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Published in the United States of America
by
Basically Bats Wildlife Conservation Society, Inc.

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Cover: Little Brown Myotis (*Myotis lucifugus*) with *Geomyces destructans* fungal growth on its face and ears. Photo courtesy of Ryan von Linden with permission from the New York State Department of Environmental Conservation.

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January 2013 Edition

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White-nose Syndrome: Introduction

White-nose syndrome (WNS) was first detected in a New York cave in February of 2006. Since then the disease has devastated bat populations throughout the northeast, with the potential to affect bats throughout the United States and Canada. WNS is characterized by a white, fuzzy, cold-temperature fungus that invades the bats' faces, ears, and wings while they hibernate (Fig. 1).

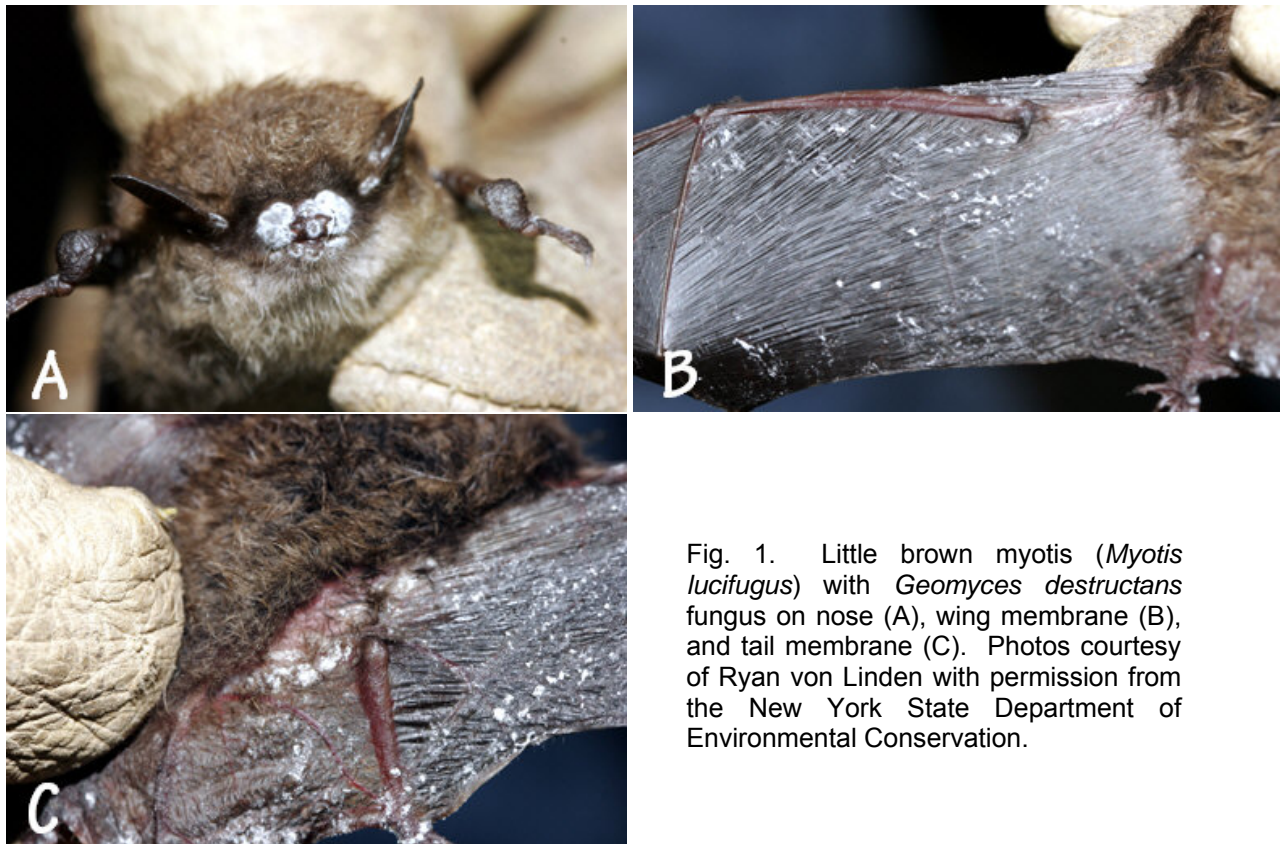


Fig. 1. Little brown myotis (*Myotis lucifugus*) with *Geomyces destructans* fungus on nose (A), wing membrane (B), and tail membrane (C). Photos courtesy of Ryan von Linden with permission from the New York State Department of Environmental Conservation.

Bats affected with WNS often arouse from hibernation months early and leave the protection of the hibernacula. Huge numbers of bats have been found flying outside during the day in winter, the consequences of which are freezing and starving to death. Depending on the source, the death toll of bats due to white-nose syndrome differs: Five and a half million was reported in a January 2012 news release by the U.S. Fish and Wildlife Service, and recent research confirms that *Geomyces destructans* is the causative agent for these mortalities (Lorch et al., 2011).

