BTO RESEARCH REPORT No. 57

POPULATION TRENDS IN BRITISH BARN OWLS, *Tyto alba*, AND TAWNY OWLS *Strix aluco*, IN RELATION TO ENVIRONMENTAL CHANGE

Dr S.M. Percival*
British Trust for Ornithology, Beech Grove,
Tring, Herts HP23 5NR.

*present address, Dept. of Biological Sciences, University Science Laboratories, South Road,
Durham DH1 3LE

JUNE 1990

S.M. Percival

POPULATION TRENDS IN BRITISH BARN OWLS, TYTO ALBA, AND TAWNY OWLS, STRIX ALUCO, IN RELATION TO ENVIRONMENT CHANGE

Published in December 1992 by the British Trust for Ornithology
The Nunnery, Thetford, Norfolk, IP24 2PU, U.K.

ISBN 0 903793 25 3

GENERAL SUMMARY

1. Analyses were carried out using the BTO Nest Records and Ringing databases, supplemented by new data collected specifically for the project, to investigate Barn and Tawny Owl breeding performance, survival and dispersal, and to establish a baseline for future monitoring.

2. Barn Owl breeding success varied both regionally and through time. More chicks were successfully raised to fledging in the 1980s than in the previous decade in both Scotland and SE England. Little regional variation was found in Tawny Owl breeding success but this species did show an increasing trend in clutch size and egg survival in recent years like that found in the Barn Owl.

3. Food supply was shown to be of prime importance in determining the breeding success of the Tawny Owl, using data from the Mammal Society woodland small mammal survey. Unfortunately no comparable data were available for habitats used by Barn Owls. Weather conditions had some effect on breeding success but explained only a small proportion of the variance: periods of snow, rain and low temperatures coincided with reduced breeding success, particularly in the Barn Owl. Their main effect was to reduce the size of the clutch laid, probably by reducing the feeding success of the birds and hence their body condition at the start of the breeding season. The timing of the increase in breeding success, coincident with declining residue levels, suggested that pesticides such as DDT and particularly dieldrin may have been reducing success in the 1960s and 1970s.

4. MAFF statistics on land use were too coarse-grained to provide an adequate measure of the habitat available and rodenticide usage data were inadequate to match the biological data on owls because it was not available on a regional basis. Thus no firm conclusions could be drawn about the effects of land use change and rodenticides on owl populations.

5. Marked regional variation in survival rate trends were found over the period 1976-87. Of particular note was the increasing trend in the survival rate of adult Barn Owls in south-east Britain and of both adult and first-years in the south-west. There did however appear to be a decline in the first-year rate in the south-east. No statistically significant trends were found in Tawny Owl survival rates but the general pattern followed that of Barn Owl.

6. Weather appeared to have a greater effect on Barn Owl survival than on its breeding success. Winter frost and summer rain were negatively related to first year survival rate, and winter rain and low temperature in spring to the adult rate. Tawny Owl survival seemed to be less affected by weather.

7. Much of the variation in owl survival rates remained unaccounted for by the data available to this project. Recovery in adult survival rates was greatest in the south and east and coincided with declining residues of dieldrin and its breakdown products in several birds of prey, suggesting that these compounds may have been important in reducing owl survival in the past. No explanation for the decline in first-year Barn Owl survival rate in south-east Britain was found and more work needs to be done to further investigate the factors behind this trend.

8. No overall regional or temporal trends in owl dispersal distances were found from the analyses of the BTO ringing database, and no relationship was apparent with the

other population parameters. This suggests that changes in dispersal had not contributed to the observed population trends.

9. Only a few observers participated in the 1989 Barn Owl sample areas census. Continued promotion of the intensive defined study area approach is necessary, linking the census with existing projects monitoring breeding performance and survival.

10. A national survey of the Tawny Owl in autumn 1989 established a baseline index of abundance for future monitoring in 122 10km squares (40% of the sample Key Squares used in the New Breeding Atlas). Habitat explained much of the variation in owl density: more birds were found in woodland and in farmland adjacent to woodland than in farmland without woodland.

11. Key factor analysis showed that post-fledging survival was the most important stage of the life cycle in determining both Barn and Tawny Owl population levels. Therefore one would expect factors affecting this parameter to have had most effect on population. Adult mortality was important in some areas in some years for the Barn Owl, and egg survival likewise for the Tawny.

12. The overall conclusion drawn from the observed trends in breeding performance and survival was that the decreasing losses, notably in the south, suggest that the Barn Owl population was increasing over the period 1976-87 and was certainly faring better in the mid 1980s than in the 1970s. The likely reasons behind this apparent population increase are several. Amelioration of weather conditions was probably one factor. Reduced levels of pesticide residues, particularly the breakdown products of dieldrin and its related compounds may have been another. The decline in first-year survival rate in the south-east could be a cause for some concern. It was not possible to offer any explanation for this decline from the data available: this is clearly an area in need of further study.

13. This study has demonstrated the value of detailed analyses of the BTO's long-term databases, bringing together information on the different aspects of population dynamics. It has also identified gaps in our knowledge of owl populations and some improvements to data collection have been suggested. A summary of recommendations for how monitoring of owls might be carried out in the future is given.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

This project was sponsored jointly by Ciba-Geigy, ICI, Shell and Sorex, making use of long-term databases collected at the BTO through funding by the Nature Conservancy Council. The data on which this report is based have been collected by many contributors to the BTO's Nest Record and Ringing Schemes, whose efforts make such analyses possible. I would like to thank everyone who has sent in data on owls over the years and encourage them to continue in their most valuable work.

I have benefited from much help and encouragement during the project. Steve Petty, Tony Hardy, Iain Taylor and Ian langford have all given much useful advice and I thank them all. Assistance at the BTO has come from many sources but in particular I would like to thank Jeremy Greenwood, Rob Fuller, David Glue, Jeff Kirby and Stephen Baillie. Graphics and secretarial support was provided by Tracey Jarvis, Nicola Beasley (who coped splendidly with the unenviable task of typing the 20,000 ringing records onto computer), Liz Murray, Sue Taylor and Steve Bowers.

Thank you to all the members of the project's advisory committee; Tom Brown, Peter Edwards, Colin Galbraith, Tony Hardy, Malcolm Hadler, Colin Shawyer, Richard Stephenson and last but not least the chairman, Chris Whittles. Jeff Martin and Tony Hardy kindly sat on the owls survey working group.

Some special thank-yous for help with fieldwork on breeding Tawny Owls. Philip Burton kindly allowed me to use his nestboxes in the Tring area. Lastly Tracey, Brenda, Helen and David Jarvis' and Patrick Thompson's logistical support carrying ladders and much else besides was invaluable.

CHAPTER 1: INTRODUCTION AND AIMS OF THE PROJECT

The British Trust for Ornithology (BTO) Owls Project was set up in October 1987 to investigate the population dynamics of Barn and Tawny Owls in Britain. The Barn Owl is a cosmopolitan species which reaches the northern fringe of its range in Britain. It was once numerous and widespread (Blaker 1934) but is now much less common. The most recent population estimate was that of Shawyer (1987) at just over 4,000 pairs. The Tawny Owl is a more northern species ranging as far south as North Africa and north into Scandinavia. Though absent from Ireland, it is widespread and common through the remainder of the British Isles and is thought to currently number between 50,000 and 100,000 pairs (Sharrock 1976).

A survey co-ordinated by the Hawk Trust during 1982-5 (Shawyer 1987) suggested that Barn Owl numbers have declined greatly since a survey in 1932 (Blaker 1934), but there is no satisfactory quantitative information available to identify how large this decline has been and whether it is still continuing. This decrease in population since the 1930s is further supported by the BTO's Breeding and Wintering Bird Atlases (Sharrock 1976, Lack 1985). Over the same period the Tawny Owl has been reported to have maintained steady population levels (Marchant *et al.* 1990), but this conclusion is based mainly on the Common Birds Census project which is primarily designed for monitoring diurnal songbirds. Thus although there is much circumstantial evidence published about Barn and Tawny Owl populations there has been no attempt to look at their population dynamics on a national scale to investigate these ideas further.

Declines have been recorded in many raptor populations during the last 30 years, which in several cases have been attributed to the use of pesticides, for example for the Sparrowhawk,(Newton, Marquiss & Moss 1979, Opdam, Burgers & Muskens 1987) and the Peregrine, (Ratcliffe 1980). Fortunately most of these populations have subsequently increased following the reduction in use of these compounds but it is possible that the Barn Owl may have suffered in a similar way to these other cases.

The use of new and more potent anticoagulant rodenticides, commonly referred to as second generation anticoagulants because they can control rats resistant to old anticoagulants such as warfarin, have led to deaths of individual Barn Owls in Britain from commercial use. This project was sponsored by four companies, Sorex, Shell, Ciba Geigy and ICI, interested in the safe use of these new rodenticides, as a precaution to check that effects are not occurring at the population level.

Studies in Malaysia (Duckett 1984) suggested that the introduction of new 'second-generation' rodenticides led to the loss of Barn Owls from oil palm plantations where they were used. These owls, however, were dependent primarily on rats, *Rattus norvegicus*, as their main food source in contrast to the mainly vole diet of British Barn Owls (Glue 1971) so would therefore be expected to be more exposed to rat poisons. Work in the United States looking at the susceptibility of Barn Owls to these pesticides in the field (Hegdal & Blaskiewicz 1984) concluded that the risk of poisoning to Barn Owls was low provided that the use of these rodenticides was restricted to areas around farm buildings, as the owls were feeding primarily in open areas away from the farms themselves.

Changes in land use and hence in habitat availability has been suggested to have been the main reason behind the decline of the Barn Owl in at least part of the United States (Colvin 1985). Similar intensification in agriculture and associated reduction in potential Barn Owl feeding areas has taken place in Britain, particularly in the south and east of the country, so this may have played an important role in the population decline.

Weather is another factor which may have influenced owl populations. Shawyer (1987) suggested that snowfall may be of particular relevance to the Barn Owl, acting by reducing food availability. He thought that this might affect both the survival of adult birds and their breeding success (as birds in poorer condition may not be able to lay such large clutches as they would otherwise have done). Drought too has been suggested as a factor which might have a serious impact on Barn Owl populations by causing increased summer mortality of chicks in the nest and of adults (Bunn *et al.* 1982).

The overall objective of the BTO owls project was to look at the long-term databanks held at the BTO to obtain more information about these two owl species' population trends and to look at how these may be developed to allow more detailed monitoring of owls in the future. The specific aims were:

a) to examine trends in owl breeding performance, survival and dispersal,

b) to investigate changes in the population patterns of owls in relation to weather, land use, food supply and pesticide usage,

c) to establish a baseline of owl abundance and population performance for the future monitoring of owl populations.

BTO databases used in the project

The BTO holds several long-term databases, collected by its membership and funded by the Nature Conservancy Council, which can provide information about owl population dynamics. The study of population dynamics involves an investigation of the balance between gains to the population through breeding and immigration, and losses through mortality and emigration :

CHANGE = BIRTHS + IMMIGRATION - DEATHS - EMIGRATION

The BTO databanks provide information about all four of these factors and thus, when integrated, can give an overall picture of the owls' populations. The Nest Record Scheme involves the systematic collection of data from nest visits through the breeding cycle and hence can be used to calculate the birth component of the equation. Data from the Ringing Scheme gives data about the three other aspects of the population: immigration and emigration rates and mortality.

Environmental databases

Several databases were used to investigate owl population trends in relation to the environment to achieve the second of the aims specified above. Information on weather was obtained from the Meteorological Office as monthly summaries of temperature, rainfall, frost and snow measurements from each of 42 stations nationwide. Land use statistics were taken from the Ministry of Agriculture, Fisheries and Food (MAFF) and the Department of Agriculture and Fisheries in Scotland (DAFS) June census results, which comprise the area of all crops grown and the numbers of stock animals on a county basis. Additional information on the abundance of the owls' food supply came from the Mammal Society small mammal monitoring programme (Mallorie and Flowerdew 1988) for woodland habitats. Though MAFF have a similar programme for monitoring small mammals in farmland their data were not available in a comparable form which could be incorporated into the analyses for this project.

Rodenticide data were not available historically on a regional basis and so could not be included in the analyses of owl population statistics in the same way as the weather and land use data. The only information that was available was an annual index of the use of second-generation rodenticides calculated on a national basis and based on national sales figures provided by the sponsoring companies independently audited by MAFF.

Further data collected specifically for the project

Neither of the two sources of data mentioned in the previous section provides information about population numbers. The New Breeding Bird Atlas, due to be published in 1992, will provide some quantitative data but, like the BTO's Common Birds Census, the methods have been designed for a wide range of species and are not ideally suited for the owls. Therefore the third aim of the owls project was to investigate methods for surveying these two species and to establish a baseline of population numbers.

Additional data for the project were also gathered on owl breeding biology to augment the basic nest record data. This aimed to look in more detail at the performance and productivity of the birds and to determine suitable methods for future nest recording and monitoring of chick growth and survival. The results from this work have been incorporated with analyses of the Nest Record Scheme data in the Chapter 2.

Outline of the report

The chapters of this report focus on each of the population factors in turn. Chapter 2 covers the breeding biology of the birds, examining this on a regional and temporal basis in relation to environmental data. Chapter 3 deals with the analysis of survival rates and the causes and seasonal pattern of mortality and Chapter 4 with the role that dispersal plays in the population dynamics. The work on the surveys of Barn and Tawny Owl numbers is presented in Chapters 5 and 6 respectively. All aspects of the population dynamics are brought together in Chapter 7, illustrating the importance of each stage of the life cycle using key factor analysis. Finally chapter 8 broaches the question of how monitoring of these two owl species might be carried out in the future.

The appendices include two papers that have resulted from work carried out during the owls project but are not directly included in the main body of the report. Appendix 1 comprises a paper on the possible observer effects of nest visiting: it was obviously important to test whether observers were affecting the birds' breeding success. The possible impact that the release of captive-bred Barn Owls may have on the population is discussed in Appendix 2: this practice is becoming increasingly common in Britain so it is important that this is taken into consideration when examining overall population trends.

CHAPTER 2: BREEDING BIOLOGY

SUMMARY

Analyses were carried out using the BTO Nest Records database, supplemented by new data collected specifically for the project and data on breeding success extracted from the BTO ringing schedules.

The Barn Owl showed regional and temporal variation in some of its breeding parameters. More chicks were successfully raised to fledging in the 1980s than in the previous decade in both Scotland and SE England. This recent increase was particularly marked in the latter area. The timing of breeding in the Barn Owl tended to be earlier in areas and years when success was higher.

Little regional variation was found in Tawny Owl breeding success but this species did show an increasing trend in clutch size and egg survival in recent years like that found in the Barn Owl. Tawny Owls tended to breed earlier further south.

The data on the size of broods at ringing, extracted from the schedules were generally in agreement with NRC results. They provided a useful additional sample to test ideas suggested by the Nest Record cards.

Weather conditions appeared to have some effect on breeding success, particularly on the size of the clutch laid and more so in the Barn Owl than Tawny. Spring snow, winter cold and winter rainfall were identified as the most important variables, all being negatively associated with owl breeding success. It was most likely that these factors were acting by reducing the feeding success of the birds and hence their body condition at the start of the breeding season.

The MAFF agricultural statistics suggested that land use had very little effect on owl breeding success. However these data were probably too coarse-grained to provide an adequate measure of the habitat available so no firm conclusions could be drawn about the effect of land use change.

Food supply was shown to be of prime importance in determining the breeding success of the Tawny Owl. The Mammal Society woodland small mammal survey provided data which explained a high proportion of the variance in breeding success of this species. Unfortunately no comparable data for Barn Owl habitats were available to allow a similar analysis to be carried out in non-woodland habitats. This emphasized the importance of monitoring food supply in order to understand owl population change.

The timing of the increase in breeding success suggests that pesticides such as DDT and particularly dieldrin may have been reducing success in the 1960s and 1970s. No conclusions could be drawn about more recently introduced compounds such as second-generation rodenticides as the pesticide usage data were inadequate.

The extended nest recording introduced for the project enabled standard curves for egg density and chick growth to be constructed. These can now be used in future monitoring to allow nests to be aged more accurately (from egg measurements or chick wing and head and bill length) and the body condition of chicks to be assessed (from standardized weights).

BACKGROUND AND METHODS

The aim of this chapter was to investigate the regional and long-term patterns of owl breeding biology and to relate these to environmental data to elucidate what factors might be affecting production of young birds. The BTO Nest Record Scheme has been collating data on bird breeding performance for the last 50 years. Though sample sizes are small in the early years, it is possible to analyze the data to look at long-term changes in breeding performance for both the Barn and the Tawny Owl. Sample sizes are larger for the Tawny Owl than the Barn in most years reflecting the former species' greater abundance. The annual totals of nest record cards submitted for each species are given in Fig. 2.1.

There is a wide geographical spread in the data, enabling spatial variation in breeding performance to be assessed. Fig. 2.2 shows the total number of nest records submitted in each of the Meteorological Office regions of Britain. These regions were chosen for this preliminary analysis as they are regions of similar climatic conditions (A. Heasman, pers. comm.).

It is important that the results from analyses of these extensive data sets are treated with caution, as the information has been collected from a wide variety of habitats and nest-sites by many different observers. Many records come from nestbox schemes, which may often be sited in prime habitat to encourage as many owls as possible to use them, rather than in a random sample covering all the habitats that the birds use. Such potential bias should always be considered as a possible explanation for the trends observed and the results should not be treated as absolute estimates of owl breeding measures. As long as any biases are not unevenly distributed it should still be possible to compare between groups to examine spatial and temporal patterns. It is possible to use existing data to test the importance of some of these biases. For example, the type of nest site can be included as a co-variate in the analyses of variance.

The first step in the analysis of the Nest Record data was to obtain an estimate of the timing of breeding for each nest. This was necessary to preclude the possibility that genuine losses could be confused with birds that had fledged successfully. It also provided useful information for identifying incorrectly recorded information (for example, the number of eggs increasing after the end of the laying period) and addled eggs (which had not hatched by their predicted hatching date). The date of the first egg hatching was calculated at two quality levels:

1. If the nest was visited at a time when its contents could be aged accurately, for example during the hatching period, this information was used. Where several estimates could be obtained from one nest an average value was used in the further analyses: differences in the hatching interval of the eggs could give rise to some variation in these estimates, though such discrepancies were usually only one or two days.

2. For nests which did not have such accurate information, the upper minimum first hatch date and the lower maximum first hatch dates were calculated for each visit to give a window between which the actual first hatch date could lie. The highest minimum and the lowest maximum estimates were then taken for each nest and averaged to give the first hatch date, providing these estimates were not more then 10 days apart. Nests which could not be aged to this degree of accuracy were designated 'unaged' and discarded from further analysis. An example of this calculation is given in below:

Number of nest visits = 3.

Max. 1st hatch estimate on each visit = 85, 77 and 72 days from Jan 1st.

Min. 1st hatch estimate on each visit = 65, 62 and 60 days from Jan 1st.

Therefore, lowest max. estimate = 72 days, and highest min. estimate = 65 days from Jan 1st; so actual 1st hatch date lies between 65 and 72 days.

Estimated 1st hatch date = mean of lowest max. and highest min estimates

= (65+72)/2 = 68.5 days from Jan 1st.

The next step was to estimate the measures of breeding performance for each nest:

a) the number of eggs laid,

b) the number of those that hatched,

c) the number of chicks that survived the first half of the fledgling period (11 days for the Tawny Owl and 20 days for the Barn), and

d) the number of chicks that fledged successfully.

The latter was taken as the number of chicks in the nest at 22 and 40 days from the first hatch for Tawny and Barn Owl respectively. Though these periods were rather shorter than the real fledgling periods (averaging 28 and 52 days for the two species respectively, Cramp 1985), examination of the data showed them to be unreliable after these dates for the separation of real losses and apparent ones due to birds fledging successfully. Intensive studies on both Barn Owls (I. Taylor, pers. comm.) and Tawny Owls (S. Petty, pers. comm.) have shown there to be generally low mortality of chicks after these stages in the fledgling period. Monitoring of the survival of chicks after these dates was continued by ringing and subsequent recovery.

Each of these four measures was calculated by taking the nest contents at the visit closest to the event in question, corrected to the exact date by using the appropriate daily survival rate. Thus if a nest was visited four days before hatching and contained three eggs, the estimate of the number of eggs hatched would be:

$$3 \times (\text{daily egg survival rate})^4$$

The daily egg and chick survival rates were calculated using the Mayfield (1961, 1975) method, splitting the nesting period into three (incubation, and the first and second halves of the fledgling period). This method assumes that survival rate is constant within the period being analysed: splitting the data up into three periods reduced the possibility that this assumption was violated. The data were too sparse to allow any further sub-division of these periods.

These breeding data were related to several sources of environmental information to examine the factors which might affect owl populations, examining both temporal and regional variation. Weather data were obtained from the Meteorological Office in the form of monthly summaries for each of the years 1959 to 1987 for 45 stations throughout the country (5 in each of the Met. Office regions). The following variables were used:

Average daily temperature = average (daily maximum-daily minimum)/2
Average maximum daily temperature
Average minimum daily temperature
Total rainfall
Number of days on which rain fell

Number of days on which snow fell
Number of days on which there was snow cover at 0900h.
Number of days on which there was ground frost at 0900h.
Number of days on which there was air frost at 0900h.

The data for each region were averaged to give seasonal (**spring** - March, April, & May - /**summer** - June, July & August - /**autumn** - September, October & November - /**winter** - December, January & February) summaries on an annual basis, then put into a principal components analysis (PCA) to generate new summary variables which were then used in stepwise multiple regression analysis to identify which of the weather data, if any, could explain the variation in owl breeding success. The PCA ordinated the data into their main patterns of variation (principal components) and avoided the problem of auto-correlation between variables in the subsequent multiple regressions. It identified nine principal components (the new summary variables) and attributed a score (the values of these new variables) for each case, that is for each season in each year in each of the regions. These scores were then used as independent variables in the multiple regression with each of the owl breeding measures as the dependent variable in turn. Where appropriate the previous year's data were used in the analysis, for example when examining autumn and winter weather effects on clutch size.

A similar treatment was given to the MAFF/DAFS June census agricultural statistics on land use. These were obtained as county totals of the area of each crop type and numbers of stock for each year from 1978 to 1987. They were processed to an equivalent scale to the Met data (that is Met Office region), and put into a principal components analysis in the same way. The land use variables used were the area of:

Wheat
Oil-seed Rape
Spring Barley
Crops for stock feeding
Young ley grassland
 (less than 5 years old)
Older grassland (over 5 years old)
Woodland on agricultural holdings
Sugar Beet
Winter Barley
Other cereals
Other crops
Rough grazing
Bare fallow

and the numbers of:

Dairy cattle
Sheep
Pigs
Poultry
Beef cattle

The Mammal Society started an annual programme of monitoring small mammal abundance in woodlands on a nationwide basis in 1982 (Mallorie & Flowerdew 1988), which provides very useful and direct information about the owls' food supply, at least for woodland Tawny Owls. A standard trapping regime is used in spring and again in autumn to give an index of abundance expressed as the numbers of animals caught per trap night, for both the Bank Vole, *Clethrionomys glareolus*, and the Wood Mouse, *Apodemus sylvaticus*. These data could not be split into the nine Met Office regions as there were not enough sampling sites in each region. Instead a broader regional classification was used, dividing the country into three major regions; Scotland/N England, SE England, and SW England/Wales. The borders of these major regions and their relationship to the smaller Met regions is shown in Fig. 2.2. An average index was calculated for each of these three major regions and related to the corresponding owl breeding data to see how small mammal abundance might affect the owl populations.

Information on the use of second generation anticoagulants was not available historically for nine years on a regional basis. This prevented its incorporation into the same analyses as used for other environmental data because with only nine points any sort of regression technique would have been of doubtful value: it would not have been possible to tease out any possible rodenticide effects from those of other factors.

Owls Project Extended Nest Recording

Historically the Nest Record Scheme has concentrated on recording the contents of the nest at each visit through the breeding cycle. Data have been collected over the whole country for many years but little encouragement was made to observers in the past to determine the age of the nest contents accurately, nor to plan their nest visits to maximize the usefulness of the data obtained on each visit. The only information on breeding performance available to the analyst from each nest is the contents at each visit and a subjectively assessed nest status code (for example a rough guess as to the age of the chicks). Although the methods have recently been strengthened this came too late to benefit the present project.

A high proportion of the Nest Record cards could not be used in any analysis because of their lack of accurate age information. Over 40% of the submitted nest records for both species failed to provide sufficient information for the calculation of the number of chicks fledged. A modified recording form (see appendix 2.1 for an example form and the instructions sent out to observers) was therefore introduced in 1988, with the aim of improving the data recorded as follows.

1) Observers were encouraged to take measurements of eggs and young, so that standard egg density and chick growth curves could be used to age them more accurately. For each egg it was recommended that the weight, length and breadth should be taken so that its density could be calculated from a standard formula:

Density = Weight (in grammes) / (0.507 (a standard constant) x length (cm) x (breadth, in cm^2))

As the density of an egg declines through incubation this measurement can be used to estimate the time left to hatching from a standard curve. Data from nests of known age (that is ones visited during the laying or the hatching period) were used to construct such a standard curve for the two species.

Measurements of chick weight, and wing and skull length were requested. These again could be used to age the nest accurately using standard curves (constructed from nest of known age), and to provide additional information about the condition of the chicks (from their weight in relation to their age and size).

By taking these measurements it was possible to age a nest even from a single visit at any stage of the breeding cycle, thus allowing that nest to be included in further analyses of breeding performance.

2) Observers were asked to make more frequent and regular visits to nests and use the ageing information from the egg density and chick growth curves to plan their visits to maximize the usefulness of the data they collected. It was recommended that visits should be made to nests once per week through as much of the incubation and fledgling periods as possible.

In 1988 the use of this new form led to an increase in the proportion of owl nest records used in the analyses of breeding performance to over 80% of those submitted.

Use of Ringing Schedules to provide information on breeding biology

When birds are ringed their details are submitted on schedules to the BTO. This information includes the size of the brood if the birds were ringed as chicks and can, therefore, be used to supplement data on breeding performance from the Nest Record Scheme. These records of the brood size at ringing were standardized with the Nest Record estimate of the number of chicks fledging per nest by using two statistics extracted from the Nest Record data:

a) the mean age at which chicks were ringed: the date of ringing was often recorded on the Nest Record cards.

b) the appropriate daily chick survival rate, calculated as explained above.

The standard estimate of the number of chicks fledged could then be calculated from the recorded brood size at ringing using the following equation:

'Fledging success' = Brood size at ringing x (daily chick survival rate) ^{y},

where y = no. of days between the end of the 'fledgling' period and the mean age of the chicks at ringing. The mean age of chicks at ringing was calculated for each region and for each year group to see whether account needed to be taken of temporal and regional variation. Significant regional difference in the age of chicks at ringing was found, so region-specific means were used in the further calculations (Table 2.1).

Table 2.1: Variation in chick age at ringing.

	Year group	Region	Mean	Range
Barn	1.57 ns	2.18 *	33.3 d.	(31.4-37.0)
Tawny	1.58 ns	3.74 ***	20.4 d.	(19.4-22.2)

Mean days = number of days from hatching of first egg.

Particular care is necessary in the interpretation of the ringing brood size data: only successful nests will be recorded (since nests which failed will not produce any chicks to be ringed) so this will over-estimate the number of chicks fledged. However, they are useful in increasing sample sizes as many owl chicks are ringed without a Nest Record card being submitted.

RESULTS

Spatial and temporal variation in breeding performance

The first stage of the analysis of the breeding performance data was to calculate daily egg and chick survival rates, primarily to standardize estimates of the various breeding statistics. The daily survival rates of the nest contents at the egg, early and late chick stages are given in Table 2.2.

Table 2.2: Daily survival rates, calculated using the Mayfield (1975) method.

	Barn Owl		Tawny Owl	
	% survival (n)		% survival (n)	
Egg stage	99.06%	(16116)	98.97%	(53690)
Early chick	98.64%	(22452)	98.00%	(29395)
Late chick	98.33%	(9169)	97.75%	(12600)

(n = number of egg/chick days of observation)

Tawny Owl survival rates were lower than those for the Barn Owl at all three stages. It is not possible to calculate statistically meaningful confidence limits of these estimates as the individual eggs and chicks in same brood are not independent. Region-specific survival rates were calculated but no major difference in the results was apparent when they were used in place of the national figures. As the sample size of available data was small when split into regions, this reduced the precision of estimates to an inadequately low level, so these national figures were used in all further calculations of the breeding success measures.

The regional and temporal variation in owl breeding performance is summarized in Table 2.3, which gives the results of three-way analyses of variance for each measure of breeding performance between regions, year groups and nest type for the two species.

Table 2.3: Regional and temporal variation in breeding performance: F-tests from 3-way ANOVAs.

Barn Owl

	Year group (5 d.f.)	Region (6 d.f.)	Nest-type (2 d.f.)
Clutch size	1.05 ns	3.80 **	2.33 ns
No. egg hatching	2.61 *	4.29 ***	2.55 ns
No. young at 20d	3.20 **	2.60 *	2.97 ns
No. young fledging	2.32 *	1.92 ns	1.06 ns
Date of 1st hatch	0.59 ns	2.02 ns	6.26 **
Mean brood at ringing	5.66 ***	2.23 *	

Tawny Owl

	Year group (5 d.f.)	Region (6 d.f.)	Nest-type (2 d.f.)
Clutch size	6.98 ***	3.25 **	5.29 **
No. eggs hatching	4.30 **	2.57 **	2.19 ns
No. young at 11d	4.93 ***	1.20 ns	0.60 ns
No. young fledging	4.43 ***	1.31 ns	0.68 ns
Date of 1st hatch	6.55 ***	17.6 ***	1.78 ns
Mean brood at ringing	4.02 **	8.99 ***	

*** = P<0.0001, ** = P<0.01, * = P<0.05, ns = P>0.05). Full explanation of the various breeding measures is given in the text.

Year groups were (1) 1944-64, (2) 1965-70, (3) 1971-76, (4) 1977-82, (5) 1983-85, (6) 1986-88. Nest types were classified as 'box', 'building' or 'natural site'. The nine regions are shown on Fig. 2.2.

The following significant two-way interactions (P<0.05) were found in the above analyses:

Barn Owl

Clutch:	Year group with area (F=1.63, 30 d.f., P=0.019)
	Year group with nest type (F=2.25, 10 d.f., P=0.014)
No. eggs hatching:	Year group with area (F=2.07, 30 d.f., P=0.001)
	Year group with nest type (F=1.88, 10 d.f., P=0.045)
No. young at 20d:	Year group with area (F=2.11, 30 d.f., P=0.001)
No. young fledging:	Year group with area (F=1.73, 30 d.f., P=0.01)
Hatching date:	Year group with area (F=2.08, 30 d.f., P=0.001)
	Year group with nest type (F=2.17, 10 d.f., P=0.016)

Tawny Owl

Clutch:	Year group with area (F=1.68, 40 d.f., P=0.005)
No. eggs hatching:	Year group with area (F=1.44, 40 d.f., P=0.038)
	Year group with nest type (F=1.91, 10 d.f., P=0.04)
	Area with nest type (F=1.72, 16 d.f., P=0.036)
No. young at 11d:	Year group with area (F=1.46, 40 d.f., P=0.032)
	Year group with nest type (F=2.08, 10 d.f., P=0.023)
No. young fledging:	Year group with nest type (F=2.19, 10 d.f., P=0.016)
Hatching date:	Year group with area (F=1.86, 40 d.f., P=0.001)
	Year group with nest type (F=2.21, 10 d.f., P=0.015)

No significant three-way interactions were found.

The Barn Owl showed significant temporal and spatial variation in some of the measures of owl breeding success but not in others. The mean clutch size exhibited no significant trend through time, but did vary on a regional basis. The mean number of chicks hatching per nest and the mean number of chicks surviving to 20 days both showed temporal and spatial variation, whilst the mean number of chicks fledged per nest changed significantly through time but not on a regional basis. The mean brood size at ringing also showed a highly significant difference between year groups and regions. No significant spatial or temporal variation was found in the mean date of the first egg hatching.

The Tawny Owl showed significant variation in all the breeding measures with time and also with region apart from the mean number of chicks surviving to 11 days and the mean number of chicks fledging per nest.

The type of nest site that the birds were using could have been important if the actual site itself was affecting breeding success, for example if boxes provided better sites and were occupied by higher quality birds or vice versa. Colvin (1984) found a greater success of birds breeding in nest-boxes in his study of breeding Barn Owls in the USA. The statistics given in Table 2.2 show that no substantial evidence was found for this: nest type was not significantly related to any of the breeding performance measures apart from hatching date in the Barn Owl and mean clutch size in the Tawny Owl.

The overall differences in the breeding performance of owls in each of the nine Met Office regions are summarized in Table 2.4. Only data from 1983-88 have been included so that the results are not confounded by temporal effects. Regional differences were tested using a one-way analysis of variance. The mean clutch size was significantly different between regions in the Tawny Owl but not in the Barn: Tawny clutches were highest in NW England/N Wales and the Midlands and lowest in East Anglia but there were no clear latitudinal or longitudinal trend. No significant regional variation was found in the mean number of eggs hatching per nest in either species, nor in the number of chicks surviving to 11 days and the number of chicks fledged in the Tawny Owl. Regional differences in chick survival did lead to significant variation in the latter two parameters in the Barn Owl: more chicks survived to 20 days in SW Scotland and SE England and these regions also fledged more chicks.

The mean date of first hatch showed a significant difference between regions in both species. Barn Owls showed a strong relationship between the timing of breeding and the success of that attempt: birds were breeding earlier in regions where they raised more chicks to fledging, SW Scotland and SE England. Tawny Owls hatching dates tended to be earlier further south but there was one notable exception to this trend in NE Scotland which was unexpectedly early. The explanation to this highlights one of the problems of dealing with a data set gathered by a wide variety of people under a variety of circumstances: birds were recorded breeding earlier in that region simply because observer effort there was greater earlier in the season. Later in the season many observers had switched their efforts to other raptors in the area such as eagles and harriers (R. Rae pers. comm.).

Table 2.4: Regional variation in owl breeding performance, 1983-88

	Barn Owl			Tawny Owl		
Clutch	Mean	SE	n	Mean	SE	n
NW Scotland				3.18	0.09	106
E Scotland				3.19	0.08	199
NE England	5.38	0.47	10	3.06	0.08	174
E Anglia	6.57	0.34	4	3.25	0.17	30
Midlands	5.82	0.38	15	3.40	0.07	243
SE England	5.87	0.30	32	2.92	0.12	83
SW Scotland	6.24	0.17	80	3.35	0.13	56
NW England/N Wales	5.33	0.31	41	3.42	0.12	95
SW England/S Wales	5.81	0.26	59	3.25	0.14	65
ANOVA result	F=1.48, P=0.19, 6 df			F=2.73, P=0.006, 8 df		
Number of eggs hatching	Mean	SE	n	Mean	SE	n
NW Scotland				2.57	0.09	107
E Scotland				2.43	0.08	199
NE England	4.29	0.38	15	2.35	0.08	175
E Anglia	3.83	0.54	10	2.55	0.18	31
Midlands	4.17	0.43	23	2.60	0.08	245
SE England	4.72	0.31	36	2.21	0.11	83
SW Scotland	4.75	0.17	97	2.41	0.15	56
NW England/N Wales	3.90	0.25	61	2.67	0.13	95
SW England/S Wales	4.44	0.23	74	2.43	0.15	66
ANOVA result	F=1.70, P=0.12, 6 df			F=1.70, P=0.093, 8 df		
Number of young at 20/11 days	Mean	SE	n	Mean	SE	n
NW Scotland				2.09	0.10	105
E Scotland				2.04	0.08	193
NE England	3.66	0.34	15	1.92	0.08	171
E Anglia	2.90	0.37	12	2.16	0.15	31
Midlands	3.10	0.35	25	2.03	0.07	244
SE England	4.08	0.24	52	1.85	0.10	83
SW Scotland	3.98	0.17	130	1.87	0.14	55
NW England/N Wales	3.23	0.21	65	2.15	0.12	95
SW England/S Wales	3.04	0.17	98	2.01	0.13	65
ANOVA result	F=4.52, P=0.0002, 6 df			F=0.86, P=0.55, 8 df		

Number of young fledging

	Mean	SE	n	Mean	SE	n
NW Scotland				1.66	0.08	107
E Scotland				1.57	0.07	199
NE England	2.83	0.25	15	1.46	0.06	176
E Anglia	2.20	0.29	12	1.63	0.13	31
Midlands	2.43	0.29	25	1.48	0.05	247
SE England	3.13	0.17	53	1.45	0.08	83
SW Scotland	3.00	0.12	134	1.50	0.11	56
NW England/N Wales	2.64	0.16	70	1.67	0.10	95
SW England/S Wales	2.40	0.14	98	1.48	0.11	66
ANOVA result	F=3.23, P=0.0041, 6 df			F=1.12, P=0.35, 8 df		

Mean date of first hatch (number of days from Jan 1st)

	Mean	SE	n	Mean	SE	n
NW Scotland				118	1.2	140
E Scotland				107	0.8	311
NE England	174	11.6	30	119	0.9	274
E Anglia	162	3.8	25	115	2.0	49
Midlands	167	3.1	52	112	0.8	363
SE England	156	3.1	95	109	1.6	112
SW Scotland	150	1.7	220	117	1.8	89
NW England/N Wales	165	3.1	110	113	1.1	147
SW England/S Wales	161	2.8	152	109	1.6	121
ANOVA result	F=5.65, P=<0.0001, 6 df			F=14.9, P<0.0001, 8 df		

Figs. 2.4 to 2.8 illustrate the temporal patterns in owl breeding performance, with the data split up into the three major regions of the country (Scotland/N England, SE England and Sw England/Wales). The main points to note about the Barn Owl results are the decline in breeding success in the 1970s and the subsequent recovery to pre-decline levels in the 1980s.

