Spatial and temporal patterns of roost use by tree-dwelling barbastelle bats *Barbastella barbastellus*

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We evaluated the spatial and temporal patterns of roost switching behaviour by a tree-dwelling population of barbastelle bats *Barbastella barbastellus* in a beech forest of central Italy. Switching behaviour was common to both sexes and did not depend on group size. We observed both individual and group switching, the latter often involving the abandonment of a roost tree on a single night. We suggest that behaviours such as flight activity around roosts or cavity inspection by bats play a role in recruiting group mates and coordinating their occupation of another site. Bats almost never crossed mountain ridges to use roosts located beyond them, possibly because ridges are regarded as boundaries delimiting main roosting areas. The rate of switching was lowest during the middle of the lactation period, probably to minimise problems related to the transportation of non-volant young by their mothers. Although the maintenance of social relationship among bats spread over large forest areas may partly explain the occurrence of roost switching, the persistence of this behaviour in solitary bats and the movement of entire groups best fit the hypothesis that roost switching represents a way to maintain or increase knowledge of alternative roosts.

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Bats spend a considerable part of their life roosting, and thus roost characteristics have important implications for survival and reproductive success (Kunz 1982). Roost location, structure and aspect determine microclimatic conditions which may influence the energetic costs of key stages of life cycle such as hibernation (Humphries et al. 2002), pregnancy and lactation (Sedgeley 2001, Kerth et al. 2001b, Chruszcz and Barclay 2002). The characteristics of the roosting environment also influence exposure to predators (Vonhof and Barclay 1996, Rydell et al. 1996), parasite load (Lewis 1996), social behaviour (Wilkinson 1985, Willis and Brigham 2004), and the cost of commuting to preferred foraging sites (Brigham 1991, Jaberg and Blant 2003). Not surprisingly, bats exhibit selection in roost choice, showing preferences linked with their ecological requirements, which differ among species, seasons (Kunz 1982, Kunz and Lumsden 2003), and geographical areas (Rodrigues et al. 2003). The approximately 830 microchiropteran species (Hutson et al. 2001) use a variety of roost types. In temperate regions, these often include underground sites, buildings and tree cavities (Kunz 1982, Altringham 1996, Kunz and Lumsden 2003). The extent of roost fidelity varies across bat species (Lewis 1995), or within species according to roost type (Kurta et al. 2002). In general, roost fidelity appears to be related to roost permanence, and inversely to roost availability (Lewis 1995): species roosting in ephemeral but abundant sites tend to change roost often, while the opposite holds for those selecting more stable but rarer structures such as caves. This interpretation

may be contradicted by the fact that some roost trees, typically regarded as short-lived, may indeed be reused for up to many years (Willis et al. 2003, Willis and Brigham 2004). Roost switching has been hypothesised to reflect needs such as avoidance of predators or disturbance, disruption of parasite life cycles, specific microclimate requirements, minimisation of distance to feeding sites, maintenance of social relationships within colonies made of sub-groups spread over large forest areas, and awareness about alternate roosts (Lewis 1995, Kerth and König 1999, O'Donnell and Sedgeley 1999, Kurta et al. 2002, Kunz and Lumsden 2003, Willis and Brigham 2004).

