

Summary of nest box monitoring 1998-2008 at Elkhorn Slough National Estuarine Research Reserve

Overview and objectives

Each spring and summer, a team of volunteers monitors about 150 nest boxes in the oak woodlands of Elkhorn Slough National Estuarine Research Reserve (ESNERR) weekly. By carefully checking the boxes and consistently recording what they see, the volunteers are able to obtain data on nest box occupancy (which boxes are occupied, and by which species), phenology (timing of reproductive events), indicators of reproductive success (clutch size, hatching rate, fledging rate) and parasitism (blowflies in nesting material). Monitoring these parameters serves as one way of keeping track of the health of oak woodland communities over time at the Slough. For instance, dramatic declines in nest box use or fledging rate would serve as a warning signal alerting managers to potential problems in these habitats, and would motivate a search by researchers for new negative environmental influences in the area. In addition to tracking patterns over time, this monitoring may also be useful for examining patterns over space. For example, following the planned restoration of the oak understory, comparisons can be made between nesting in restored and unrestored woodlots to assess community consequences of restoration. Data from ESNERR are also submitted to the Cornell Lab of Ornithology, which manages a national database of volunteer nest box records, and identifies large-scale trends using this information.

Investigators

A team of ESNERR volunteers carries out the nest box monitoring. Each year, about 5-10 volunteers meet in February, before the nesting season, to coordinate methods and training. For the following four months, each volunteer is responsible for checking all the nest boxes in one woodlot at least weekly. One volunteer in particular, S. Murphy, helps coordinate the team, substitutes for absentees, maintains the boxes, collects additional box data, and overall is responsible for the continued success of the project. Many other volunteers have spent hundreds of hours monitoring nest boxes; this work would not be possible without them. The volunteer team for 1998-2008 included R. Armstrong, J. Burke, K. Christopherson, M. Cruse, B. Davis, L. Davis, J. De La Torre, L. Easley, Ron, Eby, S. Evans, S. Fork, B. Frimodig, S. Gaebelein, R. Goldman, T. Hart, K. Hannay, G. Hartley, S. Hartley, L. Jordan, M. Kennedy, J. Kourassis, K. McFarland, J. Moir, S. Murphy, P. Olson, D. Paris, C. Patton, D. Pitschka, A. Rayburn, K. Rayburn, K. Reddy, D. Satow, J. Stacey, Sullivan, L. Taravella, R. Todd, and B. Turvey. More committed volunteers willing to monitor woodlots consistently every week are always needed to join the project; call S. Fork (728-2822) if interested.

Methods

Presently, there are 158 available nest boxes located in 9 different woodlots in oak woodlands at ESNERR; 142 of these are made of wood and 16 are made of cement. The number of nest boxes in each woodlot varies from as few as 7 to as many as 53 (Table 1). The nest boxes are attached to coast live oak tree trunks approximately 6 feet from the ground. Some boxes were first installed in 1992 (by A. Thompson, who

used them for behavioral research); these have been supplemented by additional boxes in following years. However, consistent, large-scale volunteer monitoring did not begin until 1998. The following methods were employed during 1998-2008 to determine nest box use and nesting success.

Before the beginning of the nesting season, the nest boxes were made available to birds by closing the nest box door, which had been left open during the fall and winter. Observations of nest boxes began in mid-February. As a nest box was approached, the observer looked and listened for birds in or near the box. Before the box was opened, the observer used a flashlight and mirror to peer inside the box. If the box was empty, the observer recorded this and moved on to the next box. If a mouse occupied the box, the door was opened and left open to force the mouse to vacate the box. In 2002, we put mouse proofing on 68 of the boxes. This mouse proofing is soft-sheet plastic, which is cut to fit over the front of the box with a hole cut into the material to keep the nest box-hole exposed.

As soon as nesting material was observed inside a box, the box was monitored at least once a week, but not more than twice a week. Active boxes were approached cautiously. Using the flashlight and mirror, the observer peered inside to see if there were eggs. The observer attempted to determine the date that the first egg was laid and the date when the last egg was laid based on the number of eggs first observed in the nest box and final clutch size. Once the eggs hatched, the nest boxes were checked once a week until the chicks fledged. After the young had fledged, the nest box was checked for infertile eggs or dead chicks. Chicks were assumed to have fledged if the nest box was found empty; number of chicks last seen was the number of chicks recorded as fledged. Since 2000, we have collected nests, sealed them in labeled Ziploc bags, and sent them to T. Whitworth for quantification of blowfly parasitism.

