Volume 29 ■ No. 2

W.C.T. MAGAZINE

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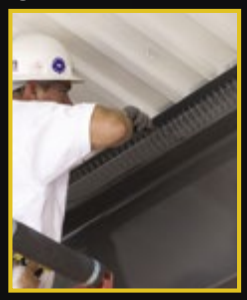

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Wildlife Control Technology Magazine

MARCH - APRIL 2022

ON THE COVER:

A female Pileated woodpecker taking flight. Females have a black stripe under their eye while males have a red stripe.

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W.C.T.

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From the Editor

ERIC ARNOLD, EDITOR

P.O. Box 357 ■ Sharon Center, OH 44272

The annual conflict between homeowners and woodpeckers is about to kick off in 2022. It is important to remember several key points when dealing with these conflicts.

First and foremost, all woodpecker species are protected by the Migratory Bird Treaty Act of 1918 (MBTA). In short, this means that without a special depredation permit issued by the Department of the Interior U.S. Fish and Wildlife Service (USFWS), it is illegal to "... pursue, hunt, take, capture, kill, attempt to take, capture, or kill, posses..." any bird species listed on the MBTA (16 USC Section 703).

Specifically, section 2(a) of the MBTA provides that unless permitted by regulations, it is unlawful to pursue, hunt, take capture, kill, attempt to take, capture, or kill, possess, offer for sale, sell, offer to barter, barter, offer to purchase, purchase, deliver for shipment, ship, export, import, cause to be shipped, exported, or imported, deliver for transportation, transport or cause to be transported, carry or cause to be carried, or receive for shipment, transportation, carriage, or export, any migratory bird, any part, nest, or egg of any such bird, or any product, whether or not manufactured, which consists, or is composed in whole or part, of any such bird or any part, nest, or egg thereof, at any time, by any means or in any manner.

Additionally, section 3(a) of the MBTA authorizes and directs the Secretary of the Interior to "adopt suitable regulations" allowing "hunting, taking, capture, killing, possession...transportation...of any such bird, or any part, nest, or egg thereof..."

This section allows the USFWS to define specific behaviors and grant depredation permits for particular species.

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Note to Chapters & Affiliates:

The Trappers College has three slots for Furbearer Biologists and/or someone who has an influence on the future of trapping. The local Chapter or Affiliate pays half, and the FTA covers the other half, and the biologist attends for free. (Transportation not included.)
Contact Robert ASAP if interested!

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Phone (260) 336-7432

E-mail:
ftatrapperscollege@gmail.com

EDITORIAL:

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A bit of a hiccup has occurred with the definition of the work take. This definition has resulted in multiple lawsuits and rulings concerning its meaning. To make matters even harder to understand, the Endangered Species Act (ESA) defines "take," while the MBTA does not.

The problem is that without defining the word "take," it leaves it up to interpretation.

Take can be defined as either a passive verb or an active verb, so which one is the correct interpretation for the MBTA? This isn't the case with the words pursue, hunt, or capture (but it is the same problem with the word kill).

However, according to contemporary dictionary definitions, the words pursue, hunt, and capture all require a deliberate action to achieve a specific goal, thus making them an active rather than passive action.

To add another wrench into the system, the USFWS implements regulations that define "take" to mean "to pursue, hunt, shoot, wood, kill, trap, capture, or collect" or attempt to do so.

It also needs to be pointed out that there is zero protection for wildlife control operators for the incidental taking of a migratory bird. This can be confusing as Director's Order No: 225, which took effect December 3, 2021, states that a member of the general public conducting otherwise legal activities that incidentally take migratory birds will not be a priority for enforcement; however, incidental take that results from activities by a public- or private-sector entity that are otherwise legal, foreseeable, and occurs where known general or activity-specific beneficial practices were not implemented will be a priority for enforcement. In addition, violators charged with taking migratory birds do not qualify for any civil penalty provisions. They only allow for criminal penalties. (View the document at ***https://www.regulations.gov/document/FWS-HQ-MB-2018-0090-19194***).

In other words, if you catch a woodpecker (or other migratory bird) in a cage trap set for raccoons, there may not be an issue. But if you set a trap for a house sparrow and catch a woodpecker, you may have violated the MBTA. (This is the same for setting pigeon traps and accidentally capturing raptors that enter the traps for any captured pigeon.)

So, why did I go through all this mind-numbing gobbledygook? I wanted to stress the point that if you are going to capture a woodpecker, regardless of the method and/or device used, you need to apply for and receive a federal depredation permit before doing so.

The second is that although it is illegal to "take" migratory birds without a permit, it is not unlawful to harass the vast majority of them (eagles and hawks have special rules I won't be going into here).

Expect in specific cases; harassment is a better method for controlling nuisance bird conflicts. With harassment, the operator is training the birds to respond in a particular manner to the harassment devices. With removal, the operator removes the existing birds allowing other birds to take their place. In other words, it is similar to treating the symptom and not the problem.

As with most harassment devices, there are good and not-so-good items available. Also, specific to birds, harassment and exclusion devices tend to be species-specific, so do some research before selling or installing devices to customers.

While I'm a firm believer in the try it as it will work or it won't mindset, the only device I would caution an operator from using is an ultrasonic repellent. This is because birds do not hear in the ultrasonic spectrum. While some research claims these devices work, I am always looking at products and services I know will work each time I use or perform them. While I've never tried them myself, I have done plenty of jobs where the birds, and other animals, have built nests on top of the devices or decorated them with guano and feces. In my opinion, if they worked, these would not be a common sight.

For those wanting more information on dealing with woodpecker or Canada goose conflicts, make sure to check out our training courses on the WCT Online Training platform at ***https://wildlifetraining.thinkific.com***. ■

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WCT Recap: Squirrels In The House

by Brad Reiter

(*Editor's note: This article first appeared in the March/April 1996 issue of Wildlife Control Technology Magazine.)*

"There's a squirrel in my house!" If you deal with squirrels, you've certainly heard that before, or you will. We all know that squirrels frequently inhabit attics. But their nature also commonly causes them to be found right in the living areas of houses and commercial buildings. The squirrels don't want to be there, and the residents don't want them there. As a professional urban wildlife specialist, you need to get that squirrel out of that structure in a safe, efficient manner. After all, that's why the customer called you.

Most of my "squirrel in the house" calls come in the fall and spring. Chimneys are the most frequent access points for these wayward squirrels; the animals fall in them. Since most fireplace and furnace chimneys have clay tile and metal flues, both too smooth for squirrels to climb back up, the animals have no place to go but out into the house. Most furnaces provide a way out and into the furnace area, usually the basement. And homeowners frequently leave fireplace dampers open.

Sometimes female squirrels will enter an attic in the spring to scout out the area for a nesting location. They get themselves lost and end up inside the house. The most common access point from the attic to the rest of the house is the plumbing wall or chase, which provides a conduit space between floors for the plumbing. In some instances, squirrels will enter through open doors and windows, at times even tearing through screens. And last but not least, a common call goes something like this: "We found out where they got into the attic and sealed up the hole, and now they're all over the house!"

Your first step should be to ask some questions. Where was the squirrel last seen, and how long ago? Before you drop everything and rush to that job, make sure it's an emergency situation, not a problem that has been there for a few days. Also, ask the client if any doors can be closed to confine the squirrel(s) to a certain area or closed to prevent access to areas where they know the squirrel isn't. Next, if you are a private trapper, finalize the sale by telling the client what the charge will b. and what you will do for that money, Since many of these calls come in outside of regular business hours. Don't be afraid to charge an emergency fee. You are a specialist. Not many can do what you will do, especially if you can walk out of that house with the squirrel, sometimes in just minutes.

After arriving at the job site, it's time to prepare for action. A flashlight, welding gloves, a fishing net, a 4-6 foot pole (a broomstick works), and at least three traps are usually all that you will find necessary to accomplish the job. A bit of skill, and hopefully a little good luck, will also play an important role. Even though I bring in a long-handled fishing net and heavy gloves, there's a good chance they will not have to be used.

My trap of choice is the Tomahawk #103. It measures 6 inches X 6 inches X 19 inches, with 1-inch mesh and a single door. The single door is important.

Once in the structure, survey the situation and get more precise details from the client. Where was the squirrel last seen or heard? Where has the client been since that time! Next, ask the client to leave the room, area of the house, or the structure. That request is usually eagerly complied with, but some people want to stay. That would not be advisable; if you are curious why just ask your liability insurance agent. The chance of anything happening to the customer is slim, but you know how the saying goes, stuff and lawyers happen.

Time now to put our plan to work. Is the squirrel confined to a room, a certain area of the house, or the whole house? If you know precisely where it is, close all doors or entry points to that area. If the squirrel has access to the fireplace, close the damper. If that was its entry point, it will frequently try to go back in there and jump inside above the damper. We would prefer that not happen, as now it's almost impossible to catch.

If you don't know the precise room the squirrel is in, then close off the area you will be searching. There may be times when you may want to leave the door open to an adjoining area. Maybe it would be easier to capture the quarry in that room. Each situation is different and must be evaluated individually.

If the squirrel just got in the house, it will be easier to locate as it will probably be running around trying to find a way out. If it has been in the house for a day or so, it will be harder to locate and catch, as it has had time to find a good hiding place. As a rule, the longer it's been there, the tougher the job.

If you don't know where the squirrel is in the house, start

WCT Recap:

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searching room to room. They can be anywhere, although, in my experience, they're most apt to be in the basement. Close the door of the room you are in, and search very closely. If the squirrel is not running around, it will be trying to hide. If they are hiding, they will let you get very close without moving. In fact, you will usually have to actually touch them to get them to move. I remember searching an entire closet while a squirrel hid in a pile of clothes on the floor at my feet. The squirrel never moved until I picked the clothes up off it.

Look everywhere and anywhere. They will hide low as quickly as high. Look in closets and clothes, behind and under furniture, behind drapes, in toy boxes, in and behind plants, everywhere. I found one hiding in a basket of stuffed animals.

This is where the pole comes in. Use it to poke and prod hiding areas to get the animal moving.

Once I've searched a room thoroughly and am satisfied the squirrel isn't there, I close the door and move on to the next one. If the squirrel escapes into another room, you've got to start all over again.

Once you've found the animal and it's moving around the room, watch where it is running. It will be using certain routes and passageways and will stick to them. Usually, by the time I've moved a squirrel around the room twice, I can see where it's going to go next time. Prime examples are behind furniture, on top of ducts, cabinets, and sill plates in the basement, along walls on the floor, and through doorways. They love to run along and through passageways about 5 to 6 inches wide.

Traps should be placed directly in these travel routes, with the open door facing the approach route, if possible, just like setting any traps in any animal trail. Bait is not needed. Once the traps are placed, get the squirrel moving again with the pole. It will usually charge right into the trap. If the ledge or shelf the squirrel is running on is too narrow to place the 6-inch wide trap on, as is sometimes the situation on basement sill walls, I use a smaller, chipmunk-sized trap. The squirrel will still enter.

Why do I prefer the single-door trap? That squirrel can be moving very quickly; half the time, I think the trap fires because the squirrel hits the back wall of the trap and not from stepping on the peddle. With a double door, they might be out the other end before the door can close. Even when running full tilt, they don't seem to hesitate entering the one-door trap. Possibly they think it might be a place to hide.

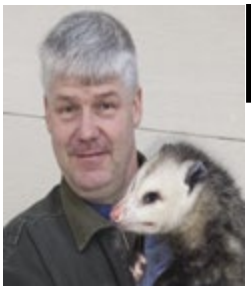
Doorways can make great barricades. Line the floor in the opening with traps set side by side against each other, and place boxes or n sheet of plywood on top of and around them, so the squirrel can't get by. Then chase the squirrel through the doorway and into a trap.

Occasionally, you will have the squirrel in a trap quickly, even within 60 seconds. But usually, you will have to work harder. Move the traps around to different travel routes if necessary. Keep the animal moving until it's in a trap. As stated earlier, each siltation is unique, so innovation and adaptation is the name of the game here. As trappers, we are all used to adapting to our quarry and the situation. An example; when chasing one squirrel, it repeatedly jumped over the trap. I stacked two more traps on top of that one, and on the next run around the room, the squirrel was mine. Every situation will present its own possibilities. Always remember that the squirrel is scared and will not be acting normally. It is often less wary, so use that to your advantage.

Squirrels can also be netted as they move around the room or while they are sitting, but I use the net only as a last resort. The problem with netting squirrels is that they are difficult to remove from the net. Like raccoons, they wrap themselves up in the mesh and hang on. This job must be done by hand. The squirrel is then placed in a cage trap for further transportation. The best place to grab a netted squirrel is by the back of the neck. They can also be held by the base of the tail, but if grabbed higher up the tail, it may break, or the skin and fur may pull off.

If you do net a squirrel, be sure to take it outside before taking it out of the net. That way, if it gets loose, it will at least not be inside the house. A word of caution; I have been bitten through heavy gloves handling netted squirrels.

Squirrels are not the only species that can be captured in this manner. I have also used this method to capture mice, rats, chipmunks, ground squirrels, groundhogs, muskrats, skunks, raccoons, opossums, and even a gray fox, that were trapped inside buildings. Undoubtedly there are other NWCOs out there who can add to this list. ■



From the Toolbox

JACK AMMERMAN

5104 Woodstock Drive ■ Swartz Creek, MI 48473

Smarter Than Your Average Bear

In my mind, I often hear Yogi Bear's voice saying, "I'm smarter than your average bear!" after he's tricked a tourist out of another picnic basket. Whether you are fur trapping or trapping for wildlife control, the whole concept of trapping is to be smarter than the animal you are after. To trick an animal into entering a trap, on their turf, in their living room is a skill that requires amazing knowledge. Certainly, some people can buy a cheap cage trap, throw a peanut butter sandwich in the back and catch an animal, but they won't be able to catch animals that way consistently. They know nothing about bedding a trap, positive setting traps, trap placement, or even using the right size trap.