Few studies have directly addressed these hypotheses (but see Lewis 1996, and Willis and Brigham 2004), mostly due to logistic difficulties. The spatial and temporal patterns of roost switching have also been little studied: such knowledge is vital, especially for threatened bats, as it likely has a direct bearing on forest management for conservation aims. The purpose of our project was to assess the spatial and temporal patterns of roost switching by the barbastelle *Barbastella barbastellus*. The barbastelle is a rare species (Urbanczyk 1999), classified as "Vulnerable" globally (Hutson et al. 2001) and "Endangered" in Italy (Bulgarini et al. 1998). Russo et al. (2004) reported that individuals from the same population preferred roosts in spaces behind loose bark in dead beech trees. These were mostly found in unmanaged forest areas; roosts were typically south-facing and at greater heights above ground than random cavities. Bats which roost in ephemeral sites such as under loose bark presumably need to maintain knowledge about the location of alternate roosts, check alternate roost suitability regularly, and discover potential new roosts. Landscape features used as "landmarks" may play an important role in helping the bats find known roosts and facilitate learning the route to new ones. This may be especially true for *B. barbastellus*, which travels long distances in search of food, often above the forest canopy (Sierro 1999), which probably represents a very homogeneous "landscape". In the forest area we studied here, landmarks potentially available to enable a large-scale spatial learning process included mountain ridges, woodland edges and main roads. We evaluated the occurrence of spatial relationships between such features and the location of roosts used by a given switching bat (or group). Besides having to cope with a challenging orientation task, a bat moving between roosts may also be vulnerable to predators, particularly during certain phases of the life cycle. During lactation, infants that are unable to fly must be carried between roosts by their mothers (Kurta et al. 2002). A female *B. barbastellus* moving her youngster in flight is conspicuous and flies slowly (unpubl.), potentially representing an easy target for predators.

We tested the hypothesis that to reduce this risk, lactating bats either reduce their roost switching rate or the distances between roosts when switching does occur. We also addressed whether group size and roost switching rate are related. If roost switching primarily functions as an anti-predatory mechanism, its rate should be lower in large groups because of the "dilution effect" (Alcock 1993). On the other hand, if switching aims to decrease parasite load by disrupting parasite life cycles (Lewis 1996), bats in large groups would be expected to change roosts more frequently because parasite risk increases with group size (Altizer et al. 2003). The *B. barbastellus* population we studied is the only reproductive population known from the Italian Apennines. Due to its high conservation value, we did not undertake invasive experiments to investigate the cause of roost switching, e.g. by manipulating roosting conditions.

Material and methods

Study area

The study was carried out during July and August 2001–2004 in the Abruzzo Lazio and Molise National Park (41°48′N, 13°46′E), a mountainous area of central Italy. Our study area, covering 700 ha, was delimited after locating roosts by setting limits corresponding to principal mountain ridges and other topographic features to encompass all roosts. Mean elevation is ca 1500 m a.s.l. (range 1278–1924 m a.s.l.). The substrate is mainly limestone, and extensively covered with beech *Fagus sylvatica* woodland; other habitats occurring in the area are pastures, often associated with woodland. Much of the woodland has not been logged since 1956; limited selective logging occurs occasionally in some forest stands (Russo et al. 2004).

Capturing and tagging bats

We captured bats with 2.5×6 m and 2.5×12 m mist-nets (50 denier, 38 mm mesh) placed near cattle troughs. The nets were erected soon after dusk and kept in place for 2–4 h. We recorded body mass and forearm length to the nearest 0.1 g and 0.1 mm respectively. Wings were trans-illuminated to distinguish juveniles from adults (Anthony 1988). Pregnancy was diagnosed by palpation (Racey 1988), and lactation by the presence of enlarged nipples surrounded by a hairless skin area and by extruding milk with a gentle finger pressure on the nipple base. Bats were classified in one of 4 categories. 1) Pre-lactating bats, tagged between 4 and 12 July, showed no sign of lactation; they included conspicuously gravid females as well as bats with no evident signs of pregnancy – possibly early pregnant subjects.

2) Lactating bats, tagged between 11 July and 2 August, including bats which were clearly lactating. 3) Late-lactating/post-lactating bats, tagged between 6 and 19 August, some of which were lactating but not others. 4) Males, rare in the study area; none of those we captured exhibited evident testicles.

We attached 0.48 g LB-2 Holohil (Carp, Canada) radio-transmitters between the shoulder blades of the bats with Skinbond glue after partly trimming the fur. On average, radio-transmitters were 4.9% of body mass. All bats were released ca 10 min after tagging. Captures were carried out under licence from the Park authorities.

Location of roosts and data recorded at roost sites

We tracked radio-tagged bats on foot during the day time, using an Australis 26 K radio-receiver (Titley Electronics, Ballina, NSW, Australia) and a three-element hand-held directional antenna. We recorded the roost tree position, determined with a Global Positioning System receiver, on to a 1:25 000 map (Istituto Geografico Militare, Florence).