Results

The following results were obtained for the 1998-2008 nesting seasons.

Nest box availability and use

In 1998 and 1999, 143 nest boxes were available for use; in 2000, the number of available boxes increased to 151. From 2001 to 2008 the number of nest boxes increased to 158. The highest proportion of nest box use (including double clutches) occurred in the 2002 breeding season; 42.4% (67) of all nest boxes had active nests, while the lowest percent of active nests occurred in 2007, 15.1% (24). Use of available boxes in the other years are as follows: 17.7% (28) of available boxes were used in 2008; 27.7% (44) were used in 2006; 25.9% (41) of available boxes were used in 2005; 21.9% (35) of available boxes were used in 2004; 40.5% (64) in 2003; 26.6% (42) were used in 2001; 25.2% (38) were used in 2000; 20.2% (29) were used in 1999 and 18.9% (28) were used in 1998 (Table 1, Figure 1). In 2002 and 2003, there were greater numbers of double clutches or birds using the same boxes to nest (7 in 2002 and 8 in 2003). From 1998 – 2001 and from 2004 - 2006, 1 to 3 of the boxes had double clutches; 2007 and 2008 had no double clutches.

The percentage of active nest boxes in each woodlot varied from 0 – 67%; use among woodlots was not significantly different in any year (1998: $P = 0.14$, 1999: $P = 0.22$, 2000: $P = 0.62$; 2001: $P = 0.93$; 2002: $P = 0.40$; 2003: $P = 0.76$; 2004: $P = 0.50$; 2005: $P = 0.33$; 2006: $P = 0.09$; 2007: $P = 0.92$; 2008: $P = 0.75$). The P value indicates the proportion of times one would expect to observe this outcome by chance alone. A low P value, e.g., $P = .005$, means it's very unlikely the pattern would have occurred by chance; in other words, a significant effect has been detected. The high P value in 2001 (0.93) means that the differences among woodlots in percentage of boxes used might have been expected to occur by chance alone in 93% of cases, so there was no significant pattern of nest box use among woodlots. However, if you look at all of the years combined, there were significant differences between woodlots ($P = 0.02$).

The number of nest attempts each year (including double clutches) ranged from a minimum of 24 nests in 2007 to a maximum of 67 nests in 2002 (Table 2). Differences among years were statistically significant ($P < 0.0001$).

Species use of nest boxes

Nest boxes were predominately used by two species: the Chestnut-backed Chickadee (*Parus rufescens*) and the Oak Titmouse (*Parus inornatus*) (Figure 2; Table 3 & 4). In all years, between 58% and 78% of active nests were occupied by chickadees; titmouse use ranged from 19% to 32%. Additional species using the nest boxes were the Tree Swallow (*Tachycineta bicolor*) and Bewick's Wren (*Thryomanes bewickii*). Species use over time did not change significantly ($P = 0.57$).

Clutch size, hatching rate, and fledging rate

Average clutch size of Chestnut-backed Chickadees was 6.2 eggs/nest and 6.3 eggs/nest for the Oak Titmouse. There were no significant differences in maximum clutch size for either species over time; however, Chestnut-backed Chickadee maximum clutch size was significantly smaller in 2003 and 2007 than in 2001 and smaller in 2002, 2003, 2006, and 2007 than in 2005. Oak Titmouse maximum clutch size was significantly smaller in 2005 and 2007 than in 2000, 2001, and 2004. Overall, maximum clutch size did not differ between woodlots ($P = 0.17$); however, clutch size for Chestnut-backed Chickadees was significantly lower in woodlot 8 than in woodlot 3 and 6. For Oak Titmouse maximum clutch size was significantly lower in woodlot 2 and 4 than in woodlot 6.

Overall hatching rate in our woodlots was quite variable, ranging from 68% (2006) to 99% (1998) and was significantly different among years ($P = 0.002$). Hatching rates were lower in 2006, 2007, and 2008 than in previous years. Total number of hatchlings mostly increased over time until reaching a peak of 354 hatchlings in 2002 and then decreased from 2004 to 2008 (Table 5). Hatching rate for Chestnut-backed Chickadees was variable, ranging from 64% to 100%. Hatching rate for chickadees did vary significantly among years ($P = 0.002$), with 2006 having the lowest hatching rate at 68%. Hatching rate for the Oak Titmouse was also variable, ranging from 52% to 98%.

