CHAPTER SEVEN
FEEDING ADULT BATS

General Information

Insects are generally a high-protein food item, although the nutritional content of insects varies from one species to another. Specific caloric requirements for many bat species are unknown. However, one proposed energy budget for a fringed myotis (*M. thysanodes*) in early pregnancy (weighing 9g) is 3,341 calories (0.37kcal/g/day) during nocturnal activity (flight and night roost maintenance), and 1,410 calories (0.16kcal/g/day) for day maintenance at 68° Fahrenheit for a regulating female, or 690 calories (0.08 kcal/g/day) for a non-regulating female. The total energy budget would thus be 4,751 calories (0.53kcal/g/day) for a regulating female or 4,031 calories (0.45 kcal/g/day) for a non-regulating female (Hill and Smith, 1984). By entering torpor and allowing their body temperature to drop to levels below the lower thermal critical, that is, below the ambient temperature at which an animal must expend metabolic energy to maintain a constant warm internal temperature or homeostasis, many microchiropteran bats are able to decrease energy demands.

The author does not presume to know the specific nutritional requirements of bats in the wild. What is known, however, are specific nutritional regimens that promote long-term maintenance of many species of bats in captivity. For example, the Bat World Sanctuary complete soft food diet described on page 76 has been somewhat modified over the years. However, the author has maintained a reproductive colony of Brazilian free-tailed bats (*T. brasiliensis*) on the same basic diets described in this chapter, and a number of individuals have survived from birth to age ten through 18 years. Some of the young conceived in these colonies are now over ten years old and continue to participate in mating activity. Third generation young are also participating in mating activity (see Table 8-1). In addition, species considered particularly difficult to maintain in captivity, such as the red bat (*L. borealis*), have been successfully raised from birth on these diets.

A detailed discussion of the success and nutritional composition of various captive diets for insectivorous bats can be found in Rasweiler, 1977. This work includes valuable information about mammalian protein, carbohydrate, fat, vitamin, and mineral requirements and discusses conditions that can result from excesses as well as deficiencies. Further information about nutritional requirements of captive bats can be found in Wilson, 1988.

Insectivorous bats probably obtain some of their vitamin and mineral requirements from green plant material present in the digestive tracts of some insects. The following chart describes plants that may provide nutrients to bats via the insects consumed.

Table 7-1
Plants that may Provide Nutrients to Bats through Insects

PLANTS	INSECTS	BATS
FOODS/PRODUCTS: Alfalfa, clover, cotton, flax, soybean, tobacco, cabbage, cantaloupe, lettuce, pea, pepper, pigeon pea, squash and tomato FLOWERS: Ageratum, bird of paradise, chrysanthemum, gardenia, geranium, mallow, marigold, petunia, snapdragon, strawflower, verbena, and zinnia	Tobacco budworm	Brazilian free-tailed bat (*T. brasiliensis*)
FOODS/PRODUCTS: Corn, tomato, alfalfa, artichoke, asparagus, avocado, cabbage, cantaloupe, collard, cotton, cowpea, cucumber, eggplant, flax, grapes, lettuce, lima bean, melon, millet, oats, okra, pea, peaches, pears, pepper, plum, potato, pumpkin, raspberries, rice, snap bean, spinach, sorghum, soybean, sugarcane, sunflower, squash, strawberry, sweet potato, tobacco, watermelon, and wheat	Cotton bollworm moth Corn earworm Tomato fruit worm	Brazilian free-tailed bat (*T. brasiliensis*)

