Roost selection by non-breeding Leisler’s bats (Nyctalus leisleri) in montane woodlands: implications for habitat management

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We investigated roost selection by Leisler’s bat (Nyctalus leisleri) before and after hibernation in 2005 in a mountain area of southern Switzerland. The study area is dominated by deciduous trees and characterised by the presence of previously managed chestnut (Castanea sativa) orchards that are now partly abandoned. In March–May and August–October, 15 radio-tracked bats (seven males and eight females) used 28 roost trees. We analysed roosts used by N. leisleri at three different levels: (i) micro-scale: features of roost cavities; (ii) meso-scale: characteristics of selected roost trees and (iii) macro-scale: structure of woodland surrounding roost trees. Selection at meso and macro-scales was obtained comparing characteristics of roost trees and surrounding woodland with potentially available trees and woodlands. Bats roosted mainly in live chestnut trees, with large diameter and absence of vegetation near the entrance. Roost trees were located closer to streams, in woodlands with a higher percentage of sweet chestnut trees and a lower tree density than random trees. Multifunctional forest management in abandoned chestnut stands, comprising recreation (chestnut harvesting) and preservation of a semi-natural habitat and its related biodiversity, would recreate the traditional woodland features – in particular an open forest structure with low tree density and presence of ancient chestnut trees – and provide suitable roosting sites to migratory N. leisleri.

Key words: Nyctalus leisleri, chestnut stands, forest composition, roost selection, Switzerland

INTRODUCTION

Understanding factors that affect roost selection is of primary importance in the study of biology, ecology and conservation of bats. Roosting habits influence local and global distribution, population density, foraging and mating strategies, social structure and seasonal movements (e.g., Findley, 1993; Altringham, 1996; Vonhof and Barclay, 1996; Fenton, 1997; Kunz and Lumsden, 2003). The thermo-physical characteristics of roosts also affect bat physiology (Altringham, 1996; Kerth et al., 2001). Almost two-thirds of the European bat species use tree cavities to roost in during part of their life cycle, and some of them rely on these roosts for reproduction and hibernation (e.g., Stebbings, 1988; Agnelli et al., 2004; Russo et al., 2004, 2005). Deforestation, causing loss of habitat, is a major threat for these species (Hutson et al., 2001), while damaging forest management techniques, for example the removal of old or dead trees, can destroy valuable habitat for tree-dwelling bats (Hutson et al., 2001; Russo et al., 2004). In these changing landscapes, studies on micro- and macro-habitat selection by bats are fundamental to provide guidelines for a sustainable forest management which aims to preserve biodiversity.

Leisler’s bat, Nyctalus leisleri (Kuhl, 1817) is a medium sized migratory bat (forearm length 40–47 mm, body mass 11–20 g — Agnelli et al., 2004; Bogdanowicz and Ruprecht, 2004) of the family Vespertilionidae. In general, such bats give birth in the northern part of Europe but hibernate in southern Europe. Being a migratory species (Olioso, 1999; SECEMU, 1999; Ohlendorf et al., 2000; L. Rodrigues, T. Ivanova and M. Uhrin, in litt.) that presents vagrant but also sedentary populations (Bogdanowicz and Ruprecht 2004; Hutterer et al. 2005), it is protected by the Bonn Convention...
Leisler’s bat is widespread in Ireland but has a patchy distribution in the rest of Europe (McAney and Fairley, 1990; Mitchell-Jones et al., 1999). In Switzerland it is not common but seems more frequent in the central and northern part of the country (Hausser, 1996; Moretti et al., 2003). According to the IUCN red list of threatened species (Chiroptera Specialist Group, 1996), *N. leisleri* is at lower risk (near threatened), but there are little data to assess its status accurately (Stebbing, 1988). Little is known about the foraging or reproductive ecology of the species. Foraging habitats include open areas, over rivers, lakes or pastures, and also deciduous and coniferous woodlands and around streetlights (Vaughan et al., 1997; Shiel et al., 1999; Waters et al., 1999; Russ et al., 2003; Russo and Jones, 2003). Leisler’s bat is considered a forest dwelling species roosting mainly in tree cavities.

