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Commentary

Euthanasia methods in field settings for wildlife damage management

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FOR MANY IN THE FIELD of wildlife damage management, the 2007 American Veterinary Medical Association (AVMA) guidelines (American Veterinary Medical Association 2007) constitute the standard protocol for euthanasia of animals. Euthanasia means "good death" (Woodhouse 1987). In theory, euthanasia occurs when an animal experiences rapid unconsciousness followed by cardiac or respiratory arrest, leading to loss of brain function with minimized stress and discomfort prior to the animal becoming unconscious (Schmidt 1995).

Unfortunately, these guidelines fail specifically to address the complexities encountered in administering euthanasia in the field. Animal welfare is an important consideration for wildlife professionals (Proulx and Barret 1991, Schmidt 1989), but many of the recommended means of euthanasia for captive animals are not feasible for wild or feral animals (Andrews et al. 1993, Beaver et al. 2000, American Veterinary Medical Association 2007). Laws on euthanasia vary from state to state. Connecticut law requires that nuisance wildlife control operators (NWCOs) follow the 1993 Report of the AVMA Panel on Euthanasia (Andrews et al. 1993, Connecticut General Assembly 2007), while California law requires methods in accordance with the 2000 Report of the AVMA Panel on Euthanasia (Beaver et al. 2000) when lethal control is used (California State Assembly 2008).

Studies have indicated that public attitudes toward animal death are often negative. Miller (2007) reported that most people who experienced damage by wildlife wanted the offending animals removed, but not harmed. In New York, residents of a suburban neighborhood with overabundant white-tailed deer (*Odocoileus virginianus*) preferred trapping and translocation and contraception over lethal methods of population control, but residents thought that lethal methods would be more effective at controlling numbers (Stout et al. 1997). Survey respondents also favored trapping and translocation and spaying or neutering feral cats (*Felis catus*) on a university campus in Texas (Ash and Adams 2003).

Despite the public's preference, wildlife managers understand that translocation is not a cure-all for resolving human–wildlife conflicts. Problems with translocation of wildlife include, (1) low survival rates of translocated animals, (2) potential for the spread of diseases, (3) impacts of translocation on resident wildlife, and (4) potential for continuing problem behavior in the animal's new location (Barnes 1995, Cunningham 1996, Craven et al. 1998). When wildlife cannot be translocated, euthanasia is an alternative. Euthanasia was the second most preferred method of dealing with problem wildlife in a survey of NWCOs (Barnes 1995). Some animal rights groups oppose lethal removal of nuisance animals and encourage the public to oppose this practice because they believe killing animals for any reason is wrong (Miller 2007, Vantassel 2009).

Because wildlife euthanasia is controversial, the National Wildlife Control Operators

Association (NWCOA) initiated this review to guide wildlife professionals in the most humane and suitable forms of euthanasia. Our objectives were to evaluate the humaneness and practicality of 8 methods of euthanasia in field settings and to present our own opinions and those of a panel of 15 other wildlife professionals who have practical knowledge on the use of those methods in the field.

We conducted a thorough review of scientific literature regarding euthanasia by searching databases (AGRICOLA, BioOne, Biological Abstracts, ISI Web of Science, and Wildlife and Ecology Studies Worldwide), and 2 Internet search engines (i.e., Google Scholar and Internet Center for Wildlife Damage Management) using combinations of key words (i.e., animal euthanasia, wildlife, humane, lethal, chemical induction, acetone, barbituric acid, carbon dioxide, carbon monoxide, cervical dislocation, decapitation, gunshot, penetrating captive bolt, and pentobarbital). We reviewed the resultant germane literature and included pertinent concepts in this opinion paper. All information was accessed between July 2007 and June 2009.

