BTO Research Report No. 468

Timing of Breeding of Moorland Birds in Wales

Authors

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A report to the Welsh Assembly Government

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EXECUTIVE SUMMARY

1. The Welsh Assembly Government is currently considering a change in the permitted burning dates of heather moorland so that they should end on 15 March instead of 31 March in lowland areas, and on 31 March instead of 15 April in upland areas, (These upland areas are defined as Severely Disadvantaged in the Less Favoured Areas[1]). In light of this proposal analysis of datasets of the laying dates of key breeding bird species in Wales is necessary, in order to assess impacts on bird populations of the proposed changes.

2. This report follows on from the work of Moss *et al*. (2005) to provide information on the current breeding periods for upland moorland breeding bird species in Wales. It uses three key datasets; nest records collected and collated by RSPB Wales; BTO's Nest Record Scheme (NRS); and BTO data on the ringing dates of pulli from the Ringing Scheme. The aim is to improve the assessment of the potential vulnerabilities of moorland bird populations to current burning practices.

3. The species chosen for detailed study were heather moorland specialists or those which breed in closely associated habitats. Less detailed information was collated for species that breed along upland lakes, rivers and streams and for species that commonly breed in uplands but are widespread in other habitats. All species included are listed in Appendix 1.

BTO datasets on nest records, ringed pulli and data from RSPB Wales

4. Using BTO Nest Record Card (NRC) data, ringing data and data from RSPB Wales the proportions of nests in which egg-laying had started by the specified burning cut-off dates in Wales for upland and lowland areas were calculated. Moss *et al*. (2005) previously examined trends at a UK scale in first egg-laying dates with altitude, latitude, longitude and year for most species included in this study. Two exceptions, which are more relevant in a Welsh context are Yellowhammer and Black-headed Gull, which we examine here, using NRC and ringing data for Yellowhammer and ringing data for Black-headed Gull.

5. There was generally good agreement between data from ringed pulli, from NRCs and data provided by RSPB Wales for potential risk from burning.

6. Table 1 shows the proportion of nests in which egg-laying had started by each of the current and proposed cut-off dates for heather burning. The table also shows dates by which laying had begun in the first 10%, 15%, 20% and 25% of nests. With the current burning regime (burning on SDA land up to 15th April) laying would have started in up to 13% of Golden Plover, 5% Hen Harrier, 59% of Lapwing, 1% Meadow Pipit, 79% of Peregrine, 100% of Raven, 20% Stonechat, 4% Wheatear and 1% of Wren. By reducing the cut-point to 31st March laying would have begun in up to 5% of Golden Plover, 29% Lapwing, 26% Peregrine, 97% Raven and 3% of Stonechat.

7. Both the NRC and ringed pulli datasets may be affected by certain biases, particularly that the proportion of nests found may decline through the season due to changes in search effort and nest detectability. Assessment of this bias, suggests that the results for most species in this study (particularly single-brooded species) are unlikely to be affected. For a small number, the proportions of nests occurring early in the season may be over-estimated, but the size of such effect is only likely to be small. This is supported by the good agreement between the NRC/ringed pulli and data from RSPB Wales.

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[1]The severely disadvantaged areas (SDAs) form part of the less favoured areas (LFAs) of the UK as listed in EU Council Directive 84/169/EEC. The LFAs are further divided for domestic purposes between SDAs and disadvantaged areas (DAs), the distinction being one of degree, most significantly of land quality. Upland SDAs are disadvantaged relative to non-SDA land in respect of a number of handicaps. These include higher altitude, harsher climate with a shorter growing season, low soil fertility, difficult topography, and remoteness.

Pre-laying occupancy of breeding grounds for Yellowhammer and Black-headed Gull

8. Moss *et al.* (2005) collated information on the lengths of time that most species of relevance here occupy breeding grounds before egg-laying, and during which they would potentially be liable to disturbance from burning operations. Exceptions are Yellowhammer and Black-headed Gull which we examine here. Yellowhammer, which is largely sedentary, may be affected by burning at any time of the winter, although there is a tendency for bird from high altitudes in the autumn and winter to withdraw from upland areas. For Black-headed Gull birds are distant from the colony during January, with return movements taking place thereafter, and birds reaching the breeding colonies by April.

9. Although these results can be used to indicate the vulnerability of moorland birds to the potentially damaging effects of burning during the approved periods, i.e. the potential of being affected, this is not necessarily the same as the percentage of nests that would actually be affected. The actual vulnerability will also depend on the frequency and timing of burning, total extent of moorland affected, and possibility for birds to re-nest. This 'true' vulnerability may depend on aspects such as the choice of nest sites in relation to the types of vegetation, especially heather, that are burnt.

Seasonal variation in breeding performance of Yellowhammer

10. Moss *et al.* (2005) previously analysed BTO nest record data to look at seasonal variation in breeding performance at a UK scale for most species included in this report for which there was adequate data. An exception, which we examine here, is Yellowhammer, which is considered important in a Welsh context. Whilst trends in clutch and brood showed a decline towards the end of the season after an increase, this species does not start breeding until well after the cut-point for burning in Wales, so is unlikely to be affected directly by burning.

Table 1 Estimates using BTO and RSPB data for the proportions of the nests in Wales with first egg-laying by key dates, and the dates by which laying has begun in the first 5%, 10%, 15%, 20% and 25% of nests. Note that nidifugous species were assumed to have been ringed aged 1 day, nidicolous species mid-way through the nestling period.

(a) Nest Record Card analysis

		% of clutches started by:					date by which X% have started laying				
	N	15-Mar	31-Mar	15-Apr	30-Apr	15-May	5%	10%	15%	20%	25%
Curlew	10	0%	0%	0%	50%	90%	22-Apr	23-Apr	24-Apr	24-Apr	25-Apr
Golden Plover	8	0%	0%	13%	63%	88%	08-Apr	12-Apr	16-Apr	16-Apr	16-Apr
Hen Harrier	21	0%	0%	5%	14%	43%	19-Apr	27-Apr	30-Apr	02-May	10-May
Lapwing	31	0%	6%	26%	61%	81%	30-Mar	31-Mar	01-Apr	05-Apr	11-Apr
Linnet	17	0%	0%	0%	0%	24%	06-May	08-May	09-May	11-May	14-May
Meadow Pipit	93	0%	0%	1%	19%	62%	23-Apr	26-Apr	27-Apr	29-Apr	30-Apr
Merlin	46	0%	0%	0%	15%	80%	26-Apr	27-Apr	28-Apr	30-Apr	30-Apr
Peregrine	70	0%	26%	79%	94%	100%	25-Mar	26-Mar	27-Mar	28-Mar	29-Mar
Raven	149	80%	97%	100%	100%	100%	23-Feb	25-Feb	26-Feb	27-Feb	29-Feb
Ring Ouzel	107	0%	0%	0%	22%	53%	20-Apr	23-Apr	25-Apr	27-Apr	29-Apr
Skylark	5	0%	0%	0%	20%	40%	29-Apr	30-Apr	01-May	02-May	04-May
Snipe	1	0%	0%	0%	100%	100%	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr
Stonechat	37	0%	3%	19%	46%	68%	03-Apr	07-Apr	09-Apr	16-Apr	17-Apr
Wheatear	24	0%	0%	4%	17%	54%	22-Apr	24-Apr	27-Apr	01-May	02-May
Whinchat	297	0%	0%	0%	0%	13%	11-May	13-May	14-May	15-May	16-May
Wren	70	0%	0%	1%	14%	47%	21-Apr	26-Apr	29-Apr	01-May	02-May
Yellowhammer	11	0%	0%	0%	0%	27%	04-May	05-May	07-May	09-May	13-May

(b) Ringed pulli analysis

Black-headed Gull	427	0%	0%	0%	0%	6%	26-Apr	30-Apr	30-Apr	2-May	5-May
Curlew	3	0%	0%	0%	33%	100%	8-Apr	8-Apr	9-Apr	9-Apr	10-Apr
Hen Harrier	77	0%	0%	1%	3%	39%	2-May	2-May	6-May	8-May	11-May
Lapwing	188	0%	29%	59%	76%	91%	15-Mar	16-Mar	17-Mar	17-Mar	19-Mar
Linnet	7	0%	0%	0%	0%	14%	10-May	13-May	16-May	19-May	22-May
Meadow Pipit	19	0%	0%	0%	5%	58%	1-May	5-May	6-May	6-May	7-May
Merlin	84	0%	0%	0%	10%	86%	25-Apr	30-Apr	1-May	3-May	4-May
Peregrine	79	0%	11%	63%	92%	99%	26-Mar	31-Mar	2-Apr	4-Apr	6-Apr
Raven	522	68%	96%	100%	100%	100%	23-Feb	25-Feb	28-Feb	2-Mar	4-Mar
Ring Ouzel	3	0%	0%	0%	67%	67%	26-Apr	26-Apr	26-Apr	27-Apr	27-Apr
Stonechat	15	0%	0%	20%	40%	53%	2-Apr	7-Apr	17-Apr	20-Apr	24-Apr
Wheatear	56	0%	0%	0%	4%	80%	30-Apr	1-May	2-May	3-May	3-May
Whinchat	65	0%	0%	0%	0%	6%	11-May	15-May	17-May	17-May	18-May
Wren	18	0%	0%	6%	28%	89%	14-Apr	19-Apr	20-Apr	20-Apr	25-Apr
Yellowhammer	2	0%	0%	0%	0%	0%	16-May	16-May	16-May	16-May	16-May

(c) RSPB data

Black Grouse	32	0%	0%	0%	0%	0%	19-May	19-May	20-May	21-May	22-May
Curlew	34	0%	0%	0%	21%	65%	26-Apr	28-Apr	28-Apr	29-Apr	1-May
Dunlin	16	0%	0%	0%	0%	44%	2-May	4-May	5-May	8-May	9-May
Golden Plover	20	0%	5%	5%	35%	65%	14-Apr	17-Apr	19-Apr	21-Apr	25-Apr
Hen Harrier	62	0%	0%	0%	8%	47%	4-Apr	7-Apr	9-Apr	11-Apr	13-Apr
Lapwing	1013	4%	18%	47%	71%	87%	18-Mar	26-Mar	29-Mar	31-Mar	3-Apr
Raven	51	76%	100%	100%	100%	100%	19-May	19-May	20-May	21-May	22-May

1. INTRODUCTION

Moorland, whether dominated by heather or grass, has been subjected to burning by man from time immemorial (Ratcliffe 1990). Heather burning has been a traditional tool, especially for grouse moor managers, to promote the growth of young shoots and plants and to reduce the cover of mature heather. But on grassland, shepherds and crofters have also traditionally used burning as a tool for promoting new grass growth and for controlling scrub encroachment. While such burns may generally be quite well controlled by grouse moor managers, burning by shepherds, graziers and crofters can be less well controlled and can result in larger areas than intended being affected. The timing and intensity (how hot the burns are) of burning and habitats burnt may influence the degree of detriment to other wildlife, particularly ground-nesting birds, and there are restrictions on how late controlled burning can occur to avoid such problems.

Information on bird breeding periods is often obtained by reference to the available published literature (for example *Birds of the Western Palaearctic* (e.g. Cramp 1977)), but this approach has several potential limitations, especially when considering data on a regional basis. Generally it only gives ranges for timing and does not enable the proportion of nest attempts by certain dates to be determined.

Moss *et al.* (2005) undertook an analysis of the current breeding periods for upland moorland birds in Great Britain using available long-term datasets. These included data from long-term intensive studies of two key species: Red Grouse and Hen Harrier, but also major multi-species analyses of data from the BTO's Nest Record and Ringing Schemes. Much of the data analysed came from Scotland, but analyses were presented at the country level (including Wales) where sample sizes permitted.

The Welsh Assembly Government is currently considering a change in the permitted burning dates so that they should end on 15 March instead of 31 March in lowland areas, and on 31 March instead of 15 April in upland areas (defined as Severely Disadvantaged Areas). Severely disadvantaged areas (SDAs) form part of the less favoured areas (LFAs) of the UK as listed in EU Council Directive 84/169/EEC. The LFAs are further divided for domestic purposes between SDAs and disadvantaged areas (DAs), the distinction being one of degree, most significantly of land quality. Upland SDAs are disadvantaged relative to non-SDA land in respect of a number of handicaps. These include higher altitude, harsher climate with a shorter growing season, low soil fertility, difficult topography, and remoteness. In the light of this proposal, further analysis to extend the Moss *et al*. analyses to include new data from Wales collected since the previous report and to analyse some additional datasets of key species in Wales would provide essential information.

This report aims to use similar methods to those carried out in Moss *et al.* (2005) to provide information on the proportions of nests in Wales in which egg-laying has started by the specified burning cut-off dates in Wales for upland (SDA) and lowland areas (non-SDA land), where sample sizes permit. The three key datasets used in this report consists of records from research reports and electronic data for several species provided by the RSPB, nesting records from the BTO's Nest Record Scheme (NRS), and the bird ringing and recoveries from the BTO's Ringing Scheme. Further records collected by RSPB Wales for Black Grouse, Hen Harrier, Golden Plover, Lapwing, Curlew, Dunlin and Raven were provided on paper within the following research reports (Thomas *et al*. 1983, Thomas & Hack 1984, Bain 1987, Green *et al.* 1994, Thomas & Young 1994, Young *et al.*1996) and further records provided electronically for Black Grouse, Hen Harrier and Lapwing. These datasets are used to assess the proportion of upland birds that have started nesting (by estimating first egg-laying dates) before the end of the specified burning periods. The complete selection of species included in this report is discussed in the Methods section below.

2. METHODS

The species analysed (Appendix 1) were selected as priority species with respect to the potential impact of burning, due to their habitat use and niche in the uplands, in particular on moorland. They were:

Heather moorland: Black Grouse, Dunlin, Golden Plover, Hen Harrier, Meadow Pipit, Merlin, Ring Ouzel, Stonechat and Whinchat.

Rough grassland / moorland edge: Curlew, Lapwing, Skylark, Snipe and Wheatear.

