CHAPTER FOUR
ENRICHMENT AND SECURITY

The primary problems captive animals face in captivity are fear and boredom. Both stimulation and emotional security can be provided for captive bats by creating an environment that is similar to their natural habitat. In order to get an idea of the requirements of a particular species, it is important to know the conditions the bats choose as natural roosts in the wild and mimic those conditions accordingly. Continual regrouping should not be preformed as a colony will no be able to stabilize. Additionally, colony group size must be appropriate for the species; enclosure space should be sufficient for maintaining any distance individual bats may prefer from other roostmates; and feeding and roosting areas must remain consistent.

The psychological needs of bats in captivity, both temporary and permanent, must be met to ensure overall health and normal behavior. The American Veterinary Medical Association (AVMA) defines animal welfare as "all aspects of animal well-being, including proper housing, management, nutrition, disease prevention and treatment, responsible care, humane handling, and when necessary, humane euthanasia. It is important to recognize that psychological well-being is a significant factor in disease prevention, as behavioral changes and deterioration in physical condition can occur when psychological needs are neglected."

Flighted and Non-flighted Bats

Flying is an important aspect of the psychological and physical health of fully flighted captive bats, and of critical importance if those bats are intended for release. It is therefore inappropriate to house flighted bats in enclosures that do not allow them to fly. Flighted pregnant females that are allowed unrestricted flight will experience fewer complications during the birthing process. Bats incapable of flight, such as bats that are permanently disabled due to injury, can also lead enriched lives in captivity and will often reproduce, providing they receive stimulation in the form of roostmates and a diverse environment.

CREVICE BATS

The social needs of bats in captivity is just as important as environmental factors such as heating, lighting and the enclosure they are house in. Many crevice-dwelling bats are gregarious and colonial. The most valuable thing that can be done to enrich the life of a colonial bat in captivity is to provide it with roostmates. Crevice bats should not be housed alone unless absolutely necessary. In circumstances where crevice bats must be housed alone, providing enrichment and simulated natural habitat will greatly enhance the emotional stability of the bat.

Deprivation of companionship in colonial bats has been known to result in symptoms that include anorexia, obesity, vomiting, hair loss, enclosure chewing, and death. Examples include an adult big brown (*E. fuscus*) that was utilized as an educational animal in a zoo for eight years. Other than a female big brown housed in an adjacent enclosure, this male big brown lived in isolation his entire life. Shortly after the female died, the male bat's physical condition began to deteriorate. He stopped self-feeding, became anorexic, and began to lose fur. The bat was ultimately transferred to a facility that housed non-releasable *E. fuscus*, where he immediately clustered with three big brown females upon introduction. He accepted blended food later the same evening, and was again self-feeding the following day. Another example is that of a Brazilian free-tailed bat (*T. brasiliensis*) which was housed alone at a wildlife center where he was being used for outreach educational programs. The bat was able to fly but was housed in a small enclosure that would not allow flight. After six months in captivity he developed what appeared to be gastrointestinal problems and would vomit profusely after every meal. The bat was fed a diet of mealworms supplemented with Vionate®, a vitamin and mineral powder sprinkled on the worms. After suffering from extreme weight loss, but not finding any physical cause, he was transferred to our

facility where he was introduced to a small colony of free-tailed bats that were housed in a spacious, simulated natural habitat flight enclosure. Within minutes the bat was tightly wedged into a cluster of his own species. No further vomiting was observed after arrival, even though he received mealworms which also were sprinkled with Vionate® powder. Johnson (1997) states that individual pallid bats housed with a colony will change their behavior when housed separately. A pallid bat housed in the "Bat Lab" at New York University appeared more irritable and likely to bite after being separated for a few days; another appeared more lethargic and inactive after it was housed alone.

Figure 4-1. A big brown (*E. fuscus*), a free-tailed bat (*T. brasiliensis*), and a cave bat (*M. velifer*) sharing a vivaruim foam roost. *Bat World facility*. *Photo by A Lollar.*

Roost Mates

Colonial, crevice-dwelling bats should always be provided with roost mates, even though they may not always roost together. Ideally, roostmates should be of the same species, although other species will suffice when individuals of the same species are not available (Figure 4-1). It is not humane to force a colonial bat to lead a solitary captive life. Housing a lone colonial bat in a enclosure that is placed against another enclosure housing a colonial bat is not sufficient. Colonial bats should be housed together in the same enclosure.

The author has enclosured the following species together, without incident, when flight areas were available: *A. pallidus, E. fuscus, M. lucifugus, M. velifer, T. brasiliensis, N. humeralis, E. perotis, N. macrotis, N. femorasaccus and L. noctivagans.* Although pallid bats (*A. pallidus*) have been reported to eat smaller bats in captivity (Engler, 1943), Lollar housed a male with a colony of Brazilian free-tailed bats (*T. brasiliensis*) without evidence of carnivory. Brazilian free-tailed pups were born into this colony and were found on more than one occasion nestled under the wing of the pallid bat. This colony was provided with an unlimited supply of mealworms each evening. Lack of an abundant food supply might be responsible for early reports of carnivory, behavior the author has not observed in any of the insectivorous species cared for over the past three decades.

Pipistrelles (P. *subflavus, P. hesperus*) have been housed without incident with Brazilian free-tails (*T. brasiliensis*) and evening bats (*N. humeralis*). Evening bats are much "fussier" bats than the Brazilian free-tailed bats (*T. brasiliensis*), however, and will sometimes make loud, complaining screeches when annoyed. It is not recommended that pipistrelles be enclosured with any of the larger crevice-dwelling species such as big browns

(*E. fuscus*), pallid bats (*A. pallidus*), mastiff bats (*Eumops*), big free-tailed bats (*Nyctinomops macrotis*), or the California leaf-nosed bat (*Macrotis californicus*). Although big brown bats (*E. fuscus*), pallid bats (*A. pallidus*), mastiff bats (genus: *Eumops*), and big free-tailed bats (*N. macrotis*) are typically gentle in captivity, it is not usually a good idea to enclosure the smallest bats with the larger ones.

There are detailed accounts of a number of mammalian species (e.g., *Mammalian Species Accounts*) written by different authors and published by the American Society of Mammalogists. These accounts include information about distribution, ecology, and behavior. Information about roosting patterns will be of value. For example, some crevice-dwellers cluster together in tight groups while roosting. Others roost somewhat separated from one another.

Mating may occur when males and females are housed together, particularly over long periods of time. Mating activity can include aggression and territorial defense. Males frequently sustain bites or other injuries during aggressive interactions. Sexually active males that are housed with females may also react aggressively toward (i.e., bite) the caretaker. Therefore, it may be preferable to segregate males and females. Neutering of males is another option for permanent captives (see Orchiectomy).

Table 4
Crevice Bat Roosting Patterns

Number	Species	Have been found in roosts with species listed in number:
Family Mormoopidae		
1	*Mormoops megalophylla* (Peters' ghost-faced bat)	26, 38
Family Phyllostomidae		
2	*Artibeus jamaicensis* (Jamaican fruit-eating bat)	
3	*Choeronycteris Mexicana* (Mexican long-tongued bat)	9
4	*Leptonycteris yerbabuenae* (Lesser long-nosed bat)	9
5	*Leptonycteris nivalis* (Long-nosed bat)	9
6	*Macrotus californicus* (California leaf-nosed bat)	38
Family Vespertilionidae		
7	*Antrozous pallidus* (Pallid bat)	9, 11, 16, 25, 28, 30, 38
8	*Corynorhinus rafinesquii* (Rafinesque's big-eared bat)	9, 31
9	*Corynorhinus townsendii* (Townsend's big-eared bat)	3, 5, 7, 8, 12, 25, 26, 38
10	*Euderma maculatum* (Spotted bat)	
11	*Eptesicus fuscus* (Big Brown bat)	1, 7, 22, 23, 26, 28, 38
12	*Idionycteris phyllotis* (Lappet-browed bat)	9, 25
13	*Lasionycteris noctivagans* (Silver-haired bat)	23, 31

14	*Myotis auriculus* (Southwestern myotis)	
15	*Myotis austroriparius* (Southeastern myotis)	22, 38
16	*Myotis californicus* (California myotis)	7
17	*Myotis ciliolabrum* (Western small-footed Myotis)	
18	*Myotis evotis* (Long-eared myotis)	
19	*Myotis grisescens* (Gray myotis)	24
20	*Myotis keenii* (Keen's myotis)	
21	*Myotis leibii* (Small-footed myotis)	
22	*Myotis lucifugus* (Little brown bat)	11, 15, 23, 26, 28
23	*Myotis septentrionalis* (Eastern or Northern Long-eared myotis)	11, 13, 22, 31
24	*Myotis sodalis* (Indiana myotis)	19
25	*Myotis thysanodes* (Fringed myotis)	7, 9, 12, 26
26	*Myotis velifer* (Cave myotis)	1, 9, 11, 29, 26, 28, 38
27	*Myotis volans* (Long-legged myotis)	
28	*Myotis yumanensis* (Yuma myotis)	7, 11, 22, 33, 45
29	*Nycticeius humeralis* (Evening bat)	45
30	*Parastrellus hesperus* (Canyon bat)	7
31	*Perimyotis subflavus* (Tri-colored bat)	8, 13, 23
Family Molossidae		
32	*Eumops floridanus* (Florida bonnetted bat)	
33	*Eumops perotis* (Western mastiff bat)	
34	*Eumops underwoodi* (Underwood's mastiff bat)	
35	*Molossus molossus* (Pallas' mastiff bat)	
36	*Nyctinomops femorosaccus* (Pocketed free-tailed bat)	
37	*Nyctinomops macrotis* (Big free-tailed bat)	
38	*Tadarida brasiliensis* (Brazilian free-tailed bat)	1, 6, 7, 11, 15, 22, 26, 28, 29

Furniture

Items intended for roosting and enrichment (i.e. furniture) should be made of materials that are easily cleaned and appropriate for the species. Roosting pouches, vivarium foam, reptile rocks and towels made of non-snagging materials all provide enrichment as well as hiding spots. Enrichment items should be clean and free from sharp edges or small holes where fingers, wrists and toes may become trapped. They should contain an opening large enough to allow the handler to easily reach inside and extract a bat if needed. It is important to take note of the spot that the bats have chosen to use as a day roost, as that roost needs to remain the same both in object and location. When this roosting spot becomes soiled, a duplicate should be available in order to mimic the preferred roosting item as closely as possible. Design the interior of an enclosure to accommodate the individual needs of a captive bat. For example, if a colony of non-flighted bats contains one or more amputees, then fill the enclosure with a variety of roosting pouches and vivarium foam items to allow these bats to nimbly move around the entire enclosure with little difficulty.