This trend was more apparent in some regions than others: the increase was particularly marked in Scotland/N England and the decline in SE England. Barn Owl breeding success in SW England was much less subject to temporal change. Different variables showed this overall pattern with different degrees of clarity, with the increase in success more marked in the later stages of the breeding cycle.

A similar pattern was found in the Tawny Owl but to a lesser degree than that exhibited by the Barn Owl. There was a slight decline in productivity during the 1970s and a small increase through the 1980s, more apparent in some regions than others. Unlike the Barn Owl, the timing of Tawny Owl breeding did change significantly through time. Breeding was earlier in the 1980s, correlating with the increase in success. The later mean date of hatching in the 1970s was associated with lower productivity, particularly in SE England.

The reliability of the estimate of the brood size from the ringing data was tested by correlating it with the annual fledging estimates. This correlation was significant for both species ($r = 0.51$, $P<0.001$ for the Barn Owl and $r=0.41$, $P<0.01$ for the Tawny, $n=39$ in both species).

The regional and temporal breakdown of the brood size at ringing is given in Fig. 2.9. In the Barn Owl there was only a slight increase in the brood size through time in

Scotland/N England but a much larger one in the other two regions. The decline in the early 1970s was less apparent than it had been with the nest record data, but this was at least partly attributable to the lack of early ringing data. Only ringing schedules prior to 1970 were put onto the computer as the sample size before that date was too small to allow a regional breakdown of the survival analyses (see chapter 3), so only national rather than regional totals were available earlier than this year.

The Tawny Owl showed no trend at all through time in Scotland/N England, but the increase in fledging success from the 1970s onwards in the two southern regions, as had been found in the nest record data, was detected.

Environmental data and owl breeding success

The weather data PCA identified nine principal axes which are outlined below (all variables in each axis with factor loadings greater than 0.5 or less than -0.5 are listed: factor loadings are given after each variable, larger absolute values of the loadings indicate that the variable has a stronger influence on that principal axis).

MET1: Winter temp (mean, 0.92, max, 0.90, & min, 0.92), snow-days (-0.80), snow-lie (-0.89), ground- (-0.72) & air-frost days (-0.82).

MET2: Summer (mean, 0.86, max, 0.83, & min, 0.80) & spring temp (mean, 0.66, & max, 0.70).

MET3: Frost days: spring ground (0.87) and air (0.65), summer ground (0.75) & air (0.64), autumn ground (0.78) & air (0.68), winter ground (0.54).

MET4: Autumn temp (mean, 0.91), max, 0.87, & min, 0.90).

MET5: Summer rainfall (0.82) and rain-days (0.75), autumn rainfall (0.80) and rain-days (0.76).

MET6: Spring snow-lie (0.84) and snow-days (0.82).

MET7: Winter rain-days (0.84) and rainfall (0.70).

MET8: Spring rainfall (0.90) and rain-days (0.81).

MET9: Summer snow-days (0.62).

The results of stepwise multiple regression analyses using these nine axes as independent variables and each of the owl breeding data in turn as the dependent are given in Table 2.5. Generally the weather data explained only a small proportion of the overall variation in breeding performance; the highest in the Barn Owl being 19.5% of the variance in clutch size and in the Tawny a maximum of 10.9%, again for clutch size. Spring snowfall and duration (MET6) gave a significant negative relationship with all Barn Owl breeding measures. Winter temperature and snow/frost days (MET1) were also important in the early stages of the breeding season, affecting the clutch size laid and the number of chicks surviving to 20 days: smaller clutches were laid and fewer chicks survived following winters with low temperatures and more snow- and frost-days. Winter rainfall was the only other significant factor identified by the analysis, also having a slight effect on clutch size and number of chicks surviving to 20 days.

The relationships between the weather data and Tawny Owl breeding success showed some similarity to that with the Barn Owl. Winter temperature and snow- and frost-days (MET1) were significant for all breeding measures, but no relationship at all was found with Spring snow (MET6). Spring and summer temperatures (MET2) were positively related to the clutch size laid and the mean number of eggs hatched per nest.

Table 2.5: Multiple regression of owl breeding data on weather PCA factor scores

Barn Owl

Clutch size	= 0.400 x MET1 + -0.352 x MET6 + -0.217 x MET7 + 5.52 (r^2 = 0.195)
No. eggs hatching	= -0.36 x MET6 + 4.02 (r^2 = 0.0853)
No. young at 20d.	= -0.297 x MET6 + -0.263 x MET7 + 0.237 x MET1 + 3.14 (r^2 = 0.149)
No. young fledging	= -0.213 x MET6 + 2.45 (r^2 = 0.0677).

Tawny Owl

Clutch size	= 0.16 x MET2 + -0.14 x MET1 + 2.97 (r^2 = 0.109)
No. eggs hatching	= -0.154 x MET1 + 0.113 x MET2 + 2.24 (r^2 = 0.0826)
No. young at 11d.	= -0.139 x MET1 + 1.82 (r^2 = 0.0707)
No. young fledging	= -0.119 x MET1 + 1.38 (r^2 = 0.0829)

The PCA of the agricultural land use data identified only three principal axes, shown below using the same criteria as the weather PCA. Again factor loadings are given after each variable.

AGR1: Pigs (0.93), Wheat (0.89), Winter barley (0.88), Poultry (0.85), Other crops (0.79), Oil-seed rape (0.73), Bare fallow (0.66), Sugar beet (0.58), Rough grazing (-0.80), beef cattle (-0.70).

AGR2: Old grassland (0.96), Dairy cattle (0.96), Sheep (0.74).

AGR3: Spring barley (0.87), Re-seeded grassland (0.80), Crops for stock-feeding (0.70), Beef cattle (0.53).

Multiple regression of the Barn Owl breeding data on these principal factors failed to find any significant relationship at all. Only a single Tawny Owl variable showed any relationship (Table 2.6): the number of eggs hatched per nest was negatively related to the area of permanent grassland/number of dairy cattle and sheep (AGR2). Even this only explained 3.4% of the variance and could well be a chance correlation.

Table 2.6: Multiple regression of owl breeding data on agricultural land use PCA factor scores

Barn Owl

No significant relationship found with any variables

Tawny Owl

Clutch size		No significant relationship
No. eggs hatching	=	$-0.091 \times AGR2 + 2.35$ ($r^2 = 0.0343$)
No. young at 11d		No significant relationship
No. young fledging		No significant relationship

The woodland small mammal data from the Mammal Society gave much more interesting results than the agricultural land use data. It was only available for the last 6 years (1982-87) and only for the three major regions as the number of sampling stations was too small to allow any finer regional division. The regional indices for the two species are given in Fig. 2.10.

A highly significant correlation was found between all measures of Tawny Owl productivity and both Bank Vole and Wood Mouse indices and explaining as much as 40% of the variance even though the analyses were carried out on such a crude scale (Table 2.7). No significant correlations were found between Barn Owl breeding performance and these small mammal data though this is not surprising as the mammal data were obtained from woodland habitats.

Table 2.7: Pearson correlation coefficients between Tawny Owl breeding measures and small mammal indices derived from Mammal Society small mammal monitoring programme.

	Bank Vole		**Wood Mouse**	
	Spring	Autumn	Spring	Aut.
Clutch size	0.629 **	0.289	0.627 **	0.278
No. egg hatching	0.585 **	0.249	0.625 **	0.196
No. young at 11d.	0.592 **	0.080	0.594 **	0.010
No. young fledging	0.438 *	-.085	0.389 *	-.110

(** = P<0.01, * = P<0.05, remainder are not significant, P>0.05).

Extended nest recording

The extended nest recording form proved to be very successful and popular amongst observers. The increase in the proportion of usable record from 60% to 80% has already been mentioned, but this forms only part of its success.

The standard egg density curves derived from the measurement of eggs of known age are given in Fig. 2.11. The data have been plotted as means for each five-day period with 95% confidence limits shown. The two species show a similar pattern of decline in density through incubation. More data were collected for the Tawny Owl so the confidence limits are closer to the mean. These curves can now be used to predict the stage of incubation of any egg provided its weight, length and breadth have been measured.

The chick growth curves for weight, wing and head and bill length with age are given in Figs. 2.12 and 2.13 respectively. As for the egg density data, means for each five-day period have been plotted with the 95% confidence limits around them. These curves can now be used to age chicks from their measurements. Confidence limits are again smaller for the Tawny Owl as more data were collected for this species.

Both wing and head and bill length were accurate predictors of chick age. Wing length was particularly useful in the latter stages of the fledgling period, when the head and bill length tended to level off in both species. Head and bill length on the other hand allowed very young chicks to be aged, when wing length was less reliable (as feathers had not yet started to grow).

Weight was not such a useful indicator of chick age: confidence limits were wider and hence variation between chicks of the same age greater. Weight will be much more dependent on food supply and therefore of more use in assessing body condition rather than ageing the chicks.

For future monitoring of owl chicks it is recommended that wing and head and bill length are measured, to give two independent estimates of chick age, and weight to allow the condition of the birds to be assessed.

DISCUSSION

Regional and long-term patterns in owl breeding performance

This chapter has shown that it was possible to extract detailed information on owl breeding biology from the BTO Nest Records database. The analyses identified long-term trends in the breeding performance of both the Barn Owl and the Tawny Owl and also found considerable regional differences. Of particular note was the observed decline in the productivity of both species during the 1970s and subsequent recovery to previous levels. It has been suggested by some authors (for example Shawyer 1987) that the decline in the Barn Owl since the 1930s is a continuing one, but it would seem that their breeding success is now on an upward trend. Even so the average number of chicks raised per pair in recent years is still well below figures obtained in other parts of the species' range: .i.Braaksma and Bruijn (1976); working in the Netherlands recorded mean fledging success of 3.0 chicks per pair, .i.Baudvin (1976); in France between 3.1 and 4.4 per pair in different regions, and .i.Colvin (1984); in Ohio, USA, 3.8 per pair.

Tawny Owl breeding success, averaging 1.5 chicks per pair, was also generally lower than in other published studies. Petty (1987) found annual means of 1.8-3.1 chicks fledged per pair in a detailed study in SW Scotland and N England, with the annual variation strongly dependent on small mammal abundance, Delmee *et al.* (1978) recorded a mean of 2.1 chicks per pair in Belgium, and Linkola and Myllymaki (1969) a range of 2.4-3.4 chicks per pair, also affected by vole abundance. Southern (1970), in his classic study in Oxford, recorded a value more similar to that found from the BTO data; 1.5 chicks fledged per breeding pair during the period 1954-59 when his population was stable. The implications of these changes in breeding performance to the overall population levels are discussed in chapter 7.

It is difficult to explain why the breeding success figures derived from the BTO data should be lower than in these other studies. Part of the difference may be accounted for by the method of calculation of the breeding measures: the Mayfield method may have over-estimated the chick losses that took place later in the fledgling period. There are also probably some biological differences apparent, particularly in the Barn Owl. The comparatively low figures for Britain may be accounted for by the species being on the northern edge of its range here. The most important consideration however is the point mentioned earlier that the BTO data are not necessarily representative of the whole population though they do allow regional and temporal trends in owl populations in Britain to be examined on a comparative basis.

Environmental data: what factors affect owl breeding success?

The multiple regressions of the owl breeding data on the environmental factors showed weather to have only a small effect on breeding success. Weather variables had most effect on clutch size in both species but they had progressively less influence further on through the breeding cycle. This agrees with the idea suggested by Shawyer (1987) that winter and spring snowfall leads to a reduction in clutch size by lowering prey availability but its overall influence is still small. No evidence was found to support Bunn *et al.*'s (1982) hypothesis that summer drought also reduces breeding success. Overall weather only explained of small proportion of the variance in owl breeding success so it is unlikely that it was the driving force behind the observed variation in breeding performance through time.

No significant relationship at all was found between Barn Owl breeding performance and the land use data. For Tawny Owls there was a very weak negative association between the number of eggs hatching and the area of permanent grass/number of dairy cattle and sheep. The conclusion must be that either the owls were not affected by land use or, more likely, these land use statistics were on too broad a scale to be appropriate to the areas and habitats that the owls were utilizing. The MAFF/DAFS June census statistics gave only a crude measure of land use and probably did not take account of the key features of the landscape that were of importance to the owls such as the width of field margins and availability of other hunting areas. They gave no measure of uncropped or marginal land. Even though the data do not show any clear relationship between land use and owl breeding performance it is not possible to conclude that changing land use has not had any effect on owl populations. More detailed work is required to investigate this hypothesis further.

The abundance of small mammals was a much more important factor, at least for Tawny Owl breeding performance. Even though data were only available for six years and broken down by three larger regions rather than the 12-year and nine Met. regions of the previous analyses, highly significant correlations were found. Food supply has been shown in many studies to be the key factor affecting owl breeding success (for example Wendland 1984, Hirons 1985, and Korpimaki 1987), so this result was not surprising. Clearly, the monitoring of owl food supply is essential for understanding changes in breeding performance.

No such correlation was found with the Barn Owl breeding data but this is not unexpected as the small mammal data were only from woodland habitats rather than the open habitats occupied by this species, and the two species monitored, the Bank Vole and the Wood Mouse do not form a major part of Barn Owl diet (Glue 1974).

The question still remains as to what affects the small mammal populations. This has been the subject of detailed research for many years (Elton 1942, Pianka 1983): the general opinion seems to be that habitat availability is of prime importance: it does not seem unreasonable to assume that a decrease in the food supply would lead to a corresponding decrease in owl breeding performance. If food supply and habitat availability had increased over the period of increase in owl breeding success, this could explain that increase.

It is not possible to draw any conclusions about the effect that second generation rodenticides might have had on owl breeding success. Both have increased steadily in the last 10 years suggesting that these compounds were not having a deleterious effect on owls but the rodenticide data were inadequate to examine whether they may still be reducing productivity below what it might otherwise be.

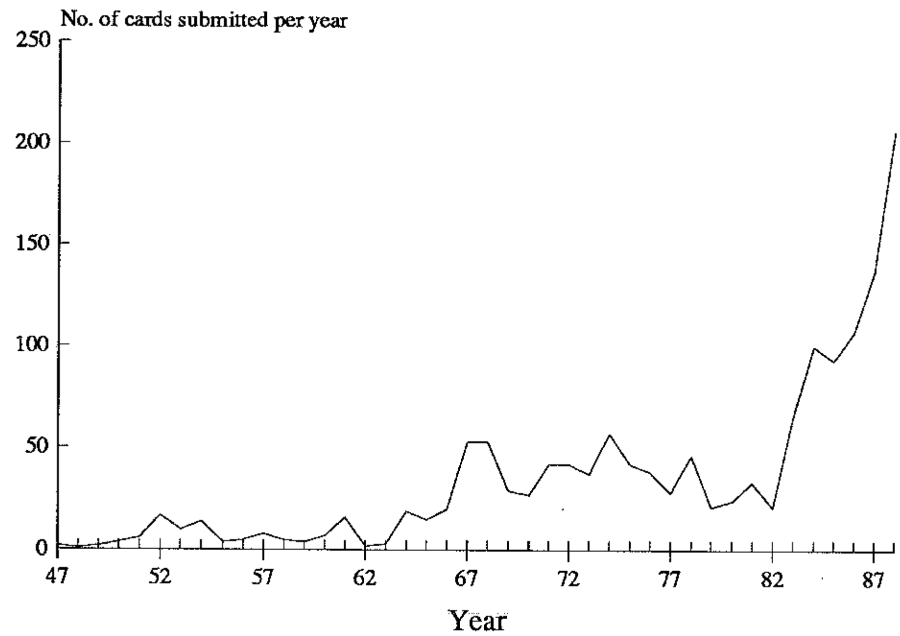
Other pesticides in the environment may have affected owl breeding success. As few owl data were available prior to the mid-1970s it is not possible to examine the main period of decline that might have been expected if Barn Owls were affected by pesticides in a similar way to the Sparrowhawk (Newton 1986). The improved breeding success in recent years may have resulted partly from declining contamination by DDT and its breakdown products (resulting in less eggs affected by shell thinning and hence improved hatching success) or dieldrin and its related compounds (primarily affecting the condition of the adult birds and hence their ability to breed successfully).

Extended nest recording

The extended nest recording form introduced for this project provided a useful means of increasing the value of owl breeding data collected by observers, with little extra effort or time required. By encouraging measurements to be taken of nest contents, more accurate ageing criteria were obtained and hence more of the data can now be used: even single visits can be useful. This also has the advantage of giving observers more information to use to plan their future visits to nests so that important breeding measures are obtained as accurately as possible. The discussion of improvements to nest recording is taken up further in chapter 8.

Fig. 2.1 Annual totals of Nest Record cards submitted

1. Barn Owl



2. Tawny Owl

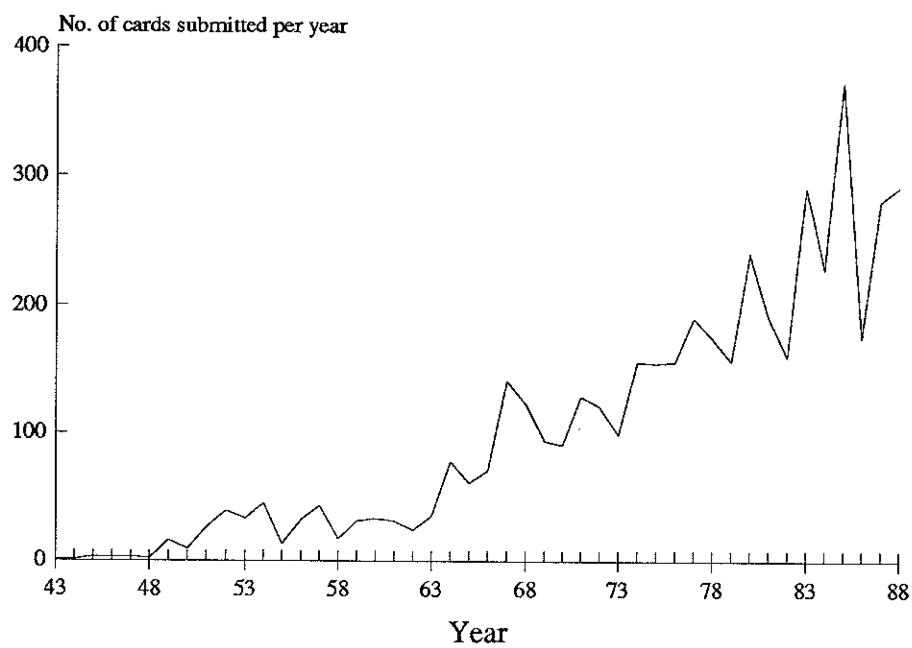


Fig. 2.2. Regional breakdown of total numbers of Nest Record cards

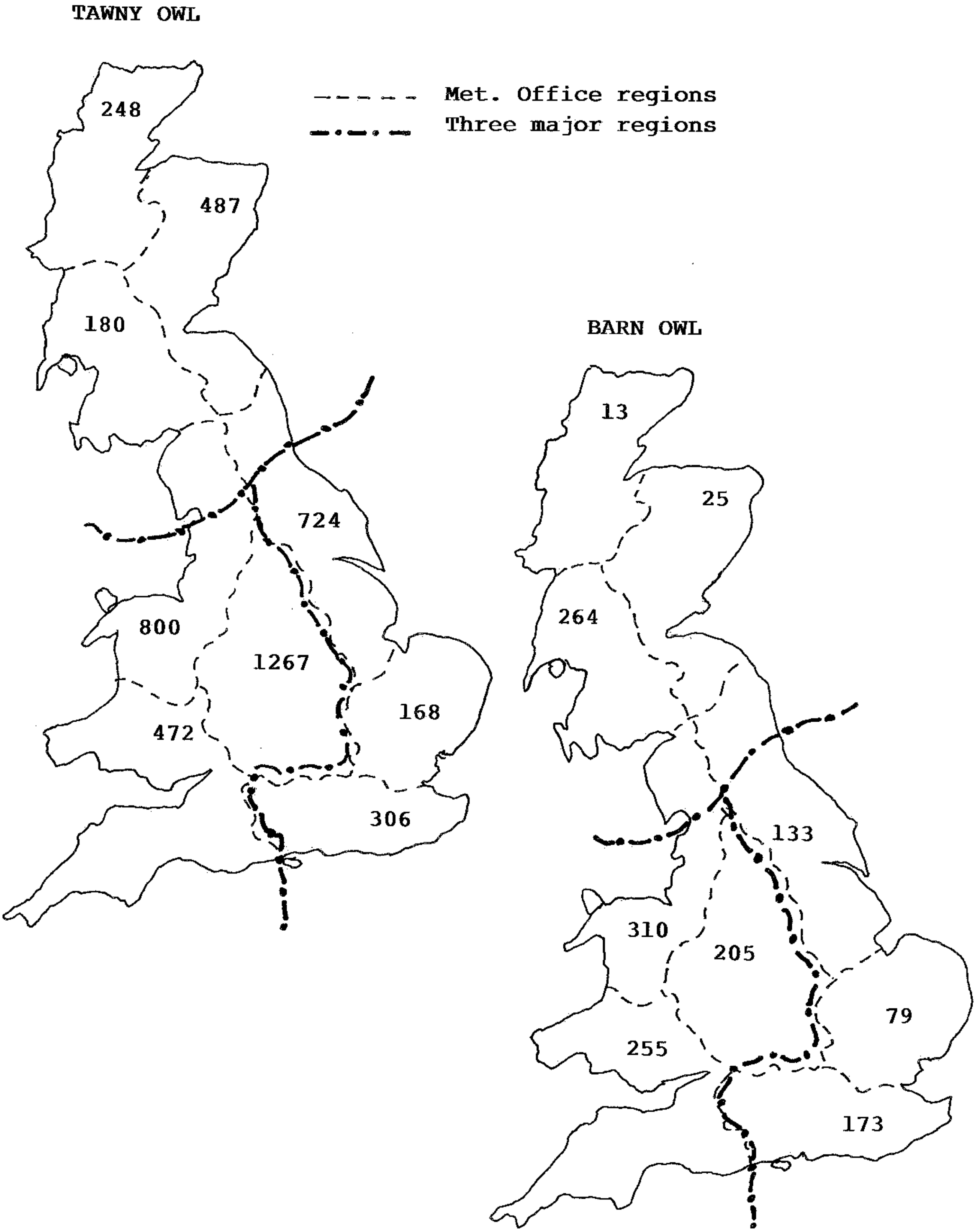
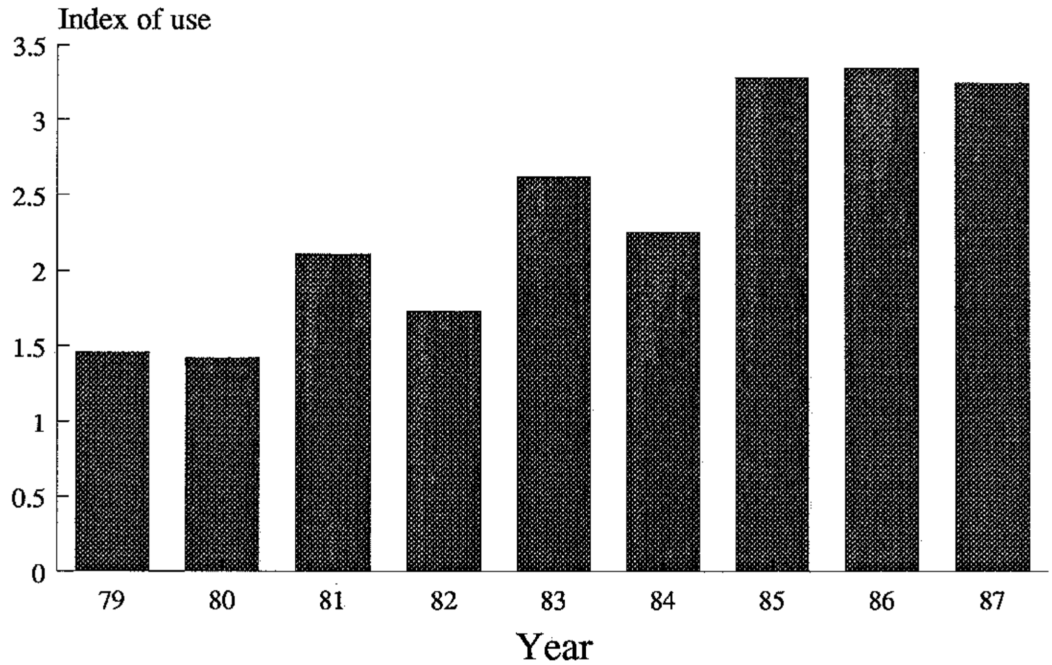
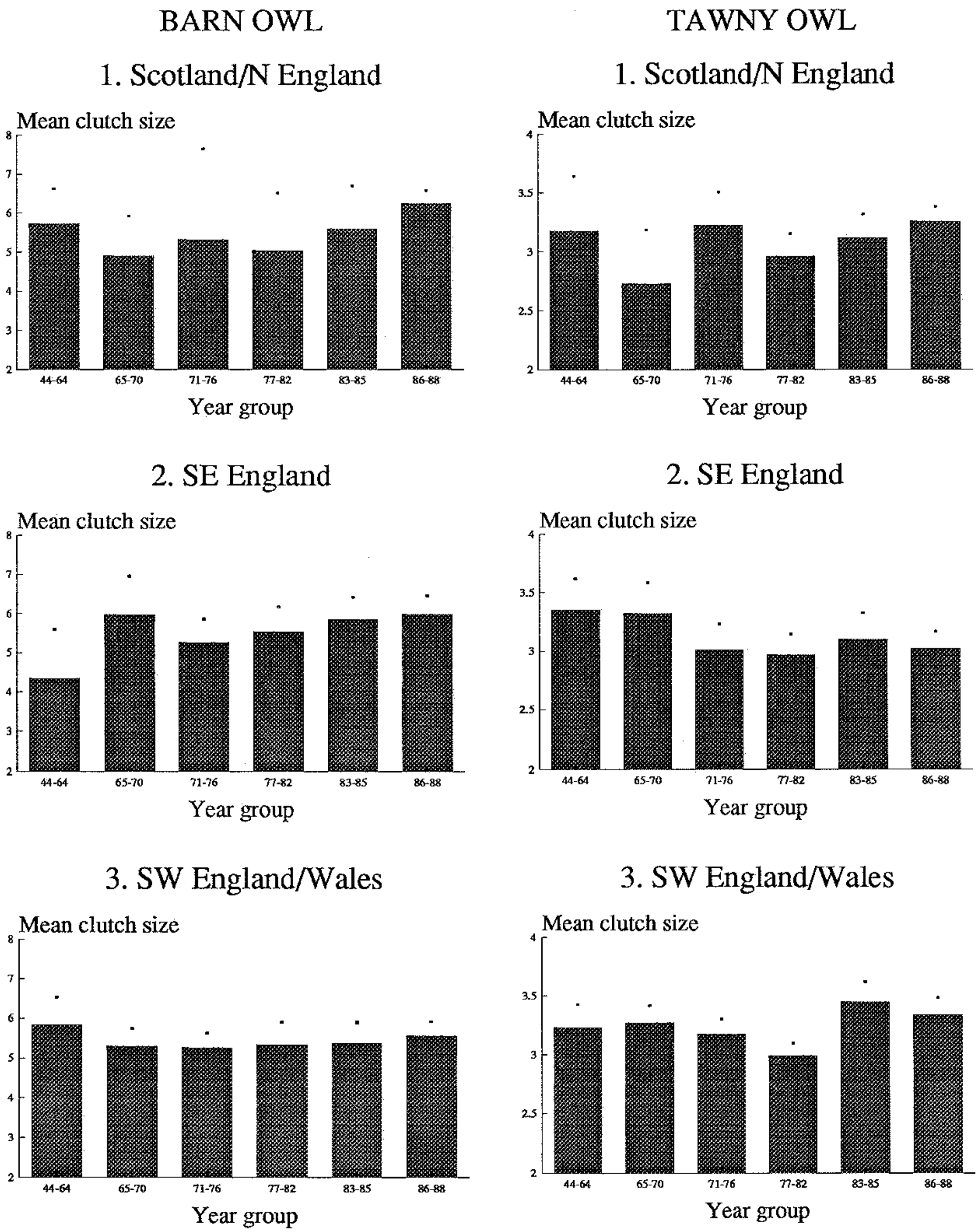


Fig. 2.3 Annual national indices of second-generation rodenticide use



Index based on sales figures, audited by MAFF (see text)

Fig. 2.4 Regional/temporal variation in clutch size

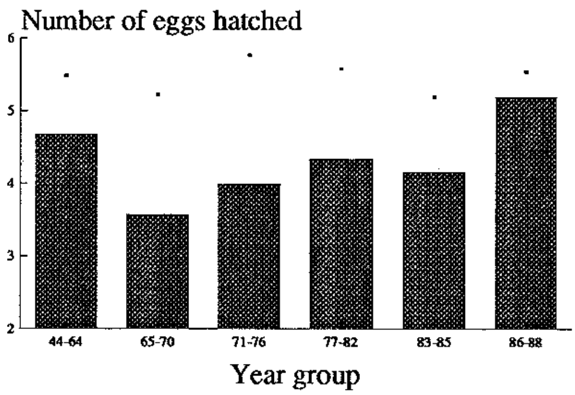


Data given are means with upper 95% confidence limit

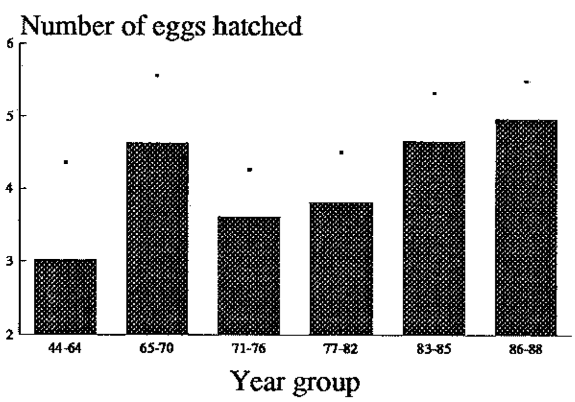
Fig. 2.5 Regional/temporal variation in no. of eggs hatched

