A comparison of different bat box types by bat occupancy in deciduous woodland, Buckinghamshire, UK

Matthew Dodds[1,2]* and Hannah Bilston[1,2]

[1] *Aylesbury Vale District Council, Haydon Mill, Rabans Lane, Aylesbury, Bucks, HP19 8RU, UK*

[2] *North Bucks Bat Group, Haydon Mill, Rabans Lane, Aylesbury, Bucks, HP19 8RU, UK*

SUMMARY

An experiment was conducted to determine if Natterer's bat *Myotis nattereri* and brown long-eared bat *Plecotus auritus* exhibited an occupation preference between five different bat box types in an ancient, lowland mixed deciduous woodland in Buckinghamshire. Groups of Schwegler 2F, 2FN, 1FS, 1FF woodcrete boxes and 1 wooden Apex box were erected in 13 locations (5 around each tree). The box clusters were located on trees with a proven history of good box occupancy levels - part of a 10 year woodland bat box scheme. The group positions were evenly spaced along a transect line of 300m in homogenous habitat of predominantly semi mature Pendunculate Oak *Quercus robur* and Ash *Fraxinus excelsior* closed canopy with lapsed Hazel *Corylus avellana* coppice understorey. The temperature regimes of the boxes were compared and found to be similar, and consistent with the ambient temperature due to the shaded nature of the sites. Aspect was experimentally controlled by progressively rotating the box positions around the tree. The occupancy rates of the five boxes were compared and showed a selection bias towards two box types, influenced by seasonal bird competition.

BACKGROUND

North Bucks Bat Group has been studying bats using bat boxes in the Buckinghamshire, Berkshire and Oxfordshire Wildlife Trust reserve Finemere Wood (SP722 216) in Buckinghamshire since 2002. During this time several aspects of bat box occupancy have been investigated with the objective of designing an accurate, repeatable, practical population monitoring methodology for woodland bats. Several authors (Boyd & Stebbings 1989, Kerth *et al*. 2000, Kerth *et al*. 2001) have demonstrated the power of box schemes to illicit detailed study of bat populations, yet they are regarded with caution by other authors (Boye & Dietz 2005). The work at Finemere Wood has sought to address perceived limitations and concerns of the use of box checking as a monitoring tool. This study was designed as a continuation of these experiments.

Previous studies at Finemere and other similar woodlands (Dodds 2008, Phillips 2009, Bilston 2011) have shown that in lowland mixed deciduous woodland most closely resembling National Vegetation Classification W8 & W10 (Rodwell 1991), Natterer's, brown long-eared bats and Daubenton's *Myotis daubentonii* will use boxes sufficiently regularly to enable accurate monitoring. These species will preferentially select boxes in shaded, stable, non-intervention woodland with closed canopy above and lapsed coppice underneath. Other box schemes (Kerth *et al.* 2000) indicate that Bechstein's *Myotis bechsteinii* will also habitually use bat boxes sufficient to enable accurate monitoring. Phillips (2009), showed that Natterer's bats spent 90% of their time in natural roost sites in Finemere. Bilston (2011) showed that box occupancy at Finemere was highest in areas with the greatest numbers of known tree roosts. Shiel et al. (2009) and Siemers & Swift (2005) have demonstrated that different sensory ecology, prey selection and hunting strategies minimise competition between sympatric bat species. These studies provided reassurance that boxes were acting as passive interception devices and not significantly disrupting natural roost usage or inter-species competition.

Accepting the inference of these studies, if regularity of occupancy could be increased in this box scheme it would improve the encounter rates for individual bats. Increased encounter rates would lead to more robust population data and facilitate more opportunities for further study. Despite the claims of manufacturers, it was not known whether box type had a significant influence on usage by these species. Work by the Vincent Wildlife Trust (Poulton 2006) has shown that there appears to be a preference for certain box types. However this study did not consider the micro climate in the immediate vicinity of the box. Dodds (2008) and Bilston (2011) have shown that the location of the box is the most important factor in box selection over other variables tested. Within this context it was decided to construct a comparative test between 5 box types. These were located in identical, optimal environments, to attempt to discern if certain boxes were selected over others based solely on their design features.

