REVIEW

FIELDWORK IN A COLD CLIMATE

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Abstract

It is essential that proper advanced preparation is in place before initiating a field project situated in a cold environment. Protection of the body from the wind, precipitation, and low temperatures through the use of appropriate clothing is a key to survival. Having appropriate cold-climate clothing is important, but also wearing this clothing in a manner that is most effective at maintaining a normal body temperature will help prevent both hypothermia and hyperthermia. Proper preparation includes working emergency equipment, knowledge of how to use the emergency equipment, and developing a field plan to leave with a contact. Special care must be provided to medications in a freezing environment, and there are methods that ensure that treatments can occur when needed. Copyright 2013 Published by Elsevier Inc.

Key words: clothing; communication; dehydration; hyperthermia; hypothermia; wind chill

This article provides basic information for those who may be involved with veterinary fieldwork in cold environments. An important, thought-provoking statement regarding veterinary fieldwork is from Dr Nigel Caulkett: "The best advice that anyone can take into the field is to consult local people, often Aboriginals, who have lived on the land for generations." Personal insights of experienced field veterinarians are described after each section and identified by the following initials: Drs John Blake and Jan Rowell (B.R.), Dr Greg Adams (G.A.), Dr Nigel Caulkett (N.C.), and the author (J.H.).

Cold climates create special conditions for the veterinarian or biologist who is working with wildlife or, indeed, domesticated animals. The term "cold" is relative, and in this regard, I define it to mean conditions that may range from about +5°C to as low as −40°C. The effects and requirements of working out of doors within this range are further moderated by other environmental conditions, particularly wind. So-called "wind chill" ("wind chill factor") can greatly increase the heat loss from an animal or human body, especially exposed human skin. A Canadian government chart is available online and provides examples of how wind can affect workers.[1] An example of the interaction of wind and cold temperatures is with wind speeds of 30 km/h, when "wind raises loose paper, large flags flap and small tree branches move"; an environmental temperature of −15°C feels like −26°C. Under these conditions, the risk of frostbite is low. However, at wind speeds of 40 km/h, when "small trees begin to sway and large flags extend and flap strongly" and there is an ambient temperature of −30°C, the wind chill makes conditions feel like −48°C, and there is a "very high risk of frostbite" and a "serious risk of hypothermia." If official government documents state that the "risk of frostbite is low" at −26°C, this by no means indicates that working conditions are comfortable. In fact, at any temperature within the "cold" range of +5°C to as low as −40°C, conditions can be unpleasant and difficult.

There are dangerous situations and risks, and there are inconveniences. Most of either category can be predicted and prepared for, but not all. The dangerous can conveniently be divided into those that are dangerous for the workers and those that are dangerous for the subject animals. Inconveniences mainly relate to problems encountered by humans.

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PERSONAL EQUIPMENT

Clothing

There are basic equipment rules that should be followed by anyone contemplating work in cold environments. All workers should be well equipped with appropriate clothing. In Arctic environments, caribou skins are the best. As B.R. stated, "Inuit hunters were tired of taking out biologists in all the latest (and expensive) [commercial] outdoor clothing. Down is great until you sweat—then it is useless." If hide clothing as developed and used by Aboriginal (Inuit or Eskimo) peoples of the Arctic is not available, alternatives must be sought. When temperatures dip well below freezing, this is likely to include good-quality base layers, warm (often woolen or high-quality fleece) trousers, layered upper body shirts and jackets, an outer wind- and moisture-proof layer for the legs and upper body, and good-quality head protection and gloves. A good technique is to use coveralls made of a waterproof, breathable material such as Gortex, under which layers can be worn. This can help to reduce the amount of bulky clothing. Cotton garments are of no use in such conditions. Inner insulated pockets are also essential. Loose clothing such as scarves that may flap must be avoided for safety reasons (as discussed by M.E. Cooper in this issue) because they can catch in motorized transport.

