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RELATIONSHIP OF JUVENILES CAPTURED IN CONSTANT-EFFORT NETTING AND LOCAL ABUNDANCE

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Abstract. Numbers of juvenile Blackbirds (*Turdus merula*), Song Thrushes (*T. philomelos*), Blue Tits (*Parus caeruleus*), and Great Tits (*P. major*) caught during constant effort mist-netting were compared with numbers of nestlings of these species banded during the years 1979–2002 in Treswell Wood, Nottinghamshire, England. There was a significant relationship between the annual numbers of juveniles captured and the annual numbers of nestlings banded in all four species. Mortality and immigration between fledging and mist-netting periods probably vary among years, reducing the strength of correlation. Results suggest that number of young birds captured in the British Trust for Ornithology Constant Effort Sites scheme across many sites is a good index of the number of young in the population following juvenile dispersal.

Key Words: constant-effort mist netting, Constant Effort Sites, productivity, banding.

The index of productivity used by the Constant Effort Sites (CES) scheme of the British Trust for Ornithology is the ratio of juveniles to adults totalled over a large number of study sites (Peach and Baillie 1990). The assumption underlying this index is that the numbers of adults and young birds captured are proportional to the true numbers of each age group in the population. This has been tested for adults by comparing CES data from many sites with results from the Common Birds Census (Peach et al. *this volume*), with positive results. Here we present evidence to support the assumption that young birds are also captured in proportion to their abundance, using data from a single site. Some of the data were previously published (du Feu and McMeeking 1991), but this paper includes additional data and discussion.

We compared numbers of nestlings banded that were deemed to have fledged with numbers of young birds captured in mist nets during the summer. There are many reasons to expect that these numbers might not be correlated. Not all birds produced at the study site will be banded as nestlings. All nestlings do not fledge at the same time as each other, or at the same time each year, which affects numbers captured in mist nets. Dispersal and mortality of young occurs throughout the netting period, and captures are affected by weather. Captures of juveniles of flocking species in mist nets may not be independent of each other. Such factors could potentially invalidate the use of juvenile captures in mist netting as an index of local fledging success.

METHODS

Treswell Wood is composed of 47 ha of mature broad-leaved trees, mainly ash (*Fraxinus excelsior*) with some oak (*Quercus robur*), with an understory predominantly of hazel (*Corylus avellana*). It is an ancient woodland designated as a Site of Special Scientific Interest, owned and managed by the Nottinghamshire Wildlife Trust. Since 1972 the Trust has restored the traditional system of "coppice with standards" (Cramp and Simmons 1977) to parts of the wood.

We have carried out year-round constant-effort mist netting at seven sub-sites in Treswell Wood since 1978. Our netting regime differs from that of the CES regime, which specifies 12 evenly spaced visits to each site throughout the months May to August inclusive. Instead, we visit each of our seven sites in the Wood five times a year, approximately once every 10 weeks. The exact order of visiting the sites varies according to weather, for some sites are more affected by wind than others, but it is kept as constant as possible from year to year. On each visit we use ten 18-m nets, in fixed positions, set for five hours from shortly after dawn. If conditions allow, extra nets are erected. Such extra nets are not sited immediately adjacent to the standard nets, to prevent interference with the standard nets. Birds caught in additional netting are not included in our constant effort analyses.

About 100 nest boxes, primarily for tits (*Parus* spp.), have been placed in the northern two-thirds of the wood. The number and distribution of boxes have remained relatively constant since 1979. We record all nests in boxes, and band all chicks. Although we make no attempt to find non-box nests, we record all natural nests of any species we detect while on the nest box rounds (e.g., when an adult is flushed from the nest), and chicks in those nests are also banded. Nest checks have been done by the same person (CdF) each year. Because the distribution of boxes is much the same from year to year, the opportunity for finding other nests is also approximately the same. No nestling tits have been banded other than those in boxes, but we have banded enough Blackbirds (*Turdus merula*) and Song Thrushes (*T. philomelos*) to analyze them here.

We assume that any bird banded has also fledged, unless

there is evidence to the contrary. Such evidence includes finding carcasses of young in the nest when the boxes are emptied at the end of the season. Sometimes predators attack nests and leave a few partially dismembered bodies, in which case we assume that all chicks failed to fledge. Evidence for success includes finding undamaged but flattened empty nests with many flakes of feather sheath, nestlings capable of fledging when last seen in the nest, and newly fledged juveniles in the vicinity of nest boxes. There have been almost no direct observations of birds fledging from nests.

