BTO Research Report No. 258

The BTO Barn Owl Monitoring Programme: 1st Report: Pilot Year 2000

Authors

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EXECUTIVE SUMMARY

1. This is the first report of the BTO Barn Owl Monitoring Programme, set up with the aim: *To monitor Barn Owl populations through standardised recording of nest occupancy rates, breeding performance and survival at a set of Barn Owl nest sites broadly representative of the distribution of the Barn Owl in Britain.*

2. The Wildlife Conservation Partnership (WCP) will undertake the development of the methodology to be used in the Programme and will undertake fieldwork at a set of core sites. A network of volunteer ornithologists will gather additional information over a wider geographical area using carefully designed protocols.

3. The general approach to fieldwork will involve repeat visits to registered sites, each preferably with a pair of nest boxes, over the nesting season of Barn Owls, from April to October.

4. The Monitoring Programme will be carried out at three levels:

    i) Primary information gathering can be carried out with minimal disturbance to Barn Owls and includes the recording of site details, site occupancy, fledging success and 2^{nd} breeding attempts.
    ii) Breeding Performance recording involves visits to the nest to record clutch size, hatching success, brood size, age of young, losses of young, prey stored in the nest and laying dates.
    iii) Qualified ringers will also be encouraged to ring and measure young and adult birds at the nest to provide information on condition, survival and movements.

    WCP will also carry out a protocol of egg measurements to allow the estimation of laying dates, with a view to developing the method for use by volunteer ringers.

5. WCP recorded information from a set of 126 core nest sites in 2000. Fieldwork could not be started until June when most nests already had young. However, the Programme's recording methods were successfully piloted and data from the latter part of the nesting season were gathered.

6. Approximately half of the sites were on tilled agricultural land, a third on mixed grass/tilled land and majority of the remainder were on unimproved pastoral land.

7. Breeding Barn Owls occupied 83% of sites and other species were recorded at 21% (including some occupied simultaneously by Barn Owls). The other species most commonly recorded were Kestrel, Stock Dove and Jackdaw.

8. Mean clutch size at core sites was 4.5 eggs and the mean brood size near fledging (excluding total nest failures) was 2.8 chicks. Only a small number of second broods were detected (5% of pairs), but the methodology for their detection requires testing in 2001. Although extremely preliminary, analysis suggested that aspects of breeding performance might be better on land broadly dominated by tillage rather than by mixed or pastoral farming. However, these results refer to the habitat at a broad scale and it may be that the micro-habitat features actually used by the birds for foraging are critical.

9. The use of within-clutch variation in egg size as an indicator of nutritional stress to laying females, and of egg densities and chick growth for determining laying dates, were explored and will be tested further in 2001.

10. The capture of adult birds at nest sites was very efficient, *c.* 62% of males and 78% of females present were caught and ringed. The Programme should provide good sample sizes for the estimation of survival rates by mark-recapture methods.

11. More than 70 volunteer ringers or nest recorders have shown interest in taking part in the Monitoring Programme and fieldwork methods will be trialled this year, although Foot-and-Mouth disease may restrict access for fieldwork in the early part of the season.

12. As a result of analysis of the first year's data, a revised schedule of nest visiting has been developed to optimise the gathering of data:

i)	Late April/mid May	-	Site occupancy Clutch size/No. chicks just hatched Catch and ring adults
ii)	Mid July/early August	-	No. chicks @ 5-8 weeks old Ring chicks 2nd broods begun
iii)	October	-	No. chicks @ 5-8 weeks old for 2nd broods

13. Fieldwork by WCP in 2001 will emphasise the validation of methods for detecting second breeding attempts.

1. INTRODUCTION

The Barn Owl is an iconic bird of farmland in Britain. Throughout the 18th and early 19th centuries, it was regarded as our most common species of owl (Latham 1781, Riviere 1830, Magillvray 1840, Holloway 1996). However, from about the middle of the 19th century, factors such as increasing persecution and collection of specimens for taxidermy are said to have contributed to a population decline. This prompted Blaker (1933, 1934) to organize one of the earliest national surveys of the breeding population of a wild bird. This involved the circulation of a request for information throughout England and Wales and resulted in a population estimate of *c* .12,000 breeding pairs, with evidence for a substantial decline over the previous 30-40 years (Figure 1.1).

The decline appears to have continued through the 1950s and 1960s (Parslow 1973, Prestt 1965) and was linked to toxic chemicals (especially organochlorine pesticides), loss of hunting habitat, increased disturbance and the hard winters of 1946/47 and 1962/63 (Dobinson & Richards 1964). In the first Breeding Bird Atlas (Sharrock 1976) the population was estimated to be between 4,500 and 9,000, but this was based on largely untested assumptions about Barn Owl distributions.

Between 1982 and 1985, the Hawk & Owl Trust initiated a four-year survey of Barn Owls in Britain that estimated the population to be 3,778 pairs in England & Wales, 640 pairs in Scotland and 33 pairs in the Channel Islands (Fig 1.2; Shawyer 1987). This suggested a decline of 69% in England & Wales since Blaker's survey. In recent years a great deal of conservation work has focused on the Barn Owl, much of this stimulated by the publication of the Hawk & Owl Trust's survey results and recommendations. Attention has been directed towards the creation and management of areas of suitable hunting habitat, increasing prey availability, providing habitat corridors to promote dispersal and coupled with the provision of nest boxes where a lack of nest and roost sites was believed to be a limiting factor.

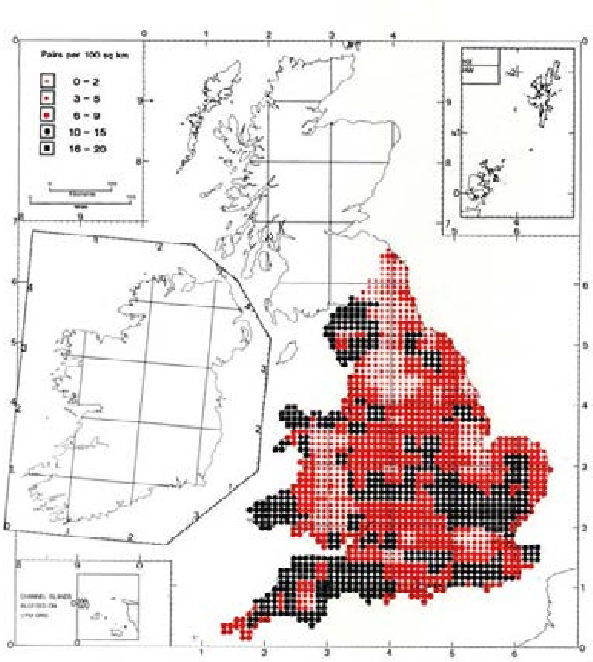

Figure 1.1 The breeding density and distribution of the Barn Owl in England and Wales in 1932. (Re-drawn from Blaker, 1934, on the basis of 10km squares; from Shawyer 1987)

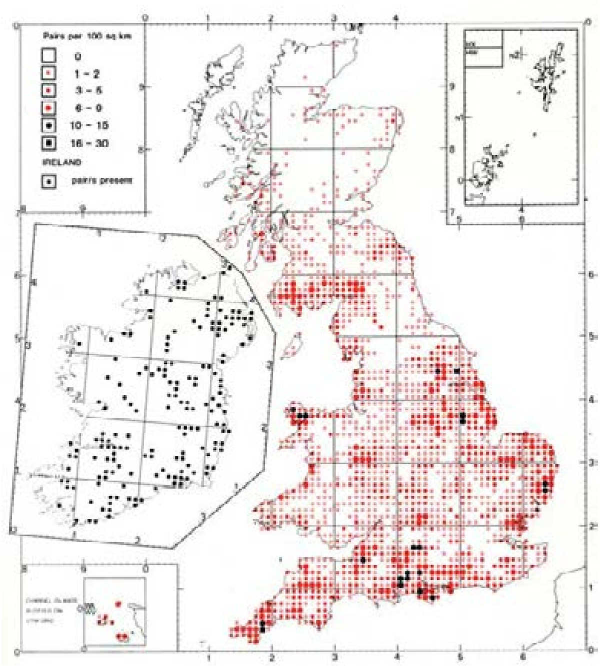

Figure 1.2 The breeding density and distribution of the Barn Owl in the British Isles1982-985 (from Shawyer 1987).

Over the same period, attention has also been focused on other factors that may have played a part in the Barn Owl's decline, in particular the use of "second generation" rodenticides and mortality due to collisions with road traffic (Bourquin 1983, Massemin & Zorn 1998, Shawyer *et al*. 1999). The second generation rodenticides, difenacoum, bromadiolone, brodifacoum and flocoumafen are used to control Brown Rats *Rattus norvegicus* in and around agricultural premises, particularly in areas where resistance to warfarin is high (Harrison 1990, Shawyer 1985). Barn Owls are potentially vulnerable to secondary poisoning from ingesting poisoned rodents. Chemical residue monitoring by the Centre for Ecology and Hydrology has found that a small proportion of Barn Owl corpses contain potentially lethal doses of rodenticide (Newton *et al.* 1990, 1991; Newton & Wyllie 1992). The detection of any widespread detrimental impact of poisoning at the earliest opportunity therefore provides one clear reason why the monitoring of Barn Owl populations and their breeding performance and survival is needed.

Concern about the status of the Barn Owl has led to the development of a conservation action plan for the species (RSPB Species Action Plan 0735) and a number of local Biodiversity Action Plans under Local Agenda 21 of the International Convention on Biodiversity. The Barn Owl has also been listed as a "Species of European Conservation Concern" because of its unfavourable conservation status throughout much of Europe (Tucker & Heath 1994). Despite this concern, conservation initiatives have been hampered by a lack of up-to-date information about population status and trends. Better information and annual monitoring are needed to maximise the benefits of future conservation effort in the UK.

Between 1994 and 1997, the BTO and Hawk & Owl Trust organised a survey of the Barn Owl population in the UK, *Project Barn Owl*. The aim was to produce a baseline against which population changes could be measured, using a method that could be repeated fully in the future. The survey estimated the UK population size to be *c*. 4000 breeding pairs (Toms *et al*. 2001). Regional population estimates suggested that numbers were similar to those found by the 1982-85 survey, except for a probable increase in East Anglia, where much conservation action had been undertaken. It was not possible to make meaningful, exact comparisons between the surveys because of differences in the methods employed (Toms *et al*. 2000).

1.1 The need for a Barn Owl Monitoring Programme

Following *Project Barn Owl*, the lack of a specifically tailored annual monitoring programme for Barn Owls was identified as a key gap in the measures being undertaken to conserve the species. Given the persistent concern over the Barn Owl's conservation status, it is important to ensure that further declines in the population do not go undetected and to measure the effectiveness of conservation action at a national level. Further, a carefully designed monitoring programme can be used to help identify the potential demographic mechanisms behind changes in abundance (i.e. whether changes in breeding performance or survival are important) and to link these to the effects of likely environmental causal factors such as habitat and land use change.

