Bat Colonies in Buildings

By

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Abstract. Bats use buildings as maternity roosts, night roosts, bachelor roosts, transient roosts, and occasionally as hibernacula. Of the 46 species of bats known from North America north of Mexico, over half are known to use buildings as roosts at least for part of the year. Use of human-made structures is a consequence of the loss of natural shelters that no longer exist and occurs wherever bats and humans co-exist. Nonetheless, the few available data suggest that the number of colonies in buildings is declining and that persistence is limited by deterioration of structures and attempts by residents to exclude bats. In North America, big brown bats (Eptesicusfuscus), little brown bats (Myotis lucifugus), eastern pipistrelles (Pipistrellussubflavus), and Brazilian free-tailed bats (Tadarida brasilensis) are the best-known species that roost in buildings. All form maternity colonies in buildings during the summer. Efforts to census bats in buildings pose several challenges. Evening emergence counts provide the most reliable estimates, especially where colonies consist of less than 1,000 individuals. Such counts should be made on at least three consecutive evenings in the period of late pregnancy to mid-lactation, which generally corresponds to the maximum adult population. With continued loss of natural habitats, bat houses offer opportunities for bat conservation as well as platforms for research on aspects of bat biology that are difficult or impossible to study in natural roosts.

Key Words: Buildings, hibernacula, maternity roosts, night roosts, transient roosts.

Introduction

Roosts and food are the two most important resources known to influence the distribution and abundance of bats (Humphrey, 1975; Kunz, 1982; Kunz and Lumsden, 2003). Bats seek shelter in a number of natural structures, including caves, foliage, rock crevices, and tree cavities, but they also exploit various human-made structures, such as mines, tombs, houses, barns, bridges, culverts, and bat houses (Kunz, 1982; Tuttle and Hensley, 1993; Keeley and Tuttle, 1999; Kunz and Lumsden, 2003). As a consequence of increased urbanization, conversion of natural landscapes to agriculture and management of forests, bats use human-made structures as alternatives to many natural shelters that no longer exist.

Buildings, mostly of European-style architecture, offer a range of internal and external habitats for roosting bats (Ginsler, 1979; Greenhall, 1982; Kunz, 1982; Entwistle and others, 1997; Jenkins and others, 1998). Interior spaces in houses, churches, barns, schools, and similar structures have, in effect, become substitutes for tree cavities and exfoliating bark (Figs. 1–4). Spaces beneath tile, corrugated metal and fiberglass roofs, wood shingles, and areas behind shutters offer physical characteristics similar to natural roosts. The widespread use of buildings by bats in both temperate and tropical regions clearly indicates that these structures are important roosting habitats for bats. Bats use buildings as maternity roosts, night roosts, bachelor roosts, transient roosts, and occasionally as hibernacula. Of the 46 species of bats known from North America (north of Mexico), over half
are known to use buildings as roosts at least for part of the year (Barbour and Davis, 1969; Wilson and Ruff, 1999; 
Table 1). At present, the use of buildings by bats ranges 
from the occasional to the obligatory.

In North America, bats that most commonly roost in 
buildings include the big brown bat (Eptesicus fuscus), 
Brazilian free-tailed bat (Tadarida brasiliensis), eastern 
pipistrelle (Pipistrellus subflavus), evening bat (Nycticeius 
humeralis), little brown myotis (Myotis lucifugus), cave 
myotis (M. velifer), southeastern myotis (M. 
austroriparius), Yuma myotis (M. yumanensis), and pal-
lid bat (Antrozous pallidus) (Wilson and Ruff, 1999).

Three species (Eptesicus fuscus, M. lucifugus, and M. 
yumanensis) have become so completely associated with 
buildings in warm months that there are few records of 
their occurrence in natural roosts (Barbour and Davis, 1969).

Exceptions include populations in western North 
America where these three species are also known to 
roost in tree cavities (Barclay and Brigham, 1996).

Since the construction of European-style buildings 
in North America, some bat species have probably 
increased in number and distribution. For example, by 
forming maternity colonies in buildings, Myotis velifer 
(Fig. 1A) and T. brasiliensis (Fig. 1B) have extended their 
summer ranges beyond the limits of historical distribu-
tions (Kunz, 1974; Genoways and others, 2000). In Texas, 
populations of T. brasiliensis have increased as much as 
15% above numbers recorded before modern building 
construction (Schmidly, 1999). Similarly, the use of build-
ings by E. fuscus (Fig. 2) and M. lucifugus (Fig. 3) has 
also made it possible for these two species to extend their 
summer ranges into previously uninhabitable regions of 
North America (Fenton and Barclay, 1980; Kurtz and Baker, 
1990; Whitaker and Gunner, 2000).

