Roosting and social ecology of the tricolored bat, *Perimyotis subflavus*, in southwestern Nova Scotia

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Introduction

In a changing ecosystem, how specialized a species' requirements are can limit that species persistence in that system. Generalist species, including those that are not limited by food type or habitat availability may be less impacted by even major changes to their environment. They are able to more easily adapt and use alternate resources to persist. Specialist species, on the other hand, may be limited in their distribution due to a lack of suitable places to live or find food. These species are often found in lower numbers and may be rarer across their range than similar generalists depending on how specific their resource requirements are.

In Nova Scotia, three bat species comprise greater than 99 % of the known population. The little brown bat, *Myotis lucifugus*, is a roost and prey generalist, foraging over open water, in cities, and over fields, while roosting in buildings and trees. The second most common species, the northern long-eared bat, *Myotis septentrionalis*, is a forest dependant specialist, roosting mostly in trees and foraging along trails in the forest. The third species, the tricolored bat, *Perimyotis subflavus*, is broadly distributed in North America but has more specialized roost requirements. In Nova Scotia, reproductive females in maternity colonies have only been found in the southwestern portion of the province, with several colonies distributed around Kejimkujik Lake in Kejimkujik National Park. Due to a lack of occurrence records elsewhere in eastern Canada and the United States, it appears that the Nova Scotia population may be at the north eastern edge of the range and also be disjunct, putting it in the same category as the eastern ribbonsnake and blandings turtle; that is, glacial holdovers with low populations and limited distributions in Nova Scotia.

The primary purpose of this research was to determine the distribution of the tricolored bat in and around Kejimkujik National Park and the roosting requirements of reproductive females. Elsewhere they roost in clumps of oak leaves and Spanish moss. The secondary objective was to determine the extent of movement between colonies in the system, and if females had an affinity to a given roost area or if roost switching occurred on a large scale (i.e., not only between trees but between colonies).

Methods

From mid-May to late August 2003, 2004, 2007 and 2008, bats were trapped at the Eel Weir Bridge in Kejimkujik National Park using up to five 12 m mist nets. The nets were checked every ten minutes and captured bats were identified to species. Reproductive status, age, mass (g) and other pertinent data were recorded and all suitable tricolored bats were fitted with a 0.32 g radio transmitter affixed dorsally using a rubber cement adhesive. This adhesive is non-permanent and typically allows the transmitter to remain attached to an animal for up to 20 days, which is the approximate battery life of the transmitter. Since tricolored bats typically have a mass of approximately 6 g, juveniles or animals with low body mass were not selected to receive transmitters to adhere to an accepted standard of keeping tracking devices to a maximum of 5 % of the total mass of the animal. It has been demonstrated that there are potential adverse effects to flight dynamics when the mass of a transmitter surpasses this threshold.

Animals were located the day after capture using a three-element yagi antenna and VHF receiver. Small transmitters are limited in their tracking range and the topography of the area, and data from the first day after capture is typically discarded due to handling stress potentially causing the bat to behave differently (i.e., roost somewhere it typically would not be found, or by itself). Tricolored bats roost in foliage so bats were visually located using binoculars at the roost site and the tree was marked with flagging tape to make identification easier in subsequent visits. To quantify the roost requirements of the species, data were collected about the roost tree and surrounding area using a 0.1 hectare circle centered on the roost tree. The species, height, diameter, canopy closure of the tree, roost height and direction were recorded. During the project, it was observed that the species always roosted in clumps of old man's beard (*Usnea trichodea).* As such, the amount of usnea coverage in the tree was visually estimated by two observers, to the nearest 25 %. To reduce disturbance, these data were collected when there were no bats roosting in the tree. To characterize the surrounding forest relative to roosting areas and determine if the bats were using specific areas, three hundred random points were selected based on the maximum distance a bat had flown from roost to capture site. Data identical to known roost sites (using the 0.1 hectare plot) were recorded at each point. Random trees were compared to known roost sites using a logistic regression framework and AIC candidate model set with variables selected based on observed behaviour and relevant literature. These variables included distance to water (*dtw*), percent softwood in a plot (*psw*), amount of usnea coverage of the roost tree (*uir*), number of other trees in the plot with usnea (*nut*) and whether or not the roost tree was a spruce (*spr*).

