

Horticultural Options for Fruit Bat Enrichment

By

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The American Zoo and Aquarium Association (AZA) – Bat Taxon Advisory Group (TAG) has identified enrichment as an important tool in the captive management of New and Old World fruit bats (Fascione, 1995). Enrichment should be given to all captive bat colonies, and can take many forms such as dietary, foraging, olfactory, acoustic, social, and environmental enrichment. The primary focus of the enrichment is towards the adults of the colony, but it also has a positive effect on the pups, since the captive environment has an immediate effect on all mammals after birth. This natal environment has far reaching effects on development, as young mammals learn to exert "control" over their unnatural surroundings (Renner, 1988; Joffe et. 1973). Enriched environments can have positive effects in behavior, physiology, and brain morphology (Uphouse, 1980; Renner and Rosenzweig, 1986; Henderson, 1980; Carlstead and Shepherdson, 1994). The keys to enrichment are to stimulate a greater range of natural behaviors, to lessen negative stress and abnormal behaviors, and to increase physical activity to optimize health and reproductive capacity (Duncan, 1997; Stone, 1997; Carlstead and Shepherdson, 1994).

As managers and keepers explore enrichment, the first step is to evaluate natural behaviors in the wild. New and Old World fruit bats are documented to feed on fruit, flowers, and leaves (Marshall, 1983; Kingdon, 1974; Kunz and Diaz, 1994), and New World fruit bats also consume insects (Gardner, 1997). Studies have shown that green-leaf fractionation by fruit bats can provide them with a protein rich supplement to their diet (Lowry, 1989; Kunz and Ingalls, 1994). These bats may also be able to obtain important nutrients such as calcium and vitamin E from leaves that are important in nutrition (Heard, 1997).

Enrichment for fruit bats can include a variety of horticultural options such as providing foliage for cover; providing scented plants for olfactory enrichment; providing branches, logs and vines for locomotion and manipulation; and food enrichment in the form of browse, flowers, and non-commercial fruits. Horticultural staff should work together with keepers to provide a better environment for these unique flying mammals.

The Lubee Foundation, Inc. houses over 300 bats of eleven different species, which is the largest collection of Old World fruit bats in North America. This collection includes the world's largest, the Malayan flying fox (*Pteropus vampyrus*) (wing span: 1.8 m, weight: 1.2 Kg) to one of the smallest which is the dog-faced fruit bat (*Cynopterus brachyotis*) (40 g). Other species housed at the Lubee Foundation, Inc., include the Indian flying fox (*Pteropus giganteus*), island flying fox (*Pteropus hypomelanus*), Rodrigues fruit bat (*Pteropus rodricensis*), little golden-mantled flying fox (*Pteropus pumilus*), straw-colored fruit bat (*Eidolon helvum*), Wahlberg's epauletted fruit bat (*Epomophorus wahlbergi*), and the Egyptian fruit bat (*Rousettus aegyptiacus*). Two species of New World fruit bats are also managed at the Lubee Foundation, Inc. for education: the Jamaican fruit bat (*Artibeus jamaicensis*) and short-tailed leaf-nosed bat (*Carollia perspicillata*).

Fruit bats that roost in trees may seek cover in foliage. Shepherdson (1997) has suggested that providing hiding areas is a successful strategy for enrichment for species that utilize cover for predator avoidance. Wahlberg's epauletted fruit bats (*Epomophorus wahlbergi*) and little golden-mantled flying foxes (*Pteropus pumilus*) seek out areas of dense foliage (Mickleburgh, 1992; Nowak, 1994). Fronds from Sabal palms (*Sabal spp.*) can provide an excellent source for cover. Southern wax-myrtle (*Myrica cerifera*), pittosporum (*Pittosporum tobira*), and loblolly-bay (*Gordonia lasianthus*) are three plant species that have waxy leaves and as cuttings withstand several days of use by bats. Although these plant species are not desirable as browse, they do offer the bats areas of refuge and branches for manipulation.

