NATURAL HISTORY

There are 3 species of vampire bats: Common Vampire Bats (Desmodus rotundus), White-winged Vampire Bats (Diamus youngii) and Hairy-legged Vampire Bats (Diphylla ecaudata). By far the most numerous and better researched are the common vampires. For the most part the information contained in this husbandry manual is based on surveys and research conducted on Desmodus rotundus.

PHYSICAL CHARACTERISTICS

Vampire bats are about the size of a house mouse. The adult wing span is between 33 and 36 centimeters. Females tend to be larger and heavier than males. The body length of an adult vampire bat is 70 - 90 mm from the rostrum to the uropatagium. Weights can vary from 25 to 45 grams. Vampire bats have short fine fur although individual hairs vary enough in length to give the bats a some-what unkept appearance. Most vampire bats are a varied shade of gray to brown, with the back being noticeably darker than the undersides. The wings are naked and look like fine leather. Vampire bats have a short neck and a pug nose. The vampire bat has no tail.

The vampire bat's most characteristic features are its elongated thumb and its specialized teeth. The long thumb on the leading edge of the wing is longer than the bat's entire hind foot. This thumb is strong enough to serve as a front foot, allowing the vampire bat to run around silently on four "feet". The vampire bat's sharply pointed and scoop-like upper incisors are joined at their bases by impressive canines, the cutting edges of the teeth form a V-like gap. Both the upper incisors and canines are very sharp, on the lower jaw only the canines are pointed and sharp; the small peg-like front teeth have cusps designed to grasp the skin of the intended prey, and are widely spaced to permit a protruding tongue to lap its blood.

The common vampire bat is the most agile of bats in that it not only flies well, but can also climb vertical walls, and scuttle about on the ground with tightly folded wings. Vampire bats are known to break into a bouncing run that propels them forward at nearly 5 miles per hour. When necessary vampire bats can jump like a toad, covering a distance of 30 cm. or more and getting up to 15 cm. off the ground. The jump is highly variable and can carry the bat in virtually any direction. No other bat is so well adapted to getting around on land. These wonderful means of locomotion are due to the bat's great upper body strength, its powerful forearms and its specialized thumbs that act like front feet.

RANGE AND HABITAT

The common vampire bat is widely distributed throughout tropical Mexico, Central America, and South America as far south as central Chile, northern Argentina and Uruguay. It has been found at altitudes ranging from sea level to as high as 10,000 feet near the equator in the mountains of Columbia and Peru. Vampire bats are also found on the islands of Trinidad and Margarita which are close to mainland South America. Vampire bats are absent in arid regions probably due to the bat's apparent difficulty in maintaining sufficient body moisture. A limiting factor in the vampire bat's range is temperature. They appear to be restricted to areas where the coldest month's average temperature remains above 10 degrees Celsius. Vampire bats are not especially choosy about their outside surroundings, and range from coastal dry forest through tropical deciduous forests to evergreen rainforests. Of more importance to the bat than the type of vegetation present is the availability of a suitable roost site. Vampire bats roost in humid caves, old mineshafts, abandoned wells, buildings and hollow trees.

FEEDING BEHAVIOR

Vampire bats are the only mammals that can subsist entirely on blood. The introduction of domestic animals into their native habitat has been a big boom for the vampire bat. Most vampire bat colonies now feed predominantly on livestock blood, with their order of preference being cattle, horses, goats, pigs, poultry, sheep, dogs and finally people (Greenhall, 1988). Vampire bats tend to repeatedly attack the same prey, with up to 30 bats sometimes feeding off the same animal. Once a vampire bat lands on a prey animal it crawls head down in search of a good location for a bite. Specialized heat-sensitive cells in the nose help the bat find a place where the victim's blood vessels are near the surface. The bat then licks the fur, pushing it out of the way. Using its razor sharp upper incisors and canines the bat slices down into the flesh. At the same time the lobed lower incisors grasp the surface of the skin. A divot of skin about 3 mm. in diameter is excised. The wound's distinctive appearance is a sure sign of a vampire bat attack. It can take up to half an hour for the bat to select a site and open a wound. After the bite is made the vampire bat inserts its tongue through the space between the two lower incisors and along the groove in the lower lip. Two channels on the underside of the tongue draw blood from the wound. While the blood is being drawn up the bottom of the tongue, saliva which contains a powerful anticoagulant, desmokinase, is flowing down a groove in the tongue's upper surface. This anticoagulant is a plasminogen activator which dissolves blood clots and prevents thrombosis, thus allowing the blood to flow freely from the bite wound (Brown, 1994).