However, roosts also occur in buildings (Mitchell-Jones et al., 1999; Shiel et al., 1999; Waters et al., 1999) and bat boxes are readily used in both coniferous and deciduous forests (Corbet and Harris, 1991; Hausser, 1996). Ruczyński and Bogdanowicz (2005) described roosting preferences of *N. leisleri* and *N. noctula* in Białowieża Primaeval Forest (Poland) during the reproductive season (May–August), but there is no information about tree roost selection by *N. leisleri* in Southern Europe during autumn (before onset of hibernation) and early spring (after emergence from hibernation), when bats are wintering.

In the foothills of the southern Alps, sweet chestnut stands are among the most common woodland types, and trees were planted for their important role as food source for humans and animals. These groves, present for centuries, are characterised by considerable numbers of old trees (some older than 100 years) with decay, hollows, cavities and deeply furrowed bark that offer habitat to many species, including bats (Bull et al., 1997; Mazurek and Zielinski, 2004). In this environment we examined roost selection by Leisler’s bat at three levels: roost-cavity, roost-tree, and woodland surrounding the roost tree. Our aim was to identify woodland characteristics useful to produce guidelines for conservation and forest management in order to preserve an environment suitable for this sensitive bat species. This study is part of the SELPI (‘Selve e Pipistrelli’ — Chestnut orchards and Bats) project that aims to evaluate the effect of chestnut stands management on the population of *N. leisleri*.

**MATERIALS AND METHODS**

**Study Area**

The study was conducted in Alto Malcantone, Cantone Ticino, Switzerland (46°03’N, 8°53’E). The area is mountainous, with an altitude ranging from 560 to 1,636 m a.s.l. and extends over 15 km² (1,507 ha). It is largely covered with woodlands (67%), dominated by sweet chestnut (*Castanea sativa*), durmast oak (*Quercus petraea*) and birch (*Betula sp.*) below 800 m a.s.l., while beech (*Fagus sylvatica*) and pastures dominate at higher elevations. Traditional chestnut orchards, that played an important role in economic activities until the first part of the twentieth century, occur close to villages. These stands are semi-natural environments characterised by the presence of sparse old chestnut trees (low tree-density), grafted to obtain edible fruits of good quality, surrounded by meadows that are managed with pruning, grazing and/or mowing. In the last decades, many stands have been abandoned and are not managed, with the result that old chestnuts have been surrounded by dense woody vegetation.

**Trapping and Handling Bats**

Leisler’s bats overwinter in Cantone Ticino, with two active seasons between hibernation, from March to May and from the end of August to the beginning of October. Bats were captured in both seasons in 2005 from bat boxes located in both managed and unmanaged chestnut stands throughout the study area. Each animal was removed from the box and temporarily held in cotton bags until handling. It was weighed to the nearest 0.1 g with an electronic scale (Maul Tronic, Germany), and forearm length (from wrist joint to elbow joint) was measured using precision callipers (±0.1 mm). Sex was assessed by inspecting external genitalia (Racey and Swift, 1981) and wings were observed by back-lighting and visually examined to distinguish juveniles from adults, the former showing cartilage epiphyseal plates in finger bones (metacarpal-phalangeal joint of the fourth finger; Kunz, 1988; Stebbings, 1988). Bats were fitted with 0.47 g Holohil LB-2 or 0.62 g Holohil BD-2 transmitters, attached between the scapulae with Skinbond® surgical glue after trimming the fur.

**Location of Roosts**

Radio tracking was conducted on foot, mainly during day time, using a JDS Executive 2000 radio-receiver (Wildlife Materials, Inc., Carbondale, USA) and a three-element hand-held directional Yagi antenna. Roosts were located daily by homing-in to the signal when the transmitter was active. After identification of the roost-tree, the cavity used by the animal was identified by assessing radio-signal strength and direction and, when possible and safely accessible, by inspecting the cavity or observing emerging bat(s) at dusk. Roost tree position was taken with a GPS (Garmin) and mapped (scale 1:25,000). Roosts chosen by bats were checked every day while the tag was active (on average 10 days).

