INTRODUCTION TO BATS

Bats (order Chiroptera) are an ecologically diverse and geographically widespread mammalian group. With over 1100 species (Simmons, 2003), members of two suborders (Microchiroptera and Megachiroptera) constitute approximately one-fifth of all extant mammals. They range in size from the tiny 2-gram Kitti's hog-nosed bat (Craseonycteris thonglongyai) to the large, Malayan flying fox (Pteropus vampyrus) weighing about 1200 grams, with a wingspan of nearly 1.5 meters (Kunz and Pierson, 1994). Bats exhibit several life history traits that make them unique among mammals. Compared to small terrestrial mammals, for example, bats of similar size have very few young and long periods of pregnancy and lactation, and they may live up to 37 years. Differences in life-history traits between bats and other mammals are often attributed to the evolution of flight and echolocation (Crichton and Krutzsch, 2000; Kunz and Fenton, 2003).

Bats are the only mammals that have evolved powered flight; thus, along with echolocation, flight has made it possible for bats to seek shelter in many different types of structures (e.g., foliage, tree cavities, caves, rock crevices) that are not generally used by terrestrial mammals and to exploit a wide variety of food sources. The diets of bats include fruit, nectar, pollen, leaves, invertebrates (e.g., insects, spiders, crustaceans, and scorpions), small vertebrates (e.g., frogs, birds, fish, and other mammals), and blood (Kunz and Pierson, 1994).

Although echolocation has evolved independently in birds and mammals, the most sophisticated and diversified form of echolocation can be found in bats. Echolocation is used for prey detection and capture, for navigation, and in some instances for communication. Several species rely on a combination of vision, olfaction, and prey-generated sounds to locate food in addition to or instead of echolocation (Altringham, 1996).

The roosting habits of bats are often highly specialized, with different species occupying tree cavities, spaces beneath exfoliating bark, unmodified foliage, leaves modified into so-called "tents," abandoned ant, termite, and bird nests, large and small caves; rock crevices; and a wide range of manmade structures, including mines, buildings, stone ruins, and bridges (Kunz, 1982; Kunz and Fenton, 2003). Caves alone provide a variety of structural substrates for roosting, including crevices, cavities, textured walls and ceilings, expansive ceilings, rock outcrops, and rock rubble on floors. In addition, the microclimates of caves that are occupied by bats can vary enormously, depending on latitude, altitude, depth, and volume, as well as the number, size, and position of openings to the outside. These variables can influence the amount of airflow, the presence of flowing and standing water, and daily and seasonal variations in atmospheric pressure, temperature, and humidity. Thus, the environmental conditions within caves may be hot, cold, dry, humid, still, or windy.

This chapter highlights the biology of bats that typically roost in caves and cave-like structures. Specifically, we discuss why bats live in caves, where they are found, their roosting requirements, as well as conservation and management issues important to protecting cave-dwelling species.

CAVE BATS AND THEIR DISTRIBUTION

Cave bats are defined as troglobionts, species that do not complete their entire life cycle within caves. Their ability to fly and echolocate has allowed microbats to exploit caves and similar subterranean habitats for roosts and to forage for food away from these structures. The vast majority of bats that
belong to the suborder Microchiroptera are able to echolocate and navigate in dark underground habitats and to feed in open fields or in dense forested areas. Rousette fruit bats (suborder Megachiroptera) may also roost in caves, but they rely on tongue clicks to produce audible sounds to help them navigate in the dark. The handful of other megachiropterans found roosting in caves are restricted to areas with enough light to make it possible for them to find their way in and out, as they largely rely on vision and not echolocation to navigate while in flight (Kunz and Pierson, 1994).

Bats are virtually ubiquitous. They are known from all continents, except Antarctica, and from many oceanic islands. Most bats occur in tropical regions, where they are often the most diverse and abundant mammals present. The diversity of bats generally increases as one travels from the poles toward the equator, a pattern that is largely attributable to an increase in habitat complexity as latitude decreases (Findley, 1993; Kunz and Fenton, 2003).