Solutions to save bats from extinction because of white-nose syndrome range in ideas from cryopreservation of cells to the captive propagation of bats. Captive

propagation of insectivorous species has not been successful to date (Baer and Holguin, 1971; National Zoo, 2010; Ruffell and Parsons, 2009) because captivity cannot duplicate the wild; bats lose immunity to wild pathogens; over time bats lose predator-avoidance behavior; and if not allowed to fly and capture natural prey, they lose the ability to hunt and recognize appropriate food items, and they may lose skeletal and muscle mass. Furthermore, because no two bat species are alike (e.g., in food habits, flight patterns, echolocation, roosting habits, and thermal and humidity requirements), gaining information about the captive breeding of one species does not necessarily translate to successful captive breeding and maintenance of another. That is not to say that *caring* for bats in captivity has not been successful. Bat rehabilitation is a well established practice, and must not be ignored.

Rehabilitating Bats with White-nose Syndrome: Background

Based on Meteyer et al. (2011), little brown myotis (*Myotis lucifugus*) confirmed with *G. destructans* infection can recover from the effects of the fungus by taking them captive and providing them with food, water, and *warmth* because *G. destructans* is a cold-temperature fungus. These authors took captive 30 *M. lucifugus* in May 2009 with confirmed *G. destructans* infection. After a 70-day period, the bats emerged free of the fungus without topical treatments or systemic medications. Of the 26 bats that survived and were later euthanized, 25 showed significant improvement in the external appearance of wing membranes, had no microscopic evidence of infection by *G. destructans*, and had wing tissue samples that were negative for *G. destructans* by PCR (Polymerase Chain Reaction) testing. Although similar studies have not been conducted on other species infected with *G. destructans*, it is likely that a positive outcome would also occur.

Some rehabilitation facilities have been promoting the use of apple cider vinegar as a treatment for *G. destructans* fungus, but the work of Meteyer et al. (2011) found that this treatment is unfounded. A subset of the bats was treated topically at the beginning of the rehabilitation study with a dilute vinegar solution, but treatment with vinegar provided no added advantage to recovery. Furthermore, handling of bats unnecessarily increases stress. Only supportive care (food, water, and warmth) for approximately 70 days is all that is required to recover from *G. destructans* infection. Once recovered, bats can be released at the capture site, but it is not known if rehabilitated bats become re-infected during subsequent periods of hibernation.

Currently, rehabilitation is performed by licensed individuals, primarily in their homes or in small facilities housing other wildlife. For rehabilitation to be an effective tool against WNS, WNS-dedicated facilities for large scale captive care would be needed. Funding would have to come from state and federal agencies, as well as private sources. Such facilities could possibly be located in zoological institutions because zoos have the expertise to administer appropriate care to a wide variety of native and exotic animal species.

Saving bats in general is a global effort, and helping bats with WNS has been well coordinated among the affected state governments, United States Fish and Wildlife Service (USFWS), United States Geological Survey (USGS), a number of academic research facilities, and conservation organizations. To keep up to date on some of the

latest white-nose syndrome research efforts, see the US Fish & Wildlife's website at <http://www.fws.gov/whitenosesyndrome/>.

Rehabilitating Bats with White-nose Syndrome: Guidelines

The following guidelines are intended to provide basic information essential for the appropriate captive care of WNS-affected bat species; it is not intended to be a substitute for the published literature on the captive management of bats (see *Literature Cited*).

Requirements for Bat Rehabilitators

- Rehabilitators working with WNS-affected bats should keep in mind that these animals require supportive care only.
- Rehabilitators must be aware of the expense and labor-intensive nature of care for this particular group of animals. If serious injuries are observed, provide the bats with veterinary medical care, or euthanize them if the problem cannot be corrected.
- Rehabilitators must be willing to work closely with state WNS coordinators and FWS contacts.
- Rehabilitators must be licensed in accordance with state regulations and must obtain applicable permits as required by state and federal law.
- Rehabilitators must be experienced working with bats prior to accepting WNS-affected bats.
- Rehabilitators must have pre-exposure rabies vaccination.
- Rehabilitators must be willing to follow established principles of wildlife rehabilitation (see Barnard, 2009a,b, 2010, 2011 and Lollar and Schmidt-French, 1998) on handling bats, their transport, quarantine, captive care, and the appropriate decontamination protocols set by state and federal governments (see *Disinfection* below).
- State agencies may want to submit WNS-affected bat carcasses for genetic material archives or histopathology. Rehabilitators should contact their local state agencies for guidance; see <http://www.whitenosesyndrome.org/partners>.
- Rehabilitators must notify the appropriate state or federal agency bat biologist as soon as possible if they suspect that they have received a federally listed endangered species such as the cave myotis (*Myotis velifer*), gray myotis (*Myotis grisescens*), or Indiana myotis (*Myotis sodalis*).

- Rehabilitators are strongly encouraged to communicate with each other about the bats they receive because each case can present unique challenges.

Recommendations for Handling and Transport

- Because bats are rabies vectors, never allow members of the public to handle them. Only vaccinated personnel should handle bats. To prevent bites to the handler, manipulate bats with lightweight, soft gloves (Fig. 2a) or other soft material (Fig. 2b). Bats likely to be infected with *G. destructans* may be in torpor or too sick to be active. However, while a bat is being handled, under normal circumstances it vibrates to increase its body temperature. When fully warmed, they can be challenging to handle: Be prepared for the unexpected.

