Fact sheet: Thoracic compression

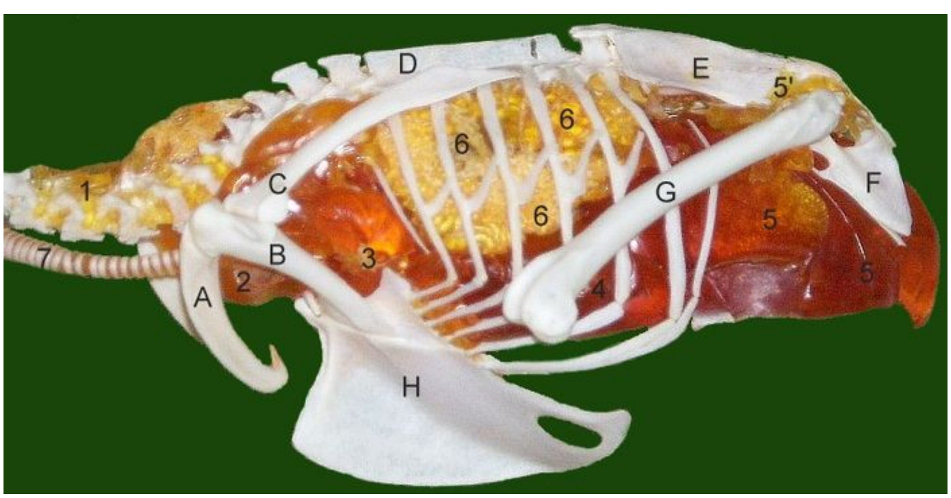
Introduction

Thoracic compression is a method of euthanasia[1] widely used by ornithologists when collecting small birds for museum specimens and tissue samples. On occasion, thoracic compression is also used to euthanize small birds that have been inadvertently injured during research manipulations and that cannot be treated with first aid or veterinary care. Ornithologists use thoracic compression because it causes very rapid loss of consciousness and death and because it has long been recognized, based on decades of experience, that the method is humane and certainly the most humane method available in many field situations.

Recently, the lack of studies that measure brain activity to assess loss of consciousness resulting from thoracic compression has caused some in the veterinary medical community to raise concerns about thoracic compression, in turn leading some Institutional Animal Care and Use Committees (IACUCs) to require extraordinary justification for approving its use. The Ornithological Council in late 2012 requested a research proposal from a leading research veterinarian to generate data that measures brain activity to determine time to loss of consciousness and death. That study will likely be completed by the end of 2013. In the meantime, for those who might find it necessary to use this method and for the IACUC members who must decide if it is scientifically justified, this fact sheet is intended to provide information about thoracic compression – including reports of observations of behavioral and physiological changes that support the contention that thoracic compression results in the rapid loss of consciousness and a rapid death.

Description of the method as used for birds

Thoracic compression involves holding the bird between the thumb and forefinger of one hand. The researcher's thumb and forefinger are positioned under the bird's wing, from the posterior, and below the spine. Two fingertips are positioned between the spine and the coracoid, and above the anterior edge of the pectoral muscle, in the space indicated by the numeral 3 on this image:



The forefinger of the other hand is placed against the ventral edge of the sternum, just below the furculum. Squeezing the fingers together rapidly with the force of a hard pinch in the space above the coracoid prevents air from entering the air sacs and causes the heart to stop (Winker 2000). The pressure placed against the sternum results from the position in which the bird is held. It is slight pressure relative to the force placed against the soft tissue above the coracoid, because the need for an intact specimen, including an undamaged skeleton, precludes the use of force that would be sufficient to break the sternum or ribs.

The bird loses consciousness within a few seconds. Continued pressure is maintained on the thorax to ensure that the heart won't restart. Death follows quickly thereafter. That corporal trauma is minimal is easily and immediately verified during preparation of the corpse by the fact that there is often no evidence of hemorrhage inside the bodies of birds euthanized in this way and the absence of broken bones or crushed organs.

This method requires only seconds of handling, unconsciousness occurs extremely quickly, and, in the hands of an experienced researcher, the method is relatively full-proof to error; the sensitivity of one's own hands allows for a degree of monitoring not possible by any other method.