PLANTS	INSECTS	BATS
FOODS/PRODUCTS: Alfalfa, asparagus, bean, beet, broccoli, cabbage, cauliflower, celery, chickpea, corn, cotton, cowpea, eggplant, lettuce, onion, pea, peanuts, pepper, potato, radish, safflower, sorghum, soybean, spinach, sugar beet, sweet potatoes, tobacco, tomato, and turnip	Beet armyworm	Brazilian free-tailed bat (*T. brasiliensis*)
FOODS/PRODUCTS: Alfalfa, apple, barley, Bermuda grass, buckwheat, cotton, clover, corn, grape, oat, orange, millet, papaya, peach, peanut, rice, ryegrass, sorghum, strawberry, sugar beet, Sudan grass, soybean, sugarcane, timothy, tobacco, and wheat	Fall armyworm	Brazilian free-tailed bat (*T. brasiliensis*)
FOODS/PRODUCTS: Pecan trees.	Hickory shuck worm	Brazilian free-tailed bat (*T. brasiliensis*)
FOODS/PRODUCTS: Tomatoes and grape leaves	Sphinx moths	California leaf-nosed bat (*M. californicus*)
FOODS/PRODUCTS: Corn, spinach, soybeans and various vine plants. Note: The greatest impact is by the larvae (corn rootworms) which damage corn crops. In one summer season, 150 bats of an average maternity colony can eat 38,000 cucumber beetles which means approximately 18 million rootworms are not produced	Cucumber beetles Corn rootworms (larvae)	Big brown bat (*E. fuscus*)
FOODS/PRODUCTS: Broad-leafed woody and herbaceous plants of many families, sedges and conifers	Leaf hoppers	Underwood's bonneted bat (*E. underwoodi*)
FOODS/PRODUCTS: Timber	Bark beetles	Northern yellow bat (*L. intermedius*), Seminole bat (*L. seminolus*)
FOODS/PRODUCTS: Orchards and soybeans	Green Stinkbugs, Brown stinkbugs	Big brown bat (*E. fuscus*), big free-tailed bat (*N. macrotis*), pocketed free-tailed bat (*N. femorasaccus*)
FOODS/PRODUCTS: Alfalfa, broad-leafed woody and herbaceous plants, conifers, soybeans, sedges, sugar beets, tomatoes, and vineyards	Beet leafhopper Potato leafhopper	Big brown bat (*E. fuscus*), pallid bat (*A. pallidus*), eastern red bat (*L. borealis*), Yuma myotis (*Myotis yumanensis*), tricolored bat (*P. subflavus*), canyon bat (*P. hesperus*), Underwood's bonneted bat (*E. underwoodi*), big free-tailed bat (*N. macrotis*), pocketed free-tailed bat (*N. femorasaccus*), Brazilian free-tailed bat (*T. brasiliensis*)
FOODS/PRODUCTS: Timber	Spittlebugs	Pallid bats (*A. pallidus*), Yuma myotis (*Myotis yumanensis*), evening bat (*N. humeralis*), big free-tailed bat (*N. macrotis*), pocketed free-tailed bat (*N. femorasaccus*)
FOODS/PRODUCTS: Tobacco and tomato	Stilt bugs	Canyon bat (*P. hesperus*)
FOODS/PRODUCTS: Sedges, broad-leafed woody and herbaceous plants of many families, and conifers	Leaf hoppers	Underwood's bonneted bat (*E. underwoodi*)

PLANTS	INSECTS	BATS
FOODS/PRODUCTS: Pine and spruce tree	Sawflies	Townsend's big-eared bat (*P. townsendii*)
FOODS/PRODUCTS: Damage many plants by causing the formation of plant galls in which the larvae live	Midges	Little brown bat (*Myotis lucifugus*)
	Mosquitoes	Little brown bat (*M. lucifugus*), Brazilian free-tailed bat (*T. brasiliensis*), northern yellow bat (*L. intermedius*), southeastern myotis (*M. austroriparius*)
	Roaches	Allen's big-eared bat (*I. Phyllotis*)
	Termites	Hawaiian hoary bat (*L.c. semotus*), big brown bats (*E. fuscus*)
	Mayflies	Little brown bat (*M. lucifugus*), gray bat (*M. grisescens)*
	Crickets	Pallid bat (*A. pallidus*), Seminole bat (*L. seminolus*), western mastiff bat (*E. perotis*), big free-tailed bat (*N. macrotis*), pocketed free-tailed bat (*N. femorasaccus*)

Mealworms

The standard diet for most insectivorous bats in captivity consists of live mealworms. Other vitamin, mineral, and fatty acid supplements are also necessary and are added to mealworms and the complete soft food diet described on page 76. It is not advisable to exceed the authors' recommendations for vitamin or mineral supplements as this can result in serious disorders.

Mealworms are the larvae of the darkling beetle (*Tenebrio molitor*). (For nutritional content see Finke, 2002.) This diet may be supplemented with crickets (*Acheta domestica*) for some bat species such as pallid bats (*A. pallidus*) and big brown bats (*E. fuscus*). Unless the bat's teeth are cleaned on a weekly basis, it is not a good idea to feed wax moth larvae (*Galleria mellonella*) except in soft food mixtures because the outer tissue layer of the larvae can become embedded in the gums of a bat's teeth, resulting in gum infections and subsequent tooth loss over a period of time (Lollar, 1994). Do not feed captive bats net sweepings (live insects caught outdoors) in areas where mosquito fogging takes place because the insects may contain pesticide residues that could adversely affect bats.

Although mealworms and crickets are often available at pet stores, they may be purchased in greater quantities at reduced prices from several commercial distributors. Mealworms may be purchased in small, medium, large, and giant sizes. The smaller worms are best for bats weighing 3g to 6g. Medium and large-sized worms may be best for species weighing more than 6g. Large or giant-sized mealworms are more simple to use when feeding a bat that is only able to eat the viscera (i.e., insides) of the mealworm. This might be the case for a bat with very worn teeth or a gum infection that makes it impossible for the animal to chew the harder, chitinous outer portion of the worm. Bats need fiber in their diet, which can be found in the chitin of mealworms. Fiber is provided in the soft food diet by blending the mealworms with other foods, as described further.

