

CHAPTER NINE

FEEDING AND CARE OF INFANT BATS

General Intake for Bat Pups

Orphaned bats are typically dehydrated when received. They should receive a subcutaneous injection with an electrolyte solution (see Dehydration and Fluid Replacement Therapy). Pups can then be fed as soon as fluids are absorbed, usually within 10 to 20 minutes. Pups that are furless, or that have tiny, sharp-hooked milk teeth should be fed milk formulas.

Do not dilute formula when feeding infant bats! Additionally, do not attempt to hydrate the pup orally by diluting milk with LRS or Pedialyte, etc.). Emaciated infants require maximum nutrition to fill caloric deficits; diluting milk formulas for starving infants only increases the risk of nutritional deficiencies such as Metabolic Bone Disease (MBD).

Pups that are fully furred or have adult teeth (i.e., canines rather than milk teeth) are juveniles. As with orphaned pups, they should be completely hydrated with SQ injections before food is offered. Failure to restore bodily fluids before introducing solid foods can be fatal (see Dehydration and Fluid Replacement Therapy). Juveniles that are underweight should be fed the intermediate mealworm diet in this section. Juveniles that are not underweight should be fed the mealworm diets for adult bats, including both live mealworms and the complete soft food diet (see Weaning and Feeding Juvenile Bats on page 109).

Orphaned bat pups need nurturing. Gentle handling and soothing tones must be used when caring for these animals. Insectivorous bat pups do not imprint. Pups spend a great deal of time in physical contact with their mothers and with conspecifics; therefore, direct handling is recommended for pups' well-being and sense of security. For this same reason, bat pups should not be housed alone.



Figure 9-2 A & B. The sunken area between the shoulder blades is a sign of emaciation. A free-tailed pup is shown on the left and a fully furred juvenile free-tailed bat on the right. Both bats are also dehydrated. *T. brasiliensis*. Bat World Facility. Photos by A. Lollar.

Feeding Implements

Once a milk formula has been prepared, an electric coffee or candle warmer can be used to keep the milk warm during feeding sessions. Note that milk formula will scald if the container is placed directly on the warmer. Instead, place the container of formula inside a bowl of warm water, and place the bowl of water on the coffee warmer (Figure 9-3). Constantly monitor the temperature to ensure it stays warm but not too hot. Bat pups typically prefer milk at a temperature that feels somewhat warmer (115° to 120° Fahrenheit) on the wrist than that appropriate for human infants.



Figure 9-3. A coffee warmer works well to keep milk formulas warm during feeding. Glass droppers are preferred as they are easily sterilized and help to keep the milk warm. *Bat World facility. Photo by A. Lollar*

While some rehabilitators prefer to use plastic syringes to feed milk formulas, the author prefers using glass medicine droppers for two reasons. 1) Plastic is not sterile and must be cleaned with a bleach solution between feedings and 2), as the milk is dispensed, plastic syringes allow the milk to cool much faster than glass. Bat pups require a consistently warm temperature of formula for proper digestion. Therefore, if plastic syringes are used it is critical to ensure the milk stays consistently warm during the feeding process.

During feedings, bat pups need to be kept warm. Never expose a pup to drafts from fans or air-conditioners. Crevice pups can be placed on a warm, clean cloth on top of a heating pad for feeding (page 100). Tree bat pups should be held in the hand (page 102).

Notes on Milk Replacement Formulas

The composition of milk varies from species to species. Composition also varies throughout the course of lactation (Table 9-1). Most U.S. commercial milk replacers developed for other mammals **do not** provide the necessary nutrition for insectivorous bat pups and some may even be toxic.

In 2007, bat care specialists across the U.S. reported a sudden increase of health issues with hand-reared orphans. The symptoms resembled poisoning and included chronic dehydration, kidney failure, vomiting, extreme hardening of the skin on the back (making SQ injections excruciating for the pup), pneumonia, diarrhea, anemia, MBD, and bones -including the shoulders, elbows and knees- fracturing under weight of the pup's own body. The only common denominator was commercial milk replacement formulas. For this reason, the author had two separate sources of the formula tested at two different laboratories. The report on these formulas came back as high in cadmium, mercury, arsenic, and lead. In addition, both samples contained little to no calcium, and one formula contained traces of an anti-malarial drug.

Seeking a solution, the author contacted Mark Finke, PhD Nutritional Scientist, in order to develop a safe alternative to commercial formulas using simple ingredients that bat care specialists could easily obtain. The milk formula recipes were developed over a one-year period, using the substantial research available on the milk compositions of crevice dwelling species (both Molossididae and Vespertilionadae). However, due to the very limited research available on the milk composition of tree bats, the formula is not recommended for foliage-roosting Vespertilionadae species. To date, thousands insectivorous bat pups of various crevice-dwelling species have been raised successfully to adulthood on the Bat World Sanctuary milk replacement formulas (Table 9-2).

Feeding Schedules

It takes only a small amount of milk to fill the stomachs of most pups. Because some infants are naked or sparsely furred for the first few weeks of life, milk can clearly be seen through the skin of the abdomen. Depending on the size, age, and condition of an infant, it will take anywhere from a few drops to 1.0ml of milk per feeding. Pups of most species should not be allowed to drink more than 1.0ml of milk per feeding; serious gastric disturbance can result from overfeeding. Pups taking 1.0ml of formula per feeding should not be fed more than four times per day (once every six hours). Because foam feeding tips (see page 98) preclude exact measurement of formula consumed, visual or tactile examination should be used to determine when a pup is full. The stomach should be slightly rounded, but not bulging with milk (Figure 9-4 A). A distended abdomen indicates the pup has been allowed to drink too much, a condition that can be fatal (Figure 9-4 B). (Also, see Overfeeding on page 107)



Figure 9-4 A: A big brown pup with a proper rounded abdomen after being fed milk formula. *E. fuscus*. Photo by C. Shaw, Shaw Wildlife.