The distribution of cave bats not only depends on the presence of caves, but is also a consequence of specific roosting requirements (Kunz, 1982). For example, although the ghost bat (Macroderma gigas), the orange leaf-nosed bat (Rhinonycteris aurantius), and the large bent-wing bat (Miniopterus schreibersi) are all found in Australian caves, their roosting requirements and hence geographic distributions are quite different (Baudinette et al., 2000). The orange leaf-nosed bat selects caves that are extremely hot and humid (28 to 30°C and greater than 94% relative humidity) and currently are known from only ten caves in Australia. In contrast, the large bent-wing bat can be found roosting at a broader range of temperatures and humidities and has one of the widest reported distributions of cave-roosting bats, encompassing southern Europe, Africa, southeast Asia, Japan, and Australia. The ghost bat is restricted in its distribution to the Northern Territories of Australia, but it occupies far more caves and mines than the orange leaf-nosed bat. As one might expect, the ghost bat has roosting requirements for which humidity is not such a vital condition as compared to the orange leaf-nosed bat.

Bats are found almost everywhere subterranean habitats exist. The distributions of cave-dwelling bats are determined largely by species-specific roosting requirements that vary depending on their ecology and evolutionary history. Local and global distributions and densities of bats that rely on caves for at least part of their life cycle are in turn determined largely by the distribution, quantity, and characteristics of available caves. For example, the Townsend's long-eared bat (Corynorhinus townsendii), known only from North America (Fig. 1), is primarily found roosting in caves and cave-like structures (Wilson and Ruff, 1999).

**FUNCTIONS OF CAVE ROOSTS**

Caves are used by bats for a variety of reasons, including courtship and mating, raising young, and hibernating. Bats seek shelter during the day and disperse from these sites to forage for food at night. During the day, bats typically rest, groom, and often interact with their roost-mates. For example, a typical day for lactating female lesser long-nosed bats (Leptonycteris curasoae) involves resting quietly for up to 16 hours, interspersed with periodic grooming and nursing behavior. Although females usually roost together in caves during the day, they seldom interact with one another (Fleming et al., 1998). In contrast, the common vampire bat (Desmodus rotundus) forms long-term social bonds, and individuals groom one another as they interact socially while occupying cave and tree roosts (Greenhall and Schmidt, 1988). In addition, many insectivorous species retreat to caves between feeding bouts, where they may call the wings and heads of insects that were captured while foraging. Frugivorous species sometimes transport large fruits to caves where they will use soft pulp and where they can reduce the risks of predation. Some species that roost in foliage or tree cavities in the warm months hibernate in caves during the winter (Kunz, 1982; Kunz and Fenton, 2003).

**Courtship and Mating**

Several types of mating systems have been described for cave-roosting bats. Mating systems of bats and other mammals are often classified into three general categories: promiscuity, polygyny, and monogamy. However, bat mating systems cannot always be easily categorized into one of these groups, as they often depict a continuous spectrum of mating behaviors (Crichton and Krutzsch, 2000).

Promiscuity is a type of mating system in which both males and females have multiple partners. Such a system is almost always highly structured, with some males siring more young than others. Promiscuity is common among temperate cave-dwelling species, possibly because of the limited time available for mating in autumn before individuals enter hibernation (Altrinham, 1996). Males and females of many temperate species generally do not roost together during...
warm months but instead roost alone or in small groups. Assemblages of bats that gather at caves and mines in the autumn (referred to as swarming) may aid individuals in finding a mate. During the swarming season, bats are active in caves and mines at night, where males can often be observed displaying and chasing females. In the United Kingdom, male and female greater horseshoe bats (Rhinolophus ferrumequinum) have a mating system in which males establish territorial sites inside caves and mines in early autumn. Females gather at these sites and selectively visit a series of different males on their territories (Crichton and Krutzsch, 2000).