Barn Owl biology and behaviour means that the species is most easily surveyed by the monitoring of potential nest sites during the breeding season. Nest visits also readily allow the recording of information on productivity and provide good opportunities to trap and ring adult and young birds, thereby enabling dispersal and annual survival to be monitored. A key requirement of a nest-site based monitoring programme is that a core set of nesting sites is defined that will then be monitored *every* year to provide consistency to the recording base. Absolute numbers of Barn Owls are difficult to assess and so site occupancy rates will need to be used as a guide to overall population levels of *breeding* Barn Owls. The sites need to provide detailed information on breeding performance and survival, which can be used to complement information gathered nationally by the BTO Nest Record and Ringing Schemes. The latter schemes do not impose a formal sampling regime on volunteers and so there is the potential for changes in bias to affect results as the set of sites monitored by volunteers changes over time. Finally, the Programme should aim to monitor populations within the core strongholds of the Barn Owl's range, which are most important to the species viability, as well as those more on the periphery, where changes are likely to occur first.

The BTO Barn Owl Monitoring Programme described in this report was set up to address these needs with the overall aim being:

To monitor Barn Owl populations through standardised recording of nest occupancy rates, breeding performance and survival at a set of Barn Owl nest sites broadly representative of the distribution of the Barn Owl in Britain.

1.2 The Objectives of the Barn Owl Monitoring Programme

The key objectives of the Programme are as follows:

- To define a set of study areas, which provide a broadly representative coverage of the British Barn Owl population, in which a standardised set of Barn Owl sites are monitored annually.

- To monitor breeding productivity of Barn Owls through the use of standardised nest-recording methods.

- To monitor survival rates and dispersal of Barn Owls through the ringing of young and adults.

- To assess annual changes in numbers attempting to breed in defined study areas from changes in site occupancy rates.

- To examine breeding performance and site occupancy rates in relation to environmental variables, in particular the habitat surrounding each site and any changes in that habitat.

- To provide an annual report of each year's results and to provide analyses and interpretation to assist conservation action and research.

The work will be undertaken by a combination of professional fieldwork and of fieldwork by volunteers:

- The Wildlife Conservation Partnership (WCP) has been contracted to undertake fieldwork to monitor a set of core sites in England and to undertake methodological development.

- The BTO will encourage, where possible, local Barn Owl fieldwork by volunteers to provide standardised information from additional constant study sites and to encourage extra contributions of information to the national Barn Owl databases held by BTO's Nest Record and Ringing Schemes.

Photo: Tom Holden

2. OUTLINE WORKPLAN

The BTO has obtained funding for the Barn Owl Monitoring Programme for its first four years. This will enable the development of the Programme, the piloting of various methodologies and the collection of a solid baseline of information over the longer term.

The general outline of work to be undertaken over the first four years is as follows:

2000 breeding season: funding for the Programme was confirmed in June. Fieldwork by WCP was therefore only started in June, when most nests already contained young, and this reduced the opportunities to catch adult birds (especially males) for ringing, which is best undertaken during incubation. Nevertheless, WCP defined a core set of sites for annual monitoring, piloted recording methods at these sites and gathered preliminary data. Following the breeding season, the methodology has been reviewed and a network of potential volunteers is being established.

2001 breeding season: This year, the volunteer network will be developed and recording methods will be piloted by volunteers. Foot-and-mouth disease may cause a problem in this year, and WCP and volunteers may not be able to obtain full access to all sites throughout the season. Although currently unclear, it is to be hoped that restrictions will be eased at the majority of monitoring sites, such that recording will be permitted by landowners in May. If recording starts later than the end of May, a contingency plan involving increased recording for October is planned. Although the late start would restrict the effectiveness of monitoring activity in 2001, the shift of recording effort to later in the year would allow a thorough investigation of the proportion of birds attempting second broods, complementing the data collected in 2000.

2002 & 2003 breeding seasons: full Monitoring Programme by WCP and volunteers, with further developments as necessary; reporting of results in *BTO News*, etc.

Throughout the project, opportunities will be taken to publicise the Programme, to recruit more volunteers, to provide feedback to volunteers and to raise public awareness about the population status of the Barn Owl. We anticipate producing an annual newsletter that will act as a forum for the exchange of ideas and information between volunteers in addition to providing feedback of results and progress with the Programme. The BTO will work with other organizations concerned with the conservation of Barn Owls when opportunities arise.

3. WHAT IS TO BE MEASURED?

The volunteer-based component of the Monitoring Programme will be carried out at two levels of commitment, each to be the subject of detailed guidelines in a dedicated fieldwork manual. At the first level, the key information can be gathered with minimal disturbance to Barn Owls. This involves checking nesting sites regularly for signs of occupancy, assessing fledging success and checking for signs of renesting and second broods. The second level of monitoring, which can only be undertaken by experienced nest recorders and trained ringers, involves visiting nests to count and measure nest contents and, for ringers, to ring chicks and adults. Work by WCP will be at the second level and will also involve the testing of methods.

It is important to note that Barn Owls tend not to be badly affected by disturbance from fieldwork that is carried out carefully. A large number of long-term studies have been successfully undertaken on the breeding biology of Barn Owls, suggesting that the monitoring of active nest sites is unlikely to bring about desertion (Colvin 1984, Lenton 1984, Wilson *et al.* 1987, De Bruijn 1994, Taylor 1994). Percival (1990) analysed nest record data to show that nests visited only during the late chick stage did not fledge significantly more young than ones that had been visited at other stages of the breeding period. Taylor (1991) examined the effect of nest inspections and radiotagging on breeding success of Barn Owls in southwest Scotland. He found that the various measures of productivity were similar between those nests only visited at the late chick stage and those that received multiple visits. Taylor also noted that side fidelity was high with only 0.9% of males and 5.6% of females changing nest sites in consecutive breeding seasons. We are confident, therefore, that nest-site inspections will not compromise the welfare of Barn Owls or the integrity of the data gathered, if carried out following the protocols that will be described in detail in the Barn Owl fieldwork manual that will be given to all participants in the Programme. These guidelines will build on those that are provided in the *Nest Record Scheme Handbook*, which have been used successfully for many years by nest recorders (Crick *et al*. 1999) and on the methods being tested by WCP.

3.1 Primary information gathering

The key information that needs to be gathered to ensure that the Barn Owl Monitoring Programme achieves its aims is as follows:

- *Site/box details*: information on the type of nest site or design of box (floor area and positioning of entrance hole (top/bottom of box)) and siting information (e.g. mounted on a pole, in a barn, in a tree).

- *Site location*: 6-figure grid reference. These will be held with strictest confidence by the BTO, given the species' protection status under Schedule 1 of the Wildlife and Conservation Act 1981.

- *Habitat/land-use surrounding site*: the habitat surrounding the site will be recorded using the standard BTO habitat codes (Crick 1992) that incorporate information on broad habitat types as well as more detailed information on crop types and livestock. Micro-habitat features near the nest (for example, ditch banks within a landscape of large arable fields) are potentially the most important factors in terms of attracting Barn Owls to breed in many boxes. Methods for recording such habitat features will be explored in 2001. Additional information on broader land-use over a wider scale can be obtained from remotely sensed, satellite-derived datasets such as the Centre for Ecology & Hydrology's Land Cover data.

- *Site occupancy*: a visit in late April/mid-May to the site should reveal whether the site is (or has been during the current calendar year) occupied by Barn Owls. Evidence of usage, including pellet remains and moulted breast feathers, should be recorded, as should occupation by any other species.

Within an area there may be Barn Owls that cannot obtain a mate, pairs that may not attempt to breed and pairs that attempt to breed in unmonitored sites, in addition to those that occupy and attempt to breed in a monitored site. Thus site occupancy provides a minimum estimate of the number of Barn Owls in an area, and changes between years could be caused by changes in the behaviour of Barn Owls in an area or by changes in natural nest site availability rather than by changes in abundance. However, if site occupancy changes appreciably, then it will provide an early warning that abundance might be changing and that further, more detailed, work is necessary.

- *Fledging success*: the number of young fledged from a site. This must include zeros (i.e. failures) to give an accurate indication of the breeding performance of Barn Owls each year. In practice, this is likely to be measured as the number of young in the nest at 5-8 weeks old, when they are ringed (in mid-July/early August; see below), with the assumption that most chick losses will have occurred by then. Information from nests that are visited at a later stage will provide additional information on any significant occurrence of later chick losses.

- *2nd broods*: the occurrence of double brooding by single pairs and the success of the second clutch. A proportion of pairs rear second broods each year, and these second broods can be important in determining the overall productivity of a pair. Double brooding can only be determined where nest boxes are placed in closely adjacent pairs, so that the second clutch is also likely to be laid at a site that can be monitored easily. For the most part, second broods will be detected on the visit made in July/August (see below) because the female will be sitting on eggs in an adjacent (paired) nest box while the male is still feeding young from the first brood (as well as his mate). The fledging success of second broods will be assessed through a final site visit in October.

3.2 Breeding performance

The gathering of more detailed information on nest contents will help in the interpretation of changes in occupancy rates and fledging success and in understanding the causes of such changes. The Barn Owl Monitoring Programme and the existing BTO Nest Record Scheme will provide complementary information and will together provide a fuller picture than either on its own. Thus, for example, while the Nest Record Scheme will be able to provide detailed information on components such as clutch size and how the probability of nest failure might change through the nest cycle, the Barn Owl Monitoring Programme will be able to provide information on important aspects such as partial losses of broods, brood sizes at fledging and double brooding, as well as more accurate measures of average laying dates. Although we hope to encourage a good proportion of current nest recorders to take part in the Barn Owl Monitoring Programme, there will be others who will not be able to guarantee the consistency of recording that the Programme requires. However, by contributing to the Nest Record Scheme, in a less structured way, they will still provide valuable information for other parts of the country that can be compared with information from core sites covered by the Barn Owl Monitoring Programme.

The following will be recorded where possible:

- *Clutch size*: a count of the number of eggs present – to be done by a visit in late April/mid-May.
- *Hatching success*: evidence of unhatched eggs/egg shells.
- *Brood size*: a count of the number of young present, preferably at early and late nestling stages.
- *Age of young*: from development of down and feathers.
- *Losses of young*: counts of any dead young, chick disappearance.
- *Prey stored at nest*: presence, species composition, number (and, if possible, weight) of prey stored at nests, to provide an indication of food availability.
- *Laying/hatching/fledging dates*: these should be recorded when visits coincide with these events.

3.3 Measurements and ringing at the nest

Qualified ringers will be asked to undertake various measurements of eggs and young, if practical, in addition to ringing chicks and adults at the nest.

- *Measurements of eggs*. Initially these will only be undertaken by WCP until a full methodological evaluation has been carried out. When combined with egg weight, measurements of length and breadth of eggs can be used to assess egg-density, which declines predictably through incubation due to respiration by the developing embryo (Rahn & Ar 1974). The use of a portable electronic pan-balance is likely to be essential to permit accurate weights to be taken. These measurements are useful for determining a relatively precise date of egg-laying and can also be used by ringers to assess when to revisit the nest to maximise data gathering efficiency and to ring the chicks at 6 weeks old. A standard calibration curve will be provided to allow ringers to determine the number of days to hatching.

- *Ringing young*: this is important for measuring survival rates and dispersal when breeding adults are recaptured in subsequent years and when dead birds are found and reported under the Ringing Scheme (10-15% of ringed Barn Owls are subsequently reported to the BTO's Ringing Office).