Since fruit bats are very destructive to plants, landscaping within the bat enclosure can be difficult (LeBlanc, 1997). Rodrigues fruit bats (*Pteropus rodricensis*) and island flying foxes (*Pteropus hypomelanus*) are the most destructive bats housed at the Lubee Foundation, Inc. Both of these species have destroyed plantings of St. Augustine grass (*Stentaphrum secundatum*), centipede grass (*Eremochloa ophiurides*), dwarf bananas (*Musa acuminata*), cannas (*Canna spp.*), and house palms (*Chamaedorea spp.*). The following plants were found to be resistant to bat destruction and could be managed with these bats: bahia grass (*Paspalum notatum*), holly fern

(*Cyrtomium falcatum*), cast-iron plant (*Aspidistra elatior*), lily-turf (*Liriope muscari*), lily-of-the-nile (*Agapanthus africanus*), Mexican heather (*Cuphea hyssopifolia*), African iris (*Dietes vegeta*), self-heading philodendron (*Philodendron selloum*), pittosporum (*Pittosporum tobira*), Southern wax-myrtle (*Myrica cerifera*), Japanese aralia (*Fatsia japonica*), Japanese privet (*Ligustrum japonicum*), and bottle-brush (*Callistemon rigidus*).

Malayan flying foxes (*Pteropus vampyrus*), Indian flying foxes (*Pteropus giganteus*), little golden-mantled flying foxes (*Pteropus pumilus*), dog-faced fruit bats (*Cynopterus brachyotis*), Jamaican fruit bats (*Artibeus jamaicensis*), and short-tailed leaf-nosed bats (*Carollia perspicillata*) are less destructive to plants. These bats could be managed with butterfly ginger (*Hedychium coronarium*), banana (*Musa spp.*), golden bamboo (*Phyllostachys aurea*), canna (*Canna spp.*), ajuga (*Ajuga reptans*), creeping jenny (*Lysimachia nummularia*), and creeping fig (*Ficus pumila*).

Dog-faced fruit bats (*Cynopterus brachyotis*) and Jamaican fruit bats (*Artibeus jamaicensis*) build “tents” in the wild by cutting the supporting fibers of palm fronds (Foster and Timm, 1976; Kunz et. al. 1994). Dog-faced fruit bats have been stimulated to build “tents” at the Lube Foundation, Inc. when housed with Washington palms (*Washingtonia robusta*). They will also roost in sabal palm (*Sabal spp.*) fronds that are cable tied to the ceiling of the enclosure.

Container plantings such as hanging baskets, window boxes, shade cloth bags, and potted plants are horticultural options that may be able to provide cover and olfactory enrichment for less destructive fruit bats. Bats may be able to interact with the scented foliage or consume the flowers while only causing minimal damage to the plant. The following plants have undergone preliminary testing with excellent results: Passion flower (*Passiflora incarnata*), spearmint (*Menta spicata*), peppermint (*Menta x piperita*), orange mint (*Menta piperita citrata*), variegated pineapple mint (*Menta suaveolens 'Variegata'*), oregano (*Origanum vulgare*), creeping marjoram (*Origanum spp.*), scented geranium (*Pelargonium spp.*), English lavender (*Lavandula angustifolia*), coriander (*Coriandrum sativum*), anise hyssop (*Agastache foeniculum*), catnip (*Nepeta cataria*), basil (*Ocimum basilicum*), thyme (*Thymus vulgaris*), lemon balm (*Melissa officinalis*), rosemary (*Rosmarinus officinalis*), dianthus (*Dianthus spp.*), firecracker flower (*Crossandra infundibuliformis*), and creeping fig (*Ficus pumila*).

Olfactory enrichment can also be facilitated by making scented vinegar that can be utilized as a cleaning agent for windows or as a novel scent in animal enclosures (Powell, 1994). This simple enrichment requires only white distilled vinegar, fresh whole herbs, and time to cure. Both the keeper staff and the bats at the Lube Foundation, Inc. have responded to this enrichment, and it offers a simple technique that is inexpensive, easy to budget time for, and can be varied by using a wide spectrum of herbs to keep the enrichment new and exciting.

