# Suggested Guidelines for Bat Enrichment

Bats in the wild have a life that is filled with dynamic experiences, such as those associated with avoiding predators, searching for and acquiring food, defending territories and producing viable offspring (Martin, 1996). The theory of natural selection suggests that only the fittest of a species survive (Darwin, 1859). In captivity, the primary survival needs of bats are fulfilled by their caregivers, leaving the animals with few choices and few consequences. According to the welfare criterion of Maple, McManamon, and Stevens (1995), treatment of captive animals should achieve a level of well-being comparable to, or better than, the life they could be expected to live in the wild (Wuichet and Norton, 1995).

Environment has an immediate effect on mammals after birth. The effects of the rearing environment can have far reaching results. Studies have shown that developing mammals are more likely to learn that they can exert “control” over their environment in a physically complex surrounding (Renner, 1998; Joffe et al,. 1973). Animal managers should provide developing bats an enriched environment that allows for exploration of novel items, play, opportunities for physical testing and flight, as well as a nurturing social environment.

As each generation of captive animals is bred, animal managers must be concerned with not only the physical characteristics of the animal (phenotype) and the genetics (genotype), but also the behavioral repertoire which can be extinguished through generations in captivity (Bukojemsky and Markowitz, 1997). Enrichment should focus on preserving all aspects of specific behavior that the animal is capable of within their captive environment.

Enrichment can be divided into several components based on 1) the natural history of the species, 2) how these species perceive their world, 3) their physical abilities, 4) their social interactions, and 5) their native environment. Each of these components will be discussed within the following topics: the fruit bats in North American zoos; dietary and foraging enrichment; exhibit furniture; olfactory enrichment; acoustic enrichment; unnatural enrichment; social enrichment; and training.

## Natural history of the species

Two major groups of fruit bats are managed in captivity in North America: microbats and megabats. The microbats are nocturnal species that live in the Caribbean and Central and South America. The microbats can be divided into two groups based on feeding behaviors: 1) Short-tongued species ( *Artibeus jamaicensis* ; *Carollia perspicillata),* and 2) Long-tongued species ( *Anoura geoffryu; Glossophaga soricins* ).

Jamaican fruit bats ( *Artibeus jamaicensis* ) and short-tailed leaf-nosed bats ( *Carollia perspicillata* ) are examples of short tongued, echolocating bats that feed predominately on fruit and insects but will take nectar, pollen and flower parts (Nowark, 1994). They roost in small groups and in large colonies, often with other bat species in caves, mines, sinkholes, hollow trees, and buildings (Fleming, 1998). Jamaican fruit bats have been documented to build “tents” in palm fronds (Nowak, 1994). These bats pluck fruit from trees and fly to

feeding roosts to avoid predators that might be attracted to trees containing a large number of feeding bats (Wilson, 1997).

Long-tongued microbats ( *Anoura geoffroyi, Glossophaga soricina* ) are echolocating bats that feed predominately on nectar, pollen and insects but will take fruits and flower parts (Nowak, 1994). These bats can hover like hummingbirds and feed on nectar and pollen. Both species roost in small colonies in caves. The common long-tongued bat ( *Glossophaga soricina* ) is also reported to roost in buildings, rock crevices, and hollow trees.

Megabats are Old World fruit bats that find food resources through vision and sense of smell. Megabats in captivity in North America can be divided into three groups: 1) Megabats that can echolocate ( *Rousettus aegyptiacus; Rousettus lanosus* ), 2) Megabats that cannot echolocate and roost in dense cover ( *Epomophorus wahlbergi; Cynopterus brachyotis* ) and 3) Megabats that cannot echolocate and roost in more open areas ( *Pteropus spp., Eidolon helvum* ). The following paragraphs illustrate examples from each group.

1) Rousette fruit bats ( *Rousettus aegyptiacus; Rousettus lanosus* ) are nocturnal megabats that feed predominately on fruit, flower resources, and leaves (Nowak, 1994). They roost in large colonies in caves and have developed a rudimentary echolocation system based on audible tongue clicking for orientation in these dark environments.

2) Wahlberg's epauletted fruit bats ( *Epomophorus wahlbergi* ) roost in hollow trees, under palm fronds, and in thick foliage. Dog-faced fruit bats ( *Cynopterus brachyotis* ) roost in shaded areas and build "tents" in palm fronds and banana leaves. The breeding system of the dog-faced fruit bat is based on males forming harems (resource defense polygyny). Male Wahlberg's epauletted fruit bats utilize display grounds where they compete against other males and females select which male they will breed with based on male display (Wilson, 1997; Nowak, 1994).

3) Flying foxes and straw-colored fruit bats ( *Pteropus spp.; Eidolon helvum* ) roost in active colonies in trees that are flooded with sunlight. These bats are crepuscular to nocturnal, although several flying foxes such as *Pteropus samoensis,* the Samoan flying fox, are diurnal. These large bats feed on fruit, flower resources, and leaves utilizing their well-developed sense of smell and vision (Wilson, 1997; Nowak, 1994).