- *Measurements of young*. On every visit, ringers should measure wing length (maximum-chord method) and weight of chicks as well as the length of the 7th primary feather. The latter has been developed by Shawyer (1998) as a potentially accurate ageing method, but this needs to be fully validated as part of the Programme. When standardized using a measure of body size (such as wing length) and measured repeatedly to average out fluctuations due to the timing of measurement with respect to daily food intake, chick weight may provide a useful measure of condition; the value of this, again, needs to be assessed as part of the Programme. In addition, records of the degree of speckling on the underside of the body and wings of the chicks' plumage can be used before birds leave the nest as a valuable indication of sex.

- *Measurement of dead chicks(length of 7th primary)*: this is important to determine the age at which any dead young died.

- *Ringing adults*: this should only be attempted by ringers who have experience of catching birds at a nest site. Guidelines will also be provided as part of the fieldwork manual and we hope to encourage the sharing of information between ringers, perhaps as part of ringing training courses. Ringing of adult birds is important to permit the analysis of survival rates and will allow an assessment of dispersal and movements by breeders. Currently the ratio of birds ringed as chicks to those ringed as adults is approximately 12:1 and very few adults are ringed each year, typically fewer than 100. A significant improvement in these figures will prove invaluable.

- *Measurements of adults*. The age, sex, moult and brood patch condition should be recorded, using standard techniques, to maximise the value of ringing activity and of subsequent recapture or recovery information.

Photo: Dr G H Higginbotham

4. RESULTS FROM 2000

The core set of monitoring sites were chosen by WCP to fulfil various requirements and to ensure a degree of standardisation:

1. Nest boxes were chosen because they are less often subject to the sudden changes in condition associated with some natural sites (e.g., dismantling of balestacks, flooding of tree cavities, etc.).
2. Nest boxes had been established for at least 3 years.
3. Nest boxes were in good enough condition that they would be functional for at least 4 years.
4. Access to the sites was freely available to WCP.
5. 125 nest sites were selected in areas of high quality Barn Owl habitat and high bird density across England. Efforts were made to distribute the sites evenly between five regions based on the administrative regional boundaries of England.
6. To maximise site occupancy year-on-year, sites were chosen only in the core nesting range, i.e. high density areas below 100 m a.s.l. (because 82% of all breeding during the 1982-85 survey occurred below this altitude).
7. Most boxes were paired (two boxes in close proximity), to allow double brooding to be monitored.
8. Two nest box designs were employed and the proportion of each within was approximately constant within a given geographical area. The two designs are ‘Pole’ and ‘A-frame’ (Dewar & Shawyer 1996); although the only available paired boxes in the southwest region were a hybrid of the two designs, they feature a similar floor area to the other designs and were sited in a similar way (isolated trees/poles in remote locations).

Fieldwork recording forms (see Appendix for example) were developed in 2000 and the nest visit data collected by WCP were entered onto them. The information was then entered into a specifically designed Microsoft Access database. They were output from the database into six simple text files, one for the data on each of site characteristics, habitat, visit details, clutch information, brood information and details of prey items found in boxes. SAS software (SAS 2000) was then used for all data analysis. The goal of the analyses was to investigate the range of information that the data currently being collected could provide, rather than to answer specific biological questions. For this reason, and because data quality was reduced by a combination of poor weather in spring 2000 (high rainfall and flooding) and a late start to fieldwork (funding was confirmed only in June), we restricted our analyses to simple exploratory summary statistics. Where appropriate, however, the results were compared with their equivalents from the BTO’s Nest Record Scheme (see below). We also present a brief summary of the Nest Record Scheme’s monitoring of Barn Owl breeding success since 1995. In future years, given better conditions for data collection and a combination of professionally collected data and those from the volunteer-based component (see below), it should be possible to make useful annual and regional comparisons and to test specific habitat-based and geographical hypotheses rigorously.

4.1 Geography and habitat characteristics

The geographical distribution of study boxes for the 2000 fieldwork is shown in Figure 4.1.1. Although there is a spatial bias, the study sites were selected in those parts of each region where Barn Owl density was relatively high (Figure 4.1.1). The volunteer component of the proposed long-term Monitoring Programme will help to fill in the gaps in the coverage of important areas for British Barn Owls.

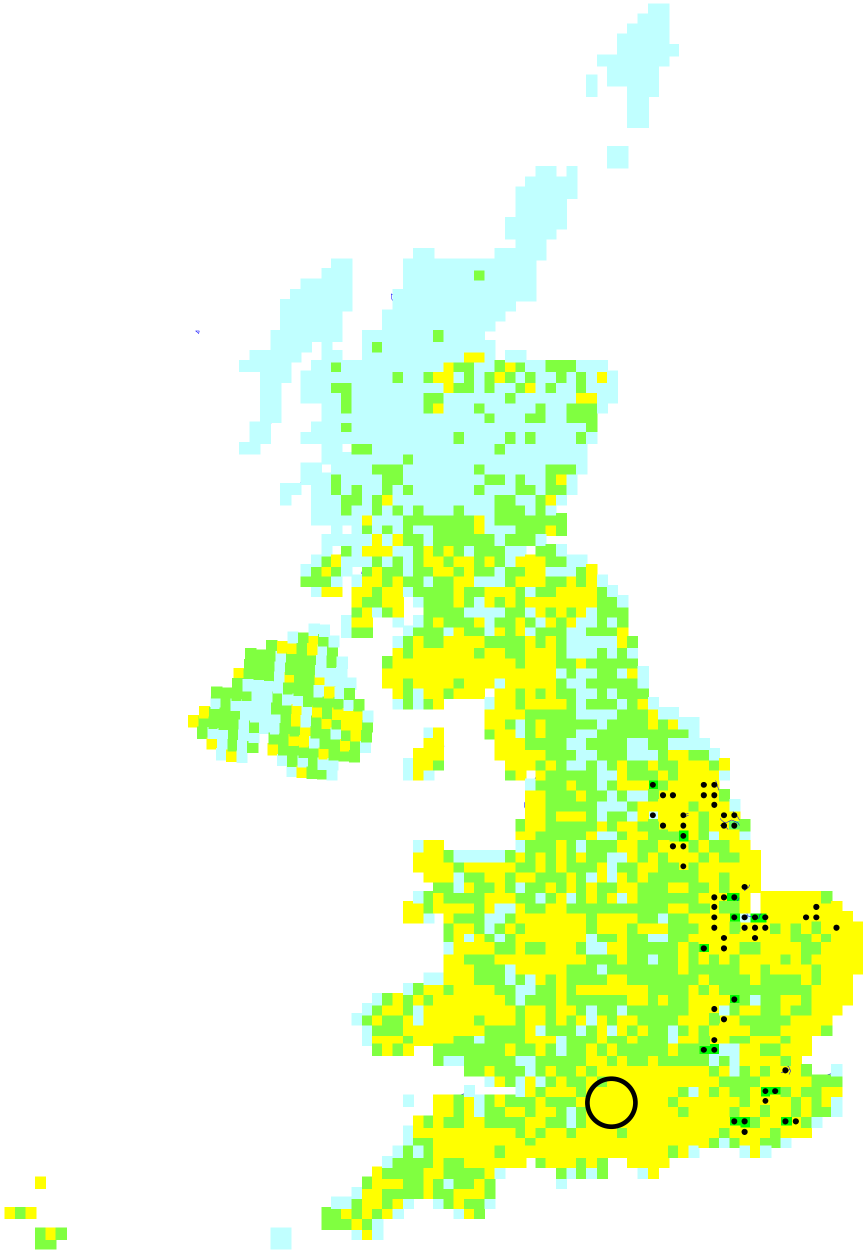

Figure 4.1.1 Geographical distribution of core (WCP) study sites with respect to Barn Owl density. The black dots show 10×10km squares of the UK national grid within which box sites were monitored. The black circle shows the approximate area in which another 20 sites were surveyed, for which grid references were not available at the time of writing. Other squares in which Barn Owls were recorded in neither the 1968-1972 Breeding Bird Atlas (Sharrock 1975) or its follow-up in 1988-1991 (Gibbons *et al*. 1993) are shown in blue, squares where Barn Owls were found in one of the two atlas projects are shown in green and squares in which they were found in both atlas surveys are shown in yellow. These three categories were used as sampling strata for Project Barn Owl (Toms *et al*. 2000).

The habitat likely to be used by Barn Owls around the monitored sites was recorded using standard BTO habitat codes (Crick 1992). The habitat records collected in the field show that the vast majority of sites are located in farmland, with nearly half coming from arable (tilled) farmland and more than a quarter from areas with mixed farming (Figure 4.1.2). This habitat distribution reflects the predominant agricultural land-uses in eastern England, where the study sites are concentrated (Figure 4.1.1). The Centre for Ecology and Hydrology's Land Cover data, collected by satellite remote sensing in 1990, provide an independent assessment of habitat at the 1×1km square scale and thus allow us to assess habitat at a larger scale as well as providing some validation of the field recording (although the land cover data do not provide as much detail). More than three-quarters of the sites monitored in 2000 were found in 1×1km squares in which the largest land-use was arable farmland (Figure 4.1.3). This shows a good match to the field-collected habitat data and again reflects the predominantly arable agriculture of eastern England. The details of the associations between the two sources of habitat information are shown in Table 4.1.1.

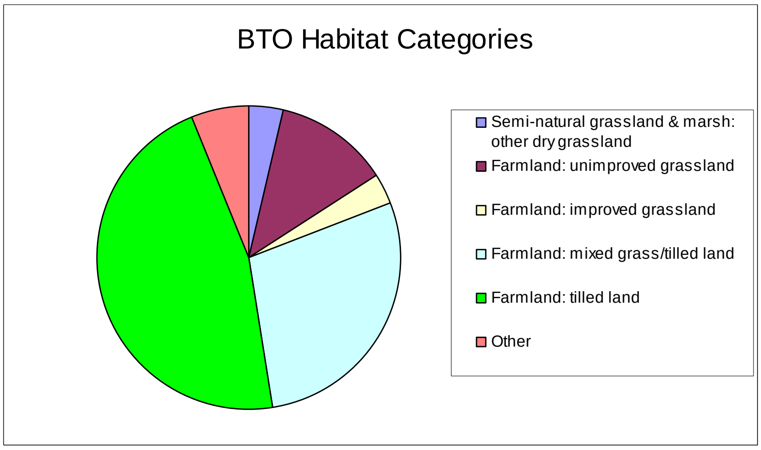

Figure 4.1.2 The distribution among sites (N=114) of broad-scale habitat categories as determined by habitat codes recorded in the field. Habitat recording focused on the areas near boxes that were most likely to be used by Barn Owls.