Figure 9-4 B: A free-tailed pup with an abdomen that is almost distended. *T. brasiliensis*. Photo by A.Lollar.

Regardless of the species or the age of an infant, feeding schedules should be determined by the amount of time it takes for an individual pup's stomach to almost empty. To determine an infant's feeding schedule, first become familiar with the look and the feel of the pup's abdomen both before and after its first feeding. Take note of the visual appearance and how the abdomen feels when gently palpated with the fingertips. Note the time and check the pup each hour thereafter. Do not let the stomach empty completely and appear concave. Keep enough formula in the pup at all times to keep the abdomen flat to slightly rounded. Feed the pup again when the milk is nearly gone (i.e., when the stomach is almost flat, or only a small amount of milk is visible in the stomach). If the pup is already furred, milk will not be visible through the abdomen and the handler will need to rely solely on tactile examination. Note the time it took for the stomach to partially empty in order to estimate when the next feeding will be due.

It is important to note that the milk formula recipes created for Molossidæ and Vespertilionadæ are very rich, much like a bat mother's own milk. Therefore, milk may remain in the stomach longer with the pup requiring less feedings. It is not unusual for an orphaned *T. brasiliensis* pups' stomach to take 8 to 12 hours to empty.

The author receives calls every summer from rescuers who simply fed a pup "every two hours" or "every four hours". It is **critically important** to realize that each pup is an individual and you will need to determine the feeding schedule according to the time it takes that pups stomach to empty. Feeding infants too often will result in bloat, i.e., distention of the stomach, severe pain, white feces and death (see Complications in this section). Younger pups and pups that are emaciated will likely need to be fed more often than older pups that are healthy. In other words, as pups grow older and become healthier, the number of daily feedings will decrease.

Determining Orphan Status with Crevice-Dwelling Pups

After observing thousands of infant *T. brasiliensis* in a nursery colony for over two decades, the author developed the following guidelines to determine orphan status in colonial crevice-dwelling bat species:

- 1) Healthy pups will appear chubby and area between their shoulder blades be flat or very slightly sunken in. (Figure 9-1 A).
- 2) Orphaned pups will gradually move away from their colony, moving first to the outside edge of other pups, and then finally away from the group entirely (Figure 9-1 B)
- 3) Severely sunken shoulder blades is a sign of emaciation and means a pup is orphaned and in need of rescue. Even if milk can be seen in the abdomen of an emaciated pup, that pup has likely been stealing milk from other mothers and still needs to be rescued as he will not survive. (Figure 9-2 A & B).

4) If a pup has fallen from a roost, and the precise location of where the pup fell is unknown, the pup should be rescued regardless of being healthy. This is especially important in roosts containing large numbers of bats, such as under a bridge (pers. Comm. Justin Stevenson). Placing the pup back in an unknown location may prohibit a mother from finding her pup and the pup may starve to death.

Only bat pups that are healthy, plump and fat should be placed back into the exact location from where they fell. These pups should be marked with a nontoxic paint before placing them back into the roost, and, if found away from the roost again, they should be recued. Pups should **never** be placed on a tree, ladder (or anything similar) in hopes the mother will come back to take her pup. The **only** exception to this is watching nonstop to make certain the mother bat rescues her pup. Too often, pups are placed up on something high at night and are then gone the following morning, leaving the rescuer to assume the mother came to get her pup. In reality, the pup likely crawled away and starved or was snagged by a predator.



Figure 9-1 A: Healthy, plump free-tailed pups in a wild colony.



Figure 9-1 B: An orphaned free-tailed pup who has moved away from his colony. The sunken area between the shoulder blades is a sign of emaciation despite that this pup has recently fed. An arrow points to the milk that can be seen in his stomach. *T. brasiliensis*. *Bat World*

Feeding Crevice Bat Pups

Vespertilionadae

Crevic-dwelling vesper bat pups will typically lap fluids and accept a drop-by-drop method of feeding. Begin by holding the pup upside down. This is extremely important because infants are likely to aspirate fluid into the lungs when learning to lap formula if the head is not kept lower than the rest of the body. Placing a small amount of warm formula onto the pup's mouth typically induces a lapping response. Continue to dispense the formula drop-by-drop as the pup drinks (Figure 9-5). Vespertilionadae pups that do not readily lap milk should be allowed to nurse from foam tips (Figure 9-9A) as described below.

Molossidae

Unlike other bat species, Molossidae are physically unable to lap liquids. Therefore, milk should be offered to these pups through soft foam sponges. Natural or white foam eye-shadow applicator tips (Figure 9-6A) are used for this purpose (Lollar, 1994). Feeding free-tail pups with latex nipples, catheters, or any thing other than foam tips is not nurturing as well as uncomfortable for the pup. Additionally, it can easily result in aspiration as pups will not be able to control the amount of milk being placed into their mouths.

Remove the foam tip from the plastic wand by immersing the wand in hot water to loosen the foam from the plastic wand, then slide the foam tip off the wand.

The foam tip has a seam that runs along the entire edge of the tip (Figure 9-6B1). While the tip is still wet, tear the tip in half along the seam to form two matching halves (Figure 9-6B2). Use small scissors to cut the tip of the foam into a wedge shape (Figure 9-363). This size and shape are readily accepted by bat pups. Note: while (due to hunger) some pups will accept tips that are not reduced in size or removed from the wand, it will not be a comfortable or nurturing experience for the pup. As rehabilitators, it is our duty to make nursing a happy experience for orphaned pups, which means not taking shortcuts.