At least in my experience, human nature is to believe that you are smarter than the animal. As wildlife control professionals, I'd put my betting money on us every time and come out a winner most of the time. I've been humbled and humiliated many times, though. I'm sure that you have too. Anyone in this business who doesn't admit to being in that situation isn't being honest and forthright. As homeowners go, I've found that many people try to solve the problem on their own before calling someone. I used to let that irk me a bit, but I realized that I'm no different. I don't know much about furnaces, but if mine acts up, I will try a few things to get it going before I call in a professional. Thinking that, because you are a human, you can take care of a lowly animal problem seems the norm. The Detroit Free Press, a newspaper that I have read for years, recently ran a story with the headline,

"4 rat control methods that don't involve poison – from string and buckets to smoke bombs"

The story gave homeowners seemingly viable ways to treat rat infestations without using a rodenticide. Their first suggestion was to use a smoke bomb. Without continuing to read just yet, my mind played back a story about a man who had burned his house down by using smoke to take care of his wildlife problem. I started to read the smoke bomb suggestion and saw that the Free Press writer suggested using the smoke bombs "in the morning while rats are still asleep in burrows." Knowing that rats are nocturnal by nature, I would guess that the rats wouldn't be sleeping first thing in the morning, but perhaps. Remember my story of the guy that burnt his house down? The writer's next advice is short and to the point, "Just light up and fire in the hole." I cannot imagine worse advice.

The next suggestion is to use dry ice in the burrows. Just as the smoke poisons the rat's breathing air, the dry ice presumably does the same thing by displacing oxygen with carbon dioxide. With all things being equal and the burrow is an airtight tunnel, this seems much more likely not to burn the place down, but I would doubt that the majority of burrows are airtight enough that it would be consistently effective. These aren't groundhog-style burrows in the earth, in most cases.

The third suggestion is to use a snap trap. While I can get behind this method, I don't think I'd recommend using cheese as my "go-to" bait as they did.

The last tip for homeowners to catch rats is to use a string and a bucket, enticing them to walk a tightrope toward some strategically placed food.

"Using a deep bucket, as rats can jump as high as 3 feet, put a peanut butter-covered string across the top."

With grammar flaws aside, I'm skeptical at best. The last time I looked, I didn't own any buckets taller than three feet. I wouldn't know where even to find a bucket that tall. Trapping rats in a bucket? Although I've seen people get chipmunks and mice in five-gallon pails, I wouldn't put my money on this idea for rats.

In my opinion, this article, while aimed at the "do it yourself-ers" of the world, didn't provide very good information.

This makes me think of all the various techniques and tactics that I've come across throughout the years that homeowners have deployed in order not to have to hire me. Some tried spearmint chewing gum in a mole tunnel to deter the moles – "I heard they hate spearmint. Maybe it was Juicy Fruit. I don't know." Others created a "raccoon ladder" that would let the

raccoon climb out of their chimney instead of being trapped inside. How about the old trick of carpet bombing the place with mothballs to deter everything from skunks to raccoons and groundhogs to deer? I've lost track of the times that I've wallowed around in a bed of naphthalene under a deck or in a crawlspace.

As wildlife control professionals, perhaps we should write a few articles of our own for local media outlets. For example, we could include such things as:

"Make sure that your chimney has a cap. Big box hardware stores sell them if you want to install it yourself, or my company would be happy to install one for you."

"Keep your garbage in cans and make sure the cans have tight-fitting lids. If that is not an option, keep your garbage bags in a garage or shed, keeping the doors closed. Take your trash to the curb only on the day that the trash haulers do their thing."

"Grub control will help eliminate grubs in your lawn. While you may have heard that this will deter moles, the moles eat mostly earthworms. Therefore, grub control will have little effect on moles. Skunks, however, will demolish a lawn in search of delicious grubs. A preemptive strike will deter them from digging in the first place. Grub control, at the time when a skunk first starts digging, will not be effective soon enough. Within a few nights, your yard will be rototilled by a hungry skunk."

"If you trap a wild animal, do a little research before deciding what you are going to do with it. For example, trapping an animal at the wrong time of the year could lead to a terrible odor if you separate the animal from a nest of babies that will surely perish. "Taking a captured animal for a ride" might not be a legal thing to do. It may not even be a useful thing to do."

"Waiting for an animal to "leave" for the day/night and then boarding up the entrance to their/your home could leave you with substantial damages. For example, if you came home from work and found that your front door is no longer an option to enter your home, you will go to a back door, a side door, or even a window. Animals are no different. They will try other ways to get in – including tearing new holes in soffits and roofs. That's their home!"

"Open bowls of pet food on a porch or deck might seem like a good idea, but while we are all sleeping, other animals agree – this is a good idea! Mice, rats, opossums, raccoons, and even skunks will opt for the free meal every time. A recent client had video footage of a coyote nosing around their pet's food bowl by the back door. Who wants that?!"

These are just some things we could and should be promoting to aid homeowners. In the process, we would be promoting our businesses – without any pressure. I know some readers are going to say something along the lines of "I'm not going to help homeowners NOT to call me." To that, I simply say PLEASE…. Those wild animals aren't evaporating. Not everyone will take the advice. There will always be a homeowner with a pet door in their garage or a huge gap in their soffit connection. I'm sure that calls will increase because of the exposure to homeowners instead of decreasing.

By educating the public, we may not be able to get them all to be smarter than the average bear, but there are enough sub-par bears out there that we'll do just fine! ■

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Urban Coyote Management: Steps 8, 9, 10

In the last issue, I devoted the entire article to Step 7 of the process, and now we're going to follow up with steps 8, 9, and 10 of the Urban Coyote Solutions mitigation process. If you had great success through Step 7, the rest of the process should go very quickly. So let's go ahead and take a look at them in order.

Step 8 (Post Control Monitoring)

I like to refer to this step as, *Proof of Work.* During the beginning stages of the process, pre-control monitoring was done to get an idea of the family group size and the number of individual coyotes to remove. In my experience, most family group sizes average four to six predators. Although this step is part of the process, it's not like it's something you have to set up, as this use of cameras is just a continuation of what has been done all along. Cameras set up in good locations where you know coyotes are traveling or will travel will let you know if there are any stragglers left still out there.

At this stage of the process, the goal is to see no coyotes on camera. Understand, *and it's very important that your client understands,* that more coyotes will most likely take over the area at some point, but that doesn't necessarily mean that a n***ew*** coyote family group is going to be problematic or overly aggressive, requiring removal.

There have been times through the process, on individual jobs, that I thought the last coyote had been caught, and post control monitoring told me differently. That is why I like to keep the cameras operational in the area for seven to ten days after the last coyote capture. Because you can't be sure of exactly which coyote or coyotes within the family group were to blame for the conflicts, it's best not to leave any aggressive disposition coyotes behind. In my opinion, this post control monitoring serves two purposes.

A. Proof that all coyotes within the family group have been captured and removed.

B. It brings about a sense of comfort and safety to the community you're working for, that all is well, and that you did, in fact, remove all coyotes within the group.

In some cases, communities will want you to continue monitoring for an extended period, outside the normal post monitoring, and be happy to pay for the extra service. However, in my experience, any coyotes showing up on camera, outside two weeks from the last capture, are either lone transients or just simply new coyotes not associated with the original family group removal.

Step 9 (Post Control Report/ Client meeting)

Since I like to keep things simple, I like to present this report on one page with capture pictures

attached of each coyote removed from the area. In addition, this report will include several pieces of information that I will list.

- Total start and end date of service, with the starting date In line with Step 3 of the process and the ending date correlating with Step 8 of the process.
- Capture dates of all animals removed.
- Interruption of service dates, with a brief description and reminder of what that interruption was and any additional costs associated with the interruption.
- Approximate ages of all coyotes removed and the number of pups found inside the pregnant female should you have captured her before giving birth.
- The approximate number of man-hours spent on the project correlating with Step 1 through Step 10.

Depending on the client, I may include a few other added things in the report, but this is the basic content provided.

Step 10 (Client Recommendations)

This step is just a continuation of Step 9, but I like to do this through a prepared document face-to-face meeting. I will reiterate all the information provided in the post control report and provide them a hard copy of recommendations to prevent coyote habituation causes (simply put, coyotes' loss of fear of humans). This is the time I also provide them with a copy of what I feel is a very good study started by Baker and Timm in 1998, "Coyote attacks on humans 1970-2015: Implications for reducing the risks." This study is readily available through a Google search

and a couple of other great studies.

Through the series of articles that I've written over the past several months, I've tried to present to you in a thorough but straightforward way the step-by-step process that I use to mitigate coyote

Continued on page 14

Urban Coyote Mgmt:

Continued from page 13

family groups in an urban setting effectively. As I've said before, this process is founded in safety, as removing coyotes in an urban environment using equipment that is not generally used in everyday nuisance wildlife services. This equipment, although extremely effective, if not properly used, can cause injury and harm to individuals, children, and domestic pets. This is also a service that is not usually provided on a regular basis, like removing raccoons out of attics and groundhogs out from under decks. It's specialized and requires much more time and effort on the part of the wildlife control professional.

In March and April of 2022, I'll be providing some rural predator control for trophy deer hunting properties In Iowa and Illinois, utilizing footholds on one property and snares on another; two different techniques individually matched to each property. I will also be providing ongoing coyote removal for a city throughout the year because of the heavy population migration into that city. I will do a complete start to finish video on the trophy deer hunting properties for both techniques, and I will share different aspects of these projects with all of you in future upcoming articles. The videos will be edited and uploaded to my website sometime in May of this year.

Usually, I tell you what the next article will be about, but I have several ideas and haven't decided on which to write about at the time of this writing. So, you will have to wait and see for all of you to follow along, but I can assure you that I will do my best to hold your attention. ■

Fur Takers of America

54th Rendezvous

Hosted by the Kansas Fur Harvesters

June 16-18, 2022

Douglas County Fairgrounds
2110 Harper St., Lawrence, KS 66046

Keep up to date at:
http://www.furtakersofamerica.com/convention
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Special Guest: Major Boddicker

Host Hotel:

Country Inn & Suites
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Lawrence, KS 66046
785-727-1825
(Make sure to mention the FTA Discount rate of $89/night plus tax when booking.)

Planned Events

Thursday June 16

FTA Banquet
National Council Meeting

Friday June 17

Bean Feed
FTA Auction

Saturday June 18

Wine & Cheese Tasting
Fish Fry
Trapping Roundtable

Lots to See and Do

• Casino • Farm Museum • River Boat Museum • Worlds of Fun • Cabelas • Bass Pro & More

Shuttle to Historic Downtown all Weekend.

Camping on grounds!
(Limited hookups)

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Vendors

(subject to change)

LKL Trapping Experience
Old South Lures
Wisconsin Trappers Association
Duke Traps
Badger Land Trapping Supply
Kansas Trapline Products
Sterling Fur
Hoosier Trapper Supply
Barnes Fur
Sawmill Creek Bait and Lure
Lone Wolf Lures
L&P Trapline Supply
Duffer's
Peterson Furs
East Fork Predator Bait
Minnesota Trapline Products
High Country Control
Texas Trappers & Fur Harvesters
Schmitt Enterprises

FTA Demo Schedule

(subject to change)

Thursday, June 16, 2022

Rick Hemseth - Trapping Coons in the Water
Marty Smith - Canines
Linda White (Trapping Girl) - Tips & Tricks for Beginners
Gerald Schmitt - Mink & Muskrats
Gary Jepson - Canines
Jeff Dunnier - Beaver
EJ Kelley - Bobcat
Doug McKenzie - Snaring Multiple Species

Friday, June 17, 2022

Clay Creech - Otter
Tom & John Beaudette - Canines
Dave Eckels - Beaver
Casey Shoopman - Predators on Managed Properties
Mike Fisher - Beaver
Robert Waddell - Coyotes and Cats
Karri Feeney - Bobcats
Lee Steinmeyer - Coyotes
Tim Wilson & Tommy Alexander - Mink & Otter

Saturday June 18, 2022

Cletis Richards - Predators
Dale Billingsley - Coon
Ed Schneider - Trapping Predators in Waterways
Mark Conner & Jackie Reed - Beaver & Otter
Lesel Reuwsaat - Predators
Red O'Hearn - Coons
Beth 'Coonburger' Hakala - Bobcat
Derrick Search - Snaring
Robert Waddell & Dale Billingsley - Animal By-products

Informational Workshops

Cristina Jones & Eric Arnold - Trapper's Guide to Social Media
Lee Steinmeyer—Fur Shed Knife Sharping & Death Ray Usage
Marty Criqui NATCA—Trap Collecting
Robert Waddell—Collecting Animal By-Products
Matt Peek (KS Furbearer Biologist)—Fur Bearer Biologist Talk
Leon Windschitl—Fur Handling (1 hour daily)

Kids Events

Snare making with Robert Waddell

Round Table Discussion Topics

Lure Making & Usage—Gary Jepson & others
Predators
Out of State Trapping

General Contact:

John Borror
9519 Marion Rd
Fredonia, KS 66736
620-332-7879
jbtrapsalot@yahoo.com

Vendor Contact:

W.R. Brecheisen
24685 Lyon Rd
Chanute, KS 66720
620-432-1074
wrb43epb@hotmail.com

Join us for this family-friendly event highlighting some of the best trapping and outdoor information available.
Plan your trip today! Don't miss out on this unique event.

Around the Cage Traps

PAUL WINKELMANN

8041 West Mequon Rd. ■ Mequon, WI 53097

Tips n Tricks

Everyone who has read my articles knows that I'm still a penny-pincher! I never had extra money growing up, and it still shows. I don't know how gasoline pricing works, but we have a huge gas storage depot a couple of miles from here, and we've gotten used to seeing lots of tanker trucks on all of our roads. You would expect the competition for your gas dollar to be pretty tight around here, but that doesn't seem to be the case. Many name brands are getting $3.17 for a gallon of regular. But Costco and a couple of smaller stations are charging $2.85. Depending on the size of your tank, that could be several dollars saved on a single fill-up. The cost of other vehicle maintenance, like oil and tire changes, can vary an awful lot as well. We have more than 15 vehicles, so service stations in our area are actually after our business!

Saving on equipment has been made easier. Discounts for belonging to organizations like NWCOA have become much more popular. Another nice saving is your state organizations. You can typically find much of the equipment you need at your local state get-togethers. This can save you some bucks by putting all of your new purchases in your vehicles and not having to pay shipping. Taking advantage of sales has always been a biggie for our business.