ACTION

Thirteen groups of Schwegler 2F, 2FN, 1FS, 1FF woodcrete boxes (compressed woodchip and concrete, Schwegler Bird & Conservation Products, Schorndorf, Germany) and 1 wooden Apex box were erected around 13 different trees in March 2011. A description of the bat box types used in this experiment is at Table 1. The habitat in which the boxes were erected was the same throughout the transect: semi-mature, closed canopy Penduculate Oak *Quercus robur* and Ash *Fraxinus excelsior* with lapsed Hazel *Corylus avellana* coppice understorey. Each group of boxes was secured by screw-hooks to the tree at a height of approximately 4 metres (Figure 1). Previous studies in this location had shown that there was no preference for box occupation as a result of being secured to the tree or held off the tree with a bracket. The advantage of using a screw hook is that it can be withdrawn progressively as the tree grows.

* To whom correspondence should be addressed mdodds@aylesburyvaledc.gov.uk

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In order to control for aspect, boxes were erected in the same order at each site and the pattern was progressively rotated by approximately 28 degrees on each successive tree i.e. each box type moved by 28 degrees from one tree to the next. Temperature sensors (DS1921G-F5 thermochron iButtons, Homechip, Milton Keynes) were installed along this run of boxes from April 2009 to December 2010 (Bilston 2011). These showed that there was no temperature difference between the 13 locations, between different box types and different aspects. The study also showed that there was no difference between the temperature within the box and the ambient temperature, which is consistent with the boxes being located in the shade.

The clusters were evenly spaced approximately 20 meters

Table 1. Descriptions of the five bat box types used in the experiment.

Bat Box type	Photo of bat box	Description
Schwegler 1FF		This bat box has a built in wooden back panel and a reducing internal width which is designed for crevice dwelling bats. The entrance is a long slit which stretches the width of the bottom of the bat box. Dimensions: Height: 43cm x width: 27 cm
Schwegler 2F		This bat box has a conical top and one entrance hole at the front of the box, situated approximately 5 cm from the bottom of the box. Dimensions: Height: 33 cm x Diameter: 16cm
Schwegler 2FN		This bat box has a domed top and a larger internal volume compared to the 2F and 2F-DFP. It has two entrance holes; one hole which runs along the front of the bat box and one hole at the back of the bat box at the bottom. Dimensions: Height: 36 cm x Diameter: 16cm
Schwegler 1FS		This bat box has a flat top and has the largest internal volume of all the boxes. It contains three internal wooden panels designed for crevice dwelling bats. Dimensions: Height: 44 cm x Diameter: 28cm
Wooden 'Apex' bat box		This bat box is made of wood, not woodcrete. It has a triangular top which is covered in tough, plastic mesh to allow the bats to grip onto it. It has a slit entrance which runs the width of the bat box at the back, bottom of the bat box. Dimensions: Height: 40 cm x Diameter: 12 cm

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tree

apart, dependant on the availability of suitable trees. The boxes were positioned in a line running parallel to the edge of the woodland, and 25-35m into the woodland from the edge. Data generated by previous regular box surveys had shown that boxes erected in these 13 locations, from 2006, had higher levels of occupancy than in other areas of the wood. Since erected, these boxes, representing 28% of the box resource, have accounted for 55% of all occupations.

Bird boxes were erected above each cluster in order to deter birds from nesting within the bat boxes. Previous studies in the wood had shown that the erection of companion bird boxes significantly increased bat occupation of bat boxes during May and June.

Box checks were conducted in mid-May, early June, late July, mid-August, mid-September and mid-October in 2011and 2012. This check frequency had been shown in previous years not to affect the condition, reproductive success or box usage levels of bats. During each check, the presence of bat droppings was recorded as an indication of previous occupancy. Where possible droppings were assigned to species and, after each inspection, boxes were cleaned to enable new occupations to be recorded on each checking session. Where bats were present, their species, number, ring number and biometrics were recorded. The presence of birds and evidence of their previous occupancy, i.e. droppings, was also recorded.

