage to skin or internal organs. This response serves as a protective mechanism, inducing a "survival" response in the animal (immediate avoidance or learned avoidance responses) minimizing its exposure to potentially harmful stimuli. The appropriate behavioral response to threat of tissue damage is likely vigorous activity while the response to damage already incurred may be inactivity. The former is easier to recognize but may not be representative of all forms of pain experienced by the animal. The two processes may represent twin selection pressures that have guided the emergence of pain perception systems across phylogeny.

Analgesics (drugs that produce pain relief) are often not administered because the presence and severity of pain may not be recognized inwildlife. Considerable variation in behavioural responses to pain may occur among species and individuals and there is no reliable or universal indicator of pain. Species that may be preyed upon are less likely to display overt pain-associated behaviour that may attract attention of predators. In addition, stress (during capture and handling) or repeated painful stimuli can induce short lasting reductions in responsiveness to painful stimuli and is termed stress-induced analgesia.

Pain is produced by any procedure or injury that causes tissue damage. Procedures that are known to be painful in humans should be assumed to cause pain in other species.

Does pain have an impact on research results?

1. Post-operative Behaviour in Assessing Effects of Surgery to Place Intraabdominal Radio Transmitters in Ruddy Ducks

As pain is produced by any procedure or injury that causes tissue damage, it is likely that waterfowl implanted with radio transmitters would experience pain. The effects of surgery to place intra-abdominal radio transmitters assessed by comparing post-operative behaviour of 20 male and 4 female ruddy ducks (Oxyura jamaicensis) implanted with radio transmitters with 20 males and 3 females that were captured and leg banded only. Ten males and 2 females were anesthetized with propofol, 10 males and 4 females were anesthetized with isoflurane, and all ducks that had surgery had bupivacaine infiltration of the surgical site. All birds survived surgery and anesthesia. No difference in behaviour was found between ducks anesthetized with isoflurane versus propofol. Six hours after capture, 19 males and 3 females that had surgery were located easily because they were resting motionless on open water or floating vegetation or on land, and had a puffed up appearance. One implanted male in the propofol group was killed by a red-tailed hawk approximately 6 hours after surgery. Ducks in the leg band only group were more difficult to locate and only 8 of 20 males and 2 of 3 females in this control group were observed. Overall, aspects of male behaviour between surgery and leg-banded-only ducks differed. Implanted males spent less time feeding and courting but more time resting than leg-banded-only males. Bupivacaine may not provide long-lasting analgesia and changes in behaviour may make ducks implanted with radio transmitters more susceptible to predation.

2. Assessment of Incubation Patterns in Nesting Female Mallard Ducks Following Surgical Placement of Intra-abdominal Transmitters

In most brood survival studies, females have been equipped with transmitters during mid- to late incubation to reduce loss of equipment and information due to predation or the possibility of nest abandonment. Placement of intra-abdominal transmitters necessitates an incision in the brood patch which may have significant implications, such as altered incubation patterns resulting in delayed hatch, for females that are implanted during incubation. Twenty six nesting female mallard ducks (Anas platyrhynchos) were used to determine the effect of implanting a radio transmitter in late incubation on incubation rhythms. The ducks were assigned randomly to 2 treatments so that a comparison of analgesia provided by a nonsteroidal anti-inflammatory drug (ketoprofen) and local anesthetic (bupivacaine) could be made among treatments. Pre- and post-operative incubation patterns, length of post-operative incubation breaks, length of time required to warm eggs, and days from surgery to hatch were compared among treatments. The incubation period is the number of days from the onset of incubation to hatch. Monitoring of nest attendance was accomplished by recording nest temperature using HOBO XT Temperature Data Loggers. Treatment did not have an effect on total time spent off the nest or number of breaks taken following surgery. However, for both drugs, the amount of time spent off the nest varied, with females spending more time off the nest in the 24 hours following surgery compared to prior to surgery and after the 24 hour period following surgery. Although not significant, ketoprofen-treated females incubated longer immediately following surgery and placement back onto the nest before taking a post-operative break and took less time to rewarm eggs to pre-surgery temperatures compared with bupivacaine-treated females. A difference between treatments in numbers of days from surgery to hatch was detected with bupivacaine-treated females taking 6.2 ± 0.7 days compared to those that received ketoprofen (5.6 ± 0.5 days). Anesthesia of the brood patch may have prevented adequate detection of egg temperature resulting in prolonged rewarming of the eggs and increased days to hatch.

Treatment of Pain

"Wildlife research may involve invasive procedures such as laparotomy, biopsies, or tooth extraction, and measures must be taken to control pain during and after any of these procedures" - proposed CCAC guidelines on: the care and use of wildlife.

Narcotics: opiates, such as morphine, and opioids, such as fentanyl, buprenorphine, and butorphanol, may cause side effects such as respiratory depression and residual sedation. Buprenorphine is a useful agent for small mammals, acting for up to 12 hours, and producing minimal sedation or respiratory depression.
Alpha-2 agonists: such as xylazine and medetomidine are potent analgesics and will produce adequate analgesia for most minor surgical procedures. The use of these drugs is limited to intraoperative analgesia as they produce excessive sedation and cardiopulmonary depression in the postoperative period and are often reversed as part of the anesthetic protocol.

Antagonism (reversal) of narcotics and alpha-2 agonists to eliminate sedation will also eliminate analgesia.