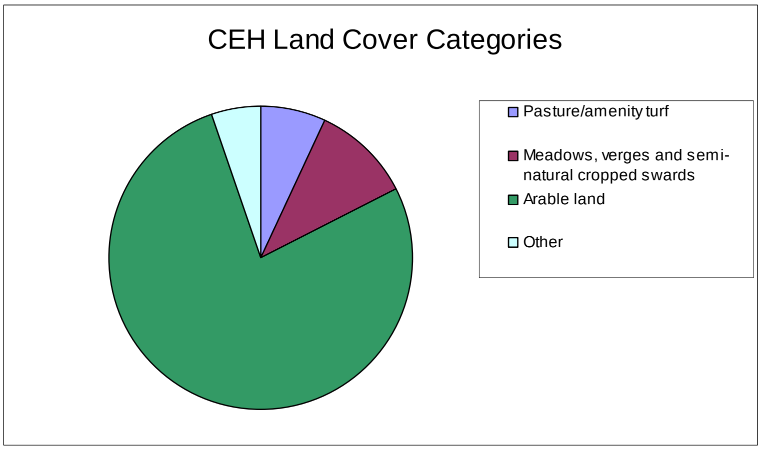

Figure 4.1.3 The distribution among sites (N=114) of broad-scale habitat categories as determined by Centre for Ecology and Hydrology Land Cover data for the 1×1km square in which each box site was found. The category assigned to a box was that which covered the largest area in the 1×1km square.

Table 4.1.1 Associations between habitat categories derived from field records around the nest site and from land cover data at the 1×1km square scale. Data from the 114 sites from which data were collected are included. Land cover categories refer to the dominant land-use category (that covering the largest area) in the 1×1km square in which a box site fell. BTO habitat categories are derived from the top two levels of habitat description: further subdivisions were supplied in most cases, so more detailed comparisons will also be possible to address specific habitat-related questions in the future.

		Land Cover Categories							Total
BTO Habitat Categories		Sea/ estuary	Pasture/ amenity turf	Meadows, verges and semi-natural cropped swards	Deciduous wood	Arable land	Urban/ farms	Dwarf shrub/ grass heath	
Semi-natural grassland & marsh:	Other dry grassland	1	0	0	0	3	0	0	4
	Water-meadow/ grazing marsh	0	0	1	0	1	1	0	3
Farmland	Unspecified	0	1	0	0	1	0	0	2
	Unimproved grassland	0	1	6	0	7	0	0	14
	Improved grassland	0	2	0	0	2	0	0	4
	Mixed: grass/ tilled land	0	4	5	2	21	0	0	32
	Tilled land	0	0	0	0	51	1	1	53
Water bodies:	River >3m wide	0	0	0	0	2	0	0	2
Total		1	8	12	2	88	2	1	114

4.2 Site occupancy

Table 4.2.1 shows the numbers of sites that were occupied by Barn Owls or by other species. Four sites were never recorded as being occupied by breeding Barn Owls and were also never recorded as containing any other species. However, another 16 of the sites where breeding Barn Owls were never found were recorded as Barn Owl roost sites on one or more visits. The latter cases may have involved birds that did not breed in 2000 (this was most probably because most (10) had bred at these sites in previous years) or birds that used other, "natural" sites instead of the boxes provided. The records of other species using Barn Owl boxes are summarized in Table 4.2.2. Records of Barn Owls sharing a box with another species often featured the latter using the roof-space chamber of boxes of the pole-box design, although incidences of owls and other species (Jackdaws and Stock Dove, but not Kestrel) attempting to nest in the same chamber occurred with both box designs.

Table 4.2.1 Nest site occupancy, on one or more visits, (a) by Barn Owls, (b) by other species (breeding or roosting, with or without Barn Owls also present), and (c) by breeding Barn Owls, but with the site being used concurrently by another species (for breeding or roosting). Note that the columns for the presence of other species and for sharing exclude the four box sites that were empty on all visits.

	Number of Sites		
	(a) Site occupied by breeding Barn Owl?	(b) Other species present (breeding or roosting)?	(c) Box shared by breeding Barn Owl and other species (breeding or roosting)?
No	22	96	102
Yes	104	26	20
Total	126	122	122

Table 4.2.2 Species other than Barn Owl found using programme nest boxes in 2000

	Total number of visits			
Species	Found alone		Found sharing with breeding Barn Owl	
	Roosting	Breeding	Roosting	Breeding
Kestrel	2	2	4	6
Tawny Owl		1		
Little Owl		1		
Stock Dove		3	1	5
Jackdaw		3		4
Grey Squirrel	1			

N.B. Kestrels were never found in the same chamber as a Barn Owl nest, but Jackdaws and Stock Doves were sometimes found in the same chamber.

4.3 Productivity

Breeding success was investigated using the methods that are standard for the Nest Record Scheme, with adaptations as necessary for the present data set. Nest recording generally requires multiple visits to a nest while it is active so that the timing of the nesting process (laying, hatching, fledging) can be estimated and so that estimates of nest failure rates can be derived using the Mayfield method (Mayfield 1961, 1975). The majority (72%) of site records in the 2000 Barn Owl data consisted of single visits, in nest recording terms (Figure 4.3.1): although many of these *sites* were visited twice, one visit was often before egg-laying or after fledging. This pattern of site visiting limits the information on productivity that can be extracted from the 2000 data set, but multiple visits during single nesting attempts should be the norm in future years of the monitoring scheme. Some overlap between the Barn Owl Monitoring Programme and the Nest Record Scheme will be useful to reveal the extent to which the data sets are matched. Comparisons with nest record data for 2000 are therefore made explicitly below.

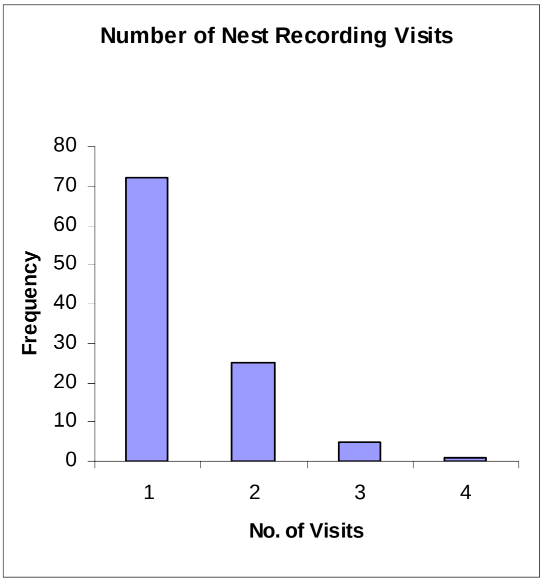

Figure 4.3.1 Numbers of sites to which different numbers of nest recording visits were made in the course of the pilot fieldwork in 2000.

Clutch size was estimated as the maximum number of eggs found in a nest, or as the sum of the number of chicks and the number of eggs, if a nest was visited during hatching and if this sum was larger than any other clutch size recorded. Clutch size was not estimated if a nest had only been visited when chicks alone were present because some egg or chick mortality was likely to have occurred (infertile or unhatched eggs usually disappear through breakage or trampling into the debris at the bottom of a nest). The mean Barn Owl clutch size in the data was 4.51 (SE 0.22, N=55), which compares very closely with a mean of 4.50 (0.45, 14) from nest record data for 2000.

In reporting on the Nest Record Scheme, "population" brood size is usually given as the mean of the maxima recorded in single nests: we have calculated an analogous figure for the pilot monitoring data as an average across all sites where one or more chicks were found in the nest. This average brood size was 3.02 (SE 0.11, N=83), notably smaller than the mean of 3.95 (0.13, 88) revealed by nest records for 2000, a difference that may reflect the timing of visits (and partial losses) rather than a real difference between the two samples.

Because Barn Owl chicks hatch asynchronously within broods and brood reduction through the loss of weaker chicks is common, the brood size at fledging is often less than the maximum and is an important demographic parameter for the species. This parameter is difficult to obtain exactly because nests have to have been visited when fledging is almost complete and because the chicks are likely to fledge and disperse over a period of two to four weeks. The closest we can come to the brood size at fledging is the average number of live chicks found on the last visit before fledging, which was 2.77 (SE 0.11, N=78) in the 2000 data. This measure could potentially be improved (notwithstanding the inevitable reduction in sample size) by the use only of broods recorded after chicks had reached a certain average age and could therefore be regarded as very likely to fledge successfully. Chick age could be calculated using the same formulae as used below to estimate first egg dates.

Given measures of clutch size and brood size, it is straightforward to derive estimates of hatching success (or chick:egg ratio), that is the number of eggs per clutch that hatch successfully. The methods used to estimate hatching success are described in detail in, e.g., Siriwardena *et al*. (2000); they use statistical procedures designed specifically for the analysis of proportions and probabilities. In the 2000 Barn Owl data, mean hatching success was 58% (95% CIs 50-65%, N=91), which was lower than the mean of 68% (53-81%, 8; N.B. small sample size) found for 2000 nest records (reflecting the larger brood size in the nest record data probably caused by the timing of visits: see above).

Using methods similar to those used for hatching success, we can examine the proportion of eggs from a clutch that result in successfully fledged chicks (or at least those that survive to the last visit to the nest, using the estimate of brood size at fledging described above). The average of this overall egg success was 51% (95% CIs 43-59%, N=91) in the 2000 monitoring data.

Measurements of chicks were used only to derive estimates of first egg date (see below); in principle, such data could also be used to investigate brood condition, but this would require repeated visits to individual nests to allow the effects of hourly fluctuations in chick weight to be accounted for. Measurements of eggs were used both to generate estimates of first egg date and to examine variation in egg morphology: widely variable egg shape may be a reflection of nutritional stress on laying birds(i.e. poor environmental conditions). The distributions of variance values for each of egg length, egg width, egg weight and egg density look promising for identifying unusually stressed individuals because they all show a predominance of small variance values (Figure 4.3.2). However, these values need calibration against other measures of the nutritional stress on adult Barn Owls to determine how they should be interpreted in detail (i.e. how stressed a bird with a highly variable clutch might be) and which of the measures is most useful.

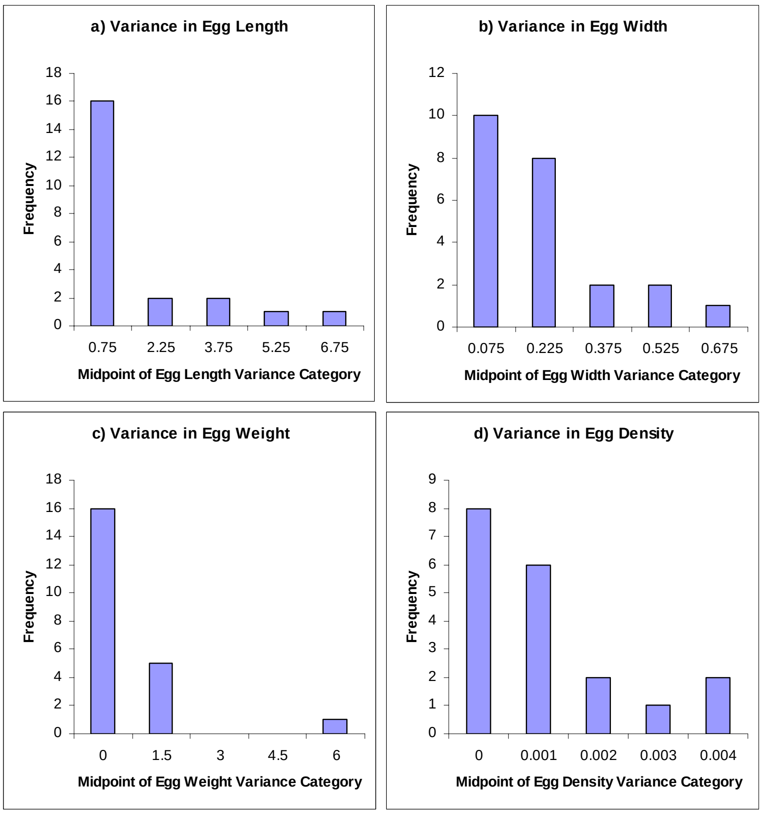

Figure 4.3.2 Histograms showing the frequency with which different amounts of nest-specific variance in egg measurements occurred. A measure that usually has a low associated variance within nests, but occasionally has a high variance, has potential to be useful in the assessment of the condition of parent birds.

