Chapter Thirteen

Hibernation, Release and Euthanasia

Hibernation

During the winter in some parts of the world, ambient temperatures drop significantly and adequate food (i.e., insects) is not available for an extended period of time. Some species of bats simply migrate to warmer climates where food is available. Other species adapt to temperate conditions by entering hibernation, a physiological state in which metabolic activity is decreased to minimal survival levels. Many bats decrease energy demands by entering a daily state of inactivity called torpor. By allowing body temperatures to approximate the ambient temperature, they are able to decrease energy demand. Heart rates of bats in daily torpor may drop to 40-80 beats per minute, while rates as low as 10 beats per minute have been recorded in some bats during winter hibernation This is a significant decrease as heart rates of 250 to 450 beats per minute have been recorded for some bats at rest, while rates in flying bats can reach 1000 beats per minute. A little brown bat (*M. lucifugus*) has a daily energy budget of 0.89Kcal/g/day which means that a 7g little brown bat requires 6.23kcal (6230 calories) per day (Hill and Smith 1984). Because smaller mammals (such as bats) have greater surface-area-to-volume ratios than larger ones, they require more calories per gram of body weight to maintain thermal homeostasis.

Many of the bats of the family Vespertilionidae in the United States and Canada enter hibernation during winter months. Some species migrate short distances to specific hibernation sites in caves or abandoned mines where temperatures remain relatively constant. Others stay in the same location year-round when the temperatures drop. Big brown bats *(E. fuscus*), a species that commonly roost in the attics of homes, sometimes hibernate there throughout the winter months.

Some bat species hibernate in tightly packed clusters. By clustering with one another they are better able to stabilize body temperatures against potential environmental fluctuations. Other species hibernate singly or in small groups. When ambient temperatures rise in the spring, hibernating bats arouse. There is an increase in both the heart rate and the respiratory rate, and a subsequent increase in body temperature. Different species of bats arouse from hibernation states at different rates, so it will take some bats longer to warm up than others.

If awakened from hibernation, bats experience an increase in metabolic activity, using up stored fat needed to survive the remainder of the winter. Although hibernating bats may arouse during winter, each arousal leads to the expenditure of almost 30 days of body fat. Hibernating bats are therefore extremely sensitive to disturbances. In addition, because some species of bats come from multi-state regions and congregate in great numbers (as many as tens or even hundreds of thousands of individuals) at a small number of hibernation sites, disruption and disturbances of any kind can result in the loss of large numbers of bats important to the agricultural interests of farmers far from the site.

Some bat species make long migrations when colder weather arrives. The hoary bat (*L. cinereus*), the red bat (*L. borealis*), and the silver-haired bat (*L. noctivagans*) can be found as far north as Canada in the summer but are known to make long migrations to the southern United States and Mexico in the winter. Some species, such as those in the family Molossidae, are not able to tolerate cold temperatures for extended periods of time and migrate to warmer climates during cold months. In the United States, southwestern populations of Mexican free-tailed bats make long migrations to parts of Mexico where they spend the winter. A sub-species of the Brazilian free-tailed bat remains in warmer parts of the southeastern United States year-round. Although the Molossidae are not true hibernators, they are capable of entering daily torpor. See Roosting and Hibernating Patterns on page 5 for additional species information.

Artificial hibernation allows a busy rehabilitator the luxury of minimizing the time needed to care for healthy bats that must remain in captivity for several months before release. If a caretaker receives dozens of bats disturbed during hibernation, artificial hibernation allows the opportunity to maintain all of the bats for the remainder of the winter, something that might not be possible if each individual required daily care. Hibernation in captivity does not appear to be necessary for the survival of a bat. Some bat care specialists hibernate bats simply because they prefer to duplicate natural conditions when possible.

Review by Wimsatt (1969), has shown that sperm storage is one facet of the complex reproductive adaptations of bats living in temperate latitudes where a period of hibernation occurs during prolonged oestrus. Females that have mated may give birth during the winter or early spring if they are kept from entering normal hibernation. Normally, fertilized ova implant when females arouse from hibernation, but artificially warm conditions, low stress, and appropriate nutrition have resulted in out-of-season births in hibernating species. Males and females housed together under artificially warm conditions may engage in mating behavior outside normal mating periods, which may also affect seasonal cycles of mating, fertilization, implantation, and gestation.

Never attempt to hibernate a non-hibernating species; nor a bat that is sick, underweight, or injured. The animal is unlikely to survive, and even if it does, healing of bones and tissue will slow significantly if not altogether. Only a healthy bat of a species that normally hibernates should be artificially hibernated in captivity.