BARN OWL

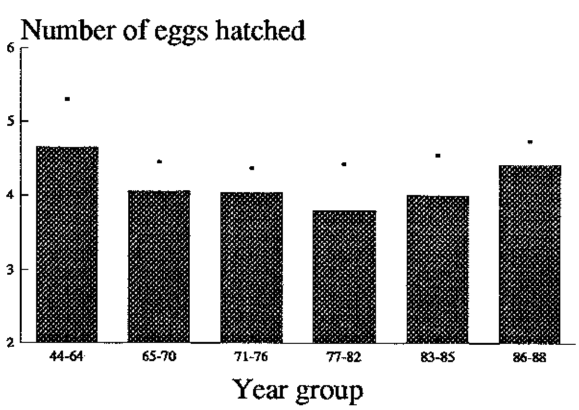
1. Scotland/N England



2. SE England

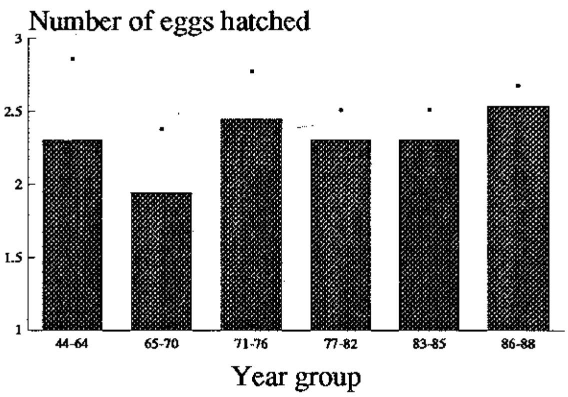


3. SW England/Wales

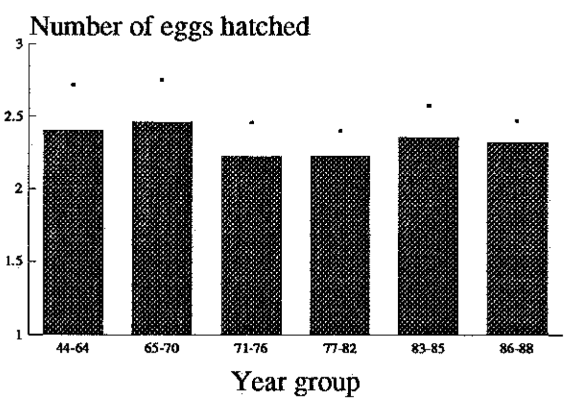


TAWNY OWL

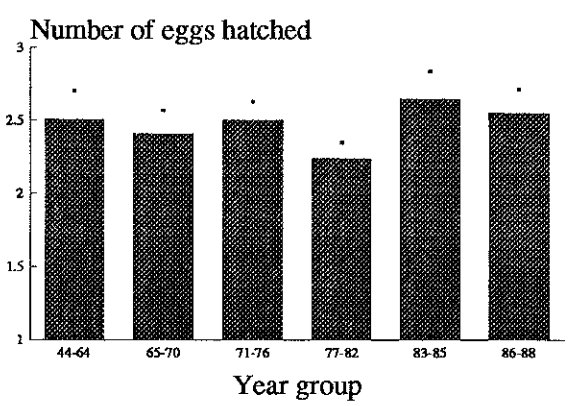
1. Scotland/N England



2. SE England

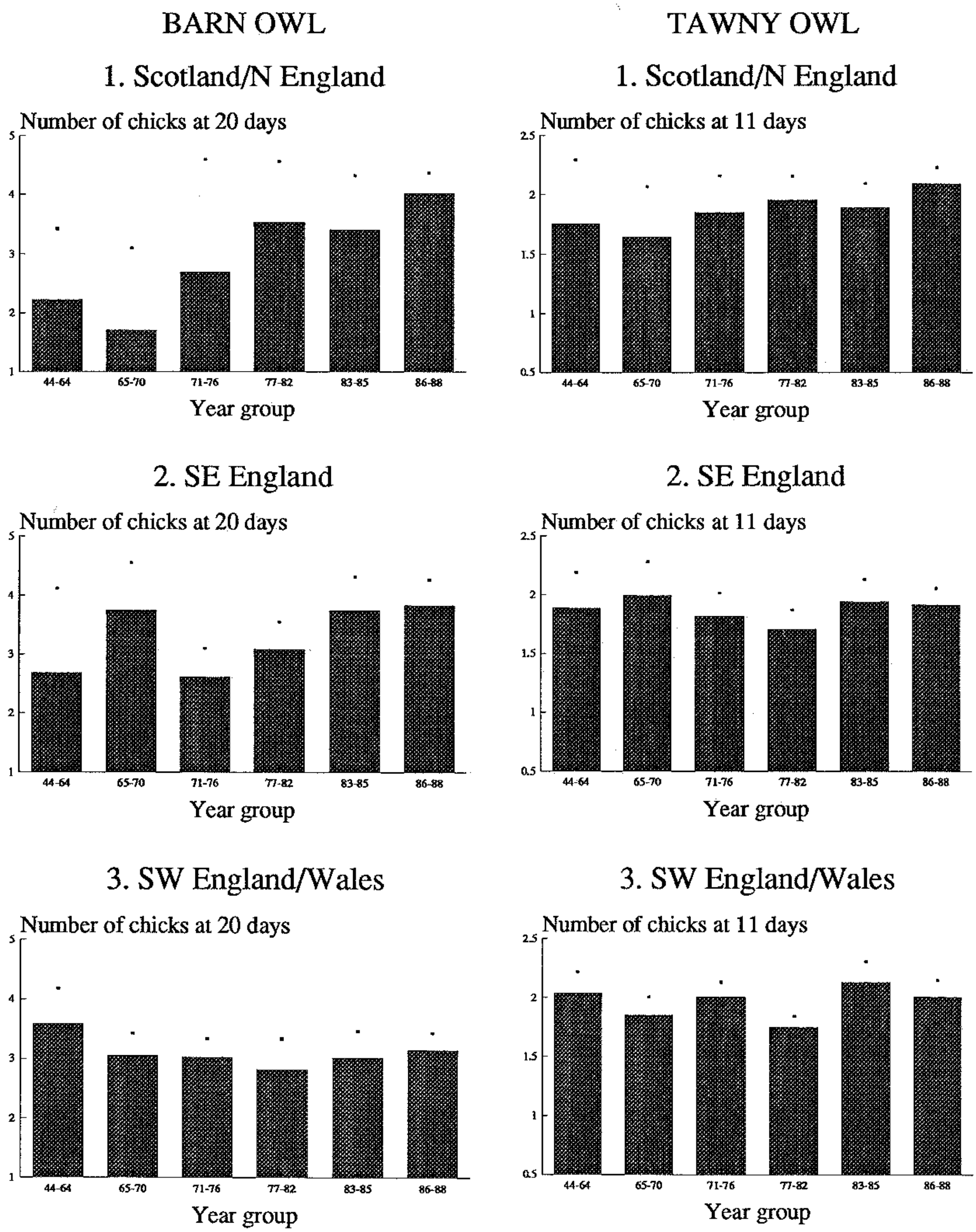


3. SW England/Wales



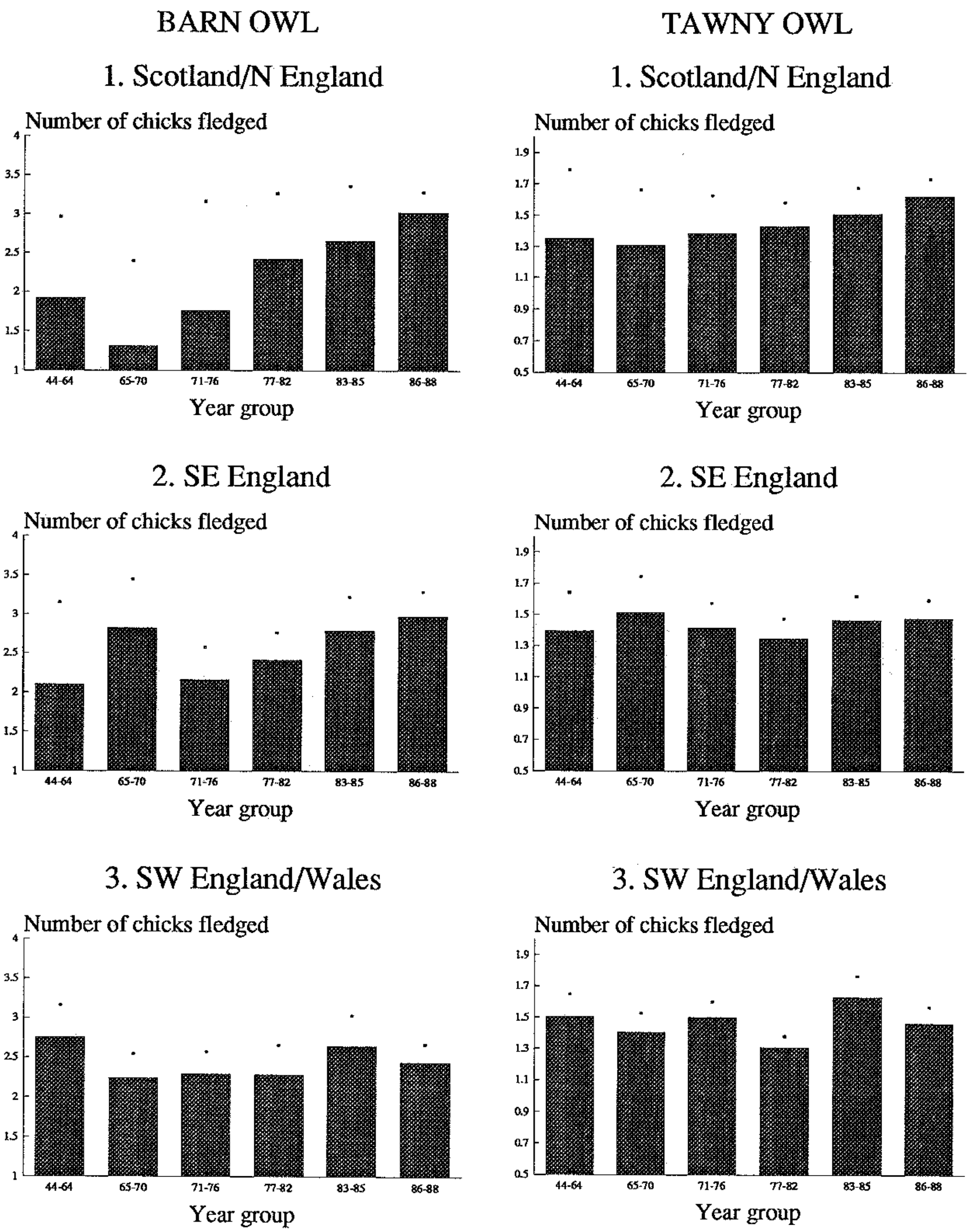
Data given are means with upper 95% confidence limit

Fig. 2.6 Regional/temporal variation in brood size



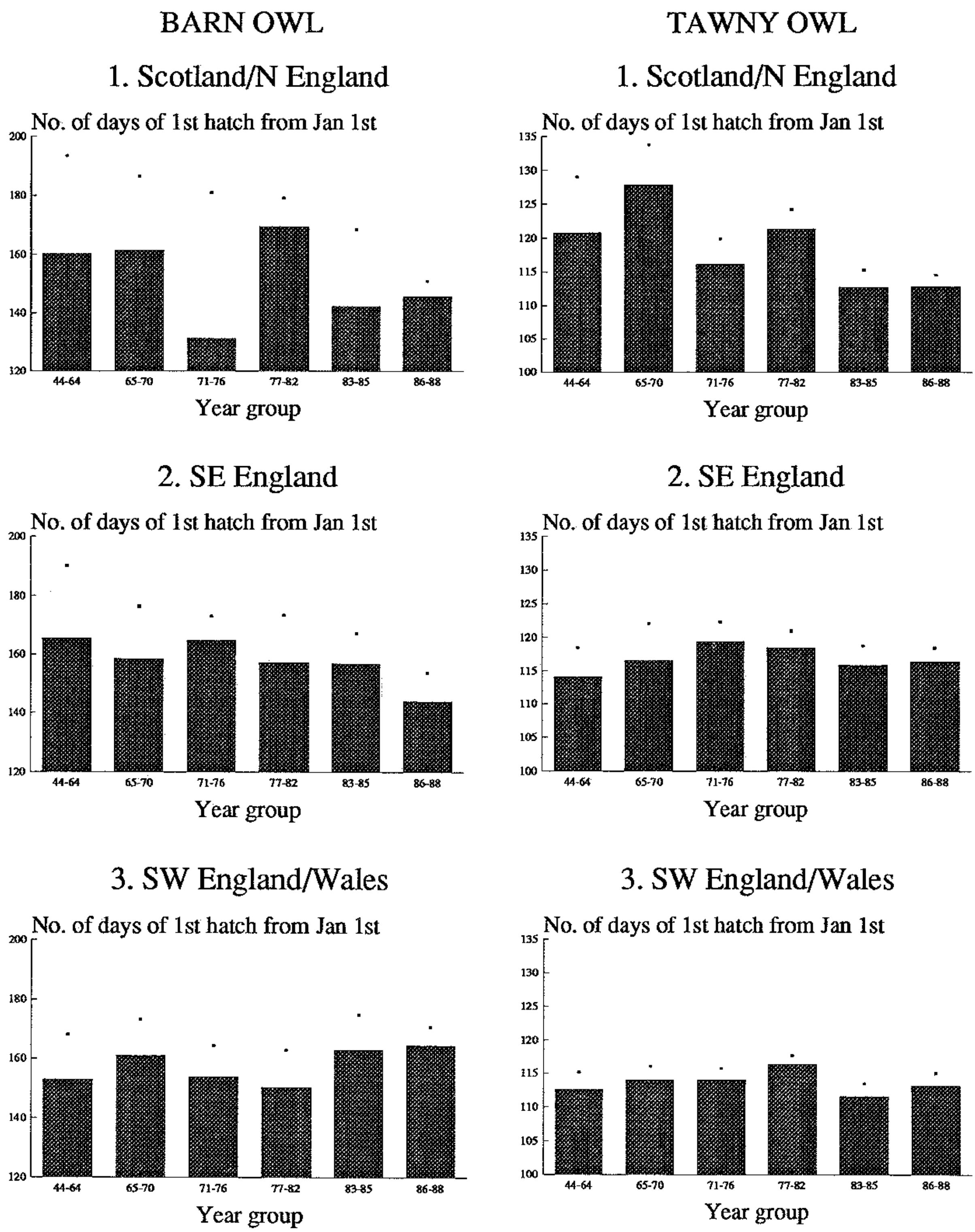
Data given are means with upper 95% confidence limit

Fig 2.7 Regional/temporal variation in no. of chicks fledged



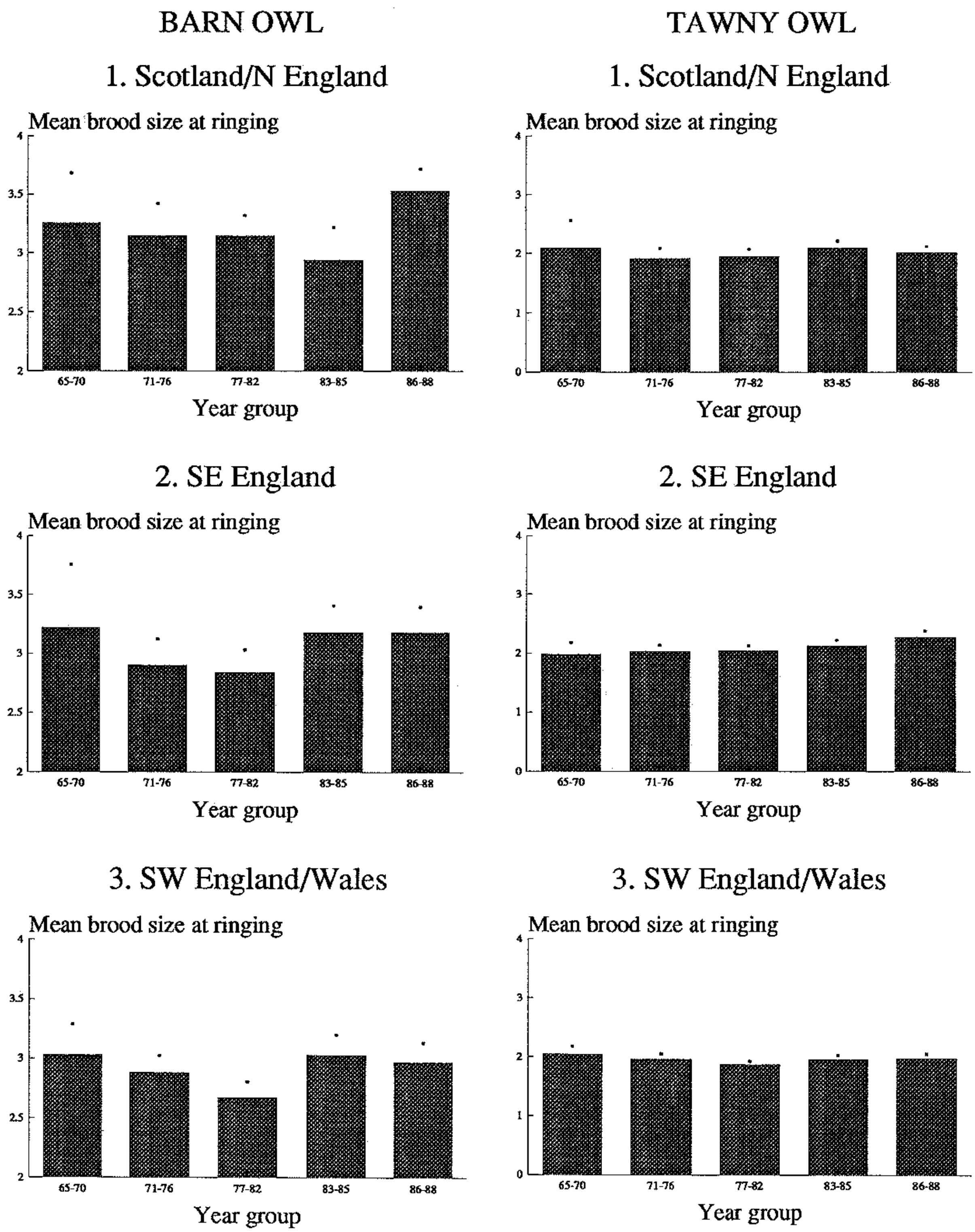
Data given are means with upper 95% confidence limit

Fig. 2.8 Regional/temporal variation in timing of breeding



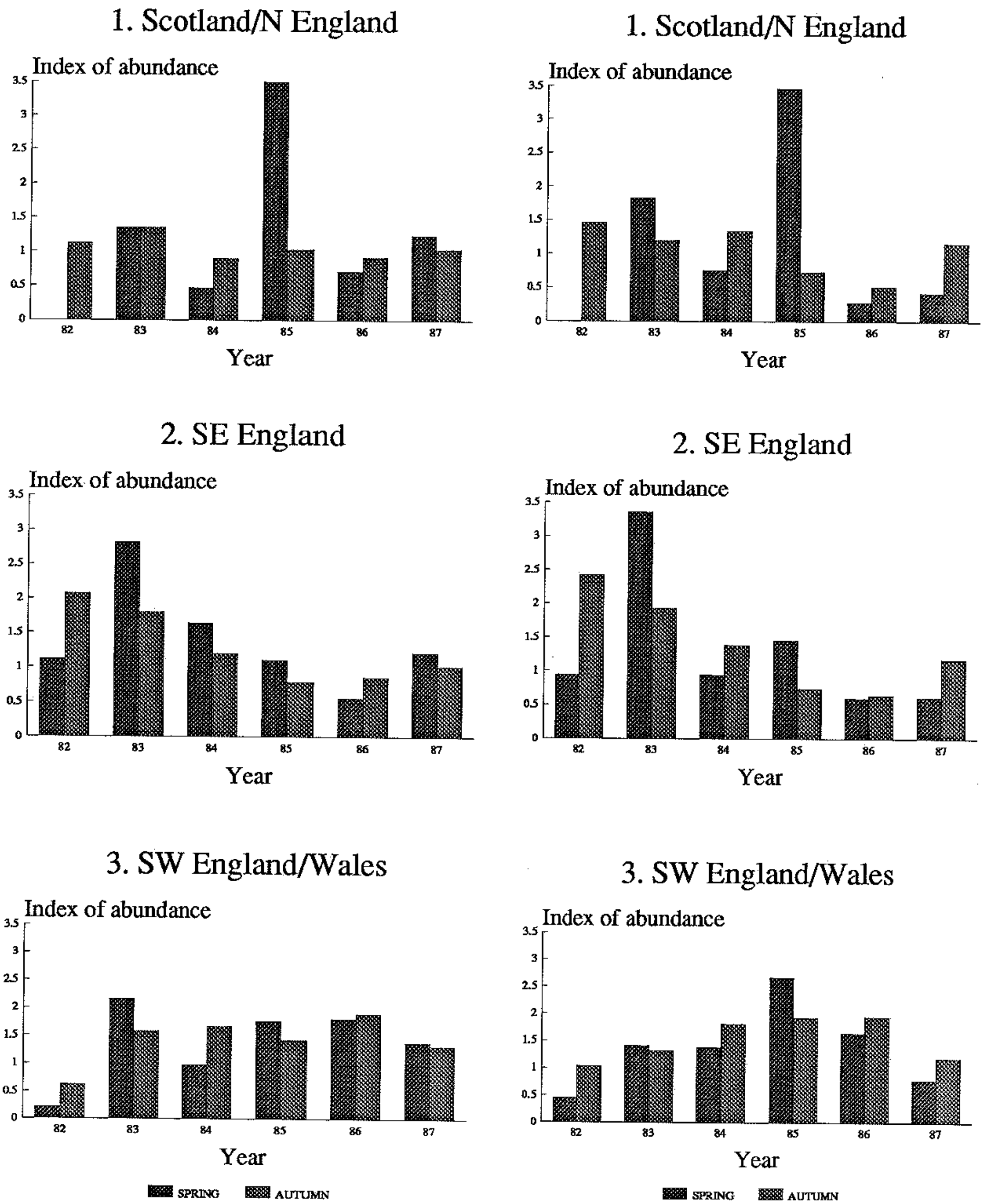
Data given are means with upper 95% confidence limit

Fig. 2.9 Regional/temporal variation in brood at ringing



Data given are means with upper 95% confidence limit

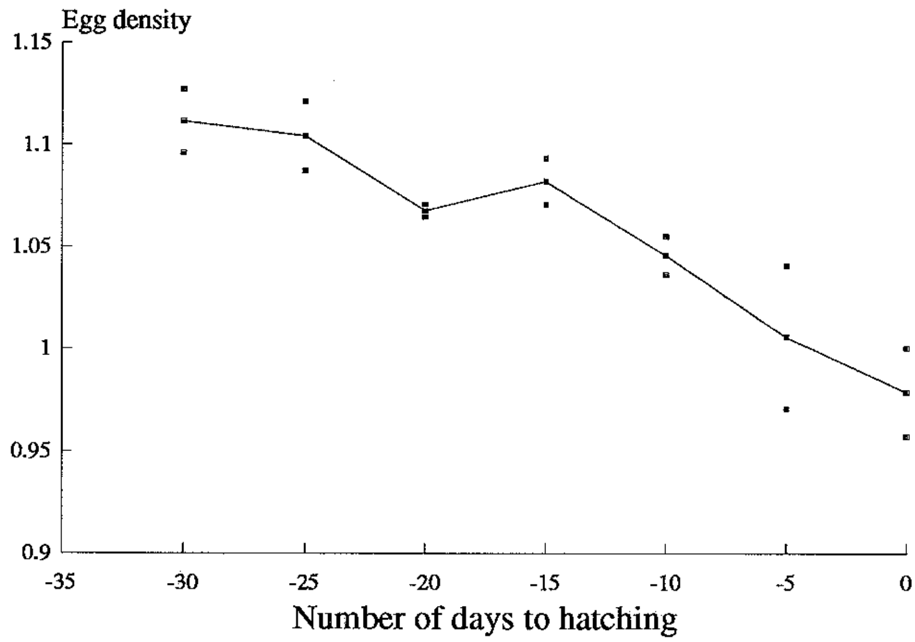
Fig. 2.10 Small mammal population indices



Data from Mammal Society (Mallorie & Flowerdew 1988)

Fig. 2.11 Owl egg density curves

1. Barn Owl



2. Tawny Owl

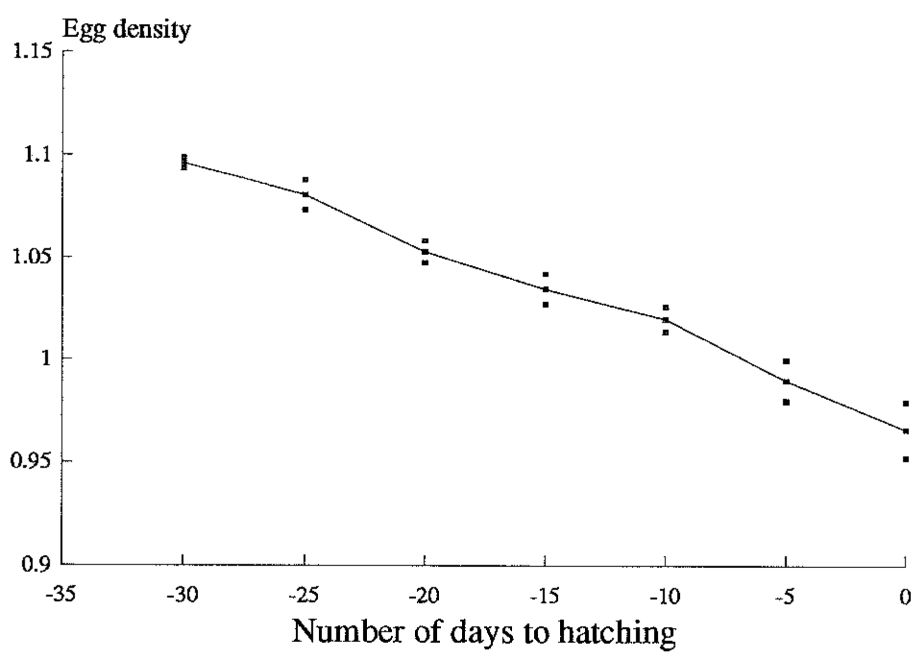
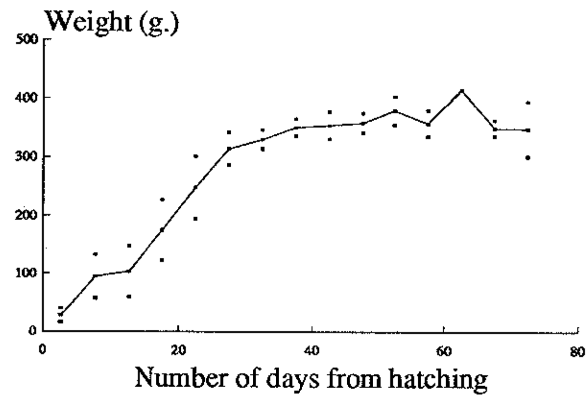
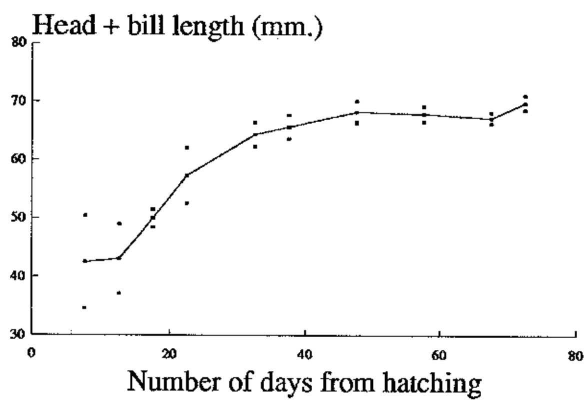


Fig. 2.12 Barn Owl chick growth curves

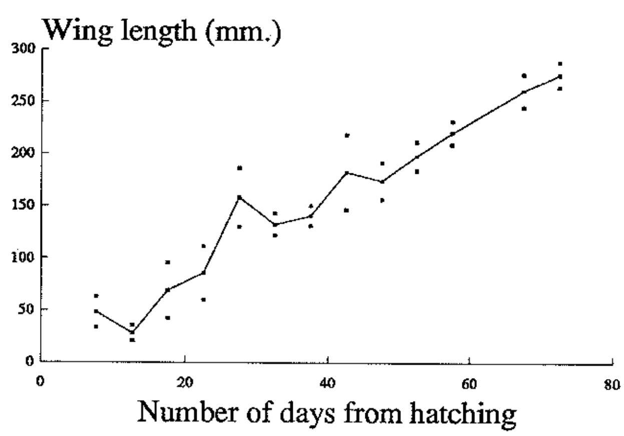
1. Weight



2. Head and bill length



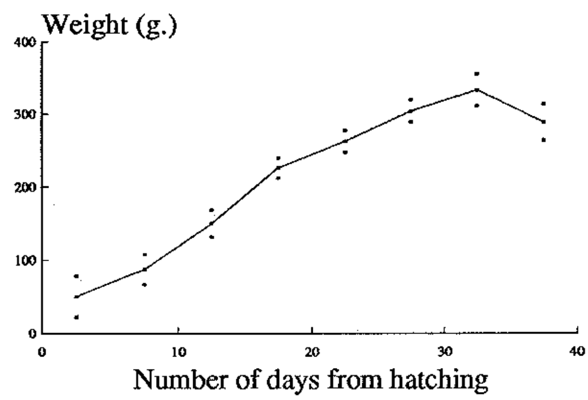
3. Wing length



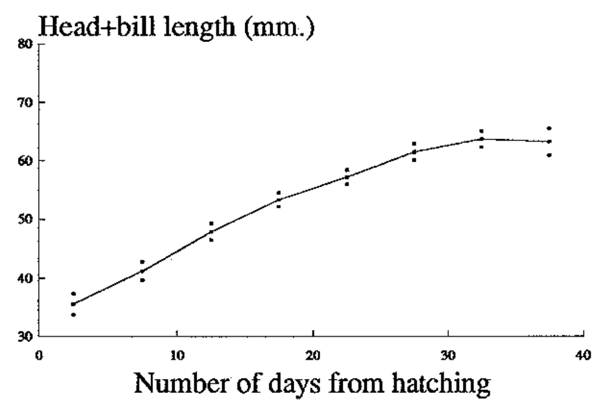
Data are plotted as 5-day means, with 95% confidence limits

Fig. 2.13 Tawny Owl chick growth curves

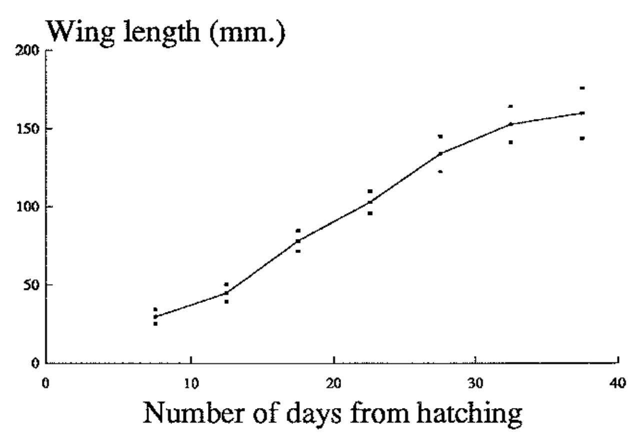
1. Weight



2. Head and bill length



3. Wing length



Data are plotted as 5-day means, with 95% confidence limits

CHAPTER 3: SURVIVAL

SUMMARY

Analysis of the BTO ringing database found marked regional variation in survival rate trends over the period 1976-87 (for which sufficient data were available). In the Barn Owl there was large short-term variation in both adult and first-year survival rates in Scotland/N England but no overall long-term trend. Both adult and first-year rates increased substantially in SW Britain, whilst in the south-east there appeared to be a decline in the first-year rate, though adult survival was increasing in a similar way . No statistically significant trends were found in Tawny Owl survival rates but the general pattern followed that of Barn Owl.

Considerable regional variation in recovery rates was found, emphasizing the need to split analyses by region so that this could be taken into account, rather than lump all the data into a national analysis.

There was a strong relationship between the weather and owl survival: the multiple regression models explained 41% and 61% of variance in adult and first year survival rates respectively. Winter frost and summer rain were negatively related to first year survival rate, and winter rain and low temperature in spring to the adult rate. Tawny Owl survival appeared to be less affected by weather; only 9% of variance of both adult and first year survival was explained by the weather variables.

Some significant relationships were found between owl survival rates and the MAFF land use statistics but the interpretation was more difficult. In most cases it appeared that the correlations were spurious and resulted from simultaneous but unrelated trends. It was concluded that the land use data were not an adequate measure of habitat available to owls. No correlation was found between survival rate and woodland small mammal abundance, even for the Tawny Owl.

Whilst weather did explain some of the variation in owl survival rates much remains unaccounted for by the data available to this project. Other factors must have been important too. The lack of data on rodenticide usage on a regional breakdown meant that it was not possible to assess their impact. The fact that recovery in adult survival rates was greatest in the south and east suggests pesticides associated with intensive agriculture may have played role. The fact that the timing of the increase coincided with declining residues of dieldrin and its breakdown products in several birds of prey suggests that these compounds may have been important in reducing owl survival in the past.

No explanation for the decline in first-year Barn Owl survival rate in south-east Britain was found. More work needs to be done to further investigate the factors behind this trend.

The increase found in the proportion of ringed birds recovered on roads through time, and the apparent decline in human persecution supports earlier work by Glue, as did the seasonal pattern of recoveries, showing when birds were most susceptible to mortality factors.

A comparison with other published studies of owl mortality rates showed the results of this study to be in broad agreement with others elsewhere in Europe, though British Tawny Owls had slightly greater adult survival rates and lower first-year ones.

BACKGROUND AND METHODS

This chapter details the extraction and analysis of data from the BTO Ringing Scheme to obtain information on the temporal and regional trends in owl survival rates. The aim was to relate these survival rates to environmental data in order to investigate some of the factors which may affect those trends.

The Ringing Scheme, like that for Nest Recording, has been collating data for many years: the earliest records date back to 1909. It too has been supported by long-term funding from the Nature Conservancy Council. Several hundred Barn and Tawny Owls have been ringed annually since 1970, so information can be extracted about their survival rates over a long period. The total number of ringed birds that have been recovered for each species each year since 1930 is shown in Fig. 3.1. Though approximately equal numbers have been recovered for the two species, more Tawny Owls have been ringed: the percentage of ringed birds recovered is much lower for the Tawny Owl (7.8%) than for the Barn (16.0%)(Mead & Clark 1989).

The regional spread of the ringing data is also wide: Fig. 3.2 shows the numbers of recoveries of each species in each of the Met. Office regions. The data were not sufficient to carry out a regional analysis of survival rates on that scale, so the data were grouped into the three larger regions discussed in chapter 2: Scotland/N England, SE England, and SW England/Wales. Separate survival analyses were carried out for each of these three regions to allow some account to be taken of geographic differences in both survival and recovery rates. The boundaries for each of these regions are shown on Fig. 3.2. The data could not be split into any smaller regions because of the low numbers of adult owls which have been ringed: 92% of Barn Owls and 86% of Tawny Owls ringed in 1987 were chicks (Mead & Clark 1989), so sample sizes for the direct calculation of adult survival rates were too small.

Traditional methods of ring recovery analysis to determine survival rates (for example Haldane 1951) are inappropriate for owls as they assume that survival rate is constant and do not allow for the short-term variation in survival rates that has been shown to occur in many owls (for example in Barn Owls by Sauter, 1956). A more suitable approach would allow survival rates to be both age- and time-specific. Recent advances in analytical techniques and computer software make such an approach possible. The SURVIV package (White 1983) was used for the calculation of survival rates in this case. The data were analysed to find the model with the fewest parameters (and therefore the one which would give greatest precision in the estimates that it produced) which still gave a significant fit to the data (with a chi-squared goodness-of-fit test, using $P=0.05$ as the threshold level of significance). The analysis was first carried out using a general model where adult and first-year survival and recovery rates were estimated separately for each year; then the model was progressively refined so that more parameters (annual recovery and survival rates) were set equal. The final model choice, for both species in all three of the regions, was one which comprised:

Year-specific first-year survival rate
Year-specific adult survival rate
Constant adult recovery rate
Constant first-year recovery rate

These survival rate values are subject to potential biases which are similar to those affecting the breeding biology data, in that ringing is carried out by a large number of mainly amateur workers, not according to some overall sampling programme. Therefore they should not be treated as absolute values but only used for comparative purposes, controlling for major factors such as the region in which the birds were ringed.

As it was only possible to calculate owl survival rates to the precision of the three major regions, the use of principal components analysis was not appropriate for summarizing the environmental variables. The smaller number of cases (as there were only three regions rather than nine in the analyses of the breeding data in chapter 2) meant that such a PCA would not have given an unreliable result. Therefore stepwise multiple regression analyses of the owl survival data were carried out using the raw seasonal weather summaries and the basic regional agricultural statistics rather than on principal factor scores.

The ring recovery database also provides information about the cause of the bird's death and the time of year at which it died (when the bird was recovered dead). Though the recorded cause of death is only the opinion of the finder of the ring and subject to much bias (Illner 1990) it can again be used comparatively to look at regional and long-term trends in the major mortality factors. The data were examined to see whether they might provide any further information on owl population trends.

RESULTS

The annual adult and first-year survival rates for each major region are given in Fig.3.3 and 3.4. There are clearly large differences in the survival patterns in the regions for both species. In the Barn Owl in the northern region no long-term trend was apparent (trend statistics for all regions are given in Table 3.1), adult and first-year survival rates were closely correlated (r=0.803, P<0.01, n=12) and there was much short-term variation. In SE England the long-term trends were highly significant for both adults and first-years but in opposite directions: adult rate has increased through time whilst the first-year rate has declined. Adult Barn Owls in SW England/Wales showed a similar upward trend in survival rate but the first-year rate also increased in this region (though not significantly).

Table 3.1: Temporal trends in survival rates, for 1976-87. Values are Pearson regression coefficients, significant correlations are marked by asterisks: * = P<0.05, ** = P<0.01, otherwise P>0.05.

	Region		
	Scot/N Eng	SE Eng	SW Eng/Wales
Barn Owl			
First-years	0.082	-0.758 *	0.306
Adults	0.262	0.846 **	0.833 **
Tawny Owl			
First-years	-0.137	-0.250	0.394
Adults	0.144	0.273	0.258

No statistically significant trends in Tawny Owl survival rates through time were found in any of the three regions, though the general pattern followed that of the Barn Owl. Tawny Owl adult survival rate in SE England showed a slight increase through time and first-year survival rate a slight decline, whilst both adult and first-year rates were increasing through time in SW England/Wales.

There were regional differences in recovery rates of ringed birds as well as in the survival rates. Table 3.2 shows the recovery rates of adults and first-year birds on a national and regional basis. The inter-regional differences were considerable in both species with lowest first-year recovery in the north and highest in the south-west whilst the adult recovery rate was highest in the south-east. Adult recovery rates were higher than those of first-years in the same region, possibly because most adults were caught in areas where birds were being studied intensively and therefore would have a greater chance of recovery.

Table 3.2: Regional variation in recovery rates (assuming that each is constant through the period 1976-87). The rate is expressed as the proportion of birds ringed that are recovered and the standard error is given in brackets.

	Tawny		**Barn**	
	Adult	1st-yr	Adult	1styr
National	0.15 (0.02)	0.082 (0.01)	0.26 (0.02)	0.15 (0.01)
Scotland /N.England	0.18 (0.05)	0.050 (0.01)	0.16 (0.03)	0.12 (0.02)
SE England	0.24 (0.06)	0.068 (0.01)	0.41 (0.07)	0.16 (0.02)
SW England /Wales	0.13 (0.01)	0.096 (0.01)	0.26 (0.04)	0.19 (0.02)

The results of the stepwise multiple regressions of the owl survival data on the weather data are given in Table 3.3. They generally support the hypothesis that Barn Owl survival is linked to weather conditions: 40.9% and 60.7% of the variance of adult and first-year survival rates respectively were explained by the models. Tawny Owl survival showed only a weak relationship with the weather data: only 9.0% and 9.4% of the variance in adult and first-year survival were explained.

