

Diurnal Retreats of Bats

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The forelimbs of bats are so highly modified for flight that they are of little value for terrestrial locomotion. Deprived of all but limited use of the front feet in terrestrial activity, roosts or resting sites are also limited. All bats are primarily nocturnal and most of them spend the day in elevated, secluded retreats. Elevation is critical, for some bats show limited ability to take flight from flat, horizontal surfaces. Many bats, however, do show marked agility on the ground, and are quite capable of gaining flight from flat, horizontal surfaces. There is little correlation between taxonomy and roosting habits, although utilization of vegetation as roosts appears to be the general rule in the Megachiroptera and rather uncommon in the Microchiroptera.

Most of the tree-dwelling Megachiroptera are colonial and form large "camps". The roosts or camps of *Pteropus* have been described by numerous authors. Wroughton (1915) stated that the bats virtually covered their roosting trees in Ceylon. McCann (1934) has discussed a large camp of *Pteropus giganteus* in India. One particular camp of *Pteropus* in Australia was estimated to contain 32,000 individuals (Cockrum, 1962). A study of the behavior of these bats by Nelson (1965) is the only detailed study of the activities of Megachiroptera in these large camps. He noted that more than one species may be present in a camp, but the degree of separation by species within the camp is related to reproductive state. If all the animals are in a non-reproductive stage, there is no species segregation.

Although many Austro-Asian pteropids form small to very large camps and are very conspicuous on the terminal branches and twigs of the taller trees, there are few reports of large predatory birds feeding on them extensively. Nelson (1965) reports that wedge-tailed eagles (*Aquila audax*) and white-breasted sea eagles (*Haliastur leucogaster*) raided camps. If the eagles missed a capture on the first pass, they were unsuccessful on succeeding passes. The flying foxes emitted alarm cries alerting others in the area. If the eagles land in the roost tree, the bats moved into other areas of the tree and exhibited threatening gestures in the form of outstretched wings and vocalizations.

The Pteropidae of Africa are generally much smaller than Austro-Asian forms, but are also colonial and arboreal. Ogilvie & Ogilvie (1964) reported 200,000 individuals of the relatively large *Eidolon* roosting in forest trees in much the manner of Austro-Asian pteropids. The smaller *Epomophorus* utilize twigs or hang from the underside of densely-

leaved, preferably well isolated, trees. *Epomops*, *Myonycteris* and *Micropteropus* form small colonies; in some cases no more than two individuals may be involved (Verschuren, 1957). *Megaloglossus* and the Nyctimeninae are solitary arboreal forms.

Other megachiropterans, however, are not arboreal. *Rousettus* usually utilizes poorly lighted caves with large openings; and *Eonycteris* is known to frequent caves (Lawrence & Novick, 1963). *Dobsonia* and *Notopterus* are also troglaphiles (Brosset, 1966).

The Microchiroptera occupy a wide array of roosting sites: caves, cavities that simulate caves such as hollow trees and man-made structures, and various types of vegetation. Crevices are preferred by some genera, and these genera usually exhibit extreme flattening of the body.

Bats of the genus *Nycteris* are only slightly gregarious; most of the time they are found in families or in very small colonies. They seldom are in mixed colonies (with other genera). *Nycteris grandis* apparently is solitary (Brosset, 1966). *Nycteris arge* is reported roosting (never more than four individuals) in the hollow of a tree (Verschuren, 1957) and to form microcolonies with *Hipposideros cyclops* and *Rhinolophus landeri* (Aellen, 1952; Verschuren, 1957). Other nycterids are reported to use hollows of trees, vegetation over erosion ditches, recesses in cliff overhangs and subterranean channels (Aellen, 1952; Verschuren, 1957). *Nycteris hispida* is reported to be a frequent occupant of buildings or human habitations (Rosevear, 1965).

Megadermatid bats are also only slightly sociable and are frequently found in small colonies. *Megaderma*, *Macroderma* and *Cardioderma* are cavernicolous, but are also found in galleries of mines, wells, garrets and old buildings (Brosset, 1966). The African genus *Lavia*, however, is a tree-dweller. It exhibits a preference for rather open shrubs, frequently the thorny acacias. From a distance they give the appearance of pods or weaver-birds' nests (Rosevear, 1965). Verschuren (1957) found them frequently suspended from vegetation over water at a height of 2-6 meters above ground. They are often active during the day (Hollister, 1918)—a characteristic not found in other genera of the family.

Rhinolophids exhibit a wide spectrum in colony size. *Rhinolophus euryale* or *rouxi* is very gregarious, *R. hipposideros* is only slightly social, and *R. lanosus* and *luctus* are solitary forms (Brosset, 1966). Although the family is quite widely distributed, it seems to show a general preference for caves. They also have been found roosting in culverts, wells, storerooms and other buildings (Rosevear, 1965). Sexual segregation at the roost apparently occurs in some species (Brosset, 1966). Verschuren (1957) does report that *Rhinolophus alcyone* was taken from roosts in hollows of trees. Two European species of

Rhinolophus are known to use caves as hibernaria. *Rhinomegalophus* is reported only from the type specimen collected from a cave (Walker, 1964).

Hipposiderids are highly variable in colony size, between species and geographically. *Hipposideros caffer* and *H. lankadiva* form large aggregations; *H. beatus* occurs in small family groups and *H. cyclops* is a solitary form. *H. galeritus* is a solitary form in India, but forms colonies of more than 100,000 in Sarawak. It is not uncommon to find more than one species of *Hipposideros* in a roost. In the gregarious species, social groups based on age classes and sex occur (Brosset, 1966).

Members of the genus *Asellia* form huge colonies in dry caverns and dark ruins and are typically suspended from the roof or wall by means of the feet and thumbs (Harrison, 1964). In Asia these bats inhabit grottos and seek shelter under rocks. Males reportedly form distinct groups (Brosset, 1966). This bat has been found associated with *Pipistrellus kuhli* under the iron roof of a shed in Iraq (Walker, 1964).

Very little is known of the biology of *Anthops*, *Syndesmodis* and *Paracoelops*. *Cloeotis* is reported found in large colonies in caves with narrow entrances; and *Coelops* is reported from a warm air cave with evidence that it was hibernating there (Walker, 1964). Certainly one of the most unusual bats is *Rhinycteris* that is reported to live among flowers and whose coloration approaches a form of mimicry (Brosset, 1966). *Triaenops* has been reported from caves and underground water tunnels. It apparently roosts with *Coleura* and *Asellia* (Walker, 1964).

Rhinopomatids have been reported from caves, cavernous buildings, rock crevices, tombs, various ruins, wells, and subterranean Hindu places of worship (Rosevear, 1965). *Rhinopoma microphyllum* and *R. harwicki* are known to share the same or similar roosts, although *R. harwicki* may frequently be solitary. It, like *Asellia*, will cling to the wall or roof by means of the feet and thumbs (Harrison, 1964).

Among the sheath-tailed bats there are some interesting roosting habits. *Emballonura* habitually roosts in low-growing palms as well as rock crevices and caves, usually in small groups (Walker, 1964). Sanborn (1947) reports a roost in a narrow fissure in a wall. *Coleura* is reported to use caves and houses as roosts; in houses, they utilize the space between over-lapping tiles or corrugated iron sheets (Walker, 1964). Harrison (1964) reported them from the same cave as *Asellia* and *Triaenops* although they remained apart from these bats. Rosevear (1965) reports that *Coleura* utilize more open, incompletely dark caves. These bats apparently seldom rest in the typical head-down position, but prefer a prone position with the body flat against the wall at some other angle.