Perhaps the major risk with the layering effect of clothes is overheating. If a worker is faced with periods of vigorous activity—and even slow walking or wading in deep snow can readily be classed in this category—followed by periods of relative stagnation, sweat generated during the exercise can quickly make clothing wet, and this moisture can turn cold. Workers should be able and willing to remove or add layers as conditions change.

The range of temperatures that I have defined as cold creates particular problems when it comes to the choice of footwear. At the upper end, from +5°C to about −5°C, good waterproof hiking boots and waterproof gaiters may be sufficient if one is able to return to base camp and a heated shelter. At the coldest temperatures below −25°C, some form of insulated boots is required because cold feet and especially cold toes are difficult to warm up once affected. A major problem with footwear is the tendency for feet to sweat, and sweat can quickly turn to ice. Many fieldworkers use layered boots that reach to just below the knee and have felt or other insulating inner material with exchangeable inner soles on top of mesh pads. These pads collect the moisture below the inner sole and felt liner, and that moisture freezes but is not in direct contact with the feet.

If conditions are near or even above freezing, waterproof boots are required. The Inuit/Eskimo solution to this requirement is to use sealskin with the fur shaved off. The shaving can go well up the leg if needed (B.R.). Another solution is to wear oversized rubber boots and line them with wool felt and pads. Hand and boot warmers or heated socks are options, but fuel and/or battery life may not last for the duration of exposure.

The dangers of working in wet conditions on marine mammals or other aquatic creatures are also of concern. Appropriate dry suits or wetsuits should be considered. Dry suits provide thermal insulation or passive thermal protection to the wearer while immersed in water. As a general rule, dry suits are worn where water temperatures are below 15°C or with extended immersion. Wetsuits, on the other hand, do not provide more than a limited amount of insulation. When one is working from a boat, standard clothing should include a buoyant immersion suit. In conditions of snow and ice, good-quality dark glasses are essential to prevent the effects of headache-inducing glare or ultraviolet B rays that can lead to snow blindness.

Part of a paragraph from Judson[2] that lists the complete issue of clothing suitable for Antarctic exploration reads as follows: "long underwear, two pairs of fleece trousers (thick and thin), two fleece jackets (ditto), a pair of windproof overalls, a light jacket of synthetic down, a windbreaker, a heavy jacket of real down, two pairs of boots, two pairs of thick socks, down tent slippers, nine pairs of gloves and mittens, a hat, a balaclava, a neck gaiter (a scarf shaped like a tube), snow goggles, and sunglasses."

Personal Experiences

Clothing. B.R.: "The only downside to caribou clothing was that it shed constantly so anything I ate or drank had caribou hair in it."

J.H.: "Despite the most careful of planning, things can go wrong. During an airport transfer, one entire backpack of clothing did not make it onto the final plane. Luckily, because they were too bulky to pack, I was wearing my boots, gloves, and parka. Colleagues loaned me sweat-

FIGURE 1. Mongolian deel, or del, in use on horseback.

ers, shirts, and socks and gave me underwear that had been in its original store packaging. I was able to recover the backpack on my way home."

A parka is a knee-length cold-weather jacket or coat, usually stuffed with down or synthetic fiber, with a fur-lined hood. In contrast, an anorak is a waterproof, hooded, pullover jacket without a front opening.

The most useful garment that this author has used in cold conditions (to −10°C) was the Mongolian *deel*, or *del*. It was no colder than −10°C during the day, but the del covered me from its lifted collar to a point below my knees. It was also windproof. It is an ideal garment when one is on horseback (Fig. 1). Furthermore, it is easy to wear layers underneath or even on top of a del, and when it rains, one's entire body can quickly be protected with a poncho. Dels are available in several different weights (summer/winter and so on). Locals wear them in the coldest of conditions.

N.C.: "A minimum 700 fill weight down jacket that is carried in a backpack at all times can be used as an emergency item. It should never be left in a helicopter but should accompany the researcher to the worksite by the animal."