In Europe, at least 11 species of bats are associated 
with buildings. The most common of these are the 
pipistrelle (Pipistrellus pipistrellus), noctule (Nyctalus 
noctula), greater horseshoe bat (Rhinolophus ferrumequinum), 
common long-eared bat (Plecotus auritus), serotine (Eptesicus 
serotinus), northern bat (E. nilssonii), Natterer’s bat (M. nattereri), and greater mouse-
cared bat (Myotis myotis) (Entwistle and others, 1997; 
Schober and Grimmberger, 1997; Jenkins and others, 1998; 
Racey, 1998). Several species that commonly roost in 
buildings are listed as vulnerable or are considered at 
severe risk (Schober and Grimmberger, 1997; Hutson and 
others, 2001) largely due to a decrease in natural roosts 
(Racey, 1998), contamination of human-made roosts with 
pesticides and wood preservatives (Voutie, 1980–1981), 
and loss of foraging habitats (Limpens and Kapteyn, 

The exploitation of buildings by bats in tropical 
regions also appears to have contributed to expanded 
distributions and increased local abundance. For example, 
in tropical Africa, several crevice-dwelling species 
regularly roost in buildings, such as Mops midas, Nycteris 
grandis, Chaerephon pumila, Pipistrellus nanus, and 
Scotophilus spp. (Kingdon, 1974; O’Shea, 1980; Fenton 
and Rautenbach, 1998). Several members of the genus 
Eptesicus, including E. tenuiptinis, E. capensis, and E. 
redalli, show strong affinities for buildings (Verschuren, 
1957; Rosevear, 1965). In the Indian subcontinent, 
Taphozous melanopogon, T. perforatus, and Megaderma 
lyra almost exclusively roost in buildings (Bates and 
Harrison, 1997).

Several neotropical species use buildings as roosts, 
including Saccopteryx bilineata, Desmodus rotundus, 
Artibeus jamaicensis, Phyllostomus hastatus, and Carollia 
perspicillata (Nowak, 1994), although they rarely do so 
exclusively. Two widely distributed insectivorous spe-
cies, Myotis nigricans (Wilson, 1971) and Molossus 
molossus (Greenhall and Stell, 1960; Rodriguez-Duran and 
Kunz, 2001), commonly roost in buildings in the Neotropics.

Impact of Human Attitudes 
and Activities

Although the relatively recent availability of build-
ings as roosting sites may have contributed to expanded 
ranges and increased numbers in some species, other 
human activities such as overuse of non-target pesti-
cides, contamination of water, and misguided forest man-
agement have had detrimental effects on their roosting 
and foraging activities. Extensive deforestation and habi-
tat deterioration has had a marked effect on the availa-
bility of roosting and foraging habitats for many species 
(Barclay and Brigham, 1996; Racey, 1998). Fear of rabies 
as well as fear from the mere presence of bats in human 
dwellings, indifference, and misunderstanding have also 
led to the extermination of bats from some buildings 
(Tuttle, 1987). Building restorations have led to the elimi-
nation of some bat roosts. In addition, the direct applica-
tion of toxic chemicals and repellents has contributed to 
the reduction and/or extirpation of some bat colonies in 
buildings (Kunz and others, 1977; Daan, 1980; Hurley 
and Fenton, 1980; Tuttle, 1987; Clark, 1981).

Factors Affecting Roost 
Preferences in Buildings

Few studies have been conducted to assess 
preferences of bats for roosting in buildings. Entwistle 
and others (1997) compared the characteristics of
Table 1. Primary roosting habits of North American bats north of Mexico, summarized from Keeley and Tuttle (1999), Whitaker and Hamilton (1996), and Wilson and Ruff (1999).a

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*Some species may have roosting habits in other parts of their range that differ from what has been observed in North America. Bat houses are not included.*
buildings selected by *Plecotus auritus* with a random sample of buildings in the United Kingdom. This species preferred older buildings with attics divided into several compartments constructed from rough-cut wood. Buildings that were located near forested areas and bodies of water were also preferred, suggesting that feeding habitat near the roost was an important factor affecting roost selection. In contrast, *Pipistrellus pipistrellus* did not select roosts with specific structural attributes (Jenkins and others, 1998), but instead roosted in buildings that were surrounded by trees and had associated linear landscapes, often near a major river. When compared to a random sample of buildings, maternity colonies of *Eptesicus fuscus* in North America were often found in older, taller, and more accessible structures, often having tin roofs (Williams and Brittingham, 1997).