**Characterisation of Roosts**

Roost use was investigated at three different levels scaling from (i) roost features, (ii) roost tree characteristics, and (iii)
Roost selection by *Nyctalus leisleri*

Data were analysed with SAS v 8.0 (SAS, 1999). Relative abundance of tree species, herb cover, shrub cover and tree-canopy cover were expressed as proportions (p). All proportional data were transformed using the arcsine (p) transformation to improve normality (Sokal and Rohlf, 1995). Descriptive statistics (± SD and range) of habitat variables are shown in Table 2. Univariate inferential procedures, student *t*-test for normally distributed variables and Kruskal-Wallis tests for those that did not meet assumptions of normality, were used to test for differences between habitat variables in sample plots with roosts and random plots. For circular variables analysis, we used Rayleigh test (cavity aspect) and the circular analysis of variance (roost neighbourhood aspect). Parameters which described roost trees were compared with those of the nearest tree (height) and those sampled in the roost plots (DBH and life stage) using paired-*t* test when the variable was normally distributed and Wilcoxon-matched-paired signed-ranks test when it was not (Sokal and Rohlf, 1995). Multivariate discriminant function analysis (MDA) with cross-validation was applied to determine habitat variables that were related with woodland around roost trees, by exploring habitat differences between the 84 plots in woodlands used by bats (3 random plots along a 50 m transect for each woodland) and 84 plots in random areas. Exploratory data analyses showed that several habitat variables co-varied: (percentage of chestnut correlated with herb cover and canopy structure; herb cover with tree density; elevation with percentage of beech and distance to buildings; distance to main roads with distance to buildings and dust roads; elevation with distance to buildings and main roads; distance to dust roads with distance to buildings and main roads; all *r* > 0.37, *P* < 0.01).

Therefore, in order to reduce multicollinearity in MDA models, a stepwise forward method (Proc stepdisc, SAS, 1999) was used to select variables to be included in the multivariate discriminant analysis model (MDA), with significance level to enter and stay set at *α* = 0.10 (Table 3). Our dataset did not conform to multivariate normal distribution, but MDA tests are robust to departures from normality (Dillon and Goldstein, 1984). Wilk’s lambda values were obtained with a MANOVA to test for statistical significance of the selected MDA model (Proc stepdisc — SAS, 1999).

**RESULTS**

**Bats Tagged**

A total of 18 adult Leisler’s bats were radio-tagged, five females and four males in spring and three females and six males in autumn. We detected signal from tagged bats for 10 ± 8 days (range 2–21). Mean forearm length was 43.6 ± 2.3 mm for males and 44.6 ± 1.0 mm for females; mean weight was 14.9 ± 2.9 g for males and 15.3 ± 1.6 g for females. Since three animals could not be detected after release, roost selection was investigated for 15 bats (eight females and seven males).

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**Table 1. Mean and SD of cavity parameters for each cavity type**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Loose bark (n = 6)</th>
<th>Mechanical breaks (n = 4)</th>
<th>Rot cavity (n = 3)</th>
<th>Woodpecker hole (n = 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrance height (cm)</td>
<td>44 ± 76</td>
<td>44.5 ± 32</td>
<td>14 ± 9.5</td>
<td>6.0 ± 1.4</td>
</tr>
<tr>
<td>Entrance width (cm)</td>
<td>2.5 ± 1.3</td>
<td>2.4 ± 0.5</td>
<td>4.7 ± 1.5</td>
<td>6.0 ± 1.4</td>
</tr>
<tr>
<td>Inner height (cm)</td>
<td>41.3 ± 37</td>
<td>44.8 ± 24.3</td>
<td>261 ± 17</td>
<td>6.0 ± 1.4</td>
</tr>
<tr>
<td>Inside cross section (cm²)</td>
<td>26.4 ± 28.7</td>
<td>61.2 ± 23.8</td>
<td>882 ± 1316</td>
<td>60 ± 14</td>
</tr>
<tr>
<td>Volume (dcm³)</td>
<td>2.4 ± 0.03</td>
<td>2.7 ± 2.0</td>
<td>330 ± 545</td>
<td>0.3 ± 0.2</td>
</tr>
</tbody>
</table>
Twenty-eight trees in which Leisler’s bats roosted, and 15 roost cavities were identified. Roosts were always located daily during the time the transmitters were active (mean 10 ± 8 days, range 2–21). Single bats used an average 1.9 ± 1.3 (range 1–5) roosts during the time radio transmitters stayed attached, with mean inter-roost distance of 465 ± 524 m (range 31–1749 m). Bats switched roost frequently, each roost being occupied on average during 2.6 ± 3.7 days (range 1–17 days). Tagged bats never roosted together and inspection of the cavities showed they were either solitary or rarely in small groups (of maximum three individuals). Bats were also found roosting in bat boxes (n = 6) and wall crevices in houses (n = 6).