A Common Bird Census (CBC) is carried out in the wood by other workers. For all years, we have a record of the total numbers of territories recorded, but a breakdown of where these territories lay within the Wood is available only for some years (1981–1994 and 1997–1998).

In this paper, we compared the numbers of banded Blackbirds and Song Thrushes deemed to have fledged each year with the numbers of free-flying juveniles caught in mist nets between 28 May and 15 August (1979–2002). These dates correspond approximately to the CES breeding season sampling period. We also compared the numbers of nestling Blue Tits (*Parus caeruleus*) and Great Tits (*P. major*) fledging from boxes with the numbers of juveniles mist netted in the same period. We use the terms "sampling period" for the late May through August netting period and "study period" for the years 1979–2002.

Because data for both numbers of nestlings banded and juveniles caught are count data, we used log(N+1) transformations in correlation analyses, as described in Fowler and Cohen (1986). Scatter diagrams were plotted on logarithmic axes and all regression lines were fitted using the model 2 reduced major axis regression described by Fowler and Cohen (1986).

RESULTS

Annual numbers of each species banded as nestlings within the wood, and the numbers of juveniles captured in constant effort nets in the sampling period are given in Table 1. We found a significant, positive correlation between these annual numbers for all four species: Blackbird ($r = 0.49$, $N = 24$, $P = 0.02$), Song Thrush ($r = 0.40$, $N = 24$, $P = 0.05$), Blue Tit ($r = 0.64$, $N = 24$, $P = 0.001$), Great Tit ($r = 0.46$, $N = 24$, $P = 0.03$). Only four points lay more than two standardized residuals away from any regression line

TABLE 1. NUMBERS OF NESTLINGS BANDED AND FLEDGED AND OF JUVENILES CAPTURED IN CONSTANT-EFFORT MIST NETTING BETWEEN 28 MAY AND 15 AUGUST EACH YEAR

	Blackbird		Song Thrush		Blue Tit		Great Tit	
Year	Nestlings banded	Juveniles captured	Nestlings banded	Juveniles captured	Nestlings banded	Juveniles captured	Nestlings banded	Juveniles captured
1979	14	16	33	2	91	0	65	4
1980	9	8	10	4	222	7	51	5
1981	0	5	6	4	215	45	55	9
1982	0	3	4	2	171	10	49	0
1983	7	4	14	4	117	5	48	5
1984	12	5	27	2	147	8	60	5
1985	9	10	14	0	175	11	104	3
1986	13	9	26	2	226	0	125	0
1987	3	3	15	1	261	30	133	30
1988	5	2	6	0	104	8	74	5
1989	0	5	3	2	242	46	132	14
1990	0	0	0	1	173	17	38	2
1991	3	0	0	0	120	1	44	4
1992	0	0	4	4	130	0	66	9
1993	0	1	0	0	85	1	22	0
1994	0	6	6	6	120	4	21	1
1995	5	6	8	0	171	18	66	2
1996	4	6	2	2	113	3	18	3
1997	3	6	0	0	93	2	65	2
1998	0	1	0	1	41	1	20	2
1999	0	4	0	2	108	2	90	6
2000	3	1	5	2	88	0	43	1
2001	4	1	0	0	87	0	46	1
2002	4	2	8	2	63	2	70	3
Totals	96	104	191	43	3363	221	1505	116

(Fig. 1). These were the points for Blue Tit in 1986 and 1998 and for Great Tit in 1986 and 1996.

There was significant correlation between numbers of Song Thrush nests (1981–1994 and 1997–1998) and the numbers of Song Thrush territories recorded by CBC in the section of the Wood in which boxes were present ($r = 0.77$ for transformed annual indices, $N = 16$, $P < 0.001$; Fig. 2). The correlation for Blackbirds was not significant ($r = 0.39$, $N = 16$, $P = 0.14$).

DISCUSSION

Here we examine some of the probable causes of variance in the correlations between number of nestling-banded birds deemed to have fledged and number of juveniles captured during summer mist netting.