Roosting Items for Crevice Bats

Although some species, such as Corynorhinus, prefer to roost openly in both roosting and flight enclosures, most crevice-dwellers will require a choice of several areas within the roosting enclosure where they can hide in the dark folds of a soft cloth. Fabric roosting pouches (Figure 4-2A) provide crevices for bats to hide and roost without risking injury. The dark crevices simulate a natural environment. Pouches can be attached to the inside of roosting enclosures as described in Temporary Housing. They can also be placed flat inside Bat Huts and on roosting shelves.

Figure 4-2. A: A roosting pouch made of denim. **B:** Three free-tailed bats hanging inside a roosting pouch (*T. brasiliensis).* **C:** A big brown bat in a roosting pouch (*E. fuscus)*. **D:** A free-tailed bat enjoying hand-fed worms while sitting in a roosting pouch (T. brasiliensis). *Bat World facility. Photos by A. Lollar.*

Pet Tech Magnaturals large hideaway (Figure 4-3A) is made of lightweight foam polymer and measures 13" x 7.5" x 5.75". This piece has high-powered magnets embedded in the resin (Figure 4-4B). Roosting pouches do not fit inside this item so it is best used for enrichment purposes only (Figure 4-3c).

Reptile rocks made of plastic polymer make excellent roosts for molossid bats (Figure 4-3D & E). The rocks in these photos are mounted inside a galvanized metal enclosure as described in Permanent Housing. A fabric roosting pouch should be placed inside larger reptile rocks for cushioning and warmth, as well as ease of gathering bats from within.

Figure 4-3. A & B: A Pet Tech Magnaturals large hideaway. **C:** A big brown bat sitting in a hideaway mounted on the ceiling of a simulated cave (*E. fuscus*). D: A big free-tailed bat roosting in a roosting pouch placed inside a reptile rock made of plastic polymer. (*N. Macrotis*) **E:** A mastiff bat peers out of her roosting rock which is mounted with the opening facing the bottom. *(E. perotis). Bat World facility. Photos by A. Lollar.*

Cleaning

Foam and plastic polymer rocks should be cleaned as needed by scrubbing the entire rock using a small brush dipped into a 10% bleach solution along with a small amount of dish soap, then rinsed well. The rocks should be dried thoroughly before use. Alternately, these rocks can also be placed into a facility dishwasher and cleaned using the regular cycle intended for dishes. Pouches must be turned inside out and washed in the washing machine using unscented detergent. Dry pouches in the dryer inside out, turning right side out mid way through the dryer cycle to ensure the material is dried throughout.

Vivarium Foam Products

Vivarium foam products provide a unique, natural looking environment and also make excellent roosting and enrichment items for crevice bats (Figure 4-4). The foam can be carved to create larger holes when necessary so several bats can roost together in comfort. Foam roosts also aid in creating additional humidity when multiple bats roost inside. These items can be stacked inside enclosures or hung with magnets as described on the following page.

Figure 4-4. A: A "Peek-a-View Burrow," size large. The burrow has been cut in half for ease in laundering (see following page). The two halves are pieced back together to hang. This burrow is hanging inside a flight area (see flight enclosures). **B:** A big brown (*E. fuscus*) roosting inside the burrow. **C:** A cluster of free-tailed bats (*T. brasiliensis*) roosting inside a burrow. (Note that one of the bats has fur clipped between the ears, making him easier to spot due to the white patch on his head. This fur was clipped four months prior.) *Bat World facility*. *Photos by A. Lollar.*

Modifying Foam Products for Bats

This foam piece measures 20” x 6” x 4” (Figure 4-5). It is best to cut the item in half for ease in laundering. The two halves are pieced back together to hang (Figure 4-5A). Both entrances to this item should also be enlarged and deepened by carefully carving the foam (Figure 4-5B). A serrated knife works well for this purpose. Nickel coated neodymium magnets are affixed for hanging (Figure 4-5E). Always use caution as neodymium magnets are very strong and will snap together forcefully when placed within inches of each other. (Regular magnets are not recommended as they lack the strength to hold objects securely in place.) Be careful to keep individual neodymium magnets well separated from each other to avoid pinching fingers.

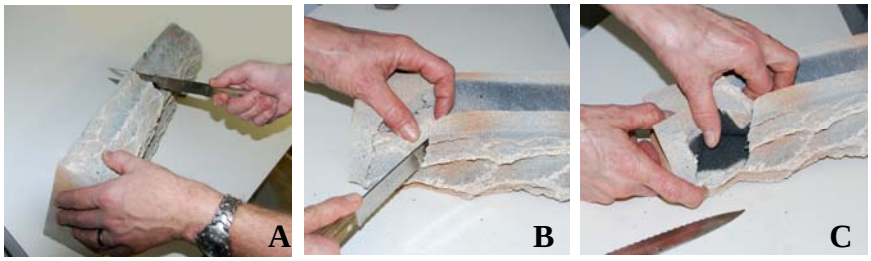


Figure 4-5. A: A Peek-a-View burrow being cut in half. Cut the foam burrow in half using a serrated knife or similar cutting tool. **B and C:** Enlarge the opening by carving out sections of foam.

Figure 4-5. D and E: Create a pocket in the center back of the burrow by making a slit into the foam that measures about 1/2” wide and about 1” deep. Insert a 1/2” x 1/4” x 1/8” magnet deep inside this pocket so that it is completely inside the foam and cannot be seen. **F:** Attach a second magnet measuring 3/4" x 1/4" x 1/4” to the outside of the foam. The magnetic force will hold both magnets in place. **G:** Item can then be attached to the metal framework of mesh enclosures as well as flight enclosures (see Permanent Housing, Flighted Bats).

This foam hiding log (Figure 4-8h) measures 10.5” x 9” x 6.25". The bottom of the log is solid foam and should be carved out as shown to accommodate more bats. These logs are not recommended for hanging but should be stacked on top of one another to hold them in place (Figure 6-1B and Figure 6-2). Alternately they can simply be laid flat to provide enrichment (Figure 6-13B, E and F).

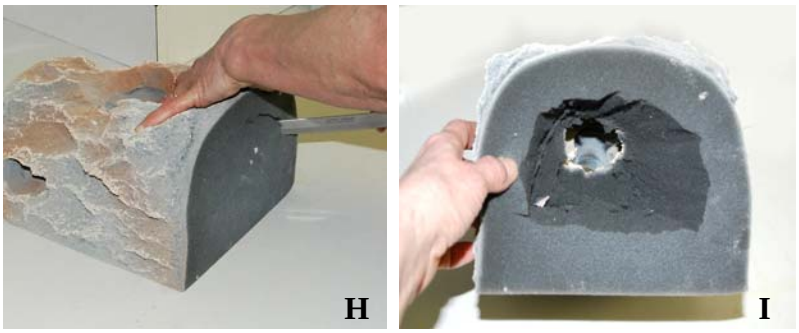


Figure 4-5. H and I: Use a serrated knife to carve out the foam hiding log to accommodate bats.

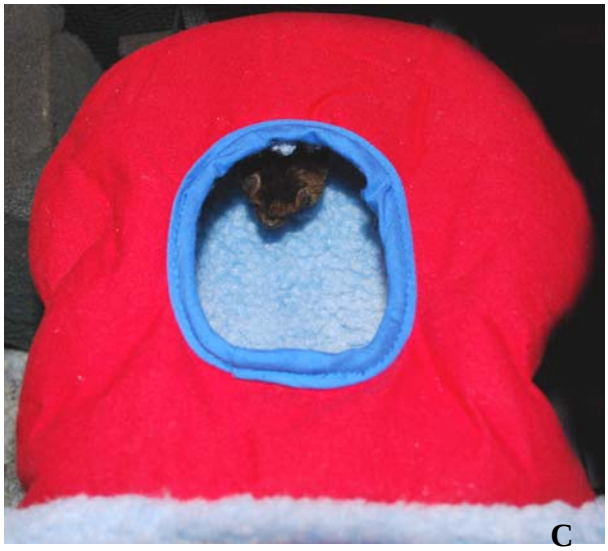
Cleaning

Foam roosts should be washed in the washing machine using unscented detergent and bleach. A cold water setting will help to extend the life of the foam. Do not place foam roosts in the dryer, instead, allow them to air dry. All magnets should be removed and set aside prior to washing, then replaced into their slots as the foam roost is air drying. Note: When carrying magnetized foam roosts, be careful not to stack one magnetized side against another magnetized side as they will snap together and be difficult to remove without tearing the foam.

Additional Roosting Items for Crevice Bats

Products made for small birds, ferrets and other animals sometimes make excellent roosting and enrichment items for bats (Figure 4-9). The items below are examples of items that require minimal modifications for use with insectivorous bats. Some come with ties attached to the top that enable them to be hung from the enclosure ceiling or enclosure frame.