HOUSING

EXHIBITS

Most vampire bats are displayed in artificial cave-like structures constructed of concrete or fiberglass. Exhibits should be free of sharp projections on which the bats could tear their wings, however they must have semi-rough surfaces for roosting. Structures should be provided in the exhibit for visual barriers and to establish areas for multiple territories. The area should be uneven and have various roosting elevations to simulate a natural environment. The exhibit must be of sufficient size to prevent overcrowding and allow maturing males to withdraw into bachelor groups. Most survey respondents with at least 5 cubic foot per bat felt that their exhibit was of adequate size. Doors and corner joints need to be carefully constructed as vampire bats can squeeze through incredibly small spaces (Greenhall, 1977). Louvered air vents with opening larger than ½ inch will also present an escape route for vampire bats. Covering them with mesh should solve the problem.

In general, enclosure surfaces should be non-porous and non-abrasive. Walls and floors must be able to withstand a great deal of hosing and should be properly sealed. If wire mesh is used as part of the exhibit, galvanized wire should be avoided because bat urine corrodes tinned surfaces and may cause zinc toxicity if ingested (Wilson, 1988). Mesh used in vampire bat enclosures is therefore recommended to be vinyl coated wire or polyethylene mesh. Quarter inch mesh is a good size for vampire bats because it is small enough to prevent animals from pushing a wing or foot through it, but not so fine that the animals' claws get stuck in the mesh (Wilson, 1988).

Enclosures with glass fronts present no special problems, although it may be necessary to tape or soap the windows for a few days after animals are newly introduced to alert them to the presence of the glass. Until the bats feel comfortable in their new exhibit it may be necessary to cover keeper access doors with a sheet or screen to prevent the bats from flying out when the keeper enters the exhibit.

Many facilities prefer to use bedding on the floor of the exhibit; this makes cleaning easier and provides a less abrasive surface for the bats when they are walking on the floor. Wood chips, bark chips, cat litter and cob bedding have all been used successfully, although care should be taken to watch for problems with the substrate adhering to the wings and bodies of the bats. In off exhibit areas, non-colored newspaper provides a good substrate that is easy to clean and won't stick to the bats.

FURNISHINGS

When designing exhibits keep in mind that although bats in the genus *Desmodus* will hang by the hindlimbs from a horizontal or vertical surface, they prefer a surface which will

provide contact for the pectoral limbs as well (Greenhall, 1988). Very few exhibits contain furnishing other than the walls and concrete structures made into the cave. Plants and branches have been used in some facilities with success. Regardless of the types of perches provided, bats frequently will congregate at the highest points of the exhibit. This suggests that either the roof should be designed to provide them with the proper perches or be so smooth as to force the bats to use the other perches provided (Wilson, 1988). Vampire bats have been known to hang from light fixtures when that was the highest point in the exhibit. Privacy can be provided by exhibit design with crevices, stalactites and areas not visible to the public, or through the use of den boxes. These boxes should be constructed of an easy to clean material such as laminated plastic or sealed wood. The spacing of grooves in the boxes should be ¼ - ½ inch (Barnard, 1995). The same guidelines regarding sharp surfaces and galvanized wire in exhibits should be followed in den box construction. Barnard suggests that vampire bats do well with a dome addition to the top of the cage. These domes were developed by Willard Wilson for moustache bats but may work well for vampire bats. They are created by cutting an appropriately sized hole in a piece of ¾" plywood which is attached to the top of the cage. A dome is fabricated from ¼" hardware cloth or lathe. Plaster of Paris is applied to the wire mesh frame and before the mortar dries small aquarium gravel is embedded into the surface. Once the mortar has thoroughly dried, the surface is sealed with 2 coats of water-based, polyurethane finish. For further information on these domes see Bats in Captivity, 1995 Revised Edition by Susan M. Barnard.

TEMPERATURE, HUMIDITY

Vampire bats are tropical bats that cannot withstand low temperatures for an extended period of time. Laboratory studies have shown that vampire bats do best in temperatures ranging from 75 to 82 degrees Fahrenheit. All bats in our initial survey were housed in facilities with temperatures ranging from 65-90 degrees F. Vampire bats have difficulty maintaining their normal body temperature of 98.6 degrees F when the temperature is below 50 degrees F. Should its body temperature drop to 72 degrees F the bat may not be able to rewarm itself. Vampire bats will die if subjected to temperatures below 35 - 40 degrees for only a few days. At the other end of the spectrum, vampire bats must avoid ambient temperatures above 86 degrees F due to their high rate of metabolism and their poor ability to cool themselves. Even a few minutes of exposure to a temperature of 100 degrees is lethal (Brown, 1994). It is best to maintain bats in an exhibit with a temperature gradient so they may seek out their thermal preference (Barnard, 1995). A relative humidity of 40 - 60 % is optimal for vampire bats (Wimsatt, 1986). In fact vampire bats can tolerate a wider range of temperatures if the humidity is not too low (Brown, 1994). Symptoms of low humidity include dry skin or wing membranes and cracked nails (Fascione, 1995).