Footwear. J.H.: "When working in Arctic conditions, I chose to use two sets of felt boot liners, beneath which were inner soles and moisture pads that could be changed regularly so that one set was always dry. The boots themselves were either US or Canadian military Arctic boots or Sorel brand boots. If the snow is melting, the military issue boots are not ideal because the rubber material only reaches up to the ankle, at most. Above the ankle, the boots are made of a tough nylon that is not waterproof."

B.R.: "Nothing before or since can match that footgear (sealskin boots with felt liners) for warmth and lightness—like walking in sock feet. I wore them for years—I wore them out. We used to put muskox wool (qiviut) around our toes to keep our feet warm—but again—once feet sweat—the qiviut becomes a slimy little wad."

J.H.: "It may sound puerile, but when working in temperatures below about −20°C, I chose to attach my outer gloves to one another with long strings through my jacket sleeves and across my shoulders. These lanyards are also known as "kiddie" or "idiot" strings, but a glove lost in deep snow can create a major problem. The glove lanyards are sometimes worn by recreational skiers. If an unattached glove falls off a snow machine or other means of transport, it may be permanently lost if not so attached. This is not a good situation. Frostbite is an obvious risk, but it is difficult to make fine movement of one's fingers when they are cold."

TRANSPORTATION

People have used a variety of transport systems for work in cold places. These include watercraft, snow machines, all-terrain vehicles, and aircraft (e.g., fixed wing, helicopters) (Fig. 2). Animal transport, including horses, sled dogs, and reindeer (in Mongolia), is also used. The potential for breakdown or failure of any of these systems cannot be ignored. It is essential to select the right equipment for the job (B.R.: "A three or four metre skiff at sea is a bad idea.").

Personal Experiences

On one occasion when working along the Arctic coast of Baffin Island at approximately 67°N, our helicopter pilot forgot to pack his fuel pump (a cardinal sin), so we could not refuel. The daytime temperatures were below freezing and dropped sharply as the half-dusk set in. The crew

FIGURE 2. Fieldwork on polar bears using a helicopter for transportation.

spent the 3 hours of near-dark in good bags and a high-quality tent. We were concerned about polar bears approaching and even attacking the machine, so each person took a shift on guard, armed with a rifle. (Warning: Snow-covered or white rocks can appear to move when one is in this stressful situation.) No rocks were harmed during the short Arctic night (!), but it was a stressful situation. B.R. noted that researchers are not at the top of the food chain.

EMERGENCY EQUIPMENT

In all cases, provision must be made for transport failure (as discussed by J.E. Cooper in this issue) and a subsequent period of overnight stay in what may become dangerously cold conditions. Other survival gear such as a knife, fire starter, compass and/or global positioning system locator, and a water bottle with built-in filter to protect against parasites such as *Giardia* spp and *Cryptosporidium* spp should also be in the same backpack as the spare down jacket.

Some means of communication with base camps or headquarters is essential. Emergency locator transmitters/transponders should be part of any basic kit (as discussed by Ojigo and Daborn in this issue). If cell phone coverage is likely to be a problem, then satellite phones should be considered. Portable solar-power panels for charging electronic equipment are readily available and should be on the checklist.

Shelter, food, drinks, heat (waterproof matches or a reliable lighter), and light sources are required as part of the emergency gear, but tent heaters create the risk of carbon monoxide poisoning in a well-sealed enclosure, especially one with double walls.

Sleeping bags with fleece liners should be included. Sleeping bags are rated according to the degree of cold that they may protect against, but there is no standard rating. One should choose a bag that will protect against the coldest conditions that one may encounter. It is easier to open a bag and sleep with it partly undone than to try and warm up a bag that lacks sufficient insulation. An inflatable mattress between the ground and the bag is also required.

