The Effects of Environmental Extremes on Working Dogs: A Collaborative Initiative

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Military working dogs (MWDs) are employed in a variety of austere and extreme environments, yet the environmental limits in which they can safely and effectively operate have never been thoroughly defined. A combat unit utilizing canine teams may experience an altitude change of 5,000 feet elevation or more for a single mission or an elevation change of over 10,000 feet within a few days of being deployed from its home base. Operational needs may dictate a rapid change in the footprint of forces on the battlefield, requiring movement to a vastly different terrain and environment. Dogs deploying in support of combat or other contingency operations where there is little time for acclimation may experience rapid changes in altitude, temperature, and humidity. A collaborative initiative spearheaded by special operations forces (SOF) veterinary personnel across the range of the US Special Operations Command seeks to characterize the physiologic capabilities of working dogs and advance their safe and effective use in these environments.

Extensive information is already known about human responses to these environments, with subspecialties in military medicine such as aviation and dive medicine. Civilian subspecialties such as wilderness medicine focus on conditions and treatment associated with exposure to the elements in various outdoor environments. These subspecialty areas of medicine provide evidence-based guidelines to ensure the safety and effectiveness of humans operating in these conditions. In addition, they are constantly advancing the ability of our forces to push further into new and unique operating environments.

The Veterinary Corps officer (VCO) and Animal Care Specialist (military occupational specialty 68T) are in a position to assist canine programs in ensuring readiness for rapid deployment, or sustained deployment to areas of extreme environmental conditions. Canine programs look to Veterinary Corps personnel for answers to questions directly affecting combat operating ability:

- Will high altitude will affect his scent detection ability?
- When my dog is deployed to the desert, it is better to have air conditioning in the kennel to help him rest between operations, or no air conditioning to help get acclimated to hot weather?
- How high can we (parachute) jump a dog before he needs supplemental oxygen?
- What ocean temperature is too cold to use the dogs in maritime operations?
- Do nutritional supplements help prevent heat injury?
- Does pre-hydration with subcutaneous fluids help prevent heat injury?

All of these questions were asked of the authors by canine program managers within the past year. It is important for veterinary personnel to remember that canine program managers are looking for facts to aid the combatant commanders, who may use this information to make high-level decisions on the use of MWDs in combat and contingency operations. The responses we provide must be accurate, evidence-based, and realistic with regard to operational tempo, environment, and operational capabilities and limitations.

Faced with these important questions, the VCO and Animal Care Specialist will naturally want to provide answers. However, based on the actual evidence in the veterinary literature, the correct answer to each of the questions above is: we don't know.

Collectively called "the effects of environmental extremes on military working dogs," the goal of the initiative is to characterize the normal and abnormal physiologic responses of MWDs to these environments, and provide recommendations based on a combination of scientific evidence, lessons learned, and practical experience of the canine units and veterinary support personnel. The effort includes extensive literature research, tracking the work of ongoing research in these areas, promoting research and development projects among our military and civilian colleagues, and conducting original research in the field.

This multifaceted initiative is not a SOF-exclusive endeavor, nor is it a finite project. It is a process that will evolve, change through research advances as well as combat lessons learned, and is expected to continue

indefinitely. Our approach follows these basic principles of the process:

1. Determine what is normal—what are physiologic parameters of MWDs in their working state?

2. Define the problem—determine end-user requirements and evaluate the epidemiologic data existing on those topics.

3. Critically evaluate the existing evidence to deter- mine current best practices for prevention and treatment of adverse reactions to extreme environmental conditions (hyperthermia, hypothermia, etc.).

4. Conduct research and development, based on validated requirements, to overcome the defined problems and increase effective range of MWDs on the battlefield.

Current efforts focus on 4 broad operational environments: extreme heat, extreme cold, maritime, and high altitude. Within those 4 environments are many subsets, such as desert versus tropical heat, and mountain-based versus aviation-based altitude. In the following sections, we highlight some of the efforts and initial accomplishments of this team, the impact of this initiative on the operational canine unit, and discuss the way ahead.

Telemetric measurement of body temperature allows a SOF Animal Care Specialist IDVT to ensure safety of a dog during cold water training.