Hatching rate for the Oak Titmouse did not vary significantly among years ($P = 0.10$). (Table 5)

Fledging rate was high, ranging from 86% to 98% of hatchlings fledged, and varied significantly among years; in 1998, 92% of chicks fledged; in 1999, fledging rate increased to 97%; in 2000, fledging rate was 92%; in 2001, fledging rate increased to 98%; in 2002, fledging rate declined to 86%; in 2003, fledging rate was 90%; in 2004, fledging rate was 96% and in 2005 was 95%. Fledging rate again decreased to 87%, then increased in 2007 to 97% and in 2008 was 98% ($P = 0.007$) (Table 6). Total number of fledglings mostly increased over time from 1998 to 2003, with a peak of 291 fledglings in 2002. During 2004 to 2008, total number of fledgings was lower; ranging from a low of 79 fledgings in 2007 to high of 150 in 2004 (Table 6). Fledging rate for the Chestnut-backed Chickadee varied significantly among years ($P = 0.03$); fledging rate in 2002 was significantly lower than in all other years except 2006. Fledging rate for the Oak Titmouse did not vary significantly among years. Fledging rates were, however, still variable among years, from a low of 70% (15 fledgings) in 2006 to a high of 98% (48 fledgings) in 2001.

Phenology

The peak egg-laying period varied significantly among years for both species ($P < 0.001$). Peak egg-laying period for Chestnut-backed Chickadees for many years (2001, 2002, 2004-2006, and 2008) occurred during the last two weeks of March. In the other years, the egg-laying period peaked later in the season (first two weeks of April for 2000, 2003 and 2007, and the last two weeks in April for 1998 and 1999). Overall from the 1998 – 2008 observations, for chickadees, reproduction began and peaked earliest in the years 2001, 2004, and 2005 (late March) and was latest (mid – late April) in 1998, 1999, and 2007. For Oak Titmouse, peak egg-laying occurred during the first two weeks of April for the years 1998 – 2000. From 2001- 2008 peak egg-laying occurred during the last two weeks of March. Overall (from the 1998 – 2008 observations) for Oak Titmouse, reproduction began and peaked earliest in the years 2002 -2005 (mid – late March) while was the latest (early April) in the years 1998 – 2001. In fact eggs were found in nest boxes housing titmice only until mid-April while chickadee eggs were found in nest boxes as late as mid-June (Figure 3).

Nest box aspect and type

No aspect was used significantly more than others ($P = 0.71$); however, the largest proportions (relative to availability) of active nests in all years combined were in southwest and west facing nest boxes (17% and 15%, respectively) (Figure 4). No significant difference was found between the types of nest box (wood or cement) used by nesting birds in 1998 – 2002 and 2005 - 2008 (1998: $P = 0.84$; 1999: $P = 0.91$; 2000: $P = 0.22$; 2001: $P = 0.65$; 2002: $P = 0.93$; 2005: $P = 0.96$; 2006: $P = 0.07$; 2007: $P = 0.06$; 2008: $P = 0.14$). However, birds nested significantly more frequently in cement boxes than in wood boxes in 2003 ($P = 0.04$) and in 2004 ($P = 0.02$).

Mouse nests

In 1999 - 2008, the presence of mouse nests in nest boxes was recorded. In 1999, 47% of nest boxes had a mouse nest at least once during the breeding season; in 2000, 35% of nest boxes had mouse nests; in 2001, 87% of the available nest boxes had mouse nests; in 2002, 32% of nest boxes had mouse nests; in 2003, 37% of the available nest boxes had mouse nests; in 2004, 47% of the available nest boxes had mouse nests; in 2005 and 2006, 42% of the available nest boxes had mouse nests; in 2007, 34% of the available nest boxes had mouse nests; in 2008, 35% of the available nest boxes had mouse nests. In most years, the majority of active bird nests were built in boxes that did not have mouse nests, except in 2001 & 2003. In 1999, 72% of bird nests were built in “mouse-free” boxes ($P = 0.02$); in 2000, 92% of nest boxes with active nests were devoid of mouse nests ($P < 0.0001$); in 2002, 69% of nest boxes with active nests were built in “mouse-free” boxes ($P = 0.97$). The values for the remaining years are as follows: 69% of bird nests were devoid of mouse nests in 2004 ($P = 0.03$), 68% in 2005 ($P = 0.11$), 61% in 2006 ($P = 0.57$), 63% in 2007 ($P = 0.71$), 79% in 2008 ($P = 0.10$). By contrast, in 2001, only 26% of bird nests were built in “mouse-free” boxes, while 74% of nests were built in boxes that had mouse nests ($P = 0.002$). This could be due to the high percentage of boxes that had mice nesting. In 2003, 56% of nest boxes with active nests were devoid of mouse nests, but there were no significant differences between birds nesting in boxes with mice and without mice ($P = 0.15$). Still, the presence of mouse nests in nest boxes may be a deterrent to birds in search of a suitable nest site.