**Exhibit Furniture and Foraging Devices:**

Exhibit furniture and foraging devices are two separate but connected components that provide environmental enrichment to bats. The goals of this enrichment are to stimulate natural foraging activity such as flight, manipulation with thumbs and feet, and locomotion on branches. Fruit bats wear down their nails by moving on a variety of surfaces. This type of enrichment can improve animal husbandry by reducing nail breakage and reduce the need to trim overgrown nails. Some bats fly with food to feeding roosts and are capable of carrying large pieces. Food stealing is a common activity and bas may fill their mouths with food and then fly off to eat in a more secure location. Exhibit furniture that is conducive to

foraging enrichment includes ropes, ladders (plastic mesh, cargo netting, rope, etc.) natural branches, palm fronds, grapevines, small diameter twigs, live trees and bushes, and small shallow pools. Exhibit furniture should vary in diameter and in placement, allowing for both horizontal and vertical access. Foraging devices such as “spinning rakes”, the “PVC log roll”, “Nectar feeders”, “fruit Kebobs”, suspended boomer balls and “pollination poles” can be utilized to promote flight in fruit bats (Porter, 1993; Cooke, 1996; Rosenberg, 1997; Seyjagat, 1996). Manipulation can be promoted with larger fruit bats when they are offered food on plastic chains and as long fruit kebobs.

Roosting surfaces are also an important aspect of exhibit design, and can be beneficial as enrichment. For those species that roost in caves, a cave-like surface can provide benefits in nail wear and in promoting the physical adaptations these bats display. For those species that build “tents” such as Jamaican and Dog-faced fruit bats, the addition of palm and banana plants can promote tent-building behavior. Bats that are managed on wire mesh may be reluctant to leave the security of this stable foothold to go down onto less stable, unfamiliar objects such as branches and grapevines. These bats may have to be enticed onto unstable cage furniture until they have gained confidence and muscle strength. Roosting areas could also benefit from having an irregular ceiling which would allow more dominant bats to roost above less dominant individuals, thus allowing for vertical segregation of the group.

Within the enclosure, the environment can be modified to create variation in humidity, temperature, and lighting. Colored lights have been utilized for enrichment with captive chimpanzees ( *Pan troglodytes* ), and certainly could be utilized with bats (Fritz et. al., 1997). Cage design should also provide areas for hiding and predator avoidance if the behavior of the species is to flee toward enclosed areas (Shepherdson, 1997).

**Dietary and Foraging Enrichment**

Dietary and foraging enrichment is often the most popular and simplest form of behavioral stimulation. Fruit bats in the wild feed on a wide variety of resources that are unavailable in captivity. They also spend a higher proportion of their daily activity budget searching for, processing and eating food. In contrast, the captive diet is relatively stable and unchanging due to economics, nutrition, cage restrictions and husbandry practices.

Dietary enrichment can take many forms such as novel fruits, vegetables and juices such as melon, mango, papaya, peach, guava, kiwi, strawberry, corn, squash, pumpkin, rutabaga, celery, chicory, collards, romaine lettuce, etc. that are not in the standard diet presentation can be changed by not peeling fruit, offering novel shapes, or by offering whole food. Fruits, vegetables and juices can be presented frozen as popsicles (Chag, 1996b) or mixed with gelatin to make bat jigglers.

Foraging enrichment aims at fostering the expression of natural food retrieval behaviors by offering the diet in less accessible ways (Reinhardt, 1993). Food enrichment can be placed in areas where the bats must search it out (Allgaier, 1992). It can also be offered in smaller

quantities several times during a normal feeding period rather than being presented all of the food at once. In reverse lighting conditions, bats that are crepuscular could be fed both at dusk and dawn.

Fruits and vegetables can be strung on stainless steel rods to make “fruit kebobs”. Pieces of food can also be placed on shower curtain rings, which can be attached to plastic chain, bungee cords, ladders, or ropes (Atkinson, 1993; LeBlanc, 1996). Fruit and vegetables can be provided to bats in novel items such as puzzle feeders, commercially available suet feeders or in grapevine wreaths. Juice or flavored water can be offered in water bottles with ball-bearing tips, hummingbird feeders, and nectar feeders (Le Blanc, 1997). Bats are often willing to work for dietary enrichment when fruit is offered in grenade feeders or presented in pinecones (Chag, 1996a; Chag, 1996b).

In the wild, fruit bats feed on flowers (nectar, pollen, petals, and bracts), leaves and insects. A variety of non-toxic flowers and browse such as roses, wisteria, daylilies, bottlebrush, willow, poplar, and hackberry are being evaluated with fruit bats for possible enrichment and nutritional benefits. Flowers can serve as both dietary and olfactory enrichment. Sources of flowers and browse must be pesticide and fertilizer free as well as checked for hidden pests like Eastern wood ticks and spiders. Flowers and browse can be tied in bundles with plastic cable ties and hung in the enclosure. Smaller flowers can also be placed in bowls that are secured to vertical posts. Fruit bats will consume a variety of grasses, fruit and vegetable seedlings, herb and flowering annuals which can be grown in planter boxes and then given to the bats (Le Blanc, 1997).