Table 3.3: Stepwise multiple regression of owl survival rates with weather data	
Barn Owl	
First-year survival =	-0.033 x Next winter ground frost days + 0.0023 x autumn rainfall + 0.0213 x next winter air frost days - 0.0125 x summer rain days + 0.544. ($r^2 = 0.607$)
Adult survival =	-0.0041 x Next winter rainfall + 0.0118 x spring rainfall - 0.0359 x spring rain days + 0.775. ($r^2 = 0.409$)
Tawny Owl	
First-year survival =	0.065 x Autumn min temperature + 0.055 ($r^2 = 0.094$)
Adult survival =	-0.053 x Spring min temperature + 1.096 ($r^2 = 0.0898$)

The multiple regression of the Barn Owl data showed three variables to be having a significant effect on first-year survival: (1) frost conditions in the winter following fledging (survival rates were lower when there were more days of ground frost but surprisingly the relationship was in the opposite direction for air frost, probably through a spurious correlation though it is possible that ground frost may be a better indicator of food availability to the owls), (2) autumn rainfall (positive relationship) and (3) summer rainfall (negative relationship). Thus, greatest first-year survival would be expected when summer rainfall was low, autumn rainfall high and few frost-days in winter. Adult Barn Owl survival rates also showed a strong relationship to the weather data but to different variables from the first-year rates. It was negatively related to winter rainfall and the number of days of rain in spring but positively associated with total spring rainfall. Adult Barn Owls appeared to be less susceptible to cold periods in winter than first-year birds.

For the Tawny Owl the only weather variable identified by the multiple regression for the first-year survival rates was autumn minimum temperature (with which there was a positive association) and for adult survival spring minimum temperature (which showed a negative relationship).

The multiple regression analysis of the owl survival data on the agricultural land use data showed a strong relationship between Barn Owl survival rates and land use (Table 3.4). First-year survival was negatively related to the area of sugar beet grown (explaining 26.1% of the variance) and adult survival positively with the area of oil seed rape (explaining 43.3% of the variance). The possible biological meaning of such relationships between these and other associated variables are addressed in the discussion.

The multiple regression of Tawny Owl survival rates on the land use data with (Table 3.4) also explained large percentages of the variance (40.5% and 12.9% of first-year and adult survival respectively). First-year survival was positively related to the area of permanent grassland and of crops for stock feeding, whilst adult survival was negatively associated with the number of dairy cattle.

Table 3.4: Stepwise multiple regression of owl survival rates with agricultural land use data

Barn Owl	
First-year survival =	-7.27×10^{-7} x Sugar beet + 0.294 ($r^2 = 0.261$)
Adult survival =	1.99×10^{-6} x Oil-seed rape + 0.53 ($r^2 = 0.433$)
Tawny Owl	
First-year survival =	1.28×10^{-7} x Permanent grassland + 1.90×10^{-6} x Crops for stock-feeding -0.0258 ($r^2 = 0.405$)
Adult survival =	-4.81×10^{-8} x Dairy cattle + 0.831 ($r^2 = 0.129$)

Owl survival rates were not correlated with either the spring or autumn indices of small mammal abundance (Table 3.5).

Table 3.5: Correlation coefficients of owl survival rates with regional small mammal indices

	Bank Vole		Wood Mouse	
	Spring	Autumn	Spring	Autumn
Tawny				
First-year	-0.084	-0.009	-0.075	0.053
Adult	-0.118	0.007	-0.247	0.111
Barn				
First-year	-0.316	-0.017	-0.261	0.016
Adult	-0.069	0.355	-0.100	0.281

Causes of owl mortality

The causes of death recorded for recovered birds were examined to see whether any regional trends were apparent. The large proportion of birds recorded as 'unknown' made interpretation of the results very difficult and no clear geographic trends were detected. More interesting results were found in the changes in the recorded cause of death through time (Table 3.6). The data were divided into six year groups and two age-classes (adults and first-years) for each species. The most interesting point to note was the increase in the proportion of traffic deaths from the earlier year periods in both age-classes in both species. There was also some evidence that direct human persecution had reduced steadily as a lower proportion were recorded killed by man.

Table 3.6: Recorded cause of owl mortality by year group and age-class. Values are the percentage of birds reported for each factor.

Barn Owl: first-years

	Year Group					
	44-64	65-70	71-76	77-82	83-85	86-88
Unknown	54.5	41.0	48.3	35.9	30.8	32.0
Traffic	27.3	33.7	40.7	39.5	48.7	49.0
Killed by man	4.0	7.2	2.1	1.8	0.9	0
Accident - man	3.0	1.2	0	0.6	1.7	0.7
Natural causes	2.0	1.2	0	3.0	6.0	2.7
Predation	0	0	0	0.6	0.9	2.0
Hit wires	5.1	3.6	2.1	1.8	0.9	0.7
Starvation	1.0	2.4	0.7	3.6	1.7	2.0
Poisoned	0	0	0	1.2	0	0.7
Other	3.0	9.6	6.2	12.0	8.5	10.2
Total	99	83	145	167	117	147

Barn Owl: adults

	Year Group					
	44-64	65-70	71-76	77-82	83-85	86-88
Unknown	42.9	44.2	37.2	38.3	32.1	41.2
Traffic	14.3	32.6	40.7	38.3	48.2	32.4
Killed by man	10.0	7.0	3.5	0.8	1.8	4.4
Accident - man	1.4	0	0	2.3	1.8	4.4
Natural causes	5.7	2.3	2.3	2.3	5.4	2.9
Predation	1.4	0	1.2	1.6	0	0
Hit wires	1.4	4.7	2.3	2.3	1.8	1.5
Starvation	7.1	0	2.3	3.1	1.8	0
Poisoned	0	2.3	0	0.8	0	0
Other	15.7	7.0	10.5	10.2	7.1	13.2
Total	70	43	86	128	56	68

Tawny Owl: first-years

	Year Group					
	44-64	65-70	71-76	77-82	83-85	86-88
Unknown	60.0	30.6	38.2	29.8	35.1	30.8
Traffic	15.8	59.2	44.1	50.0	45.9	54.9
Killed by man	7.4	0	1.5	0	1.4	1.1
Accident - man	1.1	0	2.9	0	2.7	1.1
Natural causes	1.1	0	0	4.3	6.8	2.2
Predation	1.1	0	2.9	3.2	2.7	2.2
Hit wires	4.2	6.1	2.9	1.1	2.7	3.3
Starvation	0	4.1	0	3.2	1.4	0
Poisoned	0	0	0	0	0	0
Other	9.5	0	7.4	8.5	1.4	4.4
Total	95	49	68	94	74	91

Tawny Owl: adults

	Year Group					
	44-64	65-70	71-76	77-82	83-85	86-88
Unknown	53.5	36.4	31.6	40.7	35.4	43.0
Traffic	15.5	31.8	45.3	37.0	43.9	39.1
Killed by man	15.5	6.8	3.2	3.7	3.7	2.3
Accident - man	4.2	2.3	2.1	4.4	1.2	0.8
Natural causes	2.8	0	1.1	3.7	2.4	2.3
Predation	0	2.3	2.1	0.7	1.2	1.6
Hit wires	1.4	4.5	4.2	1.5	3.7	0
Starvation	1.4	0	0	0	3.7	2.3
Poisoned	0	0	0	0	0	0
Other	5.6	15.9	10.5	8.1	4.9	8.6
Total	71	44	95	135	82	128

Seasonal pattern of mortality

Fig. 3.5 illustrates the seasonal pattern of mortality of ringed owls of both species. Barn Owl first-year mortality peaked in autumn and early winter, whilst most adults died during the late winter and spring. The Tawny Owl had a similar peak in first-year mortality in the autumn but winter survival was higher than for the Barn Owl. Tawny Owl adults showed much lower over-winter mortality than the Barn Owl: most of their deaths were recorded in spring.

DISCUSSION

Regional and temporal trends in owl survival rates

Several regional and long-term trends in owl survival rates were identified from the BTO ringing database. Patterns were similar in the two species but more marked in the Barn Owl. No long-term trend was found in Scotland/N England but there was large short-term fluctuation. Adult survival rate showed an increasing trend in the two southern regions, particularly the Barn owl in SE England. Barn Owl first-year survival had a downward trend in SE England but a slight increase in SW England/Wales.

These results gave further support to the hypothesis that the decline in the Barn Owl is not a continuing one and also suggest that there may have been a small increase in the Tawny Owl. Survival rates, like the breeding productivity discussed in chapter 2, were generally on an upward trend (apart from the first-year rate in SE England). Current levels of survival rate compare favourably with those recorded in several published studies. Barn Owl first-year survival rates in Europe were generally similar to those in Britain, whilst adult rates were slightly higher in Britain (see Table 3.7 where mean rates are given for comparison). Tawny Owl first-year survival tended to be slightly lower in Britain but adult survival greater than rates found in mainland Europe and Scandinavia. The implications of these survival rate trends on the population dynamics is taken up further in chapter 7.

Table 3.7: Comparison of survival rate derived from BTO data with those of other published studies

Study area	1st-year survival	Adult survival	Author
Barn Owl			
E. Germany	27.3%	49.0%	Schonfeld 1974
Switzerland	32.3%	57.1%	Glutz & Bauer 1980
Scotland/N Eng.	28.6%	55.1%	BTO data (this study)
SE England	17.5%	70.1%	BTO data (this study)
SW England/Wales	29.4%	64.1%	BTO data (this study)
Tawny Owl			
Study area	1st-year survival	Adult survival	Author
Sweden	28.8%	52.4%	Olsson 1958
Switzerland	50.6%	75.5%	Glutz & Bauer 1980
England (Oxford)	47.4%	68.2%	Southern 1970
Finland	44.4%	69.4%	Rinne *et al.* 1987
Scotland/N Eng.	26.7%	79.4%	BTO data (this study)
SE England	28.0%	79.2%	BTO data (this study)
SW England/Wales	46.6%	71.8%	BTO data (this study)

The regional differences in owl survival rates highlight the importance of being able to divide the data regionally rather than carrying out the analysis on a national basis. Different population processes seemed to be occurring in the different regions. This point was emphasized by the regional differences in recovery rate: a model which assumed the same recovery rate over the whole country would clearly be inappropriate. Two factors might cause such variation in recovery rates. Firstly birds in the north tend to be ringed in more remote locations and are therefore less likely to be found when they die. In addition some intensive professional studies, mostly in the northern region, in which large numbers of birds are ringed do not currently contribute their local recoveries to the BTO database (I. Taylor pers. comm.). Encouragement is needed to change this attitude and emphasize the value of holding **all** recovery data at the BTO. This also requires a change of policy with regard to the value of local controls (birds recovered alive within 5 km of their ringing site) to ensure that these details are recorded for priority species such as birds of prey, as well as the longer-distance movements.

Environmental data: what factors were affecting owl survival rates?

Barn Owl survival rates generally showed a much closer relationship to the weather data than did their breeding productivity (chapter 2). Much of the variation in first-year survival rates in particular was accounted for by the weather data: winter frosts and summer rainfall both reduced survival. Adult survival also appeared to be strongly influenced by weather conditions, being lower in years and areas of high winter and spring rainfall. Thus the relatively mild winters of recent years could well have been a component of the observed increase in survival, though there was still much variation unexplained by these weather models. Several other authors have found similar relationships between weather and Barn Owl survival (Sauter 1956, Madge and Tyson 1987).

Tawny Owl survival rates were much less related to the weather data. Significant relationships between first-year survival rate and one of the principal component factors, and between both first-year and adult survival were found with the basic weather data: there was a negative effect of winter cold on first-year survival at least. However, as with Tawny Owl breeding performance, the overall effect of the weather conditions was only slight on this species.

Some strong relationships were found between owl survival rates and the agricultural land use data. Adult Barn Owl survival rate was higher in areas and years with greater areas of oil-seed rape, whilst the first-year rate was lower in areas with less sugar beet. These analyses illustrate the dangers of applying this correlative approach without considering the biological meaning of the results. It is unlikely that some factor associated with sugar beet could be reducing the survival rate of first-year Barn Owls, and equally unlikely that oil-seed rape was providing conditions which enhanced adult survival. What seems to have happened in, for example, this last case, is that both the area of oil-seed rape and adult survival rate were increasing during the 12 years. This gave the high correlation between the two variables but this does not necessarily demonstrate a causal link: the increases in the same direction over the same period were most likely to have been purely coincidental.

Tawny Owl survival rates appeared to be less related to the land use data than those of the Barn Owl. Adult survival rate was higher in areas and years with lower numbers of dairy cattle, and the first-year rate higher in areas and years with more permanent grassland and crops grown for stock feeding. Again these could well have been spurious correlations.

No relationship was found between owl survival rates and woodland small mammal data. This was unexpected when one considers the high correlation between Tawny

Owl productivity and small mammal abundance (chapter 2). These results were also in contrast to several other studies of owl survival and food supply (Taylor 1989). This may partly be a result of the timing of the small mammal trapping: this was carried out in autumn and spring but not in mid-winter, which may be the crucial time in relation to survival. Alternatively the relationship may just not be as strong as the one with productivity and was not therefore detected by the broad-brush methods used in these analyses.

The increasing trend in survival rates was coincident with the increasing use of the second-generation rodenticides which suggests that these compounds were not causing a major problem to the owls at a gross population level. There is a possibility that rodenticide poisoning may be at least partly responsible for the decline in first-year survival in SE England, though other factors such as lack of feeding habitat and availability of nesting and roost sites must also be considered and are perhaps more likely explanations. Without further data on the regional rodenticide usage and perhaps experimental field study such hypotheses cannot be tested.

Thus even though there were several strong relationships between survival rates and the environmental data, much of the variation remained unexplained by these factors. What other factors might have led to the observed trends? The timing of the general increase in survival rates coincides with the time of declining dieldrin and aldrin residues in several species of bird of prey including the Barn Owl (Newton in press). It seems possible that this could be at least part of the answer. Detailed population studies have shown the effects of these chemicals on other raptor species (Newton 1986, Ratcliffe 1980).

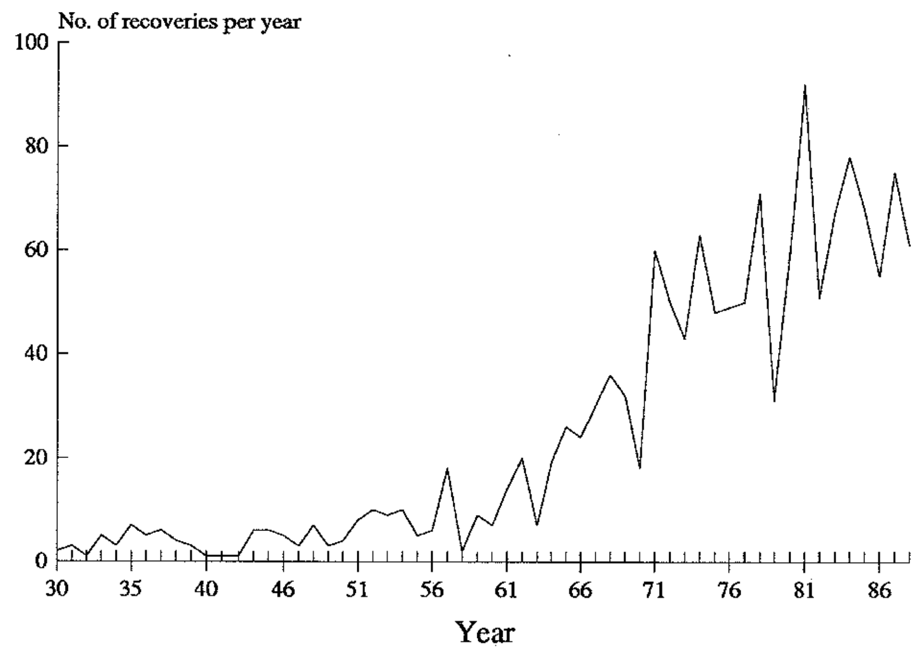
Trends in the cause and seasonal pattern of owl mortality

Little additional information to assist explanation of the overall population trends was obtained from the temporal and spatial patterns in the cause of mortality, nor in the seasonal pattern of the mortality. No major differences were found from previous analyses of BTO data made by Glue (1971, 1973). Of particular note was the increase then levelling off in the proportion killed by traffic and the decline in human persecution of both species. The seasonal pattern of deaths showed a major difference between the two species. Barn Owls were much more subject to over-winter mortality, which might be expected for a species on the northern fringe of its range (Cramp 1985).

The actual values of the proportion of deaths attributable to each cause was undoubtedly heavily biased (Illner 1990): a bird being killed by traffic on a public road stands a much greater chance of recovery than one dying of another cause in a more remote location. There was a very low incidence of poisoning but this is likely to be under-recorded. Most observers would be unable to detect poisoning as the cause of death as its effect might be to weaken rather than kill a bird outright: a bird may be killed by traffic but only because it has been weakened by poisoning. In addition poisoning may not be separable from other natural causes unless carcases are sent to laboratories for tissue analysis and post-mortem examination and thus poisoning as a cause may be underestimated. Newton (1990) has shown that as many as 10% of Barn Owls found dead have been exposed to some second generation anticoagulants.

Fig. 3.1 Annual ringing recovery totals

1. Barn Owl



2. Tawny Owl

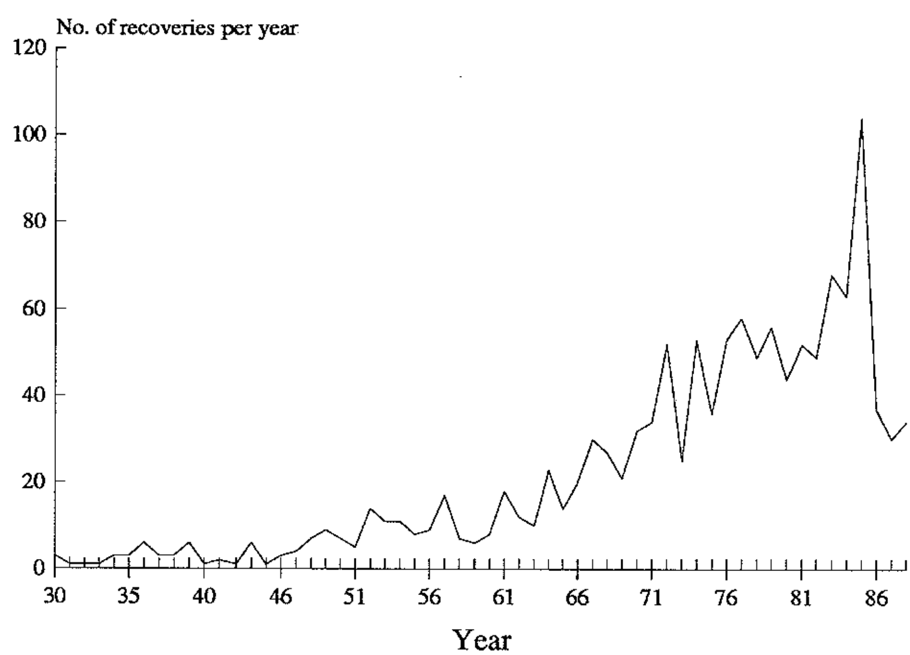


Fig. 3.2 Regional breakdown of total number of ringing recoveries

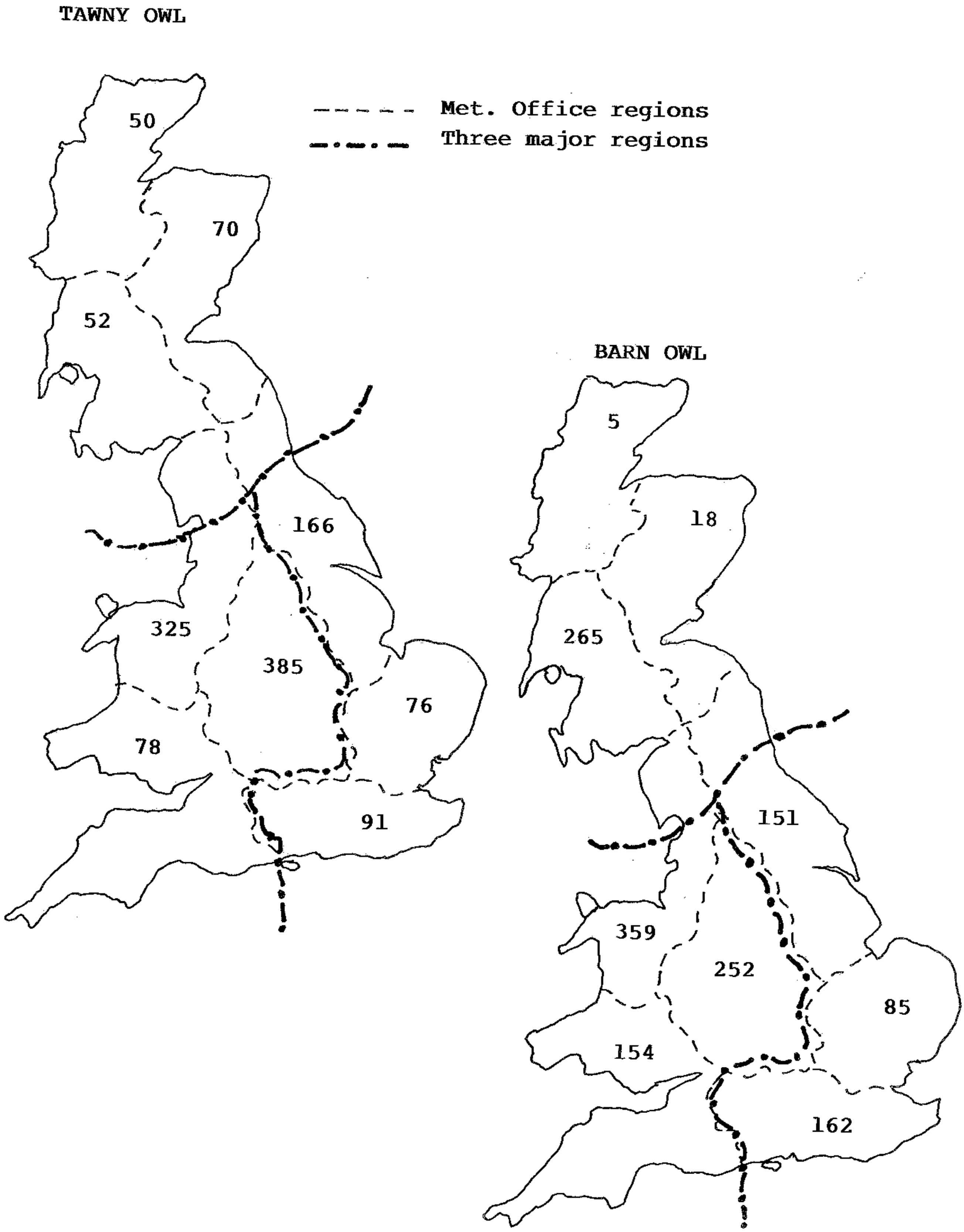
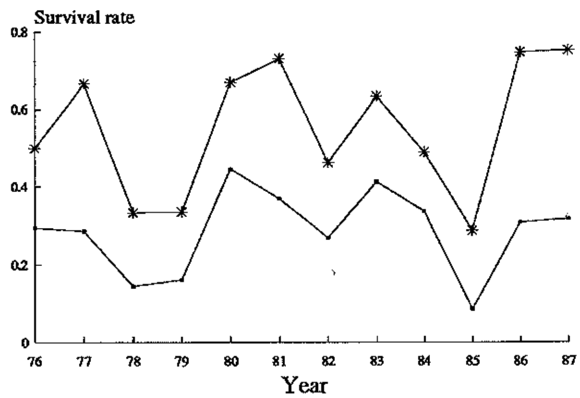
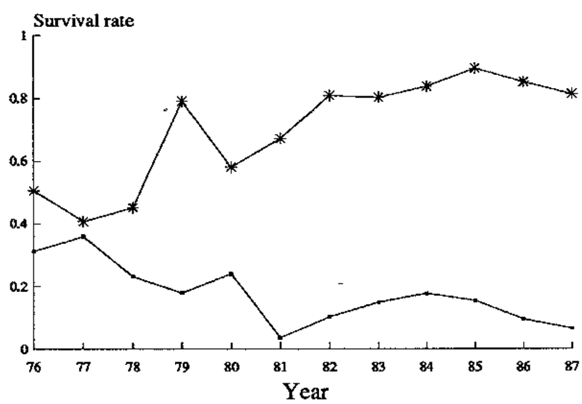


Fig. 3.3 Regional/temporal variation in Barn Owl survival

1. Scotland/N England



2. SE England



3. SW England

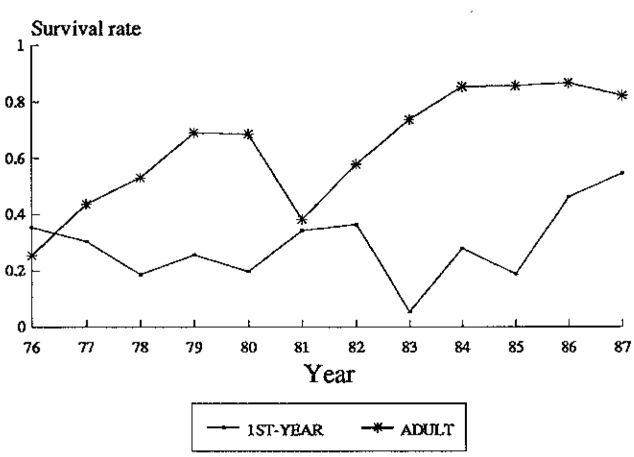
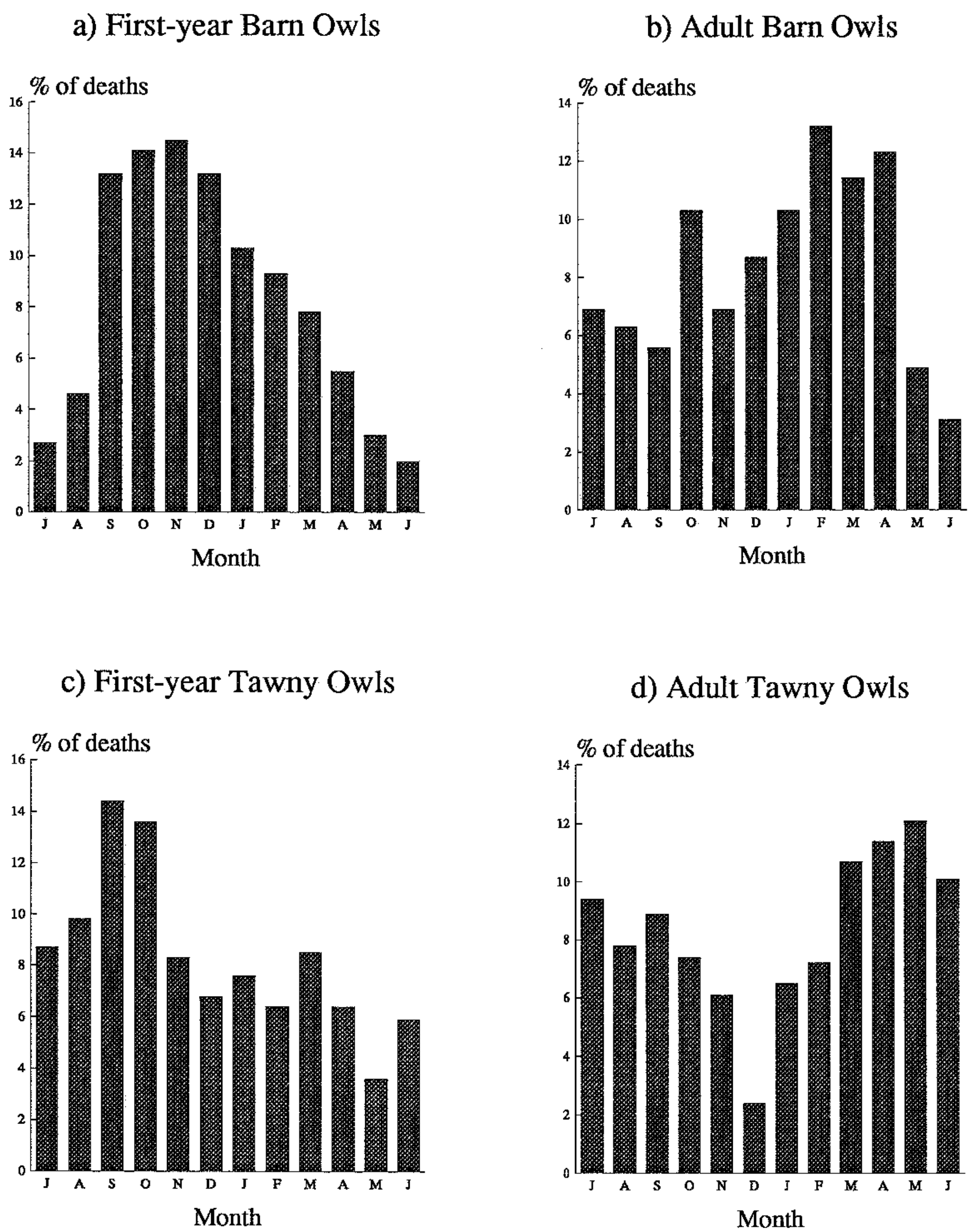


Fig. 3.4 Regional/temporal variation in Tawny Owl survival

Fig. 3.5 Seasonal patterns in owl mortality



CHAPTER 4: DISPERSAL

SUMMARY

No overall regional or temporal trends in on owl dispersal distances were found from the analyses of BTO ringing database, and no relationship was apparent with the other population parameters. This suggests that changes in dispersal had not contributed to the observed population trends.

The age-related and seasonal pattern of dispersal in the two species is described; general agreement was found with previous studies. Several problems were identified in the data set, particularly the lack of information recorded on recaptures of birds within 5 km of ringing site. This meant that data on philopatry were sparse, particularly for the Tawny Owl which is the more resident of the two species. This information was requested on the new owls nest record sheet when adults were trapped at the nest, but it is suggested that for priority species such as owls these data should be collected by BTO within the ringing database.

BACKGROUND AND METHODS

This chapter uses the ring recovery data to investigate the spatial and temporal variation in the dispersal patterns of the two owl species and to see whether changes in dispersal may have affected the overall population dynamics. For each recovery the distance that the bird has moved between ringing and recovery can be used as a measure of that bird's dispersal. As most owls are ringed as pulli these movements can be grouped according to the age at ringing and the age at recovery. Four classes were defined:

1) Birds ringed as pulli and recovered less than 3 months later (less than 3 months).
2) Birds ringed as pulli and recovered 3-12 months later (juvenile/juvenile).
3) Birds ringed as pulli and recovered more than 12 months later (juvenile/adult).
4) Birds ringed and recovered as adults (adult/adult).

The use of ringing recoveries to estimate dispersal distances is subject to a number of problems which must be considered in the analyses. Firstly the data have a greatly skewed distribution, and therefore have been log-transformed so that parametric statistics can be used on them. Secondly, no recoveries of live birds less than 5 km from ringing site are kept in the BTO databanks, so any calculation of dispersal is likely to over-estimate the actual distances moved by the birds. With both of these species the large majority of recoveries are of birds found dead, so this may not be a very great problem, but must still be taken into consideration when examining the results. A further potential problem with the owls is that many of the recoveries are of birds killed on roads: as discussed in chapter 3, this sample may not be representative of the whole population and may also be subject to some over-estimation of distances moved as some dead birds may be carried along by the vehicles with which they collided. Nonetheless the recovery data can still be used for a comparative analysis of the factors affecting owl dispersal.

RESULTS

The results of the analysis of variance to investigate the factors influencing owl dispersal patterns are shown in Table 4.1. Each species has been divided into the four age-classes described above and each analysis has looked at the variation attributable to region, year group and the finding circumstances of the bird. The latter was included to control for the possibility that birds found dead on roads could have been transported by the vehicles that killed them and would therefore over-estimate dispersal distance. As can be seen from the table, this effect of finding circumstance was highly significant in the Barn Owl for all age-classes but only for juvenile-adult dispersal in the Tawny Owl. It was therefore important that this factor could included in the analyses.

Table 4.1: Analysis of variance of log-transformed dispersal distances by age-class, year group, major region and finding circumstances. F values are given in the table.

Barn Owl			
Age-class	Region 2 df	Year period 5 df	Finding circ. 1 df
< 3 months	0.17 ns	0.87 ns	10.95 ***
3-12 months	0.67 ns	0.23 ns	15.92 ***
Juv-Adult	2.36 ns	0.53 ns	3.88 *
Adult-Adult	0.38 ns	3.99 **	4.05 *
Tawny Owl			
Age-class	Region 2 df	Year period 5 df	Finding circ. 1 df
< 3 months	0.09 ns	1.35 ns	1.06 ns
3-12 months	5.28 **	2.77 *	0.91 ns
Juv-Adult	0.53 ns	2.41 *	7.29 **
Adult-Adult	0.26 ns	2.06 ns	3.78 ns

The Barn Owl showed no significant regional or temporal variation in dispersal in any of the first-year age-classes. The only significant variation was found between adult dispersal in different year groups. Tawny Owl juvenile dispersal in the 3-12 month category was significantly different between regions and year periods, and in the juvenile-adult dispersal class between year periods. No such variation in adult dispersal was found as for the Barn Owl. The differences in dispersal in each age class through time and between regions are illustrated in Fig 4.1 and 4.2 respectively.

The differences in monthly dispersal pattern between the two species is shown in Fig. 4.3. This figure only includes birds ringed as chicks and therefore of known age. The starting point on the figure for each species is different reflecting the earlier breeding and fledging of the Tawny Owl. Both species showed an initial period of about 2-3 months following ringing when they remained very close to their natal site (presumably within their parental territory). Thereafter the Barn Owl showed two peaks of dispersal, in the March/April following fledging (associated with establishing a site for their first breeding attempt: most birds breed in their first year, I. Taylor pers. comm.), and in the September/October after that (coincident with the time when the next year's offspring would be dispersing). The Tawny Owl had three distinct dispersal peaks, in the autumn/early winter following fledging (when birds would be establishing their own territories), in May/June after that (when the next year's young would be starting to become independent) and in their second March/April period (when birds would be establishing their own breeding territories: Tawny Owls usually breed first at two years old, Southern 1970).

Comparison of dispersal with other population statistics

The correlations between dispersal distance and other owl population statistics was generally low (Table 4.2), showing that dispersal would be a poor indicator of the other measures. There were some significant correlations: Barn owl juvenile-adult dispersal was lower in years when larger clutches were laid and adult movements greater when adult survival was higher. Tawny Owl dispersal during the period of less than 3 months of age was greater when adult survival was higher, juvenile-adult dispersal was less when the number of eggs hatched per nest and the number of chicks surviving to 11 days was higher. Tawny adult dispersal was smaller when adult survival was higher; a correlation in the opposite direction to that found for the Barn Owl. It should be borne in mind however that when carrying out large numbers of correlations such as this some significant results would be expected by chance alone.

Table 4.2: Relationship between owl dispersal distances and other population statistics.