Local anesthetics can be useful for intra-operative and postoperative analgesia of wildlife and consideration must be given to route of administration, duration of action, and toxicity. While local anesthetics can be administered by a variety of routes, local infiltration of the surgical site is the most common and simplest method. Local anesthesia can also be used effectively for infiltraton of a tissue biopsy site or regional anesthesia for tooth extractions. Duration of action often dictates the choice of local anesthetic agent: lidocaine is effective for 1-2 hours and may be useful for short procedures that do not produce significant postoperative pain, while bupivicaine is preferred for prolonged postoperative analgesia as it is effective for up to 8 hours (in some species).
Nonsteroidal anti-inflammatory drugs (NSAIDs), such as ketoprofen, carprofen and meloxicam, are potent postoperative analgesics. They may have the advantage of prolonged duration of action, up to 12 to 24 hours (in some species). Toxic effects of these drugs can include renal toxicity and/or increased bleeding tendencies, although these complications are rare.

Local anesthetics and NSAIDs lack sedative effects, which make them potentially more useful in free-ranging wildlife than narcotics and alpha-2 agonists.

Other considerations

"Invasive procedures require the use of recognized veterinary procedures, including asepsis, anesthesia, analgesia and appropriate surgical techniques" - proposed CCAC guidelines on: the care and use of wildlife.

"Animals should be observed during recovery from anesthesia whenever possible, and not released from traps and enclosures until fully recovered" - proposed CCAC guidelines on: the care and use of wildlife

Animal Marking and Identification

Trent Bollinger

Most wildlife capture and handling procedures result in animals being marked for future identification. Marking takes various forms. Some, such as leg bands, tattoos, ear tags and passive integrated transponders tags (PIT tags), require the animal to be recaptured in order for the identification to be read. Other larger tags, such as neck collars and brands can be visualized from a distance. In some studies animals are marked with a radio-transmitter and animal locations can be determined by triangulation using an antenna and receiver. Antennas can be hand-held, mounted on a vehicle or plane, etc. Remote monitoring of animals using satellites is also employed. New technology is constantly coming available which allows for more sophisticated tracking of animal movements and as electronic components become smaller, the tracking of smaller and smaller animals.

The most appropriate marking technique for a particular study depends on the goals of the study. Several factors must be considered; such as: the period of time the mark must persist, the distance at which the marked animal must be detected or visualized, the number of unique identifications required, how quickly animals must be marked and released, time available for identifying marked individuals, and cost, to name a few. The ideal marking system should have the following characteristics: 1) result in minimal pain or stress on the animal, 2) produce no detrimental effects on behavior or survival, 3) be durable, 4) be simple and easy to apply, 5) easily recognized or detected, and 6) relatively inexpensive. No one marking system is ideal and the choice of markers is a compromise based on the species involved, goals of the study and often budget. An excellent review of the range of marking techniques is provided in Nietfeld et al. (1994). My intent is not review all the various techniques but to highlight a few techniques and to discuss issues related to the impacts of marking on physiology, behavior, and in some cases, survival of animals. I will provide examples of techniques or situations where marking has resulted in adverse effects and compromised study results.

Non-visible or small marks or tags often have minimal effects on animals but require recapture in order to determine an animals status. Leg bands on birds are likely the best known example of a small marker. Banding of migratory birds in North America is regulated by the federal governments. The North American Bird Banding Manual, Volumes I and II, available from the Canadian Wildlife Service, provides guidelines on permitting, capture and banding techniques, record keeping, reporting, etc. Tags can be placed in the ear, in wing webs, on fins, etc. Leg bands have good retention rates but other types of external tags can be lost due to trauma, fighting, preening, chewing, etc. Tattoos are a simple way of marking a variety of species if there is an area of hairless lightly pigmented skin.

A technique which is becoming more widely used as a permanent, non-visible, internal marker are passive integrated transponders or PIT tags. These are small tags measuring ~ 11-14mm in length and ~ 2 mm in diameter, about the size of an uncooked grain of rice, which are inserted into the body, usually under the skin. They consist of a tiny microchip, a capacitor, and a thin copper wire wound around a small piece of iron. The electronics are embedded in biologically inert glass. The transponders are passive, meaning they don't have a battery, and instead rely on a low frequency signal to electromagnetically active the circuitry resulting in emission of a radio signal which bears the transponders unique alpha-numeric identifier. The unique code is manufactured into the chip and allows for 34 billion different ID numbers. Because there is no battery the life-span of the tag is "indefinite". The major disadvantage of this technique is that the signal can only be read by a special electronic receiver or reader and only at close distances, usually less than or equal to 7.5 cm. Specialized readers with data-loggers have been developed to monitor fish movement through confined spaces and movement of rodents in burrows. The glass coating of PIT tags is smooth and there are reports of tags moving after placement and in some cases actually being expelled. Some studies report PIT tags are retained in 90-95% of animals while one study reported 53% of PIT tags implanted in the neck region of corn snakes were expelled (Roark and Dorcas 2000). Transponders partially coated with polypropylene to induce fibrous adhesions and prevent migration are available.

Larger, more visible marks have the advantage of allowing detection of marked individuals without actually re-capturing them but are more likely to have detrimental effects on the animal. Size and weight of the marking device may be of concern in small animals; color of the marker also may be a consideration. Many animals rely on cryptic coloration to hide from predators or alternatively predators may use cryptic coloration to pursue prey. Markers may alter the visibility of an animal making them at higher risk to predation or impairing their ability to hunt.

Marking devices frequently have a detrimental effect on breeding and behavior especially in birds which use plumage and other visual characteristics for mate selection. Brua (1998) reported patagial tags used to individually identify waterfowl had a detrimental effect on courtship and behavior of Ruddy Ducks. These vinyl cloth tags measured 3.0 cm by 4.5 cm at their widest point and covered the area of the secondary coverts. Patagial-tagged male Ruddy Ducks had reduced courtship behavior and spent more time preening and sleeping in comparison to males marked only with leg bands and compared to unmarked males. Patagial-marked females also spent more time preening than unmarked females and appeared unable to nest. Nasal tags and neck collars have been utilized to mark various species of waterfowl; however, under some conditions these markers have become coated in ice or encrusted with salt resulting in mortality of marked birds. These types of marking devices are still used and have provided valuable information on behavioral ecology and population dynamics of various waterfowl species but they must be used judicially to avoid these complications.