Coelura is apparently similar to *Taphozous* in roosting habits. *Taphozous*, or tomb bats, seem to show a preference for the cavernous interiors like those of ancient tombs; but their prime requisite is a surface, either wood or stone, against which they may rest their bodies, and some degree of shade (Rosevear, 1965). *T. nudiventris* (= *Liponycteris nudiventris*) exhibits a preference for crevices (Harrison, 1964); but *T. longimanus* often roosts in the tops of coconut palms. *T. sacclaiimus*, in small groups of 5 or 6, roosts in hollows of trees (Walker, 1964), and *T. mauritanus* uses the outer surface of buildings or tree trunks (Verschuren, 1957).

Except when nursing young, sharp-nosed bats of the genus *Rhynchiscus* rest over water. These resting places consist of trunks of trees growing beside or over water, undersurface of exposed logs, limbs, rock ledges, cliffs or boulders that extend over the water. The arrangement of the bats at rest is definite, either oval or linear. Each bat in the colony holds a definite position. The result is that the colony resembles a group of lichens (Dalquest, 1957). Villa (1966) reports these bats hanging from the eaves or tiles of buildings. These bats are not known to roost in the company of any other bat (Goodwin & Greenhall, 1961).

Saccopteryx forms colonies of up to 50 bats, but they more typically will rarely exceed 15 individuals. Roosts have been reported in a variety of locations; well-lighted caves, near openings in hollow trees, on tree trunks, on creepers, vines and lianas, under bridges, in sheds and buildings. This bat has been found in roosts with a wide array of other bats. Diurnal flight is apparently a common phenomenon; the flight may be in pursuit of insects or movement between small colonies in a general area (Goodwin & Greenhall, 1961). No segregation of the sexes in roosts has been reported (Walker, 1964), but it is possible that the observed diurnal movement between colonies is related to reproductive activity.

Very little is available on the biology of *Cormura* and *Drepanycteris*. *Peronymus* has been found in hollows of trees, dead trees, rotten logs on the ground and under the overhang of sandy banks; its habits appear quite similar to those of *Rhynchiscus*. *Centronycteris* has been taken from holes in trees, but little other information is available (Walker, 1964).

Hall & Dalquest (1963) have taken *Peropteryx* from cave roosts; presumably the colonies numbered only a few individuals. Open caves and crevices with more than one entrance are common roost sites (Bloedel, 1955). Goodwin & Greenhall (1961) report these bats from limestone and coral cave roosts and from the dark ceilings and rafters of buildings, as well as underneath structures built on pillars. The small

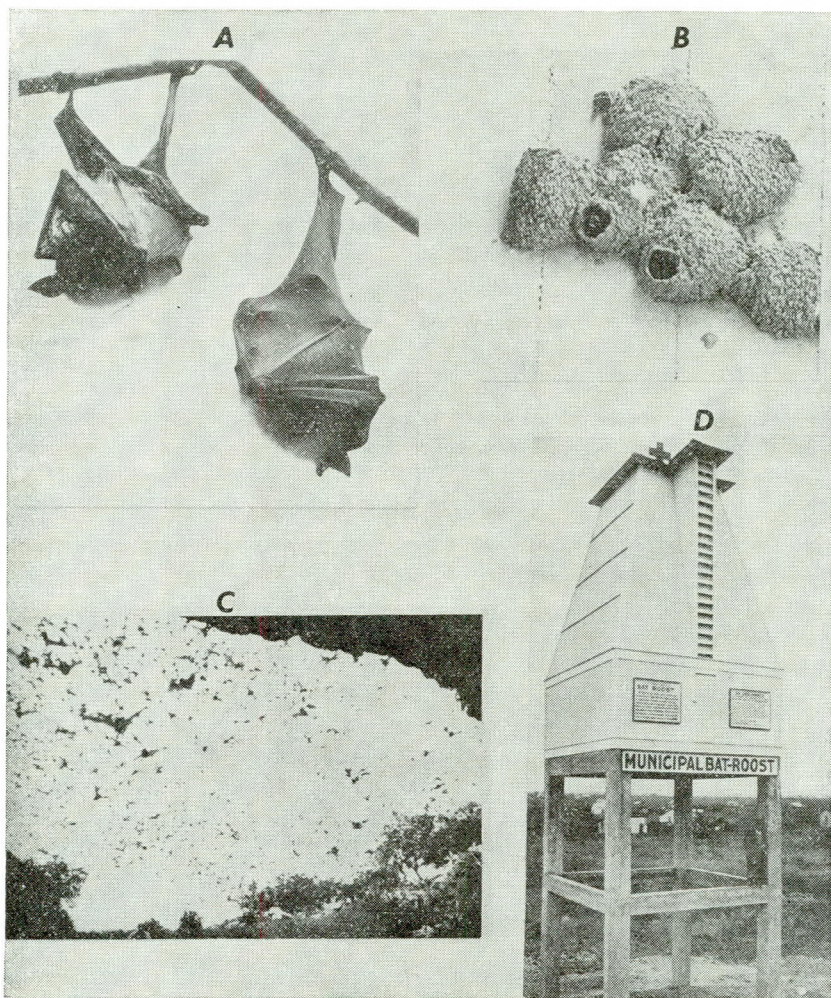


FIG. 1

- A. Typical roosting position of *Pteropus giganteus* (photo courtesy of Marsalis Park Zoo, Dallas, Texas).
- B. Swallow nests adhering to underside of bridge are often utilized by bats as roosts.
- C. Evening flight of Mexican free-tailed bats from a sink-hole cave near San Antonio, Texas (photo courtesy of Pete Lindsley).
- D. Campbell Bat Roost.

size of the roosting groups is also noted; colonies of *P. macrotis* never exceed six individuals.

Balantiopteryx seems to show a definite preference for cave roosts; and colony-size may be as high as 75 individuals (Hall & Dalquest, 1963). Burt & Stirton (1961) found roosts of these bats on the underside of boulders and in short tunnels. Depressions in sandstone rocks that line rivers, and walls of an old house are also roost sites. The caves that are used are well lighted (Villa, 1966).

Diclidurus, not only in coloration but in roosting habits, appears to be a most unusual emballonurid. Goodwin & Greenhall (1961) found it to be solitary and to roost between the leaves of tall coconut palms. They have also been reported using caverns as roosting sites (Brosset, 1966).

Noctilionid bats appear to be quite gregarious and are frequently found in roosts with other species of bats. *Noctilio leporinus* exhibits a preference for rocky clefts, dark caves and hollow trees. The smaller *N. labialis* more typically roosts in hollow trees, foliage and buildings (Walker, 1964). Goodwin & Greenhall (1961) found colonies of *N. leporinus* numbering up to about 75 individuals; the larger colonies occurred in hollows of trees. Goodwin (1946) found colonies of *Dirias minor* (= *N. labialis*) numbering several hundred individuals in attic roofs. These bats have been reported flying out of mangrove trees (Villa, 1966).

All of the chilonycterine bats form large colonies and are usually associated with other species in the roosts. A definite preference for caves is evident, although other roosting sites are known to be used. Some species of *Chilonycteris* exhibit segregation of the sexes in the roosts during particular seasons of the year. Other types of sites used as roosts include mines, and hollows of various plants (Walker, 1964; Brosset, 1966).