Polygyny, a mating system thought to be the most common in bats, is characterized by one male mating with several females (Crichton and Krutzsch, 2000). An example of this type of mating system can be observed in the greater spear-nosed bat (Phyllostomus hastatus). In this species, females roost in caves in small stable groups, often remaining together for 10 years or more. Because the females often form discrete roosting groups in solution cavities or “pot holes” on cave ceilings, it is easy for a dominant male to defend a group of females from intrusions by other males. By defending the females, or the roost cavity, a so-called harem male is often able to mate with several females. Sometimes these harem males are accompanied by a subordinate male who has positioned himself in the harem to assume a dominant role if the harem male should become injured or die. The risks and costs associated with mate-guarding behavior can be substantial. For example, a harem male greater spear-nosed bat may incur some injuries while defending the females or roost cavity and in the final analysis may sire only 60 to 90% of the young born to those females (Crichton and Krutzsch, 2000). A similar pattern of mate guarding and courtship has been observed in the Jamaican fruit bat (Artibeus jamaicensis), which commonly roosts in caves on many of the islands in the West Indies and throughout Central and South America.

Monogamy occurs when males and females form long-term pair bonds. This type of mating system has been described for only a few species of bats. Two examples are the African false vampire bat (Cardioderma cor) and the American false vampire bat (Vampyrum spectrum), both of whom are carnivorous, sit-and-wait predators. An extended period of parental involvement in which males provision both females and young may have contributed to the evolution of monogamy in these and other species (Crichton and Krutzsch, 2000).

**Rearing Young**

During pregnancy and lactation, females form maternity colonies, which are often located in separate places from roots used by males. In most species of bats, the responsibility of raising young lies solely with females. Pregnancy and lactation are both energetically expensive events, thus females and their young can benefit from the heat generated when they form clusters in the partially enclosed spaces often found in caves and cave-like structures. Roosting together in large clusters may reduce the energy expenditure of some individuals by up to 50%. When lactating females disperse from roosts in the evening to feed, they often leave their pups in a warm, incubator-like environment. Females incur high energy costs when they forage and return to the roosts once to three times each night to find and suckle their dependent young. Thus, assembling in warm places can help reduce the energy needed by small bats to remain homeothermic (Crichton and Krutzsch, 2000).

Each spring, Brazilian free-tailed bats (Tadarida brasiliensis) migrate from Mexico to the southwestern United States to form large maternity colonies in caves and sometimes other structures. This species is thought to form the largest aggregations of mammals known to mankind, where nightly emergences sometimes exceed several million individuals from a single cave (Fig. 2). Each time a female Brazilian free-tailed bat returns to a feeding bout to suckle her young, she faces the daunting task of finding her own pup among the millions of babies that are left on the ceilings and walls of the cave. A mother bat begins this adventure by returning to the area in the cave where she left her pups before emerging to feed. Next, she uses vocal and olfactory cues to identify her own pups among the thousands or more that are present (Crichton and Krutzsch, 2000). Hungry pups will sometimes attempt to nurse from almost any female, although lactating females usually guard against milk stealing from unrelated individuals (McCracken, 1984). The investment that a mother bat makes in her pups is substantial, requiring quantities of food intake equal to about two-thirds of her body mass each night at peak lactation (Kunz et al., 1995).

Young Brazilian free-tailed bats grow rapidly from a diet of energy-rich milk. Mothers nourish their young with milk for several weeks, because young bats cannot fly and feed on...
their own until their wings have almost reached adult dimensions. Within 6 weeks of birth, young free-tailed bats are able to fly and forage on their own. In contrast to most other mammals that typically wean their young at about 40% of adult size, most insectivorous bat species suckle their young until they are about 90% of adult size (Crichton and Krutzsch, 2000).

