

Attributes of Mountain Bluebird Cavity Nests

Nicole Krauss

Co-investigator: Jessica Kortmeyer

Mentor: Chris Floyd

Structured Undergraduate Research Program

Rocky Mountain Biological Laboratory

P.O. Box 519

Crested Butte, CO 81224

Abstract:

There are two types of cavity nesting birds: excavators and non-excavators. In the aspen (*Populus tremuloides*) woodlands of Colorado, the red-naped sapsucker (*Sphyrapicus nuchalis*) is the predominant primary cavity nester. Sapsuckers excavate new holes each year in trees infected with the heartwood rot fungus (*Phellinus tremulae*). A common secondary cavity-nester is the mountain bluebird. We tested if characteristics of bluebird nests were non-random in comparison to other secondary cavities. The characteristics considered were DBH, height of nest, cavity opening orientation, percent tree cover, and distance to nearest water, willows and edge. We found that mountain bluebirds inhabit trees with significantly larger diameters than other trees containing secondary cavity nesters. We suggest this is for thermoregulation purposes, because larger trees have a higher average temperature within the cavity. The cavity opening orientation was significantly non-random facing east-southeast, although this was not significantly different from other secondary cavity nesters. This may also be for thermoregulation, as this is the sunny side of the tree. Mountain bluebird cavities were slightly further from willows and water. A reason for that may be that more aggressive secondary cavity nesters may out-compete bluebirds from higher quality sites that are closer to water and willows. All other factors considered were not significantly different from other secondary cavity-nests, but based on observation we suggest that bluebirds may have large territories. They may also be generalists when it comes to specific nest site characteristics, but the distance to nearest conspecific should be considered in future studies.

Introduction:

Between the Cretaceous and the Eocene periods birds began to adopt safe nesting, which are protected sites (Owens and Bennett 2005). Woodpeckers are the main excavators of these cavities today (Aitken et al. 2002). Cavity nesting played a huge evolutionary role in the diversification of birds because of its unique benefits. A primary advantage is increased temperature. The incubation period is a time of great energy expenditure for female birds and a critical time in the physiological development of the chicks (Conway and Martin 2000). Thermoregulatory costs account for 40 - 60% of total energy expenditures (Walsberg 1983). Cavity nests provide protection from wind, as found in a study of mountain chickadees and juniper titmice in which cavities were 2.5°C to 4.9°C warmer than other types of nests, primarily due to decreased wind (Cooper 1999). Therefore, cavity nests reduce energy expenditure needed to incubate eggs. Another benefit of cavity nesting is protection from predation. A strategy used by birds that are at high risk to predation is to take longer bouts on and off the nest to decrease activity around the nest. This comes with the costs of eggs reaching lower temperatures, and females needing to spend more energy to return eggs to optimal

temperature. Because cavity nests are less accessible to predators, cavity nesters are able to make many trips in and out of the nest, relative to non-cavity nesters (Conway and Martin 2000). The increased advantages of cavity nesting results in a significant decrease in reproductive efforts (Conway and Martin 2000). Indeed, the adoption of safe nests is largely responsible for an explosion in species diversification (Owens and Bennett 2005).

Within the large and varied group of cavity nesters there are two predominant types of birds, those that excavate cavities and those that nest in existing cavities. In the aspen (*Populus tremuloides*) woodlands of western North America, the red-naped sapsucker (*Sphyrapicus nuchalis*), is the predominant primary cavity excavator, providing nest sites for many other secondary cavity-nesting birds and organisms. Sapsuckers build a new hole every year, but only in trees infected with the aspen heartwood rot fungus, *Phellinus tremulae*. The heartwood rot fungus softens the interior of the tree, making it easier for sapsuckers to excavate cavities. Together, these two organisms comprise a keystone species complex that strongly influences the avian community in the aspens (Daily et al. 1993). In a five-year study of cavity reuse in British Columbia, Aitken et al. (2002) found that 48% of sites used by secondary cavity nesters were reused the following year. However, multiple species of woodpeckers create cavities, whereas sapsuckers are the predominant excavators in the Gunnison National Forest near Gothic, Colorado.