Fig. 2. (A) Maternity colony of *Eptesicus fuscus* roosting on the ridgepole of a barn in central Massachusetts. Some individuals are marked with colored, plastic split-ring bands for identification. (B) Exterior view of an attic vent of a house in southern New Hampshire that provides an alternative roosting space for a small maternity colony of *E. fuscus*. (C) This colony roosted in the partially enclosed space between the exterior louvers and interior screening, although sometimes individuals shifted to a roost on the ridgepole in an adjacent barn. Photographs by T.H. Kunz.
Fig. 3. (A) Small maternity cluster of *Myotis lucifugus* roosting in the crevice of a barn in southern New Hampshire. (B) Solitary male *M. lucifugus* roosting in the attic of a building in southern New Hampshire. Photographs by T.H. Kunz.

**Building Roosts in North America**

Most North American bats use buildings on a seasonal basis as maternity roosts, night roosts, and transient shelters during migration. Many species of bats use buildings, such as houses, barns, sheds, porches, breezeways, and garages as night roosts (Kunz, 1982). Buildings are most commonly used during maternity periods, especially when they provide appropriate thermal conditions for rearing young (Tuttle and Stevenson, 1982; Kunz and Hood, 2000). Darkness, shelter from the wind and rain, proximity to feeding areas, and reduced predation risks are important factors that govern the selection of these shelters (Kunz, 1982). Only rarely do bats use buildings as hibernacula.

Buildings offer bats a wide range of roost microhabitats including spaces along the ridgepole, in mortises, beneath floor boards, in spaces between bricks and wood, inside insulation, beneath burlap bags, under hanging pictures, and behind curtains and drapes (Licht and Leitner, 1967; Barbour and Davis, 1969; Kunz, 1974; Anthony and others, 1981; Williams and Brittingham, 1997). Structures located on the exterior of buildings also provide roosting sites for bats, including crevices between bricks and stones, between screened and louvered vents (Fig. 3B), behind windows and screens, spaces in boxed cornices, behind shutters, and spaces beneath weathere d clapboards, facia boards, and shingles (Barbour and Davis, 1969).

**Case Studies in North America**


*Eptesicus fuscus* usually forms maternity colonies in buildings ranging from a few dozen upward to several hundred individuals (Williams and Brittingham, 1997; Kurtz and Baker, 1990; Whitaker and Guummer, 2000). Females typically roost along open ridgepoles (Fig. 2A), although others occupy enclosed or partly enclosed roost spaces in walls, boxed cornices, and between louvered vents and screens (Fig. 2B and 2C). Males are typically solitary and occupy spaces in buildings separate from females during the summer, often roosting beneath shutters and weathered shingles (Kurtz and Baker, 1990), or in crevices in cooler parts of the interior of buildings (Whitaker and Guummer, 2000).

*Eptesicus fuscus* is one of the few North American species that hibernates in buildings (Mills and others, 1975; Whitaker and Guummer, 1992, 2000). Buildings used as hibernacula are invariably heated in winter and thus provide roost temperatures that are usually above freezing. *E. fuscus* commonly roosts in buildings during warm months, although fewer individuals occupy buildings in winter (Whitaker and Guummer, 2000).

*Myotis lucifugus* invariably hibernates in caves and mines in winter months. During warm months, this species typically forms maternity colonies in buildings (Fig. 3A), although tree cavities also serve as maternity roosts. Maternity colonies range from a few hundred to several thousand individuals (Fenton and Barclay, 1980; Burnett and August, 1981; Kunz and Anthony, 1996). Maternity colonies of *M. lucifugus* seldom form one single aggregation, but instead roost in several small clusters. Males are generally solitary in summer (Barbour and Davis, 1969; Fenton, 1970; Humphrey and Cope, 1976; Fenton and Barclay, 1980), where they usually roost in small crevices, behind shutters, and similar structures.
(Fig. 3B). This species has twice been reported to hibernate in buildings during winter months, but in both instances they were solitary males (Whitaker, 1998b).