Figure 4-6. A: A "Happy Hut™" made for small birds. Measures 1.5" x 7" x 4.5". Pallid bat (*A. pallidus*). *Photo by A. Lollar.* **B:** "Hide a Squirrel™" dog toy. (Comes with three squirrel toys inside.) The empty plush tree trunk makes an excellent roost for tree bats or enrichment for crevice bats. Measures 6.5" x 7.5": x 6.5". *Photo by L. Sturges.*



C: A "Snuggle Sack™" made for small birds. Measures 8" x 6" x 9". Big brown bat (*E. fuscus*). Bat *World facility. Photos by A. Lollar.*

TREE BATS

Roostmates

Adult tree bat species received from the wild as adults should always be housed separately. An exception to this rule is females received with nursing pups. Many of the tree-roosting species have two to five pups in each litter, and they stay closely clustered during infancy, clinging to one another as they hang from the branches of a tree or other foliage where the mother places them when she leaves to feed at night. Orphans will cluster together in a similar manner in captivity and fare better when housed together (Figure 4-7A and B).

Figure 4-7. A: Orphaned red bat pups. (*L. borealis*). *Photo by J. Laney*.

A mother and her pup(s) should also be housed together until the pups have been weaned and are being hand-fed. At that time, the mother should be separated from the pups, the males in particular, because they begin interacting aggressively as they mature. It is best if pups are allowed to remain together until they are about three months of age, and then the sexes should be separated. This is particularly important for males. While female siblings sometimes continue to roost side by side, even grooming one another for as long as a year, males tend to roost somewhat separated from one another in the same enclosure and commonly make warning sounds (i.e., clicking) if another bat moves within 3" to 6" of them. (Females occasionally demonstrate the same behavior.) It may be best if bats demonstrating this behavior are enclosured separately from others.

Figure 4-7. B: Juvenile red bat pups (*L. borealis*) on the ceiling of a flight enclosure. *L. borealis. Bat World*

Yellow bats (*L. ega, L. intermedius,* and *L. xanthinus*) and hoary bats (*L. cinereus*) can be maintained in the same manner as red bats (*L. borealis*).

Although the author has found hoary bats (*L. cinereus*) to be gentle and tolerant of other species in captivity, they have been known to pursue and kill pipistrelles in the wild. Because of this, and the fact that lasiurine bats can be somewhat temperamental (*L. borealis* and *L. seminolus* in particular), it is not generally recommended that other species be housed with any of the tree-roosting species.

Several hand-raised tree bats have remained together in a full-sized flight enclosure for years without incident at Bat World Sanctuary, although artificial branches and artificial foliage secured to the enclosure ceiling separate the preferred roosting spots of these bats by several feet.

Furniture

Environmental enrichment can be provided for solitary bats by providing items in their enclosure that provide visual and tactile stimulation such as artificial foliage as well as natural leaves and small branches from trees (Figure 4-11A). Items should be secured to the enclosure ceiling with zip ties which are tied from the outside. Trim and smooth sharp branches or wires which may protrude from artificial plants before attaching these items to the enclosure. Rough tree bark and branches or thick grape vines, including some that are as large as 1" in diameter, are good choices (Use only branches with roughened, not smooth, surfaces.)

Withered leaves should be removed as they crumble easily and litter enclosures, however, dry branches can be left in enclosures and may contribute to foot health and aid in naturally trimming the toe claws. Some tree bats prefer to roost in small wicker baskets that have been hung upside down from the enclosure ceiling.

Tree bats are prone to abrasions on thumbs, forearms and toes in captivity. Enclosures such as Reptariums are convenient for the handler but seem particularly hard on the feet and thumbs of tree bats and should therefore be lined with Rubbermaid®, Duck or Con-Tact® weave drawer liner (Figure 4-8B). Breeze enclosures and similar type soft mesh crates constructed with plastic weave are not as abrasive to the feet and thumbs of tree bats and do not require being lined. Camouflage flannel fabric can also be used to provide roosting spots for tree bats (Figure 4-8C) and is helpful for bats that are healing from injuries or those who have foot and toe problems and thus require a soft surface on which to hang.

Figure 4-8. A: Red bat (*L. borealis*) roosting in fall-colored leaves. *Bat World NoVa facility*. Photo by L. Sturges. **B:** A hoary bat (*L. cinerus*) roosting against a wall of the enclosure lined with Rubbermaid™ weave shelf liner. **C:** Silk foliage and camouflage flannel fabric inside a tree bats enclosure. *Bat World Lone Star facility. Photos by D. Hyatt.*

Figure 4-9. A: A red bat mother with her juvenile pups (*L. borealis*) hanging in a BatHut. *Bat World MidCities facility. Photo by K. Rugroden*. **B:** A cube enclosure filled with enrichment items to restrict the movement of an injured yellow bat. *L. intermedius*. *Bat World Lone Star facility. Photo by D. Hyatt.*

Bat Huts are good choices for temporarily housing tree species. A vivarium foam log, cloth napkin or a surgical towel can be attached to the ceiling of the enclosure to provide enrichment and more options from which to hang (Figure 4-9A). Alternately, soft mesh cube enclosures (Figure 4-9B) provide excellent temporary housing for tree bats when limited movement is preferred such as bats healing from injuries, mother bats with pups, and panicked bats prone to thrashing and injuring themselves on surfaces. In these cases, it is advisable to add enrichment items to the enclosure which will both help to calm the bat as well as restrict movement, such as foam logs and "hide-a-squirrel" dog toys.

Figure 4-9. C and D: Rubbermaid weave shelve liner being inserted into the framework of a crate. The bars used to stabilize the crate help to hold the green mesh in place. **E:** A red bat hanging from the ceiling of a Breeze enclosure, which is constructed with plastic weave and is not abrasive to the feet and thumbs of tree bats. *L. borealis*. *Bat World facility. Photo by A. Lollar.*

CHAPTER FIVE

DISHES

Mealworm Dishes

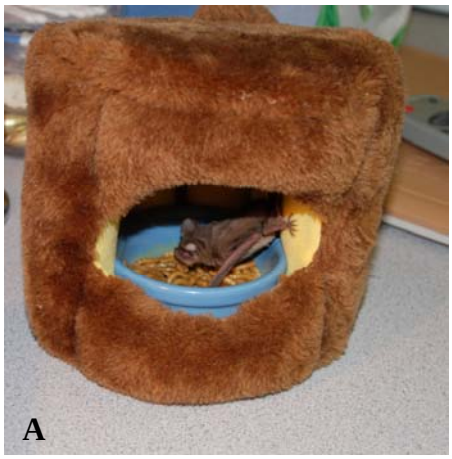
A wide assortment of dishes can be used for bats that self-feed from dishes. Dishes should be deep enough to allow the bottom of the dish to be completely covered with an ample supply of mealworms but shallow enough to allow bats to easily climb in and out of the dish. Dishes 1" to 2" deep work best for most species of insectivorous bats. A minimum of four 5" x 2"x 2" deep mealworm dishes should be provided per every ten bats. It is important to remember that mealworms can easily climb on roughened surfaces, so use dishes with a smooth surface to prevent mealworms from escaping.

CREVICE BATS

One side of the food dish should be placed against a surface on which the bat can cling. Placing trays against the walls of the enclosure allows a bat to crawl down the side of the enclosure and feed from a tray while still hanging upside down. Some bats choose to sit directly inside the dish of mealworms as they feed. Dishes placed against a climbable surface enable these bats to easily climb out when they are ready to leave the dish. For an added sense of security, the dish can be placed directly beneath a roosting cloth or pouch so shy bats can grab a worm and then crawl back into a hiding area to eat (Figure 5-1D). Do not place worms directly under roosting areas as worms may be contaminated with urine and feces. All dishes and water containers should be emptied and washed in an antibacterial detergent daily. Rinse thoroughly with hot water.

Figure 5-1. A: A Magnaturals Mushroom Ledge holds two small dishes of mealworms. The dish is magnetized and held to the enclosure wall with magnets which are attached to the outside of the enclosure. The ledge sits on top of a foam log to prevent it from tipping forward and spilling the mealworms. *Photos by A. Lollar*.

Figure 5-1. C: An enclosure shared by 15 self-feeding, non-flighted free-tailed bats (*T brasiliensis*). Plastic containers measuring 5" x 2.5" x 2" deep provide ample opportunity for all the bats to self-feed nightly. **D:** The dishes are placed with one side against a surface that allows the bat to easily climb in and out of the dish. *Bat World Lone Star facility. Photos by D. Hyatt.*



A Multipet Tree House is excellent for both training bats to self-feed as well as providing a secure place for shy bats to self-feed (Figure 5-2A). The Tree House measures 6.5" high and 5" in diameter. A glass crock measuring 3.5" x 1.75" can be placed into the bottom to hold mealworms. This item can be washed in the washing machine but should be air dried.

Figure 5-2. A: A free-tail bat self-feeding on mealworms. *T. brasiliensis Photo by A. Lollar.* **B:** An EcoGen™ Magnetic Bin can be attached to metal enclosure surfaces (see Permanent Housing). This tray measures 4" x 2" x 1.25" and is made of biodegradable material. *Photo by A. Lollar.*

Rubbermaid® drawer organizers can be used when feeding large colonies of bats (Figure 5-3A), however, wide rectangular trays as pictured below are not recommended due to the volume of waste that will occur when groups of bats sit inside the pan to eat, subsequently urinating and defecating onto the mealworms (Figure 5-3B). Instead, an art or jewelry organizer with rounded bottoms works very well. Elastic bands measuring 1.5" wide are used to create a bridge that enables bats to walk across the tray and grab mealworms from various compartments (Figure 5-3C). Bats cannot comfortably fit into the small compartments and instead sit on the elastic bridge, which absorbs urine (Figure 5-3D). This results in fewer wasted worms and a healthier feeding environment.