There are at least seven species of secondary cavity nesters in Colorado that are dependent on sapsucker cavities (Daily et al. 1993). These birds choose from the available sites, and some sites are more suitable than others (Aitken et al 2002). Limited availability of nest sites creates interspecific and intraspecific competition for the most suitable cavities among birds that use existing cavities (Aitken et al. 2004). A study of secondary-nesters found that females in areas of limited nest sites spent more time feeding their young (Jacot et al. 2009). This indicates that the quality of the nest site can impact the behavior of the nesting bird. Studies of secondary-nesters found that deeper holes with larger entrances are reused more often than shallower, narrower cavities (Aitken et al. 2002). In addition, cavities near the edge of the forest and locations with more edge were more heavily populated than those deep within the forest

(Aitken et al. 2002). In particular, cavities within 15 m from the edge were the heavily reused.

One of the most common secondary cavity nesters is the mountain bluebird, *Sialia currucoides*. Little is known about the specific cavity preferences of the mountain bluebird, because most studies used nest-boxes. Although such studies have gained insight into bluebird nesting behavior, there is a general lack of knowledge about bluebird nests in their natural habitat. Bluebird nest site preference is particularly valuable because availability of cavities is a predictor of population size (Lohmus and Remm 2005). We sought to determine which characteristics of nest trees and surrounding landscape context are selected by the mountain bluebird. We conducted an observational study in which we found bluebird nests and compared them to other second-cavity nests and unused nests. The goal of this study was to detect if there were non-random attributes that bluebirds select within the already limited cavities available.

Methods:

In order to determine nest site attributes, we measured nest height, nest opening compass orientation, the distance from the nest to the edge of the aspens, distance to the nearest willows, distance to nearest water, diameter at breast height (DBH) and percent tree cover around the nest. Nest site characteristics of mountain bluebirds were compared to characteristics of available nest cavities to determine whether bluebirds preferentially select nest sites with certain characteristics, or if their choice is random.

Between 18 June and 10 July 2009, we sampled nest sites by walking approximately 30 m wide transects in aspen forests between 2800 – 3050 m elevation in Gunnison National Forest lands near the Rocky Mountain Biological Laboratory, Gothic, Colorado. Cavity-nesting bird species fly in and out of the nest more frequently during this period, and it was easier for us to determine which species was in the cavity. All second-cavity nests found were marked with flagging and a small aluminum tag nailed to the tree. Latitude, longitude and elevation were recorded at each site using a hand-held GPS unit; we also recorded the number of occupied and unoccupied cavities.

We found 237 cavities, eight of which had nesting mountain bluebirds. However, due to time constraints, we were unable to collect data for all of the non-bluebird

cavities. Subsamples were selected by using a random number generator and selecting numbers 1 through 15 of each species to measure. If we did not have 15 cavities of a particular species, all cavities of that species were measured.

For each selected tree, we recorded the compass orientation of the opening, estimated the nest height and measured distances to willows water and edge of aspens. We found the directional orientation by lining one person up directly under the cavity, and taking a reading on a compass. To measure nest height, one person held a dead branch or tree against the tree with the cavity while the other person spotted where the nest was along the dead tree. The dead tree or branch was then lowered and we measured the distance from the bottom to the spotted point with a tape measure.

We used a tape measure to record the distances to edge, willows and water within 100 meters. The edge was determined by walking to the edge of the trees, specifically, the edge of the canopy. We defined the edge as the edge of a meadow $\geq 100 \text{ m}^2$ (10 x 10 m, 8 x 12.5 m, or 5 x 20 m) not containing any aspen trees $> 5 \text{ cm}$ DBH. We similarly defined a willow patch as covering at least 100 m^2 . If the distance to the variable was greater than 100 m, we measured the distance using GPS points.

Once all measurements that could be made at the nest sites were complete, we measured the remaining distances and calculated percent tree cover around each tree using aerial images from Google Earth. While in the field, several GPS points were taken at willows, water and edges in order to easily calculate distances using a computer. We used the existing nest site GPS points to map their locations. We used the ruler tool in Google Earth to measure distances between GPS points. We overlaid a one hectare grid onto Google Earth images, centering each point within the grid. Then, we counted the number of intersections within the grid that contained woodland cover, and calculated the percent of the hectare that was forest.