To save time, a package of tips can be soaked all at once, then divided and trimmed down for use. Allow them to dry on a flat surface before storing in a baggie for later use.

When nursing from foam tips, pups should be placed abdomen down inside a folded washcloth, and on a heated surface to keep them warm. Heating pads set low to medium can be utilized for this purpose. There should be two layers of wash cloth between the pup and the heating pad to prevent accidental burns. Allow the washcloth to warm before placing the pup into the folds for feeding. Cover the pup's body with the cloth, leaving only the head exposed, as shown in Figure 9-8A. Use a clean, dry cloth for each feeding.



Figure 9-5: An orphaned big brown pup lapping milk formula from a cannula. *E. fuscus*. Photo by D. Wilkins.



Figure 9-6. A: Foam eye shadow applicators available at cosmetic stores.



B: Foam tip removed from the wand and slightly separated at the seam. **2:** the foam tip torn in half at the seam. **3:** The tip has been trimmed to resemble a wedge shape.



C: Prongs must be buried in the foam to protect the pup's mouth as the tip is introduced. Photos by A. Lollar.

Begin by positioning the forceps on the foam (Figure 9-6C) so that the prongs are somewhat buried in the foam. This protects the pup's mouth. Dip the foam tip into warmed formula. The tip should remain in the formula for several seconds to absorb heat. Remove excess formula by dabbing the tip on a paper towel. Excess formula on foam tips can cause choking or be uncomfortable to the pup. Test the temperature of the tip against the inside of the wrist before placing it into the pup's mouth.

Next, position the index finger on one side of the pup's face and the thumb on the opposite side. Then, gently lift the pup's head which will cause the pup to open his/her mouth. When this occurs, gently guide the foam tip into the pup's mouth, positioning the end of the tip about midway onto the tongue. Some pups will begin nursing immediately while other may take several attempts. You can also encourage the pup to take the tip by gently stroking the pup's mouth with the warmed tip while making clicking sounds. Soft clicking mimics the directive calls some mother bats use to locate their pups.

Once a pup is nursing, release the forceps from the sponge tip, as the pup will keep it clamped between its teeth (Figure 9-7A & B). As the pup continues to nurse, dispense warmed formula, one drop at a time, onto the foam sponge with a glass dropper. Wait a few seconds between drops so the tip does not become oversaturated. As the pup nurses, the tragus will move up and down slightly each time the pup swallows.

Be careful to drop the formula onto the portion of the foam tip that is furthest from the pup's face so that any excess milk drips away from the infant. Also take care as to not oversaturate the foam tip with formula.

Some pups are difficult to feed and will spit the foam tip out of their mouth. Some will swallow a few drops of formula but will not begin sucking. These pups will eventually start nursing once they overcome initial fear of the handler.

Some pups will discard the foam tip as soon as they are full; others will hang onto the tip even after they have stopped drinking milk. **Do not try to remove the tip from a pup's mouth.** Any remaining formula in the tip may be accidentally forced down the pup's throat, causing it to aspirate. These pups will eventually discard the tip after being returned to the incubator. Foam nursing tips should be disposed of after use and replaced with new ones for each feeding.

It is important to note that when some pups are first handled, they may immediately grasp the cloth or fabric that encloses them with their milk teeth, refusing to let go. Do not attempt to remove the pup's teeth from the fabric. Instead, carefully dispense warmed formula onto the cloth just below the pup's mouth and allow the pup to suck the formula from the fabric.



Figure 9-7. A: Newborn free-tailed pup nursing from a foam tip. *T. brasiliensis*. Photo by A. Lollar.



B: Big brown pup nursing from a foam tip. *E. fuscus*. Shaw Wildlife facility. Photo by C. Branigan

Caring for large numbers of orphaned crevice-dwelling pups requires some modifications in care procedures. Over the course of several days, some pups can be conditioned to being fed in groups (Figures 9-8). Pups that lap formula can be taught to drink from shallow dishes. Start by holding pup over a shallow dish of warmed formula while feeding it from a catheter or dropper. While the pup is lapping, move the catheter away and carefully lower the pup until it drinks from the shallow dish. Be careful not to immerse the bat's nose in the formula. Once pups have been individually taught to lap formula from a shallow dish, they can be fed in groups on top of a heating pad. When feeding pups from foam tips, each pup should be nursing from its tip and covered before the next pup is placed into position. While Molossidæ pups will not lap and should always be fed from a foam tip, other crevice species can be fed in groups to either lap milk from a dish or nurse from foam tips. It is important to follow the pup's lead and feed him/her in a way the pup finds the most comfortable and will easily accept.



Figures 9-8. Orphaned free-tailed pups nursing from foam tips. *T. brasiliensis*. Photo by R. Myers. Orphaned big brown pups lapping from a dish sitting on a heating pad to keep both the milk and the pups warm. *E. fuscus*. Bat World Facility. Photo by A. Lollar

Housing Crevice Bat Pups

Unfurred infants require warm temperatures and high humidity and should be housed in incubators (Figure 9-9) or humidity chambers as described in Temperature, Humidity & Lighting. Caging described for adult crevice bats in Temporary Housing is also appropriate for crevice pups. A heating pad should be attached to the top and sides of the enclosure for additional warmth. Infant crevice bats should be placed in a pouch positioned close to a heat source. Be sure to leave at least two of the walls of the enclosure clear of the heating pad so that infants can move away from the heat source if needed. A thermometer should be placed inside the enclosure and close to the heat source to monitor the internal temperature. The appropriate temperature is between 90° to 100° F and with humidity levels between 70% to 90%. Bats should be moved into flight areas with padded floors by eight to ten weeks of age to ensure development of proper flight ability.