Radio-transmitters are often used to mark wildlife but, because of the high cost, typically fewer individuals are fitted with transmitters than with other types of markers. Radio-transmitters are attached to animals by glues, harnesses, collars and in some cases surgically attached or implanted in the animal. Transmitters have varying weights and confirmations depending on size of the battery, signal strength required, design, etc. On smaller animals weight and size is always a consideration. Transmitters should not exceed 5% of the animals body weight and should be attached in a way that doesn't impede movement. Transmitters on birds can produce aerodynamic drag during flight and should be mounted near their center of gravity.

Transmitters can effect behavior in some species in a fashion similar to other larger marking devices. Massey, et al (1988)was unable to use small radio transmitters to study behavioral ecology of nesting least terns because transmitter marked birds foraged and behaved differently than unmarked birds.

Radio-transmitters also can affect survival. Machin (personal communication) found one-day-old mallard ducklings marked with a radio-transmitter attached via a subcutaneous anchor and sutures had a significantly lower survival rate than ducklings treated similarly but without transmitters. In one year, 37% of transmitter marked ducklings died compared to only 7% of control ducklings. Obviously high mortality rates associated with this technique make it unsuitable for marking ducklings. Similar transmitters in adult mallards do not appear to significantly affect survival; however, we occasionally see infections arising from these attachment sites which have caused death of adult birds. More complex surgical procedures have a greater potential for complications. Techniques should be reviewed by veterinary surgeons experienced in this type of work and surgeries should be performed by trained, experienced individuals. Procedures should be implemented to ensure surgical sterility. Lack of attention to these details can seriously compromise a research program.

Improperly fitting radio-collars or harnesses can affect survival. Loose collars or harnesses can fall off or cause animals to become entangled. Radio-collars which are too tight can cause lacerations and chronic ulceration of the skin. Proper fitting of collars and harnesses in animals which undergo marked seasonal variation in body mass can be a problem.

There is no one best way to mark wild animals and choosing the best technique requires understanding the biology of the animal and familiarity with the techniques available. Most marking techniques produce some adverse affect on the animal and before they are used these effects should be determined either by reviewing the existing literature or by designing the study in a way that allows for these effects to be measured. Failure to consider the effects of marking devices on the animal can seriously bias research results.

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Assessment of Stress Through Biological Samples: Mammals

Marc Cattet

> A non-specific stress response that applies to all stressors does not exist. Different stressors elicit very different types of biological responses. It is, therefore, imperative that the selection of biological samples is appropriate to the stressor(s) of interest.

THE CHALLENGE OF MEASURING STRESS AND DISTRESS

Attempts to measure stress in wildlife have relied on a variety of endocrine, behavioral, physiological, and immunological end-points. Unfortunately, none of these measures has proved to be the definitive test for stress. One reason for this failure is that the term 'stress' has been generally applied to a broad array of situations that often share little in common. It is unrealistic to expect that a single indicator of stress will be appropriate for all types of stressors. Further complicating the use of biological responses as measures of stress is that these systems frequently have comparable responses to both threatening and harmless stimuli. For example, increased secretion of the adrenal glucocorticoid, cortisol, as long been associated with stress, and an increase in blood serum cortisol concentration is frequently cited as proof of stress occurring. However, cortisol has other important roles, aside resisting stress. Thus, in fasting animals, blood levels of cortisol often increase to help regulate carbohydrate metabolism.

Monitoring serum cortisol or other physiological responses to diagnose stress is particularly problematic when capturing and handling wildlife, as the very act of monitoring these systems is stressful, confounding the interpretation of the results. It follows that demonstration of cause and effect (i.e., stressor and stress response) in free-ranging wildlife is often impractical, if not impossible. More typically, the presence of stress or distress in wildlife is identified through associating measurements of perceived stressors (e.g., contaminant load) with measurements of biological function (e.g., immune function).

TIME SCALES OF STRESS AND DISTRESS

Distress can result from both acute stress and chronic stress, the differentiation between the two based on the duration of the stressor. Acute stress is usually considered to be a relatively brief exposure to a single stressor, e.g., capture by net gun. Although brief in time, such stresses can disrupt biological function by either disrupting critical biological events (e.g., ovulation, fetal development) or by diverting biological resources away from other biological functions. In contrast, chronic stress is usually considered to result from long-term continuous exposure to a single stressor or, more often, from experiencing a series of acute stressors whose accumulative biological cost results in distress. The latter type has also been termed chronic intermittent stress.

ASSESSMENT OF STRESS IN MAMMALS THROUGH BIOLOGICAL SAMPLES

A non-specific stress response that applies to all stressors does not exist. Different stressors elicit very different types of biological responses. It is, therefore, imperative that the selection of biological samples is appropriate to the stressor(s) of interest. The following provides a summary of some of the measures that can be made from biological samples to assess stress in wild mammals. It is important to note that the accuracy (and the interpretation) of these measures is highly dependent on biological samples being collected and handled in compliance with instructions provided by the diagnostic laboratory.

1. Hematology

Hematology is an area of laboratory medicine concerned with the numbers and morphology (shape and appearance) of cells that are found in blood, and their relationship to underlying disease states. In many animals, stress will induce a characteristic change in the relative proportions of different white blood cell types – a pattern referred to as a stress leukogram. The peak of this response generally occurs within 4 to 8 hours after the initial stressful event and, therefore, is unlikely to be detected in wild mammals that are captured, sampled, and released over a short period of time.