We analyzed all data with the exceptions of orientation and nest height using Van der Waerden tests. This test compared mountain bluebird cavity means to means of all other cavities and adjusted for non-normality. Nest height data were analyzed using a t-test because the data met the assumptions of normality. Data on cavity opening compass orientation were analyzed using Rayleigh's test to determine if the sample was

non-random and a Watson U² test was used to compare mountain bluebird cavity orientation to other cavity orientations (Zar 1999).

Results:

Analysis of DBH (Figure 1) showed that mountain bluebirds inhabited significantly larger trees than other secondary cavity nesters (Table 1). All other Van der Waerden tests did not reveal significance, however, a few characteristics showed noticeable tendencies. The distance to nearest willows was slightly farther for mountain bluebird cavities when compared to other cavities as shown in Figure 2.

Diameter at Breast Height of Tree

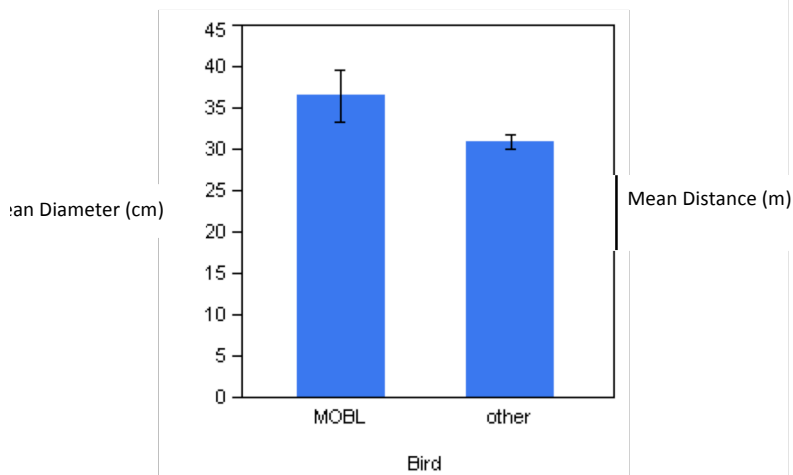


FIGURE 1. Comparison of DBH between mountain bluebird (MOBL) cavities and other secondary-cavity nest. There is a tendency for bluebirds to nest in larger trees than other second-cavity nesters ($p=0.06$).

Distance to Nearest Willows

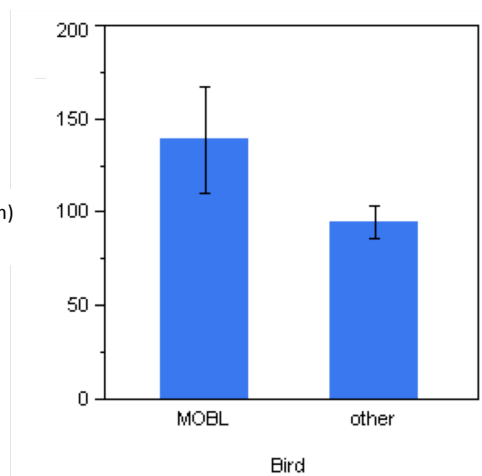


FIGURE 2. Comparison of mean distance to nearest willows between mountain bluebird (MOBL) cavities and all other cavities. The mean distance of mountain bluebird nests to willows is slightly farther from the willows than other secondary-cavity nests ($p=0.10$).

The mean distance to nearest water was slightly greater for mountain bluebirds (Figure 3).

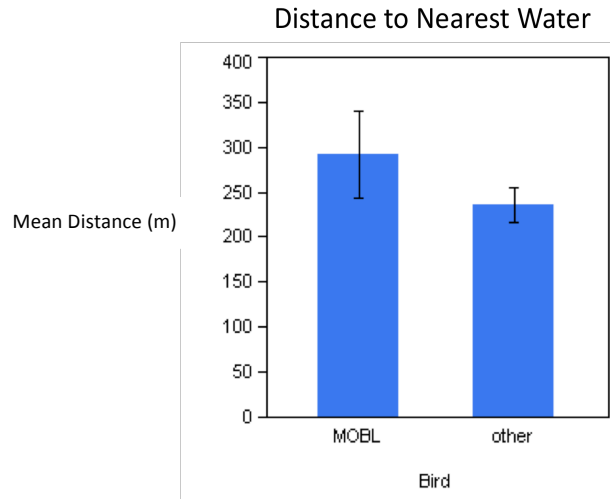


FIGURE 3. Comparison of mean distance to nearest water between mountain bluebird (MOBL) cavities and all other cavities. There is a slight tendency for MOBL cavities to be farther from water