**Hibernation**

Bats have evolved behavioral and physiological mechanisms to avoid long periods of adverse weather and low food or water availability. Some species migrate to more suitable areas, but others use daily torpor, a controlled lowering of body temperature to conserve energy. Only temperate species in the families Vespertilionidae, Rhinolophidae, and Molossidae are known to hibernate in caves and mines (Fig. 3) (Kunz and Fenton, 2003).

Hibernating bats rely on stored fat as their primary energy source during hibernation and are sustained on these reserves for upward of 6 to 8 months. Hibernation is an energy-saving strategy that is strongly influenced by the ambient conditions in a cave. When a bat is hibernating, low ambient temperatures lead to a decrease in metabolism. When the ambient temperature is too cold or too warm, bats typically arouse and move to another part of the cave. It is important for hibernating bats to occupy caves and mines that provide a variety of temperatures, because individuals often change roosting positions as the season progresses (Kunz and Fenton, 2003).

During hibernation, bats lower their body temperature to within a few degrees of the ambient temperature, but individuals arouse periodically by producing heat employing non-shivering thermogenesis. Bouts of hibernation can last anywhere from a few days to several months. In areas with moderate winters, bats such as the greater horseshoe bat (*Rhinolophus ferrumequinum*) in the United Kingdom may feed on insects on warm winter nights. Arousal from deep hibernation are energetically costly, with a single arousal expending the energy equivalent of a bat spending 68 days in deep torpor. Thus, if hibernating bats arouse too often, either because the microclimate is not optimal or from human disturbance, they may not have enough fat reserves to survive the winter (Kunz and Fenton, 2003).

**Costs and Benefits of Living in Caves**

The decision about where to roost is critical to the survival and reproductive success of bats. The type of roost that a bat selects is influenced by its morphology, ecology, and physiological requirements and often reflects a compromise between the costs and benefits associated with a particular type of roost (Kunz, 1982). For cave-roosting species, the benefits of living in a cave usually outweigh any costs that they may otherwise incur. In the following section, we discuss the major costs and benefits considered critical for the selection of roosts by cave-dwelling bats. It is important to note that roosting requirements and relevant costs and benefits are not uniform for all species and may vary intra-specifically, depending on geographic location, reproductive condition, and/or season (Kunz and Fenton, 2003).

**Benefits**

Caves offer a wide range of benefits including a structurally and climatically stable environment, and protection from predators and adverse weather. Microclimate, specifically temperature and relative humidity, is arguably the most important factor in roost selection by cave-dwelling bats (Baudinette et al., 2000). Different bat species roost in a variety of microclimates within caves and mines, and this variation is often correlated with a bat's body size, diet, phylogeny, and their ability to enter torpor (Kunz and Fenton, 2003).

Compared to non-volant mammals, bats have high rates of evaporative water and heat loss, due in part to their relatively high surface-to-volume ratio, enhanced by the large surface of their naked wing membranes. At low relative humidities (<20%), bats may lose up to 30% of their body mass per day from evaporative water loss alone. This rapid dehydration can be lethal. Many bats select caves that have high relative humidity to help conserve water during the day (Kunz and Fenton, 2003).

Bats are endothermic, meaning that they rely on the internal production of heat to maintain their body temperatures within their thermal neutral zone. Maintaining homeothermic body temperatures requires a substantial amount of energy. At ambient temperatures above and below the thermal neutral zone, bats must expend energy to cool or warm themselves, respectively. Bats use at least four different strategies for conserving energy while in their roosts (Kunz and Fenton, 2003). Some species select roosts that have an ambient temperature within their thermal neutral zone. The California leaf-nosed bat, for example, often exploits geothermally heated mines to conserve heat during the

![Figure 3](image-url)
winter. Other species form large colonies in parts of caves that have little airflow, leading to an increase in roost temperature as the metabolic heat generated by the bats becomes trapped. The lesser long-nosed bat (Leptonycteris curasoae) in South America, the large bent-wing bat (Miniopterus schreibersii) in Australia, and the Brazilian free-tailed bat (Tadarida brasiliensis) in the southwestern United States are examples of cave-dwelling species that form colonies large enough to substantially increase the temperature of their roost environment. Still other species select colder roost environments that allow them to reduce their body temperature and thus become torpid. Daily torpor not only reduces the amount of energy a bat expends in a day but also helps reduce water loss. Finally, some species form dense clusters that buffer individuals from changes in ambient temperature, a behavior that also reduces their energy expenditure.