Several species of microbats ( *Artibeus jamaicensis, Carollia perspicillata, Anours geoffroyi* and *Glossophaga soricina* ) are documented insectivores in the wild. Recent studies with megabats have shown that the Rodrigues fruit bat ( *Pteropus rodricensis* ) and Livingstone’s fruit bat ( *Pteropus livingstonii* ) will consume mealworms, waxworms and tobacco hornworms along with small wild insects that fly into outdoor flight cages (Courts, 1997; Pope, 1997). In captivity, a wide variety of insects could be given as enrichment.

Dietary enrichment can also incorporate flavored water such as herbal teas, diluted apple cider vinegar (5% solution), liquid vitamins and minerals, or even distilled water since it tastes different that the normal water source. Water can be offered in water bottles with ball-bearing tips, hummingbird feeders or in nectar feeders. Water can also be offered as ice and allowed to drip while hanging from a ceiling. Mineral blocks can be moved around the enclosure to keep the bats searching for these dietary supplements.

**Social Enrichment / Unnatural Enrichment**

Fruit bats are social creatures and social contacts with conspecifics can provide a tremendous amount of psychological enrichment. Each species has different degrees of sociability and social organization. Social groups should be modeled after wild groupings.

Addition of social companions, however, can introduce several potential hazards such as aggression due to territoriality and increased competition for food, water, or preferred roosting sites. At times, bats must be separated from the group for medical reasons, and direct contact with each other is not possible. Social enrichment can be indirect by allowing visual, vocal, and olfactory communication. The presence of keepers can also provide a rich source of stimulation to bats. Long-term positive reinforcement with keeper interaction/training may also reduce stress during medical procedures and captures.

Enrichment does not have to be natural to have a place in enriching the lives of captive bats (Bureau, 1997). The captive environment is usually less complex than the wild environment and captive bats are not able to exhibit their full gamut of natural behaviors. The complexity of the captive environment may be increased by incorporating unnatural enrichment. Under this category falls the wide classification of “toys” such as mirrors “pick-up-sticks”, commercially available parrot toys, gummy bones, bells, and teething rings (Atkinson, 1993; Pope et. al., 1997; Seyjagat, 1996). Bats initially show interest in these novel objects, but if the objects are left for long periods in the enclosure, the bats become habituated to their presence (Kuczaj et. al., 1997). Toys can be excellent surfaces for scent marking and olfactory enrichment if they can be moved to several enclosures that house the same species of fruit bat. Rodrigues fruit bats ( *Pteropus rodricensis* ) and Malayan flying foxes ( *Pteropus vampyrus* ) have also been documented to utilize responsive foraging devices in which they have to pull pins, or levers, or rotate disks in order to get food enrichment (Seyjagat per. Comm.; Chag, 1996a). This type of unnatural enrichment can provide opportunities for research into fruit bat manipulation and learning.

**Sensory Enrichment**

*Olfactory*

Fruit bats have a well-developed sense of smell, and olfactory enrichment can be utilized to promote a variety of natural behaviors such as exploration, territoriality, and breeding behavior. Fruit bats can identify individuals in their colony by scent (Nowak, 1994). Intraspecies scent marks can be placed on muslin sheets and given to bachelor groups to give them olfactory access to scents of bats of the opposite sex (Stevens et. al., 1996; Millwood, 1996). The introduction of a male scent mark may result in changes in the female estrus cycle. Male scent marks can also be given to male bachelor groups to promote territoriality and scent marking behavior. Olfactory enrichment can also allow bats to explore other scents in their territory such as other species of bats, birds, predators and flowers. A variety of cooking extracts, spices, fresh herbs, hunting lures, and perfumes have been utilized for enrichment with nocturnal mammals and may be able to be utilized with bats (Nicklaus, 1997; Rosenberg, 1997; Stevens et. al., 1996). Snake sheds and live corn snakes ( *Elaphe guttata* ) have also been offered to flying foxes as enrichment (Van Wormer, 1998). Olfactory enrichment has a benefit over dietary enrichment in that it creates activity without providing calories beyond the normal diet.

*Auditory*

Acoustic enrichment is seldom utilized in zoos, although background noise is utilized

routinely with dairy cattle to reduce stress and increase milk production. Audio recording of bat vocalizations may be beneficial for enrichment (Livingstone, 1997). Colonial species of bats that are noisy, such as flying foxes, may benefit from background noise. Some institutions report providing continuous audio enrichment by utilizing radios or environmental theme audiotapes or by running water in a pool within the exhibit.

**Training as Enrichment:**

Training can provide an opportunity for an animal to earn its living, not exactly as in the wild, but in a way that it can use its adaptations and senses to experience the consequences of its choices (Martin, 1996). Keepers utilize training daily although most don't realize it. Bats quickly learn to perform certain behaviors in response to even the most subtle cues in their environment (Martin, 1997). Effective training is often based on operant conditioning, where as in the wild, animals learn that their behavior is related to an event. Training is most effective if it has a purpose (Laule and Desmond, 1997). Bats can be trained to take medication from syringes by getting them accustomed to taking juice from a syringe. Training can be utilized to condition bats for educational presentations. It can also be applied toward abnormal and stereotypic behavior, improving life for the animal and viewing for the public.

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