	< 3 mn	3-12 mn	Juv-Ad	Ad-Ad
Barn Owl				
Clutch size	-0.181	0.057	-0.352 *	-0.059
No. eggs hatching	-0.056	0.122	-0.150	0.013
No. young at 20d.	-0.166	0.175	-0.315	0.100
No. young fledging	-0.193	-0.103	-0.235	-0.020
1st-yr survival	0.183	-0.062	-0.148	-0.036
Adult survival	0.141	0.187	0.095	0.376 *
Sample	32	36	35	32
Tawny Owl				
	< 3 mn	3-12 mn	Juv-Ad	Ad-Ad
Clutch size	0.320	-.034	-.150	0.294
No. eggs hatching	0.241	0.075	-.411 *	0.130
No. young at 11d.	0.046	0.102	-.402 *	0.129
No. young fledging	0.154	0.150	-.301	0.145
1st-yr survival	0.039	-.033	0.071	0.040
Adult survival	0.351 *	0.078	0.225	-.367 *
Sample	25	33	35	34

DISCUSSION

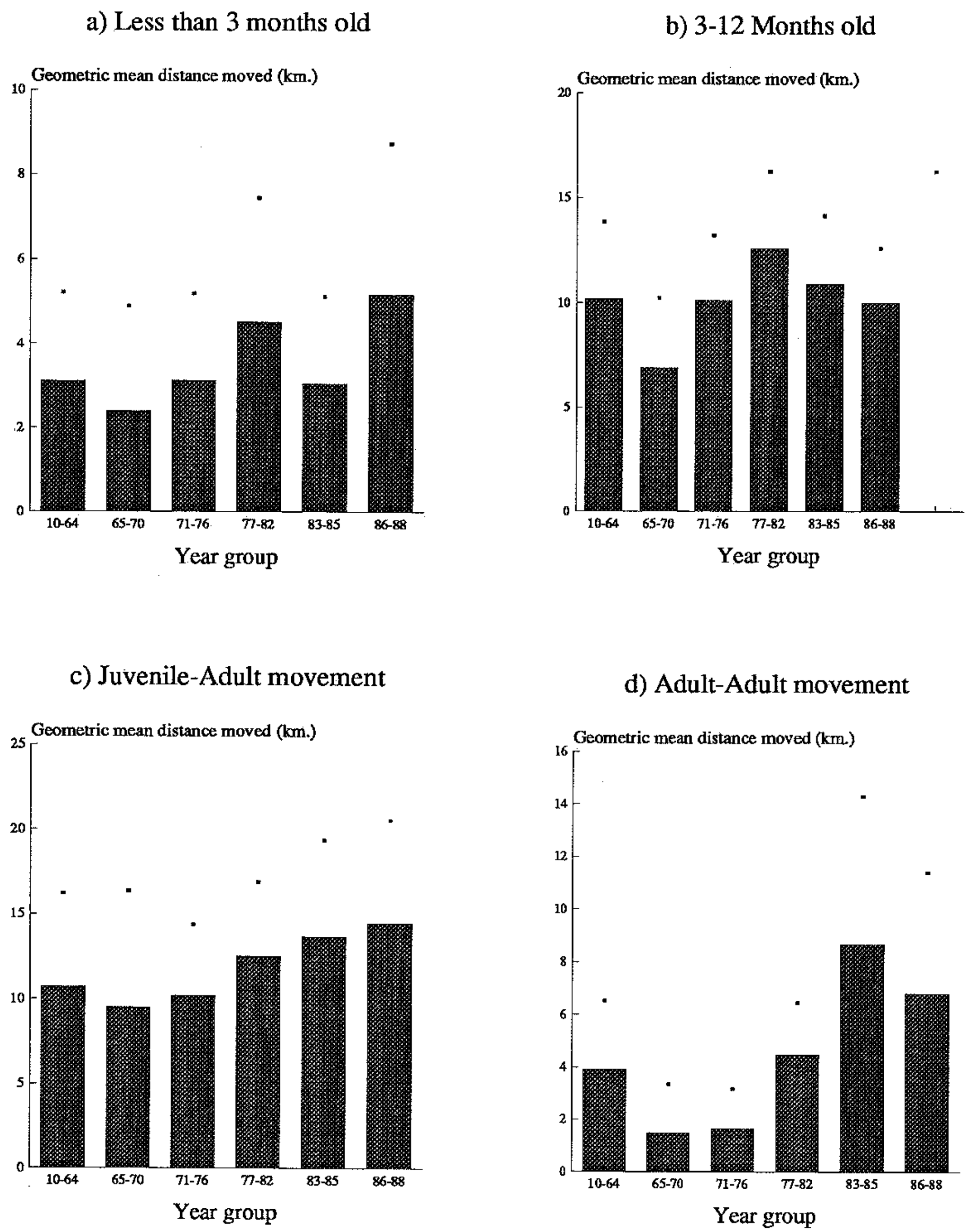
Unlike the breeding performance and survival rate data, no clear trends in dispersal were found in either space or time. The main aim of this chapter was to investigate whether dispersal might have affected the population dynamics. No evidence was found that changes in dispersal had any significant influence. Little change was detected and there was only a very weak relationship between dispersal and other population statistics. This second point meant that dispersal was not a very useful indicator of the population and would therefore be of limited use in future monitoring using data collected in the same way as previously.

One of the major problems with the dispersal data set is the large bias in the sample. This problem is not insurmountable and improvements could be introduced quickly and easily. In particular these owls could be included as a priority species for which local controls could be recorded. This would link in with the encouragement to ringers to catch more adults and could give a much better insight to dispersal patterns, a factor which could be important in understanding and monitoring population dynamics.

At the same time some interesting points did emerge from the analyses in broad agreement with those made by Bunn *et al.* (1982) of the BTO data set. Differences in the timing and the magnitude of dispersal between the two species were apparent, with the Barn Owl dispersing more steadily after fledging but moving rather greater distances than the Tawny Owl. The latter were highly resident, as found by Southern et al. (1954), and Southern (1970) in S England and Glutz & Bauer (1980) in mainland Europe. Longer Tawny Owl juvenile dispersal distances were recorded in Scotland/N England than in the two southern regions, a latitudinal trend which fits in with the findings of Olsson (1958) and v.Haartmann (1968) who both recorded greater dispersal in Scandinavia than in studies further south.

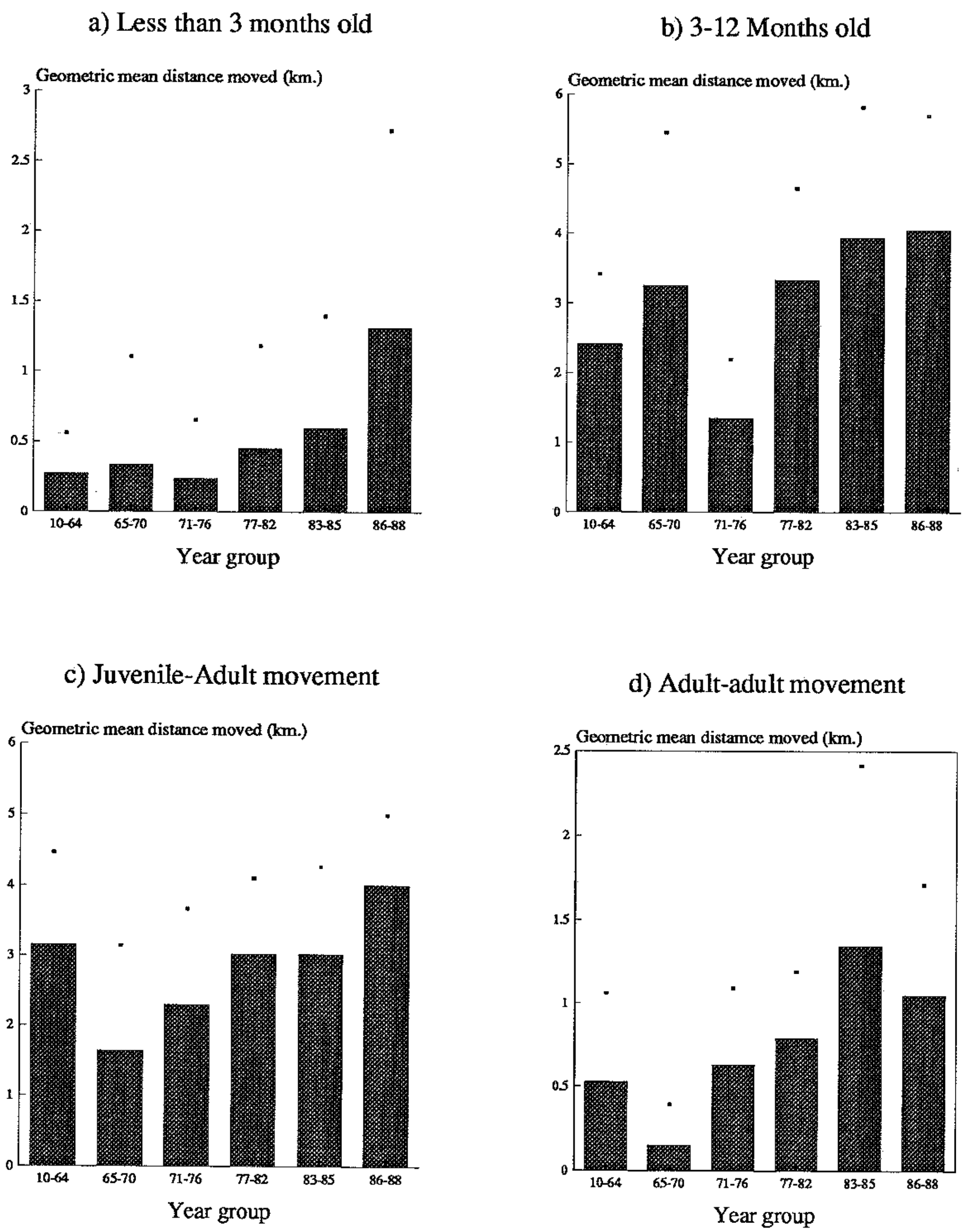
Though Barn Owls dispersed greater distances than Tawny Owls, they still remained fairly close to their original ringing site. No evidence was found for any migratory pattern recorded for this species in the USA (Stewart 1952). None was found either for any major eruptive dispersal associated with poor food supply and cold weather, as found in studies of Barn Owl dispersal in mainland Europe (Sauter 1956, Honer 1963, Frylestam 1972, Schonfeld 1974). Distances moved were rather less than those recorded in the Netherlands by Braaksma and Bruijn (1976) though direct comparisons are not strictly valid as the data sets have not necessarily been collected in the same way.

Fig. 4.1 Temporal variation in Barn Owl dispersal



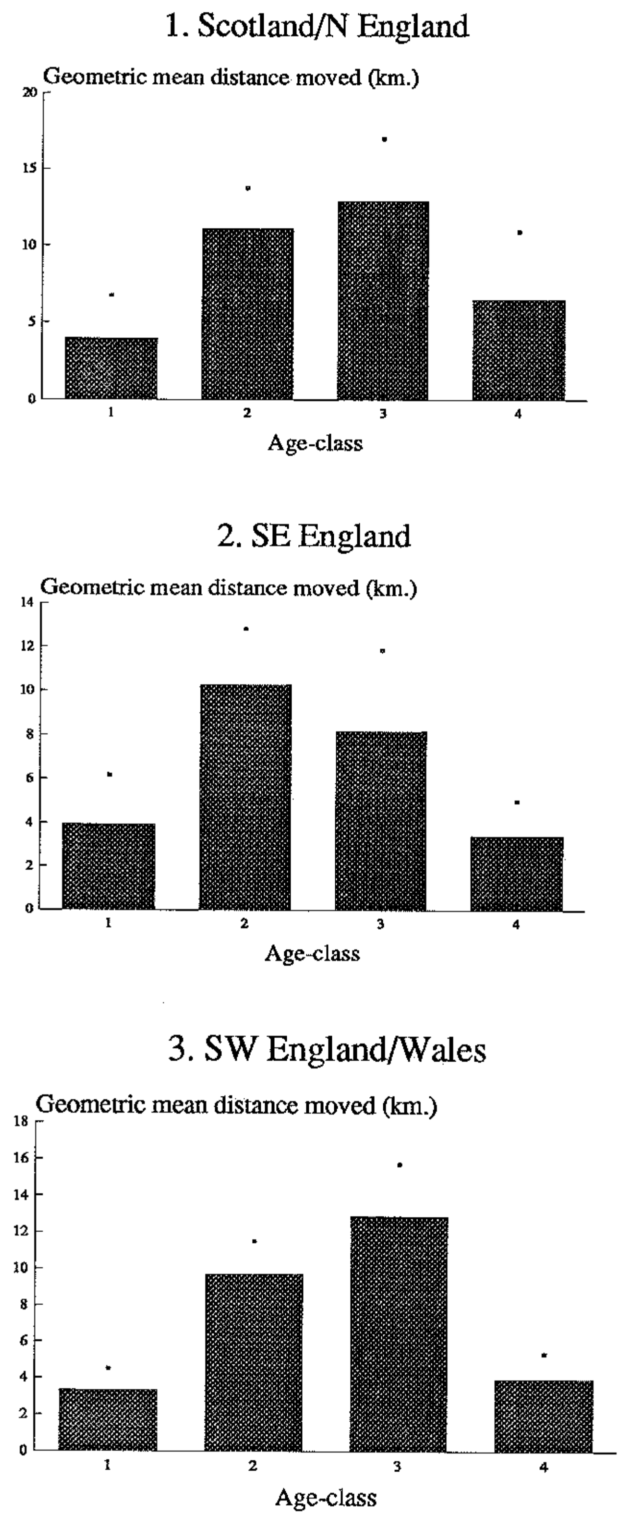
Data are geometric means with upper 95% confidence limit

Fig. 4.2 Temporal variation in Tawny Owl dispersal



Data are geometric means with upper 95% confidence limit

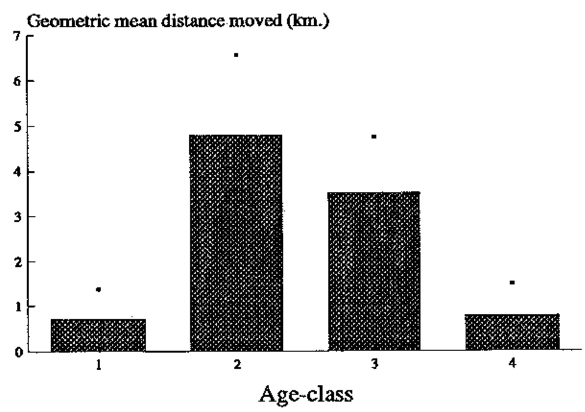
Fig. 4.3 Barn Owl regional dispersal



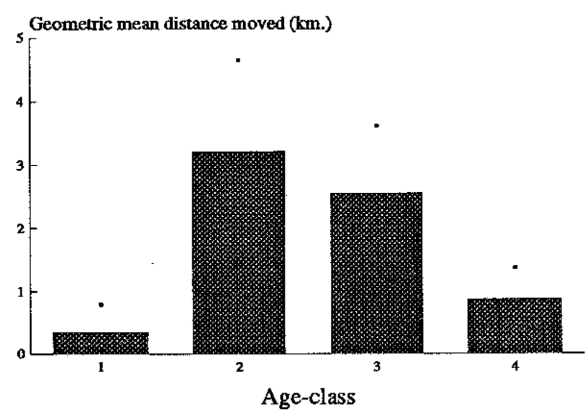
Data are geometric means with upper 95% confidence limit

Fig. 4.4 Tawny Owl regional dispersal

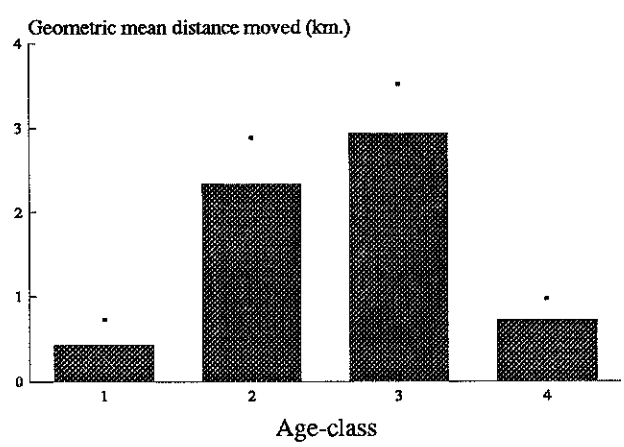
1. Scotland/N England



2. SE England



3. SW England/Wales



Data are geometric means with upper 95% confidence limit

CHAPTER 5: BARN OWL SAMPLE AREAS CENSUS

SUMMARY

The Barn Owl sample areas census was carried out during the 1989 breeding season to attempt to provide a baseline for future monitoring obtain data on owl densities. Despite much detailed consideration of methods only a few observers participated in the census. It seemed that the methods were too labour-intensive. Continued promotion of the intensive defined study area approach is necessary in the future as it seems that there are no short-cut methods for censusing this species. Its best chance of success should be to link in with current projects already monitoring breeding performance and survival.

AIMS

The Barn Owl sample areas census was carried out to obtain reliable data on Barn Owl numbers using methods which could be repeated in future years so that population changes could be assessed accurately. The aims were to provide a baseline for future monitoring of Barn Owl numbers and to obtain data on owl densities to incorporate into the analyses of the other population statistics.

METHODS

The Barn Owl poses many challenges to the potential surveyor. It is perhaps one of the most difficult of all British bird species to census. As a primarily nocturnal species it is not possible to use direct observation as a technique to locate breeding birds nor, unlike the Tawny Owl, is it predictably vocal in territorial defence and courtship, so this cannot be used either. Some preliminary pilot work was carried out during the April 1988 to test whether tape lures may be useful in detecting breeding pairs but this too proved to be unreliable. Some pairs did respond to the tape but others paid no attention to it. A small survey working group was established to consider the most appropriate methods for counting Barn and Tawny Owls as part of this project. This group decided that the only way to achieve the survey aims for the Barn Owl was to carry out intensive nest searches in sample survey areas, attempting to find all breeding pairs within a defined area and making detailed records of their search effort. The census was carried out during the 1989 breeding season, between March and September.

The details of the methods and the recording form are given in an appendix to this chapter. The sampling strategy was based on a 10km square, though observers were allowed some flexibility to incorporate an existing study area. A target of 25 10km squares was set and owl enthusiasts were approached to take part. A total of 45 sets of census forms and instructions were sent out. It was obviously important that these sample squares should be representative of the whole population: ideally they should have been selected at random. However some compromise was necessary as (a) it was unlikely that people could be persuaded to move their study from an area in which they had been working in for many years and (b) if they were prepared to transfer their efforts all historical information that they had built up during the years of their study would be lost. The second point is particularly important when the time required to search an area thoroughly is considered. Even if enough observers were willing to cover random areas the quality of the data that they would collect would inevitably be lower than that from an area where Barn Owl distribution was already fairly well-established. Therefore observers were allowed to select their own study areas but it was emphasized in the instructions that each area should include both high and low-quality owl habitats wherever possible.

RESULTS

Even though a considerable effort was made to maintain the flexibility of the methods to incorporate current studies, the number of returns from observers was disappointingly low. Only 7 completed forms had been received by the time this report was written. These are summarized in Table 5.1. The exact locations of these squares have been kept confidential but details are held at the BTO.

Table 5.1: Summary of the seven Barn Owl sample areas census forms received

Area	No. of pairs found	No of pairs missed	% of tetrads checked	Dominant habitat
Stranraer	8	1-2	100	Grazed farmland /moorland
Exeter	6	1-2	96	Grazed farmland
Norfolk	1	1-2	100	Arable farmland/parkland
Inverness	1	0	76	Moorland/conifer wood
Cheshire	0	0-2	100	Mixed farmland
Lincolnshire	1	?	8	Arable farmland
Yorkshire	5	3	100	Mixed farmland

Of the seven forms returned only one had not followed the methods correctly (it only covered two tetrads of the 10km square). A range of 0 to 8 pairs were located in each 10km square and most observers estimate that they had failed to find only 1-2 pairs.

DISCUSSION

It was clear that observers were not keen to take part in the Barn Owl sample areas census. Only seven of the 45 owl workers approached to take part returned their census forms. The main problem seemed to be that the methods were too labour-intensive and only in exceptional cases did people have sufficient time to carry them out.

With such a poor return rate, could there have been any alternative to the census methods? Other possibilities were discussed in detail at the owls survey working group and it was agreed unanimously that to achieve the aims of the census there was no alternative to labour-intensive nest-searching in a defined area. All Barn Owl census work published in the scientific literature has resorted to this technique (Hegdal & Blaskiewicz 1984, Colvin 1984, Taylor 1988). Any less intensive work where one cannot be sure that all breeding pairs have been located would be too unreliable and could not produce the required measure of Barn Owl abundance.

The wider scale approach of collating records of Barn Owls from a wide variety of sources (bird-watchers, farmers, landowners and members of the general public), as used in both the BTO Breeding Bird Atlas (Sharrock 1976) and the more recent Hawk Trust Barn Owl survey (Shawyer 1987), may give a broad idea of the species' distribution and a very rough estimate of the population, but could never validly be used to identify anything other than a major change in distribution or in abundance. The single estimate for the population produced from the Hawk Trust survey cannot be used to compare with future surveys. There are two problems with a survey such as the Hawk Trust's. Firstly it is not possible to make valid comparisons between estimates when the methods have not been carefully controlled and when no confidence limits around the estimate have been obtained. Secondly no account was taken of the short-term changes in numbers in response to the fluctuating food supply: Taylor *et al.* (1988) found a two-fold variation in the population during the course of a single three-year vole cycle. The BTO project has also shown there to be large short-term variation in both breeding productivity and survival rates (chapters 2 and 3). Any population trends detected will be unreliable unless they are based on several points through several vole cycles.

Future work on monitoring Barn Owl numbers is discussed further in chapter 7. There seems to be no alternative to the continued promotion of the intensive defined study area approach, linking in with monitoring of breeding performance and survival. The work described in this chapter has shown that it was possible to obtain some data on Barn Owl numbers. Further work must impress upon observers the value of extending the approach to as many areas as possible.

CHAPTER 6: TAWNY OWL SURVEY

SUMMARY

A national survey of the Tawny Owl was carried out in autumn 1989. The point count technique used allowed data to be collected quickly over a wide geographic area. An index of Tawny Owl abundance was obtained for each of the 122 10km squares covered (40% of the sample Key Squares used in the New Breeding Atlas), providing a baseline for future monitoring. Little regional variation in density was found. Habitat had a much more important influence on owl numbers: more birds were found in woodland and in farmland with woodland adjacent.

AIMS

No specific national survey of the Tawny Owl has ever been carried out in Britain. Some data on distribution exist from the BTO's Breeding Bird (Sharrock 1976) and Winter Atlases (Lack 198) but these did not use methods designed to collect quantitative information about owls. Collating data on breeding performance and survival can yield some information about population trends but for a complete picture and a thorough monitoring scheme it is necessary to have data on population numbers as well. A national Tawny Owl survey was therefore included in the BTO Owls Project. The aims of the survey were:

1) To obtain data on population numbers of Tawny Owls to provide a baseline for future monitoring.

2) To provide information about owl population densities to compare different areas and habitats.

METHODS

The owl survey working group, mentioned in the previous chapter, met in September 1988 to consider the most appropriate method for carrying out a national Tawny Owl survey. Two possible approaches were discussed; points counts and territory mapping. The former was chosen as the group felt that it would enable a wide coverage to be obtained across the country. Territory mapping, a much-used technique for detailed owl studies (for example Southern 1970, Hirons 1985) would probably have given a more accurate measure of the population within a small area but would have been too labour-intensive to be used on a national basis. Point counts have been used successfully for measuring the abundance of many owl species (reviewed by Smith & Carpenter 1987).

The working group decided that an autumn survey would give the most reliable and repeatable population index. The birds' autumn territory establishment and defence was thought to be more predictable and less liable to short-term fluctuation than the spring courtship behaviour. A survey held during the spring could miss birds which had already opted out from breeding in that year, as is known to occur on a large scale in the Tawny Owl (Southern 1970).

Pilot fieldwork was carried out in the counties of Hertfordshire and Buckinghamshire and sought to provide data to help answer the following questions:

a) What is the seasonal pattern of Tawny Owl vocal activity? What would be the best time of year to carry out the survey?

b) If a point count technique was thought to be the best approach, how long should such point counts be made for and at what time of day?

Point counts of up to 20 minute duration were made regularly at the centres of tetrads (2x2km square) in two 10x10km squares. Visits were made during the hours of darkness throughout the year, concentrating particularly in autumn and early spring when vocal activity was thought to be at its peak (Hansen 1952, Southern 1970). The total numbers of owls heard hooting and calling in each period were recorded with the times at which they were heard and the habitat (using the New Bird Breeding Atlas coding system).

The results of the pilot work supported the decision to carry out an autumn survey: a larger proportion of the owls were recorded during September and October than in February and March. The choice of an autumn survey had the additional benefits of (i) giving a longer window for the fieldwork to be carried out (mid-August to mid-October) and (ii) it did not clash with much other fieldwork that observers would be carrying out at that time, particularly for the New Bird Breeding Atlas.

The areas chosen for the point counts were those used for the New Breeding Birds Atlas Key Squares Survey. This gave a random sample of one in nine of all 10km squares in the country. It was decided that at least 15 of the 25 tetrads should be covered for the survey to give a reliable estimate of owl density, again following the guidelines of the Atlas. Habitat was recorded in the same way as the Atlas to maintain conformity and avoid confusing observers with different recording schemes. The details of the final methods chosen are given in the appendix at the end of this chapter, which shows an example survey form and the instructions sent out to the observers.

RESULTS

Pilot fieldwork

The pilot fieldwork for the Tawny Owl survey sought to answer two questions. The first was to find out the proportions of owls that were recorded in different months. The results are given in Fig. 6.1, which shows that autumn was the peak time for vocal activity. A peak was also recorded in the spring but this was not as high as that in autumn.

The results of the pilot work to find out the best duration for the point counts are summarized as a cumulative frequency diagram in Fig. 6.2. The plateau from 8-10 minutes after the start of the count at 80% of the total recorded indicated that the large majority of the birds had been recorded by that time: the additional records in the 10-20 minute period could well have been double-recordings of birds heard previously. Thus 10 minutes seemed to be an appropriate time for each point count.

National 1989 Tawny Owl Survey

A total of 122 10km squares were counted adequately nationwide comprising 2,521 10-minute point counts. This gave a coverage of just over 40% of the key squares in

Britain. Fig. 6.3 shows the frequency index for each of the squares covered and summarizes the regional coverage of the survey. The frequency index, calculated as the proportion of tetrads in a 10km square in which Tawny Owls were recorded, showed a high degree of similarity to one of abundance which was calculated as the mean count of the number of pairs recorded per tetrad ($r=0.941$, $P<0.001$, $n=122$), showing that it had a strong relationship to the actual number of birds recorded.

The regional and habitat trends in abundance were investigated using analysis of variance of the point count data from each tetrad (with the number of pairs log-transformed as the distribution of the data was skewed). The habitat codes recorded for each tetrad were summarized into six classes based on the primary and secondary codes (each of these six is given in Table 6.1, see chapter appendix for details of the coding scheme) and the Met. Office regions were used to compare geographical variation. The results of these analyses are shown in Table 6.1 and Fig. 6.4. The two-way analysis of variance showed there to be highly significant effects of both region ($F=2.88$, $P=0.003$, 8 df) and habitat ($F=33.3$, $P<0.001$, 5 df), with the latter clearly of greater importance. Further analysis using a Student-Neuman-Keuls test to examine the differences between each of the habitats showed most of them to differ significantly. The only groups not found to differ were (a) the low density moorland-farmland-urban classes and (b) the high density woodland-farmland with woodland. The same test on the regional analysis showed the only significant regional difference to be between SW England/S Wales and the Midlands-NW England/N Wales, the latter holding lower numbers of owls.

Table 6.1: Habitat trends in Tawny Owl abundance

Habitat	Geometric mean no. pairs/tetrad	Upper 95% c.l.	Lower 95% c.l.
1. Woodland	0.489	0.397	0.587
2. Woodland with farmland adjacent	0.735	0.574	0.912
3. Open moorland	0.191	0.140	0.243
4. Farmland	0.251	0.225	0.261
5. Farmland with woodland adjacent	0.449	0.393	0.508
6. Urban	0.151	0.102	0.201

DISCUSSION

Tawny owl population index: a baseline for future monitoring

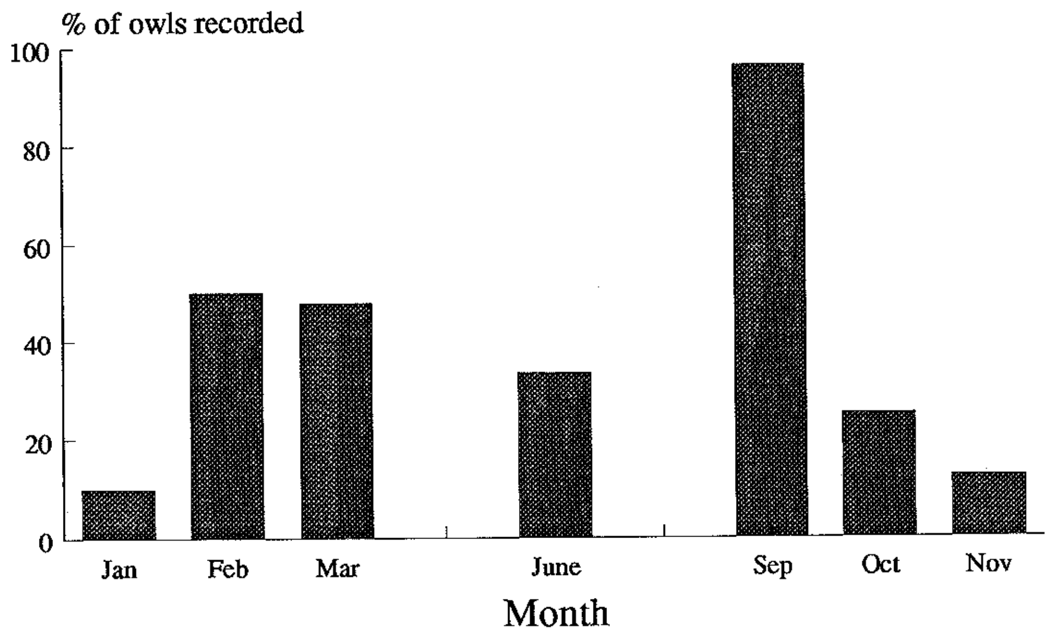
The methods of the 1989 Tawny Owl survey seemed to work well to produce a baseline index of abundance. It is important to consider that the survey was only carried out in a single year and that it is essential that some repeat coverage is obtained in the following few years over at least one vole cycle to see the effect of fluctuations in the food supply on the results. 1989 was generally a low year for Tawny Owl productivity, with almost complete non-breeding in some areas (S. Petty pers. comm.) and low breeding success in others (own observation). It might be expected in such a year that there would be less territorial behaviour than usual and hence reduced vocal activity, as fewer first-year birds would be attempting to establish themselves in the population. Low numbers were indeed recorded in many areas and several observers commented that the survey detected many fewer birds than were known to be present. The potential between-year variation in the index obtained from the survey needs further investigation.

Regional and habitat trends in the Tawny Owl abundance index

Both the frequency and abundance indices derived from the survey data showed variation between 10km squares. Habitat was found to be particularly important in affecting Tawny Owl densities recorded, with higher indices found in woodland compared to farmland, open moorland and urban habitats. Some regional differences were also detected with fewer birds found in SW England compared with the Midlands and NW England.

In conclusion to this chapter the Tawny Owl survey, unlike that of the Barn Owl was successful in obtaining indices of abundance which can be repeated in future years to monitor owl numbers. The point count method allowed many samples to be obtained across a large part of the country. Future repeat Tawny Owl surveys are discussed further in chapter 8.

Fig. 6.1 Seasonal pattern of Tawny Owl vocal activity



% recorded calculated as % of maximum heard at each site

Fig. 6.2 Cumulative frequency of propor -tion of owls heard at each point count

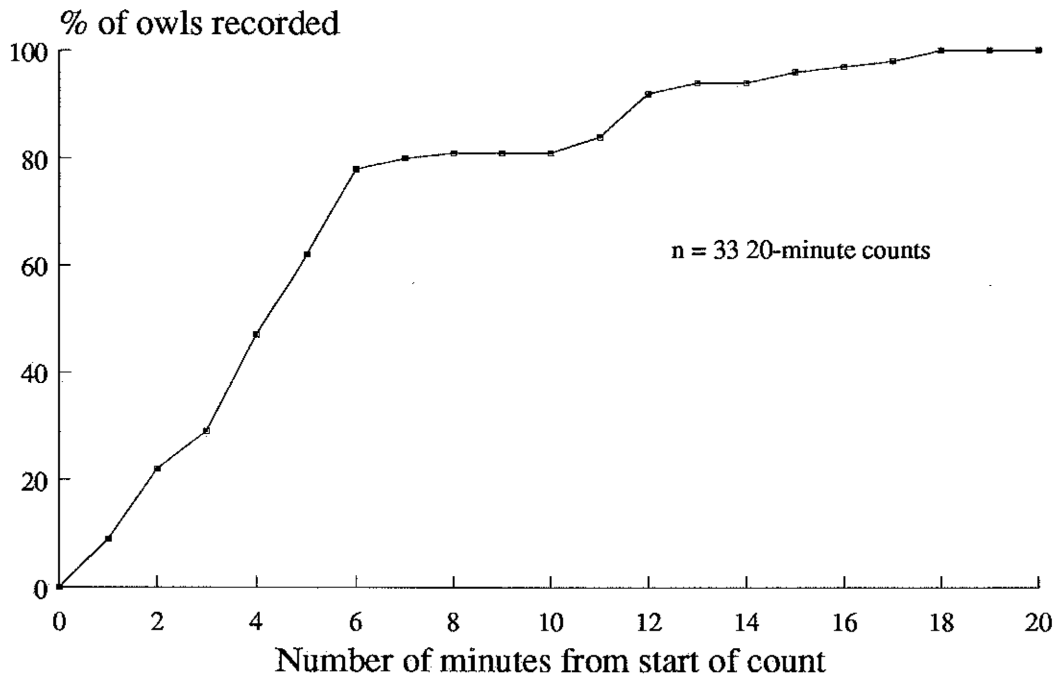


Fig. 6.3 Frequency indices for each of the 10km squares covered during the Tawny Owl Survey.