Figure 5-3. A: A Rubbermaid® drawer organizer measuring 9.5 x 7" x 2" deep. The tray on the left is filled with fresh worms. **B:** Waste which occurred from the previous night's feeding. Almost all the leftover worms are dead. **C:** An art/jewelry organizer, lid removed, measuring 13.5" x 8.75" x 1.25" deep. Each compartment measures approximately 2" x 2". The tray on the left is filled with fresh worms. **D:** The small amount of waste from the previous night's feeding. The black elastic shows crystallized urine that would have otherwise ended up on the worms. *Photos by A. Lollar.*

TREE BATS

Tree bats prefer to hang over the dish and on a comfortable surface while they eat, so the food dish should be placed against a enclosure wall or other surface to enable the bat to cling from above (Figure 5-4A). Tree bats will often urinate into the dish of worms as they feed. Allowing these bats to roost on an absorbent surface while feeding helps to prevent this from occurring.

Tree bat pups can be fed from the same dish (Figure 5-4C); however, after six months of age these bats prefer to be somewhat separated as they feed.

Small coop cups (Figure 5-4B) can also be hung from the netting of enclosures while the bats cling to the enclosure from above the dish.

Figure 5-4. A: A hoary bat self-feeds from a dish. *L. cinerus. Bat World Lone Star facility. Photo by D. Hyatt.* **B:** Small bird coop cups can be attached to mesh caging.

Figure 5-4. C: A small plastic storage container measuring 9" x 7.5" x 5.5" has been converted into a "tree bat feeder." The container is turned on its side, plastic mesh has been cut to fit the back wall and secured into place with zip ties through holes drilled into the bottom. A mesh lid has also been secured to the front of the enclosure with zip ties. The lid can be lowered and secured into place with hook and loop tabs when necessary. A black office drawer organizer serves as a dish that measures 6.5" x 3.25" x 2" deep. Red bats. (*L. borealis*). *Bat World facility*. *Photo by A. Lollar.*

Water Dishes

Water dishes can be created from numerous small objects including plastic bottles and small pill containers. Plastic has a tendency to absorb bacteria, although hard plastic, which coop cups are made of, is less absorbent than soft plastics. Glass and stainless steel items are the preferred choices for water dishes because they do not absorb bacteria and have a resistance to biofilm adherence. Galvanized items are not recommended as they are hard to clean, can oxidize, and may pose toxic risks to bats.

Bat World Sanctuary recommends a depth of 1/4" to 3/4" for water dishes, however deeper dishes can be used providing they are filled with marbles (Figure 5-6E) to prevent a bat from falling completely into the water and becoming immersed. A minimum of four 1/4" deep water dishes or two 3/4" water dishes should be provided per every ten bats.

Water dishes should be placed in an area of the enclosure that remains dark during the day so bats may drink without the stress of exposing themselves to light. Avoid placing water dishes under areas where bats may congregate and contaminate the water by dropping feces and urine into the dish. Alternately, a cover can be fashioned over the water to keep it clean. Once locations are chosen, water dishes must remain in the same spots within the enclosure to avoid confusion and undue thirst. Additionally, never fill a water dish with mealworms or vice-versa. Captive bats have been observed attempting to drink by licking the sides of a dish that previously contained water but instead had been filled with mealworms (M. Singleton, pers. comm.).

Crevice bats should have numerous water dishes placed throughout their enclosure. Tree bats should have a water dish within reach of their daytime roosting spot (Figure 5-5). These bats easily become dehydrated in captivity and therefore must have water that is readily accessible at all times to encourage them to drink.

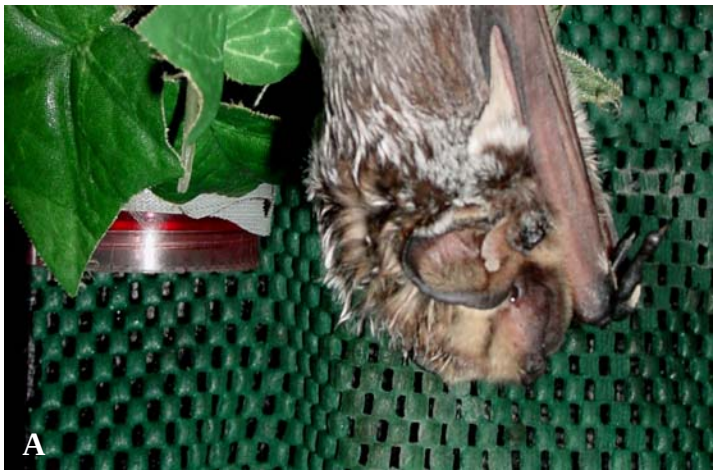


Figure 5-5. A: A modified round 1.5" x .5" "stacking organizer" used as a water dish and hanging within reach of a hoary bat (*L. cinerus*). Also see Figure 5-5D. *Bat World Lone Star facility. Photo by D. Hyatt.*

Simple water dishes that are appropriate for temporary housing can be created by using small plastic bottles such as one-ounce Boston Rounds (Figure 5-5B) or small travel bottles. Use scissors to cut the container according to the shape in the photo (Figure 5-5C). Be sure to round the sharp edges of the top of the container. Use a zip tie to create a snug-fitting loop that will allow the handle of the dish to slide in and out. The zip tie should be secured from the outside of the enclosure (see example in Figure 3-4E).

Figure 5-5. B: A small bottle known as a Boston Round. **C:** The bottle modified into a water dish. **D:** A stacking organizer attached to the support post of a mesh enclosure using a hook and loop strap.

Plastic water dishes should be washed with detergent and bleach, then rinsed thoroughly and refilled with fresh water twice daily to help prevent bacteria build-up. The glass and stainless steel water dishes described on the following page should be washed and refilled with fresh water once daily.

The importance of sanatizing water dishes on a daily basis cannot be overly stressed. Dirty water dishes can lead to the accumulation of bacterial biofilm, which is a slimy substance that can stick to the inside walls of water dishes. Biofilm can cause middle ear and sinus infections, the formation of dental plaque, gingivitis, endocarditis, systemic inflammation, cardiovascular disease, urinary tract infections and chronic kidney disease.

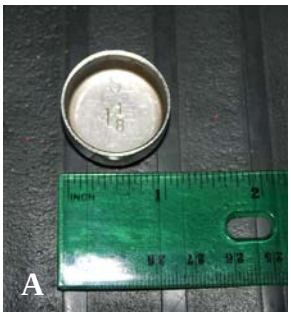


Figure 5-6. A: A stainless steel expansion plug. **B:** A tricolored bat (*P. subflavus*) drinking water from the small plug. Note the pouch above the water, which keeps the water clean by preventing debris from falling into the dish from above. *Photo by D. Hyatt.*

Stainless steel automotive expansion plugs (size 1 1/8" x 1/4") make excellent water dishes for insectivorous bats (Figure 5-6). Additionally, these plugs fit inside a modified Boston Round as pictured on the previous page.

Glass Petri dishes have been used in the past for both food and water dishes for insectivorous bats, however, these dishes are expensive, fragile and easily broken. Glass furniture casters (Figure 5-6C), available at thrift and antique stores, provide the same basic antibacterial properties as Petri dishes with the benefits of being heavier, less prone to tip over, and virtually unbreakable. Magnaturals (magnet powered terrarium environments made for reptiles) offer a water dish that can be attached to the side of crevice bat caging with magnets (Figure 5-6E). However, because this dish is over 1" deep it must be filed with marbles to prevent drowning.

Figure 5-6. C and D: Glass furniture caster measuring 2 1/4" x 3/4". A high-density foam block modified to hold a glass furniture caster. Free-tailed bat (*T. brasiliensis*). *Photo by A. Lollar.* **Figure 5-6. E:** A Magnaturals Rock Ledge Water Dish filled with marbles. An additional magnetic ledge has been placed above the water dish to prevent water from becoming soiled from the bats roosting above. *Bat World facility. Photo by A. Lollar.*

CHAPTER SIX

PERMANENT HOUSING AND FLIGHT ENCLOSURES

Housing for Non-Flighted Crevice Bats

The minimum permanent enclosure size for non-flighted crevice bats should be no smaller than two times the wingspan of the largest bat enclosed, and eight times the body length of the bat in height. An enclosure of this size is appropriate for as many as ten medium-sized (10g to 15g body weight) non-flighted colonial bats. Enclosure dimensions should increase appropriately when containing additional bats. If a heat source is provided by use of a heating pad, it should be placed only on one side of the enclosure in order to create a thermal gradient. It is important to note that heat is not required for healthy adult bats. Supplemental heat can cause dehydration, and even thermal burns, especially if placed on high settings. Therefore, if a heating pad is used it should only be used on a low setting, and should always be attached to the outside of the enclosure. In addition, several layers of cloth should be placed between the heating pad and the outside of the enclosure.

It is important that enclosures are not constructed from materials such as glass, Plexiglas, or other slick materials. Bats slip on these types of materials, causing them to panic and frequently sustain injury. Wood is not a good choice as it absorbs odor and can be difficult to clean (although that should never be used as an excuse for not adequately cleaning a enclosure—Figure 6-1C). Instead, soft mesh dog crates should be used as many of these products are netted almost entirely throughout and are easily modified into permanent housing for insectivorous bats (Figure 6-1A). In addition these enclosures can be thoroughly cleaned by removing enclosure covers for laundering and scrubbing frames.

Crates that feature a side opening are preferable as this allows the handler more convenient access to the bats (Figure 6-1B). For added convenience, enclosures should ideally be positioned so that the interior of the enclosure is at eye level. Bat enclosures must be kept in rooms that are not accessible to children, pets, or wildlife. A roosting enclosure can be placed inside a netted flight enclosure on a table or shelf to accommodate both flighted and non-flighted bats. The roosting enclosure door can remain open to allow flighted bats access to a flight area.