We also surveyed a panel of 15 wildlife professionals who were recognized leaders in their fields and represented opinions of their respective agencies, organizations, and industries. We determined attitudes toward 8 methods of euthanasia, including acetone, barbituric acid, cervical dislocation, carbon dioxide, carbon monoxide, decapitation, gunshot, and penetrating captive bolt. We selected the panel members based on their background, training, and expertise in euthanasia, much in the same way that was done by the AVMA in development of its panels on euthanasia in 1993, 2000, and 2007. We included experienced individuals from the animal rights and wildlife damage management communities so that we could establish a gradient of attitudes and opinions associated with euthanasia in field settings. One member was appointed by NWCOA to serve as the chairperson of the panel. Our panel consisted of 3 veterinarians, including Tim Julien Jr., Daryl Neans, and Eric Swanson. Tim Julien acted as the chair of the panel. We included 2 certified wildlife biologists: Art Smith, and Bob Bluett. Art Smith was program administrator for the Wildlife Damage Management Program of the South Dakota Department of Game, Fish and Parks. He was chair of Wildlife Damage Management Working Group of The Wildlife Society (TWS). Bob Bluett was a wildlife biologist with the Illinois Department of Natural Resources' furbearer program since 1989. His program responsibilities included oversight of nuisance wildlife control activities. He is the past president of the Illinois Chapter of TWS. Two people on the panel represented nonprofit animal welfare groups: John Hadidian and an anonymous panel member. John Hadidian was director of urban wildlife programs for the Humane Society of the United States (HSUS). He was past chair of the urban wildlife working group of TWS. He served on the U.S. Department of Agriculture (USDA) Wildlife Services (WS) advisory committee and was the human-dominated systems director for the U.S. Department of State's Man and the Biosphere program. The anonymous reviewer was an emeritus professor of veterinary medicine and was appointed by the Animal Protection Institute. Two members, Dave Purwin and Dirk Shearer, were certified wildlife control professionals with NWCOA. Dave Purwin was president of Desert Wildlife Services Inc. in Tucson, Arizona, since 1998. He was regional director for NWCOA since 1998 and was licensed by the Arizona Game and Fish Department for snake and wildlife management and control. Dirk Shearer operated The Wildlife Control Company of Ohio. He was a former regional director of NWOCA and president of the Ohio chapter of NWOCA. Two members of the academic community were on the panel: Charles Lee and an anonymous reviewer. Charles Lee was an extension specialist and wildlife control instructor from Kansas State University. His responsibilities included conducting a statewide program in wildlife damage control and wildlife enhancement on private lands. The anonymous reviewer had taught college courses in wildlife for >20 years. Two panel members were state directors of WS and were involved with assistance to property owners in resolving human–wildlife conflicts. Jason Suckow was the WS state director of Wisconsin. Mark Collinge was the WS state director of Idaho; he served as a vice president of the National Animal Damage Control Association. Finally, 2 members of the panel

were employed by Land Grant University Cooperative Extension Services. These included Lynn Braband, who worked for the New York State Integrated Pest Management Program of Cornell University, and Stephen Vantassel, who joined the University of Nebraska–Lincoln in 2004 as the project coordinator for the Internet Center for Wildlife Damage Management.

We used 13 criteria from the 1993 and 2000 reports of the AVMA Panel on Euthanasia (Andrews et al. 1993, Beaver et al. 2000), and the 2007 AVMA Guidelines on Euthanasia (American Veterinary Medical Association 2007) to evaluate the 8 methods of euthanasia. Panel members were asked to provide scores of 1 (lowest) to 10 (highest) for the functionality of each method of euthanasia, including (1) ability to induce loss of consciousness and death without causing pain, (2) time required to induce loss of consciousness, (3) reliability, (4) safety of personnel, (5) irreversibility, (6) compatibility with requirement and purpose, (7) emotional effect on observers or operators, (8) compatibility with subsequent examination or use of tissue, (9) drug availability, (10) human abuse potential, (11) compatibility with species, age, sex, and health status, (12) ability for equipment to be maintained in proper working order, and (13) safety for predators or scavengers, should the carcass be consumed. We summed the total scores for each method of euthanasia. The highest possible score for any method was 130. We divided the actual score by 130 to determine the method's rating from 0 to 100%, with the latter representing a perfect score. Our ranking system assumed that each of the 13 criteria used are of equal importance.