1. Determine what is normal.

The standard range for canine temperature is typically stated as between 99°F and 102.5°F, assuming that the dog is in a resting, relaxed state when examined. Several studies in canine athletes and working dogs have shown rectal temperatures to exceed 108°F during moderate exercise with no adverse effects.[1-4] Similarly, Ani- mal Care Specialists serving as SOF Independent Duty Veterinary Technicians (IDVTs) have observed for several years that many of their unit's dogs routinely develop temperatures up to or above 107°F during work without any adverse effects. Yet, by convention, most veterinary personnel learn that any rectal temperature over 106°F is a critical temperature indicating heat injury.

Body temperature and physical performance is closely monitored in new accession dogs intended for use in select SOF multipurpose canine (MPC) programs. This monitoring helps assess their physical suitability for the program. It is also performed for safety and prevention of heat injury while they acclimate to the 20°F or more increase in environmental temperature at their new location compared to their countries of origin. Using an ingestible thermistor and radiofrequency reader (Core Temperature Monitoring Systems, HQ Inc, Palmetto, FL), as well as standard digital rectal thermometers, the Animal Care Specialists noted that all of the dogs that were monitored developed rectal temperatures of over 108°F during bite and explosive detection work of less than 10 minutes duration, despite the relatively mild ambient temperatures. In contrast, their core temperatures remained between 103°F-104°F. Fully trained and acclimated dogs showed the same patterns of core and rectal temperature differential. Their relative tolerance to high rectal temperatures may be explained by the lower core temperature readings.

Veterinary personnel who work with canine athletes and working dogs are familiar with these high temperatures, and tend to rely more on the dog's physical appearance and performance than the thermometer reading when assessing the dog's thermoregulatory status. Subtle changes in these factors of performance appear to be much more predictive of heat-related illness than rectal body temperature alone.

To truly understand what is "normal" for working dogs, the VCO and Animal Care Specialist must move from behind the veterinary clinic examination table into the working and training environment of MWDs. In dogs with intensely high drive, physiologic and behavioral response of the dog during a period of recovery may be a better predictor of the dog's physical state. For ex- ample, the intensity of a dog's run toward a decoy or reward may not diminish until late in the progression of heat stress, due to his high drive. However, during the recovery phase after obtaining the reward, the dog might show more obvious signs of reaching his limits earlier than while in pursuit of a reward. When there is no incentive to work for the reward, the dog may focus more on recovery and cooling. Research on associations between subtle canine behavioral changes, body

Core temperature may be a more accurate measure of a dog's temperature while working in extreme environments.

temperature, and heat tolerance may provide insight on this topic, and lead to new approaches in educate canine handlers on prevention of heat injury in their dogs.

In humans and other species, changes in metabolic rate and peripheral vasoconstriction at various altitudes and environmental temperatures affect body heat production and loss.[5-7] Considering this model, it is possible that changes in core versus rectal temperature may differ between dogs in different states of conditioning, and between environmental extremes of heat, humidity, and extreme cold or altitude.

Teaming with researchers from Oklahoma State University and North Carolina State University, the team has performed testing to compare core against rectal temperature of canine athletes in a variety of environmental conditions, including heat and humidity, extreme cold, and high altitude. In addition, they are conducting research and development (R&D) of aids to prevention of heat injury, such as cooling mats and muzzles, that allow maximum air movement while retaining safety features.

Desert and Tropical Hot Weather Operations

At a field research station in North Carolina, part of the SOF veterinary team works with university researchers to characterize the response of heat, humidity, and comparative cooling methods in Labrador retriever explosive detection dogs undergoing exercise. As an adjunct to this study, a prototype battery-operated cooling blanket designed by a SOF canine program and Army Research Office R&D personnel is being evaluated for use in the field. The effectiveness of the blanket is being evaluated against other methods of cooling, including immersion in an ambient temperature water trough, simulating wading in natural water sources for cooling.