2. Serum biochemistry

Serum biochemistry refers to the analysis of chemical constituents occurring in blood serum (or plasma). It is an invaluable aid in establishing the health status of an animal, and in determining the presence of diseased states, including those resulting from distress. The serum biochemistry results from domestic animals are generally interpreted by comparing constituent values with reference laboratory values for normal animals of the same species. The interpretation of serum biochemistry values can be problematic for many species of free-ranging wildlife, as normal reference laboratory values are often not available. Nevertheless, this obstacle can be largely overcome through routine collection and analysis of blood samples from all animals captured, and the subsequent publication of the results.

3. Catecholamines (epinephrine and norepinephrine)

Epinephrine (adrenaline) and norepinephrine (noradrenaline) are hormones produced by the adrenal gland (and the nervous system, in the case of norepinephrine). At times when an animal is highly stimulated, as by fear, anger, or some challenging situation, extra amounts of these hormones are released into the bloodstream, preparing the body for energetic action. Although they are good indicators of acute stress, the collection and handling of blood samples for catecholamine analysis is meticulous and difficult under field conditions, and as a consequence is not routinely carried out.

4. Cortisol (or hydrocortisone)

Cortisol is a glucocorticoid hormone produced by the adrenal gland. In general, glucocorticoids are substances that increase the body's production of sugar (glucose), and include cortisone and corticosterone. Cortisol circulates in the blood in two forms – either bound to a protein or as free cortisol. In humans and domestic animals, most circulating cortisol is bound to a specific protein, corticosteroid-binding globulin (CBG). Serum concentrations of CBG (and hence, protein-bound cortisol) are not constant and can be altered by many factors, including age, diet, and chronic stress. Typically, chronic stresses affect a decrease in the concentration of CBG. In contrast, acute stresses affect an increase in the concentration of free cortisol, but have little effect on the concentration of protein-bound cortisol. It is important to be aware of these differences, because it is the measurement of total cortisol (both protein-bound and free fractions) in serum or plasma that is assayed most frequently to assess stress in wildlife. And yet, the interpretation of total cortisol values can be potentially misleading without knowing the relative proportions that are protein-bound and free. Undoubtedly, some of the bias toward total cortisol measurements has been because most diagnostic laboratories do not routinely measure CBG and free cortisol. Cortisol and its metabolites can also be measured in saliva, urine, and feces, but require validation before they can be used as reliable indicators of stress in wildlife.

5. Stress proteins (also called heat shock proteins)

In response to stressful stimuli, cells increase the production of one or more families of stress proteins. These highly conserved proteins enhance cell survival and were originally named 'heat-shock proteins' because heat stress was the first documented perturbation that induced a cellular response to stress. It is now recognized, however, that a variety of other stresses can induce expression of stress proteins, including viral infections and toxins, glucose deprivation, heavy metals, and hibernation. By and large, stress proteins have not been analyzed in free-ranging wildlife. And yet, they hold promise as a potentially useful indicator of chronic stress that is insensitive to many of the acute stresses associated with capture and handling. Further, stress proteins occur in most cells of the body and, therefore, can be measured in a broad range of biological samples, e.g., blood, feces, skin, and other body tissues.

Body Fluid Sampling in Birds: Blood, Feces and Others

Karen Machin

Blood Sampling

- **Blood sampling should never involve removal of greater than 10 % of the blood volume (1% of body weight).**

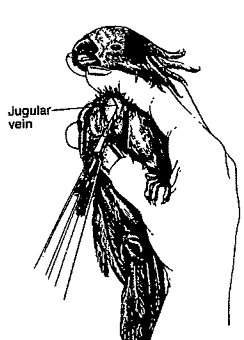
- The size of the needle is governed by the size of the vein.

- Blood can be either aspirated with a syringe but care must be taken to avoid drawing on the syringe too quickly because the thin walled veins collapse very easily. Alternatively, blood can be allowed to drip from the needle hub into a collection device.

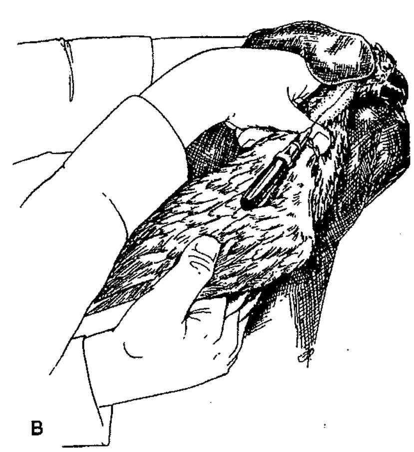
- Heparin or EDTA in the syringe or collection devices will help prevent clotting. EDTA will cause hemolysis of red cells of some species (e.g. corvids and rattites).

- Blood stop powder or other coagulant should be used if bleeding from a sampling site persists.

Jugular venipuncture is a procedure that can be used for collection blood from most avian species. It is the method of choice for small birds that do not have other blood vessels large enough for venipuncture. The jugular vein is also the site of choice when larger volumes of blood are required. The right jugular vein is usually used as the left may be absent or very small in most birds. To collect blood from the jugular vein, the bird is properly restrained with the head and neck extended. In many species, there is a featherless tract of skin overlying the jugular vein and wetting the feathers with alcohol will allow better visualization of the vein (Figs. A and B). Waterfowl do not have a featherless tract, so collection of blood from the jugular vein is blind but visualizing and palpation can be aided by wetting the feathers overlying the jugular with alcohol and by "holding off"the vein distal to where blood collection will occur.