VENTILATION

A highly efficient ventilation system is necessary to avoid the buildup of unpleasant odors, especially in enclosures housing large colonies. A suggested rate of air exchange for larger colonies is six to ten exchanges per hour with 25% fresh air. Because of the bacteriological

breakdown of bat guano, it is important that air leaving bat exhibits be vented outside and not recirculated or ducted into a public area. (Wilson, 1988).

LIGHTING

Since there are few scientific studies describing circadian rhythms of bats, lighting is probably best when it imitates natural photoperiods (Wilson, 1988). Vampire bats do well when kept on a 10/14 or 12/12 light/dark cycle. Bats should never be kept in 24 hour light or darkness. Most vampire bats are kept under reverse light cycles using artificial light. Halogen lights, fluorescent tubes and blue filters make up a good lighting system. The day cycle lights are fluorescent and the nocturnal lights are halogen with blue filters. Blue light is often used (rather than red) because it simulates the color and intensity of moonlight and does not change the color of the bats. It is strongly recommended that a dim/anti-dim cycle be used to reduce the shock of immediate bright light or complete darkness. During the "day" cycle areas of shade or dimness should be provided.

MANAGEMENT

FEED SOURCES

Cattle blood is the most common type (species) of blood fed to vampire bats. Other types may be offered but bats seem to prefer cattle to other species. Local slaughter houses offer the most consistent source of cattle blood. Vampire bats are obligatory blood feeders and therefore cannot be nourished by any other foods. Their digestive tract cannot accept solids of any type and they are therefore unable to use clotted blood. All blood fed to vampire bats needs to be treated so that it does not coagulate. Many facilities prefer to use the chemical combination of 12.5 grams dextrose, 4 grams citric acid and 11 grams sodium citrate per gallon of blood as an anticoagulant. Blood can also be manually mixed to prevent coagulation, although according to Dickson and Green (1970) defibrillation results in the removal of factors essential for the vampire bat's welfare. The blood should be stored either in the refrigerator for no more than 14 days (preferably 7 days) or frozen for no more than 6 months (preferably 30 days). Frozen blood is often kept as an emergency backup in case fresh blood is unavailable, however frozen blood deteriorates rapidly after thawing (Wimsatt, 1986). Vampire bats can only go 48-72 hours without food before they die of starvation. It is therefore extremely important to have a reliable source of blood when considering vampire bats for an exhibit. If blood is temporarily unavailable, the bats should be offered water or preferably saline (0.09% NaCl), the fasted animals will readily drink it and critical dehydration can be forestalled for a day or two (Wimsatt, 1986). Many states have regulation regarding the distribution of blood; check with your state veterinarian for further information.

Several zoos have experimented with alternative species of blood including zebu, swine, horse, camel and gaur, these have been accepted by the bats with varying degrees of success. Other blood types that have been tried with little success are chicken, sheep, elephant and human. It has been suggested that a form of enrichment for vampire bats may be offering a different species of blood in addition to their normal rations.

FEED PRESENTATION

A variety of feeders have been used successfully with vampire bats, including ice cube trays, petri dishes and bird water tubes. It should be noted that vampire bats prefer to eat low to the ground and that feeders that allow more than one animal to feed at a time are preferable to decrease aggression. The location of the feeders can be moved within the exhibit to increase foraging enrichment.

FEEDING SCHEDULE

Vampire bats should be fed at least once per day. However, it may be necessary to provide food at more frequent intervals for large colonies to ensure that each individual receives food. If only a single feeding is provided, the most recommended time is just at the beginning of the bat's night cycle (Wilson, 1988). 58% of survey respondents feed their bats twice daily. A vampire bat can consume more blood at a feeding than is contained in

its own circulatory system. Ample food should be supplied so that all bats are able to get their fill. It is best to provide several feeding stations for large groups of vampire bats. There should always be liquid blood left after a feeding to ensure that all bats receive an adequate diet. Start by feeding approximately 20 ml of blood per bat per day. This should be used as a guide to determine amount. As the colony grows the amount fed will need to be adjusted accordingly. Keep in mind that young vampire bats will begin drinking blood at 4 months of age and are fully weaned by 9 -10 months.