<u>Rapidity compared to other approaches</u>

One ornithologist (Bostwick, 2010 pers. comm. to the American Veterinary Medical Association) measured the interval between the application of pressure and the loss of consciousness as determined by relaxation of the feathers, loss of body tension, and reduction in eye "clarity" (Erasmus *et al.* 2009). Sudden feather erection was assumed to indicate time of death; this same observation that has been made in studies to determine behavioral reactions of poultry to carbon dioxide (Gerritzen *et al.* 2007). In some of the 35 small passerines studied, loss of consciousness appeared to occur virtually simultaneously with the application of pressure. It has long been thought that thoracic compression can cause a sudden and significant increase in hydrostatic pressure pulse to the brain, resulting in virtually immediate loss of consciousness. Dissection of the brains of these birds immediately after death reveals small amounts of blood in the brain, which would be consistent with this mechanism. In other cases, loss of consciousness occurred in 5-10 seconds, during which time the birds gaped (opened their bills) for air.

Five highly experienced field ornithologists - each having used thoracic compression on at least ~500->1000 birds over many years of field collecting – reported their observations on the length of time between the initiation of thoracic compression and the loss of consciousness:

The consensus among the five researchers was that birds weighing less than 100 g were typically unconscious within 5 seconds after beginning thoracic compression and dead within 15-20 seconds. Birds between 100-250 g were unconscious within 10-20 seconds and verifiably dead within 20-60 seconds. More confidence was associated with the time estimates for smaller birds, and less confidence in estimates and greater variation in bird response were described for larger birds.

These rates compare favorably to those reported for loss of consciousness resulting from the use of carbon dioxide. According to the AVMA's 2013 guidelines, which classify CO_2 as "acceptable with conditions," "time to unconsciousness with CO_2 is dependent on the displacement rate, container volume, and concentration used. In rats, unconsciousness is induced in approximately 12 to 33 seconds with 80 to 100% CO_2 and 40 to 50 seconds with 70% CO_2 (citation omitted)[2]. Similarly, a rapidly increasing concentration (flow rate > 50% of the chamber volume per minute) induces unconsciousness in only 26 to 48 seconds (citations omitted). Leake and Waters (citation omitted) found that dogs exposed to 30% to 40% CO_2 were anesthetized in 1 to 2 minutes. For cats, inhalation of 60% CO2 results in loss of consciousness within 45 seconds, and respiratory arrest within 5 minutes (citation omitted). For pigs, exposure to 60 to 90% CO_2 causes unconsciousness in 14 to 30 seconds (citations omitted) with unconsciousness occurring prior to onset of signs of excitation (citations omitted)."

Shorter times to unconsciousness reduce stress and pain to an animal. During the time an animal remains conscious, a number of painful or distressful reactions to CO_2 have been documented, including "(1) pain due to formation of carbonic acid on respiratory and ocular membranes, (2) production of "air hunger" and a feeling of breathlessness, and (3) direct stimulation of ion channels within the amygdala associated with the fear response."[2]

Why thoracic compression is used in ornithological research

The purposes for scientific collecting of birds entail very different concerns than those resulting from the need to euthanize an animal at the end of an experimental procedure, which entails a desire to end suffering or simply a means to dispose of an animal that is not suitable for future research. In ornithological research, birds are collected in the field for specific purposes. In some cases, they will become museum specimens (either skins, fluid preserved, whole specimens, skeletons, or some combination of these) and are stored in research and teaching collections. In other cases, birds are collected to obtain tissue samples that are used for stable isotope analysis, disease or contaminant assessment, and genetic analysis. A given specimen or sample may be used decades or centuries after the specimen is collected; it is not possible to know all the analyses to which a sample may be eventually subjected. The goal is to maximize the usefulness of every bird collected.

Given the importance of maintaining the physical integrity of the specimens for museum collections and research, the method chosen to kill or euthanize a bird specimen is equally important. Compromising the morphological, histological, or molecular integrity of the specimens is not acceptable. Chemical methods of killing are considered unacceptable unless it can be shown that an agent will not compromise or bias potential tissue analysis. Cervical dislocation – which can easily tear the head from a small bird – and decapitation are simply not appropriate as the carcass would not be useable for museum collections and most studies. Shotguns, historically were recognized as an acceptable means to collect birds for museums and scientific research. However, shotguns require permits and extensive training and may destroy tissue samples or wound birds. Birds that have been wounded by gunshot would have to be euthanized by other means (e.g., thoracic compression). Thoracic compression is an important research tool available to field ornithologists to humanely kill or euthanize birds.