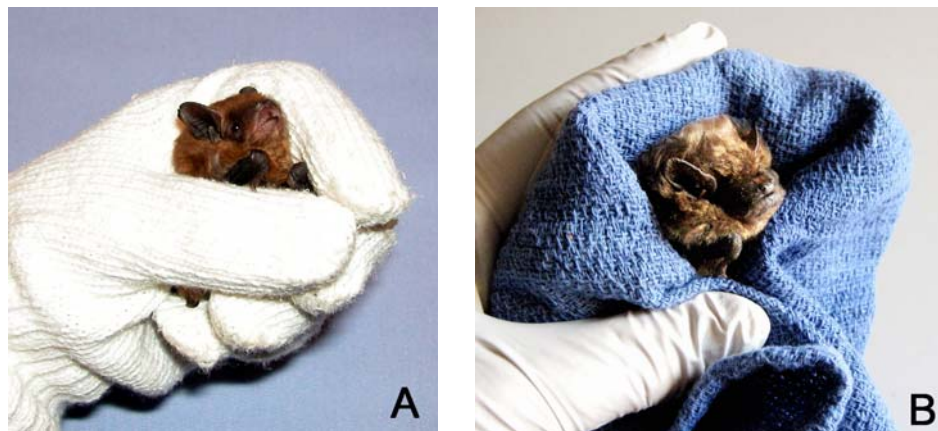


Fig. 2. Soft, cotton gloves (A) work well for handling many species of insectivorous bats. Cloths (B) allow safe manipulation of all bats, regardless of size or temperament. Photo (A) by Susan M. Barnard; photo (B) by Linda E. Bowen.

- Bats may be transported in bags made of **cotton** because cotton is absorbent and does not catch on bat claws. Inspect bags before placing bats in them to ensure there are no holes or torn seams. Prior to placing bats in bags, turn the bags inside out to prevent the animals from becoming entangled in frayed seams.
- Place a bagged bat in a sturdy container such as an appropriately sized polystyrene cooler. Polystyrene coolers are excellent transport containers because they protect the occupants from rapid changes in temperatures, are inexpensive, and lightweight for carrying. Tape the cooler top closed to contain a bat that might escape from a bag. To ensure adequate ventilation, punch one or two rows of holes on the cooler sides (from the inside to the outside). Avoid making the holes larger than the diameter of a pencil.
- Do not open a transport container holding bats until one is inside a room that has been dedicated for bat quarantine.

- Disinfect all items used to transport bats such as gloves, bags, and containers (see *Disinfection* below).

Quarantine

- A quarantine room should be quiet, free of radios, televisions, and high traffic.
- Never eat, drink, or smoke in a quarantine room.
- To eliminate the potential for spreading *G. destructans* to areas outside of caves, rehabilitators specializing in WNS-affected bats must care for local cave-roosting species **only**. Place migratory species in the care of other wildlife rehabilitators.
- Quarantine rooms should isolate bats from other animals in a rehabilitation facility, including domestic pets (if present) and other bats (such as those used in education programs). Consider all bats in a quarantine room to be infected with *G. destructans*.
- All items in a quarantine room must be disposable or have the ability to be disinfected.
- Keep quarantine rooms well-stocked with animal-care supplies to prevent repeated entering and exiting. Avoid using quarantine-room supplies elsewhere.
- To reduce the risk of cross-contamination to other bats in a rehabilitation facility, bats in quarantine must be handled last.
- Handle quarantined bats with disposable exam gloves and while wearing dedicated clothing. Launder clothing according to the disinfection information provided below.
- To reduce the risk of aerosolization of fungal spores and contamination outside a quarantine room, place containers holding WNS-affected bats as far away as possible from the entry/exit doors, and away from blowing fans or vents. Consider keeping quarantine room windows closed.
- Rehabilitated bats should go from quarantine to release once it has been established the bat is fit to fly (see *Preparation for Release* below). Euthanize non-releasable bats.
- Only qualified personnel should have access to a quarantine room.

Admission and Initial Care

- **Record Keeping.** Maintain records on all incoming bats. The intake record sheet should include, but not be limited to the following: the date a bat was received; the address or location where a bat was found; the name and phone number of the person reporting a grounded or injured bat; the species of bat; the

incoming weight of a bat, and a diagram of a bat to record remarkable abrasions and injuries. Record all treatments. If a bat was given professional medical care, also record the name of the attending veterinarian. Record any information required by state and/or federal agencies, and an animal's final disposition.

In addition to keeping accurate records on incoming bats, any person presenting a bat for rehabilitation should guarantee that no one has been bitten by the bat in question. Some rehabilitators request this guarantee in writing by having the presenter sign a prepared document.