MEALWORM MEDIUM

Mealworms commonly arrive packaged in a cloth bag filled with crumpled or shredded newspaper. Upon arrival, they should be placed immediately into the nutritional mealworm medium listed on the following page.

- Organic chick starter. Use a blender on a high-speed setting to turn the granules into powder.
- Wheat bran
- Calcium carbonate powder
  (Approximately 60% powdered chick starter, 38.5% wheat bran, and 1.5% calcium carbonate by volume.)

Allow mealworms to remain at room temperature for two days before placing the container in the refrigerator. This initial period allows the worms to "plump up" considerably and reach optimum calcium levels. During this time, provide moisture for mealworms by placing thinly sliced "moisture food" on top of the medium. Use nutritious fruits and vegetables such as apple, corn on the cob, sweet potato, squash, carrot, organic greens, kale and fresh green beans. Avoid foods which are overly juicy or sticky such as cucumber or banana, as well as bitter foods such as banana peel.

On the second day, refrigerate the worms and medium in a ventilated container. Mealworms develop into pupae, which subsequently develop into beetles. Remove any beetles that develop in the medium containing adult worms. The beetles lay eggs in the apple or potato skins, and larvae (mealworms) hatch from the eggs. Refrigeration slows down the process and helps prevent contamination by parasites such as grain mites.

Mealworm medium should be discarded and replaced with fresh preparations every one to two weeks. It is particularly important that you do not keep mealworms in a warm, moist environment such as a laundry room. An exceptionally humid environment will speed up the life cycle (i.e., development into the beetle) and will frequently result in the development of mold which could be fatal if fed to bats.

Preparing Mealworms for Self-feeding Bats

Nutrient values (dry wt) of mealworms raised on this medium*
Protein 38.1%; Fat 26.3%; Crude fiber 4.2%; Ash 7.5%; Calcium 1.77%; Phosphorus 1.38%; Magnesium 0.21%; Sodium 0.20%; Potassium 0.89%; Iron 187 mg/kg; Zinc 106 mg/kg; Manganese 33 mg/kg; Copper 22 mg/kg.
* - All values represent the average of chemical analysis of two different batches of "gut-loaded" mealworms.

Early in the day, remove mealworms that will be used for the evening feeding from the refrigerator. The use of a sifter, as pictured on the right, greatly reduces the time-consuming process of removing mealworms from the medium at feeding time. It is important that no grains adhere to worms fed to the bats.

Figure 7-1. Sifting mealworms from medium. *Photo by L. Crittenden.*

Mealworms can be easily sifted out of the mixture with a large-holed strainer (Figure 7-1), then placed under light so they will "self-clean." Sift the worms until they are free of wheat bran and other debris, then place the sifted worms into a shallow pan.

Tilt the pan so that all the worms slide to one end of the pan (Figure 7-2A). Then, place the pan under a light source. Within a few minutes the majority of clean worms will gravitate toward the opposite end of the pan, leaving debris behind (Figure 7-2B). This method of sorting worms saves hours a day on meal preparation for insectivorous bats.

After the worms have been sorted in a pan and are completely clean, place the clean worms into another pan, then place nutritious moisture food such as corn on the cob, carrot, organic greens, fresh green beans, or thinly sliced apple, sweet potato or squash on top of the worms (Figure 7-2C). Mazui Better Bug® Gut Loading Diet may also be added to the worms for additional nutrition (Kate Rugroden, pers. comm.). Place the pan in an area away from bright lights and allow mealworms to feed on the moisture food throughout the day. Mealworms frequently take on the coloration of the fruits, grains, and vegetables on which they have fed and subsequently taste different, adding variety and more nutrition to a captive bat's diet.

In the evening, remove any leftover vegetables and fruit from the pan of clean mealworms. Uneaten vegetables or fruit can be stored in the refrigerator and reused, or added to the mealworm medium. After the fruit or vegetables have been removed, sift mealworms in a strainer to remove worm feces. Place the sifted mealworms into a pan and sprinkle with the following supplements per every two cups of clean mealworms:

- 2 teaspoons of Missing Link® or 2 teaspoons of Vionate® powder (Alternate these two supplements on a nightly basis.)
- 1/4 tsp organic spirulina

Gently toss the worms with your fingers to thoroughly coat the worms with the supplements. If necessary, sift the mealworms to remove excess powdered supplements. The excess powder can be saved and reused the following night.