Figure 6-1. A: A soft mesh dog crate with a zippered door. The crate measures 18” x 24” x 28”. Several different roosting and enrichment items are available throughout the enclosure which provides housing for 15 non-flighted crevice bats*. Photo by D. Hyatt.*

Figure 6-1. C: Inappropriate dirty wooden housing for insectivorous bats, measuring 12” x 12” x 18”. *Photo by A. Lollar.*

Note: Non-flighted bats may attempt to fly inside flight enclosures when enclosure doors are left open. Others will simply take advantage of the increased space and explore or choose to roost in areas of the flight enclosure rather than the roosting enclosure itself. A mesh ladder or other means of gaining access back into the roosting enclosure should be made available to non-flighted bats (see Flighted Bats in this section).

Although some species, such as Corynorhinus, prefer to roost openly on the ceiling of roosting enclosures, most crevice bats will require a choice of several areas within the roosting enclosure where they can hide in the dark folds of a soft cloth, a roosting pouch, or vivarium foam (Figure 6-2). These dark crevices simulate their natural environment. Rubbermaid weave should be attached to any walls and ceilings that are not netted to allow the bat to climb throughout the enclosure interior. Cork bark should never be placed in bat enclosures because particles of bark may adhere to the bat's toe claws and subsequently be ingested when bats clean their toes with their mouths.

The interior of permanent housing for crevice bats should contain a variety of roosting areas and take into consideration the individual needs of the bats being housed. A single enclosure can provide housing for several different species as long as roosting apparatus meets the needs of each species.

Figure 6-2: Vivarium foam hiding logs (stacked together), a bridge made of plastic mesh, roosting pouches, non-snagging towels and a Happy Hut create security as well as enrichment for permanent non-flighted captive bats. Foam burrows are also mounted on the ceiling using magnets. *N. humeralis. Bat World facility. Photo by A. Lollar.*

In other words, *N. humeralis, M. lucifugus, T. brasiliensis and P. subflavus* can be successfully housed together providing there are enough diverse roosts available inside the enclosure to accommodate each species of bat. A enclosure housing these four species should contain roosting pouches, vivarium foam items, reptile rocks, silk foliage and other items that will provide mental stimulation (see Enrichment). Alternately, bridges, ramps and a variety of other items can be made of wood, fabrics, and plastic craft mesh. Avoid items made of loose knit fabrics such as terry cloth that may snag claws and result in injury.

Openings into enrichment items and roosts placed inside roosting enclosures should be wide enough to allow the caretaker to insert an entire hand to retrieve a bat, and should be carefully designed so that they do not provide traps where wings or legs can be caught. Bats often intentionally wedge themselves into the back corners of a roosting pouch or other objects, and can easily be coaxed forward by gently pushing the outside corner where they are roosting.

As previously mentioned, it is important to take note of the spot that the bats have chosen to use as a day roost, as that roost needs to remain the same, both in object and location, at all times. When this roosting spot becomes soiled, a duplicate should be available in order to mimic the preferred roosting item.

Figure 6-3. A: A reptile rock and modified vivarium foam provide a safe and enriched environment for non-flighted bats such as amputees. Note the reptile rock is covered with a surgical towel to protect bats that may fall from above onto the rough surface. *Bat World Lone Star facility. Photo by D. Hyatt*. **B:** An evening bat (*N. humeralis*) peers out of a vivarium foam hiding log. *Photo by A. Lollar*.

Housing for Non-flighted Tree Bats

The minimum permanent enclosure size for non-flighted tree bats should be no smaller than two times the wingspan of the bat, and eight times the body length of the bat in height. A enclosure of this size is appropriate for one tree bat. Soft mesh dog crates should be used as many of these products are netted almost entirely throughout and easily modified into permanent housing for tree bats (Figure 6-4). Rubbermaid™ weave should be attached to any walls and ceilings that are not netted to allow the bat to climb throughout the enclosure interior. This foam weave is especially important for tree bats who are prone to thumb and toe injuries (see Enrichment, Tree Bats). A heat source should be available and can be provided by a heating pad placed on the side of the enclosure.

The interior of permanent housing for tree bats should contain a variety of roosting choices for the bat to hide in and sleep. Enrichment in the form of silk foliage, tree bark, or small branches and wicker baskets turned upside down, should also be added to the interior of the enclosure. Tree bats have been known to use Snuggle Sacks, Happy Huts and Hide-a-Squirrels as roosts (see Enrichment). Avoid items made of loose knit fabrics such as terry cloth that can snag claws and result in injury. Instead, flannel, surgical cloths and Rubbermaid shelf liner are recommended.

As previously stated, it is important to take note of the spot that the bats have chosen to use as a day roost in which to sleep, as that roost needs to remain the same, both in object and location, at all times. When this roosting spot becomes soiled, a duplicate should be available in order to mimic the preferred roosting item as closely as possible. Never change an established location of water dishes as foliage bats become easily dehydrated in captivity (see Water Dishes).

Tree bats often flap around on the floor of the enclosure throughout the night, which should not be cause for alarm. This is normal behavior for non-flighted tree bats. Due to this behavior, the floor of a tree bat's enclosure should be thickly padded, and any branches or bark used inside the enclosure should never extend to the floor where they may come into contact with the bat and cause injury. Additionally, water dishes placed on the floor should be positioned against the wall or against an enrichment item such as a vivaruim foam item or a Hide-a-Squirrel. Do not place a water dish in the middle of the floor as the bat may become wet as it flaps on the floor at night.

Figure 6-4. A soft mesh crate measuring 18" x 24" x 28". This enclosure provides permanent housing for one non-flighted tree bat. Several different roosting and enrichment items are available throughout the enclosure. The padded floor is free from clutter to enable the bat to safely flap on the floor throughout the night. *L. intermedius, Bat World Lone Star facility. Photo by D. Hyatt.*

Temporary Indoor Flight Enclosures

Temporary flight enclosures are preferable when limited space is available or when small numbers of flighted bats need to be housed separately for short periods of time (Figure 6-5).

The minimum size for a temporary flight enclosure is 6' x 6' x 6'. A enclosure this size can be created using PVC pipe as framing, with connectors available from greenhouse supply companies. PVC is lightweight and easy to disassemble and move elsewhere if necessary. Construction of the frame requires a pipe cutter and a ruler. The enclosure frame should be covered with appropriate mesh covers. In the example shown below, a custom mesh cover was made from mesh Lumite (BioQuip).

Because the various connectors add dimension it is important to carefully calculate the length of pipe sections before cutting in order to end up with 6' sides. The cross brace must be omitted at the entrance.

The mesh cover does not enclose the bottom of the enclosure, therefore it must be tucked securely under all of the edges to prevent bats from escaping under the bottom framework of the enclosure. Hook and loop tabs, such as industrial strength Velcro® should also be attached to the cover as well as the PVC framework. Note: adhesive-backed hook and loop material is not recommended for mesh covers. Instead, sew-on hook and loop can be attached to mesh by hand-sewing. Foam flooring placed on top of the tucked in sections of the mesh cover, and underneath the PVC framework (pictured above), further help to prevent escapes.

Enrichment, drapes and pouches can be easily attached to the interior frame. Coop cups can be hung directly on the mesh. Silk foliage may be attached to the frame using zip ties. Interior supports can become enrichment by creating 'trees' out of carpet tubes and rubberized shelf lining, as shown to the right. High-density foam tiles can be used for flooring.

Cleaning

Floors should be swept with a broom and mopped with a 10% bleach solution. Covers and frames can be wiped down with soapy water and rinsed in place. The cover should be removed periodically for washing. A spare cover is recommend so a clean cover can be installed with minimal disruption to the bats.

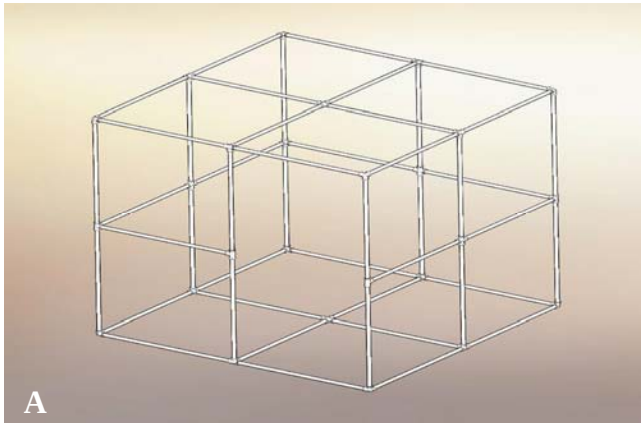


Figure 6-5. A: A PVC frame enclosure. **B** and **C:** PVC bracing. **D:** Foam flooring. **E:** The interior of frame enclosure covered with mesh. *Bat World NoVa facility. Graphic by L. Crittenden.*

Permanent Flight Enclosures

Flight Enclosure Sizes

The minimum acceptable flight enclosure size for flighted microbats is approximately 12 times the wingspan of the largest bat in the enclosure, squared. A flight enclosure measuring 12' x 12' (144 sq ft) will provide enough flight area for up to 20 flighted microbats with 12" to 14" wingspans. Flight enclosure dimensions should increase by two feet in each direction per every 10 flighted microbats contained over the number of 20. The height of the flight enclosure should be 7' to 7'5". This height provides suitable flight for the bats while allowing the ceiling to remain within easy reach of caretakers needing to retrieve bats. The shape of the enclosure can be square, rectangular, or hexagonal.

Entryway

Flight enclosures should have a double door entry (i.e. vestibule) in order to prevent accidental escapes (Figure 6-6). Microbats can squeeze through a crack as small as one-quarter by one inch. Therefore, both doors must fit tightly to the framework to prevent downed microbats from crawling under the door to the outside. The door leading into the flight enclosure should open into the vestibule rather than the flight enclosure to prevent accidents with flying bats. Before opening or closing doors, always check around the framework to make sure no bats are roosting close to the door where they may become crushed as the door is opened or closed.