- **Health Status.** Evaluate an incoming bat for its general state of health (e.g., weight, problems caused by WNS, and injuries). Some bats may be infested with ectoparasites, specifically mites. With few exceptions, mites are self-limiting under captive conditions and rarely is there a need to treat them with a parasiticide. For additional information on parasiticides in bats, see Barnard (2009c).
- **Warming.** Bats with WNS may be found outside their hibernacula and presented for care during winter. During hibernation, the body temperature of bats decreases and their heart and breathing rates decline significantly. Consequently, it cannot be determined at first glance if a bat is in normal torpor or hypothermic. In either situation, before initial care can begin, it is necessary to prevent further heat loss. If a bat has not already increased its own body temperature during handling and transport, it can be wrapped in a soft cloth and placed on a heating pad set on low. To prevent the possibility of burns to wing membranes, never place an unprotected bat directly on a heating pad. When a bat is fully hydrated, and the appropriate ambient temperature (65 °F [18.3 °C] to 75 °F [23.9 °C] and humidity (55% to 65%) is provided, discontinue supplemental heat sources (usually by the second day in care) to avoid dehydration and hyperthermia.
- **Dehydration and Fluid Therapy.** Consider all bats coming into care to be dehydrated to some degree. Within approximately 15-30 minutes of warming, administer warmed subcutaneous fluids (e.g., Plasma Lyte®-A, Normosol®-R, or lactated Ringer's solution). Winn (2006) suggested adding 1 ml of injectable B-complex per liter of fluids. The amount of fluid a bat may need depends on its hydration status, but to prevent a bat from dying of pulmonary edema, avoid over-hydration. Typically, 0.5 cc (ml)/10 g body weight injected 8-12 hours apart (i.e., 2 to 3 injections over 24 hours) is sufficient to hydrate most bats entering care with WNS. However, if a bat does not respond to this rehydration regimen, consult a veterinarian. To prevent rapid cellular fluid shifts, avoid administering fluids containing dextrose (= glucose) (Winn, 2006).
To prevent the possibility of water intoxication, do not rehydrate a bat orally. Avoid allowing a bat access to unlimited water until it is appropriately rehydrated subcutaneously (Olsson, 2009).
- **Feeding.** Many bats with WNS may come into care extremely emaciated. Rehabilitators may want to offer food immediately. However, to prevent

Refeeding Syndrome (RFS), a condition that can cause the death of an animal when inappropriate nutrition is provided to emaciated animals (Winn, 2006), withhold all food until a bat is fully hydrated. Initial food should be digestible, high in protein, and low in carbohydrates, which is not the case with products such as Vital®HN, which contains 73.8% carbohydrates; Energel™ for cats contains 39%, and Nutri-Cal® for cats contains 42%. Because of the high roughage content in mealworms, or possible high carbohydrate content from being fortified, Carnivore Care® (Table 1) mixed with water (not electrolyte solutions) is likely the most suitable food for emaciated insectivorous species. Initial feeding can be by syringe. As soon as possible (approx. 2 or 3 days), transition a bat to properly fortified mealworms (*Tenebrio molitor* larvae) because bats require chitin (roughage) in their diets for good health. To train a bat to eat on its own in captivity, see *Training Wild Bats to Feed in Captivity* below).

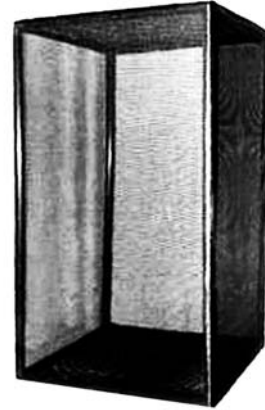
**Table 1. Nutritional Values of Carnivore Care®
(from Animal Oxbow Health, 2012)**

Nutrient	
Metabolized Energy	24 kcal/Tbsp.
Crude Protein	45%
Crude Fat	32%
Carbohydrate	1%

Holding Containers

- **Type(s), Size(s), and Number(s) of Holding Containers.** For bats in care with WNS, a holding container must be disinfected periodically. Because chemical disinfectants have strong odors and can be caustic, the ability to launder a holding cage offers a safe disinfecting method. Reptariums® (Fig. 3) work well for this purpose. Reptariums® are also lightweight, which makes them easy to manipulate. Depending on a bat's ability for activity, suitable Reptarium® sizes can be 22 or 38 gallons, with enough holding containers to house individually the number of bats allowed by the capacity of the quarantine room.

Fig. 3. Reptarium®. This product is suitable for the temporary holding of all small bats. Photo by Susan M. Barnard.



- **Container Design.** Holding containers must allow bats to traverse all surfaces for adequate exercise. The Reptarium® offers this feature, especially when positioned vertically. If using solid-walled holding containers, smooth surfaces must be covered with mesh (i.e., ¼-in. polyethylene) to allow bats an easy grip.
- **Container Contents.** Because WNS-affected bat species presented for care are secretive and require seclusion for roosting, they must be provided with **cotton** cloths that are hung in the back corners of holding containers. Reptariums® are mesh and offer no visual protection from human activities. Therefore, cover tops and all sides of such containers, with the exception of the front; leave it uncovered for easy access to the occupant.

Depending on the type of holding container used to house bats, some rehabilitators use Petri dishes (Fig. 4a) for food and water, whereas others use coop cups (Fig. 4 c). However, any small, sturdy container can be used that is unable to be tipped over and allows bats easy access.

Fig. 4. Glass Petri dishes (A) provide ideal containers for feeding bats. Either small Petri dishes (60 x 15 mm) or small culture dishes (B) work well for water. In addition, appropriately sized coop cups (C) can be used for food and water. Photos by Susan M. Barnard.