**Roost Use at Cavity and Tree Level**

Leisler’s bats roosted more frequently in mechanical breaks (40% of total roost sites), but some also roosted beneath loose bark (27%), in rot cavities (20%) or woodpecker holes (13%; see Table 1 for descriptive statistics of cavity parameters). Eleven out of these 15 cavities were in the trunk, and in 13 cases the entrance was not sheltered by vegetation (χ² = 8.07, d.f. = 1, P < 0.01). Eleven roost cavities were in living parts of trees, four in dead limbs. Tree density around roosts in live trees was lower than around those found in dead limbs (Mann-Whitney U-test: z = 2.11, P < 0.05). Mean roost height from the ground was 5.2 ± 2.9 m (range 0.5–10 m). Cavities used by bats were not facing a particular direction (Rayleigh test: r = -0.15, P = 0.78).

Out of 28 roost trees, 21 were sweet chestnut, three beech and one sycamore (Acer pseudoplatanus), green alder (Alnus viridis), bird cherry (Prunus avium) and one exotic pine (Pinus wallichiana). Roost trees had larger DBH than the trees found in roost and woodland plots (mean ± SD: roost trees 66.8 ± 30.6 cm; random trees 39.6 ± 16.0 cm; Wilcoxon signed rank test: P < 0.001). Most roost trees were live ones (19 out of 28), with less than 50% of dead limbs (life stage class 1), while seven belonged to class 2 and only two were dead trees (class 4). Mean overall height of roost trees was 20 ± 6 m, not significantly different from the overall height of available trees (18 ± 5 m; paired t-test: t = 1.35, d.f. = 26, P = 0.19). Predominant aspect on mountainsides where roost trees were located showed no significant differences if compared to the same measure carried out on a random sample covering the entire study area (roost trees µ = 323, k = 0.41; random points µ = 247, k = 0.76; Circular analysis of variance: F₁, 111 = 2.31, P = 0.13).

**Woodland Selection**

Woodland areas including tree-roosts had a lower tree density, a higher proportion of chestnut, wider herb cover (all P < 0.001) and a lower forest cover index (P < 0.01) than random plots within the study area (Table 2). Areas including roosts were also closer to main roads, dust roads and buildings (all P < 0.05) than random ones (Table 3). The MDA explained 59% of variation in woodland structure between areas with and without roosts, and showed that woodland around roosts was less dense and with wider herb cover, more chestnut trees and fewer beeches than random sites. Sites with roosts were also closer to main roads and streams than random sites (Table 4).
In this study, *N. leisleri* showed marked tree and habitat preferences for roosting during the non-breeding season. Cavity selection was not investigated because sample size was too small (number of located cavities = 15), cavities were of four different types (mechanical breaks, rot cavities, loose bark and woodpecker holes) and to investigate selection it would be necessary to compare a higher number of used cavities with random ones for each type. Radio-tracked bats used different types of roosts characterised by a narrow entrance width (all cavities less than 7 cm — 66% less than 4 cm); such findings are comparable with those by Ruczyński and Bogdanowicz (2005) in Poland (less than 6 cm). Forepart from rot cavities, the remaining roost cavities had small inner cross sections and volumes than those found in Poland: bats seemed to favour small crevices where to roost alone or in small groups, while during the breeding season they may require larger roost cavities to form maternity colonies.

Seasonal differences in cavity use may also be related to micro-habitat characteristics of roosts. A warmer roost is important during the reproductive period, when females need to maintain homeothermy during pregnancy and lactation (Racey, 1973; Racey and Swift, 1981; Grinevitch *et al.*, 1995; Altringham, 1996; Russo *et al.*, 2004). In contrast, in spring and autumn bats may save energy during the day by entering torpor, thus preferring cooler roosts (e.g., Grinevitch *et al.*, 1995; Altringham, 1996). In our study area, in spring and autumn 2005, Leisler’s bats roosting in bat boxes select those with a lower daily temperature (S. Szentkuti, unpublished data). Temperature inside a natural cavity is also influenced by several factors, i.e.: cavity entrance, the health state of the tree in which the cavity is found, tree diameter, canopy cover, and mean ambient temperature and its daily fluctuations (Law and Anderson, 2000; Sedgeley, 2001; Wiebe, 2001; Paclík and Weidinger, 2007). In particular, live and large trees provide a more stable temperature, live trees being warmer than dead ones at low ambient temperature (below 0°C), but colder in warmer days (Paclick and Weidinger, 2007). During spring and autumn (present study), at mean ambient temperatures > 5°C, most roosts were in live trees with large stem diameters, probably provide cool and stable temperatures during the day.