A good example is the Black Friday sale that AAC recently had. We bought enough Ridge Guard and other products to give our credit card company a minor heart attack! I have always purchased our lures and bait from Rob Erickson at On Target Lures. They are pretty close, so we are trying to catch the animals from basically the same types of areas. I have been buying from them long enough that they will often surprise me by slipping in a free sample occasionally. This is a great idea because it has got me to order new and different lures once in a while.

I can't mention shopping without mentioning Menards. We use Home Depot for those things that Menards doesn't carry, and Fleet and Farm is usually our source for sporting goods. I should also mention that Fleet and Farm usually has the best price on the best quality fencing as well. Getting back to Menards, they just dropped their 11% off before Thanksgiving. This usually means some fantastic sales before Christmas, so I keep my eyes open. So far, they had drinking water on sale for 24% off, and yesterday they had 6-foot, 250-pound fiberglass ladders for $39, which was less than half price. (I got three in case any of the guys needed them in their trucks. I will admit that I am more likely to buy stuff when using the company credit card!) I hope all of you get Menards stores eventually. They are great when you need stuff for the ADC business.

One of the things that we are always big on is phone calls. Phone calls are what got us going and are certainly responsible for keeping us growing. This morning was an excellent example. December is one of our slow months, so we are glad to take just about any job we can get. This was a Sunday morning, and a woman called about a stray kitten in her garage. She had no idea where it came from but was willing to pay to have it removed. I immediately donned my outfit and went a couple of miles to her house. The little bugger outsmarted me, but he couldn't resist a baited cage later on in the day. We are very fortunate to have a great gal working for us, answering the phone on Friday evenings, Saturdays, and Sundays. Although weekends may not be the busiest, you never know what extra work you may get by answering the phone and showing up. If you charge extra for weekends, it's probably a good idea to tell your customers that weekdays are

slightly cheaper if it's not an emergency. Since we have cages out that need to be checked anyway, we always have a couple of guys out. I enjoy weekends because the traffic is usually a lot better.

Because we pay our technicians a nice percentage of the gross, they are just as interested in the profits as we are. We are always willing to listen to any ideas they may have about improving our business. We are not a very expensive company compared to most of the country. We will be raising some of our animal prices for the first time in many years. This is because every bill we pay has already been raised over the years. We have been able to keep prices low by becoming faster and more competent at catching the target animals, but a slight increase is overdue! Speaking of paying bills, I never get any money back when I write a check or pay in cash, but I always get something back when I use a credit card. Think about it! Also, do not forget to get reimbursed when you use your private vehicle for business.

If you can get your clothes printed by a local company, it is probably cheaper to buy them at Kohls or some other clothing store and have the names and logos printed for you. I have not been too happy with the caps lately, but it's probably my old head that needs replacing! We also save some money over the year by getting some of our envelopes at the Dollar Tree and our stamps at Costco. The Dollar Tree also has some pretty nice 16-foot retractable tape measures. We usually buy our hand mirrors there also. We have also saved money by comparing prices and occasionally switching insurance companies. Because we are a larger company, buying in volume is also a money-saving idea. This would probably not work as well if we were still working out of our house.

Speaking of working out of our house, that is where we worked for the first 30 years. We ran across a large building in great shape and bought it. Not only was it probably a good purchase financially (it is insured for more than twice the purchase price), but I would imagine that our office gals love not having to work in our basement anymore. We are erecting a pole barn in the back to store our cages and vehicles. I'm a little surprised that they accepted our offer. The property is located off the main drag in town and is not even a mile from one of Wisconsin's main freeways! I'm sure FedEx and the rest of the truck drivers will be happy not having to pull into our little driveway anymore!

Something that has not only saved me money but made me some is setting extra traps. There is nothing that makes me smile more than setting two extra squirrel cages and having all three of them filled the next day. If I had only set one cage, it would have taken two extra trips to catch the same number of animals. I have already caught an entire family of raccoons on several occasions because I set three cages in all. I usually have one or two babies in the same cage as mom and one or two together in the other cages. When a family is involved, the cages are set relatively close together!

I hope one or two of the things I mentioned in this article will save you guys some money. The way everything is going up in price, we'll need it! ■

Aerial Lifts

by Gordon Betts

Aerial lifts (lifts) are excellent when used on a job that would otherwise need a 40-foot ladder or scaffolding. Depending on bucket size and weight limits, many allow for more than one person to do elevated work, which makes things go easier and faster. Several types of lifts can be used depending upon what fits the job best. The boom arm style comes in at least three different forms. The truck-mounted (cherry picker), self-propelled, quadpod, tow-behind, and man lift platforms come with either an articulated arm (jointed) or straight arm. Then there are scissor-type lifts as well as a hydraulic piston or vertical mast extension.

Self-propelled scissor lifts tend to be the best style for interior work, followed by the piston type and the vertical extension type. These require a flat, solid surface where all you need is elevation. They can be great for putting up netting or other exclusion material. They go up and down, and that's about it. Any sideways movement has to be done by moving the whole machine. The straight boom also works well here.

Boom lifts give you elevation as well as side-to-side movement. For example, there is a lift called the Atrium Lift, of which a small version I saw had a reach of 55 feet with a 21-foot horizontal reach. The overall machine was 14 feet 8 inches X 2 feet 7 inches wide and 6 feet 6 inches high with a total weight of 4,630 pounds and was self-propelled on tracks. It can get inside doorways, reach all over, and is stabilized by outriggers that take up a lot of ground (floor) space. The drawback is the weight. Now we come to the articulated boom.

These are limited by the space where they will be used and the operator's experience. They can go up, down, sideways, over the top, down, and in other ways, especially if they have a jib. Decide on the length of reach you will need, and away you go. Let me give a word of caution here. Not all companies measure the working height of lifts the same. Some companies will include the working height of the operator (generally seven feet from the platform), while others will stop at the platform. This can cause issues as a 45-foot lift may only reach 45 feet when fully extended (straight up) with an operator that

can reach seven feet above the platform, which could leave you short (and being two feet short with a rental lift is more than frustrating). For other companies, the actual working height would be 45 feet plus the technician's reach. So, if you need a lift that can reach 50 feet, don't think all 45-foot lifts will allow you to reach it. Check with the manufacturer or rental company to see how they determine maximum work height to ensure you have enough lift for the job.

One of the significant drawbacks to drivable boom lifts is the overall weight of the machine. The two that I looked up were 12,650 pounds and 21,640 pounds, respectively. That's over 6 tons and 10 tons for boom counterbalance. Try putting that weight on wet ground, over a shallow septic system, or drive it up a poorly paved driveway. There are lighter ones out there, but you get the point. This weight also makes them hard to move from job to job. Another consideration is the level of clearance between the carriage and the ground.

Most of the articulating self-propelled lifts have only inches of bottom clearance. So the wheels may be off-road, but the clearance isn't. Some straight arm types have higher clearance and can go a lot of places if it is reasonably level. The truck-mounted versions can be lighter and better for getting into some places but take up more room.

The tow behind is the lightest model of lift. A friend of mine towed one with his Toyota Tacoma, but you need room to back it in or tow it into position. Both the tow behind and many of the truck-mounted lifts have stabilizers (called outriggers) that need to be engaged before they can be used. These can level the machine and, as the name says, stabilize it instead of using a weighty counterbalance. Just remember that you may have to put boards under the stabilizer pads to help disperse the weight and keep them from sinking into the ground or tearing up a lawn.

Aerial lifts may be bought new or used. They range from four figures to high five figures to probably well into the six-figure range for new truck models. If you own it, you are responsible for maintenance and safety inspections. Aerial lifts have to be inspected every time they are used to be sure that they meet OSHA (and other) specs. To avoid the hassles of ownership, most style lifts can be rented at the local rental centers. Some companies may require proof of aerial lift training before allowing you to rent, especially when renting a self-propelled lift.

Many centers give a discount for a long-term lease, with rates generally by the day, week, or month, so it may pay to line up your jobs. The day rental can add up fast, $500 and up a day around here, so be sure to figure the expense into your job estimate. Most rental locations, if not all, offer delivery and pick up of the machine for an extra charge. Moving it from one location to another will cost extra for sure, and their schedule may not be the same as yours. At these prices, you do not want one stuck in the mud for a few weeks, and because of the weight, you may have to wait for the ground to dry before the machine can be moved again too.

This is by no means a definitive account of lifts, and there is more that I didn't touch on. They can make your work life easier or, in some cases, not so much. But, again, as I have said in the past, use what works for you and work smarter, not harder. Above all else, work safely. ■

Questions & Answers

Have a question on Wildlife Control work?
Email us at ***ask@wctmagazine.com*** or write us at PO Box 357, Sharon Center, OH 44274

Q: I have a client with a dead animal, probably a squirrel or chipmunk, in an air duct under the house in a crawl space. The odor is very overpowering and smells like dirty mildew. I don't want to disassemble the ductwork. Is there anything I can do to mask or neutralize the order **while the carcass dries up? S.K., OH**

A: We would suggest first determining if the "dirty mildew" smells might be mildew. Dead animals and mildew are strong odors; however, they are very different. Start with a thorough inspection of the crawl space, checking for moisture and odors. Inspect the ductwork for leaks, holes, and loose connections. The problem may be as simple as providing airflow to the crawl space to allow drying or be as complicated as removing mold, insulation, ductworks, and many other related issues.

Q: As the snow was melting, we were getting calls from customers noticing significant damage to their lawn, which appears to be caused by voles and/or moles. I don't have a pesticide license, so I can't use rodenticides on them. What is the best way to control them without using rodenticides that is also safe for pets and small children? **B.N., VA**

A: Voles and moles can both be controlled by trapping and removal. Voles create approximately two-inch-wide cuts or trails through the blades of grass. As the snow melts, the trails are exposed, and so are the voles. Many are captured by predators such as cats, hawks, owls, and skunks. Follow the trails and locate the burrows and other places the trail begins, ends, or goes under structures. Place simple unbaited mouse traps in these trails. Put the trap pan directly on the trail so any vole traveling the trail will cross over the trigger and be captured. Fill empty trails with topsoil and monitor to see if you have removed all animals. Another method for voles is to use two snap traps on either side of the hole they are using. Place the traps in the trails with the trap pans facing the hole and cover with a shoebox, piece of K gutter, or a bucket. When the voles climb out of the hole, they will step on the trap pan triggering the trap.

Moles will create raised trails by pushing the soil up as they feed underground. There will not be any openings in these raised trails if the moles are still present. We suggest stepping on the raised trails and repairing any damage before attempting to trap moles. Moles will often cross through an area in the spring and may not still be there. An article on mole trapping can be found in this magazine's January/February 2022 issue.

Q: My customer has a lot of small holes in their yard. According to them, this has never happened in previous years. The holes appear to have been made with a rod and not by an animal. **J.S., IL**

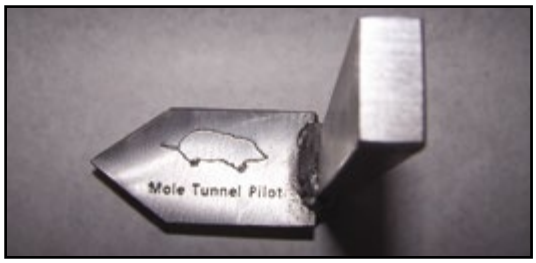
A: Two possibilities come immediately to mind—American crows and cicada nymphs. I have had one case early in my career where crows were going to a yard during the day and making holes that made the yard look as if it had been aerated without the dirt plugs. Why the crows choose that yard, I never found out. All I know is that they were looking for something (possibly cicada?) and finding it. The second option involves insects, specifically cicadas.

While primarily known for their 17-year cycle, other cicada species emerge early or have different delayed timeframes (i.e., 13 years). They spend most of their lives underground in one of five nymphal stages until they finally emerge to shed their exoskeleton as an adult and mate.

If the problem is crows, visual harassment products (spinners, effigies, dogs, etc.), along with noise dispersal products (e.g., bangers, clapping, distress calls, etc.), can be used to move the birds away from the site. For cicada issues, education is the preferred treatment. Information specific to managing cicadas can be found online at ***https://www.epa.gov/safepestcontrol/cicadas***. ■

The Future of Mole Control Has Arrived! Introducing the

Mole Tunnel Pilot



Designed and developed specifically for the use with the 'Trapline' mole traps, the 'Mole Tunnel Pilot' (MTP) tool is constructed of solid aluminum welded stock material that is lightweight, very durable and rustproof. Weighing less than a pound, this "Professional Model Tool" was built to hold up to very vigorous commercial mole trapping use.

This tool provides a consistent trap setting chamber by enlarging and configuring the mole tunnel while compressing the soil or sod for the Trapline mole trap. The action of the MTP tool speeds up trap setting and prevents trap malfunction due to small rocks, roots and a poorly enlarged tunnel that can cause your traps to hang up resulting in a missed catch.

"Jameson's MTP is a perfect match for the Trapline Mole Trap. You'll no longer have to worry about unseen tunnel obstructions (roots, rocks, etc) interfering with a sure catch. It's as good as it gets!"

Jason Turner, Wildlife Removal, Etc.

The professional Mole Tunnel Pilot tool helps to eliminate a lot of trial and error, unforeseen problems, miss fires and wasted field time as a result of poorly set traps in general. The overall design and function of the MTP tool provides all the needed steps to use the Trapline traps most effectively.

All you must do is select the best place to set your traps and the Mole Tunnel Pilot will do the rest for you. Just stabilize and anchor the traps as needed. The development and use of the MTP for commercial mole control work has been a game changer for mole work. It will reduce trap setting time, significantly reduce misses due to ground conditions and increase your effectiveness as a result of its basic function.

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www.jamesonsultrablend.com

"I had the opportunity in February of this year to visit Bob Jameson at his lure shop in Daisytown, Pa. When I was at his shop, I noticed a tool in his mole trapping equipment. Bob explained to me it was a tool he had been working on to make setting the Trap Line mole trap easier. He calls this tool the Mole Tunnel Pilot.

He developed the tool through trial and error until he came up with a prototype. (Not available to the public at that time). He gave me the new tool to try out in the spring. The tool is built like a tank yet light-weight and will not rust and will last many years.