A bat that appears healthy but has been disturbed during hibernation is a potential candidate for artificial hibernation. (Renovation of buildings sometimes disturbs hibernating bats.) Bats should be rehydrated and fed for at least two days before being placed in artificial hibernation. If the bat does not approach the upper end of the weight range for its species, it should not be artificially hibernated (i.e., do not hibernate a thin bat, which is often the case with juveniles).

Hibernating bats require very specific temperatures and humidity levels. An artificial hibernaculum needs to duplicate these conditions as much as possible. Older refrigerators have been used successfully to hibernate bats; however, the use of modern, frost-free refrigerators is considered an unnatural and inhumane practice as the humidity levels are much too low (Barbosa, 1996).

The ambient temperature during the winter may allow caretakers to hibernate a bat in an unheated room, such as a garage. However, the temperature in this room should not drop below 40° Fahrenheit, and in some parts of the United States and Canada, temperatures in garages will drop far below freezing for extended periods of time. Many bats may not be able to survive such conditions. If this is the case in your area, unused rooms or basements that have some heat, but remain relatively cool, may provide more appropriate temperatures. Temperatures in a room used to hibernate bats should remain at least in the low to mid 40℉s. Surprisingly, some species, such as big brown bats (*E. fuscus*), have been successfully hibernated for the winter without supplemental feedings at temperatures ranging from the lower 50℉s to the mid 60°'s. In some parts of the U.S. various species of bats have different temperature preferences in the wild. Variations may even exist within the same species from one geographical area to another. However, it is not recommended that either the upper or lower temperature ranges exceed these temperatures, as they have proven optimal for hibernating bats in captivity. Do not hibernate bats at freezing temperatures. Bats undergoing artificial hibernation must also be able to maintain sufficient body temperature with minimal outlay of energy.

Once an appropriate location has been chosen, set up an enclosure with a heating pad over a section of the top or on one side of the enclosure for warmth. In the wild, many bat species arouse from hibernation if temperatures drop below a certain level and move to areas where conditions are more favorable. While a heating pad will allow a bat to move on or away from a warmer spot. Roosting pouches should be placed in numerous positions throughout the enclosure for crevice dwelling species. When possible, it is best to allow bats to hibernate in clusters of individuals as they normally do in the wild. For example, if a caretaker receives a small colony of big brown bats that were disturbed during hibernation, it would be best to hibernate them together as a group.

High humidity levels in a natural hibernaculum can result in the condensation of water droplets on bat's fur, thus making water available to the bat. In addition, relative humidity in many hibernacula approaches 90%. Bats in the wild sometimes arouse from hibernation to find water and replenish their fluids. In captivity, a small, shallow dish of water should be placed inside the enclosure and fresh water should be available to hibernating bats throughout the entire hibernation period.

We cannot perfectly duplicate natural hibernation. Because bats kept in artificial hibernation do not have access to their natural environment, the author recommends that bats be deliberately reawakened (see below) and provided with food and water periodically throughout the entire hibernation period.

Record the weight of the bat before initial hibernation and each time it is awakened and fed. The bat's initial weight should be in the upper end of the weight range for this species. The author recommends that a hibernating bat be reawakened, weighed, and fed after the first three days. If the bat appears healthy and has not experienced a significant weight loss (i.e., it is not at or below the lower end of the weight range for the species), continue to awaken and care for it once every one to six weeks thereafter throughout the normal period of hibernation (i.e., winter months).

To awaken a bat from hibernation, allow it to warm up to room temperature slowly. Do not force the animal into any kind of heated container. Instead, move the entire enclosure into a warmer room. Allow the animal to warm up slowly on its own. It will take different species of bats different periods of time to arouse, so allow the bat at least one to two hours to warm on its own before handling. Once it has warmed, weigh it, and then offer it water and food. Then return it to the enclosure (which should have remained at room temperature) for the night so it can complete the digestion process. If the bat appears well and has maintained a body weight at the upper end of the weight range for the species, it can be placed back into hibernation.

If the bat is kept out of hibernation for longer than 12 hours, it should be fed again as metabolic activity will have increased. The procedure of awakening and caring for a bat that is hibernating in captivity should be repeated once every one to six weeks throughout the hibernation period. Although many researchers have artificially hibernated bats for a matter of months without intermittent feeding, more frequent feedings allow caretakers to ensure the continued good health of each individual which will likely result in higher survival rates.

If intended for release, artificially hibernated bats should not be released until outdoor ambient temperatures have warmed sufficiently to allow an insect population. It is not necessary to hibernate bats kept in permanent captivity, even if they would normally do so in the wild. Hibernation is a method by which bats in the wild survive periods of sub-optimal temperatures and an insufficient food supply, a problem bats in captivity do not experience.