WATER

Vampire bats are known to drink water especially under conditions such as unusually high temperatures (Wilson, 1988). Although bats are seldom observed drinking water, the safest management plan would be to provide water at all times. Many facilities offer water in the same type of container in which blood is fed. Other exhibits have flowing water or ponds as part of the exhibit design. Water depth should not exceed 3 - 5 mm. as there is the danger that sick animals may drown (Pye, 1967). No matter how water is provided, it should be changed frequently and kept fresh.

IDENTIFICATION

Several methods of identification are available for use in vampire bats. Some facilities do not individually mark their vampire bats, however, for management purposes, it is strongly recommended. There are advantages and disadvantages to most forms of marking. Transponders may be used with vampire bats for permanent identification. The implant is best placed in the posterior dorsal region where it will not interfere with movement. When placed between the shoulder blades the transponder may interfere with muscle and shoulder blade movement associated with flight. Some facilities have reported that their transponders fail to read after a period of time but most have had no problems associated with transponders in vampire bats. While transponders are good for permanent marking they do not aid in identifying individuals from a distance. Bands have also been used with vampire bats with varying degrees of success. Bands need to be checked frequently for problems.

CAPTURE, HANDLING AND RESTRAINT

The unusual agility of bats in the genus *Desmodus* requires constant alertness by keepers in order to prevent their escape (Greenhall, 1977). All institutions surveyed use aquarium nets and leather gloves to capture their vampire bats. Wearing loose fitting gloves may prevent the handler from being bitten through the gloves. When holding the bat handlers

need to be careful to keep a good grip so that the bat does not escape. If the bat bites the glove and holds on tenaciously one can usually get the bat to release by blowing into its face. Wing bones of bats are delicate and can be broken easily during capture, so care should always be taken to immobilize the wings. Do not hold any bat by the wing tips during restraint and always fold the wings close to the body. To remove bats that are hanging on wire or perches, unhook their nails rather than pulling on the bat. Care must be taken not to apply excessive pressure to the bat. While there is no evidence that holding a bat's head in an upward position for prolonged periods of time is a risk factor, it is recommended that it be held in a downward position or at least horizontally.

PEST CONTROL

The best control is to exclude pests. Cleanliness in and near bat enclosures is of the utmost importance. Be sure the area around your bat enclosure is free of places that harbor pests, such as cardboard boxes or piles of trash. Seal all cracks and holes into the exhibit. Cockroaches are the most common pest found in and around vampire bat exhibits. Roach traps and ivermectin in peanut butter have both been used successfully to control roach populations.

SANITATION

Bats prefer to live in a less than sanitary environment and frequent hosing may distress the animals. Using bedding on the floor of the exhibit will allow dry or spot cleaning on a daily basis. Scrubbing waste from surfaces is necessary, however, on at least a weekly basis, and more frequently for large colonies. It is important to scrub exhibit walls because feces frequently adhere to them. Food and water dishes should be cleaned and sanitized daily to remove urine and feces. When disinfectants or bleach are used to clean dishes or exhibits, it is critical to rinse them well as these chemicals are potentially harmful to bats (Wilson, 1988). Appropriate disinfectants include diluted bleach, quartenary ammonium compounds, dilute Nolvasan, or dishwashing soap. One facility recommended Simple Green as a great non-toxic degreaser. Do not expose bats to noxious vapors in enclosed or poorly ventilated areas. Do not allow contact with disinfectants. Ensure that all organic material is removed before applying disinfectants. Allow adequate contact time (> 15 minutes), scrub in disinfectant well, then rinse thoroughly.

CRATING AND TRANSPORT

Vampire bats can be shipped communally. Mothers with nursing infants should not be shipped. A mesh cage inside of a wooden crate or "sky kennel" has been used successfully to ship vampire bats. Zoos must follow IATA standards for all international shipments.

When shipping within the United States, IATA standards are still recommended by the Center for Disease Control (CDC), the United States Department of Agriculture (USDA), Animal Plant Health Inspection Service (APHIS) and the United States Department of the Interior (USDI). Construction plans for an approved transport box successfully used to ship vampires over long distances can be found in the *Handbook of Live Animal Transport*, Supplement #30, (P.O. Box 441110, Fort Washington, MD, USA, 20749-0653).