Euthanasia in the field setting

Thoracic compression is used because in the field setting, no other humane methods are available in many cases.

In the veterinary clinics and hospitals, zoos, or other facilities where animals are held in captivity, all methods of euthanasia are or should be readily available. However, most of these methods of euthanasia are not possible, practical, or appropriate for use in ornithological field research, which most commonly takes place at some distance from a traditional research facility and often takes place in remote field locations.

If available, an inhalant can be a useful and practical method of euthanasia when research is conducted near a field station or in a situation where supplies can be stored or replenished. However, inhalants are not practical in situations where field research will be conducted over a period of weeks in very remote areas or when all equipment and supplies are carried in on foot.

Inhalants such as isoflurane can be difficult to obtain. Although isoflurane is not a controlled substance to which access is limited by the Drug Enforcement Agency, state licensing requirements in the United States and in most countries limit access to inhalants to licensed veterinarians. Thus, a veterinarian must be willing to obtain it and provide it to the ornithologist for use in field research though the veterinarian is not likely to be available to supervise its use and assure that it will not be acquired by others who do not have authorization to possess or use the substance. Some states restrict the use of substances by licensees to situations where a Veterinary-Client-Patient Relationship exists. According to the AVMA, this relationship is established only when "the veterinarian has sufficient knowledge of the animal(s) to initiate at least a general or preliminary diagnosis of the medical condition of the animal(s). This means that the veterinarian has recently seen and is personally acquainted with the keeping and care of the animal(s) by virtue of an examination of the animal(s), or by medically appropriate and timely visits to the premises where the animal(s) are kept. The veterinarian is readily available, or has arranged for emergency coverage, for follow-up evaluation in the event of adverse reactions or the failure of the treatment regimen." Of course, these conditions are essentially inapplicable to most field research or to the methods of euthanasia used in the context of field research, but as it is a legal restriction in some states, veterinarians in those states may be unwilling to provide it to field researchers.

In some states, the license restricts the use of the substance to a particular building, making it impossible to use the substance legally at a field site. In some countries, inhalants are not available to anyone but licensed physicians and veterinarians, who are not permitted to supply it to others. Some inhalants, including isoflurane, cannot be carried on aircraft or are highly restricted. Researchers who use CO_2 may face similar obstacles. Both U.S. domestic and international air transport shipping regulations consider CO_2-filled cylinders to be a dangerous good requiring specialized training, packaging, and labeling; pilots are given the discretion to refuse to allow this material on board the aircraft.

The unpredictability of field research can also make the use of isoflurane impractical. For instance, investigators are presented with opportunities to capture small animals that represent important specimens in the course of conducting other research. In these instances the investigators are usually without euthanasia equipment or supplies of any kind. Also, inhalants may not readily vaporize in cold weather or at high elevations.

Controlled substances

Veterinarians often refuse to give controlled substances to researchers, particularly for off-label use, due to the Animal Medicinal Drug Use Clarification Act restrictions and out of concern for potential abuse. Some IACUCs and universities will refuse to allow the use of controlled substances unless a veterinarian is present, but few veterinarians are willing and available to accompany researchers into the field on a regular basis. These substances frequently cannot be carried legally into other countries. In fact, the Food and Drug Administration now requires the use of a separate registration for each location where veterinarians store, distribute, or dispense controlled substances. This rule places an even greater burden on veterinarians and a virtual barrier for wildlife biologists, who rarely work at fixed locations.

Limitations on use

Although there is some variation based on the size and strength of the hands of individual researchers, thoracic compression for birds over 250 g is not recommended because it can be difficult to perform, slower, generally undesirable, and probably inhumane.

Training is essential

Ornithologists practicing thoracic compression routinely train the next generation of practitioners. Today's ornithologists are well attuned to the need to minimize animal suffering, and the IACUC process further encourages this and enforces needed oversight. There is no reason why training – using captured birds that would have been euthanized for research or teaching or that were to be euthanized as the planned endpoint of a study - cannot take place in a controlled environment. In such cases, isoflurane or other inhalant or injectable to induce loss of consciousness could be used prior to the use of thoracic compression.