Phyllostomatid bats are represented by a great number of genera and species. Roosting habits of these bats reflect the vast radiation that has occurred in this family. *Micronycteris* is noted for its preference for subterranean retreats (Brosset, 1966). Hall & Dalquest (1963) found these bats roosting in drain pipes as small as 18 inches in diameter and in a burrow about 10 inches in diameter, into which an agouti had retreated. These bats roosted under the tiles of an adobe building (Tamsitt & Valdivieso, 1963). Goodwin (1946) reports finding them in hollow trees and Goodwin & Greenhall (1961) found them near the entrance of well lighted caves, under bridges, in culverts, buildings, underground drains and cisterns. Alvarez (1963) found one individual roosting in an old ranch house. Although they are found associated in

roost with a large array of other bats, the number of individuals of *Micronycteris* is generally small. There is no indication that sexual segregation occurs.

Although little is known of the biology of *Barticonycteris*, *Macrotus* is much better known. *Macrotus* has been reported from caves, mines, old forts, hollows of trees, homes and buildings (Brosset, 1966). Maternity colonies of from 20 to several hundred females with young exist during certain seasons of the year, and males, during this period, establish small bachelor groups. At other times of the year, these bats roost singly or in small numbers. Mainland forms may move into warmer areas in winter (Walker, 1964).

Lonchorhina is a troglophile. A colony of at least 500 was reported from a deep mine shaft; animals of both sexes were present in the dense clusters although the females captured were pregnant (Bloedel, 1955). Goldman (1920) found them using a cave as a roost site as did Goodwin & Greenhall (1961) and C. R. Nelson (1965). Suggestions in the literature indicate that bats of this genus prefer the darker recesses of caves or tunnels; different species of bats may occupy other portions of the roost.

Goldman (1920) found *Macrophyllum* roosting in the vaulted cellar of some ruins among bats of different species. Bloedel (1955), however, suggests that this genus may be solitary or nearly so, and found them hanging singly in a sea cave along with another species. Five males were collected from another sea cave (Walker, 1964). The possibility exists that some sexual segregation occurs in the roosts of these bats.

Goodwin & Greenhall (1961) report finding *Tonatia* roosts in termite nests, both abandoned ones and those still in use. Hollow trees, rabbit burrows and exposed vines are also reportedly roosts for these bats (Walker, 1964; Brosset, 1966).

A small limestone cave with a water floor as well as other small caves serve as roosts for *Mimon* (Hall & Dalquest, 1963). Goodwin & Greenhall (1961) found a single individual roosting in a building. Villa (1966) found roosts under highway bridges. Tree stumps, hollow trees and highway culverts also serve as roost sites. The number of individuals in a particular roost is small, usually 3-4 up to fifteen (Walker, 1964; Brosset, 1966).

The bats of the genus *Phyllostomus* are gregarious; Goldman (1920) reported one colony of thousands of individuals tightly packed on the ceiling of a cave. Neighboring caves contained smaller colonies. Both totally dark and dimly lighted caves serve as roosts (Goodwin, 1946). The underside of bridges, a shed, a church and a monument tower also serve these bats for roosts (Bloedel, 1955). Burt & Stirton (1961) re-

port collections from roosts in mines. Colonies of about 25 individuals in hollow trees as well as single individuals roosting under palm leaves are reported by Goodwin & Greenhall (1961). The general consensus seems to be that these animals are highly gregarious and are frequently found in the higher portions of roosts utilized by several other species. There is no segregation of the sexes. *Phylloderma*, similar in general appearance to *Phyllostomus*, is poorly known.

Hall & Dalquest (1963) found *Trachops* roosts in several limestone caves. These colonies were small, the largest of about 50 individuals. The collections from these roosts were not sufficient to determine whether both sexes were present, but Goodwin & Greenhall (1961) found both sexes present in small (about 6 individuals) colonies roosting in hollow trees. The underside of highway bridges also serve as roosts (Villa, 1966).

The biology of *Chrotopterus* is poorly known. Hall & Dalquest (1963) found two individuals roosting near the entrance of a small cave and one individual roosting in the more sheltered recesses of a cluster of stalactites on the edge of a cliff. Villa (1966) found a roost site in the crevices of the roof of a cave.

The largest of the Microchiroptera, *Vampyrum*, is also poorly known. Roosts are reported in the hollows of trees and, with one exception, never in association with other bats (Goodwin & Greenhall, 1961). These small colonies were comprised of both sexes and never exceeded five individuals. Large numbers were reported using a church as a roost (Goldman, 1920; Walker, 1964).

Glossophaga generally forms small colonies, often in association with different species (Brosset, 1966). Goldman (1920) found that these bats preferred poorly lighted to dark localities and roosts were located in limestone caves, the cellar and vaulted ceilings of ruins and tunnels. Culverts and houses may serve as roosts (Bloedel, 1955); these colonies were small or utilized by single individuals. Burt & Stirton (1961) report roosts in mines as do Baker & Greer (1962). Well-lighted caves, hollow trees, underside of bridges, underside of houses, sheds, churches and schools serve as roosts. Small colonies were the rule (Goodwin & Greenhall, 1961). Colonies of *Glossophaga* usually contain both sexes (Hall & Dalquest, 1963). The amount of light in the roost seems to be of only minor significance to these bats and almost any reasonably accessible site is utilized. Although they normally are found in small colonies, they commonly share the roost with other species.

Goldman (1920) reported *Lonchophylla* roosts in caves. It shared roosts with *Glossophaga*. Walton (1963) and C. E. Nelson (1965) also report a cave roost for these bats. Very little is known of the biology

of these bats, but it seems probable that they form small colonies, show no sexual segregation, and share roosts with a number of different bats.

Very little is known of the genus *Platalina* except that it has been collected roosting in an abandoned mine (Sanborn, 1936). *Scleronycteris* is also poorly known (Brosset, 1966).

Caves seem to be the preferred roosting site for *Monophyllus* (Walker, 1964). Schwartz & Jones (1967) report roosts in caves, usually very damp ones. The bats apparently prefer the higher regions of the ceiling well back from the entrance. There are suggestions from available information that there may be partial seasonal segregation of the sexes.

No sexual segregation is apparent in *Anoura*. The animals tend to form small clusters of up to 15 individuals, preferably toward the better lighted portions of the cave (Goodwin & Greenhall, 1961). Tamsitt & Valdivieso (1963) found a roost in the basement of a hotel. Banana trees and well lighted places are reported as roost sites by Villa (1966).

Information on *Musonycteris* is limited, but apparently these animals prefer roosts in vegetation, particularly hollow trees (Villa, 1966).

Choeronycteris shows a preference for well lighted caves. Baker & Greer (1962) found roosts in the fissure of volcanic rock, and Alvarez (1963) located roosts in a small cave and a mine. These bats are probably migratory in the more northern parts of their range. One of the authors (Walton) has found roosts of females with young and Baker & Greer (1962) report all male colonies. Although Walker (1964) states that the sexes roost together, it seems highly probable that seasonal sexual segregation occurs, that colonies are never large and that these bats show no inclination to share roosts with other species. Villa (1966) noted roosts in shallow excavations over-grown with vegetation, and cellars of houses.

Choeroniscus has been found using the underside of a fallen tree over water as a roost (Goodwin & Greenhall, 1961; Walker, 1964). Hall & Dalquest (1963) found *Hylonycteris* using a very small cave as a roost site, and Villa (1966) also reports cave roosts. Little is known of these two genera, but all information indicates that they form small colonies and are not gregarious in regard to other species.