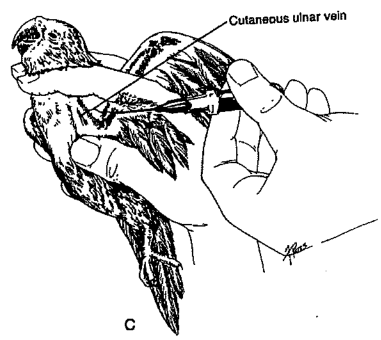
A



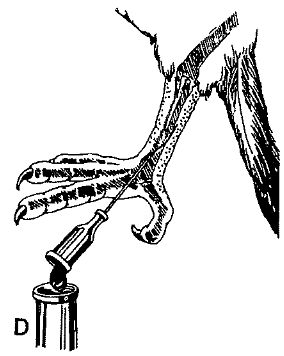
B

Complications of jugular venipuncture can include difficulty in proper restraint of the bird or stabilization of the vein and hematoma formation. Improper attention to technique and hemostatis can cause a large hematoma to form during or following jugular venipuncture. Pinching the vein, prior to removing the needle from the vein and holding it for a few seconds after the sample is taken can aid in prevention of hematomas.

Cutaneous ulnar (wing vein) venipunture is a common method for obtaining blood from medium to large birds. The vein is found crossing the ventral surface of the elbow joint (Fig. C). Hematoma formation is common at this site. Struggling during sampling (flapping of the wing) can result in tearing of the vein.



C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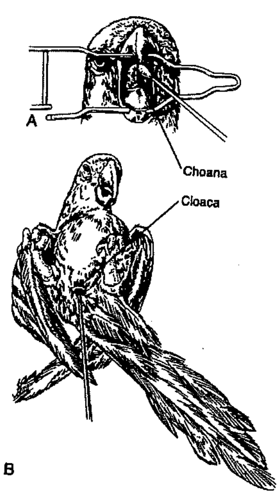
Medial metatarsal (leg vein) venipunture is another common method for blood collection in medium to large birds. The vein lies on the medial side of the tibiotarsus and near the hock (tibiotarsal-tarsometatarsal) joint (Fig. D). The primary advantage of this site, over other methods of blood collection, is that the surrounding leg muscles protect the medial metatarsal vein from hematoma formation but post-sample bleeding can be a significant problem in some species. Also in some species, the leg is more easily restrained.

Fecal Sampling

- Can be obtained indirectly (collection after defecation) or directly (direct sampling from the cloaca

Direct sampling is accomplished by gently introducing a cotton-tipped swap into the cloaca. Samples collected by this method usually do not yield large quantities of feces but may stimulate the bird to defecate (Fig. B). To avoid damage to mucous membranes, moisten the cotton-tipped swap with transport media or sterile saline solution prior to insertion.



B

Choanal Sampling

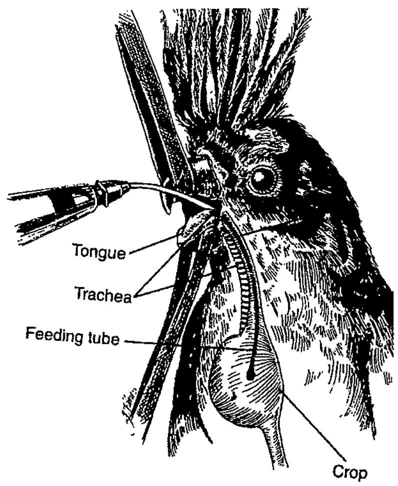
- Can be used to obtain samples for culture

Sterile fluid can also be flushed through the nares to sample microorganisms from the upper respiratory tract (Fig. A). To avoid damage to mucous membranes, moisten the cotton-tipped swap with transport media or sterile saline solution prior to insertion.

Crop wash or Aspirate

- Can be used to obtain samples for culture or ingested food matter.

In the normal bird, the crop contains very little fluid. A crop wash is performed by infusing a quantity of sterile saline into the crop and aspirating the fluid back into the syringe. The amount of fluid requires depends on the size of the bird. A sterilized stainless steel crop or feeding tube should be used.



Figures from Saunders Manual of Small Animal Practice, Birchard S.J.and R.G. Sherding (eds.). W.B. Saunders Company, Philadelphia, Pennsylvania,1994.

Body Condition and Stress

Marc Cattet

Body condition is the abundance of potential energy stored in the body tissues of an animal relative to its body size, and it reflects the outcome of energy consumption and storage over long periods of time. In the face of chronic stress, body condition is generally reduced through decreased energy intake, increased energy expenditure, or a combination of both factors.

WHAT IS BODY CONDITION?

The term 'body condition' has been used extensively in the wildlife literature, often without precise definition. Further, the term has been used interchangeably with 'nutritional condition' and 'physical condition.' To avoid confusion in the following discussion, body condition will be the sole term used, and its definition will be as follows:

Definition: "Body condition is the abundance of potential energy stored in the body tissues (primarily fat and skeletal muscle) of an animal relative to its body size."

By this definition, body condition reflects the long-term outcome (over many weeks or months) of energy consumption and storage by an animal. The definition also implies that the fuels (or substrates) for energy are not only stored in fat, but also in muscle. In contrast to body condition, body size refers to the structural dimensions of an animal and largely reflects its skeletal growth. Because there is often significant variation in body size among individuals within a species, it is important that comparisons of body condition are not biased by body size.

MEASURING BODY CONDITION

Although many methods have been used to assess body condition in wildlife, there has been far less effort to validate these methods with concurrent determinations of whole body tissue (fat and muscle) or chemical (water, lipid, and protein) composition. Such methods include:

1. **Blood analyses -** Blood chemistry levels are affected by many factors aside from body condition and, in general, appear to have little association with quantitative measurements of body composition.