CONSEQUENCES

Over the two years, 780 box checks were made, that is 156 for each box type. Box orientation was not a significant factor in selection, as would be expected because of the shaded nature of the boxes. However there were selection preferences which were relevant to the time of year. Of the149 bat occupations recorded, 1FS proved the most popular box type accounting for 33% of occupations followed by 2FN (29%), 2F (27%), 1FF (11%) and the Apex 0% (Table 2). This masked a seasonal variation in usage due to the impact of bird competition.

Despite the provision of bird boxes, during the nesting period birds routinely occupied the 1FS box. In May and June

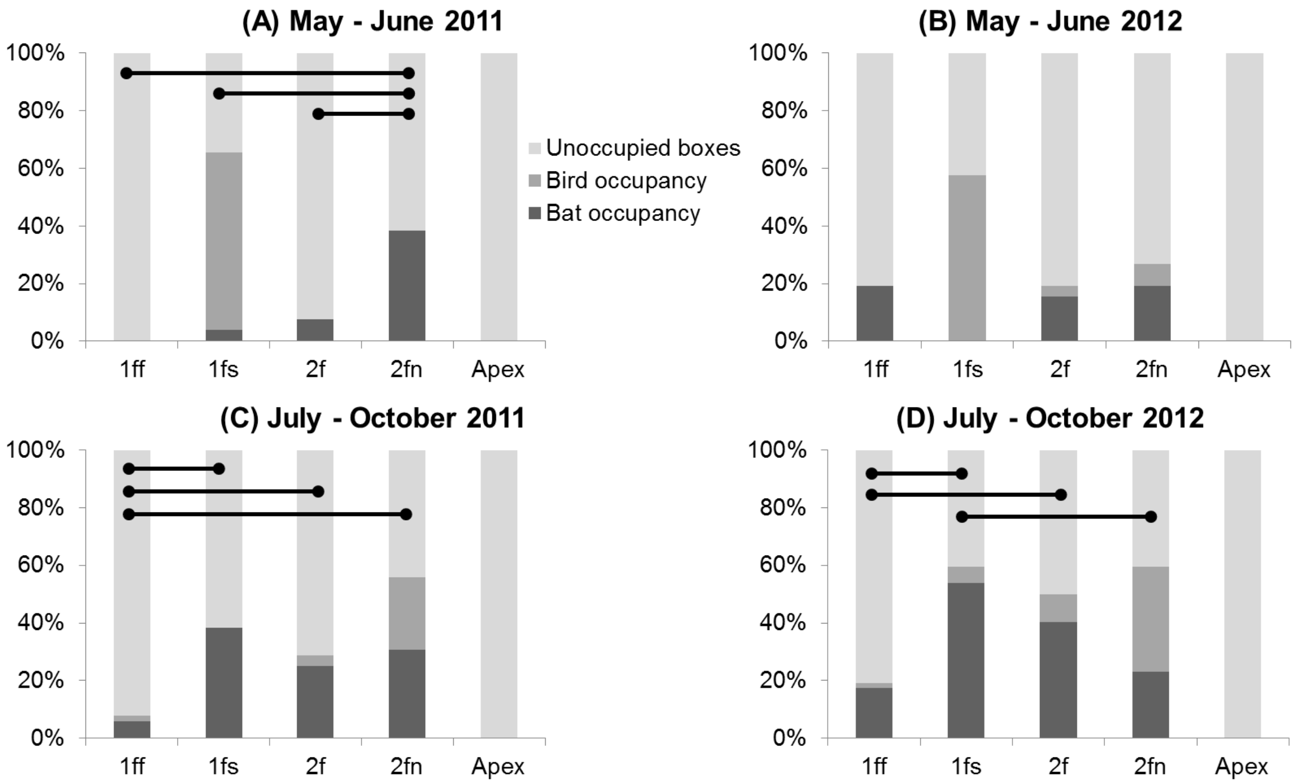

Figure 2. The proportion of each nest box type occupied by bats, by birds and unoccupied. The pairs with a significant difference (FDR adjusted p values < 0.05) were linked with black bars.

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1FS contributed only 4% of occupations, with 2FN accounting for 56% (Table 2). After the bird nesting period 40% of occupations were in 1FS whilst 2FN dropped to 23%. In this per iod evidence of roosting birds (droppings) was disproportionately discovered in the 2FN boxes. Bird occupancy in the 2FN box was recorded 34 times in the 104 checks made of this box type in the post nesting period over the two years. Evidence of roosting birds was found on only nine occasions in all other box types during this period. This may be indicative of significant bird competition for the 2FN box post nesting.