I used the tool all through the spring mole season. I can honestly say, the tool makes setting the Trap Line mole traps much easier and more efficient. The tool is the same dimension of the trap. The Mole Tunnel Pilot is placed in the mole run. By using a rocking motion, it makes the perfect trap bed for trap placement so there is a greater catch ratio. Missing moles is a thing of the past."

Pete Cappa, Cappa Wildlife Control Services

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2020 AVMA Guidelines Comments

by WCT Staff

In this issue, I'll focus on the approved methods of euthanasia approved by the Panel on Euthanasia (POE). Specifically, the areas concerning Inhaled and Noninhaled Agents.

Each section will begin with information regarding what each method is, how that method produces death, how animals react to that method and more.

Where appropriate, I've included options wildlife control operators have access to. For those wishing information on DEA-regulated products, consult the guidelines in their entirety.

Notice that there are no specific products listed under the Noninhaled Agents section. There is a section in the guidelines concerning alcohol used for euthanasia; however, the species listed for approval and the methods required don't cross over into the wildlife control industry.

While I highly recommend reviewing all of the material for self-education and talking points, I understand that a lot of it does not relate to wildlife control work. Hence, I recommend paying particular attention to the CO and CO2 sections for those wishing to skim the material.

Both of these gases are used frequently by wildlife control operators, so having a good understanding of how they perform, along with how they are best used, is critical.

I also recommend reviewing the Unacceptable Agents section. Finally, keep in mind that while these guidelines are focused on veterinarians, several states have adopted their usage. I find it interesting the pesticides are listed as each state does allow for registered pesticide usage on birds and certain rodents.

Additionally, by knowing this information, it is possible to correct others that may try and prevent these methods from being used when incorrect information is presented.

Lastly, I've included the list of references for anyone wishing more information that is noted. ■

AVMA Guidelines for the Euthanasia of Animals: 2020 Edition (continued)

Part II—Methods of Euthanasia

M1 Inhaled Agents

M1.1 COMMON CONSIDERATIONS

Inhaled vapors and gases require a critical concentration within the alveoli and blood for effect; thus, all inhaled methods have the potential to adversely affect animal welfare because onset of unconsciousness is not immediate. Distress may be created by properties of the agent (eg, pungency, hypoxia, hypercarbia) or by the conditions under which the agent is administered (eg, home cage or dedicated chamber, gradual displacement or prefilling of the container), and may manifest itself behaviorally (eg, overt escape behaviors, approach-avoidance preferences [aversion]) or physiologically (eg, changes in heart rate, SNS activity, HPA activity). Although SNS and HPA activation are well accepted as markers of a stress response, these systems are activated in response to both physical and psychological stressors and are not necessarily associated with higher-order CNS processing and conscious experience by the animal. Furthermore, use of SNS and HPA activation to assess distress during inhalation of euthanasia agents is complicated by continued exposure to the agents during the period between loss of consciousness and death.

Distress during administration of inhaled agents has been evaluated by means of both behavioral assessment and aversion testing. While overt behavioral signs of distress have been reported in some studies, others have not consistently found these effects. Through preference and approach-avoidance testing, all inhaled agents currently used for euthanasia have been identified as being aversive to varying degrees. Aversion is a measure of preference, and while aversion does not necessarily imply that the experience is painful, forcing animals into aversive situations creates distress. The conditions of exposure used for aversion studies, however, may differ from those used for stunning or killing. In addition, agents identified as being less aversive (eg, Ar or N_2 gas mixtures, inhaled anesthetics) can still produce overt signs of behavioral distress (eg, open-mouth breathing) in some species under certain conditions of administration (eg, gradual displacement). As previously noted in the section on consciousness, one of the characteristics of anesthesia in people is feeling as if one is having an out-of-body experience, suggesting a disconnection between one's sense of self and one's awareness of time and space.[1] Although we cannot know for certain the subjective experiences of animals, one can speculate similar feelings of disorientation may contribute to the observed signs of distress.

As for physical methods, the conditions under which inhaled agents are administered for euthanasia can have profound effects on an animal's response and, thus, agent suitability. Simply placing Sprague-Dawley rats into an unfamiliar exposure chamber containing room air produces arousal, if not distress.[2] Pigs are social animals and prefer not to be isolated from one another; consequently, moving them to the CO_2 stunning box in groups, rather than lining them up single file as needed for electric stunning, improves voluntary forward movement, reduces handling stress and electric prod use, and improves meat quality.[3]

That inhaled agents can produce distress and aversion in people raises concerns for their use in animals, in that the US Government Principles for the Utilization and Care of Vertebrate Animals Used in Testing, Research, and Training[4] state, "Unless the contrary is established, investigators should consider that procedures that cause pain or distress in human beings may cause pain or distress in other animals." Interestingly, more than 40% of human children 2 to 10 years old display distress behaviors during sevoflurane induction, with 17% displaying significant distress and more than 30% physically resisting during induction.[5] Fear in children undergoing anesthesia may be due to odor, feel of the mask, or a true phobia of the mask.[6] Despite evidence of distress and aversion, inhaled anesthetics continue to be administered because the benefits associated with their use greatly outweigh any distress and/or aversion they may cause.

The suitability of any particular inhaled agent for euthanasia therefore depends largely on distress and/or pain experienced prior to loss of consciousness. Distress can be caused by handling, specific agent properties, or method of administration, such that a 1-size-fits-all approach cannot be easily applied. Suffering can be conceptualized as the product of severity, incidence, and duration. As a general rule, a gentle death that takes longer is preferable to a rapid, but more distressing death[7]; however, in some species and under some circumstances, the most humane and pragmatic option may be exposure to an aversive agent or condition that results in rapid unconsciousness with few or no outward signs of distress. Our goal is to identify best practices for administering inhaled agents, defining the optimal conditions for transport, handling, and agent selection and delivery to produce the least aversive and distressing experience for each species.

The following contingencies are common to all inhaled euthanasia agents:

(1) Time to unconsciousness with inhaled agents is dependent on the displacement rate, container volume, and concentration. An understanding of the principles governing delivery of gases or vapors into enclosed spaces is necessary for appropriate application of both prefill and gradual displacement methods. The desired final concentration will be achieved more quickly by using a greater displacement rate (see M1.2).

(2) Loss of consciousness will be more rapid if are initially exposed to a high concentration of the agent. However, for

many agents and species, forced exposure to high concentrations can be aversive and distressing, such that gradual exposure may be the most pragmatic and humane option.

(3) Inhaled agents must be supplied in purified form without contaminants or adulterants, typically from a commercially supplied source, cylinder, or tank, such that an effective displacement rate and/or concentration can be readily quantified. The direct application of products of combustion or sublimation is not acceptable due to unreliable or undesirable composition and/or displacement rate.

(4) The equipment used to deliver and maintain inhaled agents must be in good working order and in compliance with state and federal regulations. Leaky or faulty equipment may lead to slow, distressful death and may be hazardous to other animals and to personnel.

(5) Most inhaled agents are hazardous to animal workers because of the risk of explosions (eg, ether, CO), narcosis (eg, halocarbon anesthetics, nitrous oxide [N_2O], CO_2 asphyxiating gases), hypoxia (eg, asphyxiating gases, CO), addiction or physical abuse (eg, N_2O, halocarbon anesthetics), or health effects resulting from chronic exposure (eg, N_2O, CO, possibly halocarbon anesthetics).

(6) In sick or depressed animals where ventilation is decreased, agitation during induction is more likely because the rise in alveolar gas concentration is delayed. A similar delayed rise in alveolar gas concentration can be observed in excited animals having increased cardiac output. Suitable premedication or noninhaled methods of euthanasia should be considered for such animals.

(7) Neonatal animals appear to be resistant to hypoxia, and because all inhaled agents ultimately cause hypoxia, neonatal animals take longer to die than adults.[8] Inhaled agents can be used alone in unweaned animals to induce loss of consciousness, but prolonged exposure time or a secondary method may be required to kill the unconscious animal.

(8) Reptiles, amphibians, and diving birds and mammals have a great capacity for holding their breath and for anaerobic metabolism. Therefore, induction of anesthesia and time to loss of consciousness when inhaled agents are used may be greatly prolonged. Noninhaled methods of euthanasia should be considered for these species and a secondary method is required to kill the unconscious animal.

(9) Rapid gas flows can produce noise or cold drafts leading to animal fright and escape behaviors. If high flows are required, equipment should be designed to minimize noise and gas streams blowing directly on the animals.

(10) When possible, inhaled agents should be administered under conditions where animals are most comfortable (eg, for rodents, in a darkened home cage[9]; for pigs, in small groups). If animals need to be combined, they should be of the same species and compatible cohorts, and, if needed, restrained or separated so that they will not hurt themselves or others. Chambers should not be overloaded and need to be kept clean to minimize odors that might cause distress in animals subsequently euthanized.

(11) Because some inhaled agents may be lighter or heavier than air, layering or loss of agent may permit animals to avoid exposure. Mixing can be maximized by ensuring incoming gas or vapor flow rates are sufficient. Chambers and containers should be as leak free as possible.

(12) Death must be verified following administration of inhaled agents. This can be done either by examination of individual animals or by adherence to validated exposure processes proven to result in death.[10] If an animal is not dead, exposure must be repeated or followed with another method of euthanasia.

M1.3 INHALED ANESTHETICS

Overdoses of inhaled anesthetics (eg, ether, halothane, methoxyflurane, isoflurane, sevoflurane, desflurane, enflurane) have been used to euthanize many species.[18] Presently, only isoflurane, enflurane, sevoflurane, and desflurane are clinically available in the United States, although halothane and methoxyflurane are still available elsewhere in the world. Halothane induces anesthesia rapidly and is an effective inhaled agent for euthanasia. Enflurane is less soluble in blood than halothane, but, because of its lower vapor pressure and lower potency, induction rates may be similar to those for halothane. At deep anesthetic planes, convulsions may occur. Enflurane is an effective agent for euthanasia, but the associated seizure activity may be disturbing to personnel. Isoflurane is less soluble than halothane, and it induces anesthesia more rapidly. However, it has a pungent odor and onset of unconsciousness may be delayed due to breath holding. Due to lower potency, isoflurane also may require more drug to kill an animal, compared with halothane. Sevoflurane is less potent than either isoflurane or halothane and has a lower vapor pressure. Anesthetic concentrations can be achieved and maintained rapidly but more drug will be required to kill the animal. Although sevoflurane is reported to possess less of an objectionable odor than isoflurane, some species may struggle violently and experience apnea when sevoflurane is administered by face mask or induction chamber.[19] Like enflurane, sevoflurane induces epileptiform electrocortical activity.[20] Desflurane is currently the least soluble potent inhaled anesthetic, but the vapor is quite pungent, which may slow induction. This drug is so volatile that it could displace O_2 and induce hypoxemia during induction if supplemental O_2 is not provided. Both diethyl ether and methoxyflurane are highly soluble, and may be accompanied by agitation because anesthetic induction is quite slow. Diethyl ether is irritating to the eyes, nose, and respiratory airways; poses serious risks due to flammability and explosiveness; and has been used to create a model for stress.[21–24]

Although inhaled anesthetics are routinely used to produce general anesthesia in humans and animalsthese agents may be aversive and distressful under certain conditions. Flecknell et al[19] reported violent struggling accompanied by apnea and bradycardia in rabbits administered isoflurane, halothane, and sevoflurane by mask or induction chamber, and

concluded these agents were aversive and should be avoided whenever possible. Leach et al[25–27] found inhaled anesthetic vapors to be associated with some degree of aversion in laboratory rodents, with increasing aversion noted as concentration increased; halothane was least aversive for rats, while halothane and enflurane were least aversive for mice. Makowska and Weary[28] also reported halothane and isoflurane to be aversive to male Wistar rats, but less so than CO_2. Aversion to inhaled anesthetics increases following initial exposure; rodents are more likely to leave the test chamber on second and subsequent exposures to inhaled anesthetics.[29–31] This may indicate the possibility of learned aversion to these agents.[32]

Anesthetic vapor is inhaled until respiration ceases and death ensues. Because the liquid state of most inhaled anesthetics is irritating, animals should be exposed only to vapors. With inhaled anesthetics, animals can be placed in a closed receptacle containing cotton or gauze soaked with an appropriate amount of liquid anesthetic[33] or anesthetic vapor can be introduced from a precision vaporizer.[34] Precision anesthetic vaporizers typically are limited to 5% to 7% maximum output between 0.5 and 10 L/min O_2 flow rate. Induction time will be influenced by dial setting, flow rate, and size of the container; time to death may be prolonged because O_2 is commonly used as the vapor carrier gas. The amount of liquid anesthetic required to produce a given concentration of anesthetic vapor within any closed container can be readily calculated[35]; in the case of isoflurane, a maximum of 33% vapor can be produced at 20°C. Sufficient air or O_2 must be provided during the induction period to prevent hypoxia.[33] In the case of small rodents placed in a large container, there will be sufficient O_2 in the chamber to prevent hypoxia. Larger species placed in small containers may initially need supplemental air or O_2.[33]

Nitrous oxide is the least potent of the inhalation anesthetics. In humans, the minimum alveolar concentration (defined as the median effective dose) for N_2O is 104%; its potency in other species is less than half that in humans (ie, approx 200%). Because the effective dose for N_2O is above 100%, it cannot be used alone at 1 atmosphere of pressure in any species without producing hypoxia prior to respiratory or cardiac arrest. As a result, animals may become distressed prior to loss of consciousness when N_2O is used as the sole agent. Up to 70% N_2O may be combined with other inhaled gases to speed the onset of anesthesia; however, the anesthetic contribution of N_2O will be only half (20% to 30%) of that expected in humans due to its reduced potency in animals.[36]

The addition of N_2O to inhaled gases may represent a refinement for euthanasia. Adding 75% N_2O to 5% isoflurane in oxygen reduced time to loss of righting in mice by approximately 18%, while at 20% displacement rate administration of a mixture of 60% N_2O with CO_2 reduced time to loss of righting by 10%.[37] However, while N_2O narcosis prior to CO_2 in 0- to 7-day-old piglets reduced the amount of time the piglets were exposed to CO_2, it did not reduce the amount of distressful behaviors observed.[38]

Effective procedures should be in place to reduce animal worker exposure to anesthetic vapors.[39] Human workplace recommended exposure limits were issued in 1977 by the National Institute of Occupational Safety and Health; concentrations for halogenated inhaled anesthetics are not to exceed 2 ppm (1-hour ceiling) when used alone, or 0.5 ppm for halogenated anesthetics combined with 25-ppm N_2O (time-weighted average during use). The American Conference of Government Industrial Hygienists has assigned a threshold limit value time-weighted average of 50 ppm for $_{NO}$, 50 ppm for halothane, and 75 ppm for enflurane for an 8-hour time-weighted exposure. These concentrations were established because they were found to be attainable utilizing clinical scavenging techniques and there are no controlled studies proving exposure at these concentrations are safe. No National Institute of Occupational Safety and Health–recommended exposure limits exist for the 3 most currently used anesthetics (isoflurane, desflurane, and sevoflurane), and, at present, the Occupational Safety and Health Administration has no permissible exposure limits regulating these specific agents.