Leptonycteris forms large colonies in caves, old ruins and abandoned mines (Brosset, 1966). Villa (1966) found them in cave roosts, generally with other species. These bats, like *Choeronycteris*, are probably migratory in the northern part of their range. Definite seasonal segregation of the sexes occurs and these animals are quite gregarious (Walker, 1964). A related genus, *Lichonycteris*, is poorly known, but probably is a solitary or small colony form.

Bats of the genus *Carollia* are very gregarious. They form colonies of up to a hundred individuals, and frequently share their roost-site with other species (Brosset, 1966). A hollow log, crevices between rocks and the underside of rocks have been reported as roosts (Burt & Stirton, 1961). Villa (1966) found roosts in caves, tree trunks, tunnels, underside of bridges, mines, houses and warm subterranean holes. The bats may be closely packed or hang separately, and darker regions of the roost site are preferred. Goodwin & Greenhall (1961) found both sexes in the roosts; but Hall and Dalquest (1963) report that male and females may form different colonies. Partial seasonal segregation of the sexes probably is the general rule.

The biology of *Rhinophylla* is poorly known. Although widespread across northern South America, they apparently do not occur in abundance and roosts have not been reported. The probability exists that they form small colonies or is solitary in vegetation.

Sturnira, the American epauleted-bats, have been reported as using houses, hollow trees and palm trees as roost sites (Walker, 1964). Villa (1966) found them using a tunnel and the underside of highway bridges. Although these are fairly common bats in collections, most of them apparently are captured in mist nets rather than from roosts. Small colonies in vegetation and isolated from the roosts of other species may be characteristic of these bats.

Anthony (1918) found *Brachyphylla* roosting in caves. They tended to be tightly packed, large colonies in the better lighted regions of the cave. Although highly gregarious, the bats were quite quarrelsome among themselves. Bond & Seaman (1958) reported a colony using the ruins of an old sugar factory. The colony was estimated to contain 2000 individuals with a ratio of about 5 females to a male.

The tent-building bat, *Uroderma*, roosts in trees, particularly the leaves of palms and bananas. They prefer the darker recesses formed by the leaves, or prepare their own shelter by cutting across the leaves in such a way that an inverted "V" is formed. The bat then roosts in the apex of the inverted "V". Reports indicate that the bats are alert and active during the day (Walker, 1964). Goodwin & Greenhall (1961) found that roosts were composed of small clusters of 10 or more individuals. Segregation of the sexes does not occur; the females are probably polyestrus (Brosset, 1966).

Goldman (1920) found bats of the genus *Vampyrops* using the well lighted portion of an old mine. Sanborn (1955) summarized some of the literature on roosting habits of these bats. Vegetation, exposed roots over stream banks and on canyon walls, caves, buildings, holes in trees and termite nests were among the roost sites reported. The bats gen-

erally form small colonies and there are indications that seasonal segregation of the sexes may occur (Walker, 1964). Villa (1966) found roosts in homes, on tree trunks and under palm fronds, under highway bridges and in small caves.

Very little is known of the roosting habits of the related genera *Vampyroides*, *Vampyressa* and *Vampyriscus*. *Vampyroides* apparently roosts in similar situations to *Vampyrops*; Goodwin & Greenhall (1961) reported that vegetation, particularly palm fronds, served as roost sites. The few sites that were located contained only a few individuals. All three genera are assumed to prefer vegetation as roost sites, and it seems probable that small colonies, or solitary individuals, is the rule.

Two other genera, *Chiroderma* and *Ectophylla*, are also poorly known. *Chiroderma* has been reported from a cave, and general speculation on roosting sites is that trees and well lighted caves are preferred (Goodwin & Greenhall, 1961). *Ectophylla* is represented by so few specimens that even less is known of its habits. The possibility exists that they prefer vegetation, perhaps the higher levels of the canopy, and form only small colonies or are solitary.

The great variation in size among the species of *Artibeus* is accompanied by variation in roosting sites. All of the larger species appear to be quite gregarious. *Artibeus jamaicensis* and *A. lituratus* show many similarities in choice of roosts (Goodwin & Greenhall, 1961). Goodwin (1946) reported roosts of *A. jamaicensis* in the upper branches of trees, and in cisterns, caves and the underside of rocks. Some of the smaller species are known to occupy tent-like roosts in the fashion of *Uroderma* in small colonies on the underside of banana leaves (Goodwin & Greenhall, 1961). The larger species of the genus also appear to form larger aggregations, to be more conspicuous, and associate with different species in their choice of roosts. No sexual segregation seems to occur in any of the species.

Very little of the biology of *Enchisthenes*, *Ardops*, *Phyllops*, *Ariteus*, *Stenoderma* and *Pygoderma* is known. *Ardops* is reported to utilize vegetation, *Stenoderma* to roost in caves, and *Phyllops* to make use of houses (Walker, 1964). Recent efforts in the area where these genera occur will, hopefully, supply much of the missing information.

Centurio is a phytophile, roosting under leaves. A particular roost will have 2-4 individuals, although the tree may contain several roosts. There is some information that suggests that segregation of the sexes occurs (Greenhall, 1965). These bats, pendant in good lighting, have the peculiar adaptation of a fold of skin that is used to cover the face during the day.

Spaeronycteris and *Ametrida* are poorly known. There is some indica-

tion that *Spaeronycteris* may roost in underground cavities, and of *Ametrida* using an off-shore drilling rig as a roost (Walker, 1964).

Phyllonycteris and *Erophylla* share many roosting characteristics. Both are extremely gregarious, forming very large colonies. They prefer caves and show no segregation of the sexes. *Phyllonycteris*, however, does form larger colonies. There are reports to indicate that *Erophylla* tends to be quite active in the roosts although the deeper, darker regions of the cave are preferred (Walker, 1964).

Because of their importance as disease vectors, much has been written on the roosting sites of desmodontid or vampire bats. This is particularly true of *Desmodus*, the common vampire. This bat prefers caves, but roosts have been reported in hollow trees, old wells, mine shafts and abandoned buildings. They are moderately gregarious bats; roosts may be occupied by 6–2000 individuals although the average size is probably closer to 100. Segregation of the sexes does not occur and generally the roosts are shared by other species of bats. In the roosts, these bats are alert, quite agile on the roost substrate and retreat to crevices when disturbed (Walker, 1964; Brosset, 1966; Villa, 1966).

Diaemus is apparently less gregarious, inter- and intraspecifically, than *Desmodus*. Hollow trees and shallow caves serve as roosts. The colonies are small and no segregation of the sexes occurs. There is an interesting suggestion that a definite pair-bond is formed between mated pairs, and that mutual grooming occurs (Goodwin & Greenhall, 1961).

The hairy-legged vampire, *Diphylla*, is apparently less gregarious than either *Desmodus* or *Diaemus*. Colonies usually number about 12 individuals although 1–3 is not unusual. Roosts have been located in caves, mine tunnels and hollow trees (Walker, 1964).

Except a few cases of isolated individuals, natalid bats show a marked preference for caves and mine shafts. The size of the colony at each roost seems highly variable. Alvarez (1963) reports a roost containing approximately 400 individuals, but Hall & Dalquest (1963) report that the number of individuals in a particular roost varies greatly from day to day. Goodwin (1946) and Goodwin and Greenhall (1961) indicate that these bats prefer the darker, drier recesses of caves. Mitchell (1967), however, reports that *Natalus* has a very low tolerance to desiccation. A change of 19% in the relative humidity (a decrease from 84% to 65%) resulted in death for many of the individuals tested. Changes in humidity in the roosts apparently induce local migrations of these bats, or at least a change in the roost site. The roost population studied by Mitchell (1967) did not show such daily fluctuations in numbers as Hall & Dalquest (1963) observed; nor did there appear to be segregation of the sexes as suggested by Bloedel (1955). *Natalus* is

known to share its roost with many other species of bats. Walker (1964) reports that some sexual segregation occurs when the young are born, and that *N. lepidus* does show partial segregation of the sexes. There exists the possibility that these bats may undergo limited periods of torpor, but there is no indication that hibernaria are established.