Again, artificial hibernation is a method by which a busy caretaker, who is already caring for several bats, or who receives dozens of bats disturbed during natural hibernation in the wild, can minimize his or her time. This allows a caretaker the opportunity to care for many more individuals than would be possible if each bat required daily care. In addition, artificial hibernation may also help to ensure normal timing of fertilization, implantation, or fetal development in females of reproductive age. Timing of births is important because rearing young needs to coincide with optimal temperatures and food availability in the wild. It is possible that artificial hibernation may help to ensure the survival of offspring of female bats released in the spring.

Releasing Bats to the Wild

First and foremost, bats must demonstrate perfect flight ability before being released. Bats that do not demonstrate perfect flight are not likely to survive in the wild. Bats depend on flight for feeding, avoiding predators, etc. Wing injuries will render a bat non-releasable. Tooth loss, back or leg injuries (i.e., fractures of the leg bones), and some complications associated with pregnancy will also render a bat non-releasable (see Infections of the Gums and Teeth, Back and Leg Injuries, and Caring for Pregnant and Lactating Females sections).

Releasing Hand-Raised Orphans

Questions have long been raised regarding the wisdom of releasing insectivorous bat orphans raised in captivity. Research suggests that young bats need time to acquire the skills necessary to successfully capture flying insects (Davis and Hitchcock, 1965). It is further suggested that young may learn these techniques by spending a considerable amount of time foraging with their mothers when they are young (Brigham and Brigham, 1989).

The author has recaptured several tattooed hand-raised Brazilian free-tailed (*T. brasiliensis*) bats after they were rescued as orphans ranging from a few hours to a few weeks old. These bats were subsequently hand-raised and released back to the wild after they were determined to be able to survive on their own. Microscopic examination of a fecal sample from a juvenile recaptured two days after release revealed insect parts (Lollar, 2008). Another juvenile was recaptured 11 days following release and three were recaptured three, five and seven days after release. In 2006, a tattooed adult female was found approximately 400 miles away five years after release, and in 2015, a tattooed adult female *T. brasiliensis* was found 13 years after release.

Additionally, the recapture of a hand-raised evening bat (*N. humeralis*) was reported 16 days following release (Laura Finn, pers. comm.), and the recapture of a hand-raised pallid bat (*A. pallidus*) was reported approximately seven months after release (Christine Scott, pers. comm.). Orphaned red bats (*L. borealis*) and yellow bats (*L. intermedius*) have learned to forage on their own and also exhibited predator avoidance behavior by darting into small trees when an owl flew over their flight enclosure (French, pers. comm.) Microscopic examination of feces of red bat orphans (*L. borealis*) indicates that orphans begin feeding preferentially on available prey when placed in large outdoor flight enclosures (French and Whitaker, 2000). On June 17th, 2003 an orphaned big brown pup (*E. fuscus*) weighing 2.9 grams was rescued with eight other orphaned big browns. This female was released on August 24th, 2003, and recaptured one month later on Sept. 24th, 2003. The bat was in excellent physical condition with a recorded weight of 17.0 grams (Barbosa, 2003). Most significant, however, involved a report of a small colony of seven-year-old big brown bats (*E. fuscus*) which had remained in captivity since infancy. These bats had never been exposed to live prey but were fully flighted. At age seven, the bats were moved into an outdoor flight enclosure, and a bucket light trap containing live flighted insects was emptied into their enclosure. Although the bats were provided with their normal ration of mealworms, they began to prey on the insects the very same night, as evidenced by insect wing parts on the flight enclosure floor the next morning. The following evening insects were again introduced into the flight area, and the next morning the flight enclosure floor was again littered in insect wings. A number of these wings were subsequently identified as belonging to the following families:12 *Arcttidae* wings; 25 *Nocturidae* wings; 5 *Nymphalidae* wings; 1 *Torticidae* wing; and 5 *Saturnidae* wings. Four unknown wings were also found. These bats remained in the outdoor flight enclosure for approximately one month where they continued to feed on flying insects and were eventually released into a maternity colony of *E. fuscus* (Barbosa, 2005). These reports demonstrate beyond doubt that hand-raised pups can survive after release, even though they did not have any opportunity to spend a considerable amount of time foraging with their mothers beforehand.

Supplemental feedings of mealworms or the soft food diet is recommended for orphaned bats while in a pre-release flight enclosure. Milk formula appropriate for the species may also be offered to these bats. Juvenile bats must maintain appropriate weights before being released. Additionally, these bats must exhibit significant flight abilities before release to successfully forage and avoid predators in the wild.