Proportions Banded

The relationship between nestlings banded and juveniles captured was weaker for Song Thrush and Blackbird than for the tit species. A contributing factor was the relatively low proportions of the nestling populations of Song Thrush and Blackbird that were banded. The correlation between Song Thrush nests found and CBC territories (Fig. 2) suggests there was fairly constant nest finding effort, although data for Blackbirds do not support this as strongly. Nest-finding effort was not exhaustive, however, and although 605 Blackbird and 327 Song Thrush CBC territories were recorded in the study period, only 55 and 104 nests were found, respectively. Because both species are multiple brooded, the overall percentage of nests found is unlikely to be higher than 10%. The percentages of juveniles banded at nests and later caught in constant effort nets, 0% for Blackbirds and 9.7% for Song Thrushes, are compatible with this low figure. The number of juvenile Song Thrushes netted has always been so low that chance factors are relatively important in determining variation in numbers. Thus, it is not surprising that the correlation between the numbers of nestlings banded and the numbers of juveniles netted was weakest in this species.

For tits, the number of nests in natural sites is

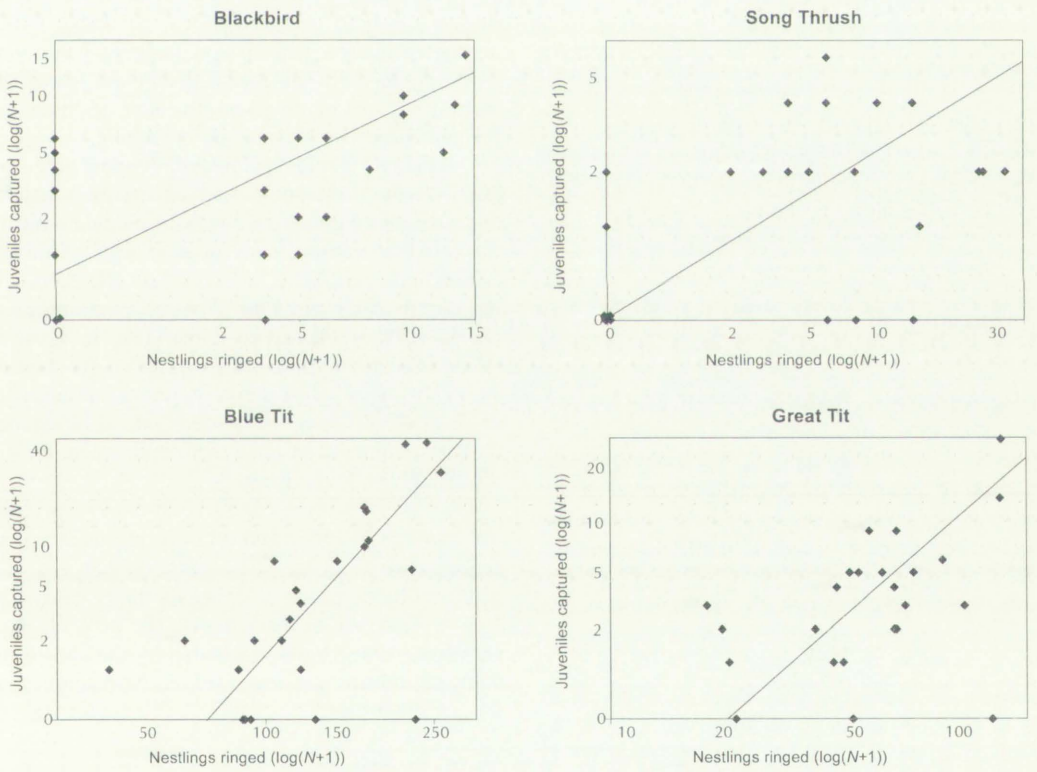

FIGURE 1. Nestlings banded and juveniles captured in constant-effort mist nets in Treswell Wood, 1979–2002 (model 2 reduced major axis regression method).