Figures 9-9. An incubator set up for crevice-dwelling pups. Bat World Facility. Photo by A. Lollar

Determining Orphan Status in Tree Bat Pups

Unlike other bat species, tree bats will give birth from two to five infants. These bats are solitary and are only found roosting together when mothers are raising their pups. An orphaned tree bat found grounded should always be considered an orphan and should be rescued. Placing the pup into a tree in hopes the mother will come back is almost always a death sentence for these pups as they are frequently eaten by blue jays.

Tree-bats in particular are prone to dehydration and should receive a subcutaneous injection with an electrolyte solution on intake (see Dehydration and Fluid Replacement Therapy). Pups can then be fed as soon as fluids are absorbed. Pups that are furless, or that have tiny, sharp-hooked milk teeth should be fed milk formulas. Pups that have canines can be fed the intermediate formula (See page 109).

Feeding Tree Bat Pups

Unlike crevice pups, tree bat pups must be fed formula while being handheld. It is **critical** to keep these pups clean during the feeding process. Tree bats are furred at a very young age. If formula drips into the fur and dries on the skin, it can result in serious skin infections that often lead to death. Additionally, matted and dirty fur can interfere with a bat's ability to thermoregulate. A pup can die within just a few hours if it cannot thermoregulate. Pups that become soiled must be bathed and dried as described on the following page. As a general rule it takes about 30 seconds to feed a tree bat pup when fed correctly; it takes about 30 minutes to clean the pup when fed incorrectly. It is to your benefit to not allow a tree bat to become soiled.

Position the pup so it lies prone on the thumb, secured by the forefinger and middle finger resting on the pup's shoulder blades. Using a glass dropper, dispense formula drop by drop as the pup laps. Although some tree pups squirm when first being held in this position, most catch on quickly and sit quietly on the thumb thereafter. Some enthusiastic pups attempt to crawl forward, appearing intent on swallowing the entire dropper. These pups can be controlled with gentle pressure of the fingertips on the pup's shoulder blades.



Figure 9-10. An orphaned red bat drinking formula from a medicine dropper. *L. borealis*. Photo by L. Crittenden.

Both the pup and the glass dropper should be tilted in a "V" position, so that the pup's mouth and the dropper meet at the bottom of the V (Figure 9-10). This position helps to keep air bubbles from forming in the dropper and prevents soiling by allowing excess milk to drop away from the pup's face. **Note: the pup's head must extend past your thumb, as pictured, so that milk drops away from both the thumb and the pup.** Otherwise, milk will wick between your thumb and the pup's neck and saturate the pup's chin, neck and chest.

Housing Tree Bat Pups

Infant tree-bats require warm temperatures and high humidity and should be housed in incubators or humidity chambers as described in Temperature, Humidity & Lighting. Caging described for adult tree bats in Temporary Housing is appropriate for tree bat pups. A heating pad should be attached to the top and sides of the enclosure for additional warmth. Be sure to leave at least two of the walls of the enclosure clear of the heating pad so that the infant can move away from the heat source if needed. A thermometer should be placed inside the enclosure and close to the heat source in order to monitor the internal temperature at all times. Heating pads can be adjusted and added or removed according to the temperature reading inside. Appropriate temperatures for bat pups of many species are 90° to 100° Fahrenheit with humidity levels of 70% to 90%.



Figure 9-11. Orphaned infant tree bats hanging from the ceiling of their soft mesh enclosure. *L. borealis*. Bat World MidCities facility. Photo by K. Rugroden

Infant tree bats should be positioned so they can hang by their feet from the ceiling of the enclosure (Figure 9-11), **not the sides**. Hanging from the ceiling allows pups to urinate and defecate without becoming soiled. Position the pups so that several can hang together in a cluster. Hand-raised tree bat pups should be moved into full-sized flight cages with padded floors by eight weeks of age to ensure development of proper flight ability.

Additional Care for Tree Bat Pups

Tree bat pups should be stimulated after each feeding with a soft piece of gauze to encourage urination/defecation. If not stimulated, pups tend to urinate and defecate on themselves, which, if not cleaned and dried immediately, is likely to cause hypothermia and death. Gently dab at the pup's anus and genitals with a soft square of gauze that has been dipped in warm water (cotton swabs are too rough for this purpose). Gently rub the area until the pup urinates or defecates. While newborn tree bats require stimulation, most of the crevice species do not. (Also see Bathing and Grooming Tree Bat Pups in this chapter). At about two weeks of age, it is no longer necessary to stimulate these infants.

Be careful not to contaminate the oral or nasal cavities with fecal material by touching the face with the same gauze pad used to stimulate the pup. This can result in serious bacterial infection from *Providencia rettgeri*, resulting in a build-up of fluid in the thoracic cavity and death (D. Cottrell, DVM., pers. comm.). Also be sure to keep wing membrane and tips free of feces. Clean the wings with warm water and dry with a soft gauze pad. (Fungal infections will cause wings to become discolored and oily. This condition is painful and should be treated with Nolvasan suspension (see Skin Conditions).)

Bathing and Grooming Tree Bat Pups

Begin by holding the bat so that its head higher than the rest of the body to ensure that no water gets in the nose or mouth. If only a small section of the bat is soiled, dip a gauze pad into warm water, then saturate the soiled area on the bat and slide off any foreign particles. For bats that are extremely soiled, use a syringe to saturate the soiled area. When thoroughly saturated, feces and other foreign particles will slide easily from the fur as the area is gently wiped with a damp gauze pad. Also, be sure to clean the wings of badly soiled bats.