*Tadarida brasiliensis* is one of the most abundant bat species in North America. Migratory populations typically form enormous maternity colonies in caves in the southwestern United States and northern Mexico during warm months and spend the winter months in central and southern Mexico (Davis and others, 1962; Wilkins, 1989). Smaller colonies are known to occupy buildings (Fig. 1B) or roost beneath bridges. Thus, they have contributed to range extensions beyond the historic distribution of this species that traditionally roosts in caves (Keeley and Tuttle, 1999; Schmidly, 1999; Genoways and others, 2000). In contrast, non-migratory populations from the southeastern United States, California, and southern Oregon are year-round residents. In these areas, they typically roost in buildings, forming maternity colonies in warm months and winter colonies during cooler months (Wilkins, 1989).

*Pipistrellus subflavus* typically hibernates in caves and mines during cold months, and during warm months seeks shelter in buildings (Fujita and Kunz, 1984; Hoving and Kunz, 1998; Whitaker, 1998a; Fig. 4), tree cavities (Menzel and others, 1996) and foliage (Winchell, 1990; Veilleux, 2001). Maternity colonies in buildings range from a few up to 40 adults and their pups (Hoving and Kunz, 1998; Whitaker, 1998b), although colonies in foliage are considerably smaller (Veilleux, 2001). Females that roost in buildings often select cavities and crevices along the ridgepole of barns, houses, and similar structures (Fujita and Kunz, 1984). During warm months, entire colonies may shift roost sites within buildings (Hoving and Kunz, 1998; Whitaker, 1998a). This bat has also been observed roosting on the exterior walls of buildings (Whitaker, 1998a).

**Colony Persistence**

Few data are available on the persistence of bat colonies in buildings. Because most buildings are temporary, knowledge of colony persistence in these structures can be valuable for assessing the viability of populations. Buildings eventually deteriorate with time and are either abandoned, renovated, or replaced with new structures. Thus, bat colonies that roost in buildings are eventually displaced or, at worst, exterminated.

A survey in Indiana in 1959 revealed 190 bat colonies in buildings; 128 of these colonies were present at these sites in 1989 (Cope and others, 1991). Among the buildings that were surveyed in 1989, 95 were occupied by *E. fuscus*, 27 by *M. lucifugus*, 5 by *N. humeralis*, and 1 by *P. subflavus*. Only eight (29.6%) of the *M. lucifugus* colonies and 21 (22.1%) of the *E. fuscus* colonies identified in 1959 were still active in 1989. Among the colonies of *N. humeralis* and *P. subflavus* observed in 1959, none were found in 1989. From these observations, Cope and others (1991) concluded that an average of 3.3% of the colonies disappeared each year over a 30-year period.

A survey of buildings in New England during the 1990’s (D.S. Reynolds and T.H. Kunz, unpub. data, 1999) identified 638 bat colonies, including 172 of *M. lucifugus*, 108 of *E. fuscus*, 9 of *M. septentrionalis*, 2 of *P. subflavus*, and 347 colonies from undetermined species. Although some of these colonies appeared to be of relatively recent origin, most were initially recorded over 10 years ago, and some were recorded 40 years earlier (based on field notes of H.B. Hitchcock and D.R. Griffin). Although many of these colonies have not yet been verified, the
trends from those that have been evaluated are alarming. For example, at least 21% of the historic colonies (median record date of 1962) are known to have been extirpated. More recent colonies (recorded by T.H. Kunz, with a median record date of 1981) had a known extirpation rate of 20%. Lastly, a data set with a median record date of 1994 (primarily from Massachusetts Fish and Wildlife records) was found to have a known extirpation rate of 36%.

Interviews with building owners have revealed that some type of exclusion was attempted at 160 of these colonies; in 15 cases, multiple methods were employed to remove the bats. Physical exclusion was the most common method (47%), particularly in the most recently controlled colonies. However, chemical control (including naphthalene, DDT, rodenticides, insect sprays, and sulfur candles) accounted for 38% of all exclusion attempts, followed by electronic control (10%; lights or ultrasonic devices) and killing or relocation of individuals (10%). Clearly, these data suggest that more effort is needed to adequately census commensal bats and determine the full extent of exclusion and harassment that such colonies are experiencing.