In addition to the energy savings that bats may experience, they can also benefit from social interactions promoted by cave living. For example, the environmental stability of caves can facilitate social interactions such as finding, attracting, and guarding mates; information transfer; and interactions that evolve through kin selection and/or reciprocal altruism (Crichton and Krutzsch, 2000). Females that roost together sometimes share information about feeding resources, such as the location of flowering and fruiting trees. Female greater spear-nosed bats (Phyllostomus hastatus) typically roost in caves where they form stable groups of unrelated individuals. Information transfer, presumably facilitated by vocal contact, may help females coordinate efforts to defend food patches from other bats (Wilkinson and Boughman, 1998).

The common vampire bat (Desmodus rotundus), another highly social species, has evolved a system of sharing blood with both relatives and unrelated roost mates. Vampire bats must obtain a blood meal at least once every three days or they will invariably die. Females often share blood with roost-mates that are at risk of starving, but this sharing occurs only among individuals with whom they are closely associated. This is referred to as reciprocity (or reciprocal altruism) and occurs when the cost to the individual performing the altruistic act is less than the benefit to the recipient when such an act is later reciprocated (Greenhall and Schmidt, 1988).

**Costs**

There are several potential costs associated with living in caves, most of which are related to living in large groups. Large numbers of bats that live in close physical contact with one another may be more prone to transmit certain diseases or increase the risk of parasitic infestations. Highmite infestations on a bat, for example, may cause an increase in the amount of time an individual spends grooming, and thus increase is daily energy budget (Kunz, 1982).

That bats often emerge synchronously from a cave may increase an individual’s risk of predation. Researchers have documented birds of prey, such as owls, hawks, and falcons, swooping down into columns of bats that emerge nightly from caves and mines. As many as 14 bird species are known to feed on bats in Britain alone, with the most important predators being owls. Some birds even specialize on bats, such as the bat hawk (Machairamphus alcinus) in Africa and the bat falcon (Falco rustigudus) in Central and South America. Most predatory birds are territorial, so their numbers at any one cave are probably quite small, thus the impact on local populations is probably minimal. Other animals that sometimes prey on cave-roosting bats include snakes, raccoons, skunks, opossums, and other bats; even a frog has been observed preying on bats (Altringham, 1996). Few studies, however, have evaluated the impact that predators have on bat populations.

The distribution of caves in most terrestrial landscapes is highly variable, and some may not be located near abundant food resources upon which bats depend. Bats that roost alone or in small groups in tree cavities and in foliage can often take advantage of food resources located near their roosts, but cave bats, especially those that form large colonies, more often must commute considerable distances to foraging sites. Because flight is energetically expensive, bats must make compromises between colony size and the amount of energy spent commuting to feeding sites and the energy that is conserved by selecting a roost that has microclimate conducive to energy and water conservation (Kunz, 1982).

Local food resources may not be sufficient to support the energy and nutrient budgets of all individuals that form large cave colonies, thus some individuals must disperse considerable distances in order to secure their daily energy and nutrient requirements. Some maternity colonies of Brazilian free-tailed bats (Tadarida brasiliensis) may number in the millions, requiring some individuals to fly upwards of 50 km each night to obtain their food. This may also be the case for other species that form large colonies in caves, such as the large bent-wing bat (Miniopterus schreibersii) and the lesser long-nosed bat (Leptonycteris curasoae) (Kunz and Fenton, 2003).