Subsidiary species that, although common in the uplands, are not sufficiently dependent on moorland to be included in the main body of the report, including species that breed along upland lakes, rivers and streams and others that commonly breed in uplands but are widespread in other habitats: Peregrine, Black-headed Gull, Linnet, Raven, Wren and Yellowhammer. Whilst Peregrine and Raven may not be directly affected by burning, the effect on surrounding habitats and food availability may be deleterious nevertheless

2.1 RSPB Wales nest records

2.1.1 Data

Records of Black Grouse, Lapwing, Dunlin, Golden Plover and Raven were supplied for this study by Dave Lamacraft and Ian Johnstone. These comprised data in electronic form for Lapwing (Bolton *et al*. 2007) and Black Grouse (Johnstone & Lindley 2003) and additional records were taken from published research reports for Dunlin, Curlew, Golden Plover, Lapwing and Raven (Thomas *et al*. 1983, Thomas & Hack 1984, Bain 1987, Green *et al*. 1994, Thomas & Young 1994, Young *et al*.1996). Records of Hen Harrier nests had previously been supplied by Brian Etheridge for the Moss *et al*. (2005) report, and came from the RSPB Hen Harrier study (Etheridge *et al*. (1997). Importantly, these data comprise all available nest records for these species, and are not restricted to particular habitats or altitudes.

These comprised a total of 1228 nests within the period 1982-1994, and included details for 32 Black Grouse, 62 Hen Harrier, 34 Curlew, 16 Dunlin, 20 Golden Plover, 1013 Lapwing and 51 Raven nests. This highlights the large variation in sample size between species, which is a particular issue for some species of breeding waders and will be discussed later.

First egg dates were available for most nests. These were calculated using one of the following methods:

(i) Laying date: nest found during laying of clutch.
(ii) Egg development: based on known weight loss of measured eggs over entire incubation period and estimated using a formula derived by linear regression analysis of eggs of known weight and volume against the known period of incubation.
iii) Combination of egg development and field observations.
(iii) Hatching date: hatching date known.
iv) Laying date calculated as finding date + predicted days to hatching-incubation period-days until last egg laid.
v) Nest at egg stage with single visit made. It was assumed that the nest was found halfway through the incubation period.

Incubation period: Some minor corrections to presented laying dates were made to standardise the assumed length of the incubation periods to those in Appendix 1, and for Black Grouse 26 days (Cramp *et al*. 1980).

2.1.2 Analysis

In order to assess percentages of nests potentially at risk from burning, we calculated the proportions of nests of each species for which the first egg was laid by the relevant cut-off dates. As an alternative view of the distributions of laying dates, percentiles were calculated at 5% intervals from 5% to 100% for the same categories of nests. This analysis was made for all species listed in Appendix 1 with sufficient samples.

2.2 Nest Record Cards

The BTO Nest Record Scheme (NRS) has gathered records of individual nesting attempts from volunteer birdwatchers and others since 1939. Observers record species, county, year, place name, six-figure grid reference, altitude, and on each visit the date, numbers of eggs or young, and standardised codes to describe the development stage of nests, eggs, young, activity of the parents. The outcome of the nest (giving cause of any failure if known) completes the record. Currently around 30,000 Nest Record Cards (NRCs) are submitted each year from a network of 600 individuals and groups. For a full description of the NRS see Crick *et al*. (2003). Data were available from 1966 onwards as this was the start date of computerised records for the majority of species.

2.2.1 Selection of NRCs

Data from the NRCs were used to identify breeding periods for all the priority study species. Breeding periods were estimated from the first egg-laying date estimated from the NRCs. Laying dates are generally not recorded on NRCs and have to be estimated by back-calculation, using information on the nest contents at each visit with reference to standard information on the timing of events within the nesting cycle (e.g. length of incubation and egg-laying periods, see Crick *et al*. 2003 for details). Because nest monitoring is not carried out on a daily basis, it is often not possible to determine the first day of egg-laying. However, depending on the information that is available for the nest, a range of possible dates can be determined, within which it is certain that egg-laying was initiated. For each nest a range of possible laying dates was calculated and the mid-point used when the range was less than 10 days. Records were excluded where the range was greater than 10 days.

Only NRCs from the appropriate habitat and region were used in the analysis. For species that are found only in moorland habitat (Golden Plover, Hen Harrier, Merlin and Ring Ouzel), all records from the NRS that have estimable first egg-laying dates and altitude details were included in the analysis. For other species only records from upland habitats or upland areas were selected, as follows. NRCs which had a four-figure grid reference within Environmental Zone 3 (see below) were selected. Where there was no grid reference (a small number of cards prior to 1990), habitat data from the NRCs were used for the selection of NRCs for rough grassland/moorland edge species. The habitats selected from the classification used until 1990 for these NRCs were: upland heather moor, upland grassland, bog, wet heath, cliff or crag (not coastal), scree slope (not coastal), fast flowing river/stream, moorland (unspecified).

Great Britain is divided into six broad environmental zones using data from the Countryside Survey 2000 (CS2000) (Haines-Young *et al*. 2000). In Wales, **Environmental Zone Three** comprises applicable burnable habitat (Figure 2.2.1).

Altitude is routinely recorded on NRCs by observers and can be considered to be within a reasonable degree of accuracy. The altitude data were checked by tabulating maximum altitude per county, resulting in the correction of a few erroneous values (chiefly where altitudes in feet had been recorded as metres). So as to analyse laying dates in the different altitude zones relevant to burning, nests were differentiated as up to or above 250m above sea level which are equivalent to the non-Severely disadvantaged areas (non-SDA) and Severely Disadvantaged Areas (SDA). Thus, non-SDA comprises a narrow zone of lower-lying moorland and marginal upland and consequently has relatively few records.

For Yellowhammer analyses involving latitude and longitude, grid references were used as a surrogate (analyses of other nest record species has been covered in Moss *et al*. 2005). These were recorded at least to 1 km accuracy, and usually to 100m (i.e. 6-figure grid references). Incomplete grid references in the raw data were completed using online maps and by reference to recorded altitude and county. These were used to derive two variables, easting and northing, i.e. distances in kilometres east and north respectively of the origin of the National Grid of Great Britain.

2.2.2 Analysis

In order to assess percentages of nests potentially at risk from burning, the proportions of nests of each species where the first egg was laid by the relevant cut-off dates were calculated. These proportions were calculated separately for nests for non-SDA and SDA areas) and for both combined. As an alternative view of the distributions of laying dates, percentiles of total nests were calculated at 5% intervals from 5% to 100% for the same categories of nests. This analysis was made for all species listed in Appendix 1 with sufficient samples.

Additional analyses were carried out for Yellowhammer, as this species had not been included in the Moss *et al*. report. Least squares multiple linear regression was used to investigate possible relationships of the continuous variables altitude, easting, northing and year with first egg-laying date. Linear and curvilinear relationships were explored. So as to avoid numerical problems, the four variables were approximately centred prior to calculating the regressions, by dividing by the mean value for each variable. All four variables and their quadratic terms were entered into the model as continuous variables; year was not considered a categorical variable so as to be able to detect trends with time. However this does not allow for the relationship with year to show effects of different years due for example to weather conditions, and this should be borne in mind when considering the results of the analysis. Analyses should be treated with caution due to the small sample sizes.

Models were fitted using a stepwise procedure: predictors were entered into the model in order according to the percentage of remaining variance in first egg-laying date they explained, but also were removed if their significance level fell below 0.05. The procedure stopped when no more variables could be added with significance less than 0.05, and all those remaining had significance below 0.05. For each regression the overall significance (F value), and predictors with their coefficients and significance was tabulated.

2.3 Ringed pulli

The BTO Ringing Scheme provides information on the dates of ringing of pulli (nestlings) which can be used to estimate nesting dates. The scheme covers Britain and Ireland, and approximately 2000 trained volunteers ring around three-quarters of a million birds of a wide variety of species each year, with a total to the end of 2004 of almost 33 million ringed (Clark *et al*. 2005). Annually there are over 11,000 subsequent reports of ringed birds (recoveries) that have either been found dead or have been recaptured at least 5km from their original capture site. Over 610,000 such recoveries had been received by the end of 2004 (Clark *et al*. 2004). Ring-recovery data in this report refers to the ringing of birds at one point in space and time with later recapturing, resighting or finding. All records of dead birds have been computerised, regardless of the distance moved from ringing to later recovery. In contrast, live recoveries (recaptures & resightings) have only been computerised for those records that meet certain criteria or have travelled more than 5km from the original ringing site (Clark *et al*. 2004). All recoveries of birds ringed in Britain and Ireland since the start of the Ringing Scheme in 1909 have been computerised. However, this is not the case for ringing records, as the routine computerisation of records by ringers only started from 1995 onwards. Since that date a rapidly increasing proportion of records of all birds ringed have been computerised, and individual ringers and ringing groups are now also submitting computerised back-data from before 1995. In this analysis, ringing data from both the recoveries and ringing data sources were combined.

2.3.1 Derivation of a set of independent records

When a bird is ringed, the species, age, sex, date and place of ringing are recorded. All available ringing records for the study species were extracted. No data were available for Black Grouse, as only very few are ringed as part of the BTO Ringing Scheme. It was not possible to distinguish records derived from the ringing of birds that had subsequently been recovered, which spanned 1909 to 2004, from records derived from the routine computerisation of ringing information by ringers, mainly from 1995 to 2004. Records of the first type were considered to be statistically independent, since there was a very low probability that more than one member of a ringed brood would be recovered. However, records from ringing included all members of each brood ringed, and therefore the data would have been biased if every brood member were to be included in the analysis. The ringing records do not specifically identify members of individual broods, but they do record the number of pulli ringed in each brood. It was possible to detect the numbers of broods with identical combinations of species, grid reference, year, ringing date and brood size, and to enter just one record from each such brood. For example if there were three records with brood size three which were identical apart from the ring numbers, one of these records was retained; if there were 20 identical records with brood size four, these were assumed to derive from five distinct broods, so five copies of the record were retained.

For a number of rare species or species vulnerable to persecution, the exact coordinates for grid reference were not provided and records for these species were included if the ringing location accuracy is within at least half a degree of latitude and longitude (Wernham & Siriwardena 2002).

The availability of records of ringed pulli varies between species and to some extent year, dependent on the ease of finding the nests or chicks for that species, and whether ringers were involved in intensive studies, which may have lasted for several years but have been localised to certain areas. For example, there are very few data for Skylark, the nests of which are difficult to find, or for moorland Wrens, which generally are not ringed as pulli.

2.3.2 Selection of pulli ringed in upland areas

Pulli ringed in upland areas were selected according to Environmental Zone 3 (see above and Figure 2.2.1). Records with an accuracy of grid reference to within 1km and records with ringing date accuracy to within a day were included in the analysis. As for NRCs, eastings and northings (km east and north of the origin of the National Grid) were calculated from grid references.

2.3.3 Estimation of first egg-laying date

To enable the back-calculation of the first egg-laying date from the date of ringing, Harrison (1975) or other references were used to obtain the species-specific clutch size, egg-laying frequency, length of the incubation and length of the nestling period. See Appendix 2 for details. The average value was taken for the clutch size where a range was given, and similarly the average length of the stated range was taken for the incubation period. As there was no information available regarding the age at which the majority of pulli are ringed, it was assumed for the purposes of this study that pulli were ringed mid-way through the nestling period. Again if a range of values was given, the average value was used for the nestling period. Therefore, the first egg-laying date was back-calculated from the date at which the pulli were ringed by subtracting the sum of the following (in days): (1) length of the mid-way stage of the nestling period; (2) length of the incubation period; (3) length of the period from the laying of the first egg until incubation begins multiplied by the average number of eggs laid before incubation begins. For passerines that lay one egg per day and begin incubating on laying the last egg, item (3) was equal to average clutch size minus one.

For nidifugous species, i.e. those whose chicks leave the nest very soon after hatching, an alternative assumption that the chicks were ringed the day after hatching was also used. This may be more likely since such chicks become dispersed and more difficult to find by the middle of the nestling period. This assumption was tested for gulls and waders alongside the mid-fledge estimates.

2.3.4 Altitude data for ringing records

Altitude is not recorded on ringing records, although data at a 1km square resolution was available and matched to records. These data were derived from the DEM (digital elevation model) obtain from the USGS and form part of the HYDRO1K data project (Baer *et al*. 2003).

2.3.5 Analysis

The same procedures as for NRCs (see 2.2.2) were used for analysis of ringed pulli. The proportions of pulli that resulted from nests where laying had started by the specified dates relevant to burning were calculated. Percentiles were calculated at 5% intervals. For the 12 nidifugous species, the two assumptions for ringing age were both analysed. For Black-headed Gull and Yellowhammer, which were not analysed in the Moss *et al*. (2005) report, multiple linear regression was used to assess the possible relationship of first egg-laying date with linear and quadratic variables for easting, northing and year. Variables were centred on the mean value of each variable.

2.4 Pre-nesting periods

Information on the likely duration of pre-nesting/nuptial behaviour prior to laying for the majority of species here has previously been collated for all species except Yellowhammer and Black-headed Gull (Moss *et al*. 2005). For these two species we estimate time periods over which pre-nesting behaviour occurs on the breeding grounds.

2.5 Seasonal variation in breeding performance

Nest record card data has previously been analysed to investigate seasonal variation in breeding performance for all species where data were available except Yellowhammer in Moss *et al*. (2005), which is carried out here.

The following variables were used:

- First egg date – the date on which the first egg in the clutch is likely to have been laid – as analysed elsewhere in this report.
- Clutch size – the maximum number of eggs found in a nest. Clutch size data were rejected if egg-laying could have continued after the last visit of the recorder.
- Brood size – the maximum number of young found in a nest. This is likely to overestimate the brood size at fledging, but will approach it if mortality early in nestling life (when chicks are often most vulnerable) is the most significant form of partial brood loss.
- Hatching success – the ratio of brood size to clutch size, where the whole nest did not fail. This incorporates early losses of chicks, as well as hatching success (the proportion of eggs that hatch successfully).
- Daily nest failure rates before and after hatching (see below).

The number and timing of visits recorded on each NRC, relative to nest progress, determined which of the above variables could be calculated, so the sample sizes of the analyses differed between variables.

The variation in each nest record variable with respect to laying date was investigated using generalised linear models in the GENMOD procedure of SAS (SAS Institute 1996). Daily nest failure rates were estimated using a formulation of Mayfield's (1961, 1975) method as a logistic model with a binomial error term. Success or failure over a given number of days (as a binary variable) was modelled with the number of days over which the nest was exposed during the egg or nestling periods as the binomial denominator (Crawley 1993, Etheridge *et al.* 1997, Aebischer 1999). The numbers of exposure days during egg and nestling periods were calculated as the mid-points between the maxima and minima possible, given the timing of nest visits recorded on each NRC. (Note that exposure days refer only to the time span for which data were recorded for each nest and do not represent the full length of the egg or nestling periods). Hatching success was also modelled using a logit link and binomial errors, brood size forming the numerator and clutch size the binomial denominator. Individually, clutch and brood sizes were modelled with identity links and normal errors, as were first egg dates. In each model, both linear and quadratic terms were included and only the significant terms reported.