In our study area, most cavities, located in live parts of trees, were also situated in open stands (mainly chestnut orchards) and all without vegetation in front of and around the entrance. These features may favour movements of bats flying to and from the roost, important for Leisler’s bats.

### TABLE 3. Significance levels of single candidate variables for the stepwise discriminant analysis in the MDA model

<table>
<thead>
<tr>
<th>Variables</th>
<th>$F_{1,54}$-value</th>
<th>$P$-value</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Chestnut</td>
<td>18.17</td>
<td>&lt; 0.001</td>
<td>0.25</td>
</tr>
<tr>
<td>% Beech</td>
<td>1.77</td>
<td>0.19</td>
<td>0.03</td>
</tr>
<tr>
<td>% Birch</td>
<td>0.40</td>
<td>0.53</td>
<td>0.01</td>
</tr>
<tr>
<td>Shrub cover</td>
<td>0.12</td>
<td>0.73</td>
<td>0.00</td>
</tr>
<tr>
<td>Herb cover</td>
<td>15.60</td>
<td>0.0002</td>
<td>0.22</td>
</tr>
<tr>
<td>Forest cover index</td>
<td>8.21</td>
<td>0.006</td>
<td>0.13</td>
</tr>
<tr>
<td>Tree density</td>
<td>19.10</td>
<td>&lt; 0.001</td>
<td>0.26</td>
</tr>
<tr>
<td>Basal area</td>
<td>0.91</td>
<td>0.34</td>
<td>0.02</td>
</tr>
<tr>
<td>Distance buildings</td>
<td>4.03</td>
<td>0.05</td>
<td>0.07</td>
</tr>
<tr>
<td>Distance rivers</td>
<td>1.29</td>
<td>0.26</td>
<td>0.02</td>
</tr>
<tr>
<td>Distance main roads</td>
<td>8.31</td>
<td>0.006</td>
<td>0.13</td>
</tr>
<tr>
<td>Distance dust roads</td>
<td>4.99</td>
<td>0.03</td>
<td>0.08</td>
</tr>
<tr>
<td>Elevation</td>
<td>2.64</td>
<td>0.11</td>
<td>0.05</td>
</tr>
</tbody>
</table>

### TABLE 4. Significance levels of variables selected in the MDA model. * Order of selected variables according to their entry in stepwise procedure with Proc stepdisc implemented in SAS (1999). ASCC = Average squared canonical correlation (all $P < 0.001$)

<table>
<thead>
<tr>
<th>* Selected variables</th>
<th>$F$-value (partial $R^2$)</th>
<th>$P$-value</th>
<th>ASCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tree density</td>
<td>19.10 (0.26)</td>
<td>&lt; 0.001</td>
<td>0.26</td>
</tr>
<tr>
<td>Distance main roads</td>
<td>10.16 (0.16)</td>
<td>0.002</td>
<td>0.38</td>
</tr>
<tr>
<td>Herb cover</td>
<td>5.24 (0.09)</td>
<td>0.026</td>
<td>0.44</td>
</tr>
<tr>
<td>% Chestnut</td>
<td>3.46 (0.06)</td>
<td>0.068</td>
<td>0.47</td>
</tr>
<tr>
<td>% Beech</td>
<td>9.78 (0.16)</td>
<td>0.003</td>
<td>0.56</td>
</tr>
<tr>
<td>Distance rivers</td>
<td>3.73 (0.07)</td>
<td>0.059</td>
<td>0.59</td>
</tr>
<tr>
<td>Wilks’ Lambda final model</td>
<td>$F_{6, 49} = 0.410$</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
</tbody>
</table>
whose high wing loading allows fast flight but also determines poor manoeuvrability (Norberg and Rayner, 1987).

Mean cavity height was lower than in other studies (e.g., 18.7 m in Ruczyński and Bogdanowicz, 2005) on *N. leisleri* and *N. noctula* (Heerdt and Sluiter, 1965; Stratmann, 1978; Kronwitter, 1988; Schmidt, 1988). This difference with other habitats and/or regions may be related to: (i) lower average tree height (20 m) and canopy height (Faliński, 1986; Vonhof and Barclay, 1996); (ii) occurrence of different species and/or lower abundance of predators (Rydell et al., 1996; Sedgeley and O’Donnell, 1999; Ruczyński and Bogdanowicz, 2005); or (iii) bats actively choosing lower cavities with a cooler temperature (Sedgeley, 2001).