Results

Although trapping was attempted at more than 20 sites in and around Kejimkujik National Park, bats were only successfully captured at the Eel Weir Bridge on the Mersey River site (UTM: 20N 324218E 4911256N) within the park. Of 208 bat captures, 44 were tricolored bats: 7, 14, 15 and 8 in 2003, 2004, 2007 and 2008, in over 2293 net hours (1 net hour equaled 1 twelve meter net open for one hourr) respectively. We also captured 127 *M. lucifugus* (37 males and 90 females) and 37 *M. septentrionalis* (7 males and 30 females). With the exception of seven individuals captured in 2007 at a roost tree, all tricolored bats tracked to all colonies were trapped at the Eel Weir location. Thirty-two adult females and 1 adult male were radio tracked over four summers. Although the male was tracked for 19 days to eight different roost trees, it always roosted alone and outside of areas used by female colonies, so the data for the male were not included in the analysis. The transmitters lasted from 1 – 19 days (mean = 8.4) and we located 99 different roost trees used on 261 bat days (2.6 bat days per roost). While bats roosted in a variety of trees, including red maple (*Acer rubrum, n* = 6*)*, balsam fir (*Abies balsamea*, *n* = 3*)*, eastern larch (*Larix laricina*, *n* = 3*)*, white birch (*Betula papyrifera*, *n* = 1*)*, white pine (*Pinus strobes*, *n* = 2*)*, and yellow birch (*Betula alleghaniensis*, *n* = 2*)*, they primarily roosted in conifers, mostly spruce (*n* = 82, 83%). No matter the tree species, all roosts were in *Usnea* lichen (*n* = 99, 100%) and the mean distance to water was 212 m. The center trees of the 300 random plots were both coniferous (*n* = 174, 58%) and deciduous (*n* = 126, 42%), dominated by white pine (*n* = 67, 22.3%) and red maple (*n* = 65, 21.6%). The prevalence of *Usnea* lichen on trees in the study area was low with only 11 of the center trees in random plots had any visible *Usnea*. Random trees averaged 550 m from water.

Of the 12 candidate models, the model which included the variables *uir, dtw nut* and *psw* had nearly a 95% chance of being the best model, given the data, and therefore we use only this model for inference. The *uir* ($\beta = 2.363$, SE = 0.387) variable was strongly positively correlated with bat presence, while *nut* ($\beta = 0.223$, SE = 0.058) and *psw* ($\beta = 0.04$, SE = 0.014) weakly positively predicted presence. Variable *dtw* ($\beta = -0.005$, SE = 0.002) had a weakly negative correlation with bat presence. The best predictor of presence, *uir*, demonstrated that for each 25% increase in *Usnea* coverage in the tree there was a 10.6 times higher probability of use by tricolored bats.

Discussion

The singular use of *Usnea trichodea* lichen as a roosting medium by tricolored bats in Nova Scotia appears to be a novel adaptation relative to elsewhere in their range. The use of foliage by bats for maternity colonies in Canada is limited to tricolored bats. The affinity for a specific roost substrate by tricolored bats coupled with larger numbers of individuals found together suggests that there may be energetic as well as protective benefits to the use of *Usnea* by this species. The lichen reduces energy costs by providing insulation leading to a stable microclimate and also camouflage against predators. This is relevant to tricolored bats, given that they enter torpor during the day. A reduction in the amount of energy needed to arouse from torpor due to the insulating properties of *Usnea* is an added benefit. While *Usnea* lichen in boreal forests is common on conifers in bottomland locations due to lower temperatures and higher relative humidity, there were hardwood trees (typically *Acer* or *Betula* spp.) within the roosting areas of tricolored bats which we deemed potential roost sites (*uir* ≥ 2) but these were usually not known to be used. This could be due to higher amounts of foliage and canopy closure in the tree crowns. The preferential use of dead or dying spruce, which usually has both fewer and smaller branches closer to the crown and an open canopy, would provide benefits via microclimatic variation and increased control over exposure to solar radiation at roosting locations.

We found no evidence of movement among roosting areas by any bats within or between years. This supports the prediction that these bats form closed social roosting groups, which is similar to data collected on similar temperate bat species. We tracked bats for 8.4 days on average, and although females switched roosts regularly they never roosted with individuals within the roost area of another colony. One possible explanation for frequency of roost switching is an excess of available trees and variable microclimates between roost sites (i.e., position of roost relative to canopy, sun or distance to water) which may better suit individuals or groups depending on their needs at a given time (i.e., group size, reproductive condition, weather). More data are needed to determine if these roost areas are in fact territories or simply multiple satellite colonies of related individuals.

Females were found in groups of 2 – 18, although several individuals roosted singly in late July. This may be due in part to colony fragmentation, particularly of females who may have been non-reproductive during the summer. The majority of roosting areas identified over the four years of this study (6) were found in 2003 with one each per year in 2004, 2007 and 2008. It is estimated that the population in this system is limited to 80 to 100 individuals based on emergence counts at roost sites and number of roost areas. Female forest dwelling tricolored bats roost have an intra- and inter-year fidelity to a particular roosting area that they share with other individuals. There was no evidence that individuals roosted in or with individuals assigned to other roosting areas and therefore these roosting groups appear to be "closed". Despite this, individuals of all colonies shared foraging space.

Kejimkujik may be acting as an island for this species in Nova Scotia; it has been protected for 40 years, resulting in the establishment of areas that are ideally suited to this species. Over the long term, for the species to expand, more of these areas will need to be identified and maintained. The first step in this process would be to identify areas of a) shallow depth to ground water b) poor drainage (i.e., lower elevation relative to the landscape) and c) stands of trees which are dominantly softwood. A GIS could be used to determine if these areas exist and where they are located. It is also important to understand the effect, if any, that the intensive logging in southwest Nova Scotia may be having on this species. The potentially small, disjunct population of this species in Nova Scotia could be an important pool of genetic material in the future as biological and anthropogenic pressures reduce the populations of tricolored bats in the northeastern United States. The intraspecific variation in roost site selection documented here, relative to conspecific populations suggest that caution should be used when making local management decisions based on data collected elsewhere. The importance of peripheral populations coupled with the development of this novel roosting behavior underscores the importance of conserving this population of tricolored bats in Nova Scotia.

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