High Altitude Mountain Operations

In Alaska, the SOF veterinary team works with the Oklahoma State University researchers in a field station to study the effects of extreme cold and altitude on thermoregulation on dogs during exercise and anesthesia. Working in an environmentally controlled, low-oxygen chamber that simulates up to 15,000 ft altitude and 10°F, the VCO and Animal Care Specialist on this project don extreme cold weather gear and oxygen masks to monitor physiological parameters such as core and rectal temperature changes in Iditarod-proven Alaskan husky sled dogs running on a treadmill. This is followed by a field anesthesia protocol in a "warm" room at 50°F, simulating a field aid station at a remote mountain forward operating base. In addition, the cold weather team studied rapid acclimatization to high altitude in conditioned and unconditioned dogs. As part of the project in Alaska, the team worked closely with veterinary specialists and mushers during the Iditarod dog-sled race. The team noted the dogs' exceptional ability to withstand temperatures as low as -50°F, and tendency for heat intolerance in ambient temperatures above only 20°F. This was an excellent example of how heat injury or intolerance cannot always be attributed to high ambient temperatures. Analysis of the data may lend insight into differences in the relation of core and rectal temperature in hot versus cold environments. In addition, initial data on maintenance of body temperature during anesthesia in cold environments is hoped to aid in the development of safe protocols for short-term field anesthesia for working dogs in high altitude, cold weather environments.

Maritime Operations

Similar to monitoring the dogs in hot weather, select Navy dogs swimming in ocean waters during the winter as part of their initial assessment and training are closely monitored for hypothermia and accidental ingestion or aspiration of salt water. To ensure the dogs' safety, SOF veterinary personnel and handlers in the water with the dogs monitor their core temperatures and other measures. Data from this type of preventive monitoring is being assessed to design further study, similar to the heat, cold, and altitude studies.

2. Define the problem, determine end-user requirements, and evaluate the epidemiologic data.

A combination of evidence and lessons learned from practical experience is necessary to drive advances in military veterinary medicine. Prevention and treatment guidelines for any condition in veterinary medicine should be based on the available evidence and end-user requirements whenever possible. But as discussed previously, there has been little study into unique conditions

of working dogs on which to base MWD-specific guidelines. Two retrospective studies currently provide the only statistical analysis of possible risk factors and out- come of heat injury in dogs.[8,9]

By collecting and analyzing the available epidemiological data, we can validate end-user requirements and focus our efforts in providing accurate guidelines to ca- nine programs that are also relevant to their needs. Retrospective analysis of the available data can determine the significance of individual occupational problems and hazards for MWDs.

Before dedication of extensive effort or funds for research and development in prevention of environmental-associated conditions, we must clearly define the problem. For example, heat injury issues requiring definition might include:

- What is the incidence and prevalence of heat injury in MWDs?
- Was there any association with the type or use of dog and the likelihood of heat injury, or the experience of the handler?
- How many were working in muzzle when injury occurred?
- Is heat injury more likely in a deployed environment than a US environment?
- Is it more likely during training than actual operations?
- What is the rate of survival versus non-survival?
- What treatment measures did the handler or other nonveterinary first responders apply prior to arrival at veterinary care, and were any of these factors associated with survival or non-survival?

In order to provide the most accurate widespread recommendations on prevention or treatment, we need to know what risk factors are truly most commonly associated with specific conditions, and any factors that influence outcome. As there is currently no central database for cataloging and retrieving MWD medical data, this process will involve an intensive, combined effort of conventional and SOF veterinary personnel to retrieve and compile the data.

3. Critically evaluate the existing evidence to determine current best practices for prevention and treatment.

As discussed above, prevention and treatment guide- lines for best practices in veterinary medicine should be based on critical evaluation of the available evidence whenever possible. A critical review by the SOF team of the veterinary literature on canine heat injury found that there was very little in the veterinary literature to provide evidence-based guidelines on any aspect of canine heat injury for either working or companion dogs.[10] Furthermore, the review revealed that some widely-accepted guidelines for treatment and long-term management have never been scientifically validated, and, in some cases, may actually be refuted in the literature. For example, most treatment guidelines caution against using cold or ice water for cooling dogs with heat stroke, claiming that this can slow cooling or lead to complications such as disseminated intravascular coagulopathy (DIC). The review found that, according to the available veterinary literature, there was no evidence that ice or cold water cooling was associated with slower cooling, DIC, or worse outcomes in dogs. In fact, ice water immersion was found to be the most rapid method of cooling in hyperthermic human athletes, and is the recommended method of cooling in human medicine.[11-14] The few canine-specific studies on cooling methods were conducted 20 to 30 years ago, and involved a very small number of animals in experimental studies of induced heat stroke models.[15-20] Prospective, randomized, con- trolled clinical trials of different cooling methods would be necessary to make definite conclusions and provide evidence-based guidelines on best practices for cooling.