In common with other tree-dwelling bat species, Leisler’s bats showed marked preference for deciduous trees with a larger DBH for roosting (Gaisler et al., 1979; Boonman, 2000; Jung et al., 2004; Russo et al., 2004; Sedgeley and O’Donnell, 2004). Apart from their influence on cavity microclimate (see above), trees with large stem diameters may be preferred simply because they bear more cavities suitable for roosting (Sedgeley and O’Donnell, 2004). The avoidance of conifers for roosting is common among many bats, although they are preferred by some species, mainly Nearctic (e.g., *Myotis sodalis* — Britzke et al., 2003). The reasons of this behaviour are unknown. Boonman (2000) found pine trees to have less available cavities than broadleaves, maybe due to a different wood quality and structure. In a study on *N. noctula*, Schmidt (1988) showed that only 16% of bats roosted in coniferous trees though they covered 90% of the forest. In our study area broadleaves were dominant and small patches of coniferous woodlands were cluttered with a closed canopy and low canopy height. These habitat characteristics may be avoided by Leisler’s bats which prefer open surroundings with roosts located in woodlands with a low tree density. Open areas are also important for foraging as they fly primarily away from clutter, relying on agility to hawk flying insects (Norberg and Rayner, 1987). In a study carried out in Southern Italy (Russo and Jones, 2003) 28 out of 40 *N. leisleri* passes recorded in ten habitat types were detected in sweet chestnut woodlands, showing that this habitat may also be important for foraging.

Woodlands used as roosting sites by *N. leisleri* were characterised by a higher herb cover and a higher percentage of sweet chestnut trees than expected, suggesting that the choice of chestnut trees for roosting was not casual. In our study area, managed chestnut stands, where trees are spaced and grazing reduces understorey growth, formed the majority of open woodlands with a well-developed herb cover, thus representing the habitat most used by Leisler’s bats for roosting. Chestnut orchards also have an open canopy structure that favour bats in searching and accessing the right cavity for roosting (Barclay et al., 1982; Vonhof and Barclay, 1996). Woodland structure also affects the thermal conditions of roosts: an open structure prevents the retention of humidity and heat (Constantine, 1966; Sedgeley, 2001), while solar radiation can penetrate easily and warm roosts. Although these are the general habitat conditions, roost type plays an important role. Deep cavities located in large trees can maintain a more constant temperature because of the thick bark providing a good insulation against weather conditions (e.g., Sedgeley and O’Donnell, 2004), while other types of roosts like exfoliating bark maintain a thermal gradient, from which bats can select optimal conditions through the day by adjusting their position (Rabe et al., 1998). So, within limits determined by macro-habitat (wood-structure) characteristics, bats can choose different types of cavities that allow them to maintain the best conditions for day roosting.

Finally, we found that woodlands with roost trees were closer to roads and water sources than random woodland areas. Proximity to foraging sites is an important factor for roost selection and Leisler’s bats often forage over water bodies and in proximity of riparian zones (Vaughan et al., 1997; Shiel et al., 1999; Waters et al., 1999; Russ et al., 2003). The vicinity of roosts to main and/or dust roads in the Malcantone forests is most likely related to previous and/or current management of the chestnut stands which were created near roads to have easy access with chariots and vehicles.

We conclude that Leisler’s bats in Alto Malcantone select roosts with particular features at tree level but mainly respond to stand-level characteristics. In particular, managed chestnut stands represent one of the most suitable roosting habitats for Leisler’s bat and their preservation appears of great importance. Therefore, restoration of unmanaged chestnut orchards is desirable, especially of those characterised by low naturality: removal of trees other than chestnuts, as well as the creation of a herb cover through clearing of the understorey and grass sowing are the first actions to be taken. The remaining chestnut trees should be maintained in good health by pruning, with special attention to ancient
trees. However, it is also desirable to preserve some decaying or dead trees that may offer suitable roosts to bats as well as to other animal species. Finally, long-term management of chestnut-dominated stands should also include planting young trees and maintaining a low tree density.

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LITERATURE CITED


RUSS, J. M., M. BRIFFA, and W. I. MONTGOMERY. 2003. Seasonal...


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