In 2001–2002, once the roost tree was located, we identified the cavity occupied by the bat by assessing radio-signal strength and direction when standing near the tree. We inspected cavities with binoculars and sometimes by observing bats on emergence at dusk. In 2003–2004, we concentrated on a limited number of focal subjects per radio-tracking session (duration determined by the tag's life battery), and filmed their evening emergence with a Night-Shot function Sony PC 115 digital video-camera to determine roosting group size. On several occasions both the tree currently occupied by the bat(s) tracked, and the one used on the previous day, were watched at dusk to determine whether the whole group, or only a part of it, had moved. Occasionally, we continued to film group emergences for several days after the radio tag ceased to function, until the group left the site.

Data analysis

The data obtained in 2001–2002 were also used in the analysis of roost selection (Russo et al. 2004). In the laboratory we reviewed the roost videos to count the number of emerging bats and describe the behaviour performed on emergence. Subjects emerging significantly later than adults and often leaving the roost after performing peculiar behaviours such as wing stretching were probably volant juveniles. To assess whether group size influenced roost fidelity, we calculated Spearman's rank correlation coefficients for the number of days spent by a tagged subject in the same tree and the size of the group it belonged to. We generated a point vector map of all tree roost positions using ArcView 3.1.

We entered tree locations into a database including subject code, class and observation date, and overlaid these with a Digital Elevation Model calculated by point interpolation to assess the relationship between potential landmarks (mountain ridges, woodland edges and main roads) and the position of the trees used by each switching bat. For each radio-tagged bat we measured the following variables: a) roost switching frequency, calculated as the number of switching events by each bat tracked continuously for at least three days divided by the number of tracking days, b) mean distance between consecutive roosts for each bat, c) mean straight distance travelled daily for roost switching by each bat. This parameter provides a quantification of the *minimum* movement required for roost switching. Unlike metric (b), (c) includes zero values for days when bats did not change roosts. We compared variables (a), (b), (c) across bat sex and reproductive class categories. Body condition in *A. pallidus* was linked to parasite load which in turn affected roost switching frequency (Lewis 1996). Hence, when comparing roost switching frequency between classes, during initial data exploration we employed an ANCOVA and entered the Body Condition Index (BCI) =body mass/forearm length as a covariate. This variable proved to be non-significant, however, and this also happened when pre-lactating bats (including pregnant subjects, whose mass may not reflect their body condition) were taken out of the dataset. Thus, BCI was subsequently removed from analysis. To investigate whether roost switching frequency differs between classes we ultimately applied a one-way ANOVA followed by a Tukey's post-hoc test (Dytham 1999). When necessary, we employed log- or square-root transformations so that data would conform to ANOVA assumptions of standard distribution (checked by a Ryan-Joiner test) and variance homogeneity. Means are given ±standard deviation (SD); in all tests, significance was set at $p < 0.05$. Statistical analyses were carried out with MINITAB release 13.

Results

Roost switching behaviour

In all, we radio-tagged 56 adult *B. barbastellus*, of which all but four were females; for 43 of them, we located at least one roost, providing a total sample of 65 roost trees. Radio-tracking data from 35 subjects were used to investigate roost switching behaviour. The average length of time these bats were radio-tracked was 6.6 ± 3.0 d (range 2–11 d).

We recorded roost switching on a total 305 bat-days by *B. barbastellus* of both sexes. In two cases, dependent youngsters were observed being carried clinging to the mother's ventral fur at emergence time on the day preceding a roost switch. Each roost site was occupied

