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Medium- and long-term reuse of trembling aspen cavities as roosts by big brown bats (*Eptesicus fuscus*)

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Roost availability may limit some bat populations, implying that there may be a selective advantage associated with the ability to reuse sites on an annual basis. We monitored aspen tree use by *Eptesicus fuscus* during multi-year studies (spanning up to 10 years) at the same site in Saskatchewan, Canada. We found that reuse of live trees over the medium-term (three years) was common and that, in some instances, reuse over the long-term (nine and 10 years) can occur. Our data also suggest that, over the medium-term, aspen roosts are reused by groups of bats more often than by solitary individuals. Our findings support the hypothesis that cavity roosting bats exhibit between year loyalty, not just to patches of forest but also to specific trees.

Key words: *Eptesicus fuscus*, forests, roosts, reuse

INTRODUCTION

Within the context of current interest in the use of trees by cavity roosting bats (Barclay and Brigham, 1996; Vonhof and Barclay, 1996; Brigham *et al*., 1997; O'Donnell and Sedgeley, 1999; Cryan *et al*., 2001), Barclay and Brigham (2001) assessed between-year reuse of conifer snags by California bats (*Myotis californicus*) over a five-year period. The study showed that the likelihood of detecting colonies using snags declined more quickly than the rate of loss of the snags themselves, although snags continued to be used on a regular basis by solitary bats. Barclay and Brigham (2001) concluded that the declining suitability of conifer snags for use by maternity colonies was most likely due to the physical loss of bark under which the bats roosted.

It is becoming well known that tree cavity roosting bats switch trees frequently within years but remain loyal to relatively small patches of forest that contain a number of potential roosts (Vonhof and Barclay, 1996; Brigham *et al*., 1997; Kalcounis and Brigham, 1998; O'Donnell and Sedgeley, 1999; Cryan *et al*., 2001). Assuming that the suitability of specific trees declines rapidly, this loyalty necessitates significant annual recruitment of new roost structures and or the use of relatively large forest patches with a high availability

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of potential roost trees. Given that recruitment of new roost structures is slow because of the phenology of trees, and that forest patches are often heterogeneous on the landscape, it should be advantageous for bats to make use of the same trees for multiple years if the trees remain structurally sound.

Recent research has shown that some bats use cavities in mature live deciduous trees as roosts (Vonhof, 1996; Kalcounis and Brigham, 1998; Psyllakis, 2001). The decay characteristics of aging deciduous trees follows a pattern whereby the heartwood decays more rapidly than the sapwood resulting in a structurally solid shell, even in relatively old trees (Peterson and Peterson, 1992). Compared with exfoliating bark of conifer snags, the physical characteristics of mature living deciduous trees likely change little between years. Here we report data on the use of deciduous, trembling aspen trees (*Populus tremuloides*) as roosts by big brown bats (*Eptesicus fuscus*) collected during multi-year studies at the same site. We tested the hypothesis that bats make use of these relatively permanent potential roost structures over multiple years. We also tested the hypothesis that, in contrast to the pattern observed by Barclay and Brigham (2001) for roosts beneath exfoliating bark, deciduous roost tree cavities monitored over multiple years house similar group sizes in subsequent seasons.

Eptesicus fuscus is widespread across much of North America. During summer, adult females typically aggregate in maternity colonies ranging from 5–700 individuals (Kurta and Baker, 1990). Maternity colonies have been found in a variety of roost structures including buildings, rock crevices, and coniferous and deciduous trees (Kurta and Baker, 1990; Brigham, 1991; Hamilton and Barclay, 1994; Betts, 1996; Kalcounis and Brigham, 1998; Lausen and Barclay, 2002).

Materials and Methods

Most of the data we report come from fieldwork conducted during the summers of 2000–2002 but we also make use of some previously reported data collected in 1993 and 1994 (Kalcounis and Brigham, 1998). All data were collected in the West Block of Cypress Hills Provincial Park, Saskatchewan, Canada (49°34'N, 109°53'W). The Cypress Hills are composed of approximately 50% grassland, 45% woodland, and 5% wetland (Sauchyn, 1993). Woodland vegetation is dominated by lodgepole pine (*Pinus contorta*) forest in dry, high elevation (> 1,300 m) areas and white spruce (*Picea glauca*) forest with a dense understorey in wetter areas (Sauchyn, 1993). In the Cypress Hills *E. fuscus* roost exclusively in cavities in trembling aspen trees (Kalcounis and Brigham, 1998; this study), which are found most abundantly at mid elevations (between a minimum of ca. 1,170 m and maximum of 1,375 m) throughout the study area.