**CONSERVATION AND MANAGEMENT**

In recent years, reductions in the numbers of cave bat populations have increasingly concerned conservation biologists (Kunz and Racey, 1998). One of the major problems that places bat populations at risk is that they have relatively low reproductive rates and are unable to recover quickly from population declines. Cave bats face a variety of human threats that may vary in different regions of the world. Some threats reflect differences due to socioeconomic conditions, habitat types, and cultural attitudes toward bats. Notwithstanding, several successful approaches, such as habitat restoration and cave protection, have been employed to protect bats, their roosts, and food resources. Increasingly, most if not all geopolitical units (cities, states, countries) are
-faced with issues related to increased mining and quarrying operations, spelunking, ecotourism, vandalism, sealing of caves and mines for safety reasons, and deliberate killing of bats. Other local issues include guano mining and over-collection of bats for scientific research which can have adverse affects on cave environments. The negative image of bats often portrayed by the media can best be overcome through better educational efforts. Lack of basic information about the natural history of most cave-roosting bats is a problem in many regions of the world. Thorough knowledge about the ecology and behavior of different species is essential if natural resource managers and politicians are to make informed decisions that affect the well-being of bats and the food and roost resources on which they depend (Kunz and Racey, 2003).

ECOSYSTEM SERVICES PROVIDED BY CAVE BATS

Many cave-dwelling bats provide essential ecosystem services by helping to maintain forest diversity by dispersing seeds and pollinating flowers. Changes in bat diversity or abundance due to forest fragmentation or roost destruction can lead to the dysfunction of forest ecosystems. In addition to plant-visiting bats that disperse seeds and pollinate flowers, many insectivorous bats consume vast quantities of insects. Some insectivorous species feed on insects that cause significant damage to agricultural crops. The Brazilian freetailed bat (Tadarida brasiliensis), for example, is known to feed on insects that cause millions of dollars in damage to corn and cotton crops in the United States each year. In addition, nearly everywhere that large quantities of guano have accumulated in caves, local communities have discovered its value as a fertilizer. In some parts of the world, guano is mined locally and sold commercially for fertilizer. Although guano mining is no longer common in most industrialized countries, it is still practiced in some underdeveloped countries (Kunz and Pierson, 1994; Kunz and Fenton, 2003).

The organic input from bat guano (feces and urine) is essential for sustaining the health of cave ecosystems. Many cave-dependent organisms (e.g., fungi, arthropods, fish, salamanders) depend on bats to produce guano and thus provide critical food resources in an environment where other sources of organic nutrients are relatively scarce. Not only do bats defecate and urinate in caves, but some also discard culled wings of insects or seeds and bits of fruit and leaves as they feed, and thus supply energy and nutrients for a variety of cave organisms such as fungi, arthropods, fish, and salamanders (Kunz and Racey, 1998).

Human Disturbance

Humans enter caves for various reasons, including scientific research—exploration, shelter, tourism, mining, and even sometimes for collecting bats to eat. Whatever the intentions might be, these activities can have adverse consequences for bats (Kunz and Racey, 1998; Kunz and Fenton, 2003). Disturbing bats during the maternity period, whether they are handled or not, can cause pregnant females to abort their young or cause young to fall to the floor, leading to injury or certain death. Hibernating bats are particularly vulnerable to disturbances from human activities. When humans disturb hibernating bats, they often respond by arousing, which is energetically expensive. Non-tactile stimuli, such as light and noise, can also increase the activity of bats that hibernate in caves and thus lead to the depletion of valuable energy reserves (Kunz and Fenton, 2003).

Habitat Destruction and Alteration

Mining and quarrying activities can have adverse impacts on cave-roosting bats, because such activity often modifies the physical structure and microclimate of their subterranean habitats. Because many bats have very specific roosting requirements, such changes may cause bats to abandon these sites. Just as important is the fact that mining operations often use chemicals that are highly toxic. In some regions, modern gold-mining techniques, for example, use cyanide to extract gold from ore, and such practices have killed enormous numbers of animals, including cave bats, by contaminating water sources from which bats derive their food and drinking water.