2. **Measurement of backfat depth –** Mostly applicable to dead animals, affected by variation in body size, and has little association with quantitative measurements of body composition.

3. **Measurement of perirenal fat –** Similar to **2.**

4. **Measurement of fat in bone marrow –** Similar to **2.**

5. **Determination of tissue or chemical composition of carcass** – Labor- and time-intensive techniques requiring dead animals and laboratory analyses.

6. **Morphometric and body mass measurements** – Applicable to live animals, but the measurement of linear dimensions can be imprecise and the weighing of large mammals can be difficult. To be valid, the association of these measurements with whole body tissue or chemical composition must be demonstrated.

7. **Bioelectrical impedance** – This technique measures resistance to the flow of a weak (800 μamp) electrical current through body tissues. The flow of electrical current reflects body water content and will vary with changes in body composition. Accurate and repeatable estimates of body composition by this technique require considerable training and experience. To be valid, the association of bioelectrical impedance with whole body tissue or chemical composition must be demonstrated.

8. **Isotope dilution** – A known amount of labeled water (either tritium or deuterium oxide) is injected into an animal's blood stream and allowed to equilibrate among body tissues. Following equilibration, a blood sample is collected and the animal's body water content is calculated from the dilution of the labeled water in the blood sample. The technique is time consuming and requires laboratory analyses. And, to be valid, the association of estimated body water content with whole body chemical composition must be demonstrated.

THE ASSOCIATION BETWEEN BODY CONDITION AND STRESS

Given that body condition reflects the long-term outcome of energy consumption and storage by an animal, it follows that stresses occurring over long rather than short periods of time will be more likely to affect body condition. Such long-term stresses are either described as chronic, in the case of prolonged exposure to continuous stressors, or chronic intermittent, as in the case of a prolonged repeated exposure to short-term (or acute) stressors. In the face of significant long-term stresses, the body condition of an animal is generally reduced through decreased energy intake, increased energy expenditure, or a combination of both factors. Some long-term stresses will simultaneously affect the body condition of a large number of animals and are identified when making quantitative comparisons of body condition over time, e.g., declining habitat quality. Other long-term stresses may only affect the body condition of a few animals at any one time, and are identified through comparisons of body condition among many animals at the same time, e.g., chronic disease.

AN EXAMPLE: THE BODY CONDITION OF POLAR BEARS DURING THE ICE-FREE PERIOD ON HUDSON BAY

Polar bears typically consume large quantities of seal fat during the spring, whereas the remainder of the year is characterized by intermittent periods of food deprivation ranging from days to months. From April to June, polar bears prey intensively on fat, young-of-the-year, ringed seals. After killing a seal, a polar bear often will eat only the fat and leave the rest of the carcass. As a result of the exceptional ability of polar bears to digest large quantities of fat, and the large fat content of young weaned seals, polar bears become fat between spring and summer. In Hudson Bay, the sea-ice melts completely by July, and polar bears become land-bound and deprived of seals for the next 4 to 5 months. During this time, it is believed that most bears reduce physical activity and fast. When sea-ice reforms during late fall, seals become accessible again and most polar bears return to the ice to resume hunting.

The body condition of polar bears can be quantified easily, reliably, and accurately using the Body Condition Index (BCI). The BCI is the standardized residual of the regression of total body mass against straight-line body length, and ranges as a continuous value from -3.0 to +3.0. Bears with BCI values approaching –3.0 are in extremely poor body condition and appear emaciated, whereas bears with BCI values approaching +3.0 are in excellent body condition and appear rotund due to their large subcutaneous fat stores.

To illustrate the effect of prolonged food deprivation (chronic stress) on the body condition of polar bears, BCI values for 623 polar bears from two populations in Hudson Bay were compared by month during the ice-free season from July to November (Figs. 1 and 2). In the western Hudson Bay population (WH), body condition declined significantly during the ice-free season. This is consistent with reports from the field that most polar bears are inactive and fasting from July to November. It is important to recognize, however, that this loss of body condition does not represent distress, but instead reflects an adaptive response to prolonged periods of food deprivation. In comparison, polar bears of the southern Hudson Bay (SH) population maintained body condition throughout the ice-free season. Although little is known of the on-land habits of SH bears, the BCI results suggest that bears in this population either continued to feed on seals or exploited alternate food sources.

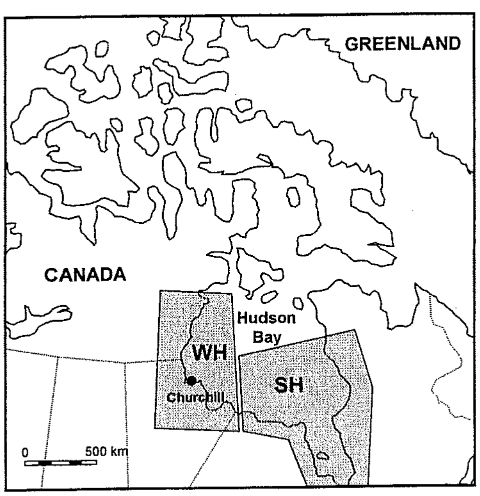


Figure 1. Geographical boundaries for two populations of polar bears inhabiting Hudson Bay. Populations are **WH** – western Hudson Bay and **SH** – southern Hudson Bay.

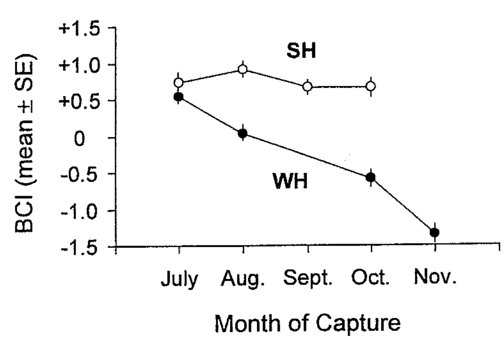


Figure 2. Comparison of BCI values by month for 623 polar bears from two populations in Hudson Bay during the ice-free season from July to November.