- **Suggested Substrates.** The best substrate for quarantine-holding containers is one that is easy to clean, is disposable, and one that will not adhere to bats when

they descend to the container floor. Newspapers or paper towels are best for this purpose.

- **Cleaning Holding Containers.** Bats use scent-marking to communicate a wide variety of information, including territory (Dapson et al., 1977; Gustin and McCracken, 1987; Scully et al., 2000). Removing a bat's scent from its living space may cause undue stress; therefore allow bats to live in a slightly soiled environment. This also applies to roosting cloths. Routine cleaning can include substrate changes and removal of uneaten food and stale drinking water. All cages must be disinfected after bats have been released. Never use disinfectants in the presence of bats. Have extra holding containers available to house bats while soiled containers are being disinfected and/or laundered.

Temperature, Humidity, and Lighting

To measure temperature and humidity levels in a quarantine room, use a thermometer/hygrometer (Fig. 5).



Fig. 5. AcuRite® thermometer/hygrometer.
Photo by Susan M. Barnard.

- **Temperature.** Because *G. destructans* is a cold-temperature fungus, maintain bats at an ambient temperature ranging from 65 °F (18.3 °C) to 75 °F (23.9 °C) (Meteyer et al., 2011).
- **Humidity.** Maintain temperate-zone bats at relative humidity levels ranging between 55% and 65%. Humidity levels that are too low may cause wing membranes to dry and crack. This problem occurs primarily during winter months when heaters are running. The use of humidifiers can alleviate the problem. Conversely, when humidity is constantly high, the moisture can support the growth of mold and mildew. Note: Warm-moisture humidifiers are preferred over other types (e.g., cool mist, ultrasonic) because they offer warmth with humidity, as the name implies. Although ultrasonic humidifiers do not interfere with a bat's echolocation, they do leave white powder on the surfaces of items that are near them.
- **Lighting.** Bats must never be maintained in constant darkness or light. When not being hibernated, maintain all bats in rooms with windows to receive the light/dark cycle of the outside environment (Barnard, 1995). When windows are unavailable, a natural cycle can be simulated with artificial lights controlled by a

timer. Lights can also simulate the rising and setting sun by using a dimmer switch or rheostat. If a rehabilitator needs to check on bats after sundown, a low-wattage light can be used to illuminate a quarantine room.

Training Wild Bats to Feed in Captivity

In captivity, bats may be fed a variety of commercially reared insects. However, mealworms are convenient and can be fortified in a way that provides a balanced diet for most insectivorous bat species. Because bats use flight to hunt prey, those taken into captive care must be trained to take insects from a dish as follows:

- Place an animal in a cotton cloth with its head exposed.
- Decapitate a mealworm and hold it to the bat's lips with a pair of blunt forceps.
- If the bat does not snap at the mealworm in a display of defensive behavior, smear mealworm viscera on the animal's lips.
- Repeat this process until the bat eats a mealworm.
- After a bat eats one mealworm, quickly offer another *tail first*.
- Once a bat is comfortable eating mealworms tail first, start offering them head-first.
- Bats that are eating mealworms consistently from forceps can then be taught to take them from a dish. While still holding the bat in a cloth, bring its head close to a dish of mealworms. As the bat focuses on them, with forceps, bring one mealworm slightly above the others. Repeat this step until the bat picks up mealworms from the dish on its own.
- Depending on the individual bat and the experience of the rehabilitator, this method can be accomplished in 30 minutes to several days.

Daily Management

- **Water.** Be sure water is fresh and available daily. Bats being fed properly fortified mealworms do not require the addition of dietary supplements in the drinking water (Barnard, 2009a), and wild insectivorous bats may be reluctant to drink because of the unfamiliar taste.
- **Diet.** Insectivorous bats are predators, not carrion-feeders, and therefore frozen mealworms and other frozen insects are not satisfactory food items (Barnard, 1985; Wilson, 1988). If bats do not eat the defrosted insects, they decay and not only emit a foul odor, but also lose essential nutrients (Healthy-food-site.com, 2012). Furthermore, when insects are puréed, they stick to the animal's fur, and over time leave it with a naked venter as the bat grooms off the food (Barnard et al., 2011).

Because insectivorous bats feed on crop pests, provide dark leafy greens as a staple in the mealworm medium. The medium listed in Table 2 is a complete diet when changed frequently (e.g., every 3-5 days).

Table 2. Medium for Fortifying Mealworms (from Barnard 2009a)^{1,2}

Per 10,000 mealworms (requires a container size of approx. 4 in. [10.2 cm] H x 10 in. [25.4 cm] W x 15 in. [38.1 cm] L; *do not cover unless using a **lightweight** anti-insect screen*):

- 50-75 g mealworm supplement powder³
- 2-3 large collard leaves (variations may include beet greens, dandelion leaves, kale, mustard greens, turnip greens, or watercress; see also page 39, Barnard, 2011)
- 1/2-1 sweet potato (cut lengthwise)
- 1/2-1 apple (cut in half)

After each medium change, allow mealworms to feed for approximately 12 hours before refrigerating. Refrigerating prevents insect pupation and preserves freshness of food.