Releasing Adult Bats

Bats that have been in captivity for more than a few days should be given daily flight exercise before being released. As a rule of thumb, the bat should be given one night of flight exercise in a flight enclosure for every day in captivity. Alternately, a bat can be exercised in a room, with careful monitoring. The bat should be given 10 to 20 minutes of flight exercise per day in captivity. Wait at least 10 minutes after feeding before flight exercise.

Hold the bat in your hand over your head while inside a flight enclosure or a room that is closed off from other rooms. Release your fingers so that the bat is not confined in your grip, but merely sitting in the palm of your hand. The bat will typically stretch its wings once or twice before taking flight. If the bat has sufficiently recovered from injuries and has a proper flight area, it will generally attempt to take flight. Bats must be able to sustain flight for 5 to 10 minutes and must land and roost appropriately on the ceiling or upper portion of the enclosure. A bat that seems to fly well but continually lands on the floor is not ready for release.

Bats have a strong affinity for day and night roosting sites, as well as established feeding grounds. It is always best when possible to release a rehabilitated bat in the general area from which it originated, and even back into its original colony if this information is available. Solitary bats, of course, such as red bats (*L. borealis*), may simply be released in the area from which they came. When this information is not available, attempt to release in areas that provide known roosting and feeding requirements for the species. For example, red bats *(L. borealis*) roost in tree foliage, particularly along fence rows surrounding agricultural crops. These bats should not be released in bat houses or other structures used by crevice-dwelling species. Big brown bats (*E. fuscus*), on the other hand, are crevice-dwellers and need to be released in areas with known colonies of this species where natural (or man-made) crevices exist. When the location of roosts or colonies of the species is not known, bats (including solitary tree bats) should simply be released in areas that provide appropriate habitat for the species.

On numerous occasions the author has witnessed wild free-tail bats (*T. brasiliensis*) coming to investigate other bats being released, including red bats (*L. borealis)*. The bats often swoop by in very close proximity to a bat being held overhead for release. During one instance, two dozen *T. brasiliensis* had been rescued from a building and overwintered together in a flight enclosure. The bats were released the following spring. They were released in small groups of two to four, held overhead in the hand. As each small group was set free, they began to circle back, swooping close to the next group of bats being held overhead. The number of bats circling in the air continued to increase as more bats were set free. This behavior continued until there were no bats left to release.

Always release bats at nightfall (never at dusk when predators can easily locate the bat) and always take a spotlight along for hand releases to retrieve the bat if necessary. **Always hold your hand over your head to release the bat**. Use a ladder, if necessary, to provide bats at least a 7’ to 8’ drop. Use the flashlight to make sure the bat remained airborne and flew away safely.

Never release a bat by placing it on a tree trunk or the side of a building as it may be eaten by predators before it is able to fly away. Female tree bats with pups are the only exception to this rule. However, they should also not be placed on the trunk of a tree. Instead, carefully placed them on the branches of a tree (with a clear drop below) in the early afternoon and at least 10 feet off the ground. There should be several branches with foliage surrounding the mother and her pups to help conceal them from possible predators. Do not hang the mother from a single branch. It is best to place her in a forked branch within a clump of leaves so she has better support and is somewhat hidden from view. If not disturbed before being placed in the tree, she will hang quietly with the pups until dark. Females that become stressed during this move will fly off and may not return for the young. Although the female may hang the pups in the tree after dark and then fly off to feed, she may return for one or more of the pups before dawn. The tree must be checked again in the early morning to determine if any pups were abandoned. A red bat will frequently abandon one or more of the young; these pups must be retrieved and hand-raised.

Euthanasia

Euthanasia is defined as the act of inducing humane death. Ideally, the method used to administer painless death to an animal should cause minimal stress throughout the procedure. It should result in rapid unconsciousness, followed by cardiac or respiratory arrest, and ultimately, loss of brain function. The current preferred methods of euthanasia for insectivorous bats are by inhalant anesthetics such as isoflurane and halothane.