Field Necropsy: Gaining Valuable Knowledge From a Handling Mortality

Trent Bollinger

Occasionally animals die during the course of capture and handling procedures. Death can occur rapidly but in some cases animals may die days to weeks after their capture due to injuries or processes which occurred during capture. It is important to fully investigate these mortalities, hopefully determine their cause, and if necessary modify procedures to reduce the probability of their re-occurrence. In order to determine why an animal died a post-mortem or necropsy must be performed. In some cases the cause of death will be obvious but in others the assistance of a veterinary pathologist will be required. In order to get the most information from the necropsy the following steps should be taken. (See "Wildlife Disease Investigation Manual" produced by the Canadian Cooperative Wildlife Health Centre for details on equipment, techniques, personal protection, etc.)

1) Perform the necropsy as soon as possible after the animal dies in order to reduce the amount of autolysis or decay. If the animal is still alive but recumbent take a blood sample for future analysis.
2) If the animal dies in reasonable proximity to a veterinary diagnostic laboratory take the whole animal to the laboratory for necropsy.
3) Go prepared to perform a necropsy.
4) Describe lesions or findings in detail and preferably take pictures. These descriptions and pictures are invaluable to a pathologist who may end up examining small pieces of formalin fixed tissue in an attempt to determine the exact circumstances of an animals death.
5) Perform the necropsy in a systematic fashion and examine all organ systems but especially the lungs, heart and skeletal musculature. Estimate or preferably determine the exact body weight of the animal.
6) Collect tissues in formalin and include areas of normal and abnormal tissue.
7) Collect pieces of liver, kidney, lung and spleen and freeze for future analysis if required. Also collect and freeze any lesions.
8) Provide a complete history detailing the timing of the capture procedure, techniques used, and dosages of immobilizing agents.
9) Submit history, descriptions, photos and all tissues to a veterinary diagnostic laboratory for further study.

Occasionally animals have pre-existing disease conditions which contribute to the cause of the animals death. More typically the death is a direct result of the capture and handling procedures. There are five common causes of death related to capture and handling. They are: 1) trauma, 2) hypothermia (low body temperatures) or hyperthermia (elevated body temperatures), 3) cardiopulmonary dysfunction, 4) aspiration pneumonia, 5) bloat and 6) capture myopathy.

The lesions of trauma are hemorrhage, fractures, swelling and edema. In some cases the lesions are obvious but in other cases, such as head trauma or fractured/luxated necks, careful dissection and close observation is required to identify the lesions.

Drugs used for sedation and anesthesia suppress the central nervous system. Reflexes that normally respond to low oxygen (hypoxia) or high CO_2 levels and elevated or decreased body temperatures no longer function normally and it is important that procedures are used to compensate for these depressed responses. Animals suffering from hypoxia will develop a bluish discoloration of the skin and other tissues. Animals that die of heart and respiratory failure typically have dark red, congested lungs which may be very wet and edematous. Body temperature measurements can be useful in determining the role hyperthermia or hypothermia had in an animals death. Animals under anesthesia also don't have normal laryngeal reflexes and may aspirate regurgitated stomach contents into the lung. Aspiration of large amounts of material may cause sudden death due to asphyxiation but in other cases the animal may recover and go on to die of aspiration pneumonia due to necrosis and bacterial proliferation associated with the aspirated material in the lung.

In ruminants, which includes all cervids, bovids and antilocaprids, animals can die under anesthesia or during recovery if they are positioned so that gases normally produced within the rumen cannot be eructated. Bacteria within the rumen breakdown vegetation producing gas which accumulates above the rumen contents. Normally this gas is released via the esophagus; however, if fluid rumen contents cover the esophageal opening normal eructation or gas release does not occur. Distension of the rumen by gas is called bloat. Severe bloat impairs respiratory and circulatory function and can cause death.

Capture or exertional myopathy is one of the most important diseases associated with capture and handling procedures in wildlife. If efforts aren't taken to deal with this disease losses can be high and the subclinical and clinical effects in animals that survive days, weeks or even as long as a month can seriously bias research results. Capture myopathy is caused by intense over exertion of skeletal muscles resulting in systemic acidosis and muscle degeneration and necrosis. Hyperthermia typically is a complicating factor. Animals may die acutely due elevated levels of lactic acid in the body associated with anaerobic metabolism in skeletal muscles. Animals which die acutely often have only mild lesions consisting of muscle swelling and edema, and occasionally edema and multifocal hemorrhage of the lung. Animals must live for several hours before lesions in skeletal muscle and heart can be visualized grossly or with the light microscope. Animals that live long enough for gross lesions to develop typically have areas of edema, hemorrhage and pallor in skeletal muscles particularly these subjected to the most exertion. Lesions are often bilateral and areas of pallor may be seen in the heart. Severe muscle necrosis can result in release of myoglobin into the blood which results in swelling and brown discoloration of the kidney cortex. Renal failure can result. Congestion, edema, hemorrhage and emphysema of the lung may be present. Clinical signs, not surprisingly, consist of muscle weakness, ataxia, stiff gait, increased pulse and respiration. If severe animals become recumbent and die.

Capture and handling of wildlife is stressful to animals and is often time consuming and costly. Capture techniques are constantly being improved to reduce stress on animals and minimize mortality. Full investigations of situations where things go wrong are important in order to improve techniques in the future.