Not much is known of the roosting habits of furipterid bats. *Furipterus* has been found roosting in a well lighted cave with *Mimon*. They were apparently quite alert in the roost. *Amorphochilus* has been taken from roosts in an abandoned sugar mill, wine storehouses and an irrigation tunnel (Walker, 1964).

Thyroptera also is poorly known. It has been found roosting in curled leaves of banana and *Heliconia*. They have been found as close as 3 feet from the ground in such a roost. There are usually few (eight or so) to each roost, and they also roost head-up. On one occasion they shared a roost in a leaf with *Rhynchiscus* (Goodwin & Greenhall, 1961). The peculiar suction discs at the wrist and ankles allow these bats to cling to the smooth leaf surface. The golden bat, *Myzopoda*, sole member of the family Myzopodidae of Madagascar, has similar sucking discs, but little is known of its habits.

The most widely distributed of all bats is the vespertilionid genus *Myotis*. These bats exhibit a marked preference for darkened retreats, are gregarious, and show definite seasonal segregation of the sexes. Caves are frequented by many species; but old ruins, buildings, houses, hollow trees, mines, tunnels, culverts, and a variety of other places have been used as sites. In the colder parts of the range of these bats, hibernaria are utilized that sometimes necessitate migrations of several hundred miles. Males, during the period of sexual segregation, may be solitary and use roosts unlike those occupied by the females. Bridges frequently serve as roosts in the arid regions of North America. Davis & Cockrum (1963) give a detailed account of the occupation of bridges by bats.

Myotis velifer was reported by Tinkle & Patterson (1965) to spend the day in the mud nests of the cliff swallow. Subsequent efforts have established that this bat is a common resident of swallow nests (Fig. 1, B) and thus is able to extend its range into areas where caves, the usual daytime retreat, are absent. This same bat has recently been found (by Dalquest) to roost in windmills. A dozen of *M. velifer* were found clinging in the darkened space formed by the convergence of the four angle irons of the windmill tower, oblivious to the noise and movement of the windmill vanes and the moving piston rod a few inches from their backs.

Since windmills are common on open plains where caves and trees, the common roosting areas of bats, are absent, occupation of the wind-

mills by bats may open vast places to colonization by *M. velifer*. It remains to be seen how common is the utilization of windmills for roosts.

Within the roosts, *Myotis* may be in association with other species. Some species, such as *M. emarginatus*, form "bee swarm" clusters of several hundred individuals, while others form roosts on a rock surface in a series of small holes, each hole containing a few individuals (Harrison, 1964). *M. bocagei* roosts singly or in pairs in the darker areas of banana plants and other types of vegetation (Rosevear, 1965). *M. formosus* is also known to roost in various types of vegetation (Walker, 1964). Villa (1966) reports roosts of *Myotis* in the hollows of large tree trunks. There is a tendency for these bats to employ both the hind legs and the thumb claws for support whenever possible.

Although quite similar in appearance to *Myotis*, except for the enlarged hind feet, *Pizonyx* roosts are quite different. Piles of boulders (Burt, 1932), sea caves, fissures and half-buried turtle shells have been reported as roosts for the fishing-bats. Its roosts have been located amid nesting colonies of black and least petrels, in rock piles and slides. These bats are apparently solitary or form only small colonies; and sexual segregation is, therefore, of no consequence (Walker, 1964).

The silver-haired bat, *Lasionycteris*, is quite sociable, forming large colonies. Generally, these large colonies are composed of all females, or females with young. Single individuals have also been reported roosting in vegetation or in the hollows of trees. It seems quite likely that the males are less gregarious than the females and that sexual segregation is the rule. It is a migratory species and hibernaria include various types of buildings, ships, tree bark, and hollow trees (Hamilton, 1943).

The genus *Pipistrellus* includes some of the largest as well as the smallest bats in the family Vespertilionidae. They are known to hibernate in the northern portions of their range. Segregation of the sexes, at least seasonally, is common. Barret-Hamilton (1910) reports that cracks, crevices, openings in trees or buildings, inside or out, serve as roosts for *P. pipistrellus*. Bels (1952) never found this species hibernating in caves. *P. culex* exhibits a preference for human dwellings (Verschuren, 1957). *P. kuhlii* is colonial and roosts were located in crevices of walls and the roof of buildings (Harrison, 1964). The banana bat, *P. nanus*, roosts in two's and three's in unfurled leaves of banana and plantains, in the cavities of bunches of the fruit of these plants, in oil palms and thatched roofs. Adhesive pads are present on the wrist and ankles that allow adherence to the smooth leaf surface (Rosevear, 1965). *P. subflavus* is similar to *P. pipistrellus* in choice of roost sites, but utilizes caves as hibernaria (Hamilton, 1943). The canyon bat, *P. hesperus*, is typically a crevice dweller (Cross, 1965) and has also been

reported spending the day in loose boulder piles (von Bloeker, 1932).

The degree of sexual segregation varies among the species of *Pipistrellus*. There does appear to be a tendency for the males to be somewhat more solitary than the females. Large aggregations normally are maternity colonies. Both sexes, however, stay together throughout the year in *P. ceylonicus* (Walker, 1964).

Glischropus, a close relative of pipistrelles, has well developed pads at the wrist and ankles. Roosts have been reported in hollows of trees and the open ends of bamboo joints (Walker, 1964). These bats are apparently mildly gregarious, but very little is known about segregation of the sexes.

Hollows of trees are the preferred roosting site for *Noctula*. Barrett-Hamilton (1910) found roosts in the hollows of ash and Bels (1952) in "beech woods". Buildings are also used by solitary individuals or very small aggregations of noctules. Harrison (1964) found a roost in an unusual location, a rock crevice. Segregation of the sexes is common, and the larger colonies that have been reported are maternity colonies comprised almost totally of females. Bels (1952) found that movement between roosts is common; density in a single roost varies greatly, and that colonies frequently are in fairly close proximity. Small colonies of males are found in the fall. Colonies of up to 400 are reported (Walker, 1964), but the average colony size seems to be 80–100 individuals. Migrations are also reported for these bats, but Bels' (1952) returns from banded individuals indicate that these movements are not of great distance.

Very little biological information is available on *Eudiscopus*. The presence of well developed adhesive discs on the feet suggests that roosting sites are in vegetation, probably leaf surfaces (Walker, 1964).

Bats of the genus *Eptesicus* are quite wide-spread in their distribution, and the taxonomy of the various species in many cases is not clear. Roosts vary, but in general can be restricted to two major locations: human habitations and vegetation. Inside the roof, or eaves of houses serve as roost sites for *E. fuscus* (Hamilton, 1943); *E. tenuipinnis*; *E. capensis* (Rosevear, 1965); *E. rendalli* (Verschuren, 1957); *E. serotinus* (Barrett-Hamilton, 1910), and *E. bottae* (Harrison, 1964). *E. tenuipinnis*, *E. rendallo*, *E. capensis* (Rosevear, 1965) and *minutus* (Verschuren, 1957) are known to use vegetation for roosting sites. Although *E. fuscus* and *E. propinquus* are known to utilize caves to some extent (Goodwin, 1946), Bels (1952) reports that *E. serotinus* is seldom found in caves.