3. RESULTS

3.1 Proportion of nests for which laying had started by specified burning cut-off dates

The proportions of nests for which laying is estimated to have started (first egg-laying date) for five cut-off dates 15th March, 31st March, 15th April, 30th April and 15th May and categorised by SDA and non-SDA areas are presented for BTO nest records, BTO ringing pulli and for data from RSPB Wales in Appendices 3-5. This information is also presented graphically for SDA and non-SDA areas combined in Figures 3.1.1a-s. All results are presented regardless of sample size, although caution should be made where results are based on a small sample size. We suggest that a caveat be placed on samples of less than 20 nests, although this is an arbitrary cut-point.

Ringing of pulli was assumed to be mid-way through the nestling period for most species for nidifugous species, ringing is at age one day.

3.1.1 Moorland and rough grassland/moorland edge species

The NRC analysis shows that by 15th March in the upland Environmental Zone 3 no species had begun laying in SDA and non-SDA zones. By 31st March 23% of Peregrines, 7% of Lapwing and 3% of Stonechat had started laying on SDA land. By 15th April the percentages had increased to Peregrine (78%), Lapwing (26%) and Stonechat (19%).

For the ringed pulli by 15th March 34% of Lapwing had started laying (assumed at mid-nestling). By 31st March Peregrine (8%) had started laying on SDA land, whilst on non-SDA land, Peregrine (19%) and Lapwing (31% 1-day) had started nesting. By 15th April Peregrine (70% non-SDA, 60% SDA), Lapwing (60% 1-day) and Hen Harrier (2% >250m) had begun laying.

The RSPB Wales data shows that by 15th March 4% of Lapwing had begun laying, whilst by the 31st March 18% of Lapwing and 5% of Golden plover had started laying. By 15th April the percentages had increased for Lapwing (47%) and remained at 5% for Golden Plover.

3.1.2 Subsidiary upland species

By 15th March of species in the upland Environmental Zone 3, Raven (81% non-SDA, 80% SDA) is well into the breeding season. By the 31 March the majority of Ravens had laid eggs (100% non-SDA, 97% SDA) and Stonechat had started laying (3%). The percentage of Stonechat that had laid by the 31 March was 3%, which had increased to 19% by the 15th April.

The ringed pulli data show that by 15th March a large proportion of Ravens had started laying (75% non-SDA; 66% SDA), whilst by the 31st March the majority of Raven had laid eggs (93% non-SDA, 97% SDA).

The RSPB Wales data shows that by 15th March 76% of Ravens had begun laying, whilst by the 31st March this had increased to 100%.

3.2 Analyses of national data for Yellowhammer and Black-headed Gull

Table 3.3 gives the results of the multiple linear regression for NRC and ringed pulli data of first egg-laying date with altitude, easting, northing and year for species which showed a significant effect with one or more of the predictors. Linear and quadratic terms were used. All predictors are centred around their overall mean values. As there were few data for pulli ringed before 1950, they were also excluded from the dataset so as to reduce skew in variable year.

Statistical significance does not always imply biological significance, and the strength of the association of first egg-laying date with the predictors is often weak, suggesting other factors are important in explaining first egg-laying date. The percentage of total variance in first laying date explained by the ringing pulli regression model was low (Black-headed Gull 10% & Yellowhammer 8%. The total variance explained by the nest record Yellowhammer data was 12%. The remaining variation was due to factors which could not easily be assessed, and were not available for these data, for example: year-to-year variations in weather, food supplies, fitness of breeding birds, habitat quality and density dependence.

Using ringing data, Black-headed Gull showed a quadratic relationship with year and latitude, showing an earlier laying date in recent and early years and at highest and lowest latitudes. For Yellowhammer, nest records showed that laying was later as one moves northwards, and for ringing data laying was later becoming later at a greater rate as one goes northwards.

3.3 Pre-nesting periods for Yellowhammer and Black-headed Gull

Information gathered from the literature review for Yellowhammer and Black-headed Gulls is given in Table 3.4. Table 3.4 indicates that Yellowhammer, which is largely sedentary may be affected by burning at any time of the winter, although there is a tendency for birds from high altitudes in the autumn and winter to withdraw from upland areas. For Black-headed Gull birds are distant from the colony during January, with return movements taking place thereafter, with birds reaching the breeding colonies by April.

3.4 Trends in breeding performance for Yellowhammer

Analysis of trends in breeding performance for Yellowhammer are detailed in Table 3.5. Trends in clutch and brood size declined towards the end of season after an increase. There was no evidence for a seasonal pattern in hatching success, nest failures at the egg or young stages in this species.

4. DISCUSSION

4.1 Analyses of NRCs / ringed pulli and data from RSPB Wales

With the current burning regime in Wales (burning on SDA land up to 15th April) laying would have started in up to 13% of Golden Plover, 5% Hen Harrier, 59% of Lapwing, 1% Meadow Pipit, 79% of Peregrine, 100% of Raven, 20% Stonechat, 4% Wheatear and 1% of Wren. In comparison, by bringing forward the last burning date to 31st March, laying would have begun in up to 5% of Golden Plover, 29% Lapwing, 26% Peregrine, 97% Raven and 3% Stonechat. With regard to Peregrine and Raven, although burning may not affect nests of these species directly, the effect on surrounding habitats and food availability may be deleterious nevertheless.

4.2 Limitations of the results

One of the major biases of NRCs is the potential for seasonal variation in the proportion of nests found due to changes in search effort and nest detectability (Crick *et al*. 2003). The majority of the nest records are collected between March and October, with the peak occurring during April to June. Thus for those species for which their breeding season falls largely within this period, particularly single-brooded species, there is little to suggest that NRCs will be biased with respect to season. Furthermore, the breeding season in upland areas is likely to be shorter generally than in lowland areas, due to climatic conditions, also making the problem of reduced late season recording effort less of an issue. Crick *et al*. (2003) assessed this problem by comparing recorded search effort with the nesting seasons for UK species provided diagrammatically by Campbell & Ferguson-Lees (1972) and adding on the length of the stage of nesting at which 75% of nests are found by nest recorders. Species in the current study, for which seasonal variation in search effort might compromise estimates of the distribution of laying dates because their egg-laying can extend into August are: Meadow Pipit, Skylark, Stonechat, Wheatear, Whinchat; and among the subsidiary species: Linnet and Wren. Similar factors may influence the ringed pulli data. The effect will be to truncate the later end of the laying date distributions, making the proportions of nests slightly higher in the early part of the season for these species. Given that the bulk of the nesting activity for these species occurs within the period of peak activity by volunteer nest recorders and ringers, it is unlikely that the under-recording of the diminishing tail of the distribution of late nests will exert a major effect on the results presented here. However, without knowing the true proportions of nests that occur during the latter part of the season, it is hard to quantify the extent of this potential problem. In this respect, it is reassuring to note that the results from the analysis of the RSPB data where available for particular species are in good agreement with those from the NRC and ringed pulli datasets.

Although the detectability of nests tends to decrease through the season, due to vegetation growth (Dwernychuk & Boag 1972, Yahner & Cypher 1987), this is unlikely to be a major factor in upland habitats where growth rates tend to be restricted due to the harsher conditions experienced than in lowland areas. Thus, although there might be a tendency for the later nests of multi-brooded species to be under-recorded in the uplands, as elsewhere, this is unlikely to be a major bias in the results presented here.

4.3 Seasonal trends in breeding performance in Yellowhammer

Seasonal patterns in breeding performance among birds have long been known to occur and have been ascribed to a range of different factors (Lack 1968, O'Connor 1984, Clutton-Brock 1991). For example, younger, relatively inexperienced birds tend to be less efficient at breeding than older, more experienced individuals, thus they tend to start laying later and lay smaller clutches (e.g. Coulson & White 1961, Newton 1976; see review in Saether 1990). Birds nesting in poorer quality habitats may also be constrained to lay smaller and later clutches, due to poor food supplies (Boutin 1990). Species that rely on short periods of food abundance, following closely after the date on which laying becomes energetically possible (usually single-brooded species), start laying at a time when the adapted clutch size is already declining, so that any delay will result in a decline in clutch size (Perrins

1970). Early breeding may be an advantage because it allows parents to re-nest after successful breeding or after failure, for example climate warming has permitted some European populations of Great Tits to increase the proportion of second broods raised, as birds have been able to start breeding earlier (Visser *et al.* 2003).

Crick *et al*. (1993) analysed BTO nest record data to show that seasonal declines in clutch size were the norm for single-brooded species, as well as for multi-brooded long-distance migrants. They also demonstrated that multi-brooded residents were more likely to show patterns of seasonal increase to a peak followed by decline. The trends revealed in Moss *et al*. (2005), using data for birds breeding in upland habitats, also followed these patterns.

Yellowhammer was not covered by Moss *et al*. (2005) but BTO nest record data are available for this species. Whilst trends in clutch and brood showed a decline towards the end of the season after an increase, this species does not start breeding until well after the cut-point for burning in Wales, so is unlikely to be affected directly by burning.

4.4 Other potential data sources and further research

This study highlights the lack of information available on the pre-nesting stage of moorland birds. In particular, it would be useful to have more information on when migrants (whether long- or short-distance) arrive back on their breeding grounds, and on the impact of burning on site fidelity in the short- and longer-term. In addition, there is a lack of information on how birds respond if they lose a nest to burning – do they attempt to renest? Are they able to move elsewhere to renest? How successful is re-nesting after burning? How does renesting after burning affect the survival of adults? It would be a valuable exercise to see whether any information on nest loss due to burning can be gleaned from the NRC data, as such losses are likely to be recorded by observers.

Finally, this analysis has revealed that the sample sizes for NRCs and ringed pulli in the uplands are often relatively small. There is a need to promote more volunteer effort in these areas by raising the profile of the conservation importance of the habitats and the issues concerning them. Increased effort in the areas would help in the monitoring of the impacts of burning in these areas in the future.

4.5 Risk analysis

Although these results can be used to indicate the vulnerability of moorland birds to the potentially damaging effects of burning during the approved periods, they do not show what proportion of nests are actually affected. This ‘true’ vulnerability may depend on aspects such as the choice of nest sites in relation to the types of heather that are burnt, which may in turn vary depending on the objectives of burning. For example, Golden Plover tend not to nest in stands of mature heather that are ready for burning as part of grouse moor management (though they do nest in shorter and fragmented heaths, e.g. Ratcliffe 1976), but may be affected if a fire spreads into other more suitable habitats. They may also be affected by burning (swaling) on grass moorland and blanket bog.

A number of additional factors must be taken into account to assess that risk:

(1) The proportion of suitable habitat subject to management through burning;
(2) The frequency with which a managed moor is burned;
(3) The effect of burning operations on the species’ nesting attempt .

A number of potential approaches to creating a vulnerability index are possible:

One approach would be to assess the proportions of the populations of each species that occur in areas likely to be subject to burning. Advice from Country Agencies would be needed to define such areas. or, alternatively, the Defra Moorland Line could be used. A cruder approach would be to use data from the 1988-1991 Breeding Bird Atlas (BBA; Gibbons *et al.* 1993) to assess the proportions of each population that occurs above and below certain altitude levels within the areas covered by the CS2000 upland Environmental Zones (see above). Relative abundance in the BBA is not a direct measure but is estimated from the frequency of occurrence of species in the tetrads surveyed in each 10-km square: the assumption being that frequency of occurrence is related to relative abundance.

Another approach would be to use the BTO/JNCC/RSPB Breeding Bird Survey (BBS) data to undertake a similar analysis. BBS data would be available for recent years and the information on relative abundance would be based on count data instead of presence/absence data. This would require the Kriging of BBS abundance data to produce a smoothed map of abundance for each species that could then be overlaid against the altitude and Environmental Zone information to estimate the proportion of each population within the potential burning areas.

A third approach would be to use BBS data to estimate the proportions of each species occurring in the key burning habitats within each country. BBS surveyors record bird densities and habitat for each of the ten 200 m transect sections within their 1-km survey squares. These data could then be used to estimate habitat-specific densities and the extent of each habitat within a country to provide total population estimates for that habitat. A further refinement would be to consider low and high altitude squares separately to estimate the proportions of each population in these altitude bands.

Other factors associated with each species' natural history could also be included, as qualitative measures to scale the vulnerability indices estimated from the proportions of each population at risk. For example ground-nesting species that tend to nest in tall rank heather would have a higher risk factor than a species that tended to use recently burnt areas or trees for nesting. The development of a risk analysis method would benefit from comment with stakeholders and experts in the field, followed by revision and potentially a further round of comment, before the production of a final index.

Some evidence on (1) and (2), above, is available from a recent study (Thomas *et al.* in prep.) which used aerial photographs to assess the extent of burning in a random sample of 1km squares covering upland habitats in England. They were unable to identify evidence of the often extensive burning of grass moorland and bog habitats due at least partly to limitations of the method. In dwarf shrub heath (which probably included wet heath and bog dominated by *Calluna*), which covered 24% of their study area, 71% of samples showed visible evidence of burning. Of this total, the average proportion of the *Calluna* area showing new or recent burning (up to 12 years old) was 38%. Frequency of burning of any given area was also estimated, with a modal return time of 16-20 years. Combining these estimates, we would conclude that the probability of burning a random sample area in upland heather moor in a given year could be 4-5%. Thomas *et al.* (in prep.) found that the typical area of individual heath burns ranged between 0.12ha and 0.55ha with a median value between 0.25 to 0.28ha.

Tucker (2003) included a literature review of the potential impacts of upland burning management, rather than the burning event itself, on some birds of conservation concern in England. Of these species, Hen Harrier, Merlin and Short-eared Owl were likely to suffer detrimental effects from heather burning due to loss of cover for nesting or for their prey. Black Grouse, Golden Plover and Skylark might gain some benefits due to regeneration of short swards or encouragement of grassland. Peregrine was considered not likely to suffer or benefit since they are cliff nesting. Certainly Rebecca & Cosnette (2003) reported a temporary decline in a Merlin population on Donside as a result of extensive burning, including on some steep heather banks. They noted that much of the burning was carried out into April, when Merlins would have been established on territory.