A key parameter in the determination of overall productivity is the probability that a nest will fail or succeed, which is usually calculated as a daily failure probability, or failure "rate". Mayfield (1961, 1975) developed methods to analyse these probabilities whilst avoiding bias due to the failure of nests before they can be found by an observer, and methods derived from his approach form part of the standard set of analyses for Nest Record scheme data (e.g. Siriwardena *et al*. 2000). These methods require nests to have been visited at least twice so that there is a defined, nest-specific period within which it is known whether or not the nest failed. The rarity of multiple visit nest records in the 2000 Barn Owl data means that failure rates are difficult to calculate and cannot be split into failures at the egg stage and at the nestling stage. Data from some multiple-visit records also have to be omitted because the exposure period the data suggest is unrealistic (for example, if eggs are found cold and reported as a nest failure but only long after desertion): we used a maximum number of exposure days of 88 (32 for the egg period and 56 for the nestling period). The average daily failure rate over the whole nest period estimated from the remaining data was 0.0077 (95% CIs 0.0042-0.0143, N=29),i.e. 0.77% of nests failed, on average, each day. Assuming a complete egg-to-fledge period duration of 80 days, this equates to a nest survival of 54%, but this figure was based on rather a small sample size and may not be reliable. The nest record data for 2000 produced a mean daily failure rate of 0.0028 (0.0016-0.0049, 108), which equates to an overall nest survival of 80%. Such a difference would be extremely significant biologically, so it is important that a future combination of Barn Owl monitoring and nest record analyses determines which is likely to produce more realistic estimates of nest survival probabilities. Not only is each data set likely to be subject to different biases, but how useful this parameter is ever likely to be also needs to be considered. It is based on whole nests, as a monitoring unit, when individual Barn Owl chicks within a brood often have very different fates, having hatched at different times, so partial brood losses are common.

Barn Owls can rear more than one brood in a single season, but rarely do so at a single nest site because second clutches are usually started before the fledging of the first clutch is complete. Monitoring only single boxes could therefore seriously underestimate productivity. It is also possible that a second brood would be reared in a monitored box after a first attempt elsewhere. Further, the success of individual breeding attempts is likely to vary through the breeding season. Approximately 75% of box sites in this study were paired, allowing single territorial Barn Owl pairs potentially to rear successive broods in boxes, although not eliminating the possibility that second (or first) broods could be reared at other nest sites nearby. The restrictions on the timing of site visits in 2000 (as discussed above) meant that a thorough analysis of the occurrence and success of second versus first broods was not possible, but we could nevertheless summarize the cases that were identified to look for patterns. Four pairs were definitely recorded as making two breeding attempts in 2000, two of which used the same box for their first and second attempts, having waited until the first brood had fledged. A further late attempt was identified as probably being a second attempt by a pair from a nearby box. Of the first attempts by these five pairs, three were successful, one failed at the egg stage and the fate of one was unknown (visited once, when chicks were present). Of the second attempts, one definitely failed at the egg stage and one probably did so, one probably succeeded and the fates of two were unknown (each visited once, one when eggs were present and one when chicks were present). No obvious pattern of success and failure by breeding attempt presents itself from these results, but the sample size is small and the fates of several attempts are unknown.

4.4 Timing of laying

In standard nest record methodology, first egg dates are estimated from the age of the contents on each visit and back-calculated using standard values for the lengths of the egg and nestling periods. Nest visiting patterns in the 2000 fieldwork did not allow this approach to be used and it is not best suited to asynchronously hatching species such as Barn Owl. First egg dates, however, could be estimated from standard curves for relationships between the time-to-hatching of eggs and egg density and between chick wing or seventh primary length and chick age. This approach has the potential to be more accurate than the standard nest record method (provided that the key growth relationships are known accurately).

The growth curves used were derived from Percival (1990; egg density vs. days-to-hatching), Shawyer (1998 and pers. comm.; egg density vs. days-to-hatching, a revision of Percival's method, and 7th primary length vs. chick age) and P. Mentink (pers. comm.; wing length vs. chick age). Curves showing the observed dependency of each timing variable on the appropriate developmental variable were plotted and a polynomial function fitted to each plot in Microsoft Excel. Quadratic or cubic functions were used initially, but the order of the polynomial was increased until a fit was obtained that differed negligibly from the real data. The equations from these lines were then used to predict days-to-hatch for each egg measured and age for each chick measured (excluding dead chicks). Two separate curves were used for 7th primary length: one for feathers still in pin and one for subsequent growth. All the curves used are shown in Figure 4.4.1. Note that all the equations were merely descriptions of the observed curves and that their form does not imply any causal relationship. All four estimates of timing relate to hatching date: these estimates were converted to laying dates by assuming an incubation period of 31 days. The earliest egg- or chick-specific estimate, by each measure, was taken to be the estimate of a nest's first egg date; Table 4.4.1 shows the mean values of first egg date estimated across all nests, nationally.

Table 4.4.1 National estimates of first egg date (FED, where 1 = 1 January; thus 109 = 19 April and 140 = 20 May). Note that these figures are not inter-comparable at the nest level because all measures were not collected at all nests.

Measure	FED	SE	N
Percival Egg Density	141.3	4.0	21
Shawyer Egg Density	144.3	4.0	21
Chick Wing Length	109.2	17.4	2
Chick 7th Primary Length	114.4	3.1	64

Where the necessary egg and/or chick measurements were collected for single nests, we can show directly how the first egg date estimates derived by the four different methods compare. Comparisons matched by nest are shown in Table 4.4.2: agreement is generally close, with the largest differences found in the comparisons of the egg density measures with the one derived from chick 7th primary length. Across the five nests concerned, 7th primary length consistently gave rise to earlier estimates of first egg date. These measures need to be compared more rigorously, with larger sample sizes and, preferably, independent validation of age, to determine which is best and most suitable for use in future Barn Owl monitoring. The eggs and chicks of Barn Owls breeding in captivity might be suitable subjects for such validation through the regular monitoring of growth parameters.

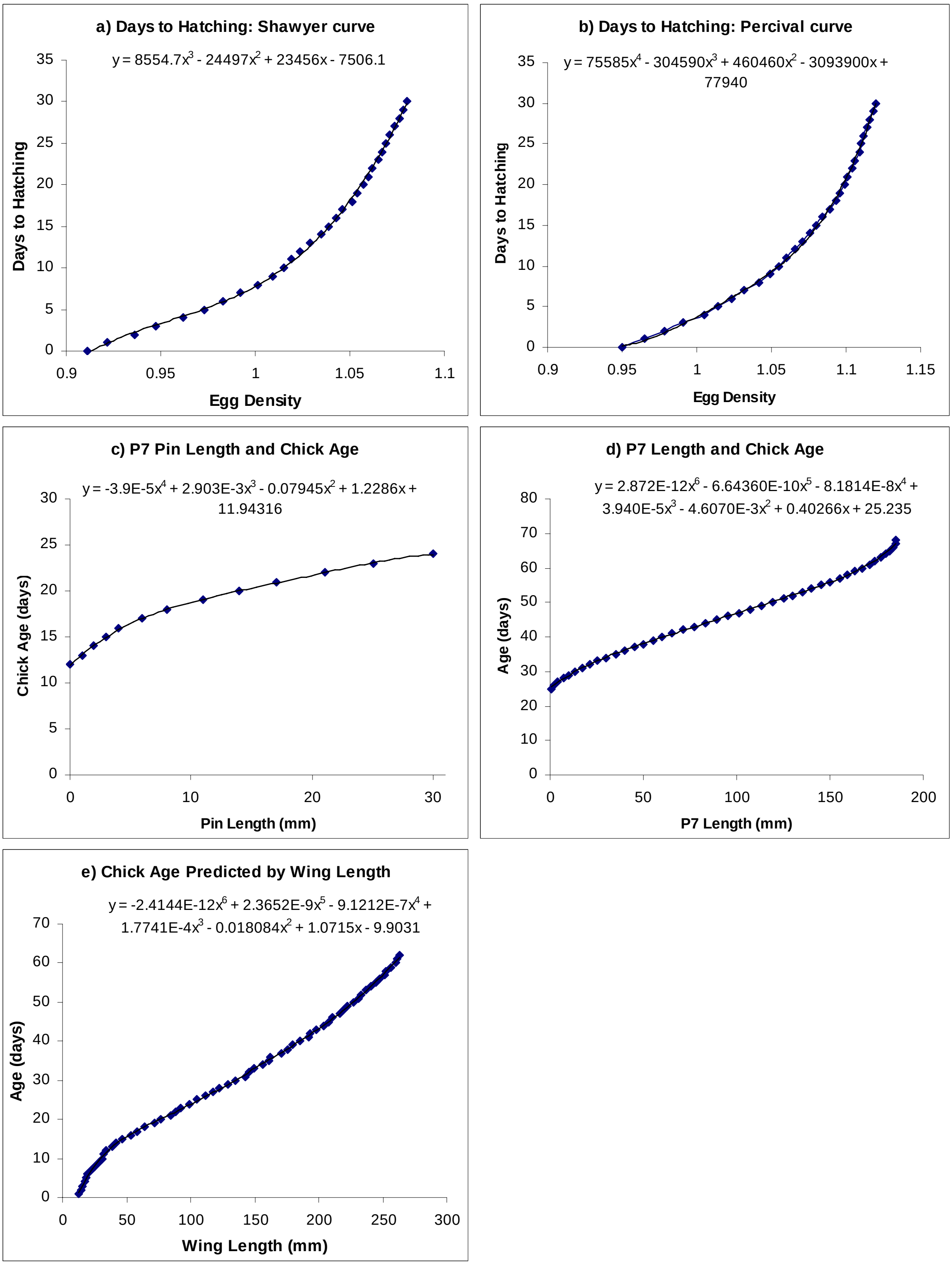

Figure 4.4.1 Curves showing relationships between egg and nestling measurements and age (leading to first egg date). The graph symbols show the observed points for each curve and the lines show the fitted equations (also written mathematically on each graph). Note that the *x* and *y* axes on the graphs are orientated in the reverse of the standard scheme for independent and dependent variables; this has been done because the fitted lines are required for predictive purposes rather than to describe probable causation.

Table 4.4.2 Comparisons of different methods for estimating first egg date (FED), using data matched by nest. FED is numbered such that 1 = 1 January; thus 109 = 19 April and 130 = 10 May.