None of the species of *Eptesicus* appears to be extremely gregarious; small colonies seem to be the general rule. Partial seasonal segregation

of the sexes may occur, although there is no definite evidence in this regard. In the northern part of the range, these bats are known to hibernate and the hibernaria are generally similar to roost sites at other times of the year (Brosset, 1966).

Although they occur in different regions of the world, what little is known of *Rhinopterus* and *Hesperopterus* suggests that they have similar roosting habits. Both roost singly or in small groups of both sexes in vegetation. *Rhinopterus* roosts in acacia thickets near the roots, while *Hesperopterus* roosts in the foliage of trees (Walker, 1964).

One of the smallest bats, *Tylonycteris*, has a greatly flattened skull and heavy pads on the wrist and feet. The flattening of the skull would indicate a preference for crevices as a roost-site, and the pads the use of vegetation. This apparently is the case, for they are reported to spend the day in hollow joints of bamboo; entrance is gained through narrow cracks in the joint. These bats are moderately gregarious and may form small colonies, but there is no indication of sexual segregation.

Very little is known of the biology of *Mimetillus* and *Philetor*. Although there exist various speculations on the roosting preferences of *Mimetillus*, Rosevear (1965) notes that the only known roost was found in the roof of a house, and comments on the various speculations on the roosting habits of this bat.

Histiotis has been collected from roosts in old buildings in association with other species of bats (Walker, 1964). Greer (1965) found a small colony (apparently females with young) in a hollow tree. One of the authors (Walton) has in his collection specimens collected by A. A. Arata from a cave in Colombia. These were apparently part of a small maternity colony. These bats are probably moderately gregarious and form small colonies in association with other species and show at least seasonal segregation of the sexes.

The genus *Laephotis*, quite similar to *Histiotis*, is poorly known. There are some indications, however, that roosts selected by these bats are in vegetation and that some sexual segregation does occur (Walker, 1964).

Ryberg (1946) found that bats of the genus *Vespertilio* showed a marked preference for using human dwellings or other buildings as roost sites. Crevices were preferred, although individual bats were occasionally found sharing the roosts of other genera. Summer aggregations of great size (presumably nursery colonies) have been reported, as well as small colonies of males (Walker, 1964). In the northern parts of its range it hibernates, and short migrations to hibernaria occur. Segregation of the sexes during the period of parturition is reported to occur in Russia (Brosset, 1966).

Virtually nothing is known of the biology of *Otonycteris*. There are reports of these bats roosting in buildings. Harrison (1964) reports a roost in a tiny rock crevice in the steep side of a hill. He also concludes that this may be a more accurate representation of the roosting places of these bats.

Nyctecius is basically a tree dweller. Hamilton (1943) indicates that *N. humeralis* prefers hollows in trees as roosting sites, and Villa (1966) reports roosts in holes of cypress trees. Verschuren (1957) found *N. schlieffeni* roosting singly under the bark and in cavities of dead tree branches. Rosevear (1965) notes reports of this same species emerging from cellars, and that it has been taken from huts and larger houses. The closely related genus (subgenus?) *Scotoecus* is reported to roost among palm leaves (Rosevear, 1965).

Hamilton (1943) states that seasonal segregation of the sexes occurs in *N. humeralis*. One of the authors (Walton) found a maternity colony roosting in the small space under the peak of the roof of a park pavilion. *Nyctecius* is only moderately gregarious and the males appear to be more solitary than the females.

Although very little is known of *Scotomanes*, these bats are reported to mimic bunches of fruit as they roost in the foliage of trees (Walker, 1964). They are brilliantly colored and hang in compact masses from the vegetation (Brosset, 1966).

Although Walker (1964) states that the little yellow bats of the genus *Rhogeosa* probably prefer roosts in trees, Villa (1966) asserts that they show a preference for caves. They have been found in hollows of trees, thatched roofs of huts, under palm fronds, and between boards. There is no evidence on the sociability or sexual segregation of this species. Females, however, probably do form small maternity colonies. The related genus, *Baeodon*, is poorly known.

Bats of the genus *Scotophilus* appear quite variable in their preference of roosts, and in the size of the colonies which occupy the roosts. Rosevear (1965) reports roosts in the roofs of houses, in tree holes and hollow palms. These were all small colonies. Verschuren (1957) also reports roosts in hollow trees. The African species also make use of woodpecker holes and abandoned barbet nests. Asiatic forms may make large, usually maternity, colonies, composed of several hundred individuals (Walker, 1964; Brosset, 1966). Seasonal segregation of the sexes occurs, therefore, and the bats are apparently quite gregarious. Over portions of their range, in roosting habits as well as other aspects of their biology, these bats may well parallel those of *Eptesicus*, as Brosset (1966) suggested.

Chalinolobus shows a marked preference for caves and mines as

roosting sites (Walker, 1964). Dwyer (1962) reports the use of hollow trees as roosts, as well as the upper branches of trees amid vines and epiphytes. These bats show variation in number of individuals that may occupy a roost, but there is no indication of sexual segregation. Brosset (1966) notes that the large colonies occur in caves. Perhaps choice of roosting site is influenced by availability of particular types of sites and season.

Although similar to *Chalinolobus* in many characteristics, *Glauconycteris* is quite different in its roosting preferences. It is a distinct phytophile. Roosts have been reported on the leaves of banana and plantain leaves, and on palm fronds. These bats are not gregarious; usually no more than two-to-four will be associated with a particular leaf, although more may be present elsewhere on the same plant. No apparent segregation of the sexes occurs (Walker, 1964; Rosevear, 1965; Brosset, 1966).

Bats of the genus *Lasiurus* (including *Dasypterus*) are phytophiles. Pendant from the stem or branch, these bats are thought to resemble dead leaves. Holes in trees and buildings also serve as roost sites, but the foliaceous portions of the vegetation are preferred. Spanish moss (*Tillandsia*) has also been reported to serve as roosts. These bats are not particularly gregarious, although several may roost together. Segregation of the sexes in both time and space may occur, but the tendency toward solitary life is such that it is difficult to term this a true segregation. Extensive seasonal migrations evidently occur in *L. borealis* and *L. cinereus*, but very little is known of the other species (Hamilton, 1943; Walker, 1964; Greer, 1965; Villa, 1966).

Barbastella exhibits a definite seasonal preference of roost sites. During the warm seasons it is a phytophile, and in the colder periods, a lithophile (Walker, 1964). Barrett-Hamilton (1911) reports the use of buildings, also in the summer, and mines in the winter. In the absence of caves and mines, Ryberg (1947) found winter roosts in the attics and ceilings of buildings. Bels (1952) found several winter occupants of caves. These bats are only slightly sociable. The females in the spring may form small colonies, but the males appear to be much more solitary. In the winter, the solitary pattern appears to be the rule (Brosset, 1966).

The long-eared bats, *Plecotus*, are moderately gregarious. During spring and summer, females form small to moderate size maternity colonies while the males remain somewhat more solitary. Caves and trees are the preferred roosting sites, although a variety of other roost sites is reported. Ryberg (1947) and Bels (1952) report roosts in bird boxes. Buildings are common sites for roosts. Caves are used during the winter period as hibernaria, although not to the exclusion of

hollow trees and buildings. Extensive migrations apparently do not occur (Walker, 1964; Brosset, 1966). Villa (1966) found that these bats occur in small groups, less than 100 individuals, or singly. Available information suggests that these bats are quite alert in the roost and may abandon a roost if sufficiently disturbed.