In some situations, bats have taken advantage of human technology by readily using manmade structures such as bridges and mines. Increases in the number of abandoned mines and bat-friendly bridges have also increased the abundance and distribution of some cave-dwelling species. However, reclamation of mines and the closing of others have also led to an increase in bat mortality when these structures are closed without first verifying their presence (Tuttle and Taylor, 1994).

The habitat surrounding caves can be just as important as the environment within the cave itself. Many hibernating species, such as the endangered Indiana bat (Myotis sodalis), typically roost beneath exfoliating bark during the warm months but hibernate in caves during the winter. To survive a prolonged period of hibernation, bats must be able replenish their fat reserves following migration, thus productive foraging habitats located near hibernacula are essential to their success. The vegetation around a cave not only supports source populations of insect prey but also may buffer the interior of the cave from severe changes in wind flow and temperature.

The Paradox of Vampire Bats

A source of myths and legends, vampire bats offer a valuable lesson about the need to learn more about these and other species before it is too late to protect them from extinction. Three species of vampire bats range from northern Mexico...
through South America, but only the common vampire bat 
(Desmodus rotundus) is abundant enough to be considered a 
nuisance to humans and their livestock. All three species 
depend on a diet of blood, but they feed on a variety of 
different animals. Most of our knowledge of vampire bats 
comes from the common vampire bat, which specializes 
on mammalian blood as a source of food. Populations of 
vampire bats increased sharply in areas of Latin America 
following the introduction of livestock by European settlers 
over 500 years ago. Because the common vampire bat 
feeds on cattle and occasionally on humans, this species has 
become a pest in most of Central and South America. The 
economic loss due to cattle dying from bat-transmitted rabies 
alone is a major concern in many regions of Latin America 
(Greenhall and Schmidt, 1988).

Lack of education and misguided attempts to control 
vampire bat populations have led to the mass destruction of 
these and other non-targeted species. Nonselective killing 
techniques, such as fire and gas (fumigating), have been used 
either because local landowners are often unaware of the 
differences between vampire bats and other species or because 
they are uninformed about the value of bats in general. 
Poisons, such as strychnine or anticoagulants, are often 
employed to the wounds on livestock because vampire bats 
return to wounds that they made the previous night 
(Greenhall and Schmidt, 1988). Selective approaches that 
concentrate on controlling vampire bats should be used 
whenever possible. Recent discoveries by researchers indicate 
that chemicals present in the saliva of common vampire bats 
have important medical benefits (e.g., reducing the risks of 
stroke and heart attacks in humans). Thus, a bat species that 
is considered a nuisance or public health threat by some 
segments of society may also offer enormous benefits to 
others.

Many local, national, and international organizations have 
become engaged in efforts to support research on bats and 
have also helped to educate the public about the benefits of 
bats to humankind. Many cave organizations have joined this 
effort to protect cave bats. Television programs, newspaper 
articles, and other media must be used to promote the 
ecological value of bats and the importance of caves for sustaining 
many bat populations on a worldwide scale. Organizations 
such as Bat Conservation International (www.batcon.org), 
Bat Conservation Trust (www.bats.org.uk), the Lubee Bat 
Conservancy (www.lubee.com), and the Organization for 
Bat Conservation (www.batroost.com) are among a growing 
number of non-governmental organizations that are 
contributing to these efforts. Notwithstanding, additional efforts 
are needed to help promote and protect the nearly 1100 
species of bats known worldwide.

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Beetles

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INTRODUCTION

As part of the Insects class, representatives of the order of 
Coleoptera usually have a sclerotized body with sclerotized 
forewings that are leathery or horny and modified to act as 
rigid covers (elytra) over the membranous, reduced, or even 
absent hindwings. The mouthparts are adapted for cutting,