Bats should have access to food just prior to shipping. Ideally they should not remain in the shipping container for more than 15 hours. It is best to ship bats when the environmental temperature is close to their thermal preference (in this case, around 75-80 degrees F). (Barnard, 1995)

RECORD KEEPING

All bats should be included in ISIS records as individuals rather than as a group count . Neonatal deaths, stillborn, and aborted fetuses should be recorded when possible. While this may be difficult in large colonies, it is an important tool in determining population demographics.

BEHAVIOR AND SOCIAL ORGANIZATION

GROUPINGS

Vampire bats are social creatures and therefore should not be maintained singly. The only exception to this is if an animal requires special medical care and then it should be separated for the shortest period possible. When setting up a breeding group of vampire

bats it is advisable to start with more females than males. The typical wild vampire bat colony consists of an adult male, 8 - 20 adult females and their young. Bachelor males commonly roost together in an adjacent site. Results of the husbandry survey indicate that in facilities with fewer than 20 bats, the bats form a single group. With higher numbers of bats more groups formed within the exhibit. Exhibits should be of sufficient size to prevent overcrowding and allow maturing males to withdraw into bachelor groups. Problems that can occur with maintaining too many males in a small enclosure include decreased reproduction, juvenile males pulling infants off dams and juvenile deaths. If the number of animals in an exhibit is too high or low, the resulting stress may lead to detrimental physiological and/or behavioral changes (Rasweiler, 1976). Brown (1994) suggests that a 5 foot square exhibit is a good size for 15 - 20 animals.

FOOD SHARING

Vampire bats are unique in the animal world in that individuals donate food to colony members by regurgitating blood. In a study of both wild and captive vampire bats Gerald Wilkinson (1990) discovered that the bats who share food are not always related to each other. Although most food sharing is between mothers and their pups, some females will feed another bat's youngster and even another adult. Netting studies show that on average about 30 % of the immature bats (those younger than two years) and 7 % of reproductively mature adults fail to obtain a blood meal on a given night. In the wild, communal feeding is important to the vampire bat's survival, as these bats will die if deprived of food for 48 - 70 hours. Vampire bats spend more than 5% of each day grooming and licking one another, and this behavior seems to be an important prelude to food sharing (Wilkinson, 1990). One theory is that social grooming facilitates individual recognition either by olfaction or by auditory means (Greenhall, 1988). A social kinship develops among those bats that share food with each other. Wilkinson (1990) found that a vampire bat which was fed when it failed to find a meal remembered which bat gave it blood, and reciprocated at a later date. The amount of blood given depended more on the recipient's needs rather than on filial relationship. Adult males were never fed by other bats, although males sometimes fed females and young within the colony (Brown, 1994). Food sharing was observed at one institution when a bat was ill and not eating. Other bats were observed flying to the sick bat, covering it with their wings and regurgitating blood. In another situation with two hand-reared bats, the older one was repeatedly observed feeding the younger bat.

INTRODUCTIONS AND REMOVALS

Introduction of vampire bats into existing colonies has been done by many facilities with little or no problems. Although females can be introduced easily into a colony, adding a new male may result in a fight. Initially there will be much bickering among the bat colony as the group's social structure is challenged and altered. New males may attempt to take over existing males' territories. When introducing bats into an existing colony do so at the start of a keeper shift to allow for maximum observation time.

There appears to be no major effect of removing animals from a colony except that, if the individual removed is high ranking in the social order, there may be some jostling while a new hierarchy is established. Several zoos have removed bats for shipment to other facilities with no adverse effects on the remaining bats in the colony.

MIXED SPECIES EXHIBIT

In the wild, as many as 45 different kinds of bats have been reported to be present in the same cave or mine with common vampire bats. The other species, however, do not roost in close proximity to the vampire bats (Brown, 1994). A survey of all facilities housing vampire bats indicated that no one has attempted housing them in a mixed species exhibit.

ENRICHMENT

Enrichment with vampire bats has not been studied scientifically in any detail, and few institutions have had success. As enrichment techniques are tried with colonies that have not received this stimulus, some managers have reported that the bats become stressed. Enrichment should be offered in a slow, reserved format so these bats can gradually overcome their shy nature.

Institutions have tried offering blood in a latex glove, crickets, fresh-killed mice, scents from hoofstock and snake sheds. Tapes of nature sounds have also been played. Common vampire bats have been offered blood from a variety of mammals, in addition to their normal bovine diet, with varying success. Two hand-reared common vampire bats were reported to use many objects for enrichment, including hanging from visual barriers and small cat toys.

Enrichment techniques need to be evaluated for possible benefits in vampire bat husbandry. Some ideas include novel objects, food and foraging options, changing exhibit furniture and olfactory enrichment.