Advantages—(1) Inhaled anesthetics are particularly useful for euthanasia of smaller animals (< 7 kg [15.4 lb]) or for animals in which venipuncture may be difficult. (2) Inhaled anesthetics can be administered by several different methods depending on the circumstances and equipment available (eg, face mask, open drop where the animal is not permitted to directly contact the anesthetic liquid, precision vaporizer, rigid or nonrigid containers). (3) Halothane, enflurane, isoflurane, sevoflurane, desflurane, methoxyflurane, and N_2O are nonflammable and nonexplosive under usual clinical conditions. (4) Inhaled anesthetics can be useful as the sole euthanasia agent or as part of a 2-step process, where animals are first rendered unconscious through exposure to inhaled anesthetic agents and subsequently killed via a secondary method.

Disadvantages—(1) Inhaled anesthetics are aversive to rabbits and laboratory rodents and the same may be true for other species. Animals may struggle and become anxious during induction of anesthesia, with some animals exhibiting escape behaviors prior to onset of unconsciousness. Learned aversion to inhaled anesthetics occurs in rodents. Should apnea or excitement occur, time to loss of consciousness may be prolonged. (2) Ether is irritating, flammable, and explosive. Explosions have occurred when animals, euthanized with ether, were placed in an ordinary [26] (not explosion-proof) refrigerator or freezer and when bagged animals were placed in an incinerator. (3) Induction with methoxyflurane is unacceptably slow in some species. (4) Because of design limits on vapor output, precision anesthetic vaporizers may be associated with a longer wash-in time constant and, thus, longer induction time; time to death may be prolonged as O_2 is commonly used as the vapor carrier gas. (5) Nitrous oxide used alone will create a hypoxic atmosphere and will support combustion at high concentrations. (6) Personnel and animals may be injured by exposure to these agents. There is recognized potential for human abuse of inhaled anesthetics. (7) Because large amounts of inhaled anesthetics are absorbed and substantial amounts remain in the body for days, even after apparent recovery,[40] use of inhaled anesthetics for euthanasia is unsuitable for food-producing animals due to potential for tissue residues.

General recommendations—Inhaled anesthetics are acceptable with conditions for euthanasia of small animals (< 7

kg) where the following contingencies can be met: (1) In those species where aversion or overt escape behaviors have not been noted, exposure to high concentrations resulting in rapid loss of consciousness is preferred. Otherwise, gradual-fill methods can be used, keeping in mind the effect that chamber volume, flow rate, and anesthetic concentration will have on the time constant and rate of rise of anesthetic concentration. Inhaled anesthetics can be administered as the sole euthanasia agent or as part of a 2-step process, where animals are first rendered unconscious through inhaled anesthetic agent exposure and then subsequently killed by a secondary method. (2) Order of preference is isoflurane, halothane, sevoflurane, enflurane, methoxyflurane, and desflurane, with or without N_2O. Nitrous oxide should not be used alone. Methoxyflurane is acceptable with conditions only if other agents or methods are not available. Ether is not acceptable for euthanasia. (3) Although acceptable, inhaled anesthetics are generally not used for larger animals because of cost and difficulty of administration. (4) Exposure of workers to anesthetics must comply with state and federal occupational health and safety regulations. (5) Neonatal animals will require extended exposure times.[41]

M1.4 CARBON MONOXIDE

Carbon monoxide is a colorless, odorless gas that is nonflammable and nonexplosive at concentrations < 12%. Carbon monoxide is a cumulative poison that produces fatal hypoxemia; it readily combines with hemoglobin and blocks uptake of O_2 by erythrocytes by forming carboxyhemoglobin.[42,43] Precisely because it is insidious, difficult to detect, and highly toxic even at low concentrations, the lethal properties of CO have long been recognized; indeed, approximately 50,000 emergency room visits for human CO poisoning occur in the United States annually.[44]

In people, the clinical presentation for CO inhalation is nonspecific, with headache, dizziness, and weakness the most common symptoms of low-level CO toxicosis. As concentrations of CO increase, these signs may be followed by decreased visual acuity, tinnitus, nausea, progressive depression, confusion, and collapse.[45] With higher-level exposure, coma, convulsions, and cardiorespiratory arrest may occur.[43] Carbon monoxide stimulates motor centers in the brain, such that loss of consciousness may be accompanied by convulsions and muscular spasms. Distinct signs of CO toxicosis are not evident until the CO concentration is 0.05% in air, and acute signs do not develop until CO concentration is approximately 0.2% in air. In humans, exposure to 0.32% CO and 0.45% CO for 1 hour will induce loss of consciousness and death, respectively.[46] Chronic exposure to low concentrations of CO may be a health hazard, especially with regard to cardiovascular disease and teratogenic effects.[43,44,47–49] An efficient exhaust or ventilation system is essential to prevent accidental exposure of humans.

In the past, mass euthanasia was accomplished by use of 3 different methods for generating CO: (1) chemical interaction of sodium formate and sulfuric acid, (2) exhaust fumes from gasoline internal combustion engines, and (3) commercially compressed CO in cylinders. The first 2 techniques are associated with substantial problems such as production of other gases, inadequate production of CO, inadequate gas cooling, inability to quantify delivery rate, and maintenance of equipment.

Ramsey and Eilmann[50] found that a concentration of 8% CO caused guinea pigs to collapse in 40 seconds to 2 minutes, and death occurred within 6 minutes. When used with mink and chinchillas, CO caused collapse in 1 minute, cessation of breathing in 2 minutes, and cardiac arrest in 5 to 7 minutes.[51,52] Chalifoux and Dallaire[53] evaluated the physiologic and behavioral characteristics of dogs exposed to 6% CO in air, and could not determine the precise time of loss of consciousness. Electroencephalographic recordings revealed 20 to 25 seconds of abnormal cortical function, and during this period the dogs became agitated and vocalized. It is not clear whether these behavioral responses are indicative of animal distress; however, humans in this phase reportedly are not distressed.[42] Subsequent studies[54] have revealed that tranquilization with acepromazine significantly decreases behavioral and physiologic responses of dogs euthanized with CO. Carbon monoxide is noted to be aversive to laboratory rats, but not as aversive as CO2.[55]

In 1 study on cats,[56] CO from gasoline engine exhaust was compared with a combination of 70% CO_2 plus 30% O_2. Signs of agitation before loss of consciousness were greater for the CO_2-plus-O_2 combination. Time to complete immobilization was greater with CO_2 plus O_2 (approx 90 seconds) than with CO alone (approx 56 seconds).[56] In another study in neonatal pigs,[57] excitation was less likely to precede loss of consciousness if animals were exposed to a slow rise in CO concentration.

A study of an epidemic of avian influenza in the Netherlands in 2003 compared the use of CO_2 with CO for gassing whole houses of poultry.[58] The researchers noted that more convulsions were observed in the presence of CO and recommended that CO_2 was the preferred agent for this application due to safety regulations required for the use of CO.

Advantages—(1) Carbon monoxide induces loss of consciousness without pain and with minimal discernible discomfort, depending on species. (2) Hypoxemia induced by CO is insidious. (3) Death occurs rapidly if concentrations of 4% to 6% are used.

Disadvantages—(1) Carbon monoxide is an aversive agent for laboratory rodents and the same may be true for other species. (2) Safeguards must be taken to prevent and monitor exposure of personnel. (3) Electrical equipment exposed to CO (eg, lights and fans) must be spark free and explosion proof.

General recommendations—Carbon monoxide is acceptable with conditions for euthanasia, provided all of the following contingencies are met: (1) Personnel using CO must be instructed thoroughly in its use and must understand its hazards and limitations. (2) The CO chamber must be of the highest-quality construction and should allow for separation of individual animals. If animals need to be combined, they should be of the same species, and, if needed, restrained or

separated so that they will not hurt themselves or others. Chambers should not be overloaded and need to be kept clean to minimize odors that might distress animals that are subsequently euthanized. (3) The CO source and chamber must be located in a well-ventilated environment, preferably out-of-doors. (4) The chamber must be well lighted and must allow personnel direct observation of animals. (5) The CO flow rate should be adequate to rapidly achieve a uniform CO concentration of at least 6% after animals are placed in the chamber, except for those species (eg, neonatal pigs) where it has been shown that less agitation occurs with a gradual rise in CO concentration.[57] (6) If the chamber is inside a room, CO monitors must be placed in the room to warn personnel of hazardous concentrations. (7) It is essential that CO use be in compliance with state and federal occupational health and safety regulations. (8) Carbon monoxide must be supplied in a precisely regulated and purified form without contaminants or adulterants, typically from a commercially supplied cylinder or tank. The direct application of products of combustion or sublimation is not acceptable due to unreliable or undesirable composition and/or displacement rate. As gas displacement rate is critical to the humane application of CO, an appropriate pressure-reducing regulator and flow meter combination or equivalent equipment with demonstrated capability for generating the recommended displacement rate for the size container being utilized is absolutely necessary.

M1.6 CARBON DIOXIDE

Inhalation of CO_2 causes respiratory acidosis and produces a reversible anesthetic state by rapidly decreasing intracellular pH.[81] Both basal and evoked neural activity are depressed soon after inhalation of 100% CO_2.[81–84] Inhalation of CO_2 at a concentration of 7.5% increases pain threshold, and concentrations of 30% and higher cause deep anesthesia and death with prolonged exposure.[16,17,85–87] Methods to administer CO_2 include placing animals directly into a closed, prefilled chamber containing CO_2, or exposure to a gradually increasing concentration of CO_2.

Carbon dioxide has the potential to cause distress in animals via 3 different mechanisms: (1) pain due to formation of carbonic acid on respiratory and ocular membranes, (2) production of so-called air hunger and a feeling of breathlessness, and (3) direct stimulation of ion channels within the amygdala associated with the fear response. Substantial species and strain differences are reported.

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%.[88–91] Humans report discomfort begins at 30% to 50% CO_2 and intensifies to overt pain with higher concentrations.[92–94] 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.[95] In rats, 100% CO_2 elicits apnea and bradycardia, but CO_2 at concentrations of 10%, 25%, and 50% does not,[96] suggesting that gradual displacement methods are less likely to produce pain prior to unconsciousness in rodents where unconsciousness occurs before chamber concentration reaches levels associated with nociceptor activation.[32] On the other hand, bradycardia associated with CO_2 exposure in rats is reported to occur prior to loss of consciousness.[97]

Carbon dioxide has a key role as a respiratory stimulant, and elevated concentrations are known to cause profound effects on the respiratory system, cardiovascular system, and SNS.[98–100] In humans, air hunger begins at concentrations as low as 8% and this sensation intensifies with higher concentrations, becoming severe at approximately 15%.[101–103] 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.[104–106] Adding O_2 to CO_2 may or may not preclude signs of distress.[94,107–109] 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[110] found an increase in norepinephrine in rats following 30 seconds of exposure to 100% CO_2. Similarly, Reed[111] 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 SNS activation, such as elevated heart rate and blood pressure, have been complicated by the rapid depressant effects of CO_2 exposure. Activation of the HPA 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[112,113] and cortisol in dogs.[114] In a single-blind study in healthy human volunteers, a single breath of 35% CO_2 was found to result in elevated cortisol concentrations and exposure was associated with an increase in fear.[115] 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.[116] In fact, Kc et al[117] 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 by means of behavioral assessment and aversion testing. Variability in behavioral responses to CO_2 has been reported for rats and mice,[15–17,65,108,118–120] pigs,[76,121–124] and poultry.[66,72–75,125–128] 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,[25,26] and are willing to forgo a palatable food reward to avoid exposure to CO_2 concentrations of approximately 15% and higher[28,63] after up to 24 hours of food deprivation.[107] Powell et al9 reported a significant increase in anxious behaviors in mice with exposure to isoflurane, high-flow CO_2, and brightly lighted chambers. Mink will avoid a chamber containing a desirable novel object when it contains 100% CO_2.[129] 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.[67,72,121] Following incapacitation and prior to loss of consciousness, birds in these studies show behaviors such as open-beak breathing and head-shaking; these behaviors, however, may not be associated with distress because birds do not withdraw from CO_2 when these behaviors occur.[73] Thus, 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. Using an approach-avoidance model, a preliminary study by Withrock et al[130] suggests that dairy goat kids exhibit no avoidance behaviors to 10% to 30% CO_2 and do not develop conditioned aversion.

Genetics may play a role in CO_2 response variability. Panic disorder in humans is genetically linked to enhanced sensitivity to CO_2.[131] The fear network, comprising the hippocampus, the medial prefrontal cortex, the amygdala, and its brainstem projections, appears to be abnormally sensitive to CO_2 in these patients.[132] The genetic background of some pigs, especially excitable lines such as the Hampshire and German Landrace, has been associated with animals that react poorly to CO_2 stunning, while calmer lines combining the Yorkshire or Dutch Landrace conformations show much milder reactions.[133] Given a choice, Duroc and Large White pigs will tolerate 30% CO_2 to gain access to a food reward, but will forgo the reward to avoid exposure to 90% CO_2, even after a 24-hour period of food deprivation.[76,121] A shock with an electric prod, however, is more aversive to Landrace X Large White pigs than inhaling 60% or 90% CO_2, with pigs inhaling 60% CO_2 willing to reenter the crate containing CO_2.[122] Until further research is conducted, one can conclude that use of CO_2 may be humane for certain genetic lines of pigs and stressful for others.[133]

Recent studies involving mice have found regions of the amygdala associated with fear behavior to contain ASICs sensitive to elevated CO_2.134 Fear behaviors and aversion in response to CO_2 exposure were reduced in mice in which the ASIC receptors were eliminated or inhibited, suggesting that aversive responses to CO_2 in rodents, and potentially other species, are mediated in part by an innate fear response. Further studies defining the presence of ASICs and their role in CO_2-induced fear in other rodent strains, as well as other animal species, are warranted.