Hand-feeding Adult Bats

The number of mealworms a bat will consume in captivity depends on a variety of factors including the species, the general health and condition of the individual animal, its nightly activity (i.e., is it flying), the season, and the ambient temperature. Bats that are not self-feeding should be fed twice a day, once in the morning and again in the evening. Feeding times should be roughly 12 hours apart. Species weighing between 10g to 20g typically eat anywhere from 10 to 20 one-inch mealworms at each feeding, while smaller species weighing between 3g to 10g may only eat 5 to 10 mealworms at each feeding. Large species weighing 30g to 70g can eat 5 to 10 giant mealworms at each feeding.

Feed a bat as many worms as it will accept at each feeding twice a day for the first couple of days. It is important to check the distention of the abdominal area periodically as the bat feeds. The area on the underside of

Figure 7-2. A: Sifted worms are bunched up at one end of the pan and placed under a light source. **B:** Within minutes, clean worms move to the opposite end of the pan, leaving debris behind. *Photo by A. Lollar.*

C: A pan of clean mealworms feeding on carrots. These worms are intended for the evening feeding. *Photo by A. Lollar.*

D: Adding vitamin supplements just before feeding time. *Photo by L. Crittenden..*

the bat just between the legs should not be sunken in as this is a sign that the bat has gone without food for too long. A flat abdomen means the bat has not yet had enough to eat. An overly distended abdomen means the bat has been allowed to consume too much food.

Teaching Adult Bats to Self-feed

Some wild bats can be tempted to eat when first received by offering them a live mealworm. Allow the bat to hang head down on the side of its cage (tree bats) or to rest horizontally inside a roosting pouch (crevice bats), and, using forceps, gently run a mealworm along the bat's jaw line. This usually causes the bat to open its mouth, allowing the mealworm to be placed inside. A bat will often clamp down on the worm, recognize it as food, and continue to eat. If the bat will not eat a mealworm whole, try offering it a decapitated worm. Pinch off the head of the mealworm, and, using forceps, squeeze out a small amount of the viscera (i.e., insides) into the bat's mouth.

Some bats will immediately open their mouths and bare their teeth, tasting the viscera in the process and providing an opportunity to again place a worm in their mouth. However, some bats will shy away from food offered in this manner and must be held gently but firmly in the hand with the head somewhat lower than the rest of the body. Mealworm viscera can then be offered as described above. If a bat still appears too fearful to eat mealworms, soft food should be offered.

The length of time it takes for a bat to learn to feed from trays or dishes varies from species to species and from individual to individual. Bat species that glean insects from surfaces or forage for insects on the ground may learn to eat from a tray placed on the bottom of a cage more quickly than species that feed mainly in flight. Molossid bats can be difficult to teach to self-feed. The facial structure of these bats appears to make it difficult for them to grasp a moving insect from a flat surface, although many can be taught to self-feed over time (Lollar, 1994). Some species, such as *M. lucifugus,* will feed from trays of mealworms on their own without ever being taught. Some bats never learn to self-feed and must be hand-fed twice daily (Figure 7-3A and B).

Bats should be accustomed to eating hand-fed mealworms before training is initiated. When first training a bat to self-feed, hold the animal over a small tray of mealworms (crevice bats) or allow it to hang freely on the side of a cage and directly over the dish (tree bats). The tray should be shallow but large enough for the bat to climb in and out without allowing the mealworms to escape and heavy enough so the bat can't tip it over. Mealworms can easily climb on roughened surfaces, so use a tray with a smooth surface. Remove mealworms from the tray with blunt forceps, and offer them to the bat one by one. Hold the bat close to the tray or dish so

Figure 7-3. A: A 4g *P. hesperus* appears to enjoy a hand-fed, small-sized mealworm. *Photo by D. Hyatt.* **B:** A 60g *E. perotis* being hand-fed a giant-sized mealworm while hanging in her roost. *Photo by A. Lollar.* Both species typically require being hand-fed in captivity.

it can watch as you pick up each mealworm (Figure 7-4A). Hand-feed it several mealworms until it begins reaching into the tray on its own. Once the bat has taken a few worms from the dish completely on its own, do not continue to use the forceps to help the bat. To do so will hinder the training process and may result in the bat becoming dependent on the caretaker's help during each meal.

The training process will build trust between the caretaker and the bat, and should be a pleasant experience for the bat. Teaching bats to self-feed can be frustrating; it is very important to stay calm even when things aren't going well. Always end a training session in a positive manner. If the bat appears stressed during the training process, give it a "treat" of viscera, then put it away and allow it to calm before trying again. It is important to remember that some bats may never learn to self-feed. These bats should be fed the complete soft-food diet discussed later in this section.