Of the 8 methods of euthanasia, carbon dioxide received the highest score of 82%. Carbon dioxide ranked high for safety of predators or scavengers and safety of personnel. It scored lowest for irreversibility and emotional effect on operators. Carbon dioxide is most commonly used for euthanizing raccoons (*Procyon lotor*), skunks (*Mephitis mephitis*), Canada geese (*Branta canadensis*), and other birds. Panel members noted that this method is best for small birds and nonburrowing mammals. They also noted that proper equipment, such as containment chambers, regulators, and tubing, are required and must be kept in good working condition to ensure safety of personnel. Carbon dioxide is heavier than air and nearly odorless. It acts as an anesthetic agent and causes loss of consciousness (Green 1987). Carbon dioxide is an inhalant that causes death through oxygen deprivation, thus, panel members scored it high for safety to predators or scavengers. Concentrations of carbon dioxide >7.5% volume to volume have a rapid anesthetic effect. Carbon dioxide is favored as a rapid-depressant; anesthesia is induced within 1 to 2 minutes without undue stress when concentrations are between 30% and 40% by volume (Andrews et. al 1993, Beaver et. al 2000, American Veterinary Medical Association 2007). Hackbarth et al. (2000) concluded that this method of euthanasia was in accordance with animal welfare criteria, as it leads to rapid death without severe distress or pain, and was therefore humane. Carbon dioxide can be obtained in cylinders that are easy to transport. It is cost-effective, nonflammable, nonexplosive, and safe when used by trained personnel with proper equipment. Conlee et al. (2005) and Leach et al. (2002, 2004) argued that carbon dioxide was highly aversive to rodents, caused considerable distress, and should not be used for rodents when other methods of euthanasia are available.

Cervical dislocation scored high with our panel (81%). It was ranked high in safety of predators or scavengers and ease of equipment maintenance. It scored lowest for its emotional effect on operators. The method involves the separation of the first vertebrae and the skull and subsequent disruption of the spinal cord. Panel members noted that personnel should be properly trained to use this technique and that its use should be limited to small mammals and birds. Cervical dislocation is a common method for poultry, small birds, mice, immature rats, and rabbits (Andrews et al. 1993, Beaver et al. 2000, American Veterinary Medical Association 2007). The small bones of these animals enable operators to separate the vertebrae quickly and easily. Advantages of cervical dislocation are rapid unconsciousness and no chemical contamination of tissues, thus meeting the criteria for euthanasia methods of the American Society of Mammalogists (Gannon et al. 2007) and USDA/Animal and Plant Health Service (APHIS). The severed spinal cord does not deliver painful stimuli from areas posterior to the separation thus,

painful stimuli cannot be perceived, although significant muscular movements may take place (Allred and Berntson 1986, Rowsell 1990, Derr 1991). Cervical dislocation may be aesthetically displeasing, and brain activity may persist for up to 14 seconds following the procedure (Mikeska and Klemm 1975).

Decapitation is caused by severing the head from the body. It was favored by panel members (ranking = 78%) and scored high for safety to predators and scavengers. Our panel commented that personnel should be properly trained to use this technique and that its use be limited to small mammals and birds. Allred and Berntson (1986) and Holson (1992) noted that decapitation provided a painless death when properly performed, despite suggestions that brain activity may persist for up to 14 seconds (Mikeska and Klemm 1975). Allred and Berntson (1986) further reported that the presence of EEG activity in the severed head is not sufficient to infer a state of consciousness, thus, pain. Special devices called guillotines are commercially available for decapitation of small rodents. Decapitation is often used to euthanize rodents and small rabbits. Advantages include rapid unconsciousness and no chemical contamination of tissue (Andrews et. al 1993, Beaver et. al 2000, American Veterinary Medical Association 2007). Some disadvantages are stress to the animal due to handling and restraint prior to euthanization, and hazards to personnel. Proper restraint may not always be possible under field conditions to use this technique properly. Decapitation may be aesthetically displeasing, leading to low scores by panel members for its emotional effect on operators.

Carbon monoxide typically is used to euthanize small animals. It is colorless, tasteless, odorless, nonflammable, and nonexplosive at concentrations of <10% volume. Carbon monoxide combines with hemoglobin in red blood cells more readily than with oxygen, causing rapid death through hypoxemia (Close et. al 1996). Panel members ranked it at 77% and noted that safety of personnel was a major concern with this method, but it scored well in safety to predators or scavengers. Advantages of carbon monoxide are inducement of unconsciousness without pain or discomfort and rapid death when concentrations are 4 to 6% by volume (Andrews et. al 1993, Beaver et. al 2000, American Veterinary Medical Association 2007). Onset of loss of consciousness and death from carbon monoxide (5 and 134 seconds, respectively) is shorter than it is from carbon dioxide (i.e., 15 and 151 seconds, respectively; Hansen et al. 1991). Animals may have convulsions and muscular spasms associated with unconsciousness.