Mouse proofing

In 2002, mouse-proofing material was placed on 68 nest boxes. There were significantly fewer mice nesting attempts in boxes with proofing than without ($P = 0.02$). In 2002, 79% of mice nesting attempts occurred in boxes without proofing, while only 21% of mice nesting attempts occurred in boxes with proofing. The years 2004 – 2008 had similar outcomes. Significantly fewer mice nesting attempts occurred in nest boxes with mouse proofing; 9 – 22% of mice nesting attempts occurred in boxes without proofing, while 78 – 91% of mice nested in boxes without proofing (P -values ranging from 0.01 to <0.0001).

In 2002, 47% of boxes without mouse proofing had birds nesting while 29% of boxes with mouse proofing had birds nesting ($P = 0.02$). This may indicate that birds do not prefer to nest in boxes with mouse proofing. However, from 2003 – 2008, there were no significant differences in birds nesting in boxes with or without mouse proofing ($P > 0.05$). This may indicate that birds will nest in boxes either with or without mouse proofing.

Banding

Volunteer T. Hart has banded many nestlings and a few adults each year. With a few exceptions, banded birds have not been seen in subsequent years.

Parasitism

In 2000, 20 nests were sent to T. Whitworth, a parasitologist, for analysis. He reported that none of these nests were infested with blowflies (*Protocalliphora*). In 2001, an

unknown number of nests were sent for analysis; none were infested with blowflies. In 2002, 47 nests were sent for analysis, and none were infested with blowflies. In 2003, 53 nests were sent in for analysis, and none were infested with blowflies. For the remaining years, numbers of nests submitted for blowfly analysis were as follows: 2004 and 2005, unknown; 2006, 27 nests; 2007, unknown; 2008, 20 nests. None were infested with blowflies. According to Dr. Whitworth, this is a very unusual phenomenon. In most cases, at least some nests are infected.

Discussion

Ecological correlates of nest box occupancy and reproductive success

Our results revealed a significant difference among woodlots in nest box occupancy. In the future, we would like to attempt to understand the underpinnings of this pattern, by assessing ecological parameters (canopy density, understory composition, proximity to grassland, etc.) for each box site. Such an assessment would allow us to determine the factors that shape nest box choice at ESNERR. Moreover, we could look for correlations between these ecological parameters and reproductive success. Understanding what aspects of oak woodlands are valuable to their nesting bird communities might shape future restoration decisions.

Timing of chick development

Little is known about the length and timing of different phases of chick development in Chestnut-backed Chickadees. Weekly monitoring is not sufficient to determine exact timing. However, the ESNERR nest boxes lend themselves ideally to such a study by a volunteer or local student able to invest the time in checking and recording chick stages (naked, “in pin”, fully-feathered, etc.) on a daily basis, for ten or more nests.

Mice and nesting birds

Our results revealed a negative correlation between occupancy of boxes by nesting mice and birds in most years, suggesting that birds avoid nest boxes occupied by mice at any point in the season. Removing nesting mice once they have young is inappropriate on an ecological reserve, whose mission is to protect all native species. Therefore, we will focus efforts on prevention. To increase the number of nesting birds in these woodlands, we are rigorously testing simple and inexpensive mouse proofing designed by volunteer J. Stacey from soft-sheet plastic. If over time our results reveal a decrease in mouse nests (but not bird nests) in boxes with plastic surrounding the entrance hole, this will be a useful result for nest box studies at ESNERR and elsewhere.

Chickadees as bioindicators

We observed changes in the timing of reproduction among years, suggesting that chickadee nesting may vary in response to environmental differences. While these short-term trends may simply reflect non-directional year-to-year variation, the sensitivity of this index suggests that it may be useful for assessing long-term trends, such as climate warming or prey declines.

Based on moderate to very high hatching rate and very high fledging rates observed and the absence of parasites, we conclude that the ESNERR oak woodlands are in good

health, at least with regard to nesting cavity-nesting birds. Tracking reproductive success and parasitism in the future will be one good way of keeping our finger on the pulse of our oak woodlands.