AGGRESSION

Of the institutions surveyed, 50% have observed aggression among their vampire bats. Most have experienced only small squabbles involving pushing, vocalization and minor bite wounds; while two have experienced deaths in their colonies related to aggression. At one facility all animals killed were juvenile males. In the wild, males leave their natal groups at 12-18 months. In captive environments, there may not be enough space for the juveniles to relocate. In the facilities surveyed, however, size of exhibit or number of animals does not seem to be a factor in the occurrence or severity of aggression. Even in the wild fighting must be relatively common among males, because virtually every adult male captured in one study had wounds and scars which appeared to be the result of biting (Greenhall, 1988). Managers should observe colonies for excessive fighting and potential injuries

while being aware that squabbles among bats are common in the wild and in captivity. These squabbles often result in harmless wing tears that heal quickly and are of little concern. To help avoid undue fighting among animals, be sure to have sufficient feeding and roosting areas in the enclosure.

REPRODUCTION

BEHAVIOR

Vampire bats give birth throughout the year, although several institutions reported that the majority of births occur in the spring and summer. While the dominant male engages in most of the breeding, other males will breed with receptive females when they get the

opportunity. Females are larger than males and are therefore able to repulse any unwanted attention by pushing the male away or at times even attacking it. When the female is receptive the male grasps the female from behind while both hang with their back feet. In order to hold the female securely the male grasps the fur on her neck with his teeth. This may cause the female's neck to appear quite raw. Copulation is reported to last from one to three minutes (Brown,1994). Vampire bats have also been observed breeding on the ground. Female common vampire bats may mate again as soon as 45 days after giving birth. The average interbirth interval is just under one year, thus it is possible for a female to produce up to 20 young during her lifetime (Brown, 1994).

AGE SPECIFIC FECUNDITY, GESTATION AND PARTURITION

Both male and female common vampire bats reach sexual maturity at about one year of age. Gestation is rather long, 205 - 215 days (Emmons, 1997), while labor is relatively short, lasting 3- 5 minutes (Brown, 1994). About seven weeks prior to parturition, the area surrounding the vagina becomes darkly pigmented and a few days later the skin lateral to the nipples also becomes stained (Greenhall, 1988). In cases where births have been observed, the female had moved away from the rest of the group. The mother hung head down, clutching the ceiling or wall of the cage with her feet and thumbs. Near the end of the birthing process other females gathered around and began sniffing and licking the infant. Vampire bats are known to adopt orphans and to care for unrelated individuals.

NEONATAL EXAMS

The neonate should be visually assessed soon after birth. Make sure it is nursing, has normal activity for its age, and that there are no gross congenital abnormalities.

INFANT DEVELOPMENT

Pups are born nearly hairless with pink wings and functional eyes. They weigh 5 - 7 grams at birth and double their birth weight in 20 -25 days (Brown, 1994). Adult measurements are attained by 5 months although adult weight is not reached until about 10 months of age. The mother generally carries the pup continuously for the first 20 to 30 days; after that the pup will be left behind for periods of time (Brown, 1994). The ability to fly develops at about two months of age, and by four months the young fly well. Wild females have been observed to feed blood to their infants minutes after birth. It is thought that by receiving blood at an early age, the youngster will develop the microbes necessary to survive on a blood diet (Brown, 1994). Pups are fed both milk and regurgitated blood by their mother. Although vampire bat youngsters begin feeding on blood by themselves at around 4 months

of age, they are not fully weaned until about 10 months. Females stay with their mothers, whereas males leave between the ages of 12 and 18 months, when they become reproductively mature (Greenhall, 1988). Female vampire bats have been observed nursing two young of different ages, due to their long weaning period and short interbirth interval (Brown, 1994).

CONTRACEPTION

Little or no information is available on reversible, chemical contraceptive methods in bats. The only contraception method that has been used with vampire bats is to house them in single sex colonies.

INFANT AND JUVENILE MORTALITY

Seventy-five percent of survey respondents that are breeding vampire bats have experienced neonatal or infant mortalities. Half were attributed to trauma and the rest were for unknown reasons. Many respondents felt that the trauma could be due to overcrowded conditions. In large colonies, young bats, (5 to 60 days old), are often bitten in the head and the genitals by other bats, sometimes resulting in death. If a single case of infant killing has occurred in a colony, then all subsequent babies are endangered (Greenhall, 1988). The ages between 4 and 5 months have been shown to be a critical phase in the development of young vampire bats. In particular, juveniles of inexperienced females often die during this period. Young of inexperienced mothers tend to beg for food from other colony members. Many males do not tolerant this and may bite the youngster to get away from it (Wimsatt, 1986). It is thought that the change in food from milk to blood may also cause special difficulties for the young bats (Greenhall, 1988).