Key

Open circles = uncovered Key Squares
Large dot = frequency index of >40%
Medium dot = " " " 20-40%
Small dot = " " " < 20%

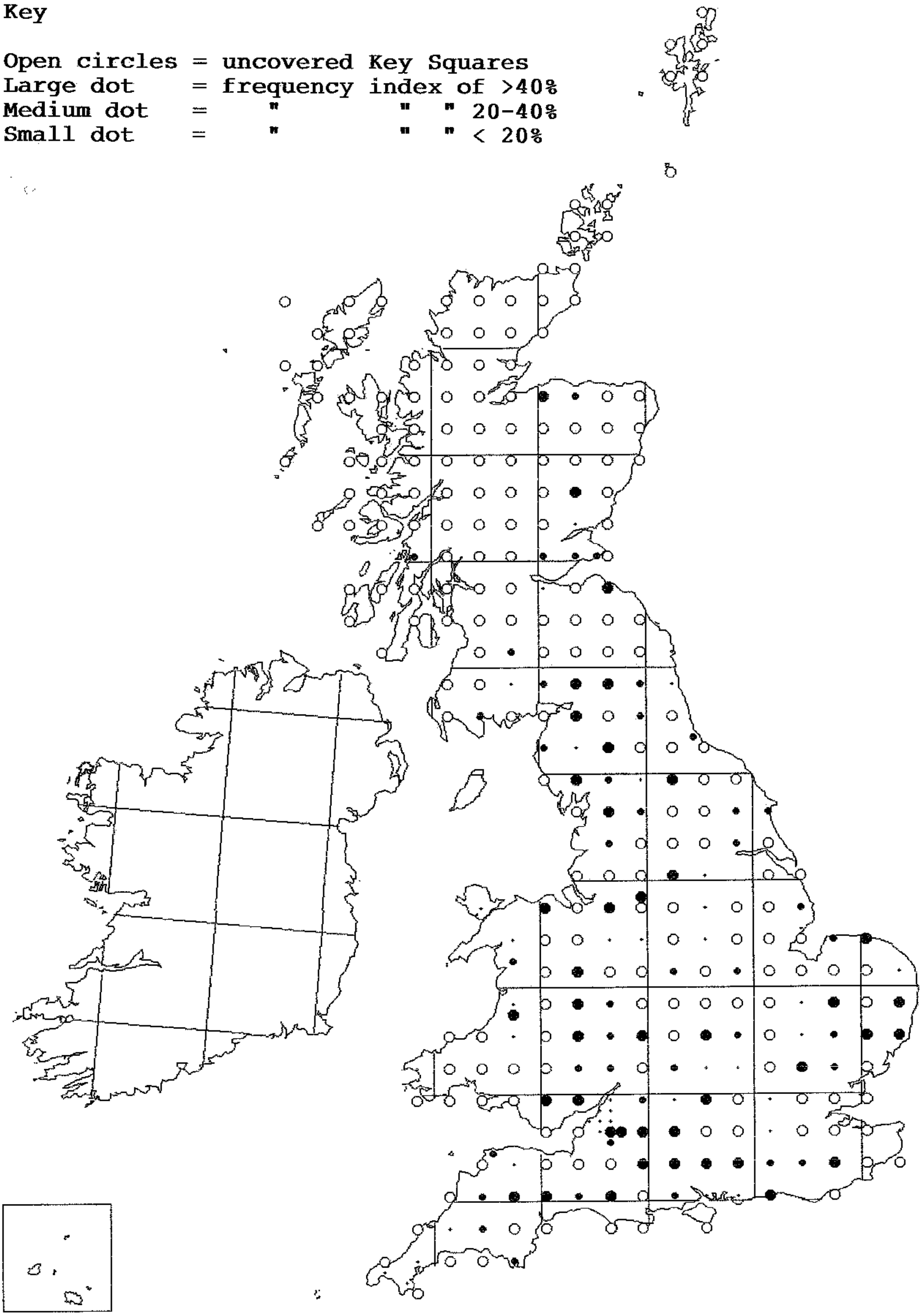
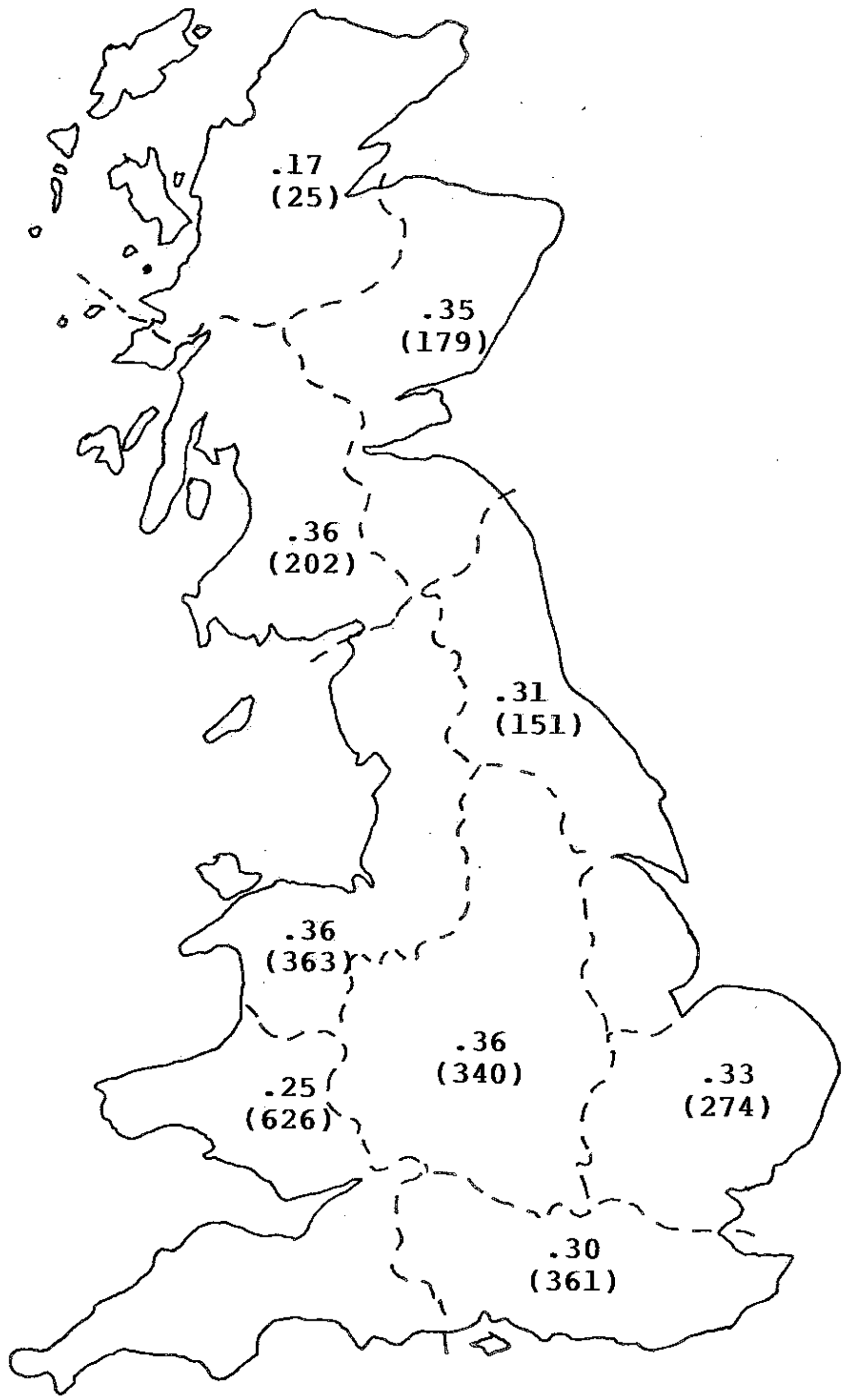


Fig. 6.4 Regional variation in Tawny Owl abundance

Values are geometric mean count per tetrad in each region, with the total number of counts in brackets.



CHAPTER 7: OWL POPULATION DYNAMICS - WHAT FACTORS AFFECT OWL POPULATIONS?

SUMMARY

Key factor analysis was used to investigate which of stages in life cycle were most important in determining Barn and Tawny Owl population levels. In both species in all regions of the country post-fledging survival most important. Therefore one would expect factors affecting this parameter to have had most effect on population. Adult mortality was important in some areas in some years for the Barn Owl, and egg survival likewise for the Tawny.

The overall conclusion drawn from the observed trends in breeding performance and survival was that the decreasing losses, notably in the south, suggest that the population was increasing over the period 1976-87 and was certainly faring better in the mid 1980s than in the 1970s. The reasons behind this apparent population increase are several. Amelioration of weather conditions may have been a contributory factor, as may reduced levels of pesticide residues, particularly the breakdown products of dieldrin and its related compounds. Unfortunately the information available on land use was too coarse-grained to allow any conclusions about the role that changes in habitat may have played.

The decline in first-year survival rate in eastern England could be a cause for some concern, particularly as post-fledging survival was shown to be key factor in determining population levels. It was not possible to offer any explanation for this decline from the data available: this is clearly an area in need of further study.

AIMS

The aim of this chapter is to bring together the results of the various parts of the project to take an integrated look at owl population trends and the factors affecting them, and to identify the stages of the life cycle which are most important in determining population levels.

METHODS

The relative importance of each stage of the life cycle was investigated by carrying out a key factor analysis of the breeding performance and survival data (Varley and Gradwell 1960). There are sufficient data to be able to carry out such an analysis on a regional basis for the last 12 years. The analysis plots out the relative contribution that each stage makes (known as its killing power, k) to total K, the overall reduction in the population from its possible maximum (that is with 100% survival of adults and full realization of potential breeding productivity through to recruitment into the breeding population).

The lack of adequate long-term data on owl abundance makes it difficult to look at density-dependence within these population processes. This would be very useful, for example, to see whether the populations are limited by their habitat or if they are being kept below their maximum level by other factors. Some information on the possible occurrence of density-dependence was sought by comparing annual adult and first-year survival rates in each of the three major regions. If the habitat were 'full' and density-dependence were in operation, then one might expect an inverse relationship between adult and first-year survival rates: first-years might only be able to recruit into the population when adult mortality is greater.

RESULTS

The results of the population key factor analyses are shown in Figs. 7.2 and 7.3. A separate analysis was carried out for each of the three major regions. The results have been plotted as graphs of the cumulative loss attributable to each killing factor, illustrating the relative contribution made by each factor to the overall losses.

The key factor affecting Barn Owl populations in all regions was found to be post-fledging mortality of juveniles. Indeed the whole pattern of the key factors was similar in all regions. Other factors made a much smaller contribution to the total loss and did not show such variation between years. Adult mortality did make a large contribution to losses in some years, particularly in the late 1970s in the two southern regions, and some of the breeding losses were high in some years, but overall their contribution was dominated by post-fledging mortality.

The patterns in the Tawny Owl key factor analyses were very similar. Post-fledging juvenile mortality was the prime factor affecting total losses. Adult mortality was generally lower than that of the Barn Owl and less annual variation in breeding losses was apparent. An important point to consider, for the Tawny Owl in particular, is that the non-breeding of adults has not been included in these key factor analyses as no information is available from the BTO databases. This factor has been shown to be of considerable importance in this species (Southern 1970).

The correlation coefficients between each factor and the total loss are given in Table 7.1, to further illustrate the relative importance of each of these factors. A higher correlation coefficient indicates that a factor made a greater contribution to the overall losses. No confidence limits or probability values are given as they would not be statistically valid: as each factor is a component of the total loss they are not independent. It again emphasizes the importance of post-fledging mortality in both species in all regions.

Table 7.1: Correlations between each killing factor and total losses

K-FACTOR	National	Scot/N Eng	SE Eng	SW Eng/Wal
Barn Owl				
Clutch	-0.067	0.037	-0.207	0.024
Egg	0.330	0.453	0.206	0.146
Early chick	-0.059	-0.005	-0.011	-0.282
Late chick	0.048	-0.286	0.483	-0.335
Post-fledge	0.838	0.939	0.854	0.826
Adult	0.382	0.941	-0.207	0.392
Tawny Owl				
Clutch	0.302	0.105	0.264	0.278
Egg	0.175	-0.462	0.688	-0.205
Early chick	0.069	-0.143	0.361	-0.035
Late chick	-0.103	0.111	0.028	0.156
Post-fledge	0.981	0.989	0.978	0.961
Adult	-0.239	-0.054	-0.353	0.381

Table 7.2 compares the survival rates of adult and first-year owls. The regional differences in Barn Owl population processes are apparent again: in Scotland/N England there was a high positive correlation between adult and first-year survival whilst in SE England the correlation was in the opposite direction and no relationship was found in SW England/Wales. The Tawny Owl showed no significant correlations between adult and first-year survival rates.

Table 7.2: Correlations between adult and first-year survival rates in the three major regions of the country

	Barn	**Tawny**
Scotland/N Eng	0.803 **	0.048
SE England	-0.747 **	-0.358
SW Eng/Wales	-0.010	0.519

n=12 for all cases, ** = $p<0.01$.

DISCUSSION

The key factor analyses identified post-fledging mortality as the key factor affecting populations of both species in all three regions. In seeking to explain the population changes, this factor should therefore be addressed first. Population studies of several other birds of prey have found a similar result (for example Newton 1988). Other factors were important in some regions in some years. In Scotland/N England adult mortality was highly correlated with total losses though this could have resulted from auto-correlation with first-year mortality. Egg loss in the Tawny Owl in SE Britain was also identified as an important factor.

As post-fledging mortality was the most important factor overall, one would expect environmental variables affecting this stage to have the greatest influence on the population levels. Referring back to chapter 3, it can be seen that Barn Owl post-fledging mortality was related to weather conditions, being significantly increased by winter frost and summer rainfall. Tawny Owl post-fledging mortality was only weakly affected by any of the environmental variables: it was slightly increased in colder autumns.

The post-fledging mortality of both species was also correlated with various of the agricultural land use statistics. Colvin (1985) found a relationship between the intensification of agriculture and the decline of the Barn Owl in Ohio, USA, (using similar land use statistics as those in this report) and concluded that this could have been the reason behind the observed trend in Barn Owl numbers. With the British population generally increasing its breeding success and survival rates whilst agriculture continues to intensify, such a conclusion is less tenable even though a strong (but probably spurious) correlation does exist. The main finding of the BTO study in relation to land use was that these agricultural statistics did not provide a sufficiently detailed measure of the habitat available to owls and therefore could not adequately explain the population trends.

If weather only explained a small proportion of the variation in breeding performance and survival, and the agricultural land use data were too coarse-grained, what can be concluded from this study about the factors affecting owl populations? Almost all the measures of breeding performance and survival strongly suggest that owl populations have increased over the period of 1976 to 1988, so one ought to look first at which factors might have made the owls' environment more favourable. There has been some amelioration of the weather but this study has shown that it is unlikely that this could have been the main driving force behind the increase. Habitat change such as management of farmland and forestry in ways which provide owls with more favourable feeding and nesting areas is another possible contributory factor.

The increasing trends in owl survival rates were generally coincident with decreasing dieldrin and aldrin residues in several raptor species (Newton 1986). These pesticides have been shown to have had a major effect on some raptor species on a population level causing widespread mortality (.i.Newton 1986;, .i.Opdam, Burgers & Muskens 1987;). It is possible that they may have had an impact on British Barn Owls and perhaps Tawny Owls too.

Though most of the owl population statistics were increasing through 1976 to 1988, the survival rate of first-year Barn Owls in south-east England declined through this period. Though adult survival in that region was increasing in the same period, this could lead to a reduction in the population through reduced recruitment. Several hypotheses might explain this reduced survival of first-years. It is unlikely that the use of second generation rodenticides could be the main factor influencing this trend. If owls in this area were exposed to higher levels of these compounds than in other parts of the country one might expect adults to show a similar declining trend to first-years. It could still be possible that first-year birds could be more susceptible to rodenticides or that they were feeding in a situation in which they were more likely to be poisoned. A more likely explanation is that the habitat available to the owls was becoming filled up as adult survival increased and there were progressively fewer opportunities for the first-years to become established in the population. Shortages of, for example, feeding areas or roost sites for first-years could have lead to the increase in their mortality.

The current data are not sufficient to assess the impact of rodenticides on owl populations. It seems unlikely that they are a primary factor affecting owl populations at a gross level but they could still be having some impact. Newton's (1990) study of rodenticide residues in owl corpses has shown that contamination is widespread (10% of corpses examined showed traces of these compounds) and there is the potential for damage to the population. There is an urgent need for more detailed data on pesticide usage and in particular that of second generation rodenticides to be collected on a regional basis before any impact on owls at the population level can be properly assessed.

Fig. 7.1 Key Factor Analysis Explained: stages of the life cycle of each k-factor

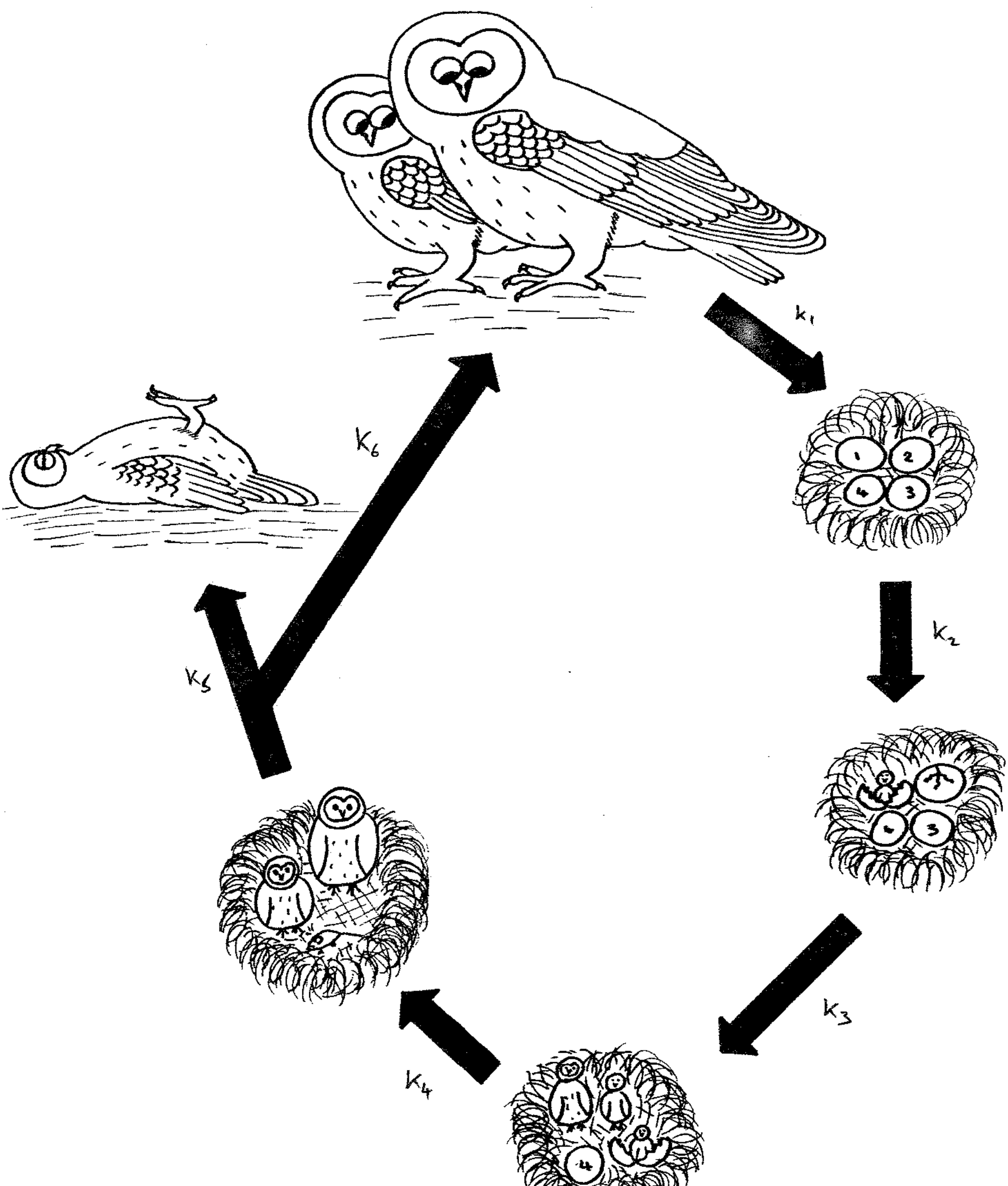
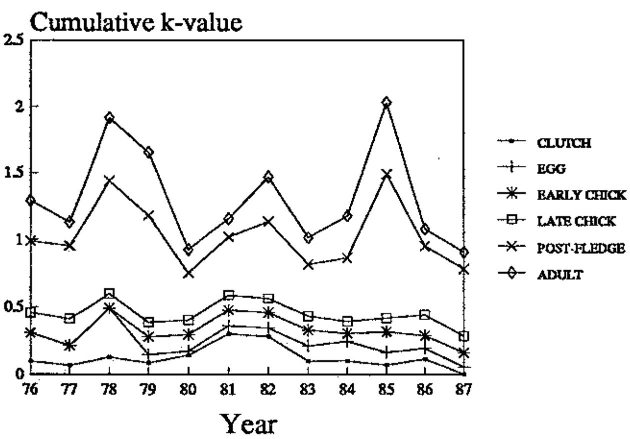
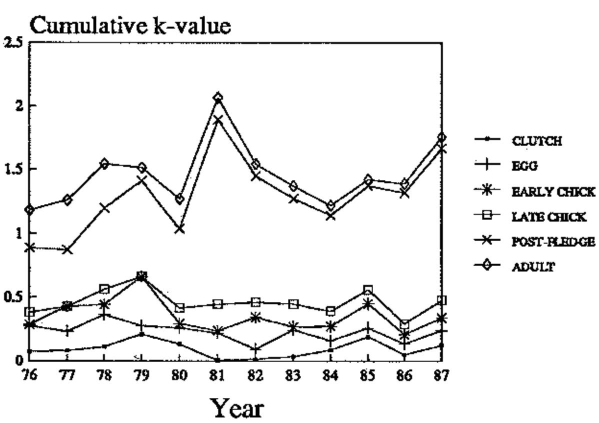


Fig. 7.2 Barn Owl key factor analyses

1. Scotland/N England



2. SE England



3. SW England/Wales

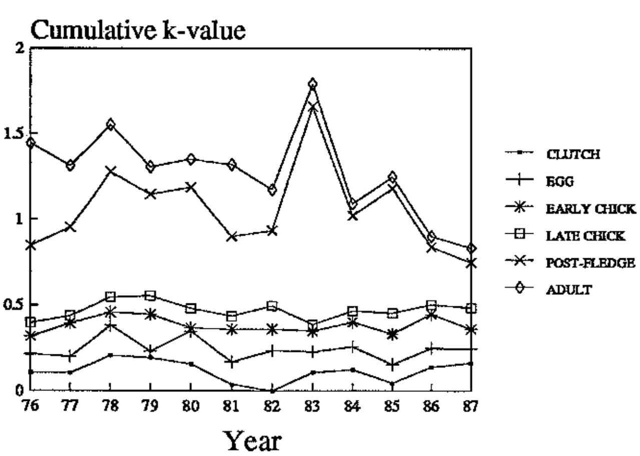
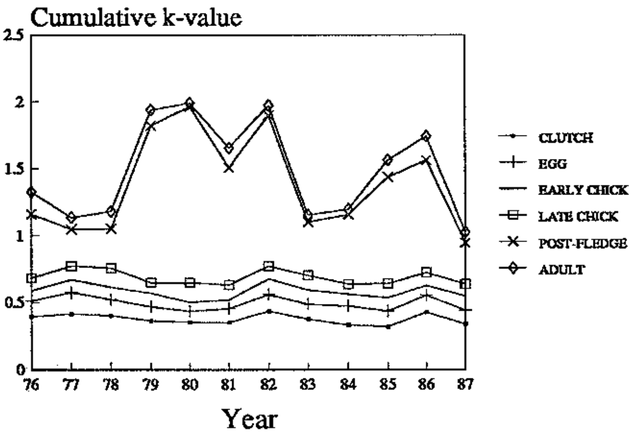
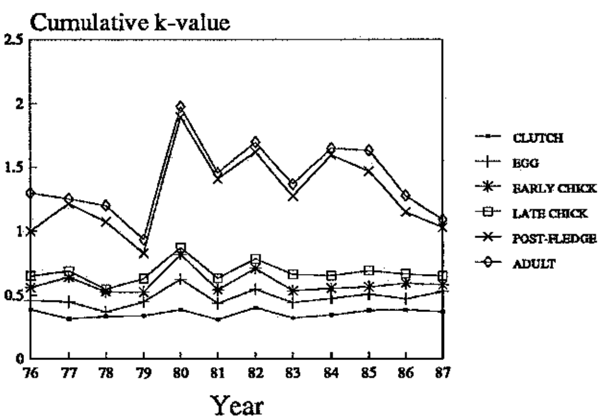


Fig. 7.3 Tawny Owl key factor analyses

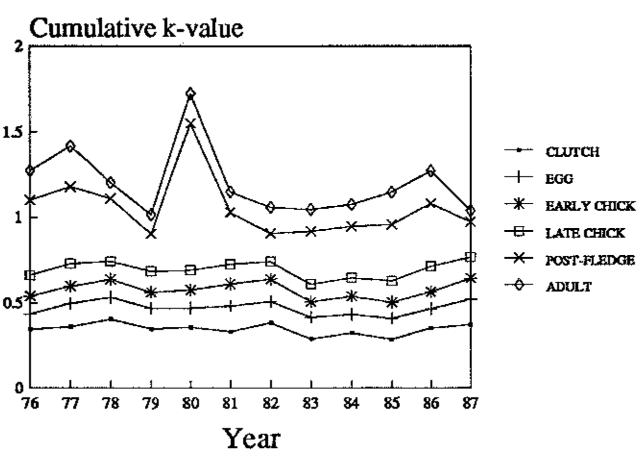
1. Scotland/N England



2. SE England



3. SW England/Wales



CHAPTER 8: FUTURE MONITORING OF OWL POPULATIONS

SUMMARY

This study has further demonstrated the value of detailed analyses of the BTO's long-term databases, bringing together information on the different aspects of population dynamics. It has also identified gaps in knowledge of owl populations and some improvements to data collection have been suggested. A summary of recommendations for how monitoring of owls might be carried out in the future is given below:

1. Continued detailed monitoring of breeding performance and survival by nest visiting and ringing.

2. More ringing of adult owls to improve survival rate estimates and obtain data on multiple brooding.

3. Integration of wide-ranging monitoring with detailed studies to fill in gaps in knowledge.

4. Regular repeat of Tawny Owl survey in autumn on an annual basis in at least some areas and perhaps in spring too. Initially these need to be carried out on an annual basis to look at the short-term variation in the owl indices in relation to their food supply but less frequently thereafter.

5. Encouragement of a defined study area approach to integrate information on population levels with that on breeding performance and survival for both species.

6. More co-operation between owl studies and those on small mammal populations to provide information on food supply.

7. Annual and regional monitoring of rodenticide usage.

8. Further work to investigate methods for monitoring Barn Owl numbers. This could link in with plans to run a National Raptor Monitoring Scheme at the BTO.

9. More research to investigate the decline in first-year Barn Owl survival in south-east England.

INTRODUCTION

This report has shown that useful information on owl populations can be extracted from the long-term databases held at the BTO. Adequate data were available to carry out detailed population analyses for both the Barn and the Tawny Owl on a temporal and a spatial basis. Regional differences in the population processes for both species showed that it was essential to take these into account in all analyses.

However the project has also identified some major gaps in our knowledge of owl populations, which need to be filled if future monitoring is to be effective to its maximum. In this last chapter these shortcomings are addressed and some suggestions made as to how they may be overcome to form an effective integrated monitoring programme for British owls in the future. Each of the main databases are dealt with in turn.

BREEDING PERFORMANCE

The extended nest recording methods introduced for this project aimed to improve the standard BTO nest recording scheme for owls. Details of these improvements were given in that section. It is important that the encouragement of this detailed nest recording should continue, in particular the taking of measurements of nest contents at each visit and the planning of regular visits through the whole breeding cycle. Incorporation of the new standard BTO habitat recording system should further assist analysis.

A point which is relevant to all aspects of data collection, not only those on breeding performance, is the selection of study sites. It is obviously important for a monitoring scheme that a representative sample of the whole population is obtained, including both core areas of a population and ephemeral sites. It is all too easy for observers to concentrate on a few well-known and reliable sites which hold breeding birds year after year. There is a commonly held view that this would yield adequate data to provide an index of annual change but the approach is fundamentally flawed. Population changes in a core area within a population (where these observations would be made) could well be buffered by those in surrounding peripheral areas thus masking the annual variation in the whole population. The high value of attempting to sample birds within a defined area representative of both high and lower quality habitat should be encouraged strongly.

SURVIVAL

The present increasing trend in the numbers of owl ringed should be continued and the ringing of adult owls particularly encouraged. Provided observers wait until birds have chicks before attempting to catch adults there should be no problem with disturbance with either the Barn or the Tawny Owl (Taylor in press, Southern 1970). With more adults ringed the precision of the survival estimates can be increased and hence also the sensitivity of detection of any future trends.

Integration of the ringing database with the nest recording scheme could have several benefits. If ring numbers were computerised on nest records, then individuals could be followed through their time in the nest as well as post-fledging. At present many ringers record numbers on the cards but they are not put on computer file except in a general text field, which is highly inefficient for extraction for analysis. This linking of the two databases by ring number would also allow the habitat information on the nest record to be accessed for the survival analysis: data on where the bird originated could be very useful in understanding survival patterns.

ABUNDANCE

Tawny Owl

The method used for the Tawny Owl survey in 1989 seemed to work well to produce an autumn index of abundance, even in a year when productivity was generally low and hence numbers of new recruits into the population also low. It is important that this should be continued on a regular, if possible annual, basis. Perhaps the best way forward would be to have a sub-set of 10km squares which are surveyed on an annual basis and a wider survey at a longer interval. Carrying out such surveys in areas where breeding birds are being monitored could be very useful. It may also be worthwhile to look at the possibility of carrying out a similar survey during the spring in these detailed study areas to give an indication of the proportion of birds which are attempting to breed, information which at present is not collected at all (see below).

Barn Owl

Obtaining accurate and reliable data on Barn Owl abundance has proved to be very difficult. The time needed to be spent in the field intensively searching for nests made the methods suggested in this project unfeasible for many owl enthusiasts. Yet it has been agreed by several owl experts that there is no alternative if the required data are to be obtained.

The only solution would seem to be continue to encourage as many observers as possible to cover a defined area during their owl studies and try to obtain as accurate an estimate as possible of the numbers of breeding pairs in that area each year. This 'study area' approach links in with the point that was made earlier about representative sampling: by working in a defined area both these objectives can be achieved simultaneously. I would suggest that the only way forward is to make such study area recording as flexible as possible to allow observers to fit it into their own working regime whilst obtaining the necessary data.

Broad-scale Barn Owl surveys such as that carried out by the Hawk Trust (Shawyer 1987) may be useful in providing some information about the distribution of the birds and a rough indication as to their abundance but they are not suitable for studying population trends. Continued promotion of wide-scale surveys of Barn Owls by unskilled observers cannot make any contribution to their monitoring and conservation. Indeed this could be seen as a misdirection of effort and funding from proper scientifically valid population monitoring.

POPULATION MODELLING AND INVESTIGATION OF ENVIRONMENTAL FACTORS

At present there are several important aspects of the owls' life cycle on which no data are available. In particular when carrying out population analyses, two missing statistics are (1) the proportion of the population that attempts to breed and (2) the number of breeding attempts made by each pair each year. It has not been possible to take account of either of these in the analyses presented in this report.

The proportion of birds breeding is of particular importance in the Tawny Owl as in some years many birds opt out from breeding (Southern 1970). It may be possible to get some measure of this either (a) by carrying out a spring Tawny Owl survey in some areas in combination with an autumn one or (b) by asking observers to record empty sites as well as occupied ones to obtain an occupancy rate for each year, perhaps by a combination of the two. The latter technique has been used with some success to calculate site occupancy rates for owls in the Finnish raptor monitoring scheme (Haapala and Saurola 1989). The best solution might be to link in with current detailed studies of Tawny Owls to obtain these data directly. A few such detailed schemes may be adequate to provide the necessary information.

The numbers of breeding attempts per season is more relevant to the Barn Owl, as multiple broods in the species have been recorded in several studies (for example, Baudvin 1976). On the northern fringe of their range in Britain more than one attempt per season is probably rare (I. Taylor pers. comm.), but ought to be considered as a possibility especially in years of high vole abundance. The only way to achieve this is to catch and ring breeding adults so that individuals can be followed through the breeding season.

It is not just by improving the data collected on owls that can increase our understanding of owl populations. Better environmental data could yield better explanations of the factors affecting the observed trends. The high correlations found between Tawny Owl breeding success and the Mammal Society data on woodland small mammal abundance emphasized the importance of food supply data as found in many owl studies (for example, Korpimaki 1984, Petty 1987, Taylor 1989). There is an open opportunity for more widespread collaboration between small mammal- and owl- workers.

BIBLIOGRAPHY

Baudvin, H. (1976). La reproduction de la chouette effraie (*Tyto alba*) en Cote-d'Or en 1975. *Le Jean le Blanc* 15:9-13.

Blaker, G.B. (1934). The Barn Owl in England and Wales. RSPB, London

Braaksma, S. and Bruijn, O.D.E. (1976). New data on Barn Owls in the Netherlands. *Limosa.* 49:135-187.

Brownie, C., Anderson, D.R., Burnham, K.P. and Robson, D.S. (1978). Statistical inference from bird banding recovery data - a handbook. *U.S. Fish and Wildlife Service Resource Publication. 131.* Washington, D.C. 212pp.

Bunn, D.S., Warburton, A.B. and Wilson, R.D.S. (1982). The Barn Owl. Poyser Carlton.

Colvin, B.A. (1984). Barn Owl foraging behaviour and secondary poisoning hazard from rodenticide use on farms. *Ph.D Thesis, Bowling Green State University.*

Colvin, B.A. (1985). Common Barn Owl population decline in Ohio and the relationship to agricultural trends. *Journal of Field Ornithology.* 56:224-235.

Cramp, S. (1985). Birds of Europe, the Middle East and North Africa. Volume IV. Oxford University Press, Oxford.

Delmee, E., Dachy, P. and Simon, P. (1978). Quinze annes d'observations sur la reproduction d'une population forestiere de Chouettes hulottes. *Gerfaut* 68:590-650.

Duckett, J.E. (1984). Barn Owls and the 'second generation' rat-baits utilised in oil palm plantations in Peninsular Malaysia. *Planter, Kuala Lumpar.* 60:3-11.

Elton, C. (1942). Voles, mice and lemmings: problems in population dynamics. Oxford University Press, London. 496 pp.

Frylestam, B. (1972). Movements and ringing of Barn Owls in Sweden. *Ornis Scandanavica.* 3:45-54.

Galbraith, H. (1987). Marking and visiting Lapwing nests does not affect clutch survival. *Bird Study.* 34:137-138.

Glue, D.E. (1971). Ringing recovery circumstance of small birds of prey. *Bird Study.* 18:137-146.

Glue, D.E. (1973). Seasonal mortality in four small birds of prey. *Ornis Scandanavica.* 4:97-102.

Glue, D.E. (1974). Food of the Barn Owl in Britain and Ireland. *Bird Study.* 21:200-210.

Glutz and Bauer (1980). Hanbuch der Vogel Middeleuropas. Volume 9. Akademische Verlagsgesellschaft, Wiesbaden.

Haapala, J. and Saurola, P. (1989). Breeding and population trends of common raptors and owls in Finland in 1988. *Lintumies* 24:27-36.

Haartman, L.G. von (1968). The evolution of resident versus migratory habits in birds. Some considerations. *Ornis Fennica* 45:1-7.

Haldane, J.B.S. (1958). The calculation of mortality rates from ringing data. *Proc. Int. Orn Congress.* 11:454-458.

Hansen, L. (1952). The diurnal and annual rhythm of the Tawny Owl. *Dansk Orn. Foren. Tiddskr.* 46:158-172.

Hardy, A.R. (1977). Hunting ranges and feeding ecology of owls in farmland. *Ph.D thesis, University of Aberdeen.*

Hegdal, P.L. and Blaskiewicz, R.W. (1984). Evaluation of the potential hazard to Barn Owls of Talon (brodifacoum) rodenticide. *Environmental Toxicology and Chemistry.* 3:167-179.

Hirons, G.J.M. (1985). The importance of body reserves for successful reproduction in the Tawny Owl. *Journal of Zoology (B).* 1:1-20.

Honer, M.R. (1963). Observations on the Barn Owl in the Netherlands in relation to its ecology and population fluctuations. *Ardea.* 51:158-195.

Illner, H. (1990). Road deaths of Westphalian owls: methodological problems, influence of road type and estimate of effect on population. In *Ecology and Conservation of European Owls symposium*, September 1989, Edinburgh, in press.

Korpimaki, E. (1984). Population dynamics of birds of prey in relation to fluctuations in small mammal populations in western Finland. *Ann. Zool. Fennici.* 21:287-293.

Korpimaki, E. (1986). Gradients in population fluctuations of Tengmalm's Owls in Europe. *Oecologia.* 69:195-201.

Korpimaki, E. (1987). Breeding performance of Tengmalm's Owl: effects of supplementary feeding in a peak vole year. *Ibis.* 131:51-56.

Lack, P.C. (1985). The atlas of wintering birds in Britain and Ireland. Poyser, Berkhamsted.

Linkola.P. and Myllymaki, P. (1967). Der Einfluss der Kleinsaugerfluktuationen auf das Bruten einiger kleinsaugerfressender Vogel im sudlichen Hame, Mittelfinnland 1952-66. *Ornis Fennica* 46:45-78.

Madge, G. and Tyson, K. (1987). Decline of the Barn Owl in relation to mid-Devon weather records. *Devon Birds.* 40:84-87.

Mallorie, H. and Flowerdew, J.R. (1988). Mammal Society National Small Mammal survey. Poster display at Mammal Society Easter Conference, Ripon.

Marchant, J., Hudson, R.W., Carter, S. and Whittington, P.A. (1990). Population trends in British breeding birds. BTO, Tring.

Mayfield, H. (1961). Nesting success calculated from exposure. *Wilson Bulletin.* 73:255-261.

Mayfield, H.F. (1975). Suggestions for calculating nest success. *Wilson Bulletin.* 87:456-66.

Mead, C.J., and Clarke, J.A. (1989). Report on bird ringing in 1988. *Ringing and Migration.* 10:158-196.

Newton, I. (1972). Birds of prey in Scotland: some conservation problems. *Scottish Birds.* 7:5-23.

Newton, I., Marquiss, M. and Moss, D. (1979). Habitat, female age, organochlorine compounds and breeding of European Sparrowhawks. *Journal of Applied Ecology.* 16:777-793.

Newton, I. (1986). The Sparrowhawk. Poyser, Carlton

Newton, I. (1988). A key factor analysis of a Sparrowhawk population. *Oecologia.* 76:588-596.

Newton, I., Wyllie, I. and Freestone, P. (1990). Rodenticides in British Barn Owls. *Environ. Pollut.*, in press.

Newton, I., Wyllie, I. and Asher, A. (in press). Mortality causes in British Barn Owls with a discussion of dieldrin poisoning.

Olsson, V. (1958). *Acta Vert.* 1:86-189.

Opdam, P., Burgers J. and Muskens, G. (1987). Population trends, reproduction and pesticides in Dutch Sparrowhawks following the ban on DDT. *Ardea* 75:205-212.

Pearce, G. and Woodland, H. (1988). Barn Owl release schemes - progress. Devon Birds. 41:76.