Figure 7-4. A: Training a free-tailed bat to self-feed on mealworms. *T. brasiliensis. Bat World facility. Photo by J. Waltz.*

Crevice Bats

After a crevice bat has taken mealworms from a dish on its own while being held in the hand, dishes can be added to the cage to encourage self-feeding. After training, most bats begin eating from the dish the first night. Cover the bottom of the tray or dish with mealworms (see Mealworm Dishes for photos of dishes filled with the proper amount of mealworms). Alternately, a Multipet Tree House is an excellent device for training bats to self-feed as well as providing a hiding place for shy crevice bats to self-feed (see Mealworm Dishes). Place trays against the walls to allow bats to crawl down the side of the cage and feed from a tray while still hanging head down. Be sure that mealworms placed in trays for self-feeding are free of medium, shed skin, pieces of worms, and dead worms.

In the morning, remove guano, dead worms, and mealworm feces, then place the remaining live worms back into the mealworm medium in the refrigerator. Bats should never be fed dead mealworms. Wash the dish in antibacterial detergent after each use, and rinse well.

Tree Bats

As a general rule, tree bats that have been taught to self-feed from mealworm trays do not find the mealworms left in their cages for self-feeding. More importantly, due to the tendency of tree bats to overfeed, leaving trays of mealworms in their enclosures can be dangerous. Instead, hang the bat over the dish so it can self-feed (Figure 7-4B), then remove the bat five to ten minutes later, when the bat appears full. Check the distension of the abdomen, and if the bat appears full, remove the tray of mealworms.

B: A hoary bat learning to self-feed on mealworms. *L. cinerus. Bat World facility. Photo by A. Lollar.*

Be sure that mealworms placed in trays for self-feeding are free of medium, shed skin, pieces of worms, and dead worms. Always offer water by hand to tree bats, allowing them to drink their fill. Be sure to wipe any debris and moisture from the bat's face and neck using a cotton swab or soft piece of gauze, then return the bat to its normal roosting place.

Remove the dish after the bat has been fed. Remove guano, dead worms, and mealworm feces, then place the remaining live worms back into the mealworm medium in the refrigerator. Wash the dish in detergent after each use.

Additional Notes

- Nitrile finger cots worn on the thumb and index finger will prevent staining of the fingers from mealworms.

- Mealworms should never be left in enclosures with severely debilitated bats or with bats that have sustained back or other injuries that seriously impede terrestrial movement because they can be overcome and eaten by the mealworms. On the contrary, trays or dishes of fresh mealworms should be left in enclosures both day and night when large colonies of healthy crevice bats are being maintained.

- Upon first learning to self-feed, some bats will overeat. This is true of big brown bats (*E. fuscus*) in particular. However, the author has found that bats of several different species including big brown bats (*E. fuscus)*, Brazilian free-tailed bats (*T. brasiliensis*), cave bats *(M. velifer*), evening bats (*N. humeralis*), and pallid bats (*A. pallidus*) will in fact regulate their consumption within a period of approximately two to three months and remain within appropriate ranges for the species, despite initial (and sometimes dramatic) weight gains. It should be noted, however, that because some bats initially become obese when given unlimited access to food, bats intended for future release may need to be hand-fed the complete soft food diet.

- If a bat allowed to self-feed has exceeded the upper end of the weight range for the species, its diet can be carefully adjusted by reducing each feeding by only two or three mealworms until the desired weight is attained. Many captive bats will also increase their consumption and body weight naturally in the fall in preparation for migration or hibernation (see Hibernation).

- Bats that do not learn to self-feed will need to be hand-fed for the duration of their captive lives. Caretakers who are not prepared to care for a bat in this manner should place the bat in an accredited sanctuary.

Feeding Crickets

Crickets (*Acheta domesticus*) constitute a part of the normal diet in the wild for species such as pallid bats (*A. pallidus*), and big brown bats (*E. fuscus)*. House crickets are available from several insect supply houses. These insects are less nutritious than the mealworm diets because crickets are more selective in their feeding habits and cannot be provided with supplemental nutrients as easily as mealworms can, which is why they are only used as a supplement to traditional diets. Information regarding the care and feeding of crickets is provided by Patricia Winters as follows:

It is best to refrigerate crickets immediately on arrival for about 30 minutes in order to reduce their activity level, making the transfer from the delivery carton to a storage container much simpler. Do not refrigerate them for any longer as they may die within just a few hours of initial refrigeration. Crickets should be maintained in a large aquarium or plastic storage container covered with a screened top. Place rabbit-food pellets, greens, and carrots on the bottom of the storage container and add a small dish of water filled with small pebbles to prevent the crickets from drowning. Then place the crickets in the container and cover with the screened lid. Keep the storage container with crickets in a dry environment at about 70° Fahrenheit. Dampness

and odor is a constant problem when housing crickets.