The study by Thomas *et al.* (in prep.) does not include any information on the timing of burning within the permitted periods. Tucker (2003) reports that most burning takes place over a relatively short period in spring when weather conditions and daylight are most favourable. This would suggest that burning is most likely near the cut-off dates which have been the focus of this study. We have found that proportions of several priority species begin nesting during the permitted burning seasons. The results presented in this study should enable policy makers to assess the potential effects on the birds of moorlands of any future legislative change in the burning season. For example, bringing the 31st March cut-off date back to 15th March on non-SDA land and from 15th April to 31st March would remove the earliest breeding species from significant risk. However, it should be borne in mind that birds will be on territories before this time, such that first egg-laying date does not equate to the start of the breeding season. Loss of a nest site during the pre-laying period will impact on the breeding season, as birds will need time to establish new territories and select/build a new nest site.

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Species name	Data source	Model R-square	F value	DF model	DF error	Prob F	Variable	Estimate	Std err	F	Prob F
Black-headed Gull	Ringing data	0.1003	225.72	5	10128	<0.0001	Intercept	324.55303	7.31015	1971.15	<0.0001
							east	-45.34862	3.47706	170.10	<0.0001
							north	-31.20070	2.12850	214.87	<0.0001
							east2	20.69233	1.97003	110.32	<0.0001
							north2	12.08777	0.88743	185.54	<0.0001
							year2	-156.15394	7.20747	469.40	<0.0001
Yellowhammer	Ringing data	0.0824	22.80	1	254	<0.0001	Intercept	165.81427	1.86747	7883.78	
							north2	-3.82917	0.80185	22.80	<0.0001
Yellowhammer	Nest records	0.1236	9.59	1	68	<0.0001	Intercept	134.10931	5.29417	641.69	
							north	15.21926	4.91538	9.59	0.0028

Table 3.3 Results of the multiple linear regression for BTO nest record card and ringing data of first egg-laying date with altitude, easting, northing and year for Yellowhammer (nest record and ringing) and Black-headed Gull (ringing). Linear and quadratic terms were used, hence altm1 = altitude, altm2 = altitude * altitude, etc. All predictors are centred around their overall mean values.

Species	Month birds return to upland breeding grounds	Present on breeding grounds in: late Feb.	early March	mid March	late March	early April	mid April	late April	Notes	Reference
Black-headed Gull	Early April					√	√	√	Adults are distant from the colony during January and return movements take place thereafter, with birds reaching the breeding colonies by April	Wernham *et al.* (2002)
Yellowhammer		√	√	√	√	√	√	√	Largely sedentary. However Lack 1988) suggests a minor change in distribution between the breeding season and winter range, with a tendency in winter to withdraw from upland areas. In Wales, bird leave the higher altitudes in autumn to congregate in small flocks on the lower ground. Median distance moved 1km.	Wernham *et al.* (2002) Lack (1988)

Key to symbols:
? Unknown; ↑ increasing during period; √ present

Table 3.4 Timing of return to breeding grounds and pre-nesting behaviour of Black-headed Gull and Yellowhammer.

Breeding variable	Parameter	Estimate	S.E.	Chi Square	P	df
Brood Size	Intercept	2.340183	0.410619			3334
Brood Size	**Laying Date**	**0.016122**	**0.005181**	**9.67**	**0.0019**	**3334**
Brood Size	**Laying Date Squared**	**-0.000064**	**0.000016**	**15.91**	**<0.0001**	**3334**
Clutch Size	Intercept	1.860631	0.449119			2328
Clutch Size	**Laying Date**	**0.023667**	**0.005622**	**17.66**	**<0.0001**	**2328**
Clutch Size	**Laying Date Squared**	**-0.000084**	**0.000017**	**23.76**	**<0.0001**	**2328**
Hatching success	Intercept	4.524102	1.921563			1438
Hatching success	Laying Date	-0.021461	0.023965	0.72	0.3609	1438
Hatching success	Laying Date Squared			23.76	0.3946	1438
Egg Failure	Intercept	-0.934371	1.089380			3565
Egg Failure	Laying Date	-0.020303	0.014064	2.03	0.1545	3565
Egg Failure	Laying Date Squared	0.000031	0.000044	0.48	0.4889	3565
Young Failure	Intercept	-3.72107	1.367003			2577
Young Failure	Laying Date	0.006372	0.017187	0.14	0.7098	2577
Young Failure	Laying Date Squared	-0.000021	0.000053	0.16	0.6889	2577

Table 3.5 Generalized Linear Modelling of aspects of breeding performance in relation to laying date for Yellowhammer. Terms that were significant at the P<0.05 level are highlighted in bold.

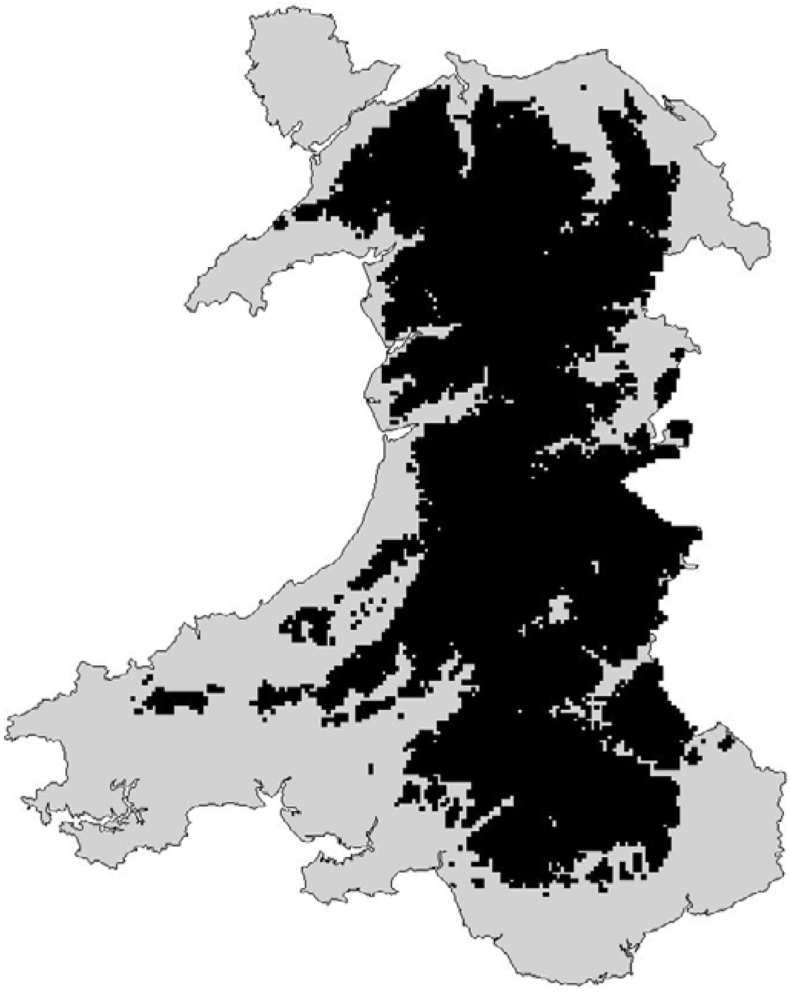
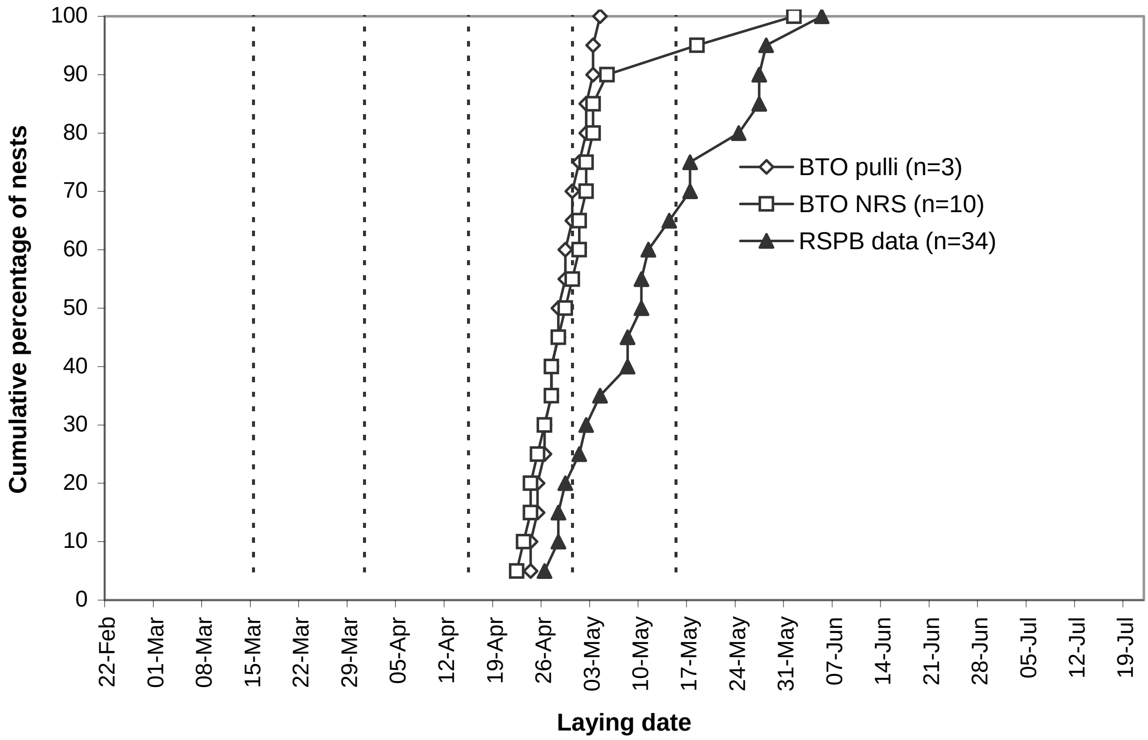


Figure 2.2.1 Great Britain is split into six environmental zones, of which upland areas in Wales are represented by Zone 3 (shown in black).

a) Curlew



b) Lapwing

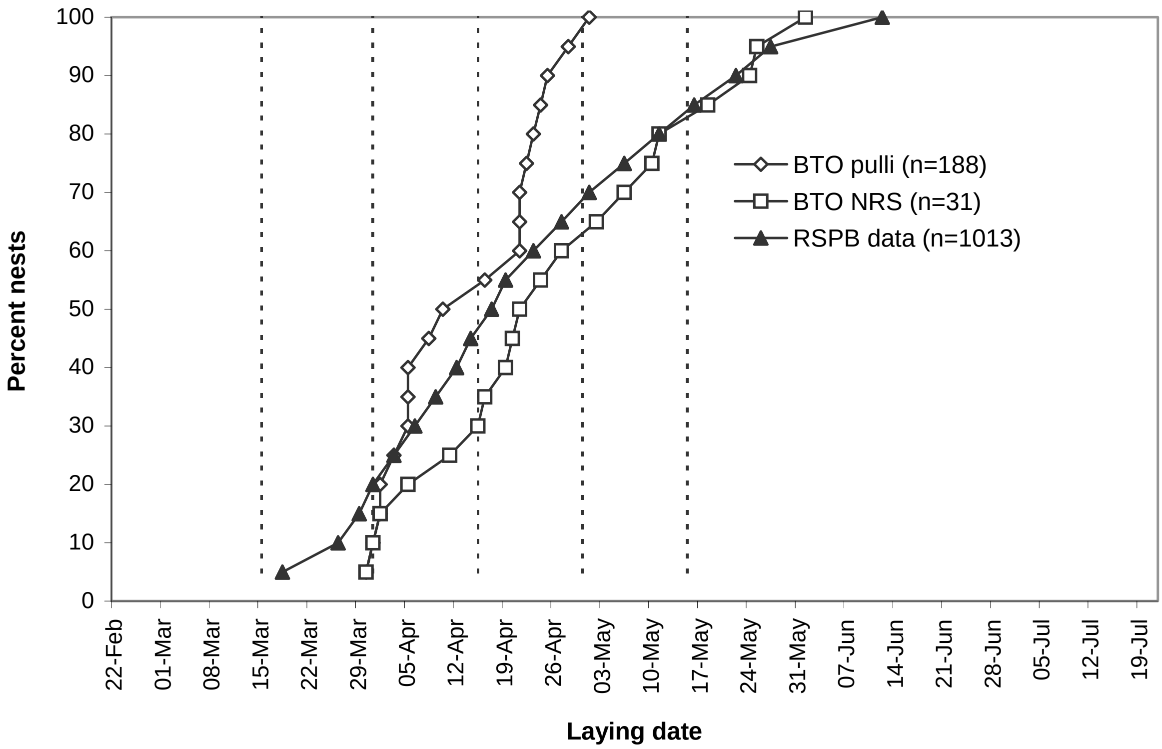
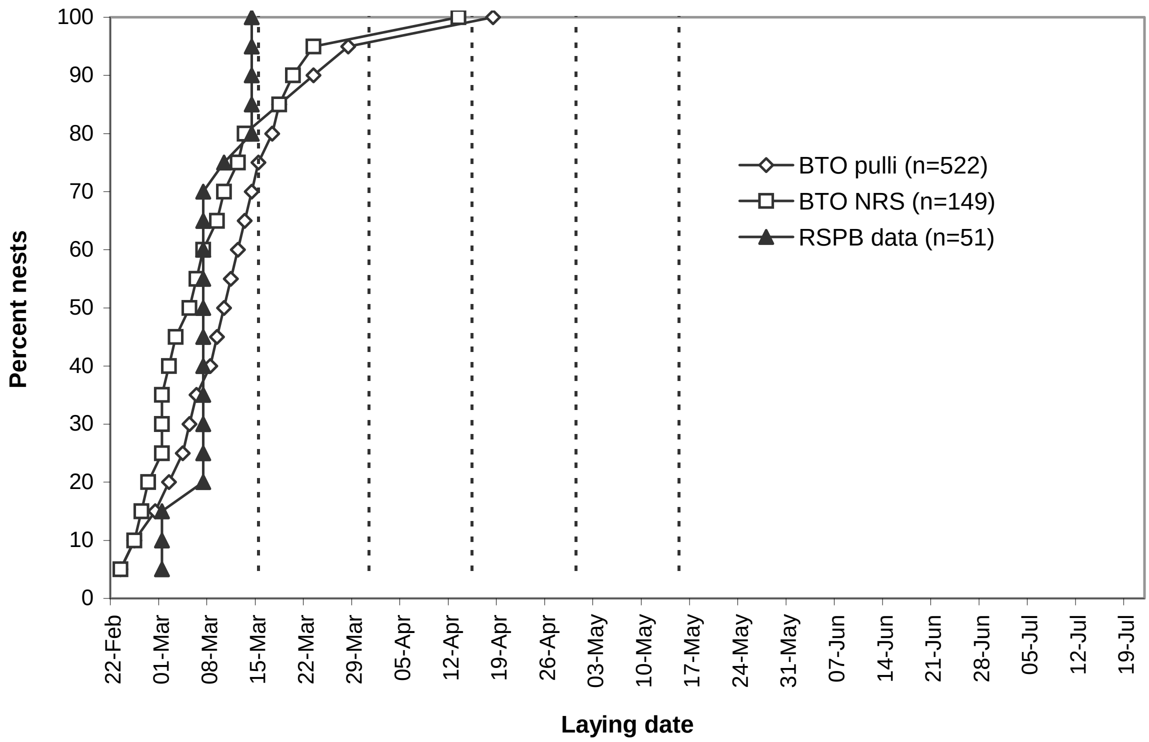