The majority of roost trees were located by radiotracking. In addition, a few roosts were detected by opportunistically watching trees with obvious cavities at dusk and, during the 1993–1994 study period, by randomly searching tree cavities during the day. Between May and August female *E. fuscus* were captured in mist nets as they emerged from trees and, occasionally, while foraging. Radio transmitters (0.7 g BD-2B, Holohil Systems Ltd., Carp, ON, Canada) were attached using surgical cement (Skin-Bond, Smith and Nephew United, Largo, FL, USA) between the scapulae after the fur was trimmed using fine scissors. We ensured that transmitter mass represented less than 5% of each bat's body mass (Aldridge and Brigham, 1988). During 2001 and 2002, individuals were also banded on the forearm with numbered plastic split-ring bands. Bats were released within several hours of capture and followed to roost trees on as many days as possible during the life of the transmitter, using hand-held telemetry receivers (R-1000, Communication Specialists Inc., CA, USA) and five element yagi antennas (AF Antronics Inc., Urbana, IL, USA). When roost trees were located, we conducted emergence counts at dusk when possible and used data-logging radiotelemetry receivers (SRX-400, Lotek Wireless Inc., Newmarket, ON Canada) to record tree use by bats remotely.

Results

Over the course of the 2000–2002 study period we found bats roosting in 47 different aspen trees. Roost trees were distributed

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among three small (ca. 1–2 km^2), apparently discrete patches of forest within the ca. 10 km^2 study area. Despite frequent switching between trees within each area, radiotagged or banded bats never switched between roosting areas within or between years (C. K. R. Willis and R. M. Brigham, unpublished data). The majority of our radiotracking effort was focused in one of these areas where we located 36 roost trees (77% of total). This roosting area was also the focus of research during the 1993–1994 study period. Twenty-seven roosts were located in the area during 1993–1994 (16 from radio tracking and 11 from random cavity searches). Therefore, we only report data on tree reuse collected from this roosting area.

Of 11 trees first identified as roosts in 2000, one was reused in 2002 but not 2001, and six were reused every year from 2000–2002. Five of these six trees were confirmed to house groups of bats (as opposed to solitary individuals) in 2002. These five trees were observed at dusk on 10 different occasions in 2002 (i.e., on days when radiotagged bats were tracked to the trees; 1–3 exit counts per tree). Group sizes observed during these counts ranged from 15–37 bats (26.6 ± 6.62, $\bar{x}$ ± SD) and solitary bats were never observed. There was no difference between the mean number of bats counted emerging from these trees in 2000 (24.0 ± 17.91) versus 2002 (paired *t*-test, $t = -0.25$, $P = 0.81$, $d.f. = 4$). The one roost tree in which a group was not directly observed in 2002 may have indeed housed groups of bats during that year, but we were unable to perform an exit count. The presence of guano on four separate occasions during 2002, in a collection trap placed at its base as part of another study, suggests it was reused repeatedly. Of eight trees first identified as roosts in 2001, six were reused in 2002. We performed exit counts at these six trees on eight different occasions (1–3 exit counts per tree) in 2002. A solitary individual was observed during one count but during the remaining seven counts, group sizes ranged from 13–24 bats (18.0 ± 3.84).

Perhaps most illuminating in the context of reuse are aspen tree roosts first recorded as being occupied by groups of *E. fuscus* in 1993 and 1994. One tree, first recorded as being used by a group of 25 bats on 25 May, 1994, was used by two bats when an exit count was performed in 2001 and by groups of 20 and 34 bats on two occasions when exit counts were performed in 2002. Thus, groups of bats made use of this tree at least eight and nine years after it was first identified as a roost tree. Another tree, first recorded as being used by 30 bats on 15 August, 1993, was used by 19 bats when an exit count was performed in 2002. A group of bats, therefore, made use of this tree at least 10 years after we first identified it as a roost tree.

Discussion

Our results show that aspen trees used as roosts by *E. fuscus* are commonly used again by groups of bats over the medium-term (two to three years) and may be reused over long-term (nine to 10 year) time frames. We have no way of knowing for how long the two roost trees still in use after nine or 10 years were used prior to their discovery in 1993 and 1994 or whether these trees were used continuously throughout the nine or 10 year periods. However, in 2002, both trees were still outwardly healthy and there appears to be no obvious reason why reuse will not continue.