Check the container carefully each day for any mold growth either in the container or on the food, and dispose of all contents, including the crickets, if contaminated materials are detected. Thoroughly clean the container with a disinfectant and rinse well before adding fresh medium. All water and any remaining food must be removed daily and replaced with a fresh supply.

The Bat World Sanctuary Complete Soft Food Diet

A variety of soft food mixtures have been used to maintain bats in captivity. These mixtures, often referred to as bat glop, are generally prepared in bulk, frozen, and then defrosted in small quantities and fed to bats. The use of soft food mixtures was generally intended to minimize the time and/or expense of caring for multiple bats used in research studies because bats will frequently refuse to eat mealworms when first taken into captivity. However, newly captive bats can usually be encouraged to eat the complete soft food diet. Soft food is also recommended for emaciated bats, bats with dental infections, and juvenile bats being transitioned to whole mealworms.

It is important to note that bats fed soft mixtures only (without live insect supplements) often did not fare well. In contrast, several species of insectivorous bats, including a reproductive colony of *T. brasiliensis*, have remained healthy for over 28 years on the soft food diet described in this section. However, these bats are supplemented daily with the viscera of live giant mealworms. It is therefore critical that viscera from live meal worms or giant mealworms are fed daily along with soft food.

Soft Food Recipe (Feeds 15 to 20 medium-sized insectivorous bats.)

1 cup frozen mealworms (about 1,200 large mealworms) or a combination of frozen mealworms & wax worms
1/3 cup of very cold water (80ml)
2 tablespoons of organic baby food
2 tablespoons of organic or non-gmo corn oil
1 teaspoon Missing Link® (Well Blend)
1 teaspoon of Vionate®
1/4 teaspoon organic spirulina

Use a high-speed glass blender to prevent overheating. Pour the water into the blender. Gradually add frozen mealworms while blending on the highest setting. Blend until it is the consistency of honey. Add baby food (use bland flavors such as sweet potato or other flavors like corn, squash, carrots, peas, green beans, apple, and pears). Add the organic corn oil, Missing Link®, Vionate® and organic spirulina. **The mixture must remain cool while blending**; if it overheats, it will spoil. If mixture is in danger of becoming heated during the blending process, add a little cold water or an ice cube. Blend the final mixture until it is very, very smooth (the consistency of applesauce), while continually checking the temperature of the mixture while blending.

Freeze soft food in small containers or an ice cube tray (store frozen cubes in freezer bags). Note: mixtures that have not been thoroughly blended will clog feeding syringes, so be certain frozen mealworms are well-blended. Soft food can be stored in a refrigerator for 3 days or in a freezer for up to 90 days. Soft food that has already been thawed should never be refrozen. Discard soft food that has been frozen for more than 90 days.

About 25 healthy bats per hour can be hand-fed soft food; however, it takes longer to feed debilitated bats. O-ring syringes are perhaps the best choice of syringe as others tend to clog easily.

Permanent captives that have lost teeth or have extremely worn teeth can remain on a soft food diet for the

rest of their lives. These permanent captives must also be offered viscera from live mealworms daily (large or giant sized) in addition to soft food.

Additional Notes

Adding an ice cube to the frozen mealworms during the blending process will help the food to remain cold while blending, which will prevent spoiling.

If not blended for a sufficient period of time, soft food may have a grainy consistency and may contain chunks of worms or softened worm skins that bats will not accept. The mixture should flow freely through the tip of a 3ml syringe. Check to make certain it is thoroughly blended by drawing the mixture into a 3ml syringe while it is still in the blender. If the entire 3ml does not flow freely back out of the syringe when the plunger is pushed in (i.e., if it clogs the syringe), continue blending until it will.

Check the temperature of the sides of the blender throughout the blending process. They should remain cool. If overheated, the mixture will spoil, and bats will not eat it. This is why frozen mealworms must be used.

Soft food that is turning rancid will develop tiny air bubbles that are easily noticed when the food is drawn into a syringe. Rancid food (or food that is even questionable) should be discarded.

Once the syringe is filled with soft food, it should be placed in a bowl of warm water. Before feeding, the temperature of the mixture should be tested by placing a small amount on the inside of the wrist; the food should be moderately warm (never hot). It is very important that the mixture not be overheated when warming it prior to feeding. If overheated, moisture will be drawn out of the mixture and it will take on a lumpy consistency that most bats will not accept.