Construction Materials

Enclosures can be constructed of softwoods as used in home construction, structural plastic lumber made from PVC, or aluminum tubing. Other materials needed are 1/6" polypropylene mesh (for the inside walls), 1/6" heavy duty polypropylene mesh (for the ceiling) and Zoomesh or PVC coated wire mesh if a second layer of mesh is called for on the exterior of the enclosure.

The walls and ceiling of the enclosure should be covered in 1/6" mesh. Never use larger than 1/6" mesh as anything larger will allow the forearm of a bat's wing to slip through the hole as he climbs across the screen, causing severe injury or self-mutilation if the wing becomes trapped (Lollar, 1994). Never use wire mesh on the inside of bat enclosures as it causes injuries to toes and thumbs.

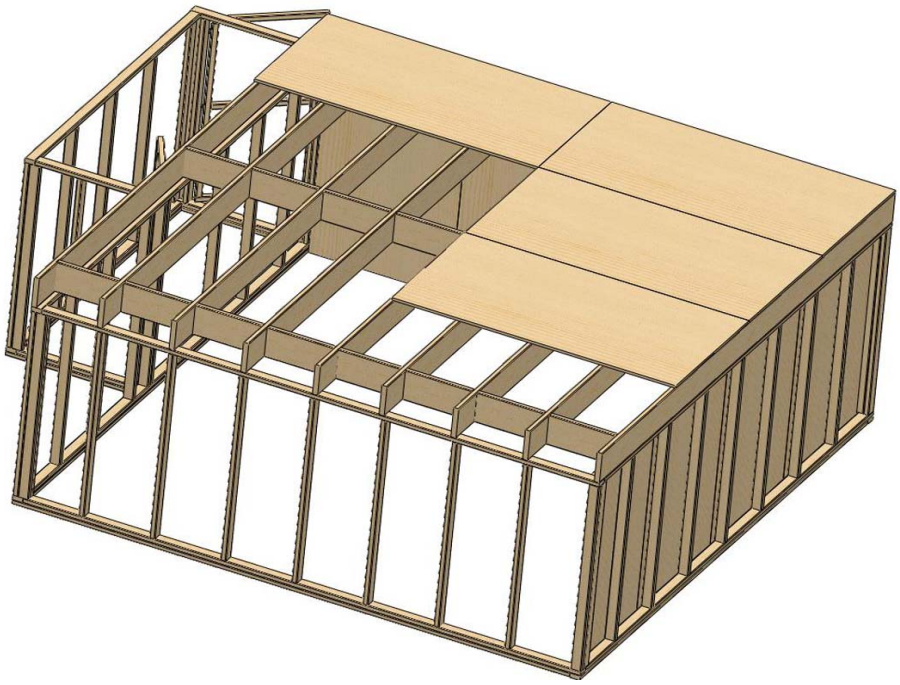


Figure 6-6. An example of a flight enclosure measuring 16' x 16' x 7'. A enclosure this size is appropriate for 40 medium-sized flighted insectivorous bats. The door to the vestibule opens to the outside; the door to the flight enclosure opens inside the vestibule. Two solid walls allow the attachment of feeding shelves and roosting items. Plywood or PVC planking on the ceiling of the enclosure provide darkened areas inside of the enclosure for necessary seclusion. *Graphic by L. Crittenden.*

Walls

The flight enclosure should consist of two solid walls and two open mesh walls (Figure 6-6). Solid walls provide darkness and a sense of security while open walls allow a natural change of the light cycle. Plywood or PVC board can be used to create the solid walls, and should be nailed or screwed to the exterior framework from the *inside* of the enclosure (Figure 6-6). This creates a completely flat wall from floor to ceiling, with no hidden areas for bats to hide or where guano can accumulate. Alternately, cinderblock walls can be utilized, although these walls should be painted using a color such as dark green.

Solid walls allow the attachment of roosting/feeding shelves in unlimited locations. Wooden walls should be covered (in wallpaper fashion) with heavy-duty tarp or plastic for ease in cleaning. Alternately, camouflage tarp or a wallpaper forest mural can be used to create a natural looking environment (Figure 6-7A). Removable panels of polypropylene mesh must be attached to provide a climbing surface over the mural or tarp covered wall (Figure 6-7C). Removable mesh panels are free-hanging (i.e. attached only at the top) to allow quick access to bats as well as ease in cleaning. Additionally, some crevice bats enjoy roosting behind these panels, allowing the keeper to visually inspect the bats ventrally.

To create removable mesh panels, first attach a strip of stainless steel binding to the very top of the wall (Figure 6-7B). The binding must be affixed at the very top of the wall, directly beneath the ceiling. Be sure to turn sharp ends under and crimp flat using pliers or a hammer, as described in Figure 6 -12C.

Use scissors to cut 1/6” polypropylene mesh into panels measuring 18” wide and the height of the flight enclosure. At the top of the panel, use a zip tie to attach one donut-shaped neodymium magnet (measuring 3/4" x 1/4" x 1/4) to each end. (Note: Regular magnets are not recommended as they lack the strength to hold the screen panels securely in place.) Cut the excess off the zip tie, and file the cut end until smooth. Attach the mesh panels to the steel binding, overlapping if necessary. The mesh panels will hang in curtain-like fashion and provide cushioning for flighted bats as they land. Note: Some crevice bats prefer to roost behind the mesh, with their backs against the wall, and should be allowed to do so (Figure 6-7D).

All mesh secured to the remaining framework of the enclosure must lay flush against the wood and be attached with staples one to two inches apart. There should be no gaps that may allow escapes. Tears or accidental holes should be immediately repaired using zip ties or by hand-sewing with a needle and thread. Staples, screws and nails must be flush, smooth and tight to prevent accidental injuries when bats land or climb inside the enclosure. Make certain sharp edges of staples do not project into the enclosure.

Cleaning

Mesh panels can be removed, washed in the sink with warm soapy water, rinsed and returned to the wall with minimal disturbance to bats. The tarp or plastic covered walls beneath the mesh can be washed at the same time the mesh is removed for cleaning. Mesh that is stapled into place can be cleaned with a scrub brush, then rinsed and dried with a lint free towel.

Figure 6-7. A: Solid and open flight enclosure walls meet in the corner. Mesh attached to open framework is secured tightly against the frame with staples, leaving no gaps in which bats can escape. **B:** A mesh panel attached to steel binding with magnets. **C:** Mesh panels provide a cushioned landing and are easily removed for cleaning. **D:** Free-tailed bats that have chosen to roost behind mesh, allowing easy inspection of body condition. *T. brasiliensis. Bat World facility. Photos by A. Lollar.*

Flooring
Wood shavings or other loose materials are not recommended as bats will hide beneath these materials and may be stepped on as caretakers enter the enclosure. Additionally, such substrates will cling to the bat's fur. Bare concrete or hard tile floors are not recommended as they can severely injure bats that fall. High-density foam or carpet padding, covered in fire resistant laminated polyester is recommended for permanent flight enclosure flooring.

A layer of two inch foam (purchased at fabric stores) or carpet padding (purchased at hardware stores) is sufficient for lightweight insectivorous bats (Figure 6-8A). The laminated polyester should be tightly secured to the framework around the bottom of the flight enclosure using stainless steel binding attached with screws (Note: It will be necessary to drill pilot holes in the binding before inserting screws.) This type of flooring prevents bats from crawling beneath the padding, and also prevents debris from filtering beneath the padding (Figure 6-8B). Additionally, mealworms are unable to crawl beneath this type of padding when it is secured correctly.

Ceiling
Flight enclosure ceilings should contain open areas to allow light to enter, as well as darkened areas for roosting and sleeping (Figure 6-8C). Sections of plywood or structural plastic lumber should be attached to the ceiling, on the top outside of the enclosure, to create the necessary seclusion and add stability to the enclosure. The solid areas of ceiling also provide access to the top of the enclosure from above if repairs are ever needed.

The entire inside of the ceiling should be lined with 1/6" polypropylene mesh stapled securely to the entire ceiling (Figure 6-8C). Heavy duty polypropylene mesh can be used on the ceiling for added security. The mesh must lay flush against the ceiling enclosure, with no gaps that may allow escapes.

Foliage should be attached to the ceiling to provide a simulated natural habitat (Figure 6-8D). Synthetic branches and artificial foliage can be attached to the flight enclosure ceiling using zip ties and staples (Figure 6-8E). It is not necessary to cut the end of the zip tie when securing branches; however, if the ends are cut they must be filed smooth to prevent the sharp edges from injuring the bats.