Measure	Measure 1		Measure 2		N
	FED	SE	FED	SE	
Percival (1) vs. Shawyer (2) Egg Density	141.3	4.0	144.3	4.1	21
Percival Egg Density (1) vs. Chick Wing Length (2)	127.2	-	126.6	-	1
Percival Egg Density (1) vs. Chick 7th Primary Length (2)	131.7	2.8	126.5	3.7	5
Shawyer Egg Density (1) vs. Chick Wing Length (2)	128.7	-	126.6	-	1
Shawyer Egg Density (1) vs. Chick 7th Primary Length (2)	133.4	3.7	126.5	3.7	5
Chick Wing Length (1) vs. Chick 7th Primary Length (2)	109.2	17.4	108.6	18.3	2

4.5 Productivity and farmland habitat

The habitat data collected in the course of Barn Owl monitoring potentially allow a wide range of habitat or environmental influences on productivity to be investigated, and the range is likely to grow as the Programme matures. In addition, the recording of site grid references allows spatial matching with other environmental information such as the CEH Land Cover database. It would be unwise to undertake detailed analyses using only the 2000 (pilot) data, but preliminary analyses can illustrate the potential of the information being collected.

An important habitat distinction for Barn Owls is believed to be the contrast between arable and pastoral agriculture, grazing land providing more opportunities for foraging. We investigated the differences between birds breeding in arable and grazing/mixed farming habitats (as assessed by the field habitat recording) in terms of clutch size, maximum and last recorded brood size, hatching success, overall egg success, nest failure rate over the whole nest period and first egg date. Sites for which habitat was not assessed in 2000 and those from habitats not recorded specifically as arable, grazing or mixed farmland were omitted. Grazing and mixed farming were pooled because of the sample sizes available: arable farming was much the commonest in the data set (Table 4.1.1; Figure 4.1.2). The breeding variables were analysed as described above, the data from each habitat type being compared using standard statistical techniques (see, e.g. Siriwardena *et al.* 2000) in SAS software (SAS 2000). The results are summarized in Table 4.5.1.

Table 4.5.1 Results of comparisons of breeding variables between arable and grazing/mixed habitats. Test results show χ^2 statistics for likelihood-ratio tests of the difference in model deviance between constant models and models allowing values for the arable and grazing/mixed categories to differ (SAS 2000). Sample sizes were too small to allow testing of the wing length-derived estimate of first egg date. Numbers in brackets after the sample sizes for the whole nest period failure rate show the numbers of nests in each sample that failed.

Variable	Number of sites		Likelihood-ratio test results	
	Arable	Grazing/ Mixed	χ^2	*P*
Clutch size	29	21	0.01	0.935
Maximum brood size	40	33	1.69	0.193
Last recorded brood size	38	30	0.70	0.402
Hatching success	20	12	5.88	0.015
Overall egg success	18	11	5.42	0.020
Whole nest period nest failure rate	15 (3)	10 (6)	2.06	0.151
Percival egg density first egg date	11	10	0.01	0.915
Shawyer egg density first egg date	11	10	0.02	0.881
Chick 7th primary first egg date	35	24	3.07	0.085

Both hatching success and egg success were higher in arable farming than in grazing/mixed farming (hatching success mean 0.66 (95% confidence interval 0.55-0.75) versus 0.46 (0.34-0.58); egg success 0.59 (0.48-0.69) versus 0.39 (0.27-0.53)), suggesting either that a higher proportion of eggs were viable in nests in arable areas in 2000 or that partial brood mortality early in nestling life was more significant in grazing/mixed areas. There was also an indication that clutches were started later in grazing/mixed areas (chick 7th primary first egg date: mean 122 (2 May) (SE 26.6) versus 110 (20 April) (23.6) in arable areas) and it is possible that these earlier nests were more badly affected by the poor weather in late spring 2000. All the tests conducted suffered from rather low sample sizes (Table 4.5.1), however, so the significant and non-significant results should be viewed with caution for this reason as well as because of the unusual weather conditions in the pilot monitoring year.

4.6 Adult captures

The presence or absence of each parent at a box was recorded on each visit and adults were captured inside the box and ringed wherever possible. Male Barn Owls were present on 20% of visits to boxes when an active nest or roosting activity was found, female Barn Owls on 48% and one or both sexes on 53%. Males were captured on 12% of these visits, females on 35% and one or other sex on 40%. These figures lead to capture efficiencies (proportions of birds present that were then captured) of 62% for males, 73% for females and 76% for either sex. Combining all visits to each site, males were seen at 24% of sites, females at 60% and one or other sex at 66%, while 15% of males and 47% of females were caught. One or other sex was caught at 52% of sites. Per site, capture efficiency (percentage of sites where birds seen were also caught) was 62% for males, 78% for females and 80% for one or other sex. Given the tendency of breeding Barn Owls to be site-faithful from year to year, these figures suggest that capture data collected under the long-term monitoring should be sufficient to allow the estimation of (changes in) annual survival rates, using methods along the lines of those being used in the BTO's Re-trapping Adults for Survival scheme (Balmer 1999).

The regular trapping of adult Barn Owls potentially allows a range of biometric data and other information to be collected and such data might be used both to contribute to the interpretation of the monitoring results (e.g. were observed population declines preceded by a reduction in the average age of breeding adults or is low breeding success associated with poor adult condition?) and to improve our knowledge of general Barn Owl biology. An example of a contribution to the latter is the development of plumage cues to aid in the sexing of Barn Owls: the amount of speckling on the underbody is thought often to be greater on females. An underbody speckling score of zero (no speckling) to five (highly speckled) was recorded for 28 independently sexed (by brood patch) adult Barn Owls in 2000. The comparison between the two sexes is illustrated in Figure 4.6.1. Although sample sizes are small, females appear to be more speckled more often. It is interesting, however, that this difference is not as clear as that found by Taylor (1994) using a similar score. Further data from subsequent years of monitoring will increase the sample size and allow a more definitive comparison to be made.

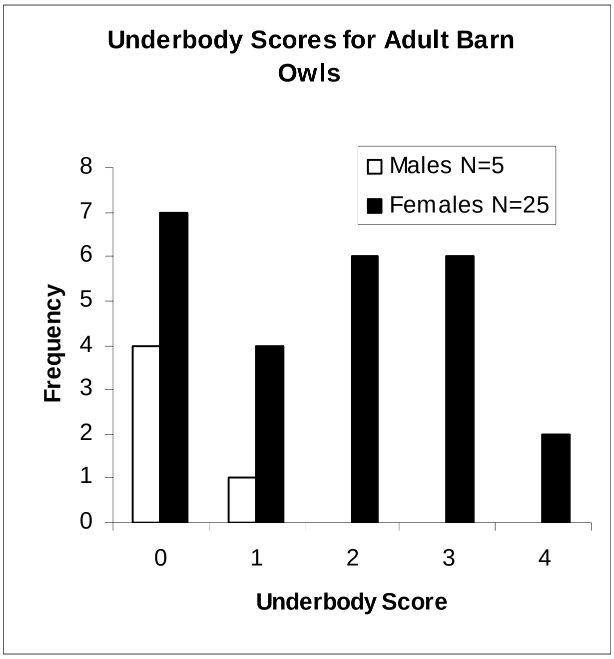

Figure 4.6.1 Numbers of male and female Barn Owls trapped in 2000 with recorded underbody speckling scores from zero to five.

4.7 Prey items in active Barn Owl nests

Prey items were recorded in nest boxes on 42 visits and 57% of these occasions involved records of Field Voles (Table 4.7.1). There was little indication of any difference in the prey of Barn Owls from arable and pastoral or mixed areas (Table 4.7.1) but sample sizes were small, so firm conclusions should not be drawn from this apparent pattern. Overall, prey was found at 24 of 104 sites with active Barn Owl nests (12 of which were in arable farmland and 11 in grazing or mixed farmland). It is likely that more prey items will be found in boxes in subsequent years of monitoring, giving more power to detect differences between habitats or regions. The wet weather in spring 2000 probably caused a low availability of prey and a reduction in birds' ability to collect and store a surplus of food.

Table 4.7.1 Frequency with which prey species were found in boxes, including a split by gross agricultural habitat. Note that no prey was found on 114 visits.

	No. of Visits			Percentage of Visits
Prey Type	Arable	Grazing/Mixed	Total*	Total
Birds	2	0	3	7.14
Brown Rat	1	0	1	2.38
Common Shrew	1	4	5	11.90
Field Vole	17	6	24	57.14
Mole	0	1	1	2.38
Water Vole	1	1	2	4.76
Wood Mouse	5	1	6	14.29

*Includes sites not recorded as being in either arable or grazing/mixed farmland so is not the sum of the preceding columns.

4.8 Analyses of BTO Nest Record Scheme data

A key goal of long-term Barn Owl monitoring is to produce data that complement existing monitoring schemes such as the BTO's Nest Record Scheme. Together with the additional Barn Owl-specific fieldwork to be undertaken by volunteers, nest records can provide a wider context and some validation for the core monitoring sites, as well as providing information on additional aspects of breeding success. For example, recording visits are likely to be more frequent in the course of nest recording than in long-term Barn Owl monitoring, providing better information on nest failure rates, especially in the egg period. Here, we present summary analyses of nest record data from 1995-2000, showing both temporal variation and differences with respect to the same broad farmland habitat split as was investigated for the 2000 pilot monitoring data above.

Nest record data were analysed using standard methods to estimate first egg date, clutch size, (maximum) brood size, hatching success, and daily nest failure rates in the egg, nestling and whole nest periods (see, e.g., Siriwardena *et al*. 2000). The analyses were conducted using SAS software (SAS 2000) and the sample sizes available for analysis are shown in Table 4.8.1. The annual variation in each parameter is shown in Figure 4.8.1. The inter-annual variation was significant only for brood size (likelihood-ratio test χ^2=42.16, 5df, p<0.0001; Figure 4.8.1), reflecting the difference of about 0.8 of a chick between average broods in "low years" like 1995 and 1998 and in "high years" like 1996 and 2000.