As with other inhaled agents, 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_2.108,135 Similarly, a rapidly increasing concentration (flow rate > 50% of the chamber volume/minute) induces unconsciousness in only 26 to 48 seconds.[16,17,29,65,109,118,136] Leake and Waters87 found that dogs exposed to 30% to 40% CO CO_2 2 were anesthetized in 1 to 2 minutes. For cats, inhalation of 60% CO_2 results in loss of consciousness within 45 seconds, and respiratory arrest within 5 minutes.[137] For pigs, exposure to 60% to 90% CO_2 causes unconsciousness in 14 to 30 seconds,[80–82,121] with unconsciousness occurring prior to onset of signs of excitation.[80,84] Euthanasia via exposure to CO_2 has been described for individual birds and small groups,[138] and its application to euthanasia of chickens, turkeys, ducks, and rabbits has been studied, resulting in information about times to collapse, unconsciousness and death, loss of somatosensory evoked potentials, and changes in EEG. Leghorn chicks 7 days of age collapsed in 12 seconds after exposure to 97% CO_2.119 Raj71 found that 2 minutes' exposure to 90% CO_2 was sufficient to kill day-old chicks exposed in batches. Broilers 5 weeks of age collapsed an average of 17 seconds after entering a tunnel filled with 60% CO_2.[72]

Unlike N_2 and Ar, which must be held within a very tight range of concentration for effective euthanasia, CO_2 can render poultry unconscious and kill over a wide range of concentrations. In tests where it took 8 seconds to achieve the target gas concentration, broilers and mature hens collapsed in 19 to 21 seconds at 65% CO_2 and 25 to 28 seconds at 35% CO_2.[139] In a gradual-fill study, ducks and turkeys lost consciousness before 25% CO2 was reached and died after the concentration reached 45%.125 At 49% CO_2, EEG suppression, loss of somatosensory evoked potentials, and EEG silence occurred in 11, 26, and 76 seconds in chickens.[140] In turkeys, EEG suppression took place in an average of 21 seconds at 49% CO_2, but was reduced to 13 seconds at 86% CO_2. In the same report, time to loss of somatosensory evoked potentials was not affected by gas concentration, averaging 20, 15, and 21 seconds, but time to EEG silence was concentration dependent (ie, 88, 67, and 42 seconds for 49%, 65%, and 86% CO_2, respectively).[141]

In rabbits, a 58% CO_2 displacement rate resulted in a significantly shorter time to insensibility and death than did a 28% displacement rate, with neither rate reported as inducing significant distress behaviors.[142] In contrast, Dalmau et al[143] compared immersion of meat rabbits into a commercial stunning system prefilled with 70%, 80%, or 90% CO_2. Loss of posture occurred within the first 30 seconds following initial exposure to CO_2; however, aversion (as nasal discomfort and vocalizations) was observed for 15 seconds prior to loss of posture. Dalmau et al concluded that despite the advantages their system provides in terms of prestunning handling and irreversibility, it is not free of animal welfare problems.

As a general rule, a gentle death that takes longer is preferable to a rapid, but more distressing death.[7] Gradual-fill CO_2 exposure causes aversion in rodents beginning at approximately a 15% concentration and lasting to onset of unconsciousness. If an appropriate gradual displacement rate is used, animals will lose consciousness before CO_2 concentrations become painful.[32,65] A 20%/min gradual displacement produces unconsciousness in 106 seconds at a CO_2 concentration of 30%[15,17,94,109]; a slower 10%/min displacement increases time to onset of unconsciousness to 156 seconds at a CO_2 concentration of 21%.[65] A 50%/min CO_2 displacement rate, while holding the chamber concentration just below 40% CO_2,

minimizes the interval between onset of labored breathing and recumbency in mice; however, even at these rates, mice experienced > 30 seconds between onset of dyspnea and insensibility.[29] For poultry, immersion into relatively low concentrations or exposure to CO_2 concentrations producing a gradual induction of unconsciousness reduces convulsions compared with immersion into N_2 or Ar.[74,144] Carbon dioxide may invoke involuntary (unconscious) motor activity in birds, such as flapping of the wings or other terminal movements, which can damage tissues and be disconcerting for observers[119,145]; wing flapping is less with CO_2 than with N_2 or Ar.[144]

Due to respiratory adaptations in immature animals, reptiles, amphibians, and some burrowing and diving species (eg, lagomorphs, mustelids, aquatic birds, nonhatched birds, newly hatched chicks), high CO_2 concentrations, combined with extended exposure times, follow-up exposure to hypoxemia, or a secondary euthanasia method, may be required to ensure unconsciousness and death. High CO_2 concentrations (> 60%) and extended exposure times (> 5 minutes) are required for effective euthanasia of newly hatched chickens.[71,146] On the day of birth, rats and mice exposed to 100% CO_2 required exposure times of 35 and 50 minutes, respectively, to ensure death. By 10 days of age, exposure times of 5 minutes were sufficient to ensure death.[147,148] For adult mink, 5 minutes of exposure is sufficient to ensure death using 100% CO_2, but not using 70% CO_2.[51] Rabbits of the genus *Oryctolagus* also have prolonged survival times when exposed to CO_2.[149]

Inhaled halocarbon anesthetics have been proposed as alternatives to CO_2 for rodent euthanasia.[7,28,34] Inhaled anesthetics also produce various degrees of aversion in rodents[25–28] and are associated in other animals and humans with aversion, distress, and escape behaviors during anesthetic induction. Both mice and rats will always choose exposure to light (an aversive condition) over exposure to CO_2 (more aversive) in approach-avoidance tests, while > 50% of mice and rats will tolerate first exposure to an inhalant anesthetic until they become recumbent. However, mice and rats also show evidence of learned aversion to inhaled anesthetic agents and are more likely to escape the test chamber, and to do so more quickly, on second and subsequent exposures to inhaled anesthetics; in contrast, aversion to CO_2 does not increase with subsequent exposures.[32] Time to death may be prolonged as O_2 is commonly used as the vapor carrier gas with precision anesthetic vaporizers. Because large amounts of inhaled anesthetics are absorbed and substantial amounts remain in the body for days, even after apparent recovery,[40] euthanasia via inhaled anesthetics is unsuitable for food-producing animals because of the potential for tissue residues. Effective procedures should be in place to reduce worker exposure to anesthetic vapors. While incorporating inhaled anesthetics can be considered a potential refinement to CO_2 and anoxic methods, further consideration of the consequences associated with this strategy is warranted.

Advantages—(1) The rapid depressant, analgesic, and anesthetic effects of CO_2 are well established. (2) Carbon dioxide is readily available in compressed gas cylinders. (3) Carbon dioxide is inexpensive, nonflammable, and nonexplosive and poses minimal hazard to personnel when used with properly designed equipment. (4) Carbon dioxide does not result in accumulation of toxic tissue residues in animals from which food is produced.

Disadvantages—(1) Substantial and conflicting differences in response to CO_2 inhalation exist between and within species, strains, and breeds, making broad generalizations difficult. (2) Carbon dioxide, whether administered by prefill or gradual displacement methods, can be aversive to some species, and therefore potential exists to cause distress. (3) Because CO_2 is heavier than air, layering of gas or incomplete filling of a chamber may permit animals to climb or raise their heads above the effective concentrations and avoid exposure. (4) Immature individuals and some aquatic and burrowing species may have extraordinary tolerance for CO_2. (5) Reptiles and amphibians may breathe too slowly for the use of CO_2. (6) Euthanasia by exposure to CO_2 with O_2 supplementation may take longer than euthanasia by other means.[94,108,109] (7) Induction of loss of consciousness at concentrations < 80% may produce postmortem pulmonary and upper respiratory tract lesions.[94,150] (8) Dry ice and liquid CO_2 are potential sources of distress or injury if permitted to directly contact animals. (9) If animals are anesthetized with inhaled agents prior to completing the euthanasia process with CO_2, sufficient time should be allowed to prevent rapid recovery during the wash-in of CO_2 and the subsequent wash-out of inhaled agent.[32,151]

General recommendations—Carbon dioxide is acceptable with conditions for euthanasia in those species where aversion or distress can be minimized. Carbon dioxide exposure using a gradual-fill method is less likely to cause pain due to nociceptor activation by carbonic acid prior to onset of unconsciousness; a displacement rate from 30% to 70% of the chamber volume/min is recommended for rodents.[15,63,65,142] Consideration should be given to the benefits of using a darkened home cage, while also keeping in mind the need to have the animal under observation.[9] Whenever gradual displacement methods are used, CO_2 flow should be maintained for at least 1 minute after respiratory arrest.[16] If animals need to be combined, they should be of the same species and, if needed, restrained so that they will not hurt themselves or others. Immature animals must be exposed to high concentrations of CO_2 for an extended period of time to ensure death. Oxygen administered together with CO_2 appears to provide little advantage and is not recommended for euthanasia. There is no apparent welfare advantage to killing animals with CO_2 when prior exposure to inhaled anesthetics has occurred.[32]

The practice of immersion, where conscious rodents are placed directly into a container prefilled with 100% CO_2, is unacceptable. A 2-step process, where animals are first rendered unconscious and then immersed into 100% CO_2, is preferred when gradual displacement methods cannot be used. Further studies are necessary before CO_2 immersion can be recommended for rabbits.[143] Immersion of poultry in lesser concentrations is acceptable with conditions as it does not appear to be distressing.

Carbon dioxide and CO_2 gas mixtures must be supplied in a precisely regulated and purified form without contaminants or adulterants, typically from a commercially supplied cylinder or tank. The direct application of products of com-

bustion or sublimation is not acceptable due to unreliable or undesirable composition and/or displacement rate. As gas displacement rate is critical to the humane application of CO_2, an appropriate pressure-reducing regulator and flow meter or equivalent equipment with demonstrated capability for generating the recommended displacement rates for the size container being utilized is absolutely necessary.

M2 Noninhaled Agents

M2.1 COMMON CONSIDERATIONS

Noninhaled agents of euthanasia include chemical agents that are introduced into the body by means other than through direct delivery to the respiratory tract. The primary routes of their administration are parenteral injection, topical application, and immersion. When it is being determined whether a particular drug and route of administration are appropriate for euthanasia, consideration needs to be given to the species involved, the pharmacodynamics of the chemical agent, degree of physical or chemical restraint required, potential hazards to personnel, consequences of intended or unintended consumption of the animal's remains by humans and other animals, and potential hazards to the environment from chemical residues. Many noninhaled euthanasia agents can induce a state of unconsciousness during which minimal vital functions are evident but from which some animals may recover. Therefore, as for any euthanasia method, death must be confirmed prior to final disposition of the animal's remains.

M2.1.1 Compounding

Products approved by the Center for Veterinary Medicine at the FDA should be used whenever feasible. When not feasible, euthanasia agents compounded in compliance with applicable guidance document(s) and compliance policy guide(s) in effect at the time of euthanasia should be used whenever feasible.[152] Use of compounded euthanasia drugs that may create human or animal health risks (eg, unintentional ingestion by other animals) is of concern.

M2.1.2 Residue/Disposal Issues

Animals euthanized by chemical means must never enter the human food chain and should be disposed of in accord with local, state, and federal laws. Disposal of euthanized animals has become increasingly problematic because most rendering facilities will no longer take animals euthanized with agents that pose residue hazards (eg, barbiturates). The potential for ingestion of euthanasia agents is an important consideration in the euthanasia of animals that are disposed of in outdoor settings where scavenging by other animals is possible[153] or when euthanized animals are fed to zoo and exotic animals.[154] Veterinarians and laypersons have been fined for causing accidental deaths of endangered birds that ingested animal remains that were poorly buried.[155] Environmental warnings must now be included on animal euthanasia drugs approved by the FDA Center for Veterinary Medicine.[156]

M2.21 UNACCEPTABLE AGENTS

Strychnine, nicotine, insulin, caffeine, cleaning agents, solvents, pesticides, disinfectants, and other toxicants not specifically designed for therapeutic or euthanasia use are unacceptable for use as euthanasia agents under any circumstances.