In the wild, fruit bats forage in a tropical environment with trees and vines, and must learn to land on these items and to locomote on both vertical and horizontal surfaces. In captivity, the thumbnails of Old World fruit bats are trimmed due to over growing and not being able to wear them down in the captive environment. Tree branches, grapevines, and sweet gum (*Liquidambar styraciflua*) logs are used to replicate natural movements and to help manage nail wear with these bats. Tree branches and grapevines are hung from the walls of the exhibit with cable ties or screw hooks. Larger branches are mounted in the floor of the cage so they can stand vertically. Small diameter logs are hung vertically from the ceiling of the cage with large eye screws or mounted in the floor of the enclosure. Branches and logs are moved in the enclosures so bats have to adapt to a changing environment. Enrichment is placed on the bottom of vertical logs or by hanging it from branches and vines to encourage the bats to use these items. Placement of exhibit furniture is very important, and flight paths for bats should not be interrupted since it could cause injuries to the bats or restrict flight in these mammals.

The last technique and the most popular is providing the bat collection with a variety of browse, flowers, and non-commercial fruits. A survey of bat enrichment by the Lube Foundation, Inc. has documented 134 species of plants that are utilized in zoological institutions throughout world for enrichment with bats (LeBlanc, 1998). Table 1. Displays a list plant species that are utilized for browse, flowers, and non-commercial fruits.

The most desirable browse species at the Lube Foundation, Inc. are willow (*Salix caroliniana*), grape (*Vitis spp.*), and sweet gum (*Liquidambar styraciflua*). The least desirable browse species are dogwood (*Cornus*

florida), sugarberry (*Celtis laevigata*), sycamore (*Platanus occidentalis*), and silverthorn (*Elaeagnus pungens*). Willow offers the benefit of providing flowers early in the year, succulent growth during the summer and fall, and the bats will consume the branches down to the bark. Grape (*Vitis spp.*) and wisteria (*Wisteria spp.*) vines are woven into wreaths for ease of hanging, and provide the bats with objects for manipulation and climbing.

Flowers are a special seasonal enrichment that provide novelty, olfactory enrichment, and a sweet source of food (LeBlanc, 1997). Fruit bats in the genus *Pteropus* are destructive to flowers (Marshall, 1983; Elmqvist et. al. 1991) and will eat flowers like roses (*Rosa spp.*), wisteria (*Wisteria frutescens*) and butterfly ginger (*Hedychium coronarium*). They are also effective pollinating agents, and behave in this manner with bottle-brush (*Callistemon spp.*). Jamaican fruit bats (*Artibeus jamaicensis*) and dog-faced fruit bats (*Cynopterus brachyotis*) have cut flowers from passion fruit vines (*Passiflora incarnata*), and transported the flowers several yards from the hanging plant. Since flowers are ephemeral in nature, the true potential for offering flowers as enrichment has not been practiced as much as it could be in zoological institutions.

The Lube Foundation, Inc. has also utilized container plantings for food enrichment by providing flowers and tender browse in window boxes. Marigolds (*Tagetes spp.*), pansies (*Viola x wittrockiana*), snapdragons (*Antirrhinum majus*), coleus (*Coleus x hybridus*), annual ryegrass (*Lolium multiflorum*), wishbone flowers (*Torenia fournieri*), purslane (*Portulaca oleacea*), and sunflower (*Helianthus annus*) sprouts all have been utilized with success. These boxes are easy to start, and replace as the bats destroy them.

Fruit trees such as fig (*Ficus carica*), loquat (*Eriobotrya japonica*), black cherry (*Prunus serotina*), mulberry (*Morus rubra*), Japanese persimmon (*Diospyros kaki*) and cattley guava (*Psidium littorale*) have been utilized on the grounds of the Lube Foundation, Inc. for aesthetics, shade, and for providing the bat collection with seasonal food enrichment. These fruits are offered directly by keepers to the bats for training or hung for enrichment so bats have to work in order to obtain this novel enrichment.

New and Old World fruit bats are dependent on plant resources for their survival in the wild, and can benefit from several horticultural options such as providing foliage for cover, providing scented plants for olfactory enrichment, and food enrichment in the form of browse, flowers, and non-commercial fruits. These horticultural options can also enhance visitor experience, as they allow the exhibit to be more aesthetically pleasing, and may capture the public attention as they learn that bats will eat flowers and leaves.

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