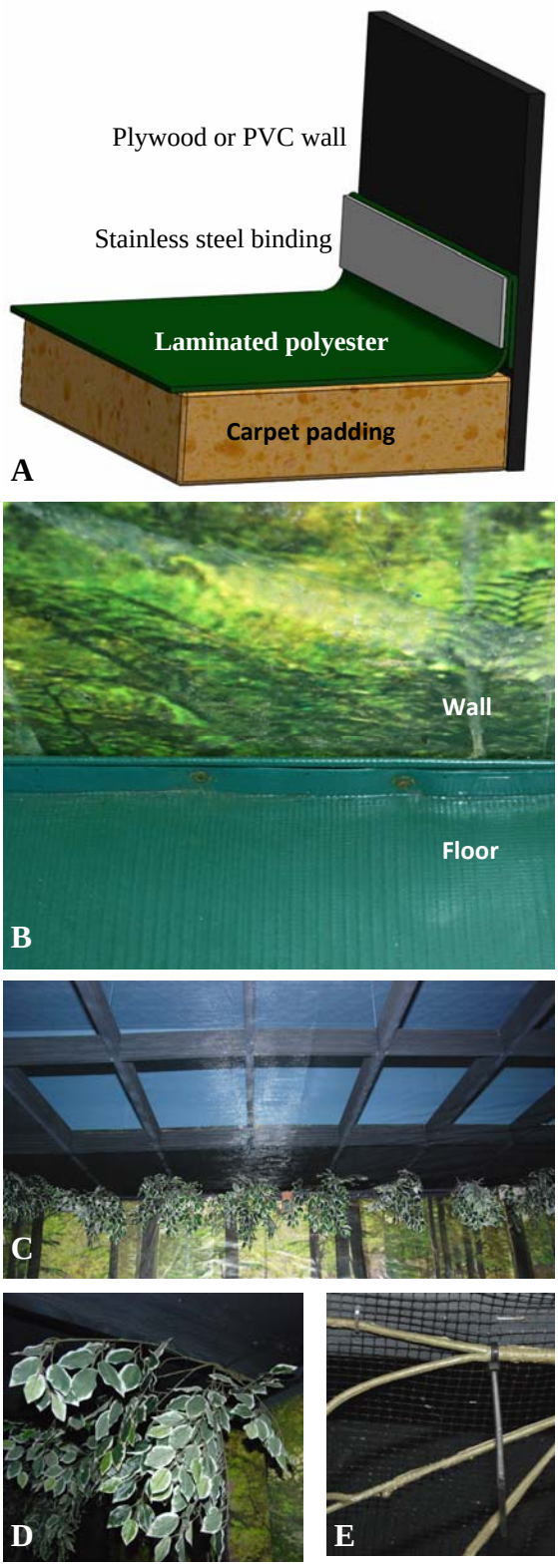


Figure 6-8. A: Layers of a padded floor. **B:** A padded floor inside a flight enclosure. Note: The walls of this enclosure are covered in a wallpaper forest mural rather than plastic. **C:** A flight enclosure ceiling showing both closed and open ceiling areas allowing secluded areas as well as light to enter. **D:** Artificial foliage attached to the flight enclosure ceiling provides roosting areas and enrichment for tree bats. **E:** Foliage can be attached using both zip ties and staples. *Bat World facility. Graphic by L. Crittenden. Photos by A. Lollar.*

Housing for Flighted Crevice Bats

Cave Roost

Although it is important that enclosures are not constructed from materials such as glass (e.g., aquariums), Plexiglas® or other hard, slick materials, galvanized metal can be used when properly covered with mesh and appropriate roosting items. The simulated cave roost below was designed to house up to 60 flighted and non-flighted crevice bats of various species, including bats that choose to roost openly on enclosure ceilings. This design allows bats to freely fly in and out of the cave roost at will, is a convenient way to access bats, and provides a permanent work station within a flight enclosure.

The cave roost is constructed of a plywood frame (Figure 6-9A). Heavy-duty wheels can be mounted on the bottom for ease in moving when necessary. The open cave area measures 56"W x 24"D x 32" H, and is lined with galvanized sheet metal on the walls and ceiling. Black magnetic sheeting material (30ml) is then attached to the galvanized metal, covering all the walls and ceiling (Figure 6-9B). A layer of outdoor mesh fabric is then attached to the magnetic sheeting using neodymium magnets to hold the mesh in place (Figure 6-9C). Note: Polypropylene mesh should **not** be attached to flight enclosure walls behind the cave; rather, these walls should be covered from floor to ceiling with plastic sheeting or tarp (see Walls, Permanent Flight Enclosures). This will prevent bats from roosting behind the cave roost where they cannot be easily reached.

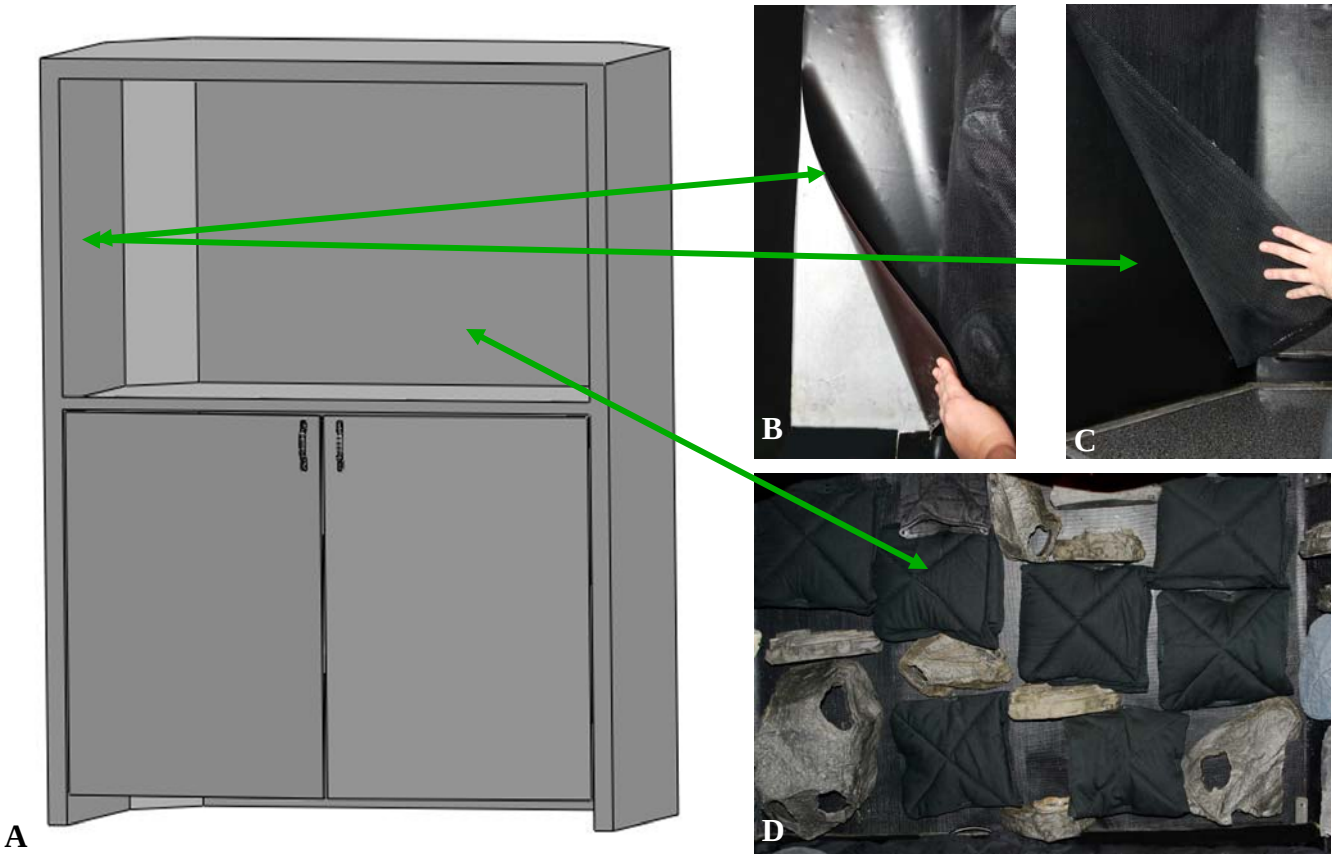


Figure 6-9. A: A cave roost designed for enrichment as well as ease for the caretaker. **B:** A layer of magnetic sheeting attached to a galvanized wall. **C:** Fabric mesh attaches over the magnetic sheeting. **D:** Cave interior with roosting pouches and Magnaturals enrichment rocks attached. **E:** EcoGen™ Magnetic Bins holding mealworms are placed throughout the cave roost. *Bat World facility. Graphic by L. Crittenden. Photos by A. Lollar.*
Bat World facility. Cave graphic by L. Crittenden.

The cave floor is covered in countertop laminate. The edges of the laminate along the walls and back are sealed with a metal strip, and secured in place with screws (Figure 6-10A). The edge of the laminate along the front opening of the cabinet is sealed with aluminum edging (1/2" high) to help prevent mealworms from escaping (Figure 6-10B).

Bats sometimes attempt to roost in dangerous spots such as the crack between cabinet doors, where they can become crushed as the doors are opened or closed. It is therefore extremely important to cover all hinged door areas with a layer of vinyl fabric (Figure 6-10C and D). Vinyl is slick and prevents bats from gaining a foothold if they attempt to roost in these dangerous spots. The vinyl should wrap the entire area where the cabinet door meets the frame, both inside and outside the door, covering the hinges in the process. The vinyl can be stapled directly onto the wooden doors and framework using a staple gun.

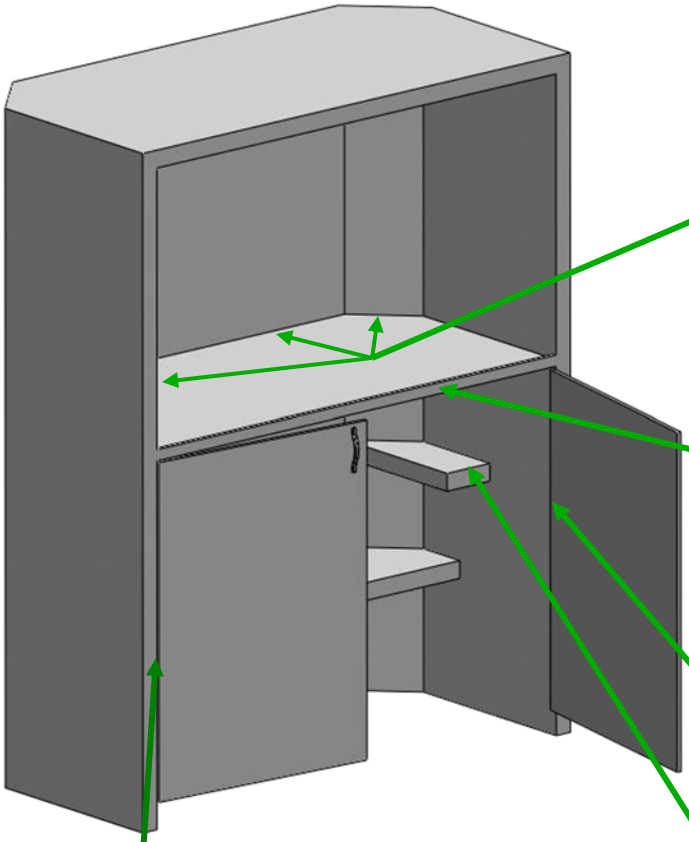


Figure 6-10. A: A laminated floor can be easily cleaned with a whisk broom. Flat metal binding is used to seal the edges of laminate.