Magnesium sulfate, potassium chloride, and neuromuscular blocking agents are unacceptable for use as euthanasia agents in conscious vertebrate animals. These agents may be used for euthanasia of anesthetized or unconscious animals as previously described. ■

M5 References

1. Alkire MT. General anesthesia. In: Banks WP, ed. *Encyclopedia of consciousness*. San Diego: Elsevier/Academic Press, 2009;296–313.
2. Sharp J, Azar T, Lawson D. Comparison of carbon dioxide, argon, and nitrogen for inducing unconsciousness or euthanasia of rats. *J Am Assoc Lab Anim Sci* 2006;45:21–25.
3. Christensen L, Barton Gade P. Danish Meat Research Institute. Transportation and pre-stun handling: CO2-systems. Available at: www.butina.eu/fileadmin/uploadimages/articles/transport.pdf. Accessed Dec 13, 2010.
4. Interagency Research Animal Committee. US government principles for the utilization and care of vertebrate animals used in testing, research and training. Available at: grants.nih.gov/grants/olaw/references/phspol.htm#USGovPrinciples. Accessed Dec 13, 2010.
5. Chorney JM, Kain ZN. Behavioral analysis of children's response to induction of anesthesia. *Anesth Analg* 2009;109:1434–1440.
6. Przybylo HJ, Tarbell SE, Stevenson GW. Mask fear in children presenting for anesthesia: aversion, phobia, or both? *Paediatr Anaesth* 2005;15:366–370.
7. Hawkins P, Playle L, Golledge H, et al. *Newcastle consensus meeting on carbon dioxide euthanasia of laboratory animals*. London: National Centre for the Replacement, Refinement and Reduction of Animals in Science, 2006. Available at: www.nc3rs.org.uk/downloaddoc.asp?id=416&page=292&skin=0. Accessed Jan 20, 2011.
8. Glass HG, Snyder FF, Webster E. The rate of decline in resistance to anoxia of rabbits, dogs, and guinea pigs from the onset of viability to adult life. *Am J Physiol* 1944;140:609–615.
9. Powell K, Ethun K, Taylor DK. The effect of light level, CO_2 flow rate, and anesthesia on the stress response of mice during CO_2 euthanasia. *Lab Anim (NY)* 2016;45:386–395.
10. Garnett N. PHS policy on humane care and use of laboratory animals clarification regarding use of carbon dioxide for euthanasia of small laboratory animals. Release date: July 17, 2002. Available at: grants.nih.gov/grants/guide/notice-files/NOT-OD-02–062.html. Accessed Dec 14, 2010.
11. Meyer RE, Morrow WEM. Carbon dioxide for emergency on-farm euthanasia of swine. *J Swine Health Prod* 2005;13:210–217.
12. Meyer RE. Principles of carbon dioxide displacement. *Lab Anim (NY)* 2008;37:241–242.
13. Nunn JF. *Nunn's applied respiratory physiology*. 4th ed. Oxford, England: Butterworth-Heinemann, 1993;583–593.
14. Davis PD, Kenny GNC. *Basic physics and measurement in anaesthesia*. 5th ed. Edinburgh: Butterworth-Heinemann, 2003;57–58.
15. Hornett TD, Haynes AP. Comparison of carbon dioxide/air mixture and nitrogen/air mixture for the euthanasia of rodents: design of a system for inhalation euthanasia. *Anim Technol* 1984;35:93–99.
16. Smith W, Harrap SB. Behavioural and cardiovascular responses of rats to euthanasia using carbon dioxide gas. *Lab Anim* 1997;31:337–346.
17. Niel L, Weary DM. Behavioural responses of rats to gradual-fill carbon dioxide euthanasia and reduced oxygen concentrations. *Appl Anim Behav Sci* 2006;100:295–308.
18. Booth NH. Inhalant anesthetics. In: Booth NH, McDonald LE, eds. *Veterinary pharmacology and therapeutics*. 6th ed. Ames, Iowa: Iowa State University Press, 1988;181–211.
19. Flecknell PA, Roughan JV, Hedenqvist P. Induction of anaesthesia with sevoflurane and isoflurane in the rabbit. *Lab Anim* 1999;33:41–46.
20. Voss LJ, Sleigh JW, Barnard JP, et al. The howling cortex: seizures and general anesthetic drugs. *Anesth Analg* 2008;107:1689–1703.
21. Knigge U, Søe-Jensen P, Jorgensen H, et al. Stress-induced release of anterior pituitary hormones: effect of H3 receptor-mediated inhibition of histaminergic activity or posterior hypothalamic lesion. *Neuroendocrinology* 1999;69:44–53.
22. Tinnikov AA. Responses of serum corticosterone and corticosteroid-binding globulin to acute and prolonged stress in the rat. *Endocrine* 1999;11:145–150.

23. Zelena D, Kiem DT, Barna I, et al. Alpha-2-adenoreceptor subtypes regulate ACTH and beta-endorphin secretions during stress in the rat. *Psychoneuroendocrinology* 1999;24:333–343.
24. van Herck H, Baumans V, de Boer SF, et al. Endocrine stress response in rats subjected to singular orbital puncture while under diethyl-ether anesthesia. *Lab Anim* 1991;25:325–329.
25. Leach MC, Bowell VA, Allan TF, et al. Aversion to gaseous euthanasia agents in rats and mice. *Comp Med* 2002;52:249–257.
26. Leach MC, Bowell VA, Allan TF, et al. Degrees of aversion shown by rats and mice to different concentrations of inhalational anaesthetics. *Vet Rec* 2002;150:808–815.
27. Leach MC, Bowell VA, Allan TF, et al. Measurement of aversion to determine humane methods of anaesthesia and euthanasia. *Anim Welf* 2004;13:S77–S86.
28. Makowska LJ, Weary DM. Rat aversion to induction with inhaled anaesthetics. *Appl Anim Behav Sci* 2009;119:229–235.29. Moody CM, Chua B, Weary DM. The effect of carbon dioxide flow rate on the euthanasia of laboratory mice. *Lab Anim* 2014;48:298–304.
30. Wong D, Makowska IJ, Weary DM. Rat aversion to isoflurane versus carbon dioxide. *Biol Lett* 2012;9:20121000.
31. Bertolus JB, Nemeth G, Makowska IJ, e al. Rat aversion to sevoflurane and isoflurane. *Appl Anim Behav Sci* 2015;164:73–80.
32. Hawkins P, Prescott MJ, Carbone L, et al. A good death? Report of the Second Newcastle Meeting on Laboratory Animal Euthanasia. *Animals (Basel)* 2016;6:50.
33. Universities Federation for Animal Welfare. *Humane killing of animals*. 4th ed. South Mimms, Potters Bar, England: Universities Federation for Animal Welfare, 1988;16–22.
34. Makowska IJ, Vickers L, Mancell J, et al. Evaluating methods of gas euthanasia for laboratory mice. *Appl Anim Behav Sci* 2009;121:230–235.
35. Schmid RD, Hodgson DS, McMurphy RM. Comparison of anesthetic induction in cats by use of isoflurane in an anesthetic chamber with a conventional vapor or liquid injection technique. *J Am Vet Med Assoc* 2008;233:262–266.
36. Steffey EP, Mama KR. Inhalation anesthetics. In: Tranquilli WJ, Thurmon JC, Grimm KA, eds. *Lumb and Jones' veterinary anesthesia and analgesia*. 4th ed. Ames, Iowa: Blackwell, 2007;355–393.
37. Thomas AA, Flecknell PA, Golledge HDR. Combining nitrous oxide with carbon dioxide decreases the time to loss of consciousness during euthanasia in mice—refinement of animal welfare? *PLoS One* 2012;7:e32290.
38. Smith RK, Rault JL, Gates RS, et al. A two-step process of nitrous oxide before carbon dioxide for humanely euthanizing piglets: on-farm trials. *Animals (Basel)* 2018;8:52.
39. Occupational Safety and Health Administration. Anesthetic gases: guidelines for workplace exposures. Available at: www.osha.gov/dts/osta/anestheticgases/index.html#A. Accessed Dec 5, 2010.
40. Lockwood G. Theoretical context-sensitive elimination times for inhalational anaesthetics. *Br J Anaesth* 2010;104:648–655.
41. Seymour TL, Nagamine CM. Evaluation of isoflurane overdose for euthanasia of neonatal mice. *J Am Assoc Lab Anim Sci* 2016;55:321–323.
42. Haldane J. The action of carbonic oxide in man. *J Physiol* 1895;18:430–462.
43. Raub JA, Mathieu-Nolf M, Hampson NB, et al. Carbon monoxide poisoning—a public health perspective. *Toxicology* 2000;145:1–14.
44. Hampson NB, Weaver LK. Carbon monoxide poisoning: a new incidence for an old disease. *Undersea Hyperb Med* 2007;34:163–168.
45. Lowe-Ponsford FL, Henry JA. Clinical aspects of carbon monoxide poisoning. *Adverse Drug React Acute Poisoning Rev* 1989;8:217–240.
46. Bloom JD. Some considerations in establishing divers' breathing gas purity standards for carbon monoxide. *Aerosp Med* 1972;43:633–636.
47. Norman CA, Halton DM. Is carbon monoxide a workplace teratogen? A review and evaluation of the literature. *Ann Occup Hyg* 1990;34:335–347.
48. Wojtczak-Jaroszowa J, Kbow S. Carbon monoxide, carbon disulfide, lead and cadmium—four examples of occupational toxic agents linked to cardiovascular disease. *Med Hypotheses* 1989;30:141–150.
49. Fechter LD. Neurotoxicity of prenatal carbon monoxide exposure. *Res Rep Health Eff Inst* 1987;12:3–22.
50. Ramsey TL, Eilmann HJ. Carbon monoxide acute and chronic poisoning and experimental studies. *J Lab Clin Med* 1932;17:415–427.
51. Enggaard Hansen N, Creutzberg A, Simonsen HB. Euthanasia of mink (*Mustela vison*) by means of carbon dioxide (CO_2), carbon monoxide (CO) and nitrogen (N_2). *Br Vet J* 1991;147:140–146.
52. Vinte FJ. *The humane killing of mink*. London: Universities Federation for Animal Welfare, 1957.
53. Chalifoux A, Dallaire A. Physiologic and behavioral evaluation of CO euthanasia of adult dogs. *Am J Vet Res* 1983;44:2412–2417.
54. Dallaire A, Chalifoux A. Premedication of dogs with acepromazine or pentazocine before euthanasia with carbon monoxide. *Can J Comp Med* 1985;49:171–178.
55. Weary DM, Makowska IJ. Rat aversion to carbon monoxide. *Appl Anim Behav Sci* 2009;121:148–151.
56. Simonsen HB, Thordal-Christensen AA, Ockens N. Carbon monoxide and carbon dioxide euthanasia of cats: duration and animal behavior. *Br Vet J* 1981;137:274–278.
57. Lambooy E, Spanjaard W. Euthanasia of young pigs with carbon monoxide. *Vet Rec* 1980;107:59–61.
58. Gerritzen MA, Lambooij E, Stegeman JA, et al. Slaughter of poultry during the epidemic of avian influenza in the Netherlands in 2003. *Vet Rec* 2006;159:39–42.
59. Herin RA, Hall P, Fitch JW. Nitrogen inhalation as a method of euthanasia in dogs. *Am J Vet Res* 1978;39:989–991.
60. Noell WK, Chinn HI. Time course of failure of the visual pathway in rabbits during anoxia. *Fed Proc* 1949;8:1–19.
61. Altland PD, Brubach HF, Parker MG. Effects of inert gases on tolerance of rats to hypoxia. *J Appl Physiol* 1968;24:778–781.
62. Arieli R. Can the rat detect hypoxia in inspired air? *Respir Physiol* 1990;79:243–253.
63. Niel L, Weary DM. Rats avoid exposure to carbon dioxide and argon. *Appl Anim Behav Sci* 2007;107:100–109.
64. Makowska IJ, Niel L, Kirkden RD, et al. Rats show aversion to argon-induced hypoxia. *Appl Anim Behav Sci* 2008;114:572–581.
65. Burkholder TH, Niel L, Weed JL, et al. Comparison of carbon dioxide and argon euthanasia: effects on behavior, heart rate, and respiratory lesions in rats. *J Am Assoc Lab Anim Sci* 2010;49:448–453.
66. Raj ABM. Aversive reactions to argon, carbon dioxide and a mixture of carbon dioxide and argon. *Vet Rec* 1996;138:592–593.
67. Webster AB, Fletcher DL. Assessment of the aversion of hens to different gas atmospheres using an approach-avoidance test. *Appl Anim Behav Sci* 2004;88:275–287.
68. Raj ABM, Gregory NG, Wotton SB. Changes in the somatosensory evoked potentials and spontaneous electroencephalogram of hens during stunning in argon-induced anoxia. *Br Vet J* 1991;147:322–330.
69. Raj M, Gregory NG. Time to loss of somatosensory evoked potentials and onset of changes in the spontaneous electroencephalogram of turkeys during gas stunning. *Vet Rec* 1993;133:318–320.
70. Mohan Raj AB, Gregory NG, Wotton SB. Effect of carbon dioxide stunning on somatosensory evoked potentials in hens. *Res Vet Sci* 1990;49:355–359.
71. Raj ABM, Whittington PE. Euthanasia of day-old chicks with carbon dioxide and argon. *Vet Rec* 1995;136:292–294.
72. Gerritzen MA, Lambooij E, Hillebrand SJW, et al. Behavioral responses of broilers to different gaseous atmospheres. *Poult Sci* 2000;79:928–933.
73. McKeegan DEF, McIntyre J, Demmers TGM, et al. Behavioural responses of broiler chickens during acute exposure to gaseous stimulation. *Appl Anim Behav Sci* 2006;99:271–286.
74. Webster AB, Fletcher DL. Reactions of laying hens and broilers to different gases used for stunning poultry. *Poult Sci* 2001;80:1371–1377.
75. Lambooij E, Gerritzen MA, Engel B, et al. Behavioural responses during exposure of broiler chickens to different gas mixtures. *Appl Anim Behav Sci* 1999;62:255–265.
76. Raj ABM, Gregory NG. Welfare implications of the gas stunning of pigs: 1. Determination of aversion to the initial inhalation of carbon dioxide or argon. *Anim Welf* 1995;4:273–280.
77. Dalmau A, Llonch P, Rodriguez P, et al. Stunning pigs with different gas mixtures: gas stability. *Anim Welf* 2010;19:315–323.
78. Raj AB. Behaviour of pigs exposed to mixtures of gases and the time required to stun and kill them: welfare implications. *Vet Rec* 1999;144:165–168.
79. Raj M, Mason G. Reaction of farmed mink (*Mustela vison*) to argon-induced hypoxia. *Vet Rec* 1999;145:736–737.
80. Dalmau A, Rodriguez P, Llonch P, et al. Stunning pigs with different gas mixtures: aversion in pigs. *Anim Welf* 2010;19:325–333.
81. Martoft L, Lomholt L, Kolthoff C, et al. Effects of CO_2 anaesthesia on central nervous system activity in swine. *Lab Anim* 2002;36:115–126.
82. Raj AB, Johnson SP, Wotton SB, et al. Welfare implications of gas stunning pigs: 3. the time to loss of somatosensory evoked potentials and spontaneous electrocorticogram of pigs during exposure to gases. *Vet J* 1997;153:329–339.
83. Ring C, Erhardt W, Kraft H, et al. CO_2 anaesthesia of slaughter pigs. *Fleischwirtschaft (Frankf)* 1988;68:1304–1307.
84. Forslid A. Transient neocortical, hippocampal, and amygdaloid EEG silence induced by one minute inhalation of high CO_2 concentration in swine. *Acta Physiol Scand* 1987;130:1–10.
85. Mattsson JL, Stinson JM, Clark CS. Electroencephalographic power-spectral changes coincident with onset of carbon dioxide narcosis in rhesus monkey. *Am J Vet Res* 1972;33:2043–2049.
86. Woodbury DM, Rollins LT, Gardner MD, et al. Effects of carbon dioxide on brain excitability and electrolytes. *Am J Physiol* 1958;192:79–90.
87. Leake CD, Waters RM. The anesthetic properties of carbon dioxide. *Curr Res Anesth Anal* 1929;8:17–19.
88. Chen X, Gallar J, Pozo MA, et al. CO_2 stimulation of the cornea—a comparison between human sensation and nerve activity in polymodal nociceptive afferents of the cat. *Eur J Neurosci* 1995;7:1154–1163.
89. Peppel P, Anton F. Responses of rat medullary dorsal horn neurons following intranasal noxious chemical stimulation—effects of stimulus intensity, duration and interstimulus interval. *J Neurophysiol* 1993;70:2260–2275.
90. Thürauf N, Hummel T, Kettenmann B, et al. Nociceptive and reflexive responses recorded from the human nasal mucosa. *Brain Res* 1993;629:293–299.
91. Anton F, Peppel P, Euchner I, et al. Noxious chemical stimulation—responses of rat trigeminal brain stem neurons to CO_2 pulses applied to the nasal mucosa. *Neurosci Lett* 1991;123:208–211.
92. Feng Y, Simpson TL. Nociceptive sensation and sensitivity evoked from human cornea and conjunctiva stimulated by CO_2. *Invest Ophthalmol Vis Sci* 2003;44:529–