Very little is known of the biology of *Euderma*. These bats have been taken in and on houses and from caves (Walker, 1964). No definite information on segregation of the sexes or gregariness is available.

Miniopterus shows a preference for caverns. Dwyer (1963) found that these bats can establish very large maternity colonies in caves. These same caves were not occupied the year-around, but the bats moved to other caves after maturation of the young. Harrison (1964) reports large colonies using underground portions of ruins as roost sites. These bats hibernate in the more northern portions of their range. Other roost-sites such as buildings, trees, culverts and rock fissures are also used (Walker, 1964). Phillips & Wilson (1968) found these bats roosting in mine tunnels.

Very little is known of the biology of *Murina* and *Harpiocephalus*. Both apparently prefer roosts in vegetation. *Murina* is known to use vegetation and to form small aggregations (Walker, 1964).

The painted bats, *Kerivoula*, have some interesting roosting habits. Rosevear (1965) notes records of these bats roosting in the hanging nests of weaver-birds or sun birds, and in a cluster of dry leaves in a tree. Although many records state that these bats are taken in houses, it is not clear whether they were roosting in the dwellings. Walker (1964) reports that hollows and trunks of trees, huts and buildings serve as roosts, as well as dry leaves of vines, plantain fronds and flowers. They are reported to mimic wasp nests and dead leaves. They are rather solitary in habit and there is no information on sexual segregation.

Pallid bats, *Antrozous*, are cavernicolous in their roosting habits. Tree cavities and buildings are also known to serve as roost sites. These bats establish maternity colonies, but in some cases the segregation of the sexes is incomplete. In the northern parts of their range these bats migrate, and probably become torpid for moderate periods of time. They are gregarious, though not often is this quality extended to other species of bats (Walker, 1964).

The roosting habits of *Nyctophilus* are similar to those of *Antrozous*. Small caves, rock crevices, hollows of trees, and under the bark of trees have been reported as roost sites. These bats vary in the colony size and a roost may be occupied by a single animal or large numbers. Activity seems to be year-round. No information on the natural history of the related genus *Pharotis* is available (Walker, 1964).

Although several specimens exist of *Tomopeas*, nothing of its natural history is known.

Mystacinid bats, known only from the single *Mystacina tuberculata*, are limited to New Zealand in their distribution. Dwyer (1962) reports roosts of these bats in hollows of trees and from caves; solitary specimens were found under the bark of trees. These bats apparently form only small colonies or are solitary and there is no indication of sexual segregation. Terrestrial agility is notable in these bats, but this may not be as closely related to roosting habits as to feeding behavior.

Of the very little that is known of the molossid genus *Myopterus* (= *Eomops*), these bats appear to be solitary and to prefer roosts in vegetation (Rosevear, 1965).

Molossops also is a phytophile. Goodwin & Greenhall (1961) record roosts in hollow branches of trees composed of 50–75 individuals. Others have been found roosting in the rotten heart of a log. There is no clear indication of sexual segregation in these bats (Walker, 1964).

The naked-bats, *Cheiromeles*, are reported to roost in hollow trees, rock crevices, and holes in the ground (Walker, 1964). Brosset (1966) notes a record of a very large colony of these bats. All indications are that these bats are very gregarious and that no sexual segregation occurs.

The natural history of *Xiphonycteris* is not known.

Bats of the genus *Tadarida* are distributed throughout tropical and subtropical parts of the world. In terms of roosting habits, it is by no means a homogeneous group. Many of them, such as *T. brasiliensis* and *T. plicata*, form very large colonies with a little sexual segregation. Others such as *T. midas* (Verschuren, 1957; Rosevear, 1965) seldom form colonies of more than 12 individuals, with a peculiar incomplete sexual segregation. Others such as *T. ansorgi* form small colonies of both sexes (Verschuren, 1957). Caves, rock crevices, buildings, hollow trees and branches have all been reported as roosts for these bats. One gets the distinct impression that caves, rock crevices and fissures and buildings are the general roost sites for these bats in the more arid portions of their range, while trees and buildings dominate in the more humid parts. Sexual segregation is highly variable; but these bats, with few exceptions, are moderately to extremely gregarious. In the northern part of their range these bats may migrate, or experience short periods of torpor.

The flat-headed bats, *Platymops*, are only slightly gregarious. Colonies seldom number over a half-dozen individuals. Roost sites are reported to be the undersides of rocks and rock slabs. The extreme flattening of the skull is apparently an adaptation for crevice-dwelling. There are no indications of sexual segregation (Walker, 1964).

Otomops is not a gregarious bat. Verschuren (1957) notes that the solitary habit of these bats is quite unusual among the Molossidae. Caves, hollow trees and buildings are reported as roost sites for these bats (Walker, 1964). *O. madagascariensis* is normally found in pairs, and larger colonies are reported for *O. wroughtoni*. In the latter species no sexual segregation occurs (Brosset, 1966).

Although similar in general aspect to *Tadarida*, bats of the genus *Molossus* have quite different roosting habits. Goodwin & Greenhall (1961) report small colonies roosting under palm leaves, hollow trees, under roofs of buildings, sheds and in attics. Hall & Dalquest (1963) also found roosts in hollows of trees as well as crevices of cliffs and openings in bridges. In some cases these bats were found in a horizontal, rather than the usual head-down, position. There is no definite indication of sexual segregation and these bats seem quite gregarious, though not to the extent seen in some *Tadarida*. The general tendency seems to be that vegetation is the preferred roosting site.

Goodwin & Greenhall (1961) report roosts of *Promops* on the under side of palm leaves. Colonies are generally small and there are indications of sexual segregation. Hollow trees are also reported as roost sites (Walker, 1964).

Mastiff-bats, *Eumops*, are not very gregarious. Colonies of up to seventy have been reported, but single individuals and colonies of 10–20 are more common. Crevices in rocks, tunnels, trees and buildings have been reported as roost sites. Their inability to launch themselves from the ground necessitates the height of the roost site. No sexual segregation is reported. Although these bats may not be migratory, roost-changes with the seasons are reported (Walker, 1964).

SUMMARY

Pteropids of the Australasian region tend to form large, conspicuous roosts (camps) among the branches of tall trees while those of Africa are also arboreal but do not tend to form the large camps. Very few (*i.e.*, *Rousettus*, *Eonycteris* and *Dobsonia*) pteropids occupy caves during the day.

The Microchiroptera are primarily cavern dwellers and occupy by day caves or cavities that simulate caves, including hollow trees and man-made structures. The Rhinopomatidae and Molossidae prefer crevices and some of the Vespertilionidae also are crevice-dwellers. Unusual roosting habits are found in some of the Emballonuridae, Phyllostomatidae and Vespertilionidae; while the Thyropteridae and Myzopodidae are uniquely specialized.

Bats that occupy crevices often fasten themselves to a crevice-side by

their thumbs as well as the claws of their hind feet. This habit is especially apparent in the mouse-tailed bats (Rhinopomatidae). Allen (1939) described a colony clinging like spiders to the roof of a chamber. The crevice-dwelling habit is well developed in some of the Molossidae. Many species of this family are colonial, and some colonies are known to contain millions of individuals (Allison, 1937). The pelage of these molossids seems to be adapted to a crevice-dwelling existence. The fur is short, dense and velvet-like. It, like the pelage of such fossorial mammals as pocket gophers, can easily be brushed in either direction. An even more extreme development of this is found in the unique *Mystacina*. The bats are said to do little flying but obtain their food by chasing insects along the limbs of forest trees (Harper, 1945; Dwyer, 1962), and spend the day in hollow trees. The fur of *Mystacina* is perfectly erect, as in moles. The extreme adaptation for crevice-dwelling is seen in the great flattening of the body and skull of *Platymops*.