for 3.5 ± 3.4 d (range 1–11 d; n = 45 roosts), and roosts for which emergence counts were carried out held 11.4 ± 7.1 bats (range 1–27 individuals; n = 30 roosts), most often in groups. All four males which were radio-tracked roosted alone. The number of consecutive days a bat stayed in a roost was not correlated with mean group size ($r_s = 0.163$, n = 30 roosts, $p > 0.05$). On 11 occasions, after one or more tagged subjects moved from a roost whose group size had been previously ascertained, we checked the number of bats left: in 10 cases, the whole group left the site; in one instance, group size decreased from 16 to 13 bats, and the roost was abandoned within 3 d. During emergence counts, we filmed bats while approaching the roost cavity in flight, sometimes apparently almost touching the bark; in one case, we recorded 35 such events in ca 16 min at a single roost while it was being abandoned by the group (in this case the tagged bat had left the site before sunset). In another instance, this behaviour, probably performed by adults that had left the roost several minutes before, elicited a clear reaction by other bats (possibly volant juveniles), apparently induced to leave the roost. At emergence time we also occasionally recorded bats, probably coming from another site, entering a roost cavity, and leaving it a few minutes later.

Spatial and temporal patterns

We ascertained the exact position of a roost tree occupied continuously for 2–11 d (6.8 ± 3.0) for 31 females (n pre-lactation = 3; n lactation = 15; n late lactation/post-lactation = 13); male position could not be determined in detail over consecutive days, so males are not included in our analyses of spatial patterns. Of the females, 17 (13 lactating) did not switch roosts during the tracking period; for the other 14, the mean distance between consecutive roosts per bat had a median value of 277 m (range 52–1569 m; Fig. 1).
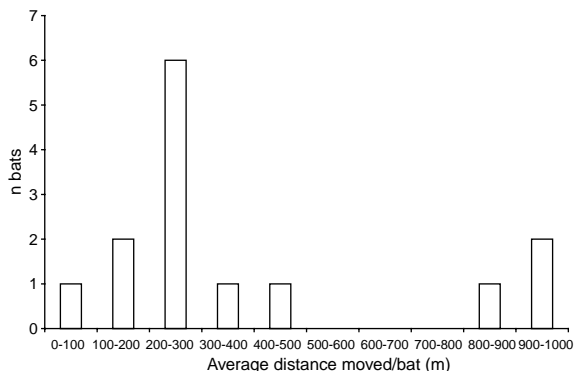

Fig. 1. Frequency distribution of mean distance between consecutive roosts travelled by 14 female *Barbastella barbastellus*. Most mean distances were below 300 m.

Because of the large number of lactating females that were faithful to the roost site, the mean distance travelled daily for roost switching by each bat was shorter for this class (ANOVA on log-transformed data, $F_{2,28} = 8.74$, $p < 0.05$, and Tukey's test; Table 1). We found no difference between bats in pre-lactation and late lactation/post-lactation.

We compared consecutive roost distances between 3 pre-lactating bats and 9 in late lactation/post-lactation respectively, because only 4 lactating females changed tree and for 2 of them we could locate consecutive roosts. Thus, we considered this sample to be too small for statistical analysis. There was no significant difference (mean distance pre-lactation = 284 ± 296 m; late lactation/post-lactation = 128 ± 112 m; ANOVA on log-transformed data, $F_{1,10} = 1.58$, $p > 0.05$).

Roost switching paths (trajectories drawn by connecting the roost trees consecutively used by each bat over the tracking period) seldom crossed major mountain ridges: this was especially evident for a ridge (dark dashed line in Fig. 2) separating two adjoining roosting areas (one of which – north to the ridge – was characterised by a concentration of roosts). A bat crossed this ridge only once in 31 switching events.

The frequency of roost switching was significantly lower in lactating females than in other bats (n pre-lactation = 3; n lactation = 15; n late lactation/post-lactation = 9; n males = 4); no differences were found between the remaining classes (ANOVA on square-root transformed data, $F_{3,27} = 9.33$, $p < 0.001$, and Tukey's test; Table 1).

Discussion

Spatial and temporal patterns of roost switching

As for other tree-dwelling bat species (Fenton 1983, Brigham et al. 1997, O'Donnell 2000, Law and Anderson 2000, Kurta et al. 2002, Willis and Brigham 2004), roost switching is a common phenomenon in *B. barbastellus*. It occurs in juveniles and adults of both sexes, thus its adaptive value is not likely related to ecological or physiological requirements restricted to a specific age or sex.