Conclusion

Ornithologists use thoracic compression because it results in very rapid loss of consciousness, and death of the bird follows rapidly thereafter. Of the many methods that have been tried, it is among the most humane. It is easy to learn, so with proper training there is little risk that it will be performed incorrectly. It maximizes the scientific utility of specimens, and thereby helps to minimize the number of individuals collected for scientific research. Given the expertise and cumulative decades of experience of ornithologists and their careful observations, and given the absence of any evidence – observational or measured by instrumentation such as an EEG – to the contrary, there is a sufficient basis to continue to accept the use of thoracic compression as a humane means of euthanasia given adequate training. It is particularly important that thoracic compression be permitted where circumstances such as the inability to obtain a reliable and legal supply of inhalants or pharmaceutical agents and associated equipment preclude the use of these methods.

[1] Euthanasia literally means "good death." The Animal Welfare Act regulations state that, "*Euthanasia* means the humane destruction of an animal accomplished by a method that produces rapid unconsciousness and subsequent death without evidence of pain or distress, or a method that utilizes anesthesia produced by an agent that causes painless loss of consciousness and subsequent death" [9 CFR 1.1]. This legal definition does not qualify or limit the term euthanasia to the taking of the animal's life for any particular purpose. However, the AVMA 2013 guidelines make a distinction based on the purpose for ending life, regarding euthanasia as both a means to end suffering and a matter of humane technique. In wildlife research, euthanasia may sometimes be used to end suffering but many studies entail the killing of a healthy animal for research purposes, including taxonomic studies that require an intact carcass for a museum specimen and studies of wildlife disease, nutrition, parasitology, and toxicology that require intact tissues for necropsy and analysis. We disagree with the construct employed by the AVMA and assert that the Animal Welfare Act definition, which represents the legal standard, is the appropriate definition. The purpose for ending life is irrelevant both legally and biologically. It matters not to the animal why its life is to be taken; it matters only that the death is humane. Therefore, we use the term euthanasia to refer to humane technique without regard to the purpose, for under the AVMA definition, no method used by ornithologists would ever constitute euthanasia, no matter how humane, except in the relatively rare instances where the purpose is to end suffering. Moreover, because the use of thoracic compression in small birds produces a speedy and humane death without evidence of pain or distress, it is entirely compatible with the AVMA directive to end a life with a humane technique.

[2] Quoted directly and in entirety from the draft AVMA 2013 guidelines (citations omitted):

> Carbon dioxide may cause pain due to the formation of carbonic acid when it contacts moisture on the respiratory and ocular membranes. In humans, rats and cats most nociceptors begin to respond at CO_2 concentrations of approximately 40% (citations omitted). Humans report discomfort begins at 30 to 50% CO_2, and intensifies to overt pain with higher concentrations (citations omitted).
>
> Inhaled irritants are known to induce a reflex apnea and heart rate reduction, and these responses are thought to reduce transfer of harmful substances into the body (citation omitted). In rats, 100% CO_2 elicits apnea and bradycardia, but CO_2 at concentrations of 10, 25 and 50% do not (citation omitted), suggesting gradual displacement methods are less likely to produce pain prior to unconsciousness in rodents.
>
> Carbon dioxide has a key role as a respiratory stimulant, and elevated concentrations are known to cause profound effects on the respiratory, cardiovascular and sympathetic nervous systems (citations omitted). In humans, air hunger begins at concentrations as low as 8% and this sensation intensifies with higher concentrations, becoming severe at approximately 15% (citations omitted). With mild increases in inspired CO_2, increased ventilation results in a

reduction or elimination of air hunger, but there are limits to this compensatory mechanism such that air hunger may reoccur during spontaneous breathing with moderate hypercarbia and hypoxemia (citations omitted). Adding O_2 to CO_2 may or may not preclude signs of distress (citations omitted). Supplemental O_2 will, however, prolong time to hypoxemic death and may delay onset of unconsciousness.