Along with addressing unanswered questions with research, it is equally important to not propagate guidelines that are not supported by the evidence. If tap water and fanning (rather than cold or ice water) is effective in cooling dogs with hyperthermia,[17] it should be stated as no more or less than that when the information is relayed to others. Veterinary personnel should be aware that the precept that ice water is contraindicated because it leads to DIC is a guideline that is not supported by the evidence; it is simply another question that falls into the "we don't know" category of answers.

It is also often asserted that dogs with history of heat injury are at more risk for recurrence in the future. In actuality, the review found no reports in the literature that this had ever actually been studied in canines, and that this assertion appears to be extrapolated from the human literature. Several human studies have shown evidence of heat intolerance in military recruits for up to 6 months following an initial occurrence of heat injury,[21-24] and standardized heat tolerance tests have been used to assess fitness for return to duty.[21,22]

Anecdotally, veterinarians may see individual dogs with repeated heat injury, apparently confirming this phenomenon. However, before blaming the recurrence on an altered thermoregulatory mechanism from prior heat injury, the veterinarian should consider if the repeated

heat injury is due to conditions which can be improved, such as decreasing body weight, increased physical conditioning, a surgically repairable upper airway condition,
or improved handler education. Once these factors have been ruled out, then they can consider the concept that something within the dog's thermoregulatory mechanism has been altered, making him more prone to heat intolerance until there is adequate evidence to support it, we cannot make this assertion to canine programs with any accuracy.

Fitness for duty following heat injury should be based on evaluation of the dog under increasingly strenuous conditions of work, similar to heat tolerance testing in human service members who have incurred heat injury. Veterinary assessments on fitness for duty based on prior heat injury have the potential to affect management decisions regarding individual MWDs within a unit, especially regarding deployment. Finding a scientifically-validated answer to the question of recurrence of heat injury could have direct effect on combat units utilizing MWDs. Thus, this topic is an excellent example of a valid end-user requirement that warrants further research.

4. Conduct research and development, based on validated end-user requirements, to over- come the defined problems and increase effective range of military working dogs on the battlefield.

The first 3 steps discussed above determine normal physiologic reactions, baseline epidemiological evidence, and evidence-based best practices. The results of these steps drive a focused effort to develop new technologies beyond what are already available. Steps in this process will also overlap to some degree. The ongoing research to determine normal working temperatures and thermo- regulatory responses of dogs in environmental extremes spans multiple phases of the process.

It is crucial to the R&D phase in development of new methods, equipment, or technologies that these efforts are based on validated operational needs of the canine unit and the mission requirements of their combat com- mand. To truly serve the Warfighter, we must listen to what they want from us, and what they regard as an operational problem or obstacle with their dogs. It does little good for us to develop a new tool or treatment regimen for their use on the battlefield if the data on battle- field injuries indicate the tool or treatment has never been needed, or they simply will not carry it with them due to size, weight, or other inconvenience. Similarly, our canine healthcare guidelines must be relevant and realistic in their operating

- What does the canine unit want from us?
- What do they view as their most significant canine problems?
- What factors of the environment (heat, cold, altitude, etc.) are limiting what they can accomplish with their dogs?
- What type of solution do they propose, that will fit into their existing operational tactics, techniques, and procedures?

CONCLUSION

The Veterinary Corps is in the unique position to facilitate not only the advancement of military working dog clinical care, but also extending the effective range of this special force protection resource on the battle-field. From determining the operational requirements through gathering the evidence and creating new and advanced capabilities, Veterinary Corps personnel have a vital role in advancement of the capabilities of military working dogs under environmental extremes. The best approach to this effort is ultimately a collaboration be-tween the end-user canine units, the VCOs and Animal Care Specialists supporting the canine units, the Veterinary Corps clinical and epidemiology specialists, military R&D specialists, and our civilian veterinary counterparts with the resources and experience in the con- duct of basic science and clinical research. Each of these collaborators has a vital role in the support of Warfighter canine programs and their operational requirements.

A SOF Animal Care Specialist IDVT works with racing sled dogs during the Iditarod sled dog race in Alaska.

environment. The best way to determine what they need is to listen, and to ask:	