Given that an entire *B. barbastellus* group may abandon a roost on one night, information transfer among roost mates is likely to occur to coordinate the behaviour. The peculiar flight behaviour we recorded near tree cavities, or roost inspection by bats, might be performed to recruit group mates and move to another site. These observations appear to be the same as "rallying behaviour" recorded for *Antrozous pallidus* (Lewis 1996) and roost visits by a "recruiter" *Myotis bechsteinii* inciting other group members to move to a newly available roost (Kerth and Reckardt 2003).

Table 1. Mean distance moved daily for roost switching by each bat (when a bat stayed in the same tree the corresponding daily value was set to zero) and roost switch frequencies (number of switches/number of radiotracking days, calculated for bats tracked continuously over at least three days). N =number of bats; SD =standard deviation. Females in lactation showed significantly lower (p <0.05) values for both variables; no difference was found between the remaining categories (ANOVA, post-hoc Tukey's test).

Status	Mean distance moved (m)			Roost switching frequency		
	N	Mean (SD)	Range	N	Mean (SD)	Range
Pre-lactation	3	284 (296)	100−626	3	0.67 (0.29)	0.5−1
Lactation	15	31 (87)	0−306	15	0.20 (0.16)	0.09−0.63
Late lactation/post-lactation	13	89 (110)	0−352	9	0.60 (0.24)	0.25−1
Males	−	−	−	4	0.54 (0.37)	0.17−1

Paths connecting consecutive roosts almost never crossed mountain ridges, although these would certainly be easy to cross for a flying *B. barbastellus*: ridges did not act as a physical barrier, nor was the observed effect a by-product of habitat discontinuity, since the forest cover was mostly uniform across the ridges. Because we were able to check daily the slopes on both sides of most ridges, where we generally clearly detected radio-signals, we would have easily located any crossing bat. Thus, we believe crossing bats were not overlooked and erroneously regarded as lost subjects or transmitters. Ridges might serve as landmarks and used by bats to delimit large-scale roosting areas. Although the nature of cues used by bats for navigation (aside from echolocation) is still poorly known, several microchiropterans rely on landmarks to maintain their orientation during foraging or commuting (Verboom and Huitema 1997, Ransome and Hutson 2000, Serra-Cobo et al. 2000, Russo et al. 2002). Ridges might be helpful to bats in recognising patches of forest: in fact, the first task performed by a bat on its way to the roost must be some form of large-scale orientation process to locate the general roosting area. Once the desired forest patch is found, the roost trees within it may be easily spotted because, at least in our study area, they often project conspicuously above the canopy (Russo et al. 2004). As with other tree-dwelling species (Kerth et al. 2000, Willis and Brigham 2004), forest patches may correspond to colony home ranges across which several related sub-groups are spread, but confirming this will require further investigation.

Our finding that lactating bats switch roosts least frequently supports the hypothesis that roost switching may be costly during this phase, probably as juveniles need to be carried in flight by their mothers. During lactation, *Myotis sodalis* also limits roost switching (Kurta et al. 1996, 2002), and lactating *A. pallidus* move shorter distances between consecutive roosts than