Figure 3.1.1 The cumulative number of nests in which laying had begun by 15th March, 31st March, 15th April, 30th April and 15th May according to BTO nest records and ringing pulli data and data provided by RSPB Wales where data were available.

c) Raven



d) Black Grouse

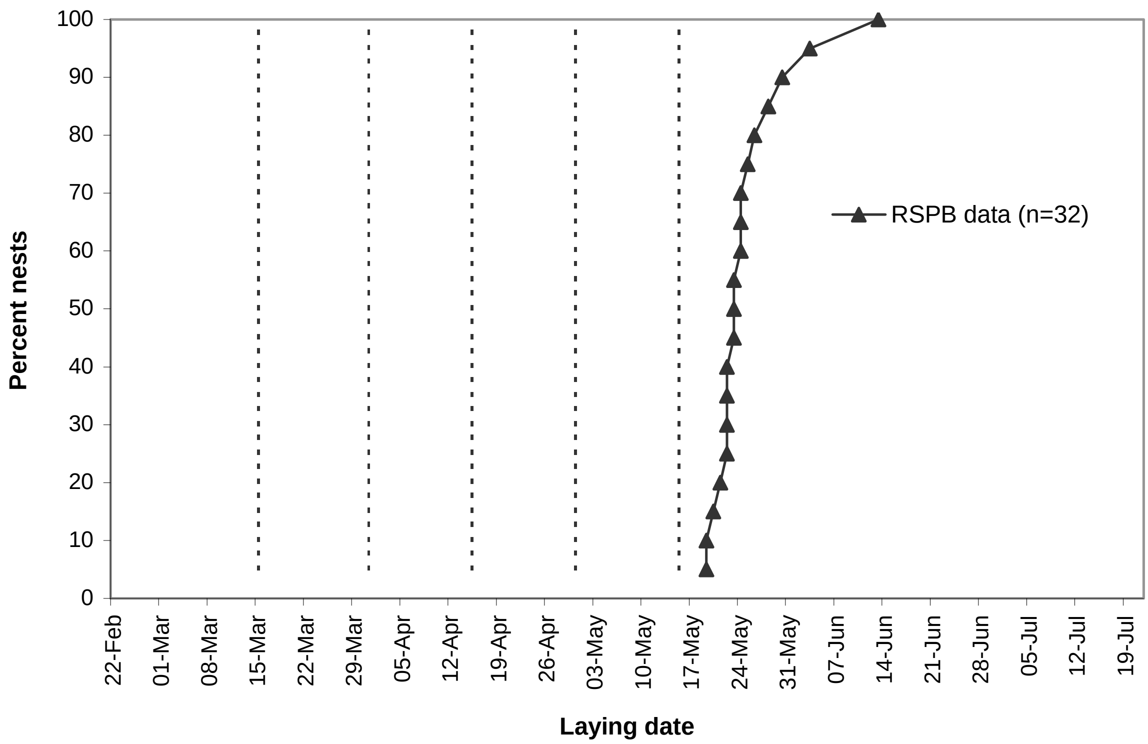
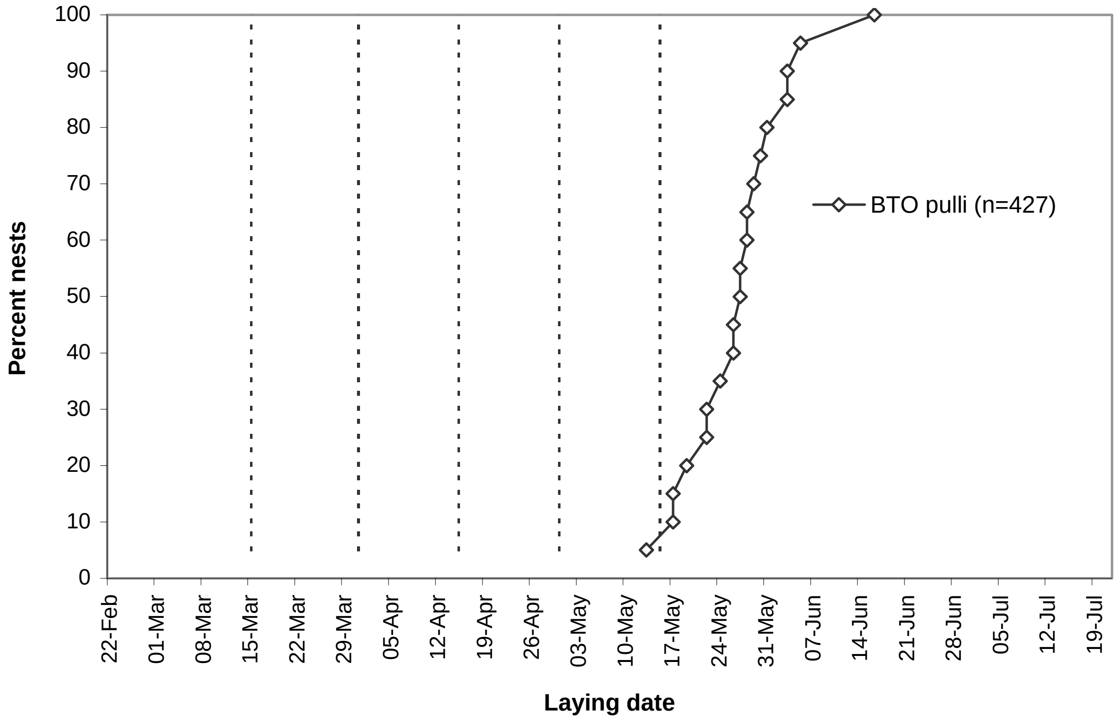


Figure 3.1.1 (continued)

e) Black-headed Gull



f) Dunlin

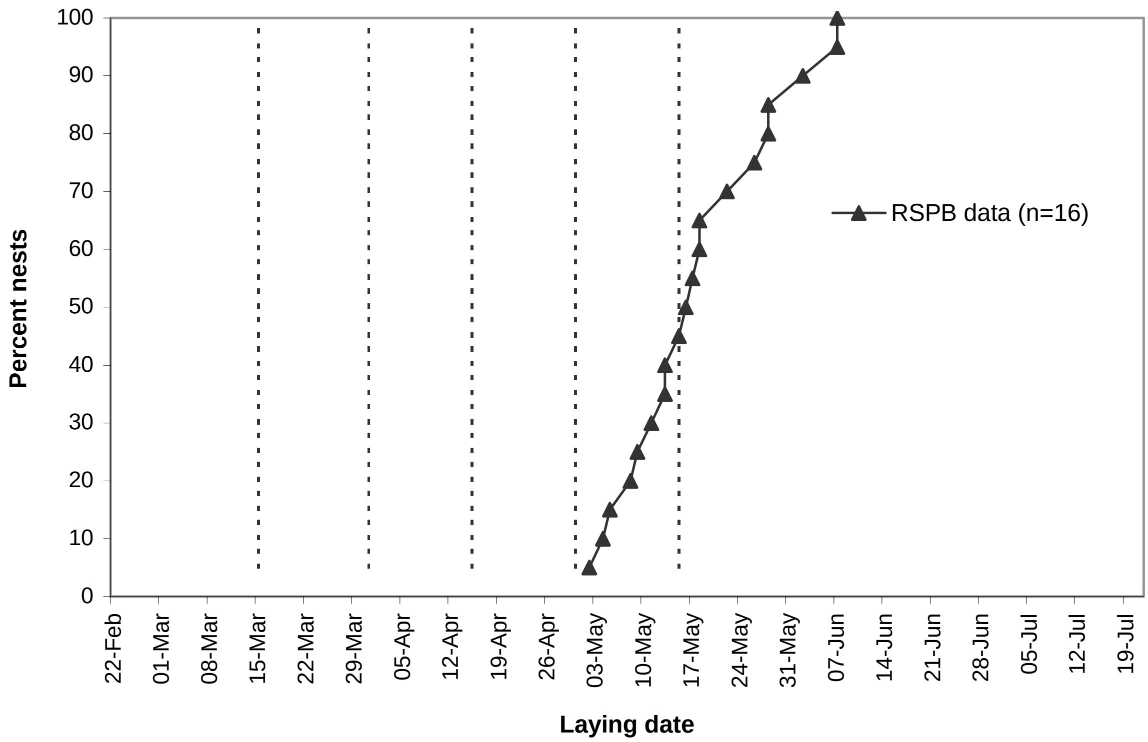
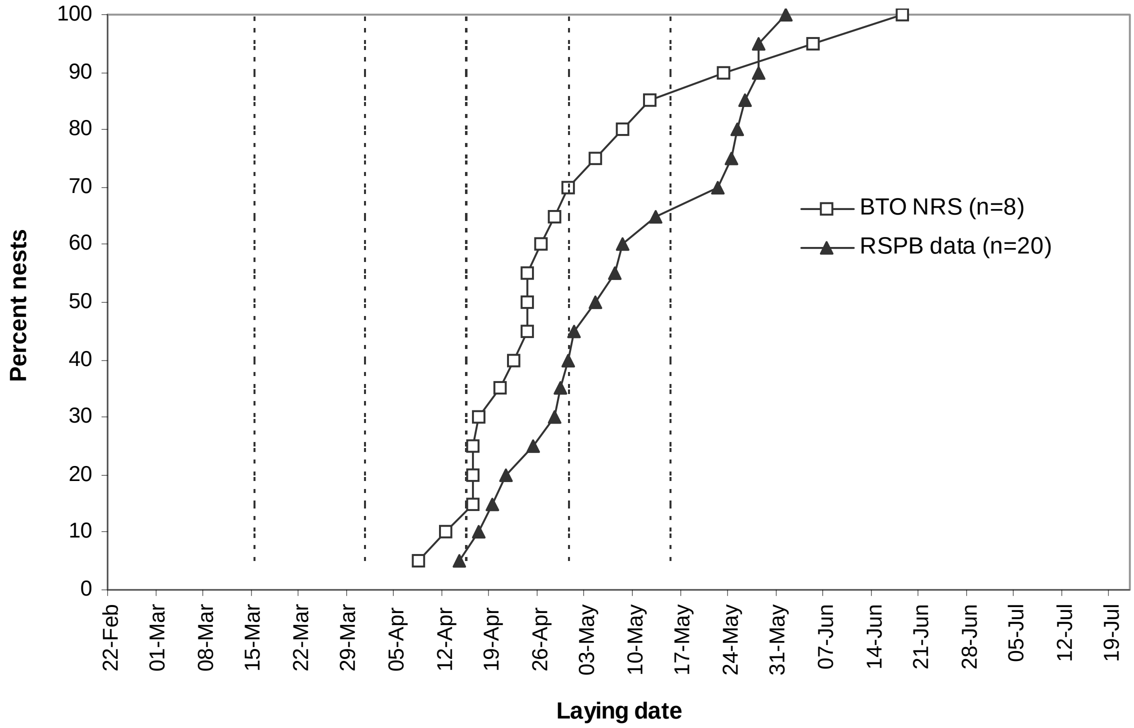


Figure 3.1.1 (continued)