Panel members ranked gunshot at 76%. Under some field circumstances, gunshot may be the quickest and only method available. Panel members commented that proper training in shot placement is critical and that operators should be aware of local ordinances on firearms. An advantage of gunshot euthanasia is that death is instantaneous if the bullet is properly placed in the brain (Andrews et. al 1993, Beaver et. al 2000, American Veterinary Medical Association 2007). Schwartz et al. (1997) recommended rifle shots to the head as the most efficient and humane method of euthanasia for chemically immobilized urban deer. Disadvantages include risks to personnel, aesthetically displeasing, incompatibility with subsequent use of tissue for evaluation, and difficulty of proper bullet placement in the brain.

Barbituric acids depress the central nervous system and cause death through respiratory and cardiac arrest. The panel gave it a ranking of 73%. Barbituric acid often causes a rapid death with minimal discomfort, depending on the dose and route of injection (Andrews et al. 1993, Beaver et al. 2000, American Veterinary Medical Association 2007), which led to high scores by the panel for time required to induce lack of consciousness. Advantages of barbiturates include rapid onset leading to minimal pain and discomfort. Quine et al. (1988) found quicker cessation of EEG and ECG readings in animals euthanized with intravenous pentobarbital solution (25 to 300 seconds) compared to nitrogen gas (285 to 3,090 seconds). In some situations, animals may need sedation prior to euthanasia. Stoskopf et al. (1999) sedated opossums (*Didelphis virginiana*) before intracardiac administration of pentobarbital solution. Little pain is associated with the needle stick used to deliver this method. Panel members noted drawbacks of this technique, including restraint of the

animal (so that the drug can be administered effectively) and difficulty in acquiring the drugs. In addition, barbituric acids have potential for human abuse; therefore, federal regulations significantly limit their availability and many wildlife professionals cannot legally obtain or dispense them (Bluett 2001, U.S. Department of Justice, Drug Enforcement Administration 2008).

The panel ranked penetrating captive bolt at 72%. This method causes death through massive brain injury, which led to high scores by panel members for rapid loss of consciousness and safety to predators or scavengers. If used in the appropriate manner, euthanasia by captive bolt gun is thought to cause less fear and anxiety in the animal than most other methods when applied in a controlled setting (Grandin 1994), but this is not always achieved in the field. Vimini et al. (1983) reported that respiratory activity in all animals ceased immediately upon stunning and did not resume, indicating immediate and irreversible unconsciousness. Panel members noted difficulty in restraining animals in the field and proper placement when using gunshot and captive bolt. A captive bolt must be properly placed so that the brain is penetrated with maximum impact. Raj and O'Callaghan (2001) discussed this method for use on chickens (*Gallus* spp.). They found that deviations from both the correct angle and the force had significant impacts on effectiveness. Improper placement may cause inhumane death and the method may be aesthetically displeasing, which led to low scores from our panel for its emotional effect on operators.

Acetone was tied with penetrating captive bolt for the least favored method of euthanasia among our panel members (72%). They commented that this technique should be used exclusively on skunks because it renders them unconscious before death and before they can spray. Acetone is injected into the heart or lung area of an animal. Upon injection, the animal is unconscious within 3 to 6 seconds (Andrews et al. 1993). A second injection is administered to ensure death. Advantages include ability to induce loss of consciousness with minimal pain; disadvantages include limitations on the ability of the operator to inject the solution accurately into the heart–lung area. Acetone ranked high for availability of the product. Panel members added that further study is needed about this method, as questions remain regarding its humaneness and safety to scavengers. Our literature review resulted in no relevant articles aside from the AVMA reports (Andrews et al. 1993, Beaver et al. 2000, American Veterinary Medical Association 2007). One panel member did not evaluate this method due to a strong opposition to it, noting that this method has not been scientifically tested and is unacceptable under the 2000 Report of the AVMA Panel on Euthanasia (Beaver et al. 2000) and the 2007 AVMA Guidelines on Euthanasia (American Veterinary Medical Association 2007). So, those scores were not included in calculations. The AVMA did not provide references or reasons to justify its decision on acetone. Our data suggest, from comments of our panel members and the high variability of scores, that acetone is a controversial method of euthanasia.

Our results indicate that each method of euthanasia that we evaluated has advantages and disadvantages. All methods of euthanasia should be preformed discretely and only by properly trained personnel. We suggest advocation of regulations that provide licensed or properly trained NWCOs easier access to barbituric acids. Wildlife professionals are obligated to consider animal welfare in activities they endorse and oversee (Bluett 2001). We suggest that NWCOs use this guide along with local laws, regulations, and their professional judgment to determine the best method of euthanasia in each situation.

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