The usage of the 2F box remained relatively consistent through the year but 1FF usage seemed to be concentrated into periods of colder weather i.e. earlier and later in the year. The Apex box was not occupied once for the entire duration of the study.

The difference in the bat occupancy in different box types during and after the bird nesting period was further tested with Fisher's exact test. The Apex box was excluded from the tests as this box type was not occupied at all. During the bird nesting period (May-June), occupancy patterns were significantly different among box types in 2011 ($p < 0.01$) but not in 2012 ($p = 0.076$). In 2011, there was a significant difference between 2FN and each of 1FF, 1FS and 2F (Figure 2A), indicating that 2FN was preferred over other box types during the bird nesting period. The low bat occupancy in 1FS was presumably due to the high bird occupancy during the nesting period in this type (Figure 2A, B). After the bird nesting period (July - October), occupancy patterns were significantly different among box types in both 2011 ($p < 0.01$) and 2012 ($p < 0.01$). In particular, there was a significant difference between 1FF and each of 1FS, 2F and 2FN in 2011 (Figure 2C), and between 1FF and 1FS, 1FF and 2F, and 1FS and 2FN in 2012 (Figure 2D). This suggests that after the bird nesting period, bat occupancy increased in 1FS and 2F.

During the bird breeding season the pattern of usage between species was not substantially different, other than the occasional usage of the 1FF and 1FS box by brown long-eared bats (Table 2). However, these data are less reliable because of the fewer number of occupancies it was possible to identify to species level.

Average and maximum bat cluster sizes in the occupied box types showed that the boxes with the largest internal volume exhibited the largest mean cluster size. The data for maximum cluster size were not as definitive but the largest three clusters were recorded in the largest box (1FS).

DISCUSSION

These data indicate that in this environment, given a choice, brown long-eared bats preferentially select 1FS boxes in the post nesting period. Bird competition for 2FN may influence this selection. During the bird nesting period 1FS are denied to them by bird competition and they switch their selection to 2FN boxes.

Natterer's bat show a slight preference for 2F over 2FN boxes post bird nesting which may also be influenced by bird competition. They do not show the same preference for 1FS exhibited by brown long-eared bat. During the bird breeding season they show a strong preference for the 2FN design.

The reasons for these selection preferences are not clear but it may be as simple as the size of the cavity available; the bigger the cavity, the more attractive the box is to the bats. This may be due to the distance of the roost location from the entrance, as suggested by Ruczynski & Bogdanowicz (2005), and the energetic advantage offered by the ability to form larger cluster sizes in larger boxes. The data for the different boxes support this hypothesis i.e. the 2 largest boxes had the highest number of occupations and higher mean cluster sizes.

The influence of bird competition was significant. Bird boxes were not effective in dissuading bird access to 1FS and 2FN in the pre and post bird nesting period. More work is necessary to test selection preferences after removing the influence of bird competition by modifying boxes to exclude bird use.

The implications for bat box schemes in woodland is that 1FS and 2FN boxes appear to be more effective than the other three boxes tested in attracting more regular use by larger numbers of brown long-eared and Natterer's bats. Higher frequency of bat encounter and higher number of bats recorded per box check enhance the data base for monitoring and modelling bat populations. This finding should be considered when designing population monitoring schemes for woodland bats using bat boxes.

Table 2. Use of the five bat box types by Natterer's bat, brown long-eared bat and birds

Box type	**1FF**	**1FS**	**2F**	**2FN**	**Apex**
Natterer's					
Number of occupations	3	10	27	24	0
Number of boxes used	2	9	11	8	0
Number of occupations May-June	0	0	4	8	0
Number of occupations July - October	3	10	23	16	0
Mean cluster size	dd*	34	10	15.8	0
Brown Long-eared					
Number of occupations	11	38	10	16	0
Number of boxes used	6	12	8	9	0
Number of occupations May-June	4	1	2	7	0
Number of occupations July - October	7	37	8	9	0
Mean cluster size	6.1	18.5	7	13.4	0
Number of boxes used by birds	0	12	5	10	0

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