Although CO_2 exposure has the potential to produce a stress response, interpretation of the subjective experiences of animals is complicated. Borovsky (1998) found an increase in norepinephrine in rats following 30 seconds of exposure to 100% CO_2. Similarly, Reed (2009) exposed rats to 20 to 25 seconds of CO_2, which was sufficient to render them recumbent, unconscious, and unresponsive, and observed 10-fold increases in vasopressin and oxytocin concentrations. Indirect measures of sympathetic nervous system activation, such as elevated heart rate and blood pressure, have been complicated by the rapid depressant effects of CO_2 exposure. Activation of the hypothalamic pituitary axis has also been examined during CO_2 exposure. Prolonged exposure to low concentrations of CO_2 (6 to 10%) has been found to increase corticosterone in rats (Raff, 1988; Marotta, 1976) and cortisol in dogs (Raff, 1983).

In humans, a single breath of 35% CO_2 was found to result in elevated cortisol concentrations and exposure was associated with an increase in fear (citation omitted). It has been suggested that responses to systemic stressors associated with immediate survival, such as hypoxia and hypercapnia, are likely directly relayed from brainstem nuclei and are not associated with higher order CNS processing and conscious experience (citation omitted). In fact, Kc et al. (citation omitted) found that hypothalamic vasopressin-containing neurons are similarly activated in response to CO_2 exposure in both awake and anesthetized rats. As stated previously, assessment of the animal's response to inhaled agents, such as CO_2, is complicated by continued exposure during the period between loss of consciousness and death.

Distress during CO_2 exposure has also been examined using behavioral assessment and aversion testing. Variability in behavioral responses to CO_2 has been reported for rats and mice (citations omitted), pigs (citations omitted), ducks (citations omitted) and poultry (citations omitted). While signs of distress have been reported as occurring in animals in some studies, other researchers have not consistently observed these effects. This may be due to variations in methods of gas exposure and types of behaviors assessed, as well as strain variability.

Using preference and approach-avoidance testing, rats and mice show aversion to CO_2 concentrations sufficient to induce unconsciousness (citations omitted), and are willing to forgo a palatable food reward to avoid exposure to CO_2 concentrations of approximately 15% and higher (citations omitted) after up to 24 hours of food deprivation (citation omitted). Mink will avoid a chamber containing a desirable novel object when it contains 100% CO_2 (citation omitted).

> In contrast to other species, a large proportion of chickens and turkeys will enter a chamber containing moderate concentrations of CO_2 (60%) to gain access to food or social contact (citations omitted). However, following incapacitation and prior to loss of consciousness, birds in these studies show behaviors that may be indicative of distress such as open-beak breathing and head-shaking. Regardless, it appears that birds are more willing than rodents and mink to tolerate CO_2 at concentrations that are sufficient to induce loss of posture, and that loss of consciousness follows shortly afterwards."

[3] Citations have been omitted for brevity and because we do not question the underlying sources cited by the AVMA in support of its statement. We quote the text from the AVMA guidelines to delineate the metrics upon which the AVMA classifications are based and to demonstrate that the conclusions reached are inconsistent. The full text and citations can be obtained from the AVMA Guidelines on Euthanasia.

Literature cited

Erasmus, M.A., P.V.Turner, and T.M.Widowski. 2010. Measures of insensibility used to determine effective stunning and killing of poultry. Journal of Applied Poultry Research 19:288-298.

Gerritzen, M., B.Lambooij, H.Reimert, A.Stegeman, and B.Spruijt. 2007. A note on behavior of poultry exposed to increasing carbon dioxide concentrations. Applied Animal Behaviour Science 108:179-185.

Winker, K. 2000. Obtaining, preparing, and preserving bird specimens. Journal of Field Ornithology 71:250-297.

About the Ornithological Council

The founding premise of the Ornithological Council is that the ability to make sound policy regarding the scientific study of birds requires the application of impartial scientific data and the continued collection of such data. The Council works to support this important mission. The Council was founded in 1992 and proudly counts as its members twelve ornithological societies in the Western Hemisphere: American Ornithologists' Union, Association for Field Ornithology, Cooper Ornithological Society, Pacific Seabird Group, Raptor Research Foundation, Waterbird Society, the Wilson Ornithological Society, the Society of Canadian Scientists, the Society for the Conservation and Study of Caribbean Birds, the Neotropical Ornithological Society, CIPAMEX, and the North American Crane Working Group.