If a bat is arousing from daily torpor, it will shiver as it warms up. It needs to be sufficiently warmed before feeding so that it can digest its food. A bat is also more likely to aspirate or choke on food if forced to feed while it is shivering. You can speed up the arousal process by holding the bat in your hand. When it has stopped shivering, hold it so that the head is parallel to its body, and place a small drop of the soft food in the bat's mouth. Never hold the bat in a head-up position when feeding any kind of food.

When feeding species of the family Vespertilionidae, point the syringe towards the chin or to one side of the mouth to avoid getting soft food in the bat's nostrils. Molossid bats may require more prompting to get them to begin eating. Gently force the lower jaw downward with the tip of the syringe against the top of the lower teeth, and then place a small amount of food directly in the bat's mouth, as shown on the following page. Although many weak bats cannot be forced to eat live mealworms or even mealworm viscera, most can be coaxed into eating soft food.

It may take a few minutes for the bat to begin eating. Bats that are very weak will swallow the food placed in their mouths very slowly, and patience is needed to insure adequate food intake and a positive experience for the bat. Allow them to take their time with each mouthful. Even for bats that readily accept soft food, it is critically important to wait a few seconds between mouthfuls to make certain they have swallowed all of the food before offering more. Some bats may to eat to fast and will aspirate if not forced to wait a few seconds between mouthfuls.

Feed soft food mixtures twice a day to bats unable to eat live mealworms, once in the early morning and again in the evening, approximately 12 hours apart. Bats weighing 10g to 20g will typically eat 1.0ml to 2.0ml of a soft food at each feeding. Bats weighing 20g to 35g may eat as much as 3.0ml per feeding. Smaller species may only eat 0.5ml to 0.75ml per feeding. Even the smallest of bat species in the United States (i.e., a 3g bat) should be fed a total of at least 1.0ml per day (0.5ml per feeding). With the exception of newly volant juvenile bats, it is not advisable to exceed these quantities when feeding bats soft food mixtures.

Table 7-2
Bat World Sanctuary Complete Soft Food Diet
Nutritional Analysis

Ascorbic Acid (Vitamin C) (mg/100 g)	< 1.00/100g
Ash	1.11%
Calcium	0.41%
Copper (ppm)	4.06
Crude Fiber	1.46%
Crude Protein (%)	9.41%
Fat (acid hydrolysis)	10.33%
Iron (ppm)	35.8
Magnesium	0.038%
Manganese (ppm)	6.36
Moisture	77.03%
Phosphorus (ppm)	1,714
Potassium	0.23%
Sodium	0.26%
Vitamin A (as Retinol only) (IU/100g)	5,395.58
Zinc (ppm)	10.61

Amino Acid Analysis

Alanine	0.72%
Arginine	0.44%
Aspartic Acid	0.61%
Cystine	0.12%
Glutamic Acid	1.57%
Glycine	0.46%
Histidine	0.24%
Isoleucine	0.22%
Leucine	0.87%
Lysine	0.30%
Methionine	0.08%
Phenylalanine	0.51%
Proline	0.75%
Serine	0.33%
Threonine	0.50%
Tryptophan	0.09%
Tyrosine	0.26%
Valine	0.59 %

Proper Feeding Technique, Crevice Bats

Figure 7-5. A: Gently force the lower jaw downward with the tip of the syringe, and then place a small amount of food directly in the bat's mouth. **B**: As the bat chews, slowly dispense more food into the mouth, being sure to wait several seconds between mouthfuls to make sure the bat has swallowed all of the food before offering more. *T. brasiliensis. Photos by M. Kreb.*

Figure 7-5. C: After the bat is full, use a damp paper towel or gauze to wipe any food that has collected on your hand beneath the bat. Be sure to clean your hand first (not the bat) as anything remaining on your hand will likely end up on the bat as you put the bat away. **D**: After your hand is clean, gently wipe the bat's face and chin with a dampened paper towel or gauze. Be sure to check the throat and clean that area if needed. If necessary, use an interdental brush to clean the fur as described in Bathing and Grooming Procedures. Be sure to dry any fur that becomes wet. **E:** After feeding, this bat is clean and ready to be returned to her roost. The total time spent feeding and cleaning this bat was approximately four minutes. *T. brasiliensis. Photos by M. Kreb.*

Proper Feeding Technique, Tree Bats

The soft food diet should be fed to tree bats using a method that prevents food from accumulating on the fur. One technique involves holding the bat with its head tilted in a downward position so it lays prone against your fingers, with its head extending past your fingertips. Rest your thumb on the shoulder blades to secure the bat in your hand. Dispense the food a mouthful at a time. As the bat chews, slowly dispense more food into the mouth, being sure to wait several seconds between mouthfuls to ensure the bat has swallowed all of the food before offering more.