A good first aid kit should also be a part of every fieldwork group's equipment list. If one is working in remote areas, for more than short periods, a handbook guide for wilderness medicine (as discussed by J.E. Cooper in this issue) is an optional addition.[3]

NUTRITION

Emergency rations and drinks must always be available because dehydration is a real problem. The solution to reduce the risk of dehydration for some researchers is tea, and more tea. A basic supply of high-energy foods should be readily available. If one has to "live off the land," some foods need careful preparation. For instance, because of the risk of parasites, especially *Trichinella spiralis*, polar bear meat should be boiled for at least 45 minutes (B.R.).

Personal Experiences

This author has been in a van that was stuck in a high-altitude (1,000-meter) bog on the Mongolian steppe for 36 hours. Inside the van were fluids, food (mixed nuts and chocolate bars), and a sleeping bag; therefore the author had no difficulty surviving the experience.

N.C.: "Wax paper burns hot and slow and is a useful addition to the emergency gear in the backpack. Tinfoil is another useful addition as it can be turned into cups or plates."

OTHER RISKS

Apart from the obvious risks associated with attack by carnivores or rutting cervids, there are wildlife disease situations to consider. As B.R. put it, "If a fox trots into camp—don't think cute—think rabies." There has been a debate over the use of one or other form of bear deterrent. An official US Fish and Wildlife Service factsheet suggests that pepper spray is safer for the handler and at least as effective as a firearm in deterring a bear.[4] When the author was working with polar bears at Churchill, Manitoba, a shotgun with a flash cartridge in one barrel and a slug in the other was readily accessible. The flash cartridge was only used once, making sure that the flash did not ignite beyond the bear. On one occasion, a colleague had to use lethal force with a rifle when a polar bear, apparently safely immobilized, charged as soon as the research team emerged from the helicopter (J. Lee, written communication, 2012).

FIELD AND RESEARCH EQUIPMENT

Each scientific project demands different field equipment. However, there are some basic guidelines that apply to most investigative situations in a cold environment.

All drugs, sample tubes, and other similar ancillary equipment must be kept warm. Keeping this equipment warm can be a challenge. If one is working from a helicopter or other form of transport with an enclosed cab and a heater, the box can be opened and the air vents directed at its contents. If the drug box is kept outside for prolonged periods of time at ambient temperatures well below freezing, some other solution (e.g., heating pads) must be used. Although unused syringes and cased needles can be placed in inside pockets, as can smaller bottles of pharmaceutical agents, there are obvious risks associated with potent immobilizing drugs being held in this manner. One solution is to put small vials in hard protective cases that can themselves be kept inside pockets or on belt loops. The generous chest pocket created by wearing the belt (boos) of a Mongolian del is an ideal place for such storage.

Another problem is that immobilizing darts may freeze in the barrel of a gun. Dart guns can be kept inside helicopters or trucks until needed. When the author worked from a helicopter, the warm air vents were directed down the barrel while searching for study animals. When the author was on foot or riding an all-terrain vehicle or snow machine, the whole dart gun was contained in an insulated gun case until the time it was needed. Similarly, the darts themselves must remain warm until the moment of use. The author keeps darts warm and safe by placing them in syringe cases (30 or 60 mL) that are then capped and sealed with tape before putting them under clothing.

Sample tubes, especially those for blood, must be warm before use. Vacuum tubes do not work in the cold. The author routinely uses large syringes (warmed inside clothing) and then transfers the samples to tubes (also warmed). Once blood samples have been collected, they must be protected from freezing. Filled blood tubes ideally should be maintained at room temperature with care not to overheat, which is difficult to do.

One faces a major challenge when performing detailed physiologic studies using equipment such as the Abbott i-STAT (Abbott Laboratories, Abbott Park, IL, USA). The operating temperature of these instruments lies between +15°C and +30°C. An insulated box may provide a partial solution and can be kept in the transport vehicle, but a supply of water in a hot-water bottle, with backup hot water in vacuum flasks, can alleviate some of the problem. When the instrument is outside of the insulated box, it can be kept inside warm clothing or something similar to a camera case heated with Hotshot Hand Warmers (Mountain Equipment Co-op., SW, Calgary, Alberta, Canada).