HAND-REARING

Two similar but slightly different formulas have been successfully used to hand-rear vampire bats. These are:

10 g. Multi-Milk powder
2 g. dextrose powder
75 ml. tap or distilled water (reduced to 60 ml at 6 weeks of age)
2 drops Avitron multivitamins
4 drops Avimin multiminerals

This gives a formula with 13% solids, 7.5% fat, 4.1% protein, and 2.3% carbohydrates. (Barnard, 1995)

3.5 g Esbilac powder (changed to 4 g at one week)

0.9 g dextrose powder (changed to 1 g at one week)
34 ml distilled water (changed to 30 g at one week)
1 drop Avitron multivitamins
2 drops Avimin multivitamins
1 drop Lactaid
The formula is refrigerated for 24 hours before using, to allow the Lactaid to take effect. (D. Devison, Toronto Zoo, pers.com.)
Note: the new Esbilac could be lethal, the old Esbilac is now Zoologic 33/40 (Barnard, pers. com.).

Initially, infants should be fed every three to four hours from six a.m. until midnight. A one cc syringe works well for a feeding device. Blood should be added to the milk formula beginning at one week of age at a 1:10 ratio (Barnard, 1995). The blood/milk mixture must be fed right away after warming as it clots and turns into a gel which the bats do not like. Fecal infusion has been used for up to 6 months of age in both instances. Although the young bats will quickly prefer the blood to the milk it is important to feed milk for at least 24 weeks. Young bats should be kept in a warm, draft free environment at temperatures between 80 and 85 degrees F and at relative humidities of 55 - 80%. Infant bats placed in incubators will die of dehydration if the humidity is not high enough. For more detailed information on hand-rearing see Bats In Captivity (Barnard, 1995), or contact Diane Devison at the Toronto Zoo.

HEALTH

PARASITES

Parasites have not been a big problem in vampire bats. Most institutions surveyed reported no incidence of internal or external parasites, with only one institution reporting an incidental finding of *Sarcocystis* in one bat. Several wild caught bats have had external parasites when first acquired but these soon disappeared with little or no treatment. Fecal examinations for parasites should be performed on a regular basis by people capable of identifying the parasites likely to be found in bats. Routine medications work well on internal parasites and are probably safe for most bat species (Wilson, 1988). According to

the USDA Inspection criteria for bats and bat enclosures, panacur (fenbendazole) can be used to treat endoparasites in bats at a dose of 50 mg/kg.

ILLNESS

Signs of illness that have been seen in vampire bats include equilibrium problems, head tilts, weakness, and lethargy. All survey respondents reported that they had experienced no chronic health problems with their vampire bats.

COMMON INJURIES AND TREATMENTS

Fighting among vampire bats is not uncommon and therefore injuries do occur. Generally, these injuries are minor abrasions and wing tears which will heal on their own. Severe wounds have been treated successfully at one facility by applying "liquid skin" to the bite wounds. Female bats are known to lose hair behind their heads when males cling to this area while copulating. These areas will occasionally appear quite raw. If an animal needs to be treated for medical purposes, it is best to provide veterinary care while leaving the animal in the main enclosure. If it is absolutely necessary to remove the animal for treatment, be sure to minimize separation time from the colony and follow recommendations for introductions when reintroducing the animal.

IMMOBILIZATION

Isofluorane has been used successfully at a number of institutions to immobilize vampire bats. Induction was done at 3 - 5% and the immobilization was maintained using 2 -3 %.

INNOCULATIONS

There are no vaccinations presently recommended for bats. Bats should not be vaccinated against rabies for two reasons. First, there is no vaccine legally licensed for use in bats, and second, the vaccine may interfere with tests for rabies detection (Fascione, 1995).

PHYSIOLOGICAL REFERENCE VALUES

Normal body temperature for vampire bats has been reported to be 98.6 degrees F (Brown, 1994).

Normal blood values for common vampire bats are reported to be:

Erythrocytes	8.20 - 12.39 x 10^6/mm^3	n=17	(Krutzsch and Wimsatt, 1963)
	5.90 - 11.00 x 10^6/mm^3	n=19	(Breidenstein et al., 1979)

Leucocytes	3,678 mm^3	n=?	(Krutzsch and Wimsatt, 1963)
	4,358 mm^3	n=19	(Breidenstein et al., 1979)
Hematocrit	50.3 - 61 %	n=17	(Krutzsch and Wimsatt, 1963)
Hemoglobin	19.40 g/100 ml	n=17	(Krutzsch and Wimsatt, 1963)
	17.40 g/100 ml	n=31	(Breidenstein et al., 1979)

LIFESPAN

Vampire bats have very long life spans for their size. Two institutions reported having vampire bats that were over 20 years of age, with the oldest being 22+ years.