g) Golden Plover



h) Hen Harrier

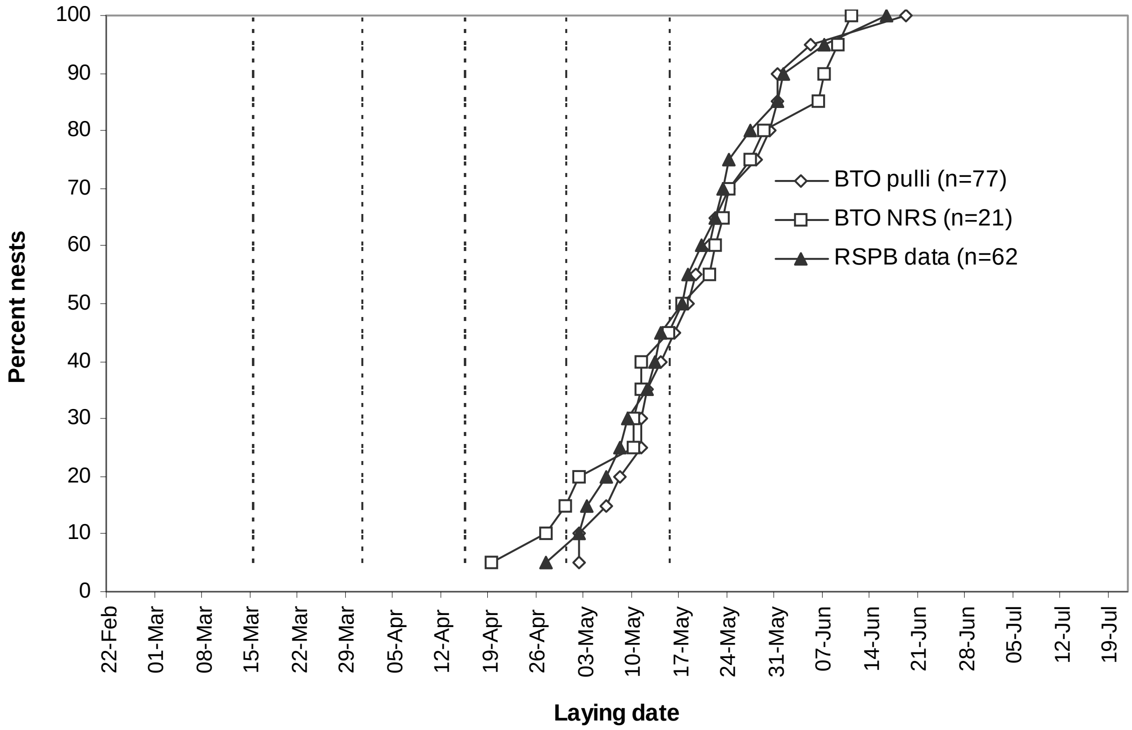
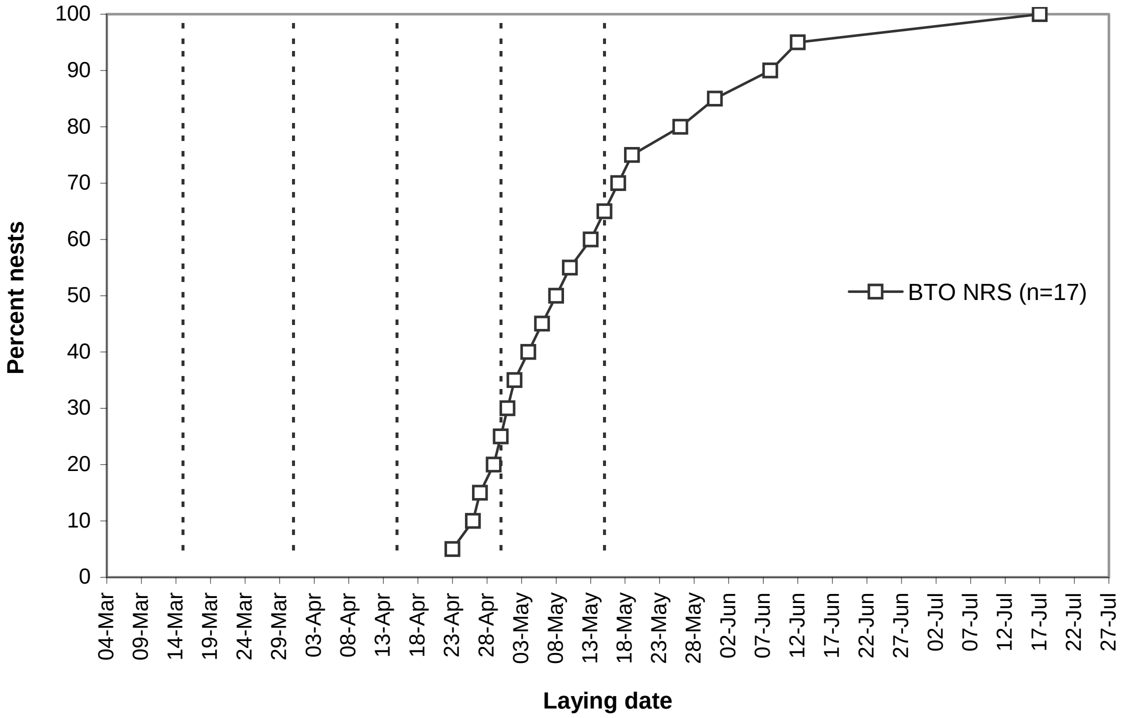


Figure 3.1.1 (continued)

i) Linnet



j) Meadow Pipit

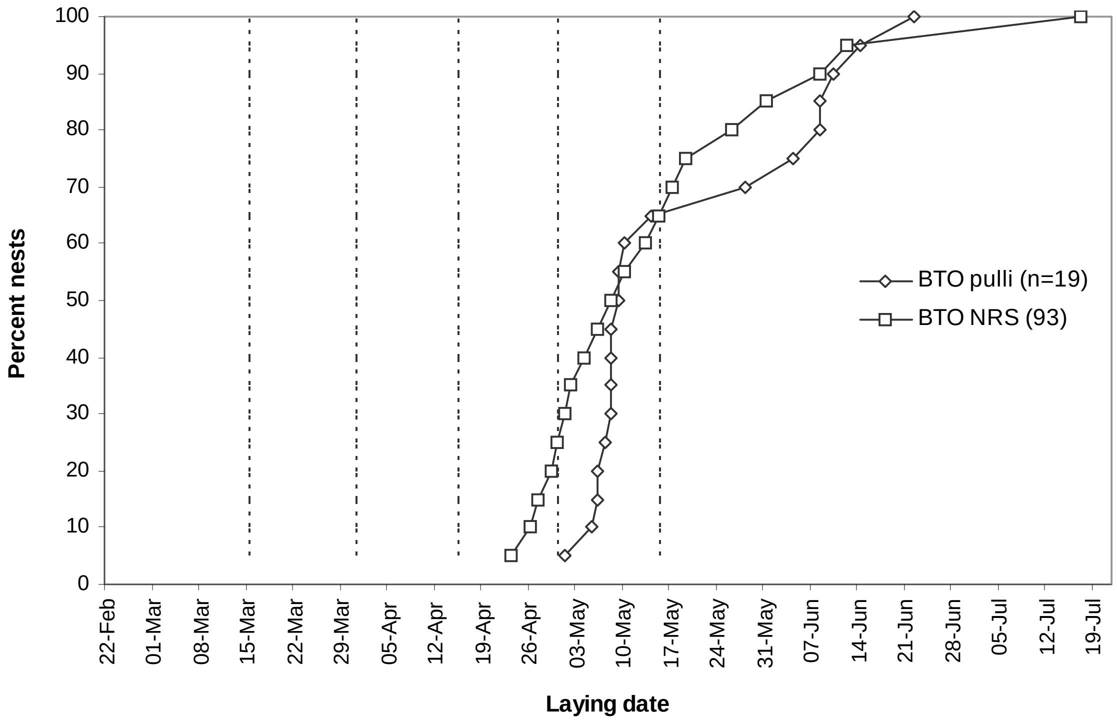
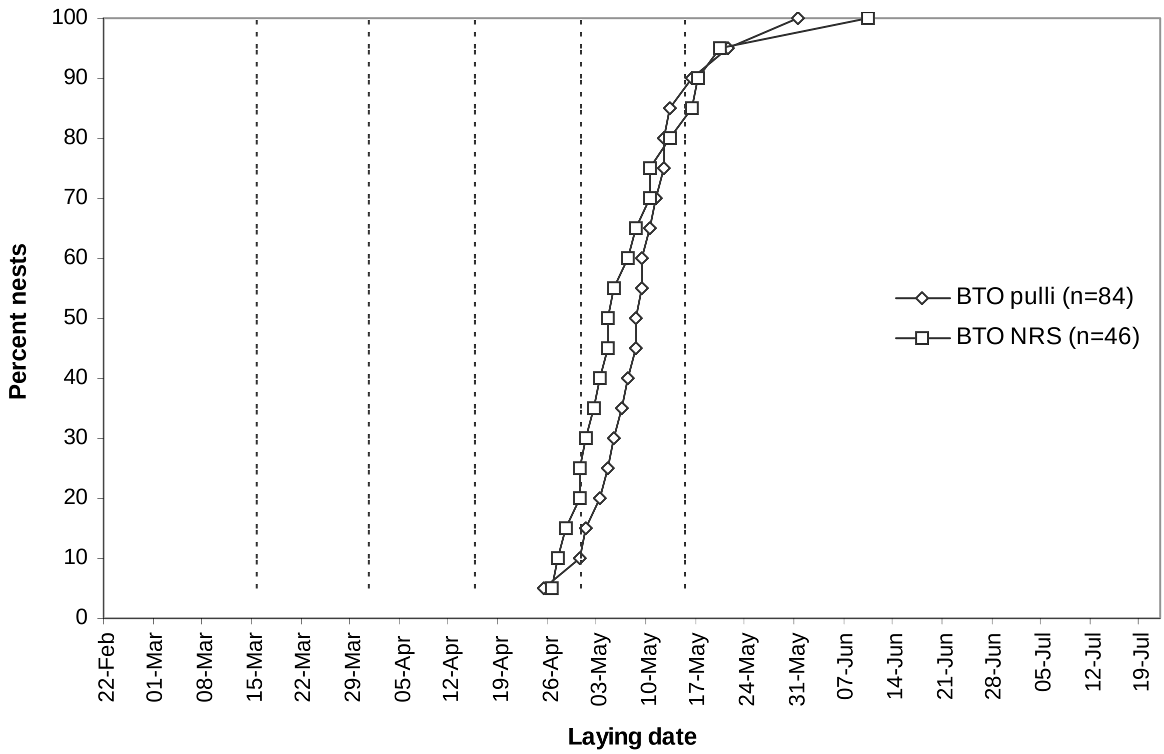


Figure 3.1.1 (continued)

k) Merlin



l) Peregrine

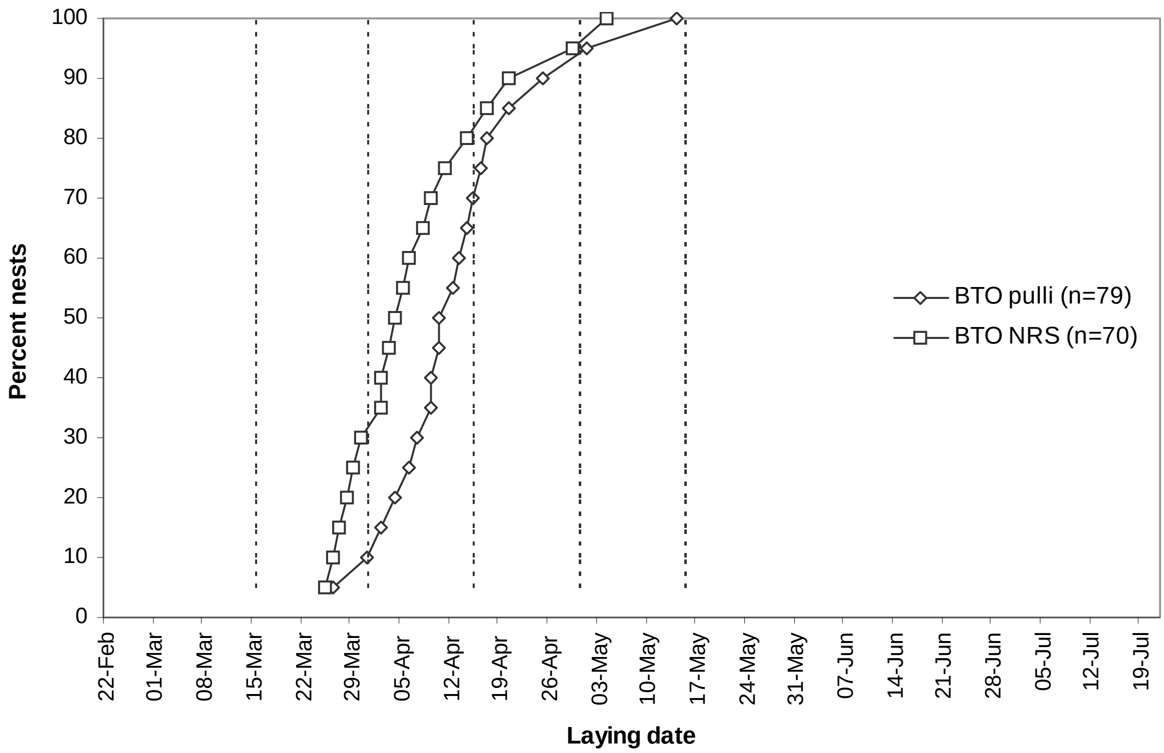
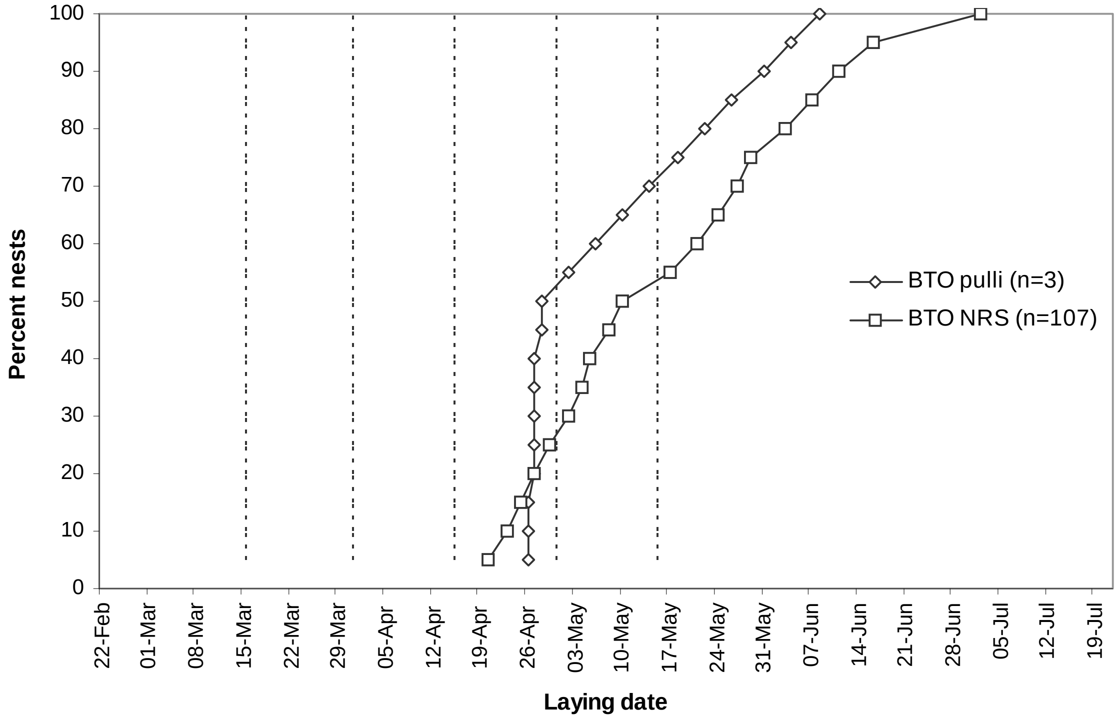