Censusing and Inventorying Bats in Buildings

Efforts to census bats that roost in buildings pose several challenges. Some homeowners do not permit researchers to enter buildings for the purpose of inventorying and censusing bats, and even if access is allowed, many bats that occupy crevices and cavities cannot be observed and counted directly. Mark-recapture studies seldom yield reliable estimates because the assumptions inherent in using this method cannot be met (see Kunz, 2003). Evening emergence counts provide the most reliable estimates and are most successful when colonies are relatively small (<1,000 individuals) (Kunz and others, 1996). Depending on the number of observers, it may be possible to count all or most bats that emerge from buildings at dusk by observing their silhouettes against the sky (Kunz and others, 1996; Hoying and Kunz, 1998), or by recording (and counting) them using infrared video cameras (Frantz, 1989). Notwithstanding, colony censuses based on nightly emergence counts can be biased when bats shift to alternate roost sites (Brigham and Fenton, 1986; Brigham, 1991; Lewis, 1995; Barclay and Brigham, 1996; Whitaker, 1998a). Roost-shifting behavior highlights the need for researchers to explore all possible exit routes and alternate roosts before conducting a colony inventory or census (Thomas and LaVal, 1988; Kunz and others, 1996).

Whenever emergence counts are used to assess long-term trends in colony size, they should be made on at least three consecutive evenings in the period from late pregnancy to mid-lactation. This period generally corresponds to the maximum adult population [Thomas and LaVal (1988); Kunz and Anthony (1996); Kunz and others (1996); also see Kunz (2003)]. If additional time is available for censusing, emergence counts should be repeated after young-of-the-year have become volant, but before adults have emigrated for a given year. When assessing annual or seasonal changes in colony size, emergence counts should be made at weekly intervals to insure that seasonal patterns of reproductive phenology can be detected (Hoying and Kunz, 1988; Kunz and Anthony, 1996).

Guano accumulation can also be used as a crude method of inventory to estimate the relative size of a colony. Once the species has been verified by direct observation and all pre-existing guano has been removed, an analysis of fresh guano accumulation can be used as a rough estimate of colony size. This method is useful for extensive, long-term surveys where regular emergence counts are unrealistic, but the quality of the estimates is limited to broad classes that can be delineated by successive orders of magnitude (one or few, 10–20, around 100, and over 1,000).

Estimates of colony size based on guano accumulation are more reliable in colonies where bats roost in the open (e.g., on the ridge pole of a barn that is too high to reliably count) or where the bats roost in a crevice that opens below (such as bats roosting under fascia boards, flashing, or between the wood structure and the chimney of a house). In situations where roosts are not known, or no clear accumulation of guano occurs, this method is not appropriate. To validate the guano estimation method, an emergence count or visual count should be performed periodically and compared to estimates derived from guano accumulation.

Roosts for Research and Conservation

Buildings offer ideal opportunities for investigating aspects of bat biology that are difficult or impossible to study in natural roosts (e.g., Kunz, 1974; Burnett and August, 1981; Burnett and Kunz, 1982; Kunz and Anthony, 1982; Kurta and others, 1989; Wilkinson, 1992; Winchell and Kunz, 1996; Hoying and Kunz, 1998). With continued loss of natural habitats, structures (bat houses) specifically designed to mimic the physical and thermal conditions of tree cavities have been increasingly used in Europe and North America for conservation purposes.
(Stebbins and Walsh, 1985; Tuttle and Hensley, 1993; Fig. 5). In addition to their conservation value, bat houses offer excellent opportunities for research on topics ranging from social and mating behavior, population structure and dynamics, and energetics (but see Gerell and Lundberg, 1985; Lundberg and Gerell, 1986; Wilkinson, 1992; Kerth and König, 1996, 1999; Kerth and others, 2000). If properly designed, located, and maintained (Tuttle and Hensley, 1993), bat houses of varying design and size can serve both research and conservation interests.

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Fig. 5. (A) Small bat house used to attract *Tadarida brasiliensis* for insect control in south-central Texas. (B) This large bat house, designed for *T. brasiliensis*, is occupied by thousands of individuals that were displaced from buildings and other human-made structures on the University of Florida campus, Gainesville, Florida. Photographs by T.H. Kunz.


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