¹ Change medium every 3-5 days to maintain food freshness and to meet the nutritional requirements of bats.

² See Barnard et al. (2011), Tables 2-2 and 2-3 for nutrient content of mealworm medium.

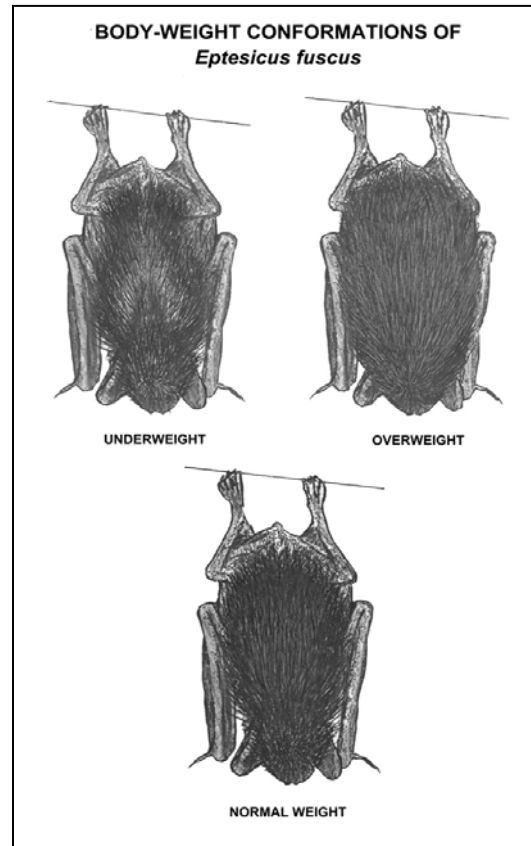
³ Mealworm supplement powder. Mix together:

210 g corn meal
 90 g oat bran
 65 g wheat bran
 215 g Vionate® vitamin/mineral powder
 215 g calcium carbonate powder

- **Amount of Food to Feed.** There is no definite rule as to the number of insects a captive bat should consume nightly. Variables include the size of the insects, size of the bat, time of year, ambient temperature, a bat's nightly activity level, overall health, and genetic disposition. Once a bat learns to self-feed (see *Training Wild Bats to Feed in Captivity* above), it can be fed fortified mealworms *ad libitum*. If weight problems occur, adjust the amount of food being offered.
- **Nutritional Supplements.** A great deal of attention is paid to nutritional deficiencies and hair loss, but over-feeding dietary supplements also contributes to this problem. This is especially so when placing vitamins and minerals directly into a bat's mouth, or when supplementing base rations (e.g., Carnivore Care®) that already contain adequate levels of vitamins and minerals.
- **Food Presentation.** To make food easily accessible, present mealworms to bats in a shallow vessel such as a Petri dish (see Fig. 4a), or coop cups (see Fig. 4c) hung on the side of a holding container.

- **Maintaining Appropriate Body Weight.** Because the weight of an insectivorous bat fluctuates greatly, it is often easier to judge its weight by its body conformation (Fig. 6).

Fig. 6. Body-weight conformations of the big brown bat (*Eptesicus fuscus*). Note the sunken area between the scapulae (shoulder blades) of the underweight individual. Overweight bats are rotund and have a “jellylike” feeling to the touch. Illustration by Susan M. Barnard.



- **Maintaining Proper Quarantine.** Place water and food dishes in a pan of disinfectant before taking them to the area where they are to be washed (using dish detergent and hot water). After washing, rinse thoroughly. Because bats may be sensitive to the odors of disinfectants, keep disinfectants as far away as possible from holding containers.
- **Checking on Bats.** There are two schools of thought for checking on bats. Some rehabilitators manipulate them on a daily basis to examine them physically. Other workers attempt to reduce stress to the animal by observing them as they roost. Whichever method is preferred, a careful check ensures individuals have not escaped, are maintaining weight, are not injured from flaws in a holding container, and are not developing health problems.

Preparation for Release

- Preparation for release is merely a matter of checking each bat's flight ability. **Dedicated**, free-standing screen houses/tents work well for this purpose. If a

tent has no floor, pad the ground where it meets the tent walls to prevent bats from escaping.

- Bats must be in good body condition with pelage intact prior to release. Bats have the best chance of surviving if they are released in the area where they were found. A carefully planned release allows a bat continued use of its regular drinking sites, feeding grounds, roosts, and hibernacula. Release bats just before or after sundown, and when weather conditions support flying insects. Some states may require the banding of bats by agency personnel prior to release. Banding can provide information on the survivorship of rehabilitated animals.

Euthanasia

One of the most troubling aspects of euthanizing an animal is the method used. If a wildlife rehabilitator lacks experience, or the best method for a given animal is too inconvenient or objectionable to the rehabilitator, the animal may not die well. The definition of a “good death” is one that induces rapid unconsciousness with minimal pain or distress. There are three basic methods used for euthanizing animals: inhalants, injectable agents, and physical methods. Anesthetic inhalants and injectable agents should be administered by a veterinarian, not only because of laws governing those drugs, but to minimize distress to a bat, and appropriate delivery systems are often required (i.e., anesthesia machines). Methods considered acceptable by the American Veterinary Medical Association (AVMA, 2007), which are readily available to the wildlife rehabilitator, are gas inhalants and physical methods, and euthanasia methods must conform to AVMA guidelines. For an in-depth discussion on euthanasia in bats, see Barnard (2009d).