Fig. 2. Digital Elevation Model of the study area showing the location of 65 *Barbastella barbastellus* roosts (filled circles). Roost switching paths (trajectories drawn by connecting the roost trees occupied consecutively by one or more tagged bats) are shown. Letters A−E show a typical roost switching sequence recorded in a post-lactating female. The distance between these trees averaged 302 m (range 230−411 m). The bat stayed three days in tree A, spent one day in each of the roosts B, C, D, and was further tracked over three days in E. The dashed line shows a mountain ridge separating two adjoining areas characterised by a significant roost concentration, crossed only once in 31 switching events; the exception was made by a bat mainly roosting north to the ridge, which once moved south to reach the tree indicated by the black arrow.
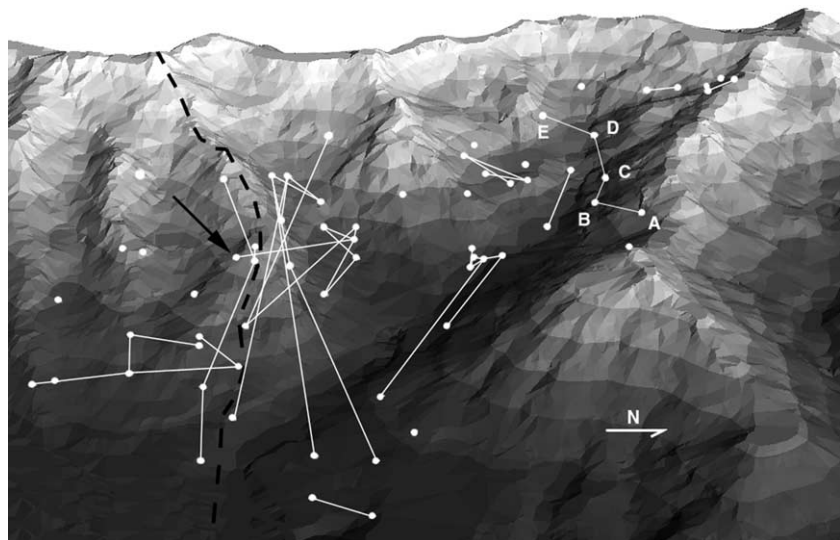
do pregnant ones (Lewis 1996). As soon as juveniles become volant, they may change roost independently, and this may account for the sudden increase in frequency of roost switching in late lactation or post-lactation groups. Roost switching by juveniles on their first flights may be important to begin memorising the location of key sites and routes; this could be especially valuable if this period represents a phase of maximum sensitivity to learning (Forgays and Read 1962).

Why do B. barbastellus switch roosts?

To date, no study has fully answered the question of why roost switching occurs in bats; undoubtedly, this is partly due to the difficulty of testing alternative hypotheses in controlled experiments by individuals in a natural situation.

In agreement with previous work on other bat species (Fenton 1983, Brigham 1991, Lewis 1996, Kerth et al. 2001a, b, Kurta et al. 2002, Kunz and Lumsden 2003), the limited distances (often <300 m) between consecutive roosts we recorded are well below the species' foraging range (2–18 km from roosting sites; Greenaway 2001), so they do not support the hypothesis that roost-switching is for the purpose of reducing commuting costs to foraging sites. The lack of correlation between the roost fidelity of tagged bats and the size of roosting groups runs counter to the "anti-parasite" hypothesis, which would predict that small groups should switch less and solitary bats should be most roost faithful. We found that male B. barbastellus exhibited a switching rate similar to that of colonial females. Lewis (1996) found that A. pallidus hosting greater numbers of parasites were more likely to change roost; the poorer body condition found in these subjects was attributed to the detrimental effect of parasites. Although we did not specifically evaluate parasite load (it appeared to be low for most bats; unpubl.), we found no effect of B. barbastellus body condition on roost switching frequency. Recent work (Zahn and Rupp 2004) on seven European bat species found that a high number of parasites in weak bats would be a symptom, rather than the direct cause, of poor physical condition. Should this hold true for other species, it would suggest that weaker bats might move more frequently for reasons other than parasite load. The lack of correlation between individual roost fidelity and group size also does not support the hypothesis that the purpose of roost switching is to reduce predation risk. However, if, as in other tree-dwelling species, B. barbastellus colonies comprise several sub-units spread across a forest area, reduced predation risk may still be related to colony size (Willis and Brigham 2004), although this advantage may not be apparent by studying sub-units in single trees. Sociality