Figure 9-12. A juvenile tree bat being groomed with an interdental brush

As soon as the fur is clean, quickly place the bat in a pre-warmed, absorbent drying cloth on top of the heating pad. Wrap the cloth around the bat and gently dab the wet areas of its body with the cloth to absorb excess moisture. Replace the cloth with another warmed one when it becomes damp. After gently towel drying the fur, wrap the bat inside another dry cloth and turn it upside down, keeping the head lower than the rest of the body, and carefully wipe the mouth and face with a damp piece of gauze. Make sure the gauze is only slightly dampened so that no excess water can be inhaled during cleaning. After gently rubbing the bat's fur, and wing and tail membranes with a soft, dry cloth to absorb excess moisture, use a small blow dryer to finish drying the fur. The dryer should be placed at least one foot from the bat. If a pup squirms to get away while being held, the dryer is too close, and the air stream is too forceful or too hot. Keep the dryer at an appropriate distance so the bat remains passive, enjoying the warmth.

Fluff the fur with the brush while drying the pup. Brush the dense fur backwards to dry the fur closest to the body, then brush the fur forwards in the natural direction it lays, to dry the top of the fur (Figure 9-12). While some prefer using mascara brushes, the author prefers to use dental brushes with softer bristles. Only minimal pressure should be used when brushing a bat. (To fully realize the small amount of pressure needed, place the bristles on a sensitive area of your body such as the inside of a wrist or elbow, then brush in one direction.) Make certain the pup is completely dry—both the fur and wing membranes—before returning it to its enclosure. Tree bat pups will usually begin grooming their bodies vigorously once they have been bathed and dried.

Again, feeding a tree-pup in the correct V position will help you avoid the tedious process of bathing and drying these pups.

General Cautionary Notes in Caring for Bat Pups

Pups can aspirate fluids or choke on food while being hand fed. A bat may be choking if it suddenly gags and/or appears to gasp for breath during feeding. If aspiration is suspected, keep the bat's head down with the abdomen against the palm of the hand. Gently but firmly tap the bat's back with your index finger, just below the shoulder blades to force the substance from the airway. Force of tapping should be no more than that of fingertips lightly drumming a tabletop. Fluid in the nasal passages should be cleared by applying gentle pressure with a cotton swab on the nasal passages just below the eye and down the bridge of the nose. Repeat the process until the nose is clear. Normal respiration will sometimes be restored immediately. However, if liquids or food enters the lungs, the bat is likely to develop aspiration pneumonia. Signs of respiratory distress include soft squeaky sounds with each breath. Treat as described in Respiratory Disorders. After feeding, the face and chin should be gently wiped clean with a foam sponge dipped in warm water.

Never put a pup away with milk on its face or body. Doing so will result in eye infections and/or skin infections, that may result in death.

BAT WORLD SANCTUARY MILK REPLACEMENT RECIPE**VESPERTILIONIDAE, EXCLUDING TREE BAT SPECIES**

- 3.5 ounces (100ml) canned Meyenberg evaporated goat milk, reconstituted
- 1.5ml corn oil (non-GMO preferred)
- 1.5 scoops Similac Neosure Baby Formula
- 1 tsp dried egg white

MOLOSSIDAE

- 3.5 ounces (100ml) canned Meyenberg evaporated goat milk, reconstituted
- 2 scoops Similac Expert Care Neosure Baby Formula
- 2.5ml corn oil (non-GMO preferred)

Start by reconstituting the entire can of Meyenberg goat's milk with an equal amount of water. Store in a separate container in the refrigerator. To make either of the above recipes, use a small container with a tight-fitting lid and add 3.5 ounces of the reconstituted goat milk, then add the Similac Neosure and corn oil. Also add dried egg white if required for the species. Shake well to mix. This makes about 1/2 cup. Store in the refrigerator. Do not freeze. Discard after 24 hours or sooner if it begins to thicken or smell spoiled. Wash the container thoroughly with soap and water before making new formula. Use bleach to disinfect if necessary. Rinse thoroughly. If the container has any residual smell then it has not been washed thoroughly enough and the next batch of formula will be contaminated. Discard any unused reconstituted goat's milk after seven days or sooner if it begins to smell spoiled. Store Neosure at room temperature and discard any unused powder after 30 days.

Calculated Nutrient Values for Vespertilionidae (As Is)

Energy 1.42 kcal/ml; Moisture 73.5%; Protein 7.3%; Fat 8.2%; Carbohydrate 9.8%; Calcium 0.20%; Phosphorus 0.15%; Vitamin A 3,340 IU/kg; Vitamin D 430 IU/kg.

Calculated Nutrient Values (Dry Wt)

Energy 5.36 kcal/ml; Protein 27.4%; Fat 30.9%; Carbohydrate 36.8%; Calcium 0.75%; Phosphorus 0.58%; Vitamin A 12,500 IU/kg; Vitamin D 1,650 IU/kg.

Calculated Nutrient Values for Molossidae (As Is)

Energy 1.60 kcal/ml; Moisture 72.2%; Protein 4.7%; Fat 10.7%; Carbohydrate 11.2%; Calcium 0.22%; Phosphorus 0.16%; Vitamin A 3,830 IU/kg; Vitamin D 540 IU/kg.

Calculated Nutrient Values (Dry Wt)

Energy 5.76 kcal/ml; Protein 17.0%; Fat 38.5%; Carbohydrate 40.3%; Calcium 0.79%; Phosphorus 0.59%; Vitamin A 13,700 IU/kg; Vitamin D 1,900 IU/kg.

RECOMMENDED MILK FORMULA FOR TREE BAT SPECIES

For reasons we do not yet understand, tree bats do not fare well on either of the above milk formula recipes. Instead, a successful formula for tree bats consists of the following ingredients (Kate Rugroden, pers. comm.).