Carcass Disposal

Rehabilitators should have a separate holding refrigerator and/or freezer for carcasses prior to disposal, and they should check with the WNS coordinator of their state concerning bats that die during care. If the state has no specific regulations on carcass disposal, double-bag dead bats, and make arrangements with the local health department or the attending veterinarian to discard animals and other contaminated materials. Never contaminate indoor or outdoor trash with dead bats.

Disinfection (see also *Additional Reference Sources* below)

Disinfection is defined as the application of a disinfectant to materials and surfaces to destroy pathogenic organisms.

Disinfectant Concentration

See product labels for the appropriate concentration of a particular disinfectant. Although under diluting a product may cause risk to personnel, and damage to surfaces and equipment, over diluting a product may render it ineffective.

Method of Application

Depending on the surface to be disinfected (e.g., counter tops, walls, instruments, cages, clothing), methods of application may include wiping, brushing, soaking, spraying, or misting.

Contact Time

Disinfectants may vary in the time needed to inactivate (-static) or kill (-cidal) micro-organisms (i.e., *G. destructans*). The minimum contact time is usually stated on the product label. Avoid allowing products to dry before the end of the optimum contact time.

Stability and Storage

Some disinfectants (e.g., sodium hypochlorite) lose stability after being prepared for use or when stored over long periods, especially in the presence of heat or light. Therefore, store such products in dark, cool places. Always check product labels for the shelf life of products (noting whether full strength or dilutions).

When diluting a disinfectant, mark the preparation container with the content, percent dilution, and date prepared.

Safety Precautions

Because most disinfectants can cause irritation to eyes, skin, and/or the respiratory tract, apply them with caution. When mixing disinfectants, wear gloves, masks, and eye protection. Consult the Material Safety Data Sheets (MSDS) before using a product. Information in the MSDS includes product stability, hazards and personal protection needed, as well as first aid information. Place the MSDS for each product used for bat care in one accessible location.

Physical Methods of Disinfection

In addition to chemical disinfection, radiation, heat, and light are also appropriate methods to inactivate or kill microorganisms. Barnard (1995, 2009a) advocates the use of sunlight to disinfect cages.

Decontamination Protocol

- Prior to removing items from a quarantine room, remove debris and spray/soak the items in disinfectant. Bag items securely before transporting them out of a quarantine room for laundering or disposal.
- All non-disposable items (e.g., holding containers, feeding equipment, cloths, and clothing) that have been in contact with bats must be cleaned with hot water and detergent, followed by disinfection (see *Recommended Decontamination Products* below). Items must be in contact with a disinfectant solution for a minimum of 10 minutes, or as directed on product application information. Rinse each item thoroughly with clean water at least 3 times. However, if a disinfectant odor remains in a fabric, or on the surface of a moveable item, it may be necessary to leave the item outside until the odor dissipates.

- Spray all disposable items and trash with disinfectant and discard into a dedicated trash receptacle. When full, trash from the dedicated receptacle is then double-bagged and discarded as directed by the local health department.
- Place vacuum cleaner bags in two plastic bags and discard them after being used in a quarantine room. When steam cleaning carpets, the CDC recommends a temperature of 115 °F (45 °C). However, it is best to **avoid carpeted flooring** in a quarantine room. Discard furnace and air conditioner filters weekly.
- Disinfect a bat quarantine room thoroughly after the release/removal of all bats.
- After all bats have been released, flight houses/tents can be disinfected with a 10% bleach solution using a 1-gallon bleach and chemical sprayer, followed by a thorough rinsing with clean water. If bleach is allowed to dry on tent fabric, the fabric will deteriorate quickly. Prior to reusing these cage types, be sure all odors have dissipated.

Recommended Decontamination Products (USFWS, 2012)

The following chemical products were found to be effective against killing resistant spore-forms of *G. destructans* and hyphae at dilutions and treatments printed on the product labels:

- Lysol® IC Quaternary Disinfectant Cleaner (with a minimum of 0.3% quaternary ammonium compound; 1 part concentrate to 128 parts of water or 1 ounce of concentrate per gallon of water).
- Lysol® All-purpose Professional Cleaner (with a minimum of 0.3% quaternary ammonium compound). If using a similar product containing a minimum of 0.3% quaternary ammonium compound, read product label for appropriate dilution.
- Formula 409® Antibacterial All-purpose Cleaner (Effective at concentrations specified by label).
- 10% solution of household bleach (1 part bleach to 9 parts water).
- Lysol® Disinfecting Wipes (Effective at 0.28% dimethyl benzyl ammonium chloride).
- Boiling water - boil submersible items for 15 minutes. Alternatively, submersible items can be placed in hot water ≥ 122 °F (≥ 50 °C) for 20 minutes.

Products Mentioned in Text

Products mentioned in the text can be purchased from a variety of sources, including the suggestions listed below.