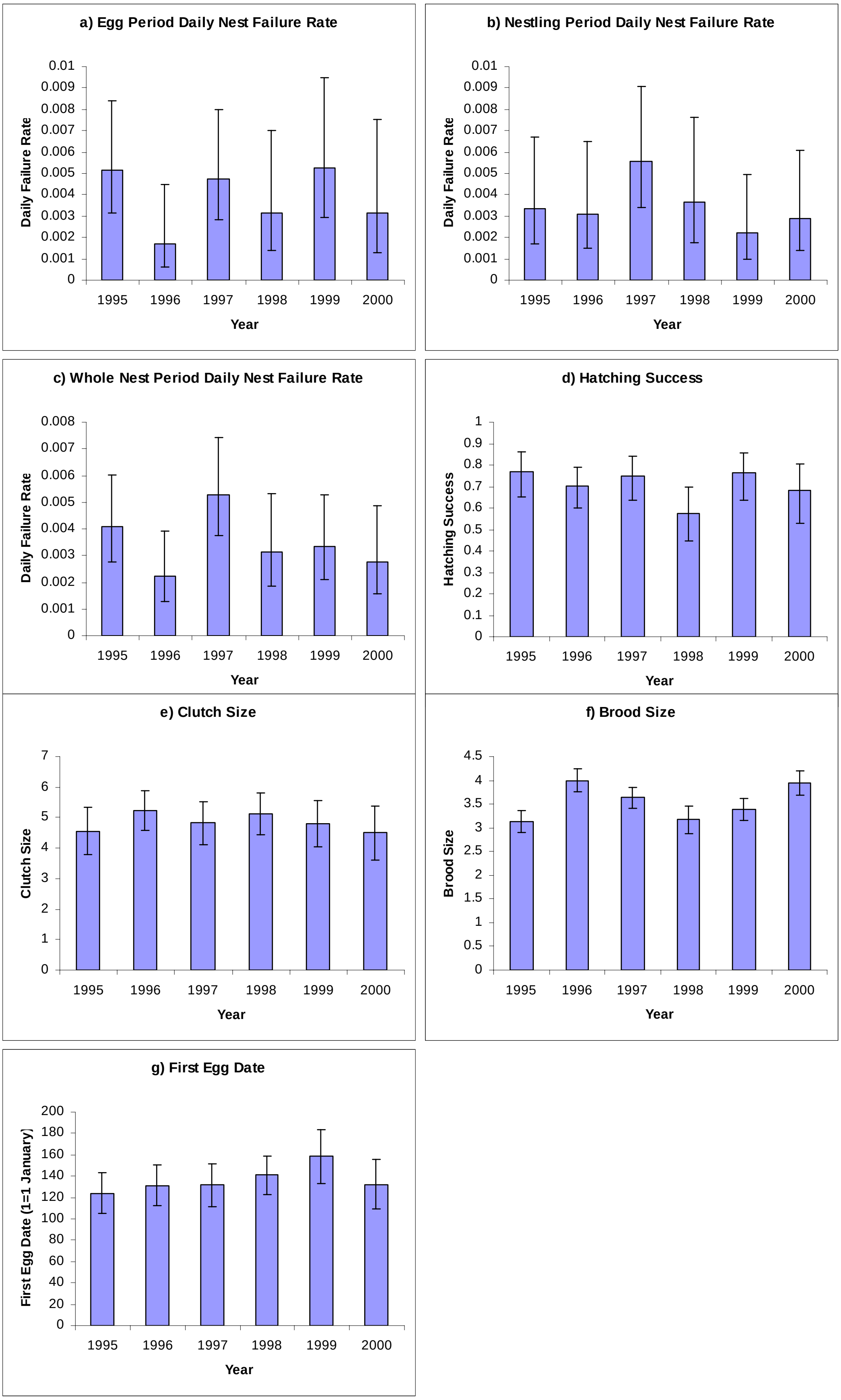

Figure 4.8.1 . Annual estimates of breeding success parameters derived from BTO Nest Record Scheme data. All error bars show 95% confidence intervals.

The results of the tests of differences with respect to farmland habitat are shown in Table 4.8.1. As in the 2000 pilot field data, hatching success was higher in nests in arable areas (mean 0.94 (95% confidence interval 0.68-0.99) versus 0.76 (0.62-0.86) for grazing/mixed farming), but the absolute estimates can be seen to be much higher than was found in the field data. The latter difference probably reflects a difference in the timing of nest visits relative to the occurrence of partial losses of nestlings, but the consistent effect of farming type on hatching success is suggestive of a real ecological difference. Further analyses of the Barn Owl monitoring database, as it develops over the coming years, should help to clarify both of these issues. The only other near-significant result saw an indication of higher nestling period failure rates in grazing/mixed farmland, but this pattern depended on a rather small sample (only 22 nests on arable farms, none of which failed) and could be detected in the failure rate over the whole nest period (Table 4.8.1). Indeed, sample sizes were small for several of the comparisons conducted (Table 4.8.1), so all these results should be viewed with caution. All such cases represent parameters for which the new long-term Barn Owl scheme will aim to and should improve national monitoring.

Table 4.8.1 Nest record card sample sizes used in analyses of annual variation in breeding success, 1995-2000.

Year	Sample Sizes of Nest Record Cards available for:						
					Daily Failure Rates (no. that failed)		
	First Egg Date	Clutch Size	Brood Size	Hatching Success	Egg Period	Nestling Period	Whole Nest Period
1995	9	18	106	13	103 (16)	91 (8)	135 (25)
1996	9	25	96	17	86 (4)	89 (7)	126 (12)
1997	8	22	114	15	105 (14)	97 (16)	144 (33)
1998	10	24	70	10	73 (6)	66 (7)	105 (14)
1999	5	19	113	12	86 (11)	98 (6)	133 (18)
2000	6	14	88	8	68 (5)	82 (7)	108 (12)

Table 4.8.2 Analyses of variation in breeding success between arable and grazing/mixed habitats, 1995-2000. Test results show χ^2 statistics for likelihood-ratio tests of the difference in model deviance between constant models and models allowing values for the arable and grazing/mixed categories to differ (SAS Institute, Inc. 2000). Nest record card sample sizes used in each test are also shown; figures in brackets for the failure rate estimate sample sizes show the number of nests in the sample that failed.

Variable	Number of sites		Likelihood-ratio test results	
	Arable	Grazing/ Mixed	χ^2	*P*
Clutch size	6	17	1.08	0.361
Maximum brood size	23	112	0.18	0.399
Hatching success	4	10	3.34	0.667
Egg period nest failure rate	17 (2)	79 (7)	0.52	0.068
Nestling period nest failure rate	22 (0)	97 (8)	3.36	0.472
Whole nest period nest failure rate	27(2)	130 (16)	0.51	0.067
First egg date	2	4	0.83	0.477

4.9 Barn Owl movements - information from ring-recoveries

Some 2,000 to 3,000 Barn Owls are fitted with metal rings annually as part of the National Ringing Scheme. This is coordinated on behalf of the British & Irish Governments by the BTO. The vast majority of these Barn Owls are ringed as chicks, the remainder being ringed as adults, typically caught at nest sites during the breeding season. About 10-15% of ringed Barn Owls will be recovered, either found dead or recaptured at some future date, and these "ring-recoveries" provide important information on the movements and survival rates of wild Barn Owls. The ring-recoveries for Barn Owl have recently been analysed as part of the Migration Atlas project (Wernham *et al., in press*), providing an overview of the range of movements made by Barn Owls in Britain & Ireland.

Ring-recoveries show Barn Owls to be largely sedentary within Britain & Ireland, with natal dispersal being the predominant movement undertaken (Figures 4.9.1 and 4.9.2). Young Barn Owls disperse away from their natal sites over the first few weeks after fledging. The median distance moved between ringing and recovery by birds ringed as chicks rises from 3km during the second month to 12km in the fourth month (Fig 4.9.3). These recoveries suggest that movement is completed within the first four or five months post-fledging and that there is little additional movement after this period. Insufficient numbers of Barn Owls have been sexed as chicks to allow an examination of potential differences in natal dispersal distances between males and females, although detailed studies in North America (Marti 1999) and Scotland (Taylor 1994) suggest that females disperse significantly further than males, a pattern seen in a many bird species (Greenwood 1980). Through the annual Monitoring Programme we aim to encourage ringers to record the sex of those chicks that they ring (using underbody speckling, as described above), thus providing much-needed information on sex differences in dispersal patterns.

Once Barn Owls reach breeding age they are far more sedentary in nature, with movements between the breeding and non-breeding season showing a median distance of 4km (90% confidence limits = 0-50 km, n=121) and between breeding seasons of 3km (90% confidence limits = 0-84 km, n=23). Although the sample size is small, the lack of movement is supported by the work of Taylor (1994) in southwest Scotland. During the winter months, adult Barn Owls may be forced to forage over an increased area in order to find sufficient food and this can lead to an increase in foraging range from 1-2km in the breeding season up to 4-5km in winter (Cayford 1992).

Some Barn Owls do move greater distances, although some of these long-distance movements may involve assistance from man. There are documented cases of Barn Owls being hit by lorries and transported some distance before falling from the vehicle. With 41.2% of Barn Owl ring-recoveries coming from birds found dead on the road, there is a risk that the average distance moved by Barn Owls may be inflated.

The overall picture though, is one of a generally sedentary species within Britain & Ireland, with the main movements being undertaken during the period of natal dispersal. The annual Monitoring Programme will provide information sexes differences in this dispersal and will additionally, through the trapping of adults at the nest, greatly increase the information available on breeding dispersal.

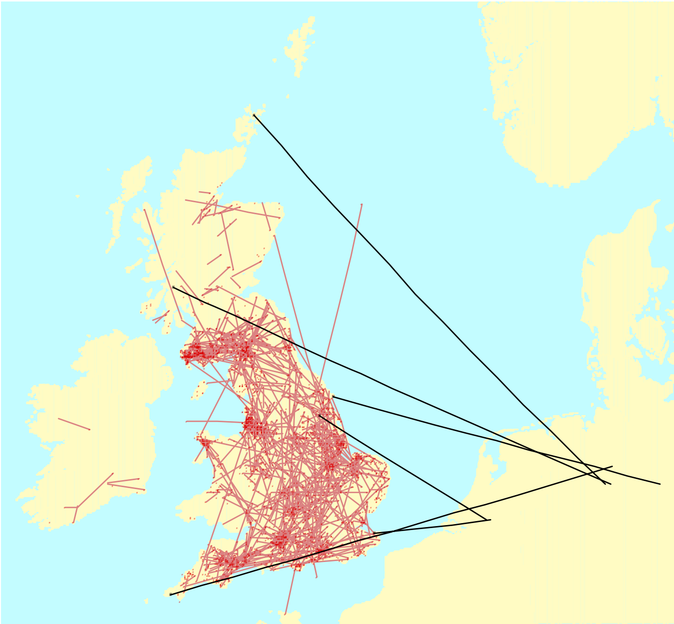

Figure 4.9.1 Recovery locations and movements of over 20km for the included recoveries of Barn Owls ringed or recovered in Britain & Ireland, with those ringed in Britain & Ireland (3146, red) differentiated from those ringed abroad (6, black). The two pre-1979 foreign-ringed Barn Owls (Belgium 1 and the Netherlands 1) are not shown.

Figure 4.9.2 Movements of over 20km and recovery locations of Barn Owls ringed as pulli in Britain & Ireland and recovered in a subsequent breeding season when of breeding age. There were 345:141 movements under:over 20km but only those over 20km are plotted.