- Fox Valley 32/40, 13.7g (7 teaspoons)
- Fox Valley Ultraboost, 5.74g (2.5 teaspoons)
- Body Boost Colostrum Plus (or similar brand), 1.24g (3/4 teaspoon)
- 1 Lactaid tablet [9,000 FCC Lactase units] (.27g), crushed to a fine powder
- 3.5 ounces (100ml) water

Tree bat orphans with developed canines should receive a milk formula mixed 50/50 with soft food (see Feeding Adult Bats). If the bat will accept live mealworms, feed milk formula and live mealworms on a 50/50 ratio.

Table 9-1
Comparison of Bat Milk Compositions

	Fat %	Protein %	Carbohydrate %	Energy kj/g
Family: Vespertilionidae				
<i>Eptesicus fuscus</i>				
Early lactation	12.8	9.5	3.6	6.7
Late lactation	21.2	9.5	3.6	10.5
<i>Myotis lucifugus</i>				
Early lactation	12.4	9.4	3.9	7.4
Late lactation	15.8	8.5	3.9	8.6
Milk replacement recipe: Vespertilionidae	8.2	7.3	9.8	5.6
Family: Molossidae				
<i>Tadarida brasiliensis</i>				
Early lactation	17.3	8.3	3.6	9.0
Peak lactation	25.8	7.7	3.4	12.1
Milk replacement recipe: Molossidae	10.7	4.7	11.2	5.8

IMPORTANT NOTE: Do not substitute or omit any of the ingredients in the Bat World milk replacement recipes. Each ingredient is critical and specific for the following reasons.

- Egg white powder is critical for the additional protein needed by crevice-dwelling Vespertilionidae pups.
- The amino acid profile in the Molossidae milk replacement recipe is very good, thereby minimizing the need for excess protein.
- Corn oil contains a very specific chain of fatty acids necessary for proper growth.

Table 9-2
Ten Year Study on Pup Survival Rates Using Select Milk Replacement Formulas[◊]

Year	# of Pups	Species	Emaciated at intake	Injured at intake	Secondary complications	Died from secondary complications	Died from injury	Survived	Formula used
1999	47	<i>T. brasiliensis</i>	22	5	MBD (4) Bloat (2)	3	4	40	MH*
	5	<i>E. fuscus</i>	—	—	—	—	—	5	MH*
	35	<i>L. borealis</i>	2	7	Bloat (3)	—	5	30	
	3	<i>N. humeralis</i>	1	1	—	—	1	2	MH*
2000	55	<i>T. brasiliensis</i>	31	7	MBD (12)	5	2	48	MH*
	52	<i>L. borealis</i>	—	7	Bloat (4)	—	7	45	MH*
2001	62	<i>T. brasiliensis</i>	27	10	MBD (11)	—	7	55	MH*
	28	<i>L. borealis</i>	—	7	Bloat (4)	4	4	20	MH*
2002	115	<i>T. brasiliensis</i>	67	22	MBD (24)	6	19	90	MH*
	49	<i>L. borealis</i>	5	11	Bloat (1) MBD (3)	2	11	36	MH*
	1	<i>L. cinerus</i>	—	—	—	—	—	1	MH*
	1	<i>P. subflavus</i>	—	—	—	—	—	1	MH*
	9	<i>M. lucifugus</i>	9	—	SIDS (2)	2	—	7	MH*
2003	76	<i>T. brasiliensis</i>	52	13	MBD (22)	4	1	71	33/40**
	56	<i>L. borealis</i>	1	8	MBD (5)	2	4	50	33/40**
	2	<i>N. humeralis</i>	2	—	—	—	—	2	33/40**
2004	99	<i>T. brasiliensis</i>	42	22	MBD (30)	10	19	70	33/40**
	25	<i>E. fuscus</i>	25	—	MBD (11) Bloat (5)	8	—	17	33/40**
	72	<i>L. borealis</i>	3	10	MBD (1)	3	8	61	33/40**
2005	70	<i>T. brasiliensis</i>	38	18	MBD (21)	9	10	51	FV***
	64	<i>L. borealis</i>	—	14	Bloat (3)	—	12	52	FV***
	7	<i>E. fuscus</i>	7	—	MBD (4)	—	—	7	FV***
	1	<i>L. intermedius</i>	1	1	—	—	1	0	FV***
2006	102	<i>T. brasiliensis</i>	44	2	MBD (25) Bloat (14) Other (16)†	25		77	33/40**
	63	<i>L. borealis</i>	7	3	Bloat (22)	35	2	26	33/40**
2007	87	<i>T. brasiliensis</i>	36	7	MBD (21) Bloat (17) Other (58)†	58	0	29	33/40**
	26	<i>L. borealis</i>	2	1	Other (12)†	11	1	14	33/40**
	3	<i>N. humeralis</i>	—	—	MBD (3)	—	—	3	33/40**
2008	261	<i>T. brasiliensis</i>	99	83	MBD (0)‡ Bloat (7)	3	61	223	BWS‡
	72	<i>L. borealis</i>	6	2	Bloat (27)	25	2	45	BWS‡
	2	<i>N. humeralis</i>	—	—	Bloat (1)	—	—	2	BWS‡
2009	230	<i>T. brasiliensis</i>	112	19	MBD (0)‡	—	6	224	BWS‡
	48	<i>L. borealis</i>	—	9	Bloat (4)‡	1	1	46	BWS‡
	1	<i>L. cinerus</i>	1	—	Bloat (1)	—	—	1	BWS‡
	5	<i>N. humeralis</i>	5	—	—	—	—	5	BWS‡

◊ Reflects wild orphaned bat pups raised by the author over one decade. *Mother's Helper Milk Replacer Puppy Formula™, Lambert Kay®; **Zoologic 33/40 milk replacement formula, Pet Ag; ***Fox Valley 32/40 milk replacement formula. †Symptoms observed outside of bloat and MBD: chronic dehydration, kidney failure, vomiting, hardening of the skin on the back, pneumonia, diarrhea, anemia, and bones (shoulders, elbows and knees) fracturing under the weight of the pup's own body; ‡Bat World sanctuary milk replacement recipe; § No cases of MBD developed in Molossidæ using the milk replacement recipe; ¶ Bloat in Vespertilionidæ bats was alleviated when increased protein was added to the recipe.