Figure 6-10. B: A 1/2" high aluminum edge along the opening of the cave roost helps to prevent the escape of mealworms.

Figure 6-10. C: Storage area behind cabinet door. Shelves hold mealworm dishes, extra roosting pouches and rocks, as well as cleaning supplies. The edge of the door frame is covered in vinyl to prevent bats from roosting in the door frame. *Photos by A. Lollar.*

Figure 6-10. D: The outer door frame edge covered in vinyl to prevent bats from gaining a foothold and roosting in the hinged area of the door where they may become crushed. *Bat World facility. Graphic by L. Crittenden.*

Some non-flighted bats may attempt to fly inside flight enclosures, while others will simply take advantage of the increased space. They may explore or choose to roost in areas of the flight enclosure rather than the cave itself, as described on the following page. A mesh ladder or other means of gaining access back into the roosting cave should be made available to non-flighted bats. Additionally, a soft cushion should be placed on the floor directly below the cave opening to protect non-flighted bats that may fall to the floor as they attempt to fly (Figure 6-11B). **Never step directly onto the cushion without first checking for bats that may be hiding beneath the pad.**

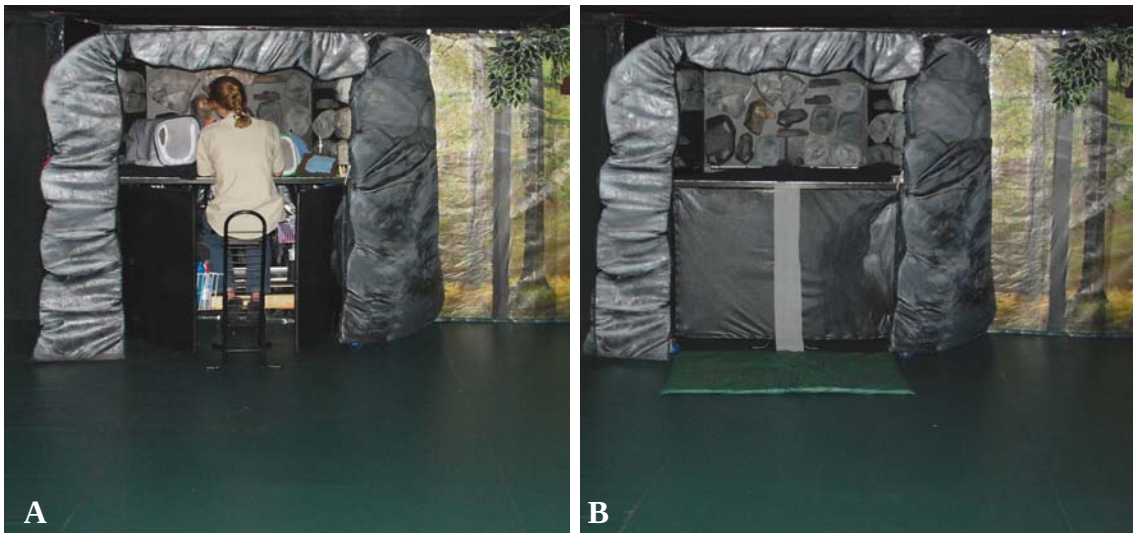


Figure 6-11. A: The cave roost serves as a convenient and permanent workstation within the flight enclosure. A false front consisting of foam covered with vinyl has been secured to the wooden frame of this cave roost with heavy duty hook and loop fasteners. A padded frame provides protection for flying bats as well as visual stimulation. **B:** A pad is placed on the floor below the opening of the cave to protect non-flighted bats that may fall or jump out at night. The light gray mesh ladder gives bats an opportunity to climb back into the cave. *Bat World facility*. *Photo by A. Lollar.*

Several roosts in the form of pouches, roosting cloths or vivarium foam items should be made available to bats that choose to roost along the flight enclosure wall or ceiling. A border of stainless steel binding attached to the uppermost portion of the flight enclosure walls, and directly below the ceiling, allows the attachment of numerous magnetized roosts (Figure 6-12D). When securing the binding in place, it is important to make sure the beveled edge of the binding is at the top to avoid any sharp edges coming into contact with bats' toes and feet as they roost Figure 6-12B). Additionally, the ends of the binding must be turned under and either hammered or folded flat with of pliers in order to eliminate any sharp edges (Figure 6-12C). Foam items can be secured to the flight enclosure wall through the use of neodymium magnets (as described in Enrichment). Magnets can also be attached to roosting pouches with zip ties.

Figure 6-12. A: Stainless steel binding.
B. Beveled edge of the binding should face up.

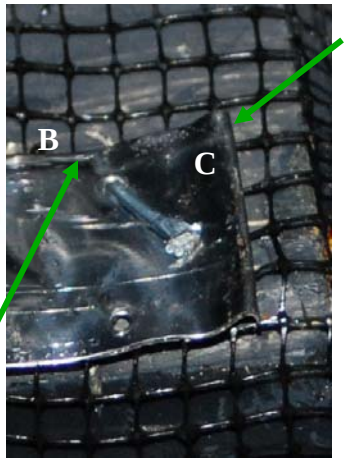


Figure 6-12. C: The end of the binding folded under, eliminating sharp edges.

Figure 6-12. D: A foam burrow being hung in place. *Bat World facility. Photos by A. Lollar.*

Feeding Shelves

Feeding shelves must also be attached to flight enclosure walls to provide food and water for bats choosing to feed and roost outside of the cave and in the flight enclosure. The most efficient way to attach shelves is to use standard adjustable shelving brackets that are attached directly to walls (Figure 6-13D and E) and available from hardware stores.

Shelves can be made from Plexiglas for ease in cleaning (Figure 6-13A). The shelf should be covered with a layer of cut-to-fit toolbox drawer liner to give traction for bats as they walk on the shelf (Figure 6-13B). Corners of the shelves should be rounded to protect flying bats and caretakers from sharp edges that may cause injury (Figure 6-13C).

Figure 6-13. A: Plexiglas shelf covered with toolbox liner. **B:** Shelf with mealworm dish, water dishes and foam enrichment item. **C:** Rounded corner. **D and F**: Examples of flight enclosure feeding shelves. *Bat World facility. Photos by A. Lollar.*

Cleaning

Cave Roost: Pouches used inside roosting rocks must be turned inside out and washed in the washing machine. Rock roosts can be scrubbed using a mild bleach solution, or simply placed into a facility dishwasher. Roosting rocks must be dry before reattaching to the inside of the cave. Screen should be lifted in sections to clean the magnetized sheeting and the fabric mesh. A scrub brush can be used to remove urine and guano from the mesh inside the cave roost. Use a small whisk broom to sweep up guano and mealworm debris from the cave floor. Plain tap water and paper towels are typically sufficient for wiping down walls and the floor of the cave roost; however, a mild bleach solution may also be used.

Roosting Shelves: A mild bleach solution (10%) can be used to wipe down the shelves and the matting. Both the shelf and the mat should be dry before returning the mat to the shelf.

Foam Roosts: Foam burrows and logs should be washed with bleach in the washing machine, then air dried. Magnets should be removed prior to washing. Note: When carrying magnetized foam roosts, be careful to not stack one magnetized side against another magnetized side as they will snap together and be difficult to remove without tearing the foam.

Flight Enclosure Floor: Padded floors covered with laminated polyester are easily maintained by daily sweeping and mopping with a 10% bleach solution.

Ill-Fated Designs

While this flight enclosure (Figure 6-14) may look decent at first glance, it actually serves as a bad example. The mesh size used for this particular enclosure was 1/4" inch rather than 1/6", allowing for the possibility that bats' forearms and feet could slip through, thereby causing severe injury or death. This mesh size also allows insects intended as food, such as crickets, to escape. Dog kennels were used as vestibules, requiring mesh to be hand-sewn inside the entire interior of the kennel. The floor is concrete, rather than padded and covered with laminated polyester, and is consequently more dangerous for bats and more difficult to clean. Note that the mesh is glued to the concrete floor with silicone around the bottom edges. While this does serve to prevent bats from escaping, the glued areas of mesh against the floor allow bacterial build-up as food and guano become trapped in the mesh. Because the enclosure is 8 feet tall, it requires a ladder to reach bats roosting on the ceiling.

There are no solid walls or framework on which to attach feeding shelves, roosting pouches, or enrichment items. While there is a corner roost that offers some seclusion, the enclosure is void of enrichment. This enclosure is free-standing, suspended in the air by the use of cables and hog rings. This free standing design is prone to degradation over time, as the weight of the hanging material causes snagging, tearing and sagging, resulting in a need for constant repairs.

The water trough is both dangerous and inconvenient. Bats that fall in may not be able to reach the edge to crawl out, and bats flying overhead will drop guano and urine into the water, resulting in unhealthy conditions and requiring gallons of water be emptied and refilled on a daily basis.

Enclosures such as this are highly inappropriate for all species of bats, and are difficult to maintain for the caretaker. Enclosures should be designed to offer a simulated natural environment, optimal comfort and a sense of security for bats while also providing convenience for the caretaker. Poorly designed enclosures typically result in needless injuries and fatalities, as well as frustration for personnel.

Figure 6-14. Example of a poorly designed flight enclosure at the Smithsonian National Zoo. *Photo by M. Singleton.*