532.
93. Thürauf N, Günther M, Pauli E, et al. Sensitivity of the negative mucosal potential to the trigeminal target stimulus CO_2. *Brain Res* 2002;942:79–86.
94. Danneman PJ, Stein S, Walshaw SO. Humane and practical implications of using carbon dioxide mixed with oxygen for anesthesia or euthanasia of rats. *Lab Anim Sci* 1997;47:376–385.
95. Widdicombe JG. Reflexes from the upper respiratory tract. In: Cherniak NS, Widdicombe JG, eds. *Handbook of physiology: the respiratory system*. Bethesda, Md: American Physiological Society, 1986;363–394.
96. Yavari P, McCulloch PF, Panneton WM. Trigeminally-mediated alteration of cardiorespiratory rhythms during nasal application of carbon dioxide in the rat. *J Auton Nerv Syst* 1996;61:195–200.
97. Chisholm JM, Pang DS. Assessment of carbon dioxide, carbon dioxide/oxygen, isoflurane and pentobarbital killing methods in adult female Sprague-Dawley rats. *PLoS One* 2016;11:e0162639.
98. Moosavi SH, Golestanian E, Binks AP, et al. Hypoxic and hypercapnic drives to breathe generate equivalent levels of air hunger in humans. *J Appl Physiol* 2003;94:141–154.
99. Millar RA. Plasma adrenaline and noradrenaline during diffusion respiration. *J Physiol* 1960;150:79–90.
100. Nahas GG, Ligou JC, Mehlman B. Effects of pH changes on O_2 uptake and plasma catecholamine levels in the dog. *Am J Physiol* 1960;198:60–66.
101. Liotti M, Brannan S, Egan G, et al. Brain responses associated with consciousness of breathlessness (air hunger). *Proc Natl Acad Sci USA* 2001;98:2035–2040.
102. Dripps RD, Comroe JH. The respiratory and circulatory response of normal man to inhalation of 7.6 percent CO_2 and 10.4 percent CO_2 with a comparison of the maximal ventilation produced by severe muscular exercise, inhalation of CO_2 and maximal voluntary hyperventilation. *Am J Physiol* 1947;149:43–51.
103. Hill L, Flack M. The effect of excess of carbon dioxide and of want of oxygen upon the respiration and the circulation. *J Physiol* 1908;37:77–111.
104. Banzett RB, Lansing RW, Evans KC, et al. Stimulus-response characteristics of CO_2-induced air hunger in normal subjects. *Respir Physiol* 1996;103:19–31.
105. Shea SA, Harty HR, Banzett RB. Self-control of level of mechanical ventilation to minimize CO_2-induced air hunger. *Respir Physiol* 1996;103:113–125.
106. Fowler WS. Breaking point of breath-holding. *J Appl Physiol* 1954;6:539–545.
107. Kirkden RD, Niel L, Stewart SA, et al. Gas killing of rats: the effect of supplemental oxygen on aversion to carbon dioxide. *Anim Welf* 2008;17:79–87.
108. Coenen AM, Drinkenburg WH, Hoenderken R, et al. Carbon dioxide euthanasia in rats: oxygen supplementation minimizes signs of agitation and asphyxia. *Lab Anim* 1995;29:262–268.
109. Hewett TA, Kovacs MS, Artwohl JE, et al. A comparison of euthanasia methods in rats, using carbon dioxide in prefilled and fixed flow-rate filled chambers. *Lab Anim Sci* 1993;43:579–582.
110. Borovsky V, Herman M, Dunphy G, et al. CO_2 asphyxia increases plasma norepinephrine in rats via sympathetic nerves. *Am J Physiol* 1998;274:R19–R22.
111. Reed B, Varon J, Chait BT, et al. Carbon dioxide-induced anesthesia result in a rapid increase in plasma levels of vasopressin. *Endocrinology* 2009;150:2934–2939.
112. Raff H, Roarty TP. Renin, ACTH, and aldosterone during acute hypercapnia and hypoxia in conscious rats. *Am J Physiol* 1988;254:R431–R435.
113. Marotta SF, Sithichoke N, Garcy AM, et al. Adrenocortical responses of rats to acute hypoxic and hypercapnic stresses after treatment with aminergic agents. *Neuroendocrinology* 1976;20:182–192.
114. Raff H, Shinsako J, Keil LC, et al. Vasopressin, ACTH, and corticosteroids during hypercapnia and graded hypoxia in dogs. *Am J Physiol* 1983;244:E453–E458.
115. Argyropoulos SV, Bailey JE, Hood SD, et al. Inhalation of 35% CO_2 results in activation of the HPA axis in healthy volunteers. *Psychoneuroendocrinology* 2002;27:715–729.
116. Herman JP, Cullinan WE. Neurocircuitry of stress: central control of the hypothalamo-pituitary-adrenocortical axis. *Trends Neurosci* 1997;20:78–84.
117. Kc P, Haxhiu MA, Trouth CO, et al. CO_2-induced c-Fos expression in hypothalamic vasopressin containing neurons. *Respir Physiol* 2002;129:289–296.
118. Hackbarth H, Kuppers N, Bohnet W. Euthanasia of rats with carbon dioxide—animal welfare aspects. *Lab Anim* 2000;34:91–96.
119. Blackshaw JK, Fenwick DC, Beattie AW, et al. The behavior of chickens, mice and rats during euthanasia with chloroform, carbon dioxide and ether. *Lab Anim* 1988;22:67–75.
120. Britt DP. The humaneness of carbon dioxide as an agent of euthanasia for laboratory rodents. In: *Euthanasia of unwanted, injured or diseased animals or for educational or scientific purposes*. Potters Bar, England: Universities Federation for Animal Welfare, 1987;19–31.
121. Raj ABM, Gregory NG. Welfare implications of the gas stunning of pigs: 2. Stress of induction of anaesthesia. *Anim Welf* 1996;5:71–78.
122. Jongman EC, Barnett JL, Hemsworth PH. The aversiveness of carbon dioxide stunning in pigs and a comparison of the CO_2 stunner crate vs the V-restrainer. *Appl Anim Behav Sci* 2000;67:67–76.51
123. Troeger K, Woltersdorf W. Gas anesthesia of slaughter pigs. 1. Stunning experiments under laboratory conditions with fat pigs of known halothane reaction type—meat quality, animal protection. *Fleischwirtschaft (Frankf)* 1991;72:1063–1068.
124. Dodman NH. Observations on use of Wernberg dip-lift carbon dioxide apparatus for pre-slaughter anesthesia of pigs. *Br Vet J* 1977;133:71–80.
125. Gerritzen MA, Lambooij E, Reimert HG, et al. Susceptibility of duck and turkey to severe hypercapnic hypoxia. *Poult Sci* 2006;85:1055–1061.
126. Gerritzen M, Lambooij B, Reimert H, et al. A note on behaviour of poultry exposed to increasing carbon dioxide concentrations. *Appl Anim Behav Sci* 2007;108:179–185.
127. McKeegan DEF, McIntyre JA, Demmers TGM, et al. Physiological and behavioural responses of broilers to controlled atmosphere stunning: implications for welfare. *Anim Welf* 2007;16:409–426.
128. Abeyesinghe SM, McKeegan DEF, McLeman MA, et al. Controlled atmosphere stunning of broiler chickens. I. Effects on behaviour, physiology and meat quality in a pilot scale system at a processing plant. *Br Poult Sci* 2007;48:406–423.
129. Cooper J, Mason G, Raj M. Determination of the aversion of farmed mink (*Mustela vison*) to carbon dioxide. *Vet Rec* 1998;143:359–361.
130. Withrock IC. The use of carbon dioxide (CO2) as an alternative euthanasia method for goat kids. Available at: search.proquest.com/docview/1733971790/abstract/C0605E819BD543A6PQ/1. Accessed Nov 11, 2019.
131. Battaglia M, Ogliari A, Harris J, et al. A genetic study of the acute anxious response to carbon dioxide stimulation in man. *J Psychiatr Res* 2007;41:906–917.
132. Nardi AE, Freire RC, Zin WA. Panic disorder and control of breathing. *Respir Physiol Neurobiol* 2009;167:133–143.
133. Grandin T. Effect of genetics on handling and CO_2 stunning of pigs (updated July 2008). *Meat Focus Int* 1992;July:124–126. Available at: www.grandin.com/humane/meatfocus7–92.html. Accessed Dec 13, 2010.
134. Ziemann AE, Allen JE, Dahdaleh NS, et al. The amygdala is a chemosensor that detects carbon dioxide and acidosis to elicit fear behavior. *Cell* 2009;139:1012–1021.
135. Kohler I, Moens Y, Busato A, et al. Inhalation anaesthesia for the castration of piglets: CO_2 compared to halothane. *Zentralbl Veterinarmed A* 1998;45:625–633.
136. Boivin GP, Bottomley MA, Dudley ES, et al. Physiological, behavioral, and histological responses of male C57BL/6N mice to different CO_2 chamber replacement rates. *J Am Assoc Lab Anim Sci* 2016;55:451–461.
137. Glen JB, Scott WN. Carbon dioxide euthanasia of cats. *Br Vet J* 1973;129:471–479.
138. Franson JC. Euthanasia. In: Friend M, Franson JC, eds. *Field manual of wildlife diseases. General field procedures and diseases of birds*. Biological Resources Division information and technology report 1999–001. Washington, DC: US Department of the Interior and US Geological Survey, 1999;49–53.
139. Mohan Raj AB, Gregory NG. Effect of rate of induction of carbon dioxide anaesthesia on the time of onset of unconsciousness and convulsions. *Res Vet Sci* 1990;49:360–363.
140. Mohan Raj AB, Wotton SB, Gregory NG. Changes in the somatosensory evoked potentials and spontaneous electoencephalogram of hens during stunning with a carbon dioxide and argon mixture. *Br Vet J* 1992;148:147–156.
141. Raj M, Gregory NG. An evaluation of humane gas stunning methods for turkeys. *Vet Rec* 1994;135:222–223.
142. Walsh JL, Percival A, Turner PV. Efficacy of blunt force trauma, a novel mechanical cervical dislocation device, and a non-penetrating captive bolt device for on-farm euthanasia of pre-weaned kits, growers, and adult commercial meat rabbits. *Animals (Basel)* 2017;7:100.
143. Dalmau AJ, Pallisera C, Pedernera I, et al. Use of high concentrations of carbon dioxide for stunning rabbits reared for meat production. *World Rabbit Sci* 2016;24:25–37.
144. Poole GH, Fletcher DL. A comparison of argon, carbon dioxide, and nitrogen in a broiler killing system. *Poult Sci* 1995;74:1218–1223.
145. Latimer KS, Rakich PM. Necropsy examination. In: Ritchie BW, Harrison GJ, Harrison LR, eds. *Avian medicine: principles and application*. Lake Worth, Fla: Wingers Publishing Inc, 1994;355–379.
146. Jaksch W. Euthanasia of day-old male chicks in the poultry industry. *Int J Study Anim Probl* 1981;2:203–213.
147. Pritchett-Corning KR. Euthanasia of neonatal rats with carbon dioxide. *J Am Assoc Lab Anim Sci* 2009;48:23–27.
148. Pritchett K, Corrow D, Stockwell J, et al. Euthanasia of neonatal mice with carbon dioxide. *Comp Med* 2005;55:275–281.
149. Hayward JS, Lisson PA. Carbon dioxide tolerance of rabbits and its relation to burrow fumigation. *Aust Wildl Res* 1978;5:253–261.
150. Iwarsson K, Rehbinder C. A study of different euthanasia techniques in guinea pigs, rats, and mice. Animal response and postmortem findings. *Scand J Lab Anim Sci* 1993;20:191–205.
151. Valentine H, Williams WO, Maurer KJ. Sedation or inhalant anesthesia before euthanasia with CO_2 does not reduce behavioral or physiologic signs of pain and stress in mice. *J Am Assoc Lab Anim Sci* 2012;51:50–57.
152. US FDA. Animal drug compounding. Available at: www.fda.gov/animal-veterinary/unapproved-animal-drugs/animal-drug-compounding. Accessed Jan 13, 2020.
153. Campbell VL, Butler AL, Lunn KF. Use of a point-of-care urine drug test in a dog to assist in diagnosing barbiturate toxicosis secondary to ingestion of a euthanized carcass. *J Vet Emerg Crit Care San Antonio* 2009;19:286–291.
154. Jurczynski K, Zittlau E. Pentobarbital poisoning in Sumatran tigers (*Panthera tigris sumatrae*). *J Zoo Wildl Med* 2007;38:583–584.
155. O'Rourke K. Euthanatized animals can poison wildlife: veterinarians receive fines. *J Am Vet Med Assoc* 2002;220:146–147.
156. US FDA. 21 CFR Part 522. Injectable or implantable dosage form new animal drugs; euthanasia solution;technical amendment. *Fed Regist* 2003;68:42968–42969.

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