Figure 7-6. A: An injured hoary bat being fed as she roosts within her cage. *L. cinerus. Bat World Lone Star facility. Photo by D. Hyatt.*

Another technique is to allow the bat to hang from the side of a cage or BatHut while being fed soft food (Figure 7-6A). This method is particularly beneficial when minimal handling and disturbance of the bat is necessary, such as for a lactating tree bat with pups attached to her body, or bats that are healing from injuries.

Improper Feeding Techniques

While gloves may be necessary for safely handling bats during initial examinations, the use of gloves and face masks will greatly impair a caretaker's ability to properly feed insectivorous bats. Masks reduce the caretaker's visibility when looking down, and may also decrease the bat's ability to reach a level of comfort and visual familiarity with its handler (Figure 7-7A). Gloves increase the likelihood that mealworm viscera and soft food will adhere to the bats fur because the handler is unable to feel that the bat is getting wet until the bat's neck and throat become saturated (Figure 7-7B).

Food must never be allowed to collect under the chin and neck of the bat. Allowing the bat to become soiled with soft food or mealworm viscera will result in loss of fur and subsequent skin infections (Figure 7-7C). These infections can become systemic if not properly treated, resulting in death. Bats with dense fur are particularly prone to infections when improper feeding techniques are used.

Pay close attention to both the face, as well as ventral surfaces as you are feeding soft food to a bat, and these problems are easily avoided. Placing gauze under the bat's chin, in bib-like fashion, or holding the bat so that excess food drips off the chin and away from the bat, rather than on the caretaker's hand, will keep the bat clean during the hand-feeding process. **Never** put a bat away with food adhering to its coat as infection will result. Use an interdental brush dipped in warm water to gently and thoroughly brush food from the fur, paying close attention to the area under the chin and neck (see Bathing and Grooming).

Figure 7-7. A: Use of masks and gloves impede proper feeding techniques, causing a bat to become soiled with food. **B:** Bats should never be held upright and/or force fed. **C:** Ulcerative dermatitis resulting from the improper feeding techniques described in A and B, occurring at the Smithsonian National Zoo. This bat did not survive due to infection. *C. townsendii virginianus. Photos by M. Singleton.*

Table 7-3
Average Weights of Insectivorous Bats
(in grams)

Family Mormoopidae	
Mormoops megalophylla (1)	13-19
Family Phyllostomidae	
Choeronycteris mexicana (1)	10-25
Leptonycteris yerbabuenae (3,2,3)	18-30
Leptonycteris nivalis (1)	24
Macrotis californicus (3,2,3)	12-20
Family Vespertilionidae	
Antrozous Pallidus (1)	12-17
Corynorhinus rafinesquii (1)	7-13
Corynorhinus townsendii (1)	7-12
Euderma maculatum (1)	16-20
Eptesicus fuscus (1)	13-20
Idionycteris phyllotis (3,2,2,)	8-16
Lasionycteris noctivagans (1)	8-12
Lasiurus blossevillii (1)	10-15
Lasiurus borealis (1)	10-15
Lasiurus cinereus (1)	20-35
Lasiurus ega (1)	10-15
Lasiurus intermedius (1)	18-24
Lasiurus seminolus (1)	10-15
Lasiurus xanthinus (2,2)	10-15
Myotis auriculus (2,2)	Unknown
Myotis austroriparius (1)	5-7
Myotis californicus (1)	3-5
Myotis ciliolabrum (1)	4-5
Myotis evotis (4,2,2)	4.2-8.5
Myotis grisescens (7,2,2)	7.9-13.5
Myotis keenii (4,2,2)	4.0-5.9
Myotis leibii (7,2,2)	4.1-5.5
Myotis lucifugus (1)	7-9
Myotis septentrionalis (1)	5-9
Myotis sodalis (7,2,2)	7.1-7.5
Myotis thysanodes (1)	6-11
Myotis velifer (1)	15
Myotis volans (1)	5-9
Myotis yumanensis (1)	4-6
Nycticeius humeralis (1)	5-7
Parastrellus hesperus (1)	3-6
Perimyotis subflavus (1)	4-6
Family Molossidae	
Eumops floridanus (7,2,2)	30.2-46.6
Eumops perotis (1)	65
Eumops underwoodi (1)	53-61
Molossus molossus (5,5)	12-15
Nyctinomops femorosaccus (1)	10-14
Nyctinomops macrotis (1)	24-30
Tadarida brasiliensis (1)	11-14

Information was derived from a diversity of sources including regional data. For bats found in in the state of Texas, information was taken from [1] Schmidly, 1991. For bats not found in the state of Texas, information was taken from: [2] Barbour and Davis, 1969; [3] Norwalk, 1994; [4] Nagorsen and Brigham, 1993; [5] Emmons, 1990; [6] Eisenberg, 1989; [7] Mammalian Species Account.