Petty, S.J. (1987). Breeding of Tawny Owls in relation to their food supply in an upland forest. *Proc. of the Breeding and Management of Birds of Prey Conference,* University of Bristol 1987.

Pianka, E.R. (1983). Evolutionary Ecology. Harper and Row, New York.

Ramsden, D. and Ramsden, F. (1989). Barn Owl re-introductions in SW England. *Devon Bird Report.*

Ratcliffe, D.A. (1980). The Peregrine Falcon. Poyser, Carlton.

Rinne, J., Lokki, H, and Saurola, P. (1987). Life table solutions: any or many? *Acta Ornithologica.* 23:61-67

Sauter, U. (1956). Barn Owl movements and survival in relation to weather and rodent abundance. *Vogelwarte.* 18:109-151.

Schonfeld, M. (1974). *Jber. Vogelwarte Hiddensee.* 4:90-122.

Sharrock, J.T.R. (1976). The atlas of breeding birds in Britain and Ireland. Poyser, Berkhamsted.

Shawyer, C.R. (1987). The Barn Owl in the British Isles; its past, present and future. The Hawk Trust, London.

Smith, D.G. and Carpenter, T. (1987). Owl census techniques; general census considerations. *Northern Forest Owls symposium.* Winnipeg, Manitoba, Feb 1987.

Southern, H.N., Vaughan, R. and Muri, R.C. (1954). The behaviour of young Tawny Owls after fledging. *Bird Study* 1:101-110.

Southern, H.N. (1970). The natural control of a population of a population of Tawny Owls. *Journal of Zoology, London.* 162:197-285.

Stewart, P.A. (1952). Dispersal, breeding behaviour and longevity of banded Barn Owls in North America. *Auk.* 69:227-245.

Taylor, I.R. (1989). The Barn Owl. Shire Natural History Series no. 42, Aylesbury.

Taylor, I.R. (1990). The effect of nest visits and radio-tagging on breeding performance and site fidelity of the Barn Owl. *Journal of Wildlife Management*, in press.

Taylor, I.R., Dowell, A., Irving, T., Langford, I.K. and G. Shaw. (1988). The distribution and abundance of the Barn Owl in south-west Scotland. *Scottish Birds.* 15:40-43.

Varley, G.C. and Gradwell, G.R. (1960). Key factors in population studies. *Journal of Animal Ecology.* 29:399-401.

Wendland, V. (1984). The influence of prey fluctuations on the breeding success of the Tawny Owl. *Ibis.* 126:284-295.

White, G.C. (1983). Numerical estimation of survival rates from band-recovery and biotelemetry data. *Journal of Wildlife Management.* 47:716-728.

Willis, E.D. (1973). Survival rates for visited and unvisited nests of Bi-coloured Antbirds. *Auk.* 90:263-267.

APPENDIX 1: POSSIBLE OBSERVER EFFECTS OF VISITING THE NESTS OF THE BARN AND THE TAWNY OWL

INTRODUCTION

Observers have been recording detailed nest histories of birds for many years. The BTO Nest Record Scheme was established in 1939 to co-ordinate and standardize such data collection and to use it to monitor breeding success on a national scale in Britain. It is clearly important that in visiting nests observers do not affect the breeding performance of the birds that they are recording. Relatively few attempts have been made to see whether such an effect could be important (for example Willis 1973, Galbraith 1987).

Intensive studies on owls have generally shown there to be little problem associated with nest visiting (for example, Taylor 1990, Baudvin 1976, Colvin 1984, Lenton 1985) though some have found potential problems at certain stages of the nesting cycle (for example Southern, 1970, found that Tawny Owls were prone to desertion if the adults were trapped early in the incubation period). This paper aims to investigate owl nest failure, both natural and observer-induced, and produce recommendations for future visiting of Barn and Tawny Owl nests to minimize the risk of disturbance.

Concern was expressed by the Hawk Trust at a meeting of the Nature Conservancy Council's Barn Owl liaison group that Barn Owls may be susceptible to disturbance by observers. As a first step to assess this potential problem a questionnaire was sent to owl workers in both the BTO and the Hawk Trust to find out their opinions on the matter. The BTO Nest Record data were then examined to test some of the ideas suggested by the results of this questionnaire, and a review was made of the literature to collate information available from other published studies.

METHODS

A questionnaire was sent out to 60 owl workers in 1988 requesting qualitative information about when observers thought that visiting nests could reduce the birds' breeding success. These 60 people comprised regular contributors of owl nest record or ringing data to the BTO or members of the Hawk Trust's Barn Owl Conservation Network. The questionnaire asked people to indicate whether they thought it likely that visiting a nest caused disturbance through the different stages of the breeding cycle for all the owl species for which they had experience. A follow-up questionnaire was sent out in 1989 to the 45 people who responded to the first, requesting quantitative information on the numbers and stage of nests which had failed both through disturbance and other causes, in relation to the total number of nests that the observer had visited. Both questionnaires have been included at the end of this appendix.

The BTO data were first analysed to see whether observers may have been reducing the number of chicks fledged from a nest. This could only be done for successful nests as it required a control sample of nests that were not visited during the stage of the nesting cycle being investigated. Complete nest failures could not be investigated in this way as they could not provide such a control: it is impossible to obtain data on total nest failures of unvisited nests. Thus this analysis gave a measure of observer effect on partial losses, testing whether observers may have reduced the number of chicks fledged from nests which raised at least one chick.

This analysis was carried out by comparing the number of chicks fledged from successful nests with different patterns of visits. Each nest in the NRC database was classified to a visit regime according to the timing of the visits that the observer made to the nest. Single-visit nest records and others for which an estimate of the number of chicks fledged could not be made were excluded. The categories were:

1) **Egg, early and late chick**: the nest was visited on at least one occasion in both chick stages and in the egg period.

2) **Egg and late chick**: visits were made only during the egg stage and again during the late chick period.

3) **Early and late chick**: visits were made to the nest throughout the chick stage, both before and after 14 days post-hatch, but not during the egg period.

4) **Late chick only**: the nest was visited only after at least 14 days from the date of the first hatch. This category was the control: the nest was only visited late in the nesting cycle when it is accepted that there is minimal risk of disturbance and thus was not visited during any of the potentially sensitive stages.

The number of chicks fledged from each nest was calculated using the methods discussed in the main breeding biology section (chapter 2). The breeding success of successful nests for each regime was then compared using an three-way analysis of variance of breeding success by visit regime, region and year group.

In addition the BTO data were used to investigate complete nest failures, to examine whether any potentially sensitive stages of the nesting cycle were apparent.

RESULTS

The percentage of people returning the first qualitative questionnaire who thought it safe to visit owl nests is given in Fig. A1.1, split according to the type of visit: 'brief' where observers simply recorded the nest contents and 'extended' where adults were trapped and nest contents measured in detail. There was a major split in opinion of the effect of observers up to the early chick stage in both species. Whilst between 50% and 80% thought it safe to visit nests, the remainder considered that visiting during these stages could cause desertion. Generally more people thought it unsafe to visit nests during the pre-laying and hatching stages, and that extended visits led to a higher risk of desertion than brief ones.

The second questionnaire sought to clear up some of the difference of opinion that had arisen from the first by asking for actual recorded examples of desertion rates which the observer thought attributable to his or her own activity. Despite the initial expression of concern about nest visiting by some people, few actually produced data to substantiate their views: only 12 of the 45 questionnaires were returned. The desertion rates recorded on these second questionnaires are summarized in Fig. A1.2: sample sizes of the total number of nests visited are given above each bar on the histogram. Two main 'high risk' periods were apparent; during the pre-laying stage in the Tawny Owl, and during hatching in the Barn Owl. Outside these two periods less than 5% of nests deserted and there was a general reduction in the rate as the season progressed.

The fledging success of nests of different visit regimes, calculated from the BTO Nest Record data, are given in Table A1.1, with summary means for each of the three major regions. No significant effect of the observers' visit pattern was found for either species: nests visited only in the late chick stage (the control 'undisturbed' nests) did not fledge significantly more chicks than those visited regularly throughout the breeding period.

Table A1.1: Fledging success of nests of different visit regimes.

Barn Owl

	Scotland/N Eng.	SE Eng.	SW Eng/Wales
Late chick only	3.54 (37)	3.74 (19)	2.87 (32)
Early and late chick	3.08 (13)	2.62 (9)	2.74 (30)
Egg and late chick	2.89 (28)	3.39 (7)	2.66 (16)
All periods	3.15 (52)	3.03 (30)	2.91 (64)

Three-way ANOVA of fledging success by nest visit regime, area and year group: F=1.83, P=0.140, 3 d.f. for nest visit regime).

Tawny Owl

	Scotland/N Eng.	SE Eng.	SW Eng/Wales
Late chick only	1.79 (27)	1.77 (45)	1.73 (82)
Early and late chick	2.02 (22)	1.65 (26)	1.69 (51)
Egg and late chick	1.84 (98)	1.57 (50)	1.71 (78)
All periods	1.85 (130)	1.65 (107)	1.80 (95)

Three-way ANOVA of fledging success by nest visit regime, area and year group: F=0.127, P=0.944, 3 d.f.).

Fig. A1.3 shows the frequency of complete nest failures in each 5-day period through the egg and chick stages for each species. On average about 5-6% of nests visited during the egg stage had failed by the time of the next visit. It should be noted that this includes **all** nest losses whatever their cause. There was some agreement in the timing of losses with the results of the questionnaire: losses were more frequent during the egg stage and those occurring during the fledgling period were concentrated within the first two weeks after hatching. The particular sensitivity of the pre-laying and hatching periods found in the questionnaire results was not apparent: losses appeared to be fairly uniform through the incubation period.

DISCUSSION

The first questionnaire illustrates the problems that can arise when people are asked for their opinions rather than for data to substantiate them. There is clearly a body of opinion that believes nest visiting can cause a reduction in owl breeding success, particularly when visits are extended to include trapping of adults and measurement of eggs and young. At the same time there is a strong view put by other observers that visiting owl nests has no effect on breeding success.

The second questionnaire aimed to quantify the evidence on which these opinions were formed. Unfortunately the return rate was low, so sample sizes are small. It is not known why there was such a reluctance to provide these data. Difficulty in extracting information may have been part of the problem but generally few examples of desertions were given, which was surprising in light of the concern expressed by some people in the first questionnaire. Two periods of higher desertion rate were identified: pre-laying in the Tawny Owl and hatching in the Barn Owl.

The BTO data showed that observers did not cause any significant partial nest losses. Nests that were visited only at the late chick stage did not fledge significantly more chicks than ones that had been visited throughout the breeding cycle. Therefore if observers were having any effect on owl breeding success it must be by causing complete desertion of the nest.

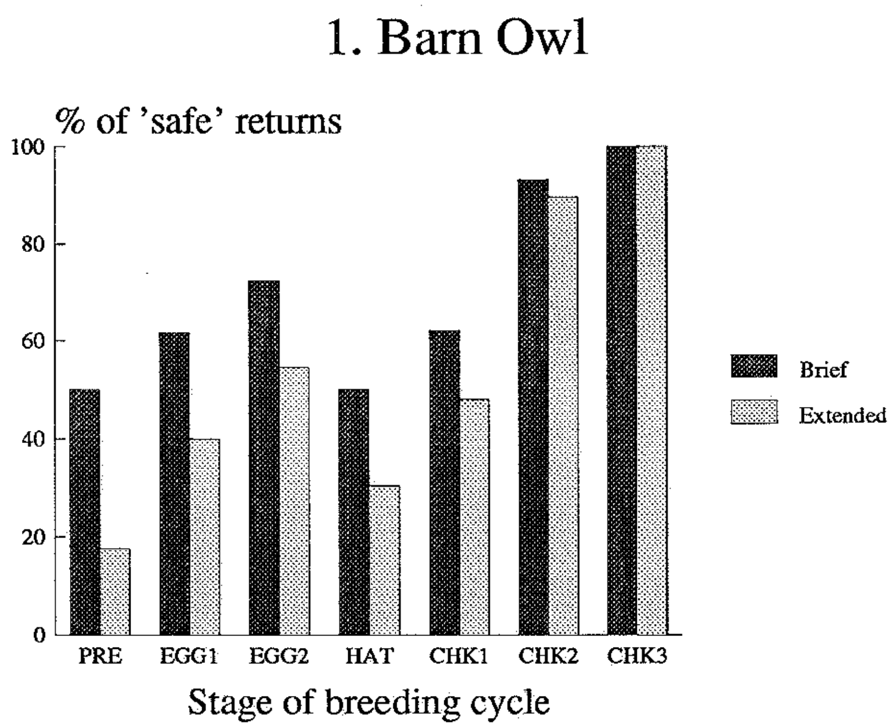
Complete nest losses recorded in the Nest Record data occurred mainly during the incubation period in both species, with virtually none once the oldest chick had reached 2 weeks old. Unlike the data from questionnaires no evidence was found for any peak periods during which losses were more frequent but losses during incubation were higher than those in the fledgling period.

So what can be said about the risks of observers causing desertion by visiting nests? The questionnaire illustrated the mixed opinions amongst people about visiting nests. Many observers (including almost all of those who were responsible for the collection of the data used in this project) thought there to be little problem but others were more concerned. The latter group however failed to provide much quantitative information to substantiate their viewpoint. There is enough information available to have confidence that the current BTO data on owl breeding biology have not been markedly affected by the observer's visits and that the owls have not been adversely affected.

With regard to recommendations for planning nest visits to minimize any possible risks of disturbance, perhaps the best plan would be to follow the guidelines of the many detailed professional studies. Little evidence has been published to suggest that nest visiting has a major impact on the breeding success of either of these two species provided a few precautions are taken. Taylor's (in press) detailed analysis of Barn Owl breeding performance in SW Scotland showed there to be no effect of nest visiting even when nests were visited regularly throughout the nesting cycle and adults frequently trapped on the nest. Other studies of the Barn Owl have also found that this species is generally tolerant of nest visiting, for example Baudvin (1976) in France, Lenton (1985) in Malaysia, and Colvin (1984) in the USA, though all made effort to minimize disturbance during the incubation period.

The Tawny Owl is perhaps slightly less tolerant than the Barn Owl (Southern 1970, S. Petty pers. comm.), not surprising when one considers that this is a much more long-lived species that can more afford to abandon a breeding attempt (as it will probably live to breed in several more breeding seasons). In my own experience carrying out detailed studies of Tawny Owls, where nests were visited every 4-5 days throughout the breeding cycle, regular measurements were taken of eggs and chicks, and adults were trapped on the nest (after the chicks were at least one week old), no desertions at all were recorded from the 18 nests that were monitored. S. Petty (pers. comm.) has also commented that during his detailed work on Tawny Owls no problems have been encountered with desertion caused by nest visiting, following a visit regime of minimizing disturbance through incubation (making a single visit, measuring the eggs to predict hatching date and returning once the chicks were over one week old). Adults were only caught after this period too.

Fig. A1.1 First disturbance questionnaire results



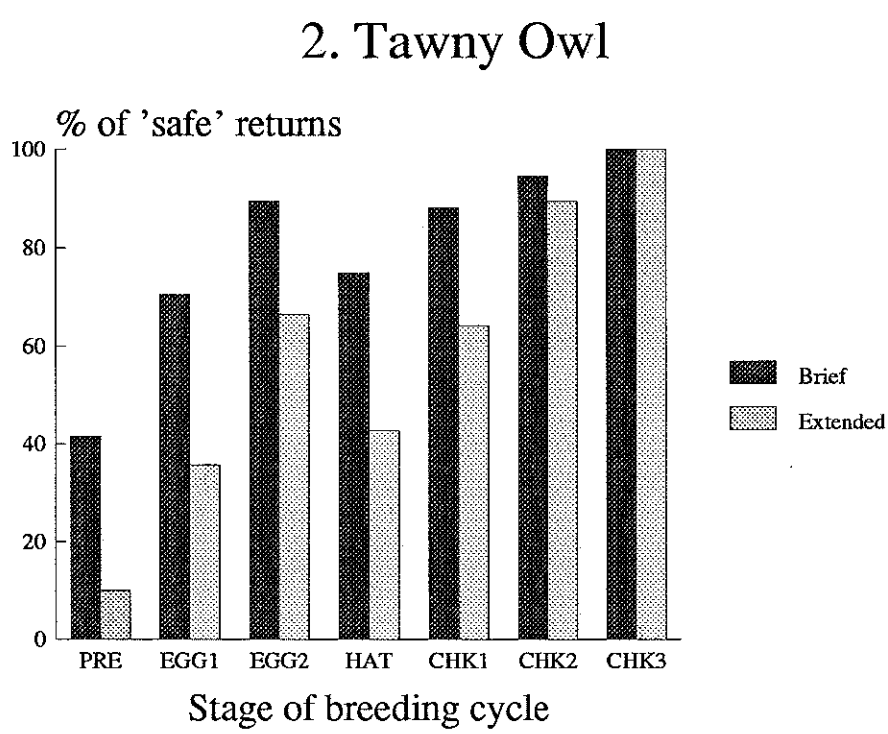


Fig. A1.2 Second questionnaire results

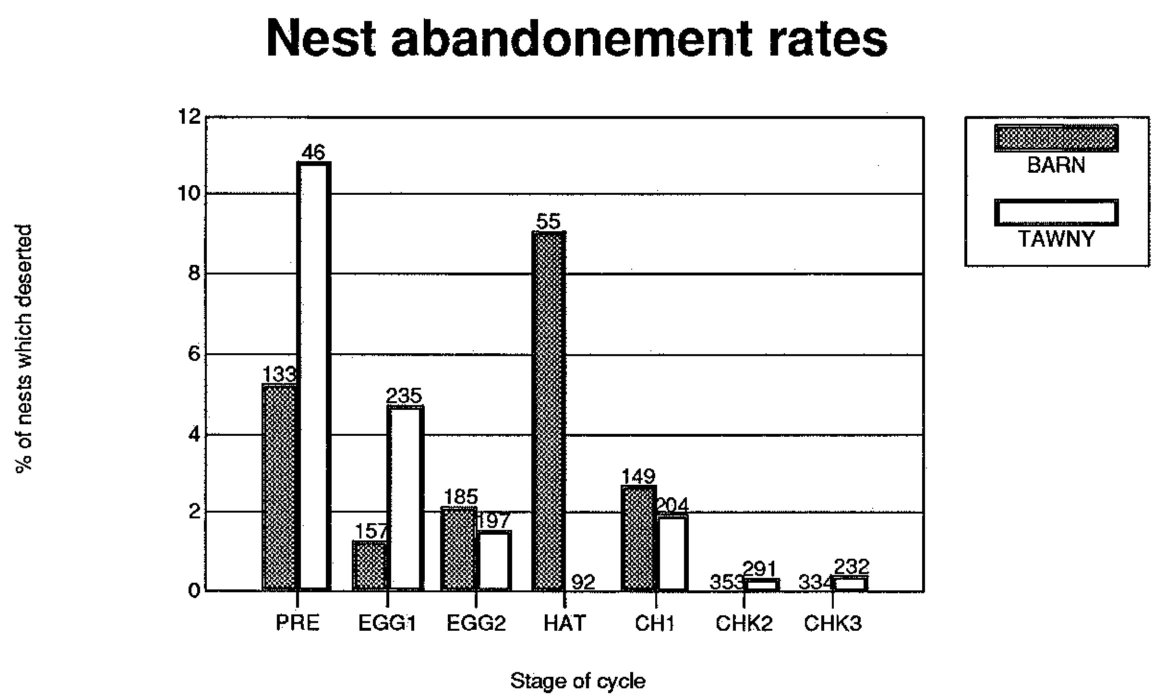
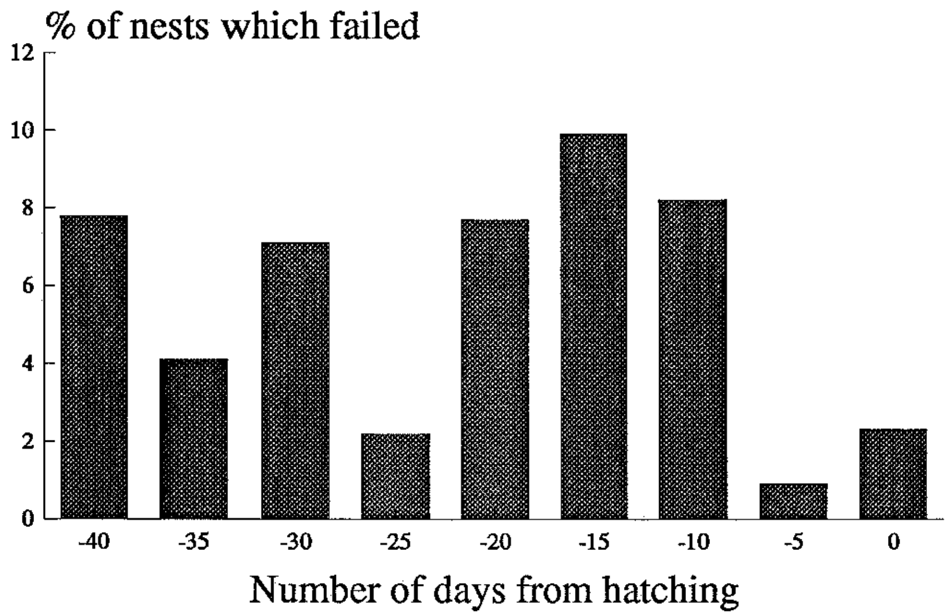


Fig A1.3 Frequency of complete nest loss
1. Losses at egg stage, Barn Owl



2. Losses at egg stage, Barn Owl

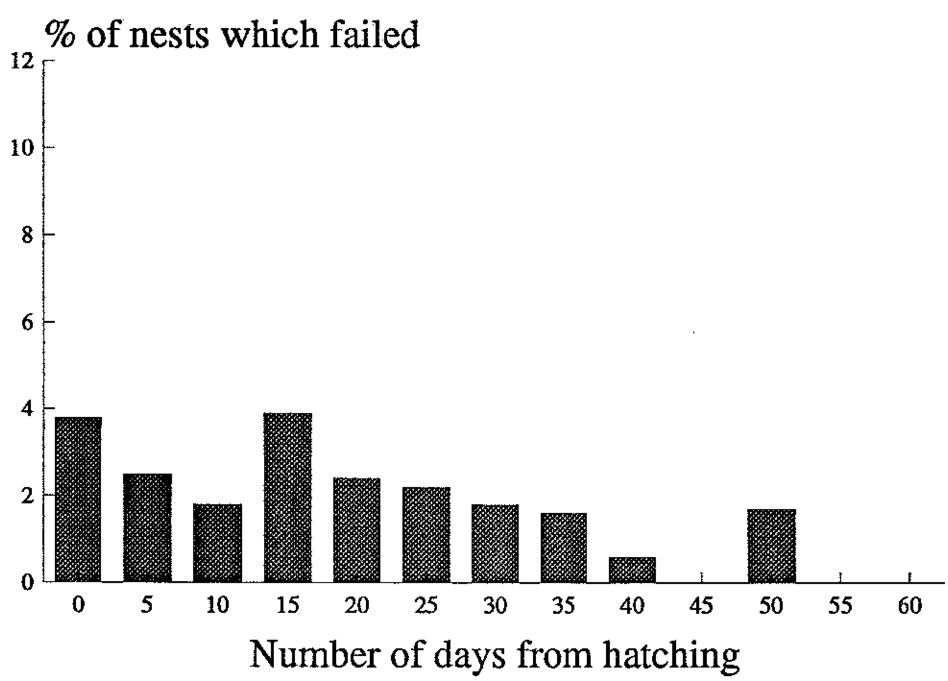
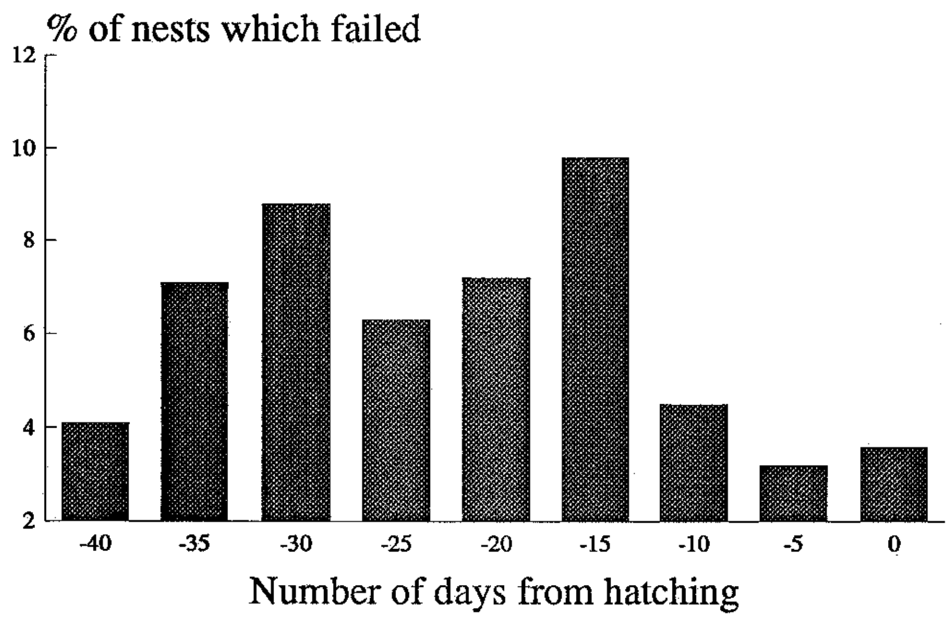
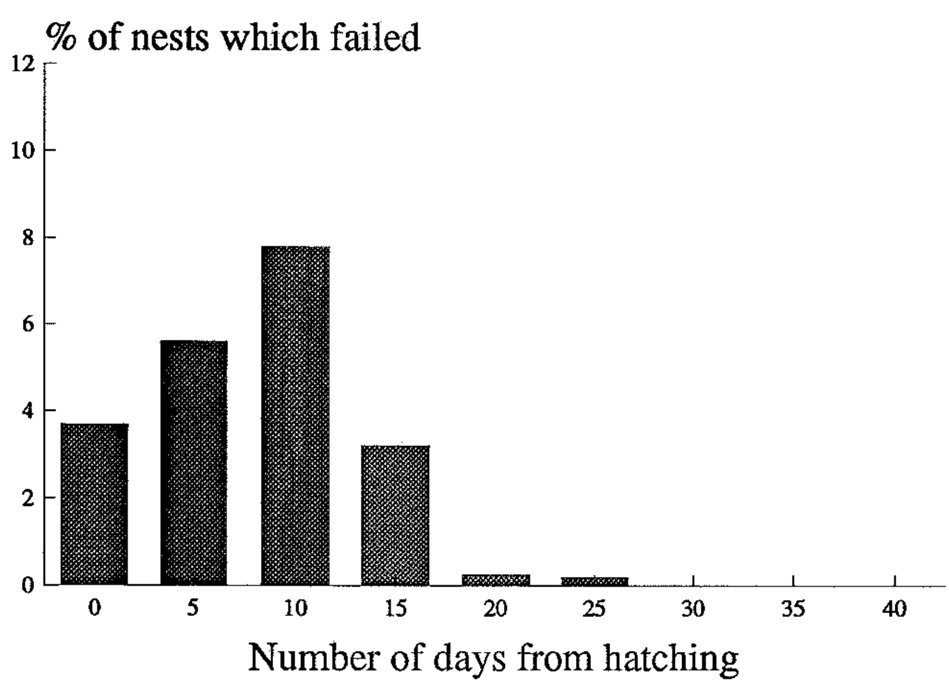


Fig A1.4 Frequency of complete nest loss

1. Losses at egg stage, Tawny Owl



2. Losses at egg stage, Tawny Owl



APPENDIX 2: MORTALITY AND DISPERSAL OF CAPTIVE-RELEASED BARN OWLS: A COMPARISON WITH WILD BIRDS

INTRODUCTION

Recent years have seen a marked interest in the captive-breeding and release of Barn Owls into the wild. Release of Barn Owls was initially prompted as a conservation tool (for example by Bunn *et al.* 1982 and Shawyer 1987) to re-introduce Barn Owls into areas from which they had disappeared and to supplement wild populations. C. Shawyer (pers. comm.) now estimates that as many as 2,000 Barn Owls are released annually. There is a considerable lack of knowledge about fate of these birds once they have been released into the wild. A few release programmes have reported some degree of success (for example Pearce & Woodland 1988 and Ramsden 1989), but little is known of the overall impact that they might be having on the wild population. These released birds could be having either a detrimental effect on wild birds, through competition for resources, or a positive one, supplementing their numbers.

Some of these birds are fitted with BTO rings immediately prior to their release, so their survival and dispersal can be monitored. The aim of this paper is to compare the mortality rates and dispersal of captive-reared Barn Owls released into the wild with those of genuine wild individuals, to investigate the success with which released birds became established in the wild population. It specifically seeks to compare survival rates, the cause of death, seasonal pattern of death and dispersal patterns of wild and captive-released birds.

METHODS

A total of 292 first-year and 279 adult captive-reared Barn Owls were ringed with BTO rings and released into the wild between 1982 and 1987, of which 82 have been recovered. They show a southerly bias in comparison to wild birds with very few being released in Scotland and northern England.

A sub-sample of the wild population was selected to give the same regional and temporal distribution as the captive-released birds. In total 1922 first-year and 319 adult ringed wild birds were used in the analyses for this paper, of which 311 have been recovered. No significant difference was found in the recovery rate of wild and captive-released birds (see table A2.1).

Table A2.1: Comparison of recovery rates of wild and captive-reared Barn Owls

	Captive-reared	**Wild**
First-years	17.9% (2.6)	13.7% (2.4)
Adults	13.4% (2.5)	15.1% (1.4)

Standard errors are given in brackets

The analysis of survival rates used the same procedure as the analysis of the main survival data set (chapter 3) though it was necessary to work with a model which held survival rate constant between years as the data on the captive-released birds were sparse. This is essentially a Haldane (1951) analysis that produces an average survival rate for each age-class result which, though not as appropriate as a year-specific model, does still allow comparisons to be drawn.

As described in chapter 3, the ring recovery database provides information about the cause of the bird's death and the time of year at which it died, when the bird was recovered dead. Though the sample of recovered birds can be subject to much bias (Illner 1990), it can be used to compare the major mortality factors and the seasonal pattern of death in captive-bred and wild birds.

The dispersal patterns of wild and captive-released birds were compared by examining the distances moved by recovered ringed birds, allowing for differences between age-classes as described in chapter 4. As samples with similar biases are being compared these analyses should be valid (see chapter 4).

RESULTS

The average survival rates of wild and captive-reared Barn Owls are given in Table A2.2. There is clearly a marked difference, with captive-released birds suffering much greater mortality rates. This was particularly true of adult birds but even the first-years had an average survival rate of only half that of wild birds. The similar recovery rates of wild and captive-released birds (Table A2.1) further supports this idea: it is very unlikely that the results could be affected by variation in recovery rates.

Table A2.2: Comparison of average adult and first-year survival rates of wild and captive-released Barn Owls

	Adult	First-year
Wild birds	54.7% (6.9%)	19.2% (4.7%)
Captive-released birds	15.1% (5.3%)	10.6% (5.4%)

Mean survival rate for each age group, 1982-88, with standard error in brackets.

Large differences in the cause of mortality of captive-released and wild birds were found, for both age-classes (Fig. A2.1). A greater proportion of first-year captive-released birds were killed by traffic (X^2 = 10.3, 3 d.f., P=0.0164) and more captive-released adults were found to have starved in comparison to the wild population (X^2 = 7.87, 3 d.f., P=0.049).

Fig. A2.2 compares the dispersal patterns of wild and captive-released birds. The latter dispersed further in all age-classes, but of particular note was the greater distances moved by them in the 4-6 and 7-9 month categories: their dispersal appeared to be both further and earlier than in wild birds.

DISCUSSION

This analysis has shown that captive-released Barn Owls suffer much higher adult and first-year mortality in comparison to wild birds. With an average first-year survival rate of only 10.6% and adult rate of 15.1% (compared with 19.2% and 54.7% for the respective values in the wild population) only a very small proportion of the captive-released birds can succeed in reaching an age at which they could be recruited into the breeding population (usually one year in the Barn Owl, Cramp 1985). The large majority die soon after release. It therefore very unlikely that the release of captive-bred birds into the wild is having any supplementary effect on the population at all. The approximate impact can be demonstrated using a very crude population model:

If 2,000 birds released each year, of which 52 % first-years and 48% adults (% taken from the % of each age-class ringed),
then no. surviving to end of first year
= 1040 x 10.6% first-years + 960 x 15.1% adults
= 255 potential recruits into breeding population in next breeding season.

If the British population were 4,420 pairs (Shawyer 1987),
and mean productivity 2.7 chicks fledge per pair (data from this study, chapter 2),
then no. of new wild birds coming into the population = 11,934,
of which 19.2% = 2,291 potential recruits in next breeding season.

The figures calculated are of potential recruits that survive to the age of recruitment. There still might be further reduction in the recruitment of the captive-released birds: if for example they were in poorer condition than wild birds (as might be expected from their much greater mortality rate) then this might further limit their ability to establish themselves in the breeding population and to subsequently breed effectively. So even with such large numbers being released annually it is unlikely that they were having any significant effect on the total population.

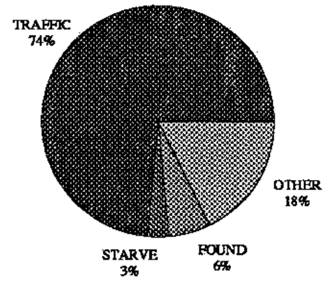
The recorded cause of mortality of ringed birds recovered dead further emphasizes the poor fitness of captive-released birds. A much greater proportion of first-years was killed by traffic, as might be expected if they were in weaker condition or released into poorer habitats, and the incidence of starvation in adults was much greater than in the wild population.

Why should there be such low survival in the captive-released birds? This clearly needs more investigation but could be a result of many birds being released into unsuitable habitats. The lack of a period when hunting experience is gained in the parental territory may also be an important factor. Whatever the reason, the release of captive-reared birds into the wild on conservation grounds seems of doubtful justification. Looking at the birds' survival rates has demonstrated this fact, without taking into account many of the other arguments against releasing such as the genetic implications (introducing genotypes which are not adapted to the environment into which they are released) and the possible negative effect that they may have on the wild population through competition where resources are scarce.