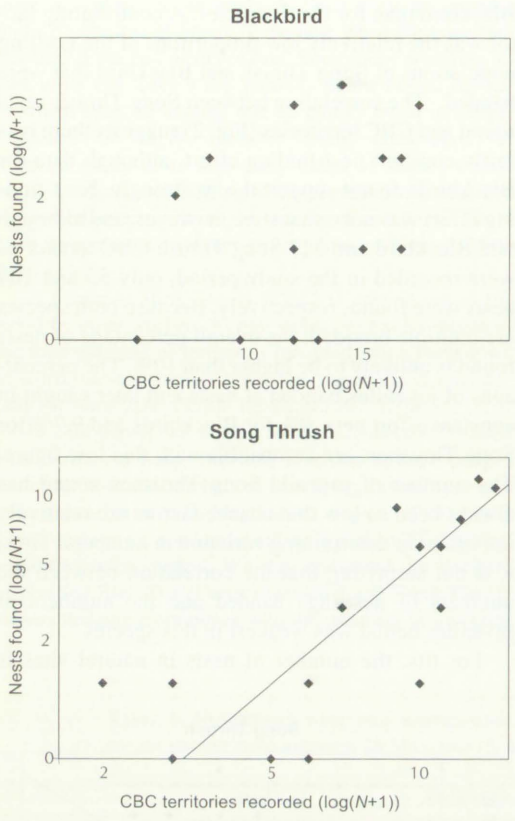

FIGURE 2. Blackbird and Song Thrush Common Bird Census (CBC) territories recorded vs. nests found, 1981–1994 and 1997–1998.

unknown, as is the number of young fledged from such sites. We have never banded nestling tits in natural sites. During the study period, 41% and 37% respectively of the juvenile Great Tits and Blue Tits captured in constant effort nets in the sampling period had been banded as nestlings. This suggests either that there are many natural nests (producing up to 60% of all nestlings), or that many juveniles captured in mist nets had moved in from elsewhere (see below). Several lines of evidence indicate that the first explanation is correct and the second has little influence.

Over 24 years, the percent of adult female tits captured in the spring in constant-effort mist nets that were later found nesting in boxes was 27% for Great Tits and 17% for Blue Tits. These percentages are lower than those given by Perrins (1979) for the percentage of these tits using boxes in Wytham Wood. However, in Treswell Wood we did not capture all females nesting in boxes every year. (For Blue Tits, 86% of females nesting in boxes were captured, but the figure for Great Tits was only 56%.) Moreover, one-third of the Wood contained no nest boxes. Another estimate of the proportion of tits nesting in boxes is the ratio of occupied nest boxes to the number of CBC territories found in the same part of the Wood. This ratio was 0.29 for Great Tit nests and 0.31 for Blue Tits, although the ratio may be biased by miscounts due to unsuccessful and replacement clutches, and by the use of nest box data in CBC.

Whereas all lines of evidence indicate that less than half of nestling tits were banded each year, the proportion is much higher than for Song Thrush and Blackbird, and is less likely to have varied among years simply as a result of chance.

Fledging Period

Song Thrush and Blackbird are multi-brooded, and it is probable that many of the year's juveniles were already dead by the time the sampling period began, whereas others had not yet fledged. Because mist-net data were collected over several visits, however, the total sample of juveniles should be relatively unaffected by variation in timing of the breeding season. Tits, on the other hand, are almost exclusively single brooded, all fledge within a relatively short period, and fledging dates vary from year to year. This means that in late years there were fewer mist-netting sessions after nestlings had fledged and become available for capture.

To gain insight on the effect of fledging date variation on the correlation between nestlings banded and juveniles captured, we reanalysed data omitting the last two netting visits in each year. Although correlations remained more or less the same for the two thrushes and Blue Tits, the correlation was considerably weakened for Great Tits. In Treswell Wood, Great Tits nest nearly a week later than do Blue Tits. This result demonstrates the importance of ensuring that sampling periods extend far enough into the summer to ensure a representative number of individuals will be trapped.

It is likely that the complete absence of juvenile tits captured in 1986 (Table 1) was primarily a consequence of the very late season (which was also followed by high post-fledging mortality caused by lack of food late in the season). The percentage of nest box-banded birds recaptured by the end of the study period was also lower for the 1986 cohort than for any other year.

Movement and Dispersal

Lack of correspondence between mist-net samples of juveniles and number of locally banded

nestlings could reflect changes in the local population of young birds between the two samples. Such changes could reflect dispersal and immigration, or mortality.