There was no significant difference between mountain bluebird cavities and other cavities for all other characteristics. The mean distances of all cavities to edge were generally equal as were mean proportions of tree cover. Nest height was evaluated using a t-test because the data were normal. The difference between mean bluebird nest height and mean height of other cavities was also insignificant.

A Rayleigh's test of the mean nest opening orientation revealed that mean mountain bluebird nest opening orientation is significantly non-random as is opening orientation of all other cavities. Mean mountain bluebird cavity orientation is east-southeast and mean other cavity orientation is southeast. However, further analysis using Watson's U^2 method showed that opening orientation of mountain bluebird cavities did not significantly differ from orientation of other cavities (Zar 1999).

Measured Variable	Mean MOBL	Mean Other	SD MOBL	SD Other	<i>P</i>
DBH (cm)	36.4438	30.8662	9.01053	7.47361	0.06
Distance to Willows (m)	139.006	94.603	80.5493	72.2943	0.10

Distance to Water (m)	291.264	235.320	135.558	154.312	0.19
Distance to Edge (m)	26.1788	23.7231	36.6834	24.1572	0.62
% Tree Cover	61.4663	65.2863	25.1302	23.2863	0.63
Orientation of MOBL cavities	114.363° (E-SE)	N/A	50.635°	N/A	0.02
Orientation of other cavities	N/A	139.049°(SE)	N/A	76.857°	<0.001
Difference between orientation of MOBL cavities and others	114.363° (E-SE)	139.049°(SE)	50.635°	76.857°	U ² =0.09
Height of Nest	3.59000m	3.76982m	1.09555m	1.20836	0.72

TABLE 1. The last column lists *p*-values for all tests comparing mountain bluebird cavities to all secondary cavity-nesters. Circular statistics were used to analyze cavity orientation, which gives a U² value instead of a *p*-value. The *p*-value for % Tree Cover was found by using an arcsine transformation. Orientation results are from Rayleigh's test of non-random orientation and the Watson U² test. The critical value for our data for the Watson U² is 0.1855.

Discussion:

The most significant finding of our research was a larger DBH of trees inhabited by mountain bluebirds. It is uncertain why mountain bluebirds would prefer larger trees, but one possibility could be for thermoregulatory purposes or protection from predators. In a study of northern flicker nests, it was found that smaller trees reached more extreme temperatures, and had a cooler average temperature than larger trees (Wiebe 2001). The same study also found a positive correlation between cavity temperature and clutch size, indicating that temperature can affect reproductive success. Birds nesting at high elevations in the Rocky Mountains endure extreme temperatures and have adapted in behavioral, physiological and morphological ways to cope with the harsh environment (Martin and Wiebe 2005). Another possible reason for large tree

preference is reduced predation. In another study of northern flicker cavities, larger cavities were found to be less susceptible to predation (Wiebe and Swift 2001). Larger cavities are positively correlated with larger trees; therefore, larger trees may be less vulnerable to predation (Wiebe 2001). The suggested reasoning is that it may be harder for predators to get into deeper holes, or birds are somehow more able to defend larger holes (Wiebe and Swift 2001). Using this reasoning, it is possible that mountain bluebirds select larger trees for protection from rodents or egg destroying house wrens.

It is likely that larger trees are selected in order to ensure higher nest temperatures. The significantly non-random orientation, east south-east, may also be selected for thermoregulation purposes. Wiebe (2001) found that cavities facing the sunny side of the tree were warmer than cavities oriented in other directions. East south-east is the sunny side of the tree in the morning, when birds are warming up from cold nights.