Figure 3.1.1 (continued)

m) Ring Ouzel



n) Skylark

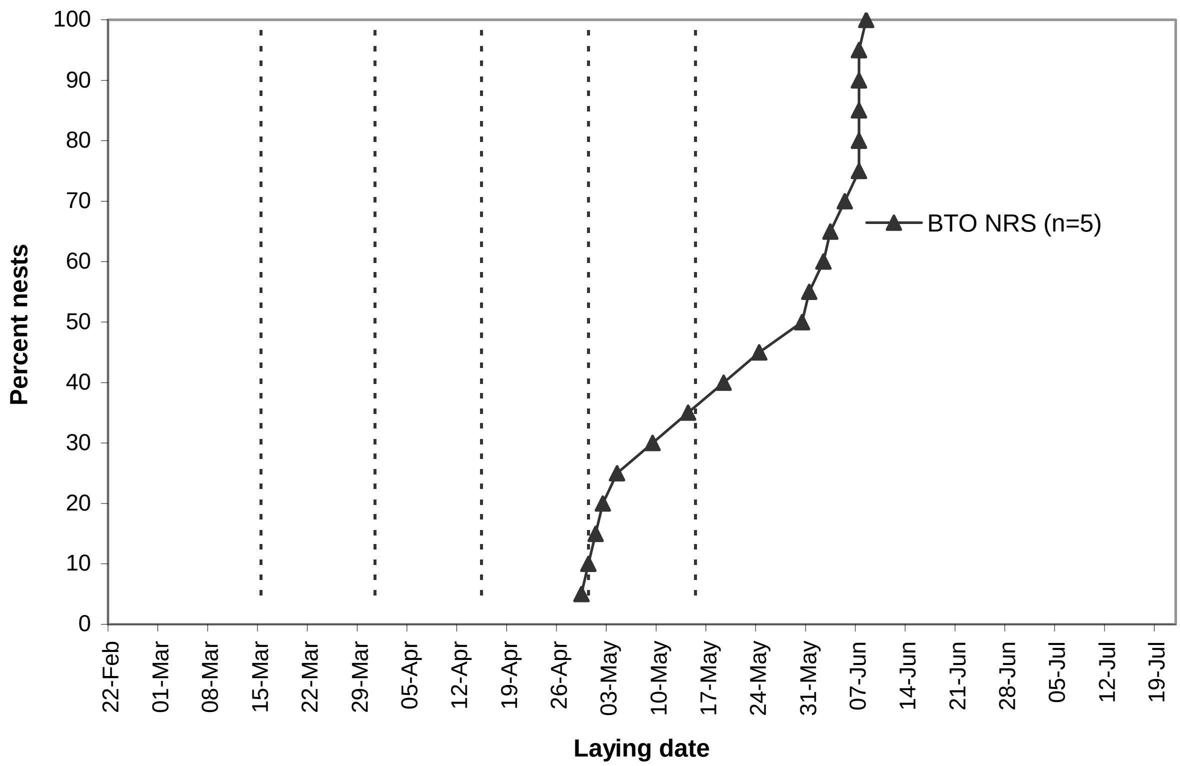
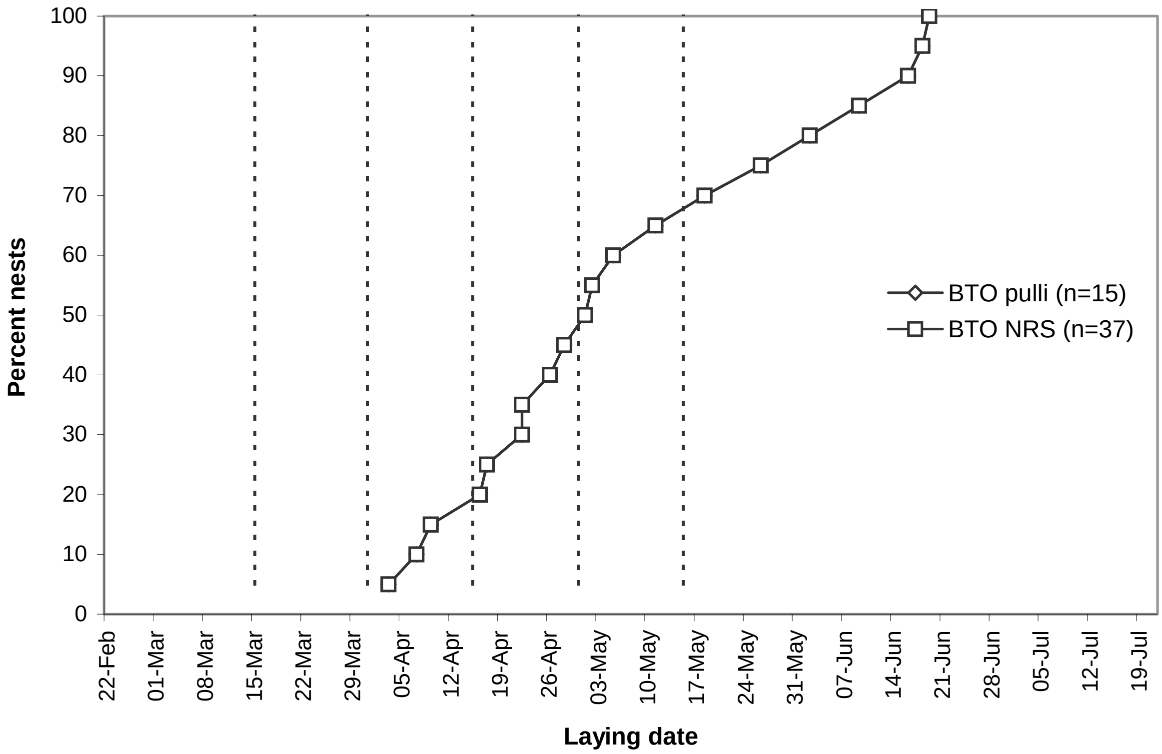


Figure 3.1.1 (continued)

o) Stonechat



p) Wheatear

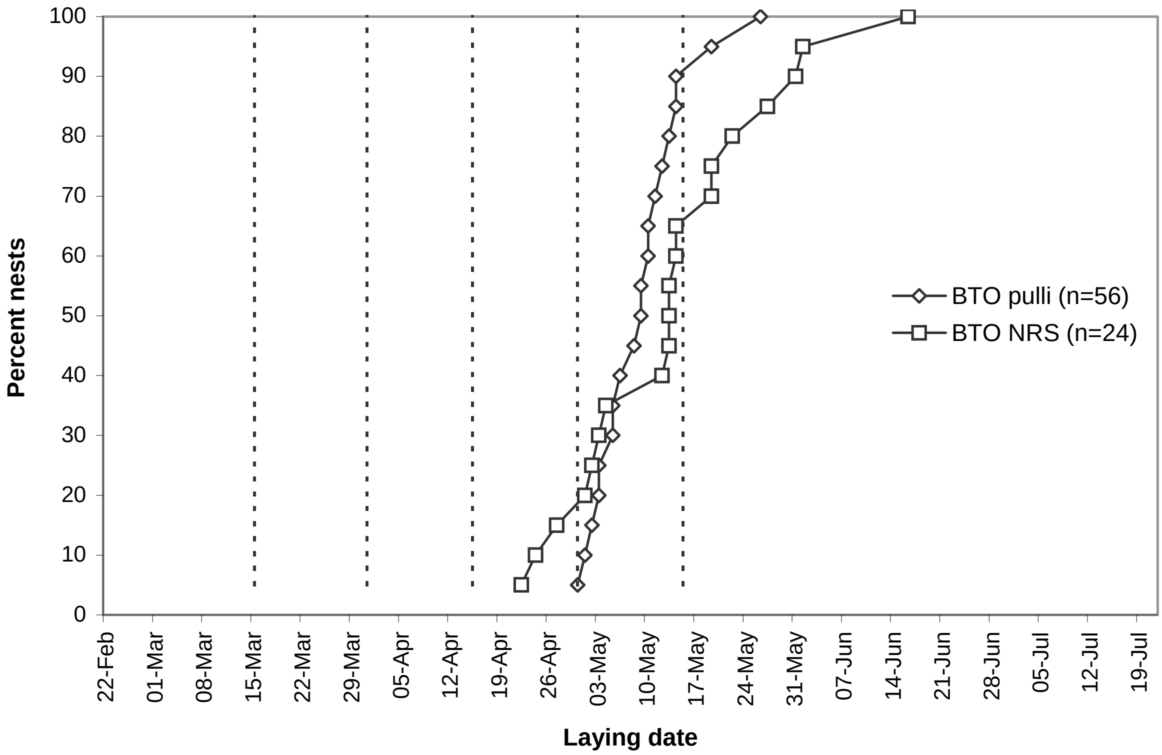
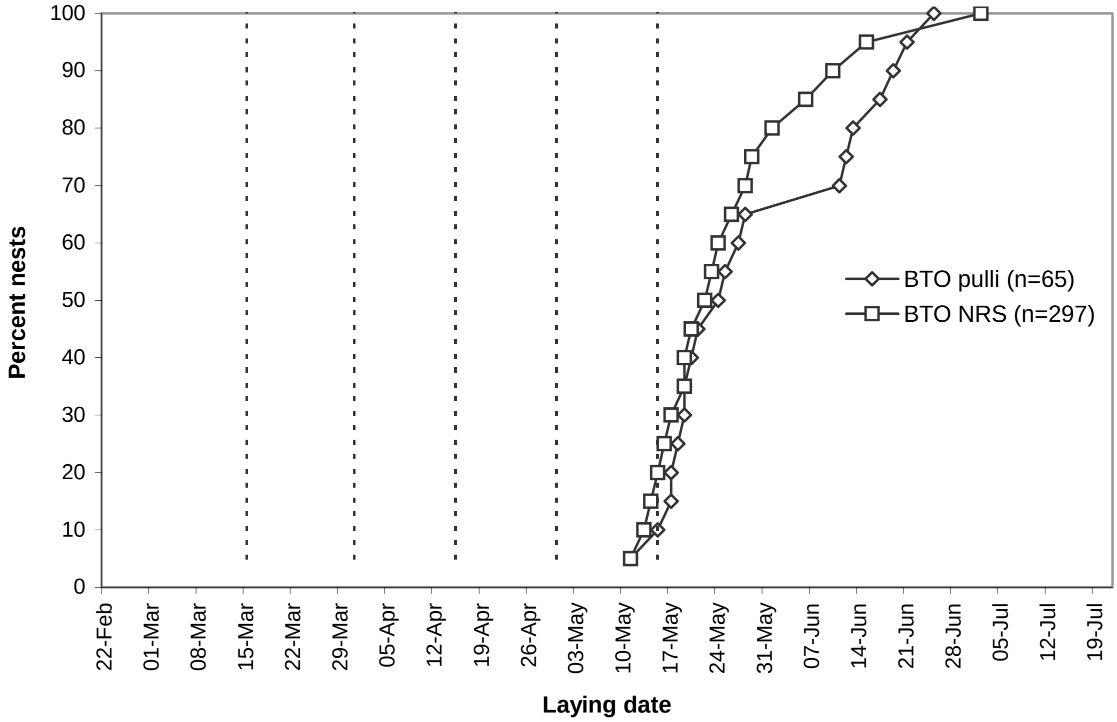


Figure 3.1.1 (continued)

q) Whinchat



r) Wren

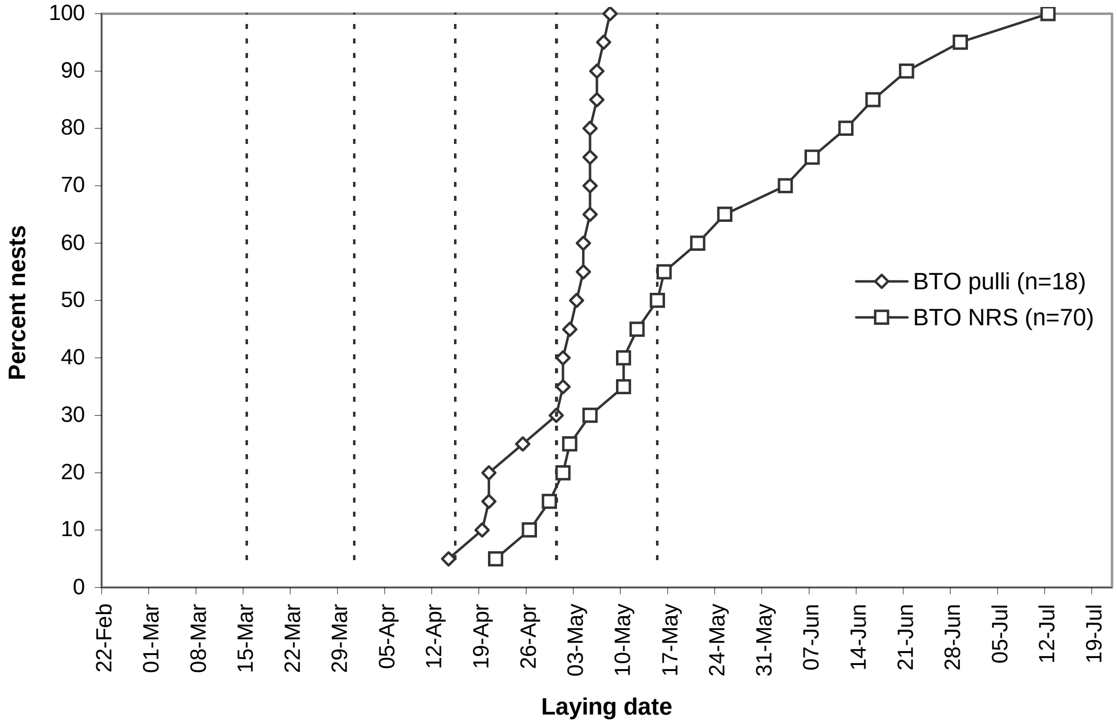


Figure 3.1.1 (continued)

s) Yellowhammer

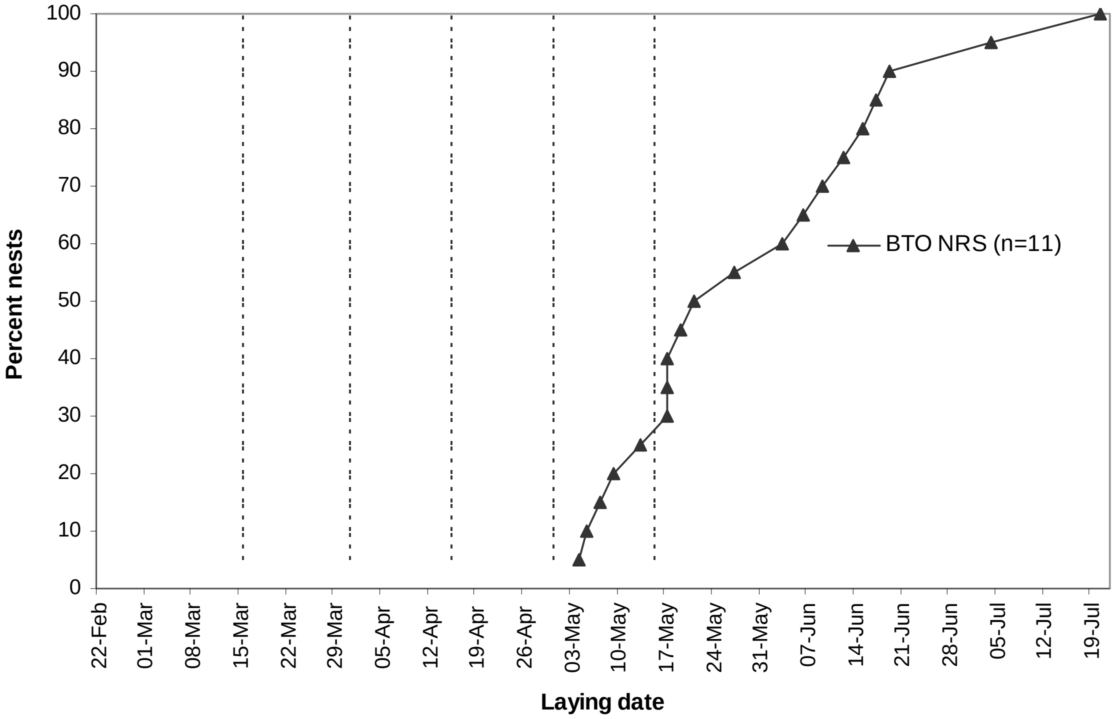


Figure 3.1.1 (continued)