appears to be a logical explanation for some roost switching behaviours, such as the patterns of fission and fusion in groups spread across large forest areas (Kerth and König 1999, O'Donnell and Sedgeley 1999, Willis and Brigham 2004). This may explain the several fusion processes observed in B. barbastellus, in which a tagged bat moved from a given group to a larger one (Greenaway 2001, unpubl.). However, sociality does not explain the movement of entire groups to a new tree (Kurta et al. 2002), which we suspect may have occurred in some of the roost switching events we recorded, or roost switching by solitary bats (male B. barbastellus; this study). This switching is most consistent with the idea that bats need to maintain knowledge of alternate roosts (Kurta et al. 2002), allowing the bats to easily reach another roost if the one they are using becomes unsuitable. Although certain tree roosts persist for many years (Willis et al. 2003) this is not likely to be the rule, especially for spaces delimited by a piece of loose bark, such as those used by B. barbastellus in this study (see also Barclay and Brigham 2001). Loss of suitable roosting conditions may be due to several factors, including structural alteration of the roost site or a predator becoming too familiar with roost location. Adverse weather conditions can remove pieces of bark from the trunk, exposing bats (Russo et al. 2004). We recorded that at least one roost cavity may have been abandoned for this reason. After being home to one of the largest nurseries we found in 2002, the next year the roost was deserted by the entire group, including a tagged bat that moved to another site in the daytime. On the evening the cavity was abandoned, we recorded high levels of activity by bats flying near the cavity or accessing it, as well as two females that emerged carrying youngsters. We compared photographs of the roost taken in the two years and noticed that a large piece of bark was missing in 2003. Roost ephemerality has been hypothesised as a cause for roost switching in M. sodalis: bats using bark roosts move more often than those using crevices, since the latter represent a more stable roost type (Kurta et al. 2002).

Exfoliating bark also offers little shelter against climbing predators such as beech martens Martes martes or disturbance by rodents, including fat dormice Glis glis, both common in our study area. Rodent activity negatively affects breeding success in cavity-nesting birds (Walankiewicz 2002) and this may also be the case for tree-dwelling bats. The day-time roost switching occasionally recorded as a reaction to the presence of an approaching observer (Russo et al. 2004) offers anecdotal evidence of how alternate roosts may be used to avoid disturbance. However, we can rule out that in this study our presence affected the rate of roost switching, which was also recorded when signals from roosts were detected from a distance and sites not checked on emergence time.

For woolly lemurs *Avahi laniger*, which rest in exposed places on the main stem of trees or in a tangle of small branches, leaves and vines (Roth 1996), frequent change of shelter site has been interpreted as an anti-predatory strategy; this behaviour is absent in other nocturnal prosimians using less accessible sites. Roost switching may in fact have evolved in different species as a response to converging selective pressures typical of roosting in ephemeral conditions such as those found in forests. By favouring sociality, roost switching also helps generate and maintain a spatial memory of the roosting environment, as each group member may benefit from communal knowledge of roost location and information transfer (Kerth and Reckardt 2003). Moreover, sociality, familiarity with a number of alternative sites and frequent and unpredictable movement between roosts may also contribute to decrease predation.

Conservation implications

Apart from its causes, the frequent occurrence of roost switching behaviour in *B. barbastellus* means that this behaviour is important. It should thus be carefully taken into account when designing management activities aimed at conserving this species. To ensure the persistence of a *B. barbastellus* population in a certain area, it is necessary to protect a large number of trees and large forest patches (Russo et al. 2004). Given that we found females in late lactation or post-lactation changed roost at an average rate of 0.6 switches d^{-1}, reuse of the same tree within the same season was almost never observed, and assuming that fission-fusion processes are infrequent in this period, we estimate that in a month a single group of a dozen bats may need ca 18 different trees. Therefore, large numbers of suitable trees are necessary to sustain even a population numbering just a few hundred individuals. Forest managers need to understand that dead trees should be saved from logging, but also that old trees must be preserved so that they can be "recruited" as replacements for the dead ones which are continuously falling in response to mechanical and biological agents. The threat posed by incorrect forest management is not inconsiderable if we take into account that the removal of dead or decaying trees is still largely practiced mainly to improve forest growth for timber production (Cappelli 1991). Finally, our study suggests that adjacent forest patches represent separate roosting areas: if this aspect of *B. barbastellus* roosting ecology is confirmed, conservation plans will have to deal with the complex task of locating such areas and treating them as independent management units.

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