Our data show that mountain bluebird cavities were further from willows than other second cavity nests. This could be because mountain bluebirds are poor competitors, and other birds out-compete them for closer nests. Aitken and Martin (2008) conducted a study in which 50% of high quality cavities in their experimental site were blocked and compared this site to a control site. European starlings, the most common secondary-cavity nester in the area, decreased its number of nests in the experimental site and increased in the control site. The mountain bluebird population did the opposite: it increased in the experimental site and decreased in the control site. This suggests that mountain bluebirds suffer due to competition. During our own study, we observed a switch of cavities between a pair of tree swallows and mountain bluebirds. This was probably the result of the more competitive tree swallows usurping the mountain bluebirds, and the bluebirds relocating to the nearest available spot. With only eight bluebird cavities in our sample, it's a good indication that mountain bluebirds are subordinate to more aggressive competitors such as tree swallows or house wrens.

We did not analyze the spatial distribution of the mountain bluebirds, but based on observation, it is clear that mountain bluebirds are more spread out than other second cavity nesters. This is consistent with Holt and Martin's (1997) findings that bluebirds will defer breeding rather than nest near conspecifics. It may be necessary for

bluebirds to be generalists in nest selection in order to find and maintain a cavity far enough away from other bluebirds.

Although most of our findings did not provide definitive answers, they do give us insight into mountain bluebird nesting selection. If bluebirds are primarily selecting nests sites based on territory, it could be that bluebirds are generalists when it comes to choosing the specific cavity. There is plenty of room for future research, especially with regards to spatial distribution of mountain bluebirds. However, it is clear that large amounts of forests need to remain undisturbed for mountain bluebirds to have adequate space to disperse and nest.

References

- Aitken, K. E. H., K. L. Wiebe, and K. Martin. 2002. Nest site reuse patterns for a cavity-nesting bird community in interior British Columbia. *Auk* 119:391–402.
- Aitken, K.E.H., K.L. Wiebe, and K. Martin. 2004. Nest sites and nest webs for cavity-nesting communities in interior British Columbia, Canada: Nest characteristics and niche partitioning. *The Condor* 106:5-19.
- Aitken, K.E.H., and K. Martin. 2008. Resource selection plasticity and community responses to experimental reduction of a critical resource. *Ecology* 89:971-980.
- Conway, C. J., and T. E. Martin. 2000. Evolution of passerine incubation behavior: Influence of food, temperature, and nest predation. *Evolution* 54(2):670-685.
- Cooper, S. J. 1999. The Thermal and Energetic Significance of Cavity Roosting in Mountain Chickadees and Juniper Titmice. *The Condor* 101(4):863-866.
- Daily, G. C., P.R. Erhlich, and N. M. Haddad. 1993. Double keystone bird in a keystone species complex. *Ecology* 90:592-594.
- Holt, R. F. and K. Martin. 1997. Landscape modification and patch selection: The demography of two secondary cavity nesters colonizing clearcuts. *The Auk*

114: 443-445.

Jacot, A., M. Valcu, K. van Oers, and B. Kempenaers. 2009. Experimental nest site limitation affects reproductive strategies and parental investment in a hole-nesting passerine. *Animal Behaviour* 77:1075-1083.

Lohmus, A., and J. Remm. 2005. Nest quality limits the number of hole-nesting passerines in their natural cavity-rich habitat. *Acta Oecologica* 27:125-128.

Martin, K. and K. L. Wiebe. 2005. Coping mechanisms of alpine and arctic breeding birds: extreme weather and limitations to reproductive resilience. *Integrative and Comparative Biology* 44: 177-185.

Owens, I.P.F., and P.M. Bennett. 1995. Ancient ecological diversification explains life-history variation among living birds. *Proceedings: Biological Sciences* 261:227-232.

Walsberg, G. E. 1983. Coat and color solar heat gain in animals. *BioScience* 33: 88-91.

Wiebe, K. L. 2001. Microclimate of Tree Cavity Nests: Is It Important for Reproductive Success in Northern Flickers? *The Auk* 118:412-421.

Wiebe, K. L., and T. L. Swift. 2001. Clutch size relative to tree cavity size in northern flickers. *Journal of Avian Biology* 32(2):167-173.

Walsberg, G. E. 1983. Incubation in Desert-nesting doves: mechanisms for egg cooling. *Physiological Zoology* 59: 88-93.

Zar, J. H. 1999. *Biostatistical Analysis*. Prentice Hall, Upper Saddle River, NJ.