NECROPSY PROTOCOL

All bats that die should be necropsied. Gross necropsy should be accompanied by submission of representative tissues (brain, skeletal muscle, heart, lung, liver, stomach, pancreas, small and large intestine, kidneys, gonads, bone and bone marrow) for pathology. Accurate necropsy records should be made, and mortality rates should be tracked on a yearly basis (including neonatal deaths). The Center for Disease Control (CDC) has recommended that all bats that die be tested for rabies. Half of the institutions responding to the survey routinely test their bats, so far no one has had a positive result.

ZOONOTIC DISEASES

1. RABIES

Rabies is the most important zoonotic disease associated with vampire bats. In Latin America, vampire bats are responsible for heavy losses of livestock and are increasingly involved in human rabies transmission. Rabies can infect any mammal but is commonly transmitted by bats and other carnivores such as dogs, fox and raccoon. Rabies is rare among rodents and cannot be spread by birds, reptiles, amphibians, fish or insects. Rabies is a viral disease that affects the central nervous system. It is almost always fatal once symptoms are evident. The rabies virus lives in the saliva and nervous tissue of infected animals and is spread when they bite or scratch. The virus can also be transmitted if infected body fluids come in contact with broken skin or mucous membranes. In caves crowded with bats, it is possible, though unlikely, to inhale the virus from the air. Vampire

bats spread rabies when they bite other animals or humans for their blood meal. They are also known to pass it among themselves through grooming and food sharing.

The incubation period for rabies, the time from exposure to signs of symptoms, is extremely variable. The average time is 2 - 12 weeks but can range from less than 10 days to over 6 months (Sikes,1970). Human symptoms of rabies are irritability, fever, inability to sleep, throat spasms, apprehension, headache, hydrophobia and paralysis (AAZK,1990). The symptoms of rabies in bats are generally characterized by anorexia, dehydration, restlessness, disorientation, sensitivity to light, sound or touch, and paralysis (Barnard, 1995). In order to protect personnel that work around bats, the CDC recommends they receive pre-exposure vaccinations for rabies and have their titers checked regularly. Each facility should establish a bite protocol and keep records of all bites. In addition bats that die should be tested for rabies.

2. HISTOPLASMOSIS

Histoplasmosis is an airborne disease caused by a fungus, *Histoplasma capsulatum*. Histoplasmosis needs certain conditions to flourish. The fungus is generally found in areas with large concentrations of birds or bats and where accumulated bird or bat droppings have existed for 3 or more years. The spores become airborne when soil containing the fungus is disturbed. It is contracted by breathing this dust. The fungus occurs primarily in the Mississippi Basin of the United States, the tropics and subtropics.

Histoplasmosis infection is not commonly associated with captive bats because fecal material is removed on a regular basis.

QUARANTINE

When captive-born bats are received from another institution, ideally they should be quarantined for 90 days. However, this may vary depending on the source of the animals and their previous standard of care and medical testing. Minimally, they should be quarantined for 30 days. If at all possible the bats should be quarantined in groups rather than as single animals or their social behavior may be adversely affected. The quarantine environment should be the same as the bats' natural ambient conditions. All bats should be examined as soon as possible after shipping for evidence of disease. An additional exam should be performed before the animals are removed from quarantine. Any bats that die during quarantine must have a complete necropsy (see necropsy recommendations) including rabies testing. If a bat dies during quarantine and the cause is unknown, the quarantine period should be extended to allow sufficient time for detection of disease in the remaining animals.

Ideally, wild-caught animals should be held in captivity for one month prior to shipping from their country of origin. This has the benefit of allowing detection and removal of any sick animals, and it allows the animals to adapt to captivity prior to shipping. During the holding period prior to shipment, the bats should be examined by a veterinarian, and treated for ecto- and endoparasites. Wild-caught bats should be quarantined for a minimum of 6 months. Following completion of quarantine, it is recommended that wild-caught animals placed on exhibit be isolated from other animals for at least 1 year and housed in cages that protect the public from bat urine and feces.

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Omaha's Henry Doorly Zoo
Philadelphia Zoological Garden
Puebla, Mexico
Sedgewick County Zoo
Staten Island Zoo
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