Samples of arterial blood that are collected for blood gas measurement back at base can be stored on crushed ice. As a transfer method from animal to machine, the author uses a custom-designed belt with pockets worn under a parka.

Manual pregnancy checking of immobilized animals in cold conditions is a 2-edged sword (Fig. 3). One arm and shoulder must be exposed to the outside environment, but naturally, once it has been inserted into the rectum, it is in a warm place. Some makes of working coveralls have detachable sleeves, which offer a partial solution. It is not only the arm that one must be concerned about, but the plastic sleeves and lubricant must also be kept warm. Lubricant does not work well when frozen.

If one is checking pregnancy with ultrasound equipment or using blood gas, pulse oximetry, or other electronic equipment in a cold environment, there are factors to consider. Standard batteries, as supplied by the manufacturer, may not last more than 1 or 2 hours. One solution (G.A.) has been to use two 12-volt, 15.5-amp lead acid rechargeable batteries (motorcycle type), which will keep a charge for up to 8 hours. However, it is not always that simple. B.R. offered experiences from Alaska and Norway. There are problems using ultrasound machines in the spring—even if one can keep equipment warm in a helicopter. The ambient light is so bright that the screen on the ultrasound machine cannot be read. A dark, black tent is required at this time, or all images must be captured to evaluate at a later time.

FIGURE 3. Pregnancy checking of animals in cold conditions.

Extreme temperatures (−40°C) also affect other electrical components. B.R. reported that cardiologists from "down south" came up north to obtain electrocardiograms on wolves. The researchers went out at −40°C and, as a result, were confronted with a huge tangle of brittle, frozen, and cracked cables. In addition, the liquid crystal display screens did not work at −40°C.

N.C. reported that with the exception of the Propac (Zoll Medical Corporation, Mississauga, Ontario, Canada), the information on most light-emitting diode screens cannot be viewed if the observer is wearing polarized glasses.

Inconveniences and Solutions

The first time that this author used a stethoscope on a wild mammal, he discovered that storing this instrument in an outside, uninsulated pocket is a mistake. When the very cold ear buds were placed in the ear canal, it was a very painful experience.[5] Thenceforth the stethoscope has been placed in an inner pocket of a down parka or del.

Risks for Animals and Mitigation

Some of the risks to animals are the same for any climatic environment (as discussed by Goodman et al in this issue). However, in cold conditions there are special circumstances of which workers need to be aware.

Overheating. Hyperthermia can develop in cold-adapted animals such as bears (*Ursus* spp), bison (*Bison bison*), and several cervids if chased. Even at a fast walk, much less a run away from a chasing helicopter, a polar bear can overheat. Some bears may have as much as 10 cm of insulating fat, and heat dissipation does not readily occur. It behooves the worker to avoid prolonged chases of subject animals.

Even at apparently cold temperatures (such as −10°C), hyperthermia can also develop in well-insulated animals that have not yet shed a winter coat after short periods of stress-induced exercise. The author has witnessed a high mortality rate (>25%) and diagnosed capture myopathy in wild wapiti (North American elk, *Cervus elaphus*) during the second half of March after the animals were handled in chutes and transported up to 100 km. The ambient temperatures at the time of the elk project were between −5°C and −12°C. In addition to their heavy coats, the animals were in late winter condition and the pregnant females were only 9 or 10 weeks from term. Wapiti habituated to handling systems had no ill effects at similar temperatures, even in April or early May.

N.C. reports that $\alpha 2$ agonists may cause hyperthermia in polar bears (*Ursus maritimus*) and brown bears (*Ursus arctos*). Body temperatures as high as 41°C have been recorded in bears administered $\alpha 2$ agonists. Research is currently in progress investigating the applicability and value of active cooling in bears using cold-water enemas and ice packed into the axillary and inguinal areas.