Report prepared by R. Goldman, and K. Wasson, ESNERR research program, July 2003; updated by S. Fork in December 2008. Please email skforkatgmail.com with questions or comments.

Figure 1. Proportion of total number of nest boxes used in each woodlot (1998 – 2008)

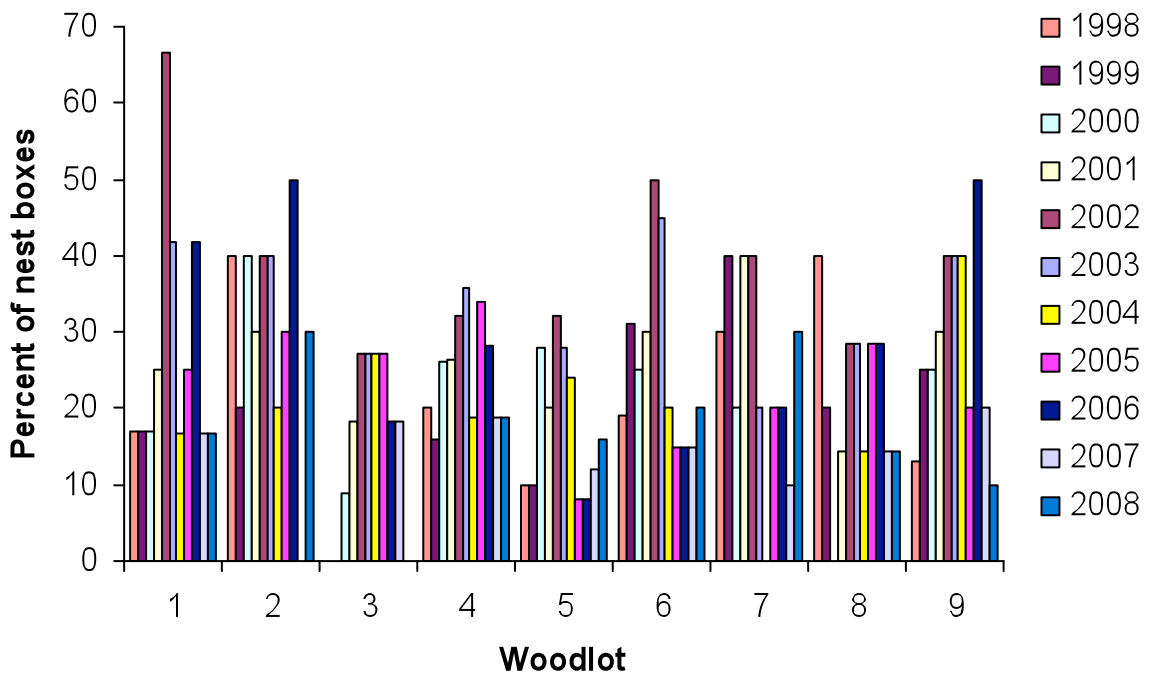


Figure 2. Percentages of avian species using nestboxes (1998 – 2008)