Holes in trees or hollows of trees are also favorite roosting sites of bats. In the tropics, bats of a number of families use these sites. In the northern coniferous forests, the trees rarely become hollow in the fashion of broad-leaved trees, but fire-blackened or lightning-blasted trunks offer long, deep vertical cracks in which bats may find shelter by day. Equally important are bark blisters or other loosened areas of bark, where a dark crevice forms between bark and trunk.

In his recent studies of European bats, Krzanowski (1956) speaks of bats inhabiting "tree holes." I (Dalquest) assumed that the author referred to hollow trees. When, however, Dr. Krzanowski personally demonstrated his study technique I realized that his term would more properly apply to what, in this country, would be termed "woodpecker holes." Modification of Dr. Krzanowski's apparatus consists of an amplifier at the end of a telescoping fishing pole, that can be pushed into woodpecker holes and similar hollows. The disturbance should cause bats present to squeak, and the noise would be audible to the ear-phones of the investigator. A reliable substitute consists of a length of rubber tubing, with one end held near the observer's ear. This apparatus certainly deserves further experimentation in the woodlands of eastern United States and in tropical America.

Bats that occupy "tree-holes" are so important in the Polish forests that Krzanowski (1955) has designed special bat-houses to encourage the animals. The houses consist of long, narrow boxes, sealed above and on the sides but open beneath. The houses are placed at least 4 meters above the ground and 50-100 meters apart. In longitudinal aspect the boxes are triangular, 3.5 cm. wide at the bottom opening but 30 cm. or so wide at the top, and 30-50 cm. high. The inside of the houses are

left of rough lumber and no perch is provided. Bats of several genera and numerous species utilize the houses.

Use of the exposed surfaces of vegetation in the fashion of the pteropids is rare among the Microchiroptera. *Lavia* and *Lasiurus* are exceptional in that they hang in exposed, rather well-lighted places. *Lavia* is often active by day (Hollister, 1918) and is said to feed by flying out to capture passing insects and then returning to its perch to await another passing insect.

Where downward-drooping vegetation offers enough shade and shelter, many kinds of bats find roosting places. Palm fronds, banana and plantain leaves appear to be very important roosting sites. Thyropterids, furipterids, some vespertilionids and emballonurids make regular use of these plants and such hiding places. Thatched roofs and eaves may present similar conditions for roost sites and are widely used by phyllostomatid, vespertilionid and molossid species.

Mimicry of the surroundings has become evident in some species of bats. *Rhynchiscus*, *Kerivoula*, *Lasiurus* and *Rhinonycteris* are notable examples where mimicry of the surroundings has been noted. Nests of birds (*i.e.*, weaver bird and sunbird), and the nests of sciurid and anomolurid squirrels are also reported as roost sites for some bats.

Undoubtedly, caves, abandoned mines and both old and new man-made structures are of supreme importance as roosts for bats. More individual bats roost in these sites than in all others combined. Man, as he has moved about the world, and built and abandoned structures, may have been thereby a very real force in the success of some species. Domesticated crops, introduced and/or cultivated, such as banana, plantain, and many palms must have been equally important to the success of other species.

Verschuren (1957) established criteria for classifying bats on the basis of their roosting sites. The bats are separated into two general categories: internal—those that utilize a site isolated from the general environmental conditions (caves, hollow trees, inside of buildings, etc.); and external—those exposed to the general environment. Each of these categories is subdivided into two types: free—those freely suspended by the hind feet (pendant) and in contact—those in direct contact with substance of the roost (wall, tree-trunk or rock). Each of these sub-categories was subdivided into three types based on the substance of the roost site: phytophiles—those utilizing vegetation as a roost site; lithophiles—those utilizing some abiotic substance such as rock, soil, etc.; and anthropophiles—those that use habitations or other structures of man. This ecological classification scheme of chiropteran roosting sites is summarized in Table 1.

The categories used by Verschuren (1957) apply to the diurnal roosting sites of bats in the Congo. Roosting sites might be further classified in the following manner: permanent or semipermanent diurnal roosts; temporary or night roosts used for rest stops during nightly feeding forays; and roosts as hibernaria. The bats in the roosts can be further described on the basis of their occurrence in aggregations or as solitaries. The specific characteristics of the roost, its use and behavior in the roost of any particular species of bat could vary according to season of the year. Table 2 presents an expanded classification of roosts that uses that presented in Table 1 as a base. The system proposed in Table 2 is obviously subject to the inherent problems encountered when a static system of classification is applied to a dynamic process.

The enormous deposits of droppings or guano that accumulate on the floor of permanent or semipermanent roosts have been mined for a variety of uses, *i.e.*, fertilizer sources and military uses (saltpeter for gun powder). In this regard, Dr. Charles A. R. Campbell of San Antonio, Texas, proposed to combine the commercial aspects of bat guano with the health aspects of the fact that bats feed on arthropod vectors of a variety of diseases of man.

In a fascinating book, *Bats, Mosquitoes and Dollars*, published in 1925, Dr. Campbell presented in detail his ideas on the use of bats as a biological control agent; the harvesting of guano; and the desirability of constructing special bat roosts. He viewed the possibilities with great enthusiasm and was able to have a number of these special roosts constructed with public funds and to develop a small market for the guano (Fig. 1, D). One roost produced in excess of two and a quarter tons of guano in a year.

The health aspects of the idea were much more difficult to evaluate and the project gradually faded.

This discussion has been limited to the diurnal retreats of bats. This, very obviously, excludes two very important aspects of roosting habits: 1. aspects of roosts used as hibernaria for those bats that experience that state; and 2. roosts used for night resting stations between activity periods. Both of these things are of importance and should be touched on in other portions of this volume.

In summary, certain general characteristics of the Chiroptera in regard to roosting habits seem evident:

1. Tree-dwelling forms, whether in or on, appear less gregarious, both interspecifically and intraspecifically. These same bats tend to exhibit little segregation of the sexes.
2. Bats that utilize caves or man-made structures tend to be more gre-

TABLE 1

		Phytophile
	Free	Lithophile
External		Anthropophile
		Phytophile
	In Contact	Lithophile
		Anthropophile
Internal		Phytophile
	Free	Lithophile
		Anthropophile
		Phytophile
	In Contact	Lithophile
		Anthropophile

TABLE 2

<i>Season</i>	<i>External</i>	<i>Free</i>	<i>Phytophile</i>	<i>Temporary</i>	<i>Solitary</i>
Hibernal	or	or	or	or	or
Prevernal	<i>Internal</i>	<i>In Contact</i>	<i>Lithophile</i>	<i>Semipermanent</i>	<i>Small</i>
Vernal			or	or	<i>Aggregate</i>
Aestival			<i>Anthropophile</i>	<i>Permanent</i>	or
Serotinal				or	<i>Large</i>
Autumnal				<i>Night Roost</i>	<i>Aggregate</i>
				or	
				<i>Hibernarium</i>	

gariou, at least interspecifically, and when large colonies occur there is a marked tendency for seasonal segregation of the sexes.

3. Bats that establish permanent roosts or favorite seasonal roosts tend to be more successful (in sheer numbers of individuals) than bats that exploit more ephemeral roosting situations.
4. In local situations, those bats found in the greatest variety of roosting situations tend to be the most successful (in sheer number of individuals) in that area.

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