Hypothermia. Even at the coldest temperatures, cold-adapted animals are unlikely to have hypothermia when being handled unless inappropriate drugs are used for sedation or immobilization or oversight is not provided during the procedure to prevent a significant drop in body temperature. However, the size of the animal also plays a role in its susceptibility to hypothermia. For example, hypothermia is unlikely to develop in immobilized adult bears because of both body size and natural insulation, whereas cubs, especially cubs of the year, need to be protected. Protection of bear cubs from hypothermia can be achieved by wrapping the animals in sleeping bags or space blankets and placing them close to their mother until the cubs recover. This requires the cubs to first be treated with antidotes to immobilizing drugs before the adult. Because the dissociative agents such as ketamine and Telazol (Telazol®, Warner Lambert Co., Ann Arbor, Michigan, USA; a mixture of tiletamine hydrochloride [HCl] and zolazepam) have no specific antidotes, the doses of this class of drugs in cubs should be reduced as much as possible to limit their time under sedation.

In small mammals the effects of hypothermia can also be ameliorated to some extent by the use of insulating covers (e.g., foil space blankets).

There are a few drugs that can cause extrapyramidal effects. Drugs that can cause extrapyramidal effects include the butyrophenones and phenothiazine sedatives, both of which are sometimes used in immobilizing mixtures to enhance the effects of opioid agents. Butyrophenones and phenothiazine sedatives cause hypotension and hypothermia and have been implicated in cases of death to subject animals.[6,7] Larger mammals (e.g., bison, moose, bear) are unlikely to be affected by the extrapyramidal effects caused by butyrophenones and phenothiazine sedatives.

In all species the $\alpha 2$ agonists cause hypertension and bradycardia. This can lead to disruption of thermoregulation; therefore doses of $\alpha 2$ agonists in drug cocktails must be minimal. $\alpha 2$ agonists can also cause hypoxia in ungulates, and cases of bloat have been observed when ruminants are immobilized with these drugs.

The dissociative anesthetics phencyclidine HCl, ketamine HCl, and Telazol can also cause hypoxemia and hypothermia in some animal species. This effect has been reported in Procyonidae even when temperatures were as high as +18°C.[4]

The physical environment can also create risks for animals, and ice is one such component. Animals running on an icy surface face risks that include slipping, injury, and drowning. There are records of mass drownings of as many as 3,000 bison that have ventured onto thin ice.[8] Immobilized animals must be carefully monitored at all times and in all situations, but snow can create an extra hazard. An animal that has its head down in snow can be asphyxiated, or the breath can melt the snow and create a water puddle that is equally hazardous. Good judgment of environmental conditions is an obvious duty for researchers working in cold climates. Cases have been recorded of moose falling and fracturing their necks when captured with net guns in deep snow. Cold conditions are also a hazard for animals that have no eye protection when immobilized. The cornea and ear tips can freeze and therefore must be protected with an appropriate ophthalmic ointment, hood, and ear coverings.

When one is working with vertebrate animals at the lowest end of the size scale (e.g., rodents), live traps should have appropriate modifications when used in cold conditions. Two common and widely used rodent traps are the Longworth and Sherman designs.[9,10] When used for winter research, a chimney can be added. The chimney is placed before snowfall and extended as the snow deepens.[11] This chimney allows access to the subnivean space without disturbance to the snow, a critical factor in avoiding disruption of the research site. This potential disturbance is known as "Schrödinger's cat" and is generally, though incorrectly, "thought of as an acronym for the problem of the observer influencing the measurements of the system being observed."[11] For the Sherman trap, an extra space (e.g., can) is added at the rear of the device. The trap itself should contain bedding and food.

CONCLUSIONS

One should learn from the experts and talk to people who have experienced and worked in cold climatic conditions.[12] Arguably the most important advice is to use local knowledge, when available. Hydration, hypothermia, and hyperthermia followed by sweating and freezing are major concerns to the researcher working at temperatures between +5°C and −40°C. Provision of proper clothing and its appropriate use are fundamental. For animals, temperature regulation is also a major issue.

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