UNACCEPTABLE METHODS

Carbon dioxide gas is often used in specially designed chambers to euthanize small laboratory animals. In mammals of similar size to insectivorous bats, such as mice, carbon dioxide has rapid depressant and anesthetic effects and is considered conditionally humane. However, insectivorous bats have a high tolerance to carbon dioxide. When 25 pallid bats (*A. pallidus*) were euthanized at Texas A&M University, a research assistant noted gasping, and contortions in each of the bats for a period of one to three minutes. When suffocation was thought to be achieved, each bat was placed into a plastic zip-lock bag and placed into a refrigerator to await tissue sample collection to test for rabies. A small number of these bats remained in a semi-conscious state after being placed into plastic bags and then awoke while being necropsied (at which time their necks were broken) (M. Singleton, pers. comm.). Two species (*T. brasiliensis* and *L. borealis*) suspected of rabies were euthanized with a specially designed $C0_2$ chamber by the author in 1998. Similar distress was noted in both species. (These bats were removed from the $C0_2$ chamber and euthanized instead with isoflurane.) The author, therefore, considers $C0_2$ an unacceptable method of euthanasia for insectivorous bats.

T-61, Ketamine, Telazol, and Diazepam are not acceptable means of euthanasia for insectivorous bats. T-61 is a non-barbiturate, non-narcotic, injectable used for euthanasia. Although it may be available to animal caretakers in Canada, it is no longer commercially available in the United States. It provides a combination of general-anesthetic, curariform, and local-anesthetic actions. The AVMA Panel on Anesthesia recommends that, if the drug is used at all, it should be administered only intravenously as there is some question as to the absorption and onset of action when administered by other routes. Because curariform causes paralysis, including that of the respiratory system, an animal could be conscious and aware as it suffocates. The author, therefore, considered it unacceptable as a means of euthanasia.

Ketaset®/PromAce is a combination of Ketamine hydrochloride and Acepromazine, a general anesthetic and a tranquilizer. Although it has been injected subcutaneously to euthanize bats, it is known to induce an excitability phase characterized by tremors and vocalization preceding loss of consciousness. The author, therefore, considers it unacceptable as a means of euthanasia in bats.

Freezing was recommended as a method to euthanize torpid bats for many years (Barnard, pers. comm). The AVMA lists the rapid freezing of conscious animals as inhumane but does not address torpid animals. Although bats enter a state of torpor when subjected to cold temperatures, they may awaken to full consciousness in an attempt to find a warmer location as their body temperature approaches lethal level. The author, therefore, considers it unacceptable as a means of euthanasia in bats.

ACCEPTABLE METHODS

Halothane and Isoflurane are the preferred inhalants and recommended by the author for euthanizing bats. Both chemicals produce a moderately rapid anesthetic effect followed by death when used in high enough doses (concentrations) or with prolonged exposure.

Insert a cotton ball into the plastic casing used as packaging for a 6ml syringe and then pour 5.0ml of Halothane or Isoflurane onto the cotton ball. If the bat is calm, it can be placed in a roosting pouch, soft cloth or held in hand. Place the open end of the plastic casing near or the bat's head. Do not shove the bat's head into

the casing so far that it panics, but rather hold the casing just above its head (see Anesthesia section) until the anesthetic effect is obvious. It should take less than a minute for the bat to succumb and it should exhibit no signs of distress during this process. Once the bat is unconscious, completely cover its head with the casing, and place the bat into a small airtight container, in a quiet location, for one to two hours. Use a neonatal stethoscope to insure the heartbeat has stopped.

Bats that are difficult to handle should be put in a roosting pouch or dark cloth and placed in a small plastic container with a tight-fitting lid (Figure 13-1). Place the plastic casing with the cotton ball (which has been saturated with the inhalant) into the container and close the lid. The plastic casing should not be placed directly in front of the bat's face. Although the bat will fall asleep quickly, wait for one to two hours before checking for a heartbeat with a neonatal stethoscope.

Figure 13-1. A euthanasia box. Crevice bats are placed inside the pouch and tree bats are placed on top of the pouch. Cotton inside the plastic casing is saturated with isoflurane and the lid is then closed. *Bat World facility. Photo by A. Lollar.*

An injectable method of euthanasia may be preferred to euthanize bats that are suffering from respiratory distress. The preferred injectable medications are Acepromazine and Butorphanol Tartrate (0.008ml/g of body weight) mixed with Xylazine (0.01ml/g of body weight). The solution should be warmed before injecting. Mix 0.05ml Acepromazine with 0.05ml Butorphanol Tartrate and 9.8ml of an electrolyte solution. Administer 0.08ml SQ. Put the bat in a roosting pouch or in the folds of a soft cloth. Wait 20 minutes before administering 0.1 ml Xylazine. Alternately, sodium pentobarbital (euthanasia solution) can be administered intraperitoneally after the bats is sedated.

Bats are usually anesthetized within minutes; however, the bat should be left undisturbed and safely contained in a quite, dark location for several hours. Ensure death has occurred by checking for respiration and heartbeat.