Complications in Hand Raised Pups

BLOAT

Bloat is one of the most common causes of death in bat pups. It can be recognized by severe abdominal distention and, sometimes, the presence of bubbles in the digestive tract visible through the translucent skin of the abdomen (Figure 9-13 A). There are several reasons why this condition occurs in bat pups.

Feeding too Often

Abdominal distention accompanied by white or grayish feces indicated bloat caused by feeding a pup too often. This type of bloat should be treated by feeding a diluted mixture of one part milk formula to nine parts very warm water (115° to 120° Fahrenheit). Do not allow the pup to drink the normal amount it consumes at every feeding as this will cause additional distention. Rather, feed the pup about one-fourth of the normal amount taken. As the stomach empties of previously undigested milk, continue to feed the water and milk dilution until feces appear normal.

Overfeeding

Bloat caused from over-feeding will be obvious immediately after the pup has been fed as the stomach will appear dangerously distended. The stomach is distended with milk to the point that it covers the bottom two ribs and extends across the abdomen and down to the pelvis. This can normally be treated by skipping the next one to two feedings until the pup's stomach has returned to normal. The condition is life threatening if the stomach is marble-sized and hard, and/or the pup is in respiratory distress. When milk inside the stomach is clearly visible through the skin of pups that aren't yet furred, excess formula can be aspirated directly from the stomach using a 1ml syringe with a 28-gauge needle attached. In order to prevent damage to the pup or its stomach, it is critical to break the seal created between the barrel of the syringe and the plunger of the new syringe prior to the procedure. This can be accomplished by moving the plunger up and down inside the barrel of the syringe. This procedure must be done as aseptically as possible to prevent the development of peritonitis, which can be fatal.

This technique requires two caretakers for the procedure. Aseptically swab the abdomen with povidone iodine and 70% isopropyl alcohol. Position the pup on its back on a padded surface, such as a soft cloth. The pup must be held firmly and gently in position by one caretaker to prevent the pup from moving. The other caretaker then carefully inserts the needle 3 to 4mm directly into the stomach. Using a steady hand, very slowly pull back on the plunger. Withdraw enough excess milk so the abdomen returns to a more normal size (Figure 9-13B). Maintain slight pressure on the plunger as you withdraw the needle from the abdomen. Pups undergoing this procedure should receive oral administration of Veraflox for 10 days (See Medication Section for dosage).

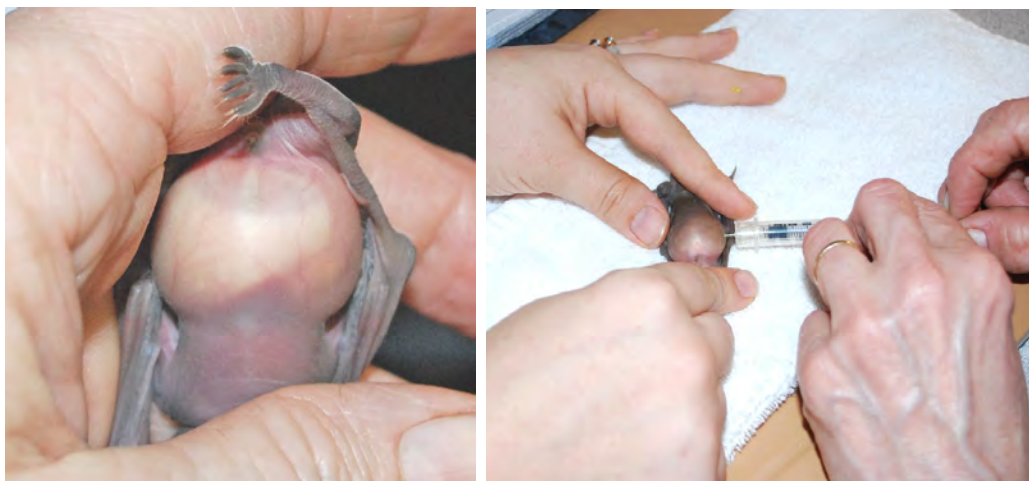


Figure 9-13 A: Excess milk in a dangerously distended stomach of a free-tailed pup. *T. brasiliensis*. Bat World facility. Photo by A. Lollar

Figure 9-13 B: The excess milk being slowly extracted with a 28 gauge needle and syringe. *T. brasiliensis*. Photo by A. Lollar

Lack of Beneficial Bacteria

The absence of beneficial organisms that normally reside in a healthy pup's intestinal tract can also cause bloat. Absence of beneficial flora allows other organisms to grow out of control, resulting in a build-up of intestinal gas. To treat this condition, administer 0.01ml of simethicone for every gram of body weight every two hours (to relieve gas) and add 0.02ml of Bene-Bac™ gel, Fox Valley LA probiotic powder or another high-quality beneficial flora product such as to each feeding until abdominal distention is relieved.

METABOLIC BONE DISEASE (MBD)

MBD that results from Vitamin D deficiency is called rickets in young individuals and osteomalacia in adults. MBD can also be caused by an inadequate intake or absorption of calcium. Vitamin D and fat are important dietary components because they facilitate calcium uptake.