Perrins (1979) states that after the first month after fledging, there is local redistribution of tit populations, with some new birds moving into the area and some natives moving out. Our sampling period ends during this redistribution period, and we have only a little evidence for it. Two young Blue Tits and one Great Tit were captured between 4 and 8 km away from the Wood within the sampling period, and several more were captured elsewhere shortly after the end of the sampling period. Evidence of movement into the Wood came from one Blue Tit that fledged from a nest box on a farm to the south of the Wood and was captured 1.5 km away within 10 days, in the northern part of the Wood. However, because the proportions of nest box-banded tits captured later in constant effort netting were so close to the estimates of percentages of all nests that were in boxes, it appears that juvenile dispersal did not have a great effect by the time our sampling period ended.

Reanalysis of the data with the last two sessions removed made little overall difference to the strength of the relationships for the three earliest fledging species. This provides further evidence that any local dispersal has not had a major impact by the time the sampling period ends.

Mortality

Two of the four points in Figure 1 with standardized residuals >2 were 1996 for Great Tits and 1998 for Blue Tits (the left-most points on the graphs in Fig. 1). In both of these years there was massive mortality of nestlings in nest boxes, largely through predation. Both species suffered in each of these years, although Great Tits rather more in 1996 and Blue Tits more in 1998. It is not known whether the predation was equally great amongst tits that nested in natural sites. Neither is it known whether predation of nests was equally great in the area surrounding the Wood. Although very few juveniles were mist netted in the standard nets in these years (three Great Tits 1996, one Blue Tit in 1998), these numbers were higher than expected (Fig. 1). Possibly this was a chance result, but may also have represented immigration from areas with lower predation.

Lack (1966) discussed the causes, timing, extent, and variation of post fledging mortality for Great Tits and Blue Tits. He found that there is heavy mortality before the beginning of November, most of it in the first month after fledging. W. Peach (pers. comm.) suggests that this mortality is greatest in the first few days after fledging. In these few days juveniles will be relatively immobile, waiting high in the tree canopy for parents to bring food, and so are particularly vulnerable to predators. Instances of early death caused by predators have been provided by bands, from one Blue Tit and two Great Tits, recovered from owl pellets within our sampling period. In some years, we also noted very heavy predation on Song Thrush nests, often at a late stage. In some cases a Tawny Owl (*Strix aluco*) systematically raided Song Thrush nests, as shown by bands of nestlings being found in the owl's nest. Blackbirds seem not to have suffered systematic nest predation by the owls, as we have only ever recovered one single Blackbird nestling band from any owl nest.

The level of immediate post-fledging mortality depends, among other things, on population size, weather, food availability, predator activity, and brood sizes. It varies greatly from year to year, and therefore weakens the relationship between number of juveniles mist netted and number of nestlings banded. However, the fact that there is correlation between number of juveniles captured and numbers banded in the nest suggests the immediate post-fledging mortality is generally similar from year to year (with the possible exception of 1986).

Capture Patterns

A major problem in any estimate of productivity based on captures of tits in mist nets lies in the erratic nature and non-independence of captures. In the early post-fledging period, tits may remain in family parties. Thus whole families are often captured together rather than as individuals. Later young tits join mixed species flocks and, again, captures tend to be of groups rather than of individuals. The flocks often spend much of their time high in the tree canopy, out of range of mist nets. Therefore tits can be abundant, but not be captured. Nonetheless, there are very few years in which we missed capturing at least some of the flocking birds. The distorting effect of flocking on mist-net captures is well illustrated by the 1980 data. Tits were abundant in 1980 (Table 1) and there was high survival, but the constant effort captures were relatively low. In fact many juvenile tits were caught but, by chance, these captures were in netting that was not part of the constant effort program, and so did not contribute data to this analysis.

CONCLUSION

For all four species considered, there was significant correlation between the numbers of young

birds caught in mist nets and the numbers of banded nestlings deemed to have fledged. Despite variance introduced by the factors discussed above, number of juveniles captured in summer appeared to provide a good index of local productivity in most years.

The CES productivity index is compiled using data from many sites (typically well over 100), such that atypical captures at one site are unlikely to bias the national index. Moreover, the CES productivity index is meant to reflect numbers of juveniles surviving the immediate post fledging period, and the index was neither intended nor expected to represent site-specific productivity. Early post-fledging mortality and dispersal therefore pose little problem for the CES scheme. Nonetheless, the fact that relationships can be demonstrated between constant effort captures and known numbers of nestlings on a single site encourages confidence that constant effort data from many sites combined will provide a measure of juvenile abundance that can reliably be used in calculating indices of adult productivity.

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