- Bleach and Chemical Sprayer (D.B. Smith 190285; available at amazon.com)
http://www.amazon.com/Smith-190285-1-Gallon-Chemical-Non-Corrosive/dp/B002YNSADU/ref=sr_1_1?ie=UTF8&qid=1325785603&sr=8-1
- Calcium Carbonate Powder (Now Foods; available at amazon.com)
<http://www.amazon.com/Calcium-Carbonate-Powder-12-Ounces/dp/B000ZL1XUK>
- Carnivore Care® (Animal Oxbow Health)
http://www.oxbowanimalhealth.com/vets/products/carnivore_care,
- Coop Cups (available in pet stores such as PetSmart®)
<http://www.petsmart.com/product/index.jsp?productId=11147485&mr:referralID=NA&mr:adType=pla&qclid=COfd9ObOua0CFYFx4Aod1VBR7g&mr:trackingCode=0310DD57-3735-E011-997F-001517B1882A>
- Corn Meal (many brands; available in grocery stores)
- Energel™ for Cats (Pet Ag) – *not recommended by authors*
<http://www.petag.com/product/cat-nutrition-supplements/energel-for-cats/>
- Formula 409® Antibacterial All-purpose Cleaner (available at Walmart® and other department stores). See also <http://www.formula409.com/>
- Lactated Ringer's Solution (Abbott Laboratories plus others; available at medi-vet.com)
http://www.medi-vet.com/prod-Lactated_Ringers_Solution_1000_ml_Bag-2183.aspx
- Lysol® All-purpose Professional Cleaner (available at Value Plus Paper)
<http://www.valuepluspaper.com/ProductDetails.asp?ProductCode=RAC75352EA&Click=1867>
- Lysol® Disinfecting Wipes (available at amazon.com)
http://www.amazon.com/Lysol-Disinfecting-Wipes-Lemon-Blossom/dp/B004S0DZ8W/ref=sr_1_1?ie=UTF8&qid=1325287993&sr=8-1
- Lysol® IC Quaternary Disinfectant Cleaner (available at Wayfair)
<http://www.wayfair.com/Lysol-I.C.-Quaternary-Disinfectant-Cleaner-1gal-Bottle-RAC74983EA-YYJ1006.html?refid=GPA49-YYJ1006&qclid=CMr63874qq0CFQXd4Aodu30OoA>
- Mealworms (Grubco, Southeastern Insectaries, plus many other distributors)
<http://www.grubco.com/>;
<http://southeasterninsectaries.com/index.html>;
- Mesh (1/4-in.; product XV1672) (Industrial Netting)
<http://www.industrialnetting.com/>
- Normosol®-R (Abbott Laboratories; available at Direct Medical, Inc.)
http://www.dmi2.com/OnlineCatalog_i2887823.html?catId=120444
- Nutri-Cal® for Cats (Tomlyn®) – *not recommended by authors*
http://www.tomlyn.com/pr_n_Nutri_Cal_cats.html
- Oat Bran (many brands; available in grocery stores)
- Petri Dishes (60 x 65 x15 water; 100 x 107 x20 mealworms; available at Right Price Chemicals and Laboratory Equipment)

<http://www.rightpricechemicals.com/lab-equipment/petri-dishes/glass-petri-dishes.html>

Plasma Lyte®-A (Baxter Healthcare Corporation; available at local veterinary clinics)
Refrigerators (available at Lowe's and other building supply and department stores)

http://www.lowes.com/pl/Compact+Refrigerators/429485796544?cm_mmc=search_google--Appliances%20Refrigerators--Refrigerators%20Small--bar%20refrigerators

Reptariums® (Apogee®)

<http://www.reptarium.com>

Screen Houses/Tents (Many styles on the market; available at amazon.com)

<http://www.amazon.com/Eureka-2624530-Hexagon-Screen-House/dp/B000EQ81OW>

Thermometer/Hygrometer (AcuRite®, plus many other brands)

<http://www.acurite.com/weather/humidity/acurite-digital-indoor-outdoor-thermometer-with-humidity-clock-silver-00891a2.html>

Vionate® Vitamin/Mineral Powder (UPCO®)

http://www.upco.com/is-bin/INTERSHOP.enfinity/WFS/Upco-Upco-Site/en_US/-/USD/ViewParametricSearch-AdvancedSearch?webform-id=WFAdvancedSearch&DefaultButton=findSimple&WFSimpleSearch_NameOrD=vionate&findSimple=GO

Vital®HN Specialized Nutrition (Abbott Nutrition Abbott Laboratories) – *not recommended by authors*

<http://static.abbottnutrition.com/PHB/pdf-individual/Vital-HN-20121102023614.pdf>

Warm Mist Humidifiers (available at local department stores or iallergy.com)

http://www.iallergy.com/category11_86_87_90/default.html?qclid=CLbU5KPxqc0CFQjd4AodV3fkmq

Wheat Bran (many brands; available in grocery stores)

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National Wildlife Rehabilitators Association; <http://www.nwrawildlife.org/>

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http://www.vmeth.ucdavis.edu/home/IDC/Small%20Animal%20Clinic%20Infectious%20Disease%20Protocol/SA%20IDC%20PROTOCOL%20July19_2011.pdf

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