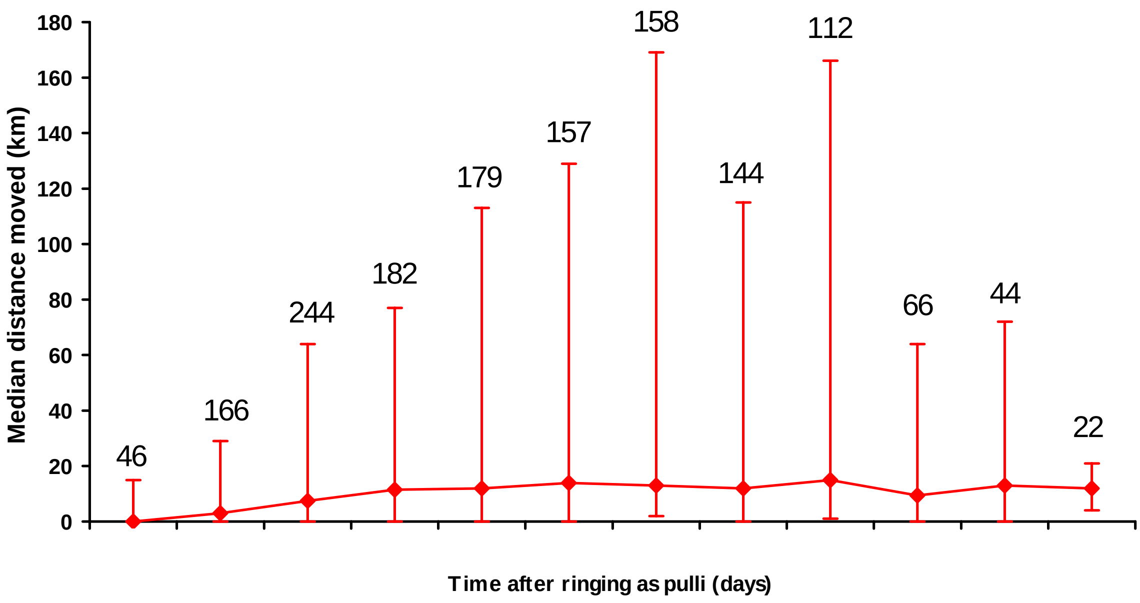

Figure 4.9.3 Variation in the distances moved by juvenile Barn Owls with time after ringing as pulli. Medians for 30-day periods (points) and inter-quartile ranges (bars) are shown.

Photo: Tom Holden

5. DEVELOPMENT OF THE VOLUNTEER NETWORK

A letter outlining the objectives of the Barn Owl Monitoring Programme was sent to more than 200 active Barn Owl ringers and/or nest recorders in early March 2001. The prospective volunteers were invited to take part on either Option 1 or Option 2 of the Monitoring Programme (the two levels of commitment discussed in section 3). The details of the options are described below.

Option 1. Guarantee to monitor at least one Barn Owl nest site for the next three years, checking nest sites regularly for occupancy, assessing fledgling success and checking for signs of re-nesting and second broods. A series of brief visits at monthly intervals from April to October is recommended. Although this option involves minimal disturbance to Barn Owls, fieldworkers will still require a nest disturbance licence to ensure full compliance with the Wildlife and Countryside Act 1981.

Option 2. As Option 1, but involves recording additional, more detailed information about eggs and young. The extra information to be recorded depends on whether the volunteer is a licensed nest recorder or a licensed ringer.

Nest recorders and ringers can record the following information:

- Clutch size
- Brood size
- Age of young and losses of young
- Presence of other species nesting in the box
- Presence, species composition, number and weight of prey stored in boxes

Ringers only can record the following information:

- Chick measurements
- Feather length, wing length and weight
- Ages/sex/moult/brood patch condition of adults captured at the nest
- Information on dispersal and survival can be obtained by the ringing of adults and young

We will not ask volunteers to take egg measurements initially, but may do so once the methods have been tested fully.

The response by early April 2001 was encouraging: 72 volunteers had expressed an interest in taking part in the Monitoring Programme. These volunteers operate in a total of 48 counties or Scottish regions: 38 in England, five in Wales and five in Scotland (Figure 5.1). Further replies are and we expect some of the gaps in coverage shown on Figure 5.1 to be filled. The majority (85%) of ringers and nest recorders opted to contribute to Option 2 of the Monitoring Programme. Many of the volunteers monitor a small number of nest sites (1-3) whilst a few contribute to larger existing studies and monitor a much larger number (to a maximum of 70 nest sites).

We will contact all interested volunteers to provide further details of the Monitoring Programme and asking them to register the nest sites that they intend to monitor over the next three years. In light of the Foot & Mouth outbreak we have suggested that volunteers should exercise caution and avoid any potentially insensitive approaches to landowners. It is likely that many volunteers will be unable to visit nest sites during the early part of the season due to access restrictions. Early in the 2001 season, we will create a fieldwork manual for volunteers, which will contain all the information required to carry out the fieldwork required for the Monitoring Programme.

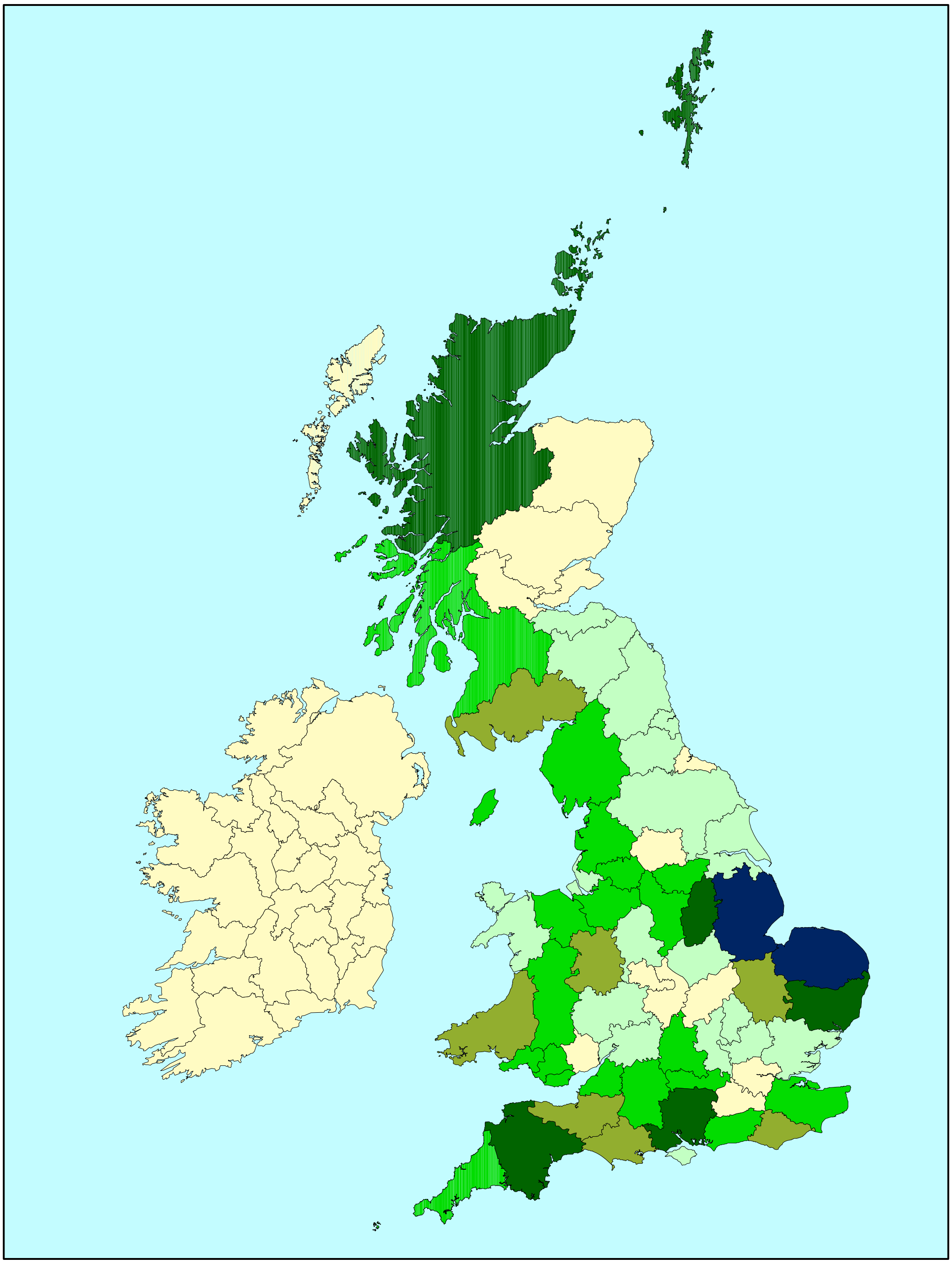

Figure 5.1 Map showing the density of volunteers by county.

Key: Light green = 1 volunteer
Bright green= 2 volunteers
Olive green= 3 volunteers
Dark green= 4 volunteers
Dark blue= 8 volunteers

6. THE 2001 FIELD SEASON

General site visiting schedule: As a result of the analysis of the first year's data, a revised schedule of nest visits has been developed which should provide information on all the key events in the Barn Owl's breeding cycle. The numbers of visits is greater than originally envisaged for WCP and thus the number of sites visited per WCP study area may have to be reduced. This schedule will be also be used as the standard for the volunteer network.

Visit Period		*Information Sought / Ringing Activity*
1. Late April/mid-May	-	Site occupancy Clutch size/No. chicks just hatched Catch and ring adults Collect/identify moulted feathers
2. Mid-July/early August	-	No. chicks @ 6-8 weeks old Ring chicks Identify whether 2nd broods begun Collect/identify moulted feathers
3. October	-	No. chicks @ 6-8 weeks old for 2nd broods Ring chicks

Validation work to be carried out by WCP: Given the likely presence of restrictions due to Foot-and-Mouth Disease, the 2001 field season provides a good opportunity for WCP to validate techniques used to detect the presence of second broods without increasing the overall annual fieldwork effort. Thus, fieldwork should start with the April/May visit (where possible), but a complete check of all sites in October should be made to look for second broods would permit validation of:

(a) the presence of incubating females at the July/August visit as an effective indicator of second breeding attempts;

(b) the presence of moulted feathers from the female at the late May-mid-July visit as an effective indicator that a second brood will not be attempted.

"Micro-habitat" recording methodology: WCP will consider methods for recording small-scale habitat features of potential importance to Barn Owls, such as grass strips, ditches, etc.. The methods will need to be clear and straightforward so that they can be used unambiguously by volunteer contributors to the Programme.

Validation of egg-density curve: The standard equation used to relate egg density to egg measurements derives from a study by Hoyt (1979) based on information from 115 species. This equation is generally applicable to the eggs of all but a few species with relatively "pointed" eggs. Percival (1990) used a slightly different equation, based on a smaller number of species reported by Hoyt (1979) and Furness & Furness (1981), and created a curve that relates egg density to hatching date, based on a sample of Barn Owl egg measurements. Shawyer (see above) has further adapted this, but these curves need to be validated for use as part of the Barn Owl Monitoring Programme, to make sure that a valid curve specific to Barn Owls is available. We suggest that attempts should be made to contact owl keepers, who breed Barn Owls in captivity, to encourage them to make regular measurements of any eggs that are laid or to ask whether volunteer ringers or nest recorders could visit to make the relevant measurements.

Publicity & dissemination of results: An annual newsletter will be created to provide a forum for feedback to volunteers and to permit the exchange of ideas on fieldwork techniques and experiences between volunteers. An article will be written for *BTO News*, to announce the development of the Programme, and a web-page, or series of web-pages will be created on the BTO website to host the Programme. The Rare Breeding Birds Panel, which publishes annual reports in the journal *British Birds*, will be alerted to the future provision of annual monitoring information for Barn Owls and the survey results will be put forward for inclusion in the annual *The State of the UK's Birds* report of the BTO, WWT and RSPB in due course.

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WCP are grateful to all the landowners who have allowed access to Barn Owl sites for monitoring purposes and to Major Nigel Lewis for undertaking a proportion of the fieldwork.

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APPENDIX

Appendix: Fieldwork recording form as used by WCP in the field. Note: Underbody speckling score diagrams adapted from Taylor (1994).