Reducing Stress Through Responsive Research: A Case Study

Gord Stenhouse – Wildlife Carnivore Biologist, Alberta Fish and Wildlife Division

> This wasn't how this was supposed to go according to the research proposal!

Wildlife researchers face a multitude of decisions when a major long-term research project is initiated. These decisions form the basis for research and funding proposals and for research permit applications that are needed to obtain the necessary permits to begin a field program. Often decisions are made based on previous experience and any available data from other studies or researchers who may have worked in this area before.

In 1999 a 5-year grizzly bear research program was initiated along the eastern slopes of Alberta. This program was designed to gain a better understanding of the linkages between human use of the landscape and grizzly bear populations in this region. This program, by necessity, assembled a team of research collaborators to address the many research questions that faced the research team.

Over the course of the first 3 years of this program many decisions have been made which directly impact the grizzly bears being studied.

Some of these decisions included:

- what types of telemetry systems should be used to collect the needed data ?
- what types of capture operations and activities would be successful within the diversity of habitats found in the study area ?
- what types of drugs should be utilized to immobilize bears ?
- what types of delivery systems should be used on study animals ?
- how will we ensure the safety of the field personnel involved in capture operations ?
- how will we ensure consistency of field techniques among the various capture crews?
- what measures and data are necessary from the immobilized bear ?
- how can we best monitor immobilized bears in order ensure their health and safe recovery?
- figuring out how are we going to pay for all this!

Throughout these, and numerous other decisions, the focus has always remained on the best way to accomplish the research objective while minimizing the stress associated with the capture and handling of grizzly bears. It should also be noted that part of our research efforts involved the question of whether landscape conditions and human activities were related to various measures of stress in this population. Since this was one of our research questions we needed to be very cognizant of the stress effects that our handling may have been having on the bears.

Over the first 3 years of this project the research team has had to adapt and modify some of the techniques and tools we have used in the capture and handling of grizzly bears. At times some of the changes that have made to our standard handling protocols have been based on problems encountered during capture. At other times the changes have resulted from field observations of a technique or approach that is more efficient and less stressful for the bear being handled.

This presentation will use the findings and experiences generated to date within this research project to show the challenges that are often faced in the capturing and handling of wildlife. A review of some of the program decisions which have been made (and when necessary modified) will be presented to show how these affect the possible effects of stress on the animal. The focus will be primarily on steps that researchers must be aware of and take to reduce and minimize the stress of capture. Lessons learned from these experiences form the basis for increased professionalism for researchers, and ultimately further improvements for the health and safety of the animals that are being studied.

Hazards of Wildlife Immobilization

Nigel Caulkett

Traumatic injuries

Animal bites and scratches are the most common injury reported by veterinary hospital workers. These bites can cause abrasion, laceration, puncture. Some animals can generate enormous force in their jaws which may produce crush injuries. Infection is not uncommon, particularly with cat bites, and can result in cellulitis, or septic arthritis. Pasturella multocida is the major infectious organism in 26% of dog bites and 50% of cat wounds. Rabies, tetanus and cat scratch fever are also concerns with bite wounds. Bites may also be inflicted by a variety of veterinary patients other than cats and dogs.

Lightly anesthetized ungulates may kick or lash out with their head. This is particularly common with bison.

Moving animals is a common source of back injury. In remote areas, personnel may be limited, and injuries can occur when large animals need to be moved.

Equipment Hazards

Equipment used for wildlife anesthesia can be a potential hazard. There are obvious concerns with helicopters and firearms, snares and traps may also produce injury if they are not respected. Compressed gas cylinders are obvious potential hazards. Needle stick injuries are common in veterinary practice. Equipment used for remote delivery of drugs is potentially dangerous. Dart rifles are capable of propelling a metal dart up to 80 yards. The dart has sufficient energy to kill a large animal such as a bear or a caribou if it hits in the wrong location, obviously there is a high risk of significant trauma from dart wounds. Darts must be loaded carefully, as leakage of drug can occur during dart pressurization, increasing the risk of human exposure.

Drugs

Anesthetic and immobilizing drugs used in wildlife anesthesia are often extremely potent. Carfentanil is often quoted as being 10000 times the potency of morphine. The commercial preparation of this product is formulated at a concentration of 3 mg/ml. One ml of this solution is therefore equivalent in potency to 30 grams of morphine. Etorphine, another narcotic used in wildlife immobilization, is 5000 times as potent as morphine. Medetomidine is a potent $alpha_2$ receptor agonist drug. A total IV dose of 120μg of medetomidine produced deep sedation, bradycardia, and a 21% decrease in cardiac output in human volunteers. Medetomidine is often formulated at a concentration of 10 mg/ml for wildlife immobilization. This is approximately 80 times the dose required for deep sedation in humans. Medetomidine is often combined with ketamine or a mixture of tiletamine and zolazepam. Tiletamine is a dissociative anesthetic that is approximately four times as potent as ketamine. Zolazepam is a potent benzodiazepine. Xylazine is another $alpha_2$ receptor agonist drug used in veterinary medicine. The large animal prep contains 100 mg/ml of active drug and has the potential to produce severe toxicity in humans. Emergency room personnel are often unfamiliar with these products, as many are only labeled for veterinary use, this can further complicate matters in the event of severe toxicity. Another factor that adds to the risk of using these compounds is that they are often used in remote locations, and medical help can not be reached quickly.

Volatile anesthesia may be used in small mammals or birds. Exposure to waste gas can be a significant problem due to the following reasons: Active scavenging is not frequently used, Air exchange may not be adequate. Veterinary masks, used for induction, do not form a good seal with the patient. Veterinary anesthetic machines are often in poor repair and leaky. Chronic exposure to these agents can lead to irritability and headaches. Exposure to nitrous oxide can result in decreased fertility and miscarriage.