Orphaned pups that have survived for a number of days without sustenance or that have been fed inappropriate diets are likely to develop growth abnormalities; however, these can be avoided if proper nutrition is provided. Rapidly growing bones like the long bones of the arm are often affected by nutritional imbalances such as MBD. Common clinical signs associated with MBD include swelling or curvature of the long bones of the wing (Figure 9-14), inflammation of the joints, muscle weakness, and neuromuscular hyperirritability often progressing to tetanic spasms and sometimes convulsions.



Figure 9-14. A juvenile big brown bat with MBD. *E. fuscus*. Photo by D. Kinamon.

The condition is painful. In severe cases, a bat will rest with its wings slightly extended at all times and may experience intermittent spasms of the wings in particular. Pups with MBD will sometimes cry out when touched.

The author has raised approximately 3,500 insectivorous bat pups of various species over the past three decades, and has observed many signs of nutritional deficiency in bat pups. MBD has frequently developed in severely emaciated pups raised on commercial milk replacement formulas, despite the addition of extra calcium as well as additional vitamin and mineral supplements. The Bat World Sanctuary milk replacement recipe, developed in 2008, eliminated all occurrences of MBD in *T. brasiliensis*, *L. borealis* and *N. humeralis* orphans. A total of 492 orphaned *T. brasiliensis* pups were raised on this recipe in 2008 and 2009, of these, almost half were severely emaciated upon arrival, and many would most certainly have developed MBD had they been raised on commercial milk replacement formulas.

Treatment

While mild cases may be reversible in early stages, MBD cannot be reversed in later stages when curvature of the bone is visible. For pups exhibiting symptoms as described above, administer Calsoorb® orally once a day until symptoms subside. (This medication should be mixed with a small amount of honey as it is extremely bitter.) Add also 1 gram (1/4 tsp) Calcium Carbonate to every 3.5 ounces of milk replacement recipe. For juveniles, add 1 gram (1/4 tsp) to every 3mls of soft food diet. Metacam® should also be administered for pain (see Medication section). Margaret A. Wissman, D.V.M., D.A.B.V.P. (ExoticPetVet.net), states that calcitonin-salmon is an effective treatment for MBD in many species of exotic animals.

Weaning and Feeding Juvenile Bats

Juvenile bats typically accept soft food or mealworms when they have reached the appropriate developmental stage, which can be gauged by the growth of canines. Depending on the species, this is usually at four to six weeks of age. Canine teeth should be fully developed before mealworms or soft food is offered. Soft food should be fed to the bat through the tip of a 3ml syringe. Crevice bats should be held in the hand, as described in Feeding Adult Bats. Tree bats should be positioned so the head is slightly lower than the rest of the body (the same V position) as described for infants.

Juvenile bats should be fed every 8 to 12 hours (two to three times per day). Juvenile bats can typically be allowed to eat as many mealworms or as much of the soft food diet as they will accept at each feeding, although small species (adult weight less than 10g) should not be allowed to eat more than 1.0ml per feeding, and medium-sized species (adult weight 10g to 20g) should not be allowed to eat more than 1.5ml per feeding. Milk should be offered after each feeding of mealworms or soft food until the bat refuses. Although the author cautions against allowing significant abdominal distention in newborn pups, juveniles will normally have somewhat distended abdomens following each feeding.

It is important to note that even when canine teeth are fully grown, both wild and captive juvenile bats will continue to supplement their diets with their mother's milk (Figure 9-15). It is therefore normal for adult-sized orphaned juvenile bats to continue drinking milk, particularly if they have been nutritionally deprived as orphans. **Juvenile bats who refuse mealworms or soft food are not ready to be weaned and should never be forced to do so, regardless of their age or the fact that they may be adult sized.**

It is also critical to note that juvenile bats sometimes accept mealworms or soft food initially, but then later revert and attempt to nurse on the syringe or the mealworm or refuse adult food entirely. These bats should be allowed to return to nursing from a tip or lapping from a syringe or medicine dropper (whichever they prefer) for another week or two, at which time mealworms or soft food can again be offered. Some pups may go back and forth from milk formula to soft food/mealworms for a few weeks. It is important to be patient and always follow their lead until they are ready to be weaned. Juvenile bats who are completely ready to be weaned will no longer accept milk.



Figure 9-15. An almost adult-sized juvenile big brown bat nursing from his mother. *E. fuscus*. Photo by Melanie M. Wells.

Caring for Geriatric Bats

Some species of bats have been successfully maintained in captivity for long periods of time. Old bats often have worn teeth, and their hair may turn gray or white. The joints of the fingers, ankles and knees may enlarge, possibly from swelling due to arthritis. These bats lose the ability to fly and often move very slowly.

In captivity, older bats are sometimes chased or crowded from roosting pouches and feeding trays by younger, more rambunctious roostmates. To protect these bats, it is best if they are housed with other geriatric bats, or other passive individuals. Roosting pouches, food and water trays should be placed within easy reach of older bats and should be placed in the same position each day (Figure 9-16). These bats do not require diversity, and in fact are likely to become stressed or even injured if anything in their living space is not where they have come to expect it to be. Enrichment can be provided by hand-feeding special treats such as mealworm and waxworm viscera, and gentle grooming.

Feeding requirements may also change for some geriatric bats. That is, they may require more frequent feedings of smaller quantities. Most older bats will be on the complete soft food diet because their teeth will eventually become so worn that they will not be able to chew solid foods. These bats may need to be fed small quantities three times a day. Some geriatric bats will also have difficulty grooming. It is therefore important that they are kept clean and brushed on a daily basis.



Figure 9-16. An elderly pallid bat expecting her daily treat of mealworm viscera. This bat stays in a modified roost made of foam which sits on the enclosure floor, with her food and water dish in close proximity. A blue surgical towel covers the bottom of the roost and is changed daily. *A. pallidus*. Bat World facility. Photo by A. Lollar.