Bats were not banded during the 1993–1994 study period so we cannot say whether the same individuals reused trees over the long-term. Over the medium-term, however, there is some evidence that individuals reuse trees between years. As part of another radiotracking study, C. K. R.

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Willis and R. M. Brigham (unpublished data) found that individual big brown bats exhibit within- and between-year fidelity to this roosting area of forest in the Cypress Hills. Furthermore, individual bats radio-tagged in multiple years reused the same trees in different years. Together with the observations we report here, this provides preliminary evidence that individuals or groups of bats exhibit between year loyalty, not just to patches of forest, but also to specific trees within those patches. The short battery life of radiotransmitters makes it difficult to draw conclusions about long-term roosting patterns. Further work is needed, perhaps relying on long-term mark recapture techniques (e.g., passive transponder (PIT) tagging), to more rigorously assess patterns of loyalty by bats to forest roosting habitat.

Barclay and Brigham (2001) observed that, over time, roosts beneath the exfoliating bark of conifer snags were more likely to be used by solitary California bats than by groups of bats. We found a different pattern for *E. fuscus* using aspen roosts. There was no difference in the size of groups counted emerging from trees between 2000 and 2002. Indeed, solitary bats were only observed during one of 18 exit counts performed during the final year of the study at trees used in more than one year. Thus, despite a small sample size, in contrast to the findings of Barclay and Brigham (2001) our data suggest that group sizes of *E. fuscus* using aspen tree roosts do not decline with time.

More of the roosts found during the 2000–2002-study period may well have been used during the earlier study, as the precise locations of roosts used in 1993 and 1994 were not georeferenced. We do know that a beaver felled at least one roost tree and another blew over in a windstorm prior to 2000. In addition, one of the trees found by radio tracking early in 2001 was felled in a windstorm later that summer. Such tree loss suggests that, despite the relative permanence of these roost structures, recruitment of new aspen trees and preservation of existing trees is important to maintaining the roosting resource for this breeding population of *E. fuscus*.

Recent studies of forest roosting bats have suggested that individuals are not loyal to specific trees but switch frequently between trees while remaining loyal to a roosting area containing many potential roost trees (Barclay and Brigham, 1996; Vonhof and Barclay, 1996; Brigham *et al.,* 1997, O'Donnell and Sedgeley, 1999; Cryan *et al*., 2001; C. K. R. Willis and R. M. Brigham, unpublished data). However, most of these studies were conducted over relatively short time-frames (1–2 years). Our longer-term results suggest that reuse of live, deciduous trees over the medium-term (3 years) is relatively common and that in some instances, long-term (9 and 10 years) reuse can occur. Given that roost availability may limit some bat populations (Kunz, 1982), reuse of tree roosts on an annual basis may confer a selective advantage. Evidence in support of this comes from studies showing that colonies of *E. fuscus* in buildings do not regularly move between roosts (Brigham and Fenton, 1986) and are known to reuse the same buildings annually, in some cases for decades (Kurta and Baker, 1990).

As in forests, *E. fuscus* roosting in rock crevices also move between roost sites frequently but reuse rates in rock crevices (within a year and over two years) appear to be low (Lausen and Barclay, 2002). This is surprising in light of our results, given the relative structural stability of rock crevices over the medium to long-term and the fact that *E. fuscus* that use buildings exhibit almost complete within and between year site fidelity (Kurta and Baker, 1990; Brigham, 1991; Hamilton and Barclay, 1994).

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As suggested above, this may reflect the shorter duration of the Lausen and Barclay (2002) study. Further work, addressing roost selection over longer time-frames, is needed to clarify differences in the roosting behaviour of *E. fuscus* in different types of natural roosts.

Lewis (1995) suggested that bats are more loyal to relatively permanent roost sites (e.g., caves and buildings) relative to less permanent structure (e.g., tree roosts). Although this idea may not fully account for the roosting patterns of forest living bats, our medium- and long-term data extend Lewis' (1995) hypothesis to different types of tree roosts and highlight the importance of roost cavities in structurally stable deciduous trees relative to more ephemeral sites, such as beneath exfoliating bark. The dynamics of bat-tree interactions warrant further study, particularly with respect to the effects of roost loss and recruitment from forests on survival and fitness in bat populations. Such research is important for forest management in the context of bat roosting requirements.

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