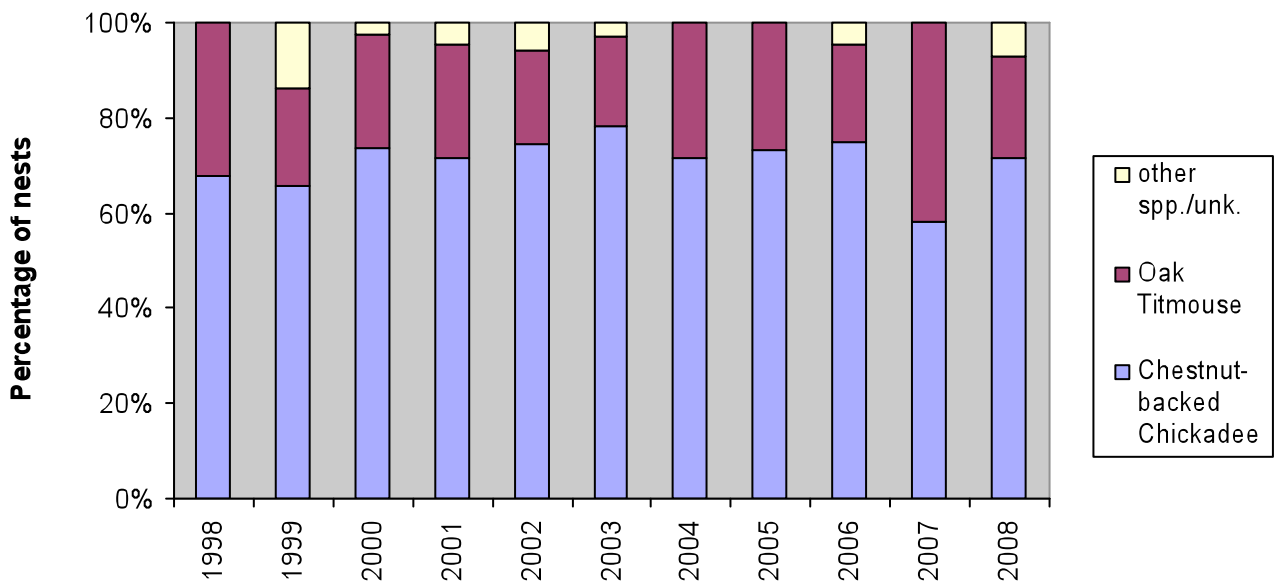


Figure 3. Phenology of nesting - first occurrence of eggs (1998 –2008)

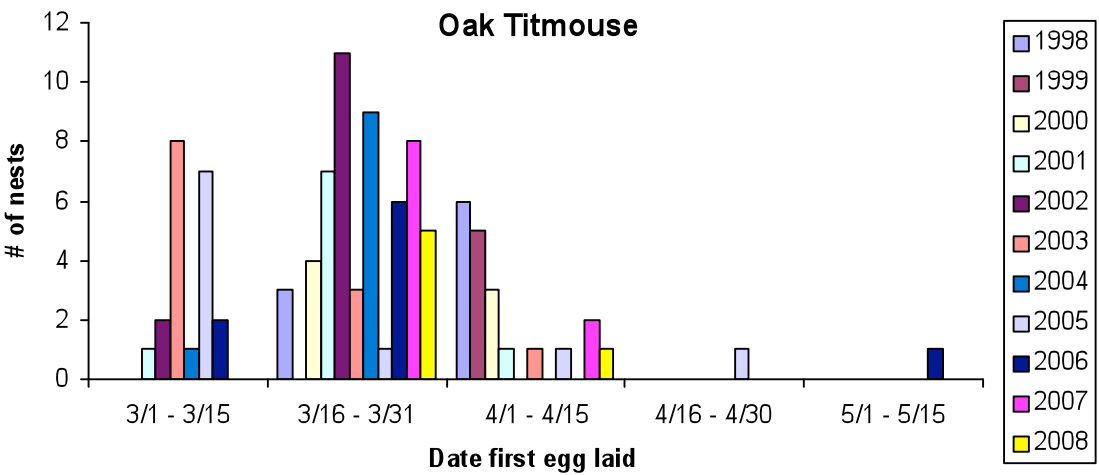
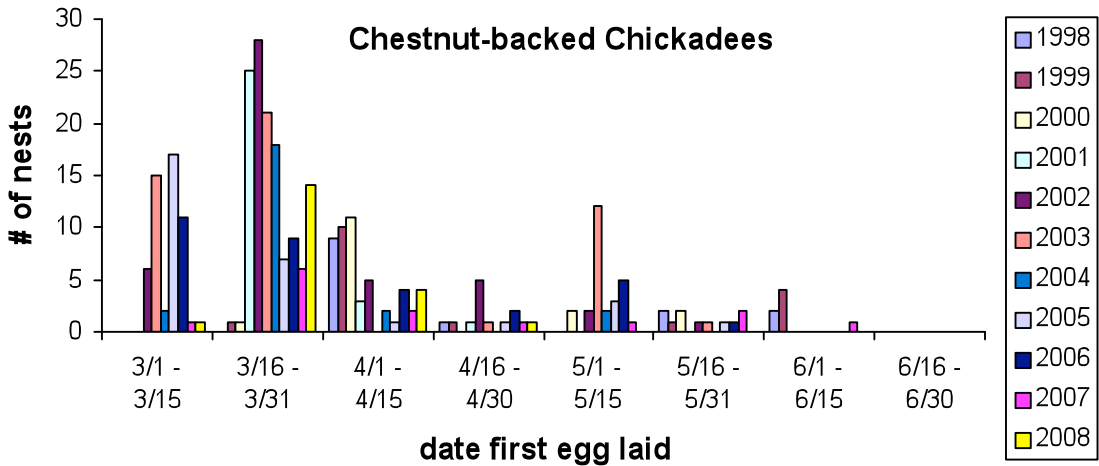


Figure 4. Percentage of available boxes at each aspect used from 1998 – 2008