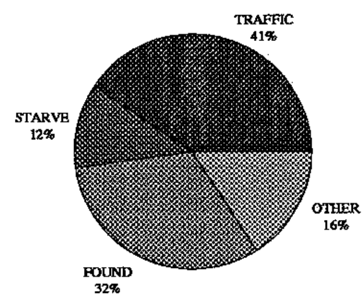
Fig. A2.1 Causes of mortality of captive-released and wild Barn owls

Captive-released birds

First-years

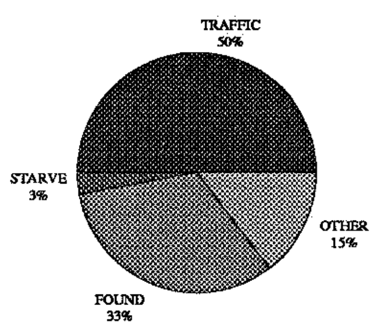


Adults



Wild birds

First-years



Adults

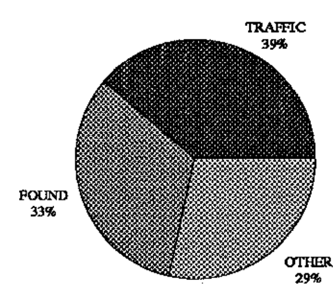
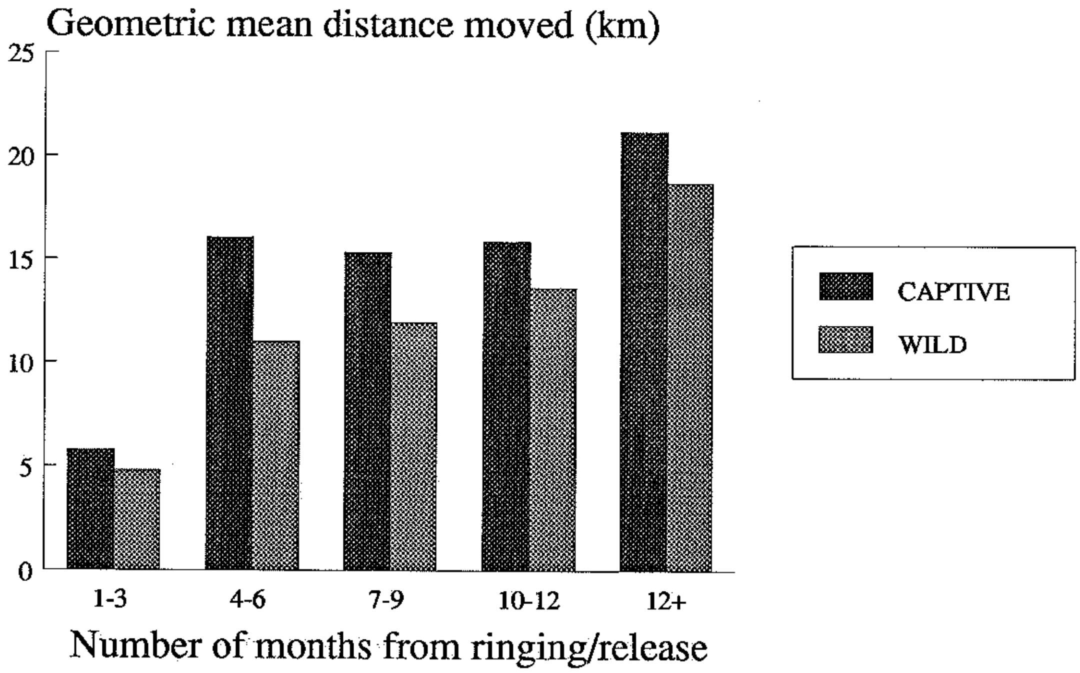


Fig. A2.2 Dispersal distances of wild and captive-released Barn Owls



BTO OWLS PROJECT

Instructions for Nest Recording

INTRODUCTION

The BTO Owls Project has been set up to investigate the factors affecting owl populations in Britain, and to set up a baseline database for their future monitoring. To achieve both these aims, it is necessary to collect data on breeding performance and survival to integrate with that on population numbers to give an overall picture of owl population dynamics. This part of the projects complements the surveys of Barn and Tawny Owl numbers that are also being carried out in this project.

The work on nest monitoring involves an extension of the BTO's nest recording scheme. More detailed measurements of the birds' growth and development are taken, to allow a more accurate and thorough assessment of their survival and condition and hence their breeding success to be made. If it is not possible to take these extra measurements, basic nest content information can still be useful to the project.

Pilot work carried out during 1988 has allowed egg density curves for the two species to be constructed. Where it is possible to obtain a single measurement of an egg's density, that egg's hatching date can now be predicted from these curves. This prediction can then be used to plan future visits to the nest to both maximize the usefulness of the data recorded whilst at the same time minimizing disturbance. Details of the curves are given below.

AIMS OF OWL NEST RECORDING

To provide accurate and reliable data on owl breeding success, to:

1. Examine owl populations in relation to land use, climate and usage of pesticides (particularly rodenticides).

2. Establish a baseline for future long-term monitoring of owls.

RECORDING INSTRUCTIONS

1. Nest contents (ie. numbers of eggs and/or chicks). This is the most important information. Even if it is not possible to take the measurements given below, this can still be useful to the project.

2. Egg measurements. Egg length and breadth (measured with calipers to the nearest 0.1mm) and weight (to nearest 0.1g using a Pesola or Salter spring balance) should be recorded on the first visit to the nest. This allows egg density and hence hatching date to be calculated (see below). Individual eggs can be numbered with a permanent marker pen to identify them and monitor their survival.

3. Chick measurements. Measurements of chicks should be taken at each visit, so that their body condition and growth can be monitored. The recommended measures are:

a. Weight, using a Pesola/ Salter balance, to nearest 0.5g.

b. Wing length, measured as maximum chord to nearest 1mm with wing rule (see Ringers' Manual for details).

c. Head and bill length, measured as the distance between the back of the head and the tip of the bill using calipers, to nearest 0.5mm.

Identification of individual chicks until ringing (usually up to about 14 days after hatching) can be made with a permanent marker pen, marking either the legs or the underwing uniquely. After ringing the birds can be identified by their ring number.

RECORDING FORM

An example of the recording form is shown below, filled out as an 'ideal' record for the project. Block A, the nest description section is similar to that of the standard BTO nest record card, with the addition of the egg measurements and details of the adult birds (if the adult has been caught). Habitat recording should follow the coding of the new standardized BTO system. Details of this are attached below. Block B, the nest visit section, should be filled out for each visit to the nest, with the contents and measurements described above, and any additional information such as 'eggs chipping' or '1 young dead'. Block C, again taken from the standard Nest Record Card, is for recording information about the outcome of the nest. If there is insufficient space in any particular box just continue onto the one below, and if necessary onto the reverse side of the sheet.

FREQUENCY AND TIMING OF NEST VISITS

It is very important that multiple visits should be carried out to nests wherever possible, to allow accurate calculation of egg and chick survival. Whilst information from one or two visits is of some use, data from three or more visits are much more valuable.

Where it is possible to obtain measurements of eggs, the ideal visiting pattern should be as follows:

- First visit to obtain clutch size and egg measurements to estimate hatching date.

- Second visit to eggs, to obtain clutch size immediately before hatching. This visit should be 3-4 days before the estimated hatching date of the first egg.

- First visit to chicks, one week after hatching.

- Thereafter weekly visits to chicks through to fledging and final visit to confirm outcome of nest.

An additional visit to eggs to obtain the full clutch size may be necessary when the first visit was during the laying period. This can be ascertained from the egg densities on the first visit: an additional visit (about 7 days after the first) is needed if any of the eggs have estimated hatching dates 26 or more days distant.

This has been outlined as the ideal record. Many observers may not be able to collect such detailed data, but less complete information can still make a very valuable contribution to the project.

Where it is not possible to obtain egg measurements, visits should be as frequent as possible, up to a maximum of once per week.

PROBLEMS OF DISTURBANCE

It is obviously very important that the birds' breeding success is not adversely affected by the observers' nest visiting. Information from detailed studies of both species has shown that, provided observers are careful, no such problems should occur, but some workers have expressed concern about visiting nests during the incubation and early chick (first week after hatching) periods. Therefore it is recommended that visits during the egg and early chick periods should be kept to the recommendations above, with egg measurements taken where possible to allow accurate planning of future visits to avoid periods when the birds may be sensitive to disturbance.

In some circumstances observers may feel that their visits, particularly to Barn Owl nests, should be restricted further to take account of the birds' political sensitivity: many farmers and landowners feel very protective about birds breeding on their land.

Further recommendations should also be followed when visiting nests so that potential disturbance to the birds is minimized. Visits should be avoided in wet or very windy weather and where possible should take place in the evening. For the Barn Owl, in sites such as nest-boxes where the adult can easily be trapped, catching the adult and returning it to the site after inspection is generally thought to cause less disturbance than flushing it from the site. This also has the advantage that the adult can be ringed and its survival monitored (see below).

SAFETY AT THE NEST SITE

It is recommended that some form of eye protection is worn when visiting Tawny Owl nests, particularly when there are chicks in the nest, as occasional females can be very aggresive to intruders. Motor-cycle or ski goggles are ideal. No such problems should occur with Barn Owls, but please take care when visiting all sites particularly in high trees or old rotten buildings.

LICENSING

The Barn Owl is a species listed on Schedule One of the 1981 Wildlife & Countryside Act, so a licence (which can be issued here at the BTO) is required to visit its nest site. Tawny Owl nests can be visited without a licence. As regards the handling of eggs and chicks of both species, either a BTO Ringing permit or, if you do not have one of those, a handling licence (also obtainable from the BTO) is needed. All ringing must, of course, be carried out under a BTO Ringing permit.

RINGING

Ringing recoveries provide essential information about bird dispersal and survival, both of which are key features of population dynamics. This project simply requires the ringing of as many owl chicks and adults as possible. Catching adults is important as data on these older birds is sparse at present. Biometrics of adults (weight, wing - maximum chord, and head and bill length are recommended) can yield additional information about the condition of the birds, which can then be related to their breeding success.

The Barn Owl is rather less sensitive to being caught at the nest than the Tawny. Guide-lines for catching the adult Barn owls at sites where this can be readily achieved are discussed above: catching at these sites at each visit is recommended as it usually causes less disturbance than flushing birds from their nest. For the Tawny Owl, and for Barn Owls where the adults cannot be readily trapped, adults should only be caught when the chicks are over one week old.

At present no data on local controls (birds found alive within 5km of their ringing site) are stored at the BTO. With such sedentary species as the Barn and Tawny Owls, this information is of considerable importance in the analysis of dispersal, so any such records will be of great value to this project. Record this information on the nest record sheet where appropriate.

Steve Percival, BTO, Beech Grove, Tring, Herts, HP23 5NR.

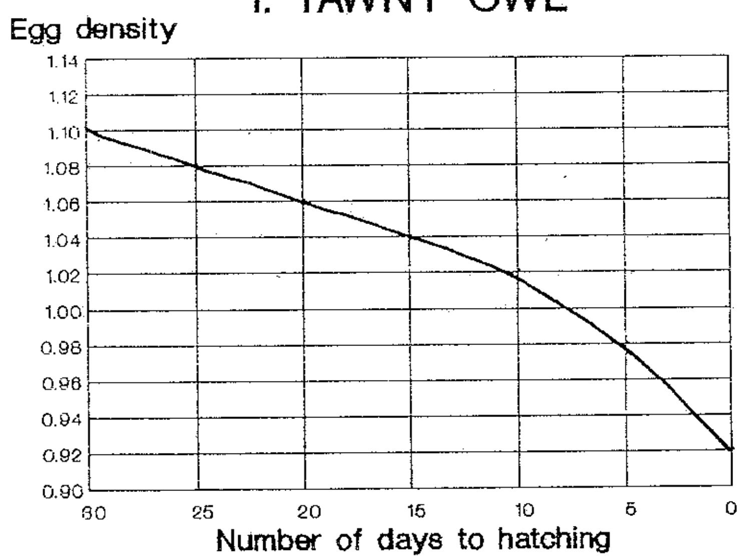
March 1989.

OWL EGG DENSITY CURVES

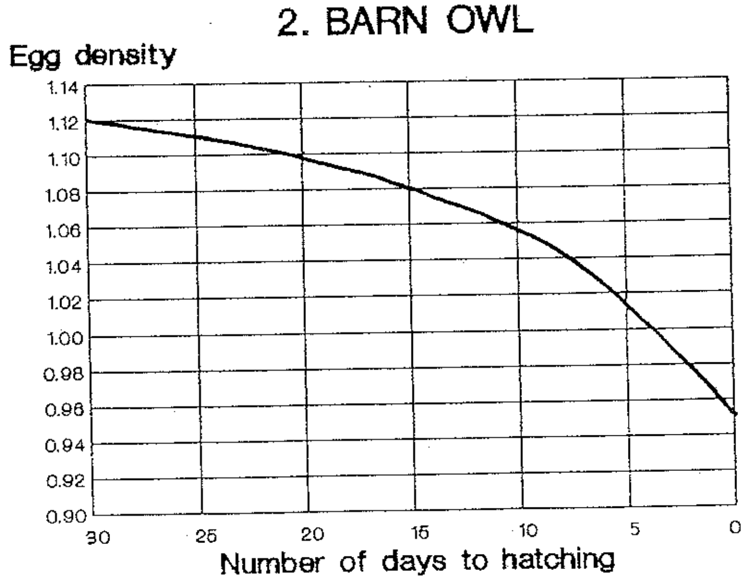
$$\text{Egg density} = \frac{\text{Weight}}{0.507 \times (\text{Breadth})^2 \times \text{Length}}$$

(Weight in g., length and breadth in cm)

1. TAWNY OWL



2. BARN OWL



BTO OWLS PROJECT

Nest Record Sheet

Please return to:- Steve Percival, BTO, Beech Grove

Tring, Herts, HP23 5NR.

Species: TAWNY	Observer: STEVE PERCIVAL	Year: 1989
Locality: ASHLEY GREEN	County: BUCKS	Grid ref: SP 834099

Nest site: Cavity in dead birch tree

Altitude: 205 m.

Height above ground: 5 m.

Habitat: PRIMARY 1113 SECONDARY 5112

Egg measurements:-

Egg no.	Length (mm)	Breadth (mm)
1	46.9	38.2
2	47.1	38.0
3	46.5	38.3
4	46.1	37.7

Adult details: ♀ caught 1/5. CONTROL - GK90805 - ringed at same site as breeding adult, 26.4.88. WEIGHT 469 g. WING 270 mm. HEAD+BILL 70.5 mm

A

Date	Time	Eggs	Young	Measurements & comments
10.3	18.00	1	0	Egg wt = 37.0g. ♀ flushed.
15.3	17.10	4	0	Egg wts: (1) 34.6 (2) 37.6 (3) 37.0 (4) 35.2 ♀ flushed.
9.4	13.30	3	0	Egg no. 4 missing. ♀ flushed.
17.4	13.00	0	2	WEIGHT / WING / H+BILL Chick (1) 139 44 48.5 " (2) 130 34 48.5 ♀ flushed.
24.4	15.00	0	2	Chick (1) 243 89 60.0 " (2) 243 71 56.0
1.5	17.30	0	2	" (1) 286 135 61.5 RINGED GH46776 " (2) 295 119 61.0 —77
8.5	18.10	0	2	" (1) 272 148 63.5 " (2) 312 136 62.5
15.5	17.30	0	0	Young heard calling in copse nearby.

B

OUTCOME OF NEST

If you have positive evidence that the young left safely, or of failure, please put a cross (☒) in the appropriate box or boxes below. Otherwise mark the appropriate "Outcome Unknown" box.

OUTCOME UNKNOWN
- Because evidence for or against success is inconclusive ☐
- Because observations on nest were not continued ☐

EVIDENCE FOR SUCCESS
- Young capable of leaving nest when last seen ☐
- Young: seen leaving naturally ☐ left when approached ☐
- Young seen and/or heard near nest ☑
- Parent bird(s): giving alarm calls ☐ carrying food ☐

EVIDENCE FOR FAILURE
- Nest: empty ☐ damaged ☐ fallen ☐ flooded ☐ removed ☐
- Eggs: damaged ☐ deserted ☐ all infertile or addled ☐
- Young: all dead, uninjured ☐ all dead, 1 or more injured ☐
- Any other evidence (e.g. type of weather causing failure, species of predator if seen, etc.):-

C

BTO BARN OWL SAMPLE AREAS CENSUS

INTRODUCTION

The BTO Owls Project has been set up to investigate factors affecting owl populations in Britain, and to set up a baseline database for their future monitoring. To achieve both these aims, it is necessary to have data on population numbers to integrate with those on breeding performance and survival, to give an overall picture of owl population dynamics. The breeding and survival data are being gathered through detailed nest recording and ringing of owls as another part of this project.

Previous national surveys of the Barn Owl have concentrated on obtaining data from as wide an area as possible, which has given good information about the distribution of the birds but only rough estimates of the total population. Such methods can detect only very major changes in population levels. To establish an effective baseline for future Barn Owl monitoring it is imperative that reliable and repeatable data on numbers are obtained. The present census of Barn Owls is made possible through funding by four chemical companies: Ciba-Geigy, ICI, Shell and Sorex.

AIMS OF THE BTO BARN OWL CENSUS

To provide reliable data on Barn Owl numbers in sample areas using methods which can be repeated in future years, so that population change can be assessed accurately. These data will be used:

1. To provide a baseline for comparing Barn Owl populations between years.

2. To compare densities of Barn Owls in different areas and habitats.

METHODS

The Barn Owl is one of the most difficult of British birds to census accurately. The only way to obtain the data required is by carrying out a very thorough count of the breeding birds in a defined area, searching for and checking all possible nest-sites. This will provide an absolute measure of the population which is as accurate as possible. To make the census easy to repeat in future years this defined area should ideally be a 10km square.

The Barn Owl is a very inconspicuous bird and can be easily missed especially in areas where it is nesting in trees. Therefore it is very important that we have some idea of the observer effort in searching for nests so that the results can be standardized. The numbers of hours spent searching in each tetrad (2x2 km square) should be recorded, together with the number of potential nest-sites visited and checked of each type (box, building, tree or other) in the tetrad. Please also estimate the numbers of potential nest sites of each type that you have not visited and checked in each tetrad. For tree sites a 'potential site' should be regarded as a cavity large enough to hold a Barn Owl nest. Additional space is provided on the form to record (1) whether or not Barn Owls in your census area use trees for nesting at all (important for assessing the search effort), (2) an estimate of the number of breeding pairs missed in the census area, and (3) any further comments on the coverage.

TIMING OF THE CENSUS: data can be gathered throughout the main Barn Owl breeding season (March to September), but the whole census area should be covered if possible during the peak of the season (May/ June) when nest-site occupancy should be at its maximum.

CHOICE OF 10KM SQUARE TO CENSUS: for many people it may be most convenient to choose their local square or the one for which they have the most knowledge of the local Barn Owl population. This is acceptable for the Census, but at the same time it is important that the overall coverage is not biased to areas that have large numbers of Barn Owls. The two main points to consider when choosing a 'new' square are:

1. Choose one which, if possible, is representative of the land-type of the region.

2. If more than one square can be covered, for example by a group of people, then choose one square with a high density of owls and one with fewer owls.

Even if it is not possible to cover a whole 10km square the data can still be useful to the project. The area covered, however, must be clearly defined and it must be searched thoroughly for nesting owls. It is particularly important that the exact area covered is recorded on the form so that the census can be repeated in the future.

DETECTION OF THE PRESENCE OF BARN OWLS: it is hoped that many local Barn Owl studies, where sites are already well-documented, will contribute to this census. For searching new areas, presence of Barn Owls can be detected in several ways:

a) Pellets at roost sites
b) White streaking of droppings at regular resting places, eg. barn roofs.
c) Sightings or vocal records.

d) Talking to local farmers - casual records can then be followed up by site visits.

All these features can give the initial information that birds are present in an area. The next and most important stage is to check all potential nest-sites for the presence of breeding pairs, to establish the numbers breeding in the census area.

Birds located in an area where no nests were found after thorough searching should still be recorded on the census form, noting clearly that no nest was identified.

RECORDING FORM: for each census area record the following

1. 'YEAR'; the year in which the census was carried out.
2. '10 KM SQUARE'; the 10km square covered, eg. SQ78. Ideally the complete square should be covered, but if this is not possible, mark the 2x2 km squares which were covered on the grid.
3. 'SQUARE HABITAT'; record the approximate percentage of the 10km square occupied by each of the major habitat types indicated.

For each occupied nest-site located, record:
4. 'SITE NAME'; a unique name to identify the site.
5. 'GRID REF'; give a 2-letter, 6-digit reference, eg. SX665324. All records will be treated in strict confidence.
6. 'STATUS'; the evidence used to determine a the presence of a breeding pair, whether the nest site has EGGS, CHICKS, PAIR PROSPECTING or has been RECENTLY DESERTED. Choose from one of these categories.
7. 'NEST-SITE'; whether the nest is in a BOX, TREE CAVITY, ACTIVELY-USED BUILDING, DESERTED BUILDING, HAYSTACK, or OTHER site. Again choose from one of these categories.
8. 'SITE HABITAT'; the specific habitat surrounding each nest-site. The primary (main) and secondary (any other adjacent) habitats should be recorded as a 2-4 digit code, using the BTO's new habitat recording scheme (details enclosed).

Birds located without nest-sites should also be recorded, in the 'OTHER RECORDS' section. The 'SITE NAME', 'GRID REF', and 'SITE HABITAT' should be recorded as for occupied nest sites. 'STATUS' of the birds should also be noted, ie. SINGLE SEEN ONCE, SINGLE SEEN SEVERAL TIMES, PAIR SEEN ONCE, PAIR SEEN SEVERAL TIMES.

Additional space is provided on the reverse of the census form for extra records, and also for observers' notes. It is important that two other factors should be recorded:
a. Any Barn Owl nest-box schemes in the census area; how many boxes have been erected and how long the scheme has been operating.
b. Any Barn Owl release schemes that are known to be operating in the census area. In some areas of Britain, particularly

southern England, large numbers of captive-bred birds have been released which could affect local wild populations. If details of these are known, then record the approximate number of birds that are released each year, both in the census 10km square and in those adjacent. If details are not known, but it is suspected that a release scheme may be operating, note this on the census form. Record the name and address of the organizers of any such schemes (boxes or releases) if known.

HISTORICAL DATA

If any historical data on Barn Owl populations in or around the census area are available, these would be very useful in examining the trends in numbers. Please enclose any such information with your census results for 1989.

LICENCES

The Barn Owl is a Schedule 1 species under the 1981 Wildlife & Countryside Act and therefore a licence is required to visit nests. Observers should make sure that they have such a licence, which can be obtained from Kevin Baker at the BTO.

NEST RECORDING

In addition to this census work, data are also being collected on the breeding performance of owls to give further information about their population changes. If repeat visits can be made to the nests and details of the contents recorded, please record the information on the Owls Project nest recording sheets (several enclosed together with the 1989 instructions, more available on request). Care should be taken to minimize disturbance to the birds and visits should follow the guide-lines of the project instructions.

Steve Percival, BTO, Beech Grove, Tring, Herts, HP23 5NR.

March 1989.

BTO OWLS PROJECT

Barn Owl Sample Areas Census

British Trust for Ornithology, Beech Grove, Station Road, Tring, Hertfordshire, HP23 5NR.

Please read accompanying instructions before completing this form

YEAR:

10 km SQUARE:

COVERAGE (mark 2x2 km squares covered on grid below):

SQUARE HABITAT (record % occupied by each type):

Farmland (tilled)	
Farmland (grazed)	
Wood (conifer)	
Wood (deciduous)	
Moorland	
Other (note below)	

....

FOR EACH OCCUPIED NEST SITE:

SITE NAME	GRID REF. (eg.SX445321)	STATUS (eg. eggs)	NEST-SITE (eg. box)	NEST HABITAT Primary	NEST HABITAT Second'y

OTHER RECORDS: (ie. birds present but no nest found)

SITE NAME	GRID REF. eg.SX445321	STATUS eg. single	SITE HABITAT Primary	SITE HABITAT Second'y

OBSERVER COVERAGE
AND SEARCH EFFORT:

TETRAD
LETTERS:

NORTH

E	J	P	U	Z
D	I	N	T	Y
C	H	M	S	X
B	G	L	R	W
A	F	K	Q	V

SOUTH

TETRAD	NO. OF HOURS SEARCHING	NUMBER OF POTENTIAL SITES CHECKED				ESTIMATED NUMBER OF POTENTIAL SITES NOT CHECKED			
		Box	Buil.	Tree	Other	Box	Buil.	Tree	Other
A									
B									
C									
D									
E									
F									
G									
H									
I									
J									
K									
L									
M									
N									
P									
Q									
R									
S									
T									
U									
V									
W									
X									
Y									
Z									

COMMENTS ON CENSUS COVERAGE:

1. Do Barn Owls in this area use trees for nesting? .....

2. How many breeding pairs do you estimate that you have missed in the area covered by the census?

.....

Other comments about census coverage and efficiency:

....

....

....

ADDITIONAL RECORDS (please use when records on previous page are full):

OCCUPIED NEST SITES:

SITE NAME	GRID REF. (eg.SX445321)	STATUS (eg. eggs)	NEST-SITE (eg. box)	NEST HABITAT Primary	Second'y

OTHER RECORDS: (ie. birds present but no nest found)

SITE NAME	GRID REF. eg.SX445321	STATUS eg. single	SITE HABITAT Primary	Second'y

NOTES: Please note any Barn Owl release or nest-box schemes operative in the area, and any other comments on the census

....

....

....

....

NAME AND ADDRESS:

....

....

Please return forms to: Steve Percival, BTO, Beech Grove, Tring, Herts, HP23 5NR.

1. BARN OWL

	JUST BEFORE LAYING	INCUBATION		HATCH	NESTLING PERIOD		
		1ST HALF	2ND HALF		EARLY	MIDDLE	LATE
No. of nests visited							
No. at which desertion caused by observer							

2. TAWNY OWL

	JUST BEFORE LAYING	INCUBATION		HATCH	NESTLING PERIOD		
		1ST HALF	2ND HALF		EARLY	MIDDLE	LATE
No. of nests visited							
No. at which desertion caused by observer							

COMMENTS:

....

....

....

NAME AND ADDRESS:

....

....

BRITISH TRUST FOR ORNITHOLOGY
TAWNY OWL SURVEY
15th August - 15th October 1989

INSTRUCTIONS FOR PARTICIPANTS

INTRODUCTION

The BTO Owls Project has been set up to investigate factors affecting owl populations in Britain, and to establish a baseline database for their future monitoring. To achieve these aims, it is necessary to have data on population numbers to integrate with those on breeding performance and survival, to give an overall picture of owl population dynamics. The breeding and survival data are being gathered through detailed nest recording and ringing of owls as another part of this project. A complementary population survey of the Tawny Owl is now proposed.

No specific survey of the Tawny Owl in Britain has ever been carried out on a national basis. As a predator at the top of a food chain, the Tawny Owl is potentially vulnerable to a wide range of environmental changes. An accurate baseline is urgently needed to enable any future effects of climate, land-use and pesticides to be monitored. The BTO 1989 Tawny Owl survey will provide this baseline. The survey has been made possible through funding by four chemical companies: Ciba-Geigy, ICI, Shell and Sorex.

AIMS OF THE BTO TAWNY OWL SURVEY

To provide reliable data on Tawny Owl numbers in sample areas using methods which can be repeated in future years, so that population change can be assessed accurately. These data will be used:

1. To provide a baseline for comparing Tawny Owl populations between years.

2. To compare Tawny Owl numbers in different areas and habitats.

SURVEY METHODS

The methods for the Tawny Owl survey are broadly similar to those used in the Key Squares Survey of the New Breeding Bird Atlas. The main points to note are:

1. <u>Where to count</u>: the Tawny Owl survey aims to cover one-in- nine of the 10km squares throughout Britain (Ireland is not included). The squares are the same as the Atlas Key Squares (see map below). Each 10km square consists of 25 2x2km squares, termed tetrads, which can be identified from the 1:50 000 Ordnance Survey map. Tawny Owls in each Key Square will be counted by carrying out a point count within each tetrad. The count should be made as close as possible to the centre of the tetrad. In most cases

this will be the nearest public access to the centre of the tetrad, but it should always be within 300m of the actual centre. Sites close to busy roads or others where extraneous noise might affect the count should be avoided where possible (choose an alternative site within 300m).

2. <u>How many tetrads and how often should they be counted?</u> Ideally all 25 tetrads should be covered, but where this is not possible a minimum of 15 will suffice. The minimum 15 target tetrads should be those illustrated on the figure below. A single point count at the centre of each tetrad during the times specified below is adequate. Additional repeat visits (up to 3) during the survey period will be useful when it is possible to carry these out.

3. <u>How to do the point counts</u>: point counts should last exactly ten minutes. They should be made in the two hours following sunset. between 15th August and 15th October. These methods have been chosen because they have been shown to give accurate results in detailed pilot fieldwork. The survey is being held in the autumn because this is the time at which Tawny Owls are most vocal: juvenile birds are then leaving their parental areas and territorial behaviour is at its peak as these young birds try to establish themselves in the population. Only carry out counts when the weather is calm and dry. Precipitation and wind both reduce calling activity of owls and therefore should be avoided.

4. <u>How to record the owls</u>: during the ten-minute count you should remain stationary and record the number of Tawny Owls hooting and calling. At the end of the period an assessment of the total number of 'pairs' heard should be made. The criteria for the identification of a pair are:

(a) Single hooting or calling bird. No other birds heard within 300m.

(b) Hooting bird with calling bird - at distance of less than 300m.

(c) Hooting bird with second bird hooting <u>softly</u> in response less than 300m apart. Both (b) and (c) represent the male and female of a pair vocalizing to each other.

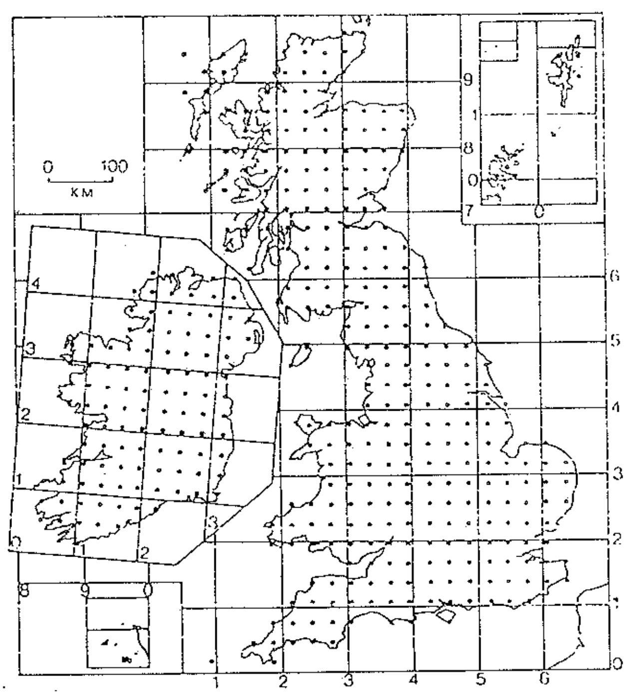
Two hooting or calling birds more than 300m apart should be recorded as two pairs. If two birds are hooting <u>loudly</u> together, even if less than 300m apart, they should be counted as two pairs, as they represent two males in a territorial dispute.

5. <u>Recording the habitat</u>: the <u>habitat</u> at each site should also be recorded, using the same habitat codes as the Atlas (see below). A main (<u>primary</u>) and a <u>secondary</u> habitat can be coded. An estimate of the percentage of the 10km square occupied by each of the major habitat types should be made at the top of the form (<u>square</u> <u>habitat</u>).

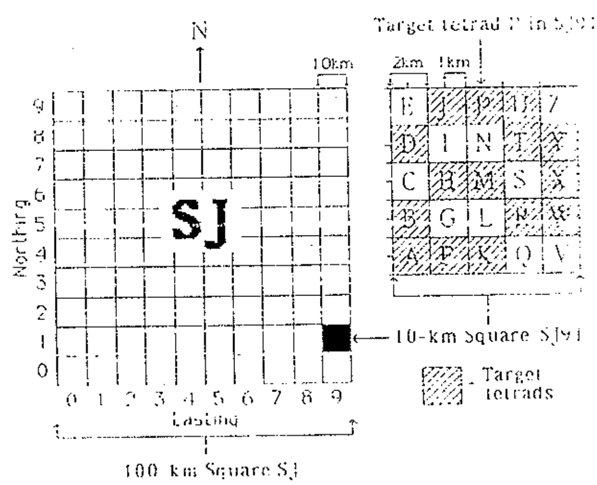
Occasionally a Key Square may contain a very high proportion of habitat that is totally unsuitable for Tawny Owls. This is only likely to occur in a small number of Key Squares in northern upland regions. If more than 60% of a Key Square is totally unsuitable habitat (treeless open moorland or high montane heath) it may be replaced with a more suitable square adjacent. Similarly, if a square is largely sea, then an exchange may be made with an adjacent one. If the Key Square contains more than 60% suitable habitat but some tetrads have wholly unsuitable habitat it is not necessary to make counts in these tetrads: substitute them with adjacent tetrads. It should be clearly stated on the survey form if this is done. <u>Only make such deviations from the standard methods in exceptional circumstances</u>. Tawny Owls can occur almost anywhere there are any trees at all, so care should be taken not to exclude sites where there is any possibility that there might be Tawny Owls present.

If you are surveying owls in remote areas make sure that you let someone know where you have gone and when you expect to return. Always carry torches, warm clothing and, in remote areas, a supply of food and drink.

Organization of the survey will be through the Regional Representatives network, so initially he/she should be contacted if you wish to take part in this survey. If you do not know the name of your Rep., contact the survey organizer, Steve Percival, at the BTO.



The 'Key Squares'. Ask your RR for the correct key square designations; do not try and decide them from this map.



The 100-km square, the 10-km square and the tetrad. An example is tetrad P in SJ91. The 15 target tetrads are shaded. Note the 2 diagrams are not to the same scale.

Each habitat has a unique two number code (e.g. coniferous woodland 01, and reedbed 22), one number from column A and one from column B. See page 4 for details on how to record the habitat at a point count position.

A	B
0 Woodland and Scrub	0 Broad-leaved woodland 1 Coniferous woodland 2 Mixed woodland (Broad-leaved and Coniferous) 3 Scrub (all scrub including downland and coastal scrub)
1 Semi-natural Grassland/Heaths	0 Bracken 1 Chalk grassland and similar 2 Damp or unimproved lowland grassland (include flood meadows) 3 Dry lowland heath 4 Wet lowland heath 5 Upland heather moor (unenclosed land; depth of peat less than 0.5 m) 6 Upland grassland (unenclosed and unimproved land; depth of peat less than 0.5 m) 7 High montane heath/grassland (on exposed summits) Note : Record reclaimed marsh and other maritime grasslands as 42 and 43 respectively. Record improved grasslands as 60, 61 or 62. Record upland heather moor or upland grassland with deep peat (more than 0.5 m) as 20.
2 Bog, Fen and Marsh	0 Acid bog (include blanket and raised bog; depth of peat more than 0.5 m) 1 Fen/marsh/swamp 2 Reedbed (with *Phragmites*) Note : Record flood meadow and wet lowland heath as 12 and 14 respectively.
3 Water Bodies (Freshwater)	0 Lowland river/stream (below 800ft = 250m) 1 Upland river/stream (above 800ft = 250m) 2 Canal 3 Standing water body less than 5 ha 4 Standing water body more than 5 ha Note : 5 ha is approximately 12 acres or 8 football pitches.
4 Coastal	0 Intertidal mud/sand (include sandy beaches) 1 Saltmarsh 2 Reclaimed marsh 3 Other maritime grasslands (include machair) 4 Brackish pools and lagoons 5 Gravel/pebbles/shells (non-sandy beaches, bar, spit etc.) 6 Sand dunes (include dune slacks, but record scrub as 03) 7 Intertidal rock 8 Cliff/small rocky island (record scrub as 03)
5 Exposed and Bare Surfaces	0 Inland cliff/crag/montane rock/scree/boulder slope 1 Limestone pavement 2 Quarry surface 3 Spoil (e.g. slag-heap, but record rubbish tip as 77)
6 Improved Farmland	0 Improved lowland grassland 1 Enclosed, improved upland grassland 2 Unenclosed, improved upland grassland 3 Arable (crops) 4 Mixed farmland (grazing and crops) 5 Farm buildings Note : Record chalk grassland, unimproved lowland grassland, unimproved upland grassland, and montane grassland as 11, 12, 16 & 17 respectively. Hedges are not included as they form part of other habitats (e.g. 60 & 63).
7 Miscellaneous (mostly artificial)	0 Urban/suburban park 1 Rural park 2 Golf course 3 Cemetery/churchyard 4 Residential housing (including gardens) 5 Non-residential buildings 6 Sewage treatment works 7 Rubbish tip 8 Waste land (record scrub as 03)

Improved grassland = grass regularly treated with artificial fertilisers, distinguished by its bright colour, lush growth and even texture.
Unimproved grassland = not treated with artificial fertilisers, usually grazed or mown regularly, may be rank and neglected.
Enclosed land = land enclosed within a hedge, stone-wall, fence or equivalent.

BTO Tawny Owl

Survey 1989

British Trust for Ornithology,
Beech Grove,
Tring,
Herts,
HP23 5NR.

Please read accompanying instructions before completing this form

10 km SQUARE:	SQUARE HABITAT (record % occupied by each type):
LARGEST FEATURE IN SQUARE:	Farmland (tilled) Farmland (grazed) Wood (conifer) Wood (deciduous) Moorland Other (note below) ....

DATE	TETRAD	TIME	NUMBER HOOTING	NUMBER CALLING	NO. OF PAIRS	HABITAT	
						Primary	Second'y

Additional records:

DATE	TETRAD	TIME	NUMBER HOOTING	NUMBER CALLING	NO. OF PAIRS	HABITAT	
						Primary	Second'y

OBSERVER (name and address):

....

....

Please return completed form to: Steve Percival, BTO, Beech Grove, Statio
Road, Tring, Herts, HP23 5NR.