Breed mainly in heather moorland	Category	Rough grassland / moorland edge species	Category	Subsidiary upland species	Category
Black grouse (*Tetrao tetrix*)	B	Curlew (*Numenius arquata*)	B	Black-headed Gull (*Larus ridibundus*)	B
Dunlin (*Calidris alpina)*	A	Lapwing *(Vanellus vanellus*)	B	Linnet *(Acanthis cannabina)*	B
Golden Plover (*Pluvalis apricaria*)	A	Skylark (*Alauda arvensis*)	B	Raven *(Corvus corax)*	B
Hen Harrier (*Circus cyaneus*)	A	Snipe *(Gallinago gallinago*)	B	Wren (*Troglodytes troglodytes*)	B
Meadow Pipit (*Anthus pratensis)*	B	Wheatear (*Oenanthe oenanthe*)	B	Yellowhammer *(Emberiza citrinella)*	B
Merlin (*Falco columbarius*)	A				
Peregrine Falcon (*Falco peregrinus*)	B				

Appendix 1 List of species considered for analysis according to their upland habitat use. Category A: all NRCs used as these species are predominantly upland; Category B: only ‘upland’ NRCs are selected according to Environmental Zone 3 (see methods).

Species	Incubation starts on egg	Mean laying interval	Mean incubation period	Mean nestling period	Subtraction for ringing at mid-nestling period	Subtraction for ringing at day 1	Reference[1]
Black-headed Gull	1	1	24	35	41.5	25	Cramp *et al.* (1977-1994)
Curlew	4	2	28	35	51.5	35	
Dunlin	4	1	21.5	25	37	25.5	
Golden Plover	4	2.5	27.5	28	49	36	
Hen Harrier	3	2	30	37	52.5		
Lapwing	4	1.5	26.5	33	47.5	32	
Linnet	5	1	12	15.5	23.75		
Meadow Pipit	4	1	13	12	22		
Merlin	4.5	2	30	27.5	50.75		Cramp *et al.* (1977-1994)
Peregrine	3	2.5	28.5	38.5	52.75		Cramp *et al.* (1977-1994)
Raven	4	2	20.5	42	47.5		Ratcliffe (1997)
Ring Ouzel	4.5	1	13.5	13.5	23.75		
Skylark	3.5	1	11	15	21		
Snipe	4	1	19	19.5	31.75	23	
Stonechat	5.5	1	14.5	12.5	25.25		
Wheatear	5	1	14	15	25.5		
Whinchat	6	1	13.5	13.5	25.25		
Wren	7	1	15.5	17.5	30.25		
Yellowhammer	4	1	12.5	11.5	21.25		

[1] Harrison (1977) unless otherwise stated.

Appendix 2 Values for back-calculation of first egg-laying dates for ringed pulli.

			Date by which X% had started laying																				
		N	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
Curlew	All	10	22-Apr	23-Apr	24-Apr	24-Apr	25-Apr	26-Apr	27-Apr	27-Apr	28-Apr	29-Apr	30-Apr	1-May	1-May	2-May	2-May	3-May	3-May	5-May	18-May	1-Jun
Curlew	SDA	10	22-Apr	23-Apr	24-Apr	24-Apr	25-Apr	26-Apr	27-Apr	27-Apr	28-Apr	29-Apr	30-Apr	1-May	1-May	2-May	2-May	3-May	3-May	5-May	18-May	1-Jun
Golden Plover	All	8	8-Apr	12-Apr	16-Apr	16-Apr	16-Apr	17-Apr	20-Apr	22-Apr	24-Apr	24-Apr	24-Apr	26-Apr	28-Apr	30-Apr	4-May	8-May	12-May	23-May	5-Jun	18-Jun
Golden Plover	SDA	8	8-Apr	12-Apr	16-Apr	16-Apr	16-Apr	17-Apr	20-Apr	22-Apr	24-Apr	24-Apr	24-Apr	26-Apr	28-Apr	30-Apr	4-May	8-May	12-May	23-May	5-Jun	18-Jun
Hen Harrier	All	21	19-Apr	27-Apr	30-Apr	2-May	10-May	10-May	11-May	11-May	15-May	17-May	21-May	22-May	23-May	24-May	27-May	29-May	6-Jun	7-Jun	9-Jun	11-Jun
Hen Harrier	SDA	21	19-Apr	27-Apr	30-Apr	2-May	10-May	10-May	11-May	11-May	15-May	17-May	21-May	22-May	23-May	24-May	27-May	29-May	6-Jun	7-Jun	9-Jun	11-Jun
Lapwing	All	31	30-Mar	31-Mar	1-Apr	5-Apr	11-Apr	15-Apr	16-Apr	19-Apr	20-Apr	21-Apr	24-Apr	27-Apr	2-May	6-May	10-May	11-May	18-May	24-May	25-May	1-Jun
Lapwing	non-SDA	4	10-Apr	13-Apr	16-Apr	19-Apr	22-Apr	25-Apr	28-Apr	2-May	5-May	9-May	13-May	17-May	20-May	23-May	24-May	26-May	27-May	29-May	30-May	1-Jun
Lapwing	SDA	27	29-Mar	31-Mar	31-Mar	2-Apr	9-Apr	14-Apr	15-Apr	17-Apr	19-Apr	21-Apr	21-Apr	24-Apr	30-Apr	3-May	8-May	10-May	11-May	18-May	24-May	25-May
Linnet	All	17	6-May	8-May	9-May	11-May	14-May	14-May	15-May	15-May	17-May	25-May	26-May	30-May	4-Jun	10-Jun	19-Jun	21-Jun	26-Jun	30-Jun	1-Jul	4-Jul
Linnet	non-SDA	1	11-May	11-May	11-May	11-May	11-May	11-May	11-May	11-May	11-May	11-May	11-May	11-May	11-May	11-May	11-May	11-May	11-May	11-May	11-May	11-May
Linnet	SDA	16	6-May	8-May	10-May	14-May	14-May	15-May	15-May	16-May	22-May	26-May	28-May	2-Jun	6-Jun	13-Jun	19-Jun	22-Jun	28-Jun	30-Jun	1-Jul	4-Jul
Meadow Pipit	All	93	23-Apr	26-Apr	27-Apr	29-Apr	30-Apr	1-May	2-May	4-May	6-May	8-May	10-May	13-May	15-May	17-May	19-May	26-May	31-May	8-Jun	12-Jun	17-Jul
Meadow Pipit	non-SDA	4	14-Apr	18-Apr	22-Apr	26-Apr	30-Apr	4-May	8-May	14-May	19-May	25-May	30-May	4-Jun	10-Jun	12-Jun	12-Jun	12-Jun	13-Jun	13-Jun	13-Jun	14-Jun
Meadow Pipit	SDA	89	24-Apr	26-Apr	27-Apr	29-Apr	30-Apr	1-May	2-May	4-May	6-May	8-May	9-May	12-May	14-May	17-May	19-May	23-May	28-May	6-Jun	10-Jun	17-Jul
Merlin	All	46	26-Apr	27-Apr	28-Apr	30-Apr	30-Apr	1-May	2-May	3-May	4-May	4-May	5-May	7-May	8-May	10-May	10-May	13-May	16-May	17-May	20-May	10-Jun
Merlin	non-SDA	3	26-Apr	27-Apr	27-Apr	28-Apr	28-Apr	29-Apr	29-Apr	30-Apr	30-Apr	1-May	2-May	4-May	6-May	8-May	10-May	12-May	14-May	16-May	18-May	20-May
Merlin	SDA	43	26-Apr	28-Apr	29-Apr	30-Apr	30-Apr	2-May	2-May	3-May	4-May	5-May	6-May	7-May	8-May	10-May	10-May	12-May	15-May	17-May	19-May	10-Jun
Peregrine	All	70	25-Mar	26-Mar	27-Mar	28-Mar	29-Mar	30-Mar	2-Apr	2-Apr	3-Apr	4-Apr	5-Apr	6-Apr	8-Apr	9-Apr	11-Apr	14-Apr	17-Apr	20-Apr	29-Apr	4-May
Peregrine	non-SDA	6	24-Mar	25-Mar	25-Mar	26-Mar	26-Mar	27-Mar	28-Mar	29-Mar	29-Mar	29-Mar	29-Mar	30-Mar	31-Mar	1-Apr	2-Apr	4-Apr	8-Apr	12-Apr	16-Apr	20-Apr
Peregrine	SDA	64	25-Mar	27-Mar	28-Mar	29-Mar	30-Mar	1-Apr	2-Apr	3-Apr	4-Apr	4-Apr	5-Apr	6-Apr	8-Apr	9-Apr	11-Apr	14-Apr	17-Apr	20-Apr	1-May	4-May
Raven	All	149	23-Feb	25-Feb	26-Feb	27-Feb	29-Feb	29-Feb	1-Mar	2-Mar	3-Mar	5-Mar	6-Mar	7-Mar	9-Mar	10-Mar	12-Mar	13-Mar	18-Mar	20-Mar	23-Mar	13-Apr
Raven	non-SDA	21	22-Feb	23-Feb	24-Feb	24-Feb	27-Feb	27-Feb	27-Feb	29-Feb	29-Feb	29-Feb	29-Feb	2-Mar	3-Mar	5-Mar	10-Mar	13-Mar	16-Mar	18-Mar	19-Mar	22-Mar
Raven	SDA	128	24-Feb	25-Feb	26-Feb	28-Feb	29-Feb	1-Mar	2-Mar	2-Mar	4-Mar	5-Mar	6-Mar	8-Mar	9-Mar	10-Mar	12-Mar	13-Mar	18-Mar	21-Mar	23-Mar	13-Apr
Ring Ouzel	All	107	20-Apr	23-Apr	25-Apr	27-Apr	29-Apr	2-May	4-May	5-May	8-May	10-May	17-May	21-May	24-May	27-May	29-May	3-Jun	7-Jun	11-Jun	16-Jun	2-Jul
Ring Ouzel	non-SDA	3	30-Apr	5-May	9-May	14-May	19-May	23-May	28-May	1-Jun	6-Jun	11-Jun	12-Jun	13-Jun	14-Jun	15-Jun	17-Jun	18-Jun	19-Jun	20-Jun	21-Jun	23-Jun
Ring Ouzel	SDA	104	20-Apr	23-Apr	25-Apr	27-Apr	29-Apr	2-May	4-May	5-May	8-May	9-May	16-May	20-May	22-May	27-May	28-May	3-Jun	6-Jun	11-Jun	13-Jun	2-Jul
Skylark	All	5	29-Apr	30-Apr	1-May	2-May	4-May	9-May	14-May	19-May	24-May	30-May	31-May	2-Jun	3-Jun	5-Jun	7-Jun	7-Jun	7-Jun	7-Jun	7-Jun	8-Jun

Appendix 3 Full list of percentiles for first egg-laying dates derived from Nest Record Cards. Combinations where there are no records are excluded from the table.

Date by which X% had started laying

		N	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
Skylark	SDA	5	29-Apr	30-Apr	1-May	2-May	4-May	9-May	14-May	19-May	24-May	30-May	31-May	2-Jun	3-Jun	5-Jun	7-Jun	7-Jun	7-Jun	7-Jun	7-Jun	8-Jun
Snipe	All	1	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr
Snipe	SDA	1	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr	16-Apr
Stonechat	All	37	3-Apr	7-Apr	9-Apr	16-Apr	17-Apr	22-Apr	22-Apr	26-Apr	28-Apr	1-May	2-May	5-May	11-May	18-May	26-May	2-Jun	9-Jun	16-Jun	18-Jun	19-Jun
Stonechat	SDA	37	3-Apr	7-Apr	9-Apr	16-Apr	17-Apr	22-Apr	22-Apr	26-Apr	28-Apr	1-May	2-May	5-May	11-May	18-May	26-May	2-Jun	9-Jun	16-Jun	18-Jun	19-Jun
Wheatear	All	24	22-Apr	24-Apr	27-Apr	1-May	2-May	3-May	4-May	12-May	13-May	13-May	13-May	14-May	14-May	19-May	19-May	22-May	27-May	31-May	1-Jun	16-Jun
Wheatear	non-SDA	1	14-May	14-May	14-May	14-May	14-May	14-May	14-May	14-May	14-May	14-May	14-May	14-May	14-May	14-May	14-May	14-May	14-May	14-May	14-May	14-May
Wheatear	SDA	23	22-Apr	24-Apr	26-Apr	1-May	2-May	3-May	3-May	10-May	12-May	13-May	13-May	14-May	16-May	19-May	20-May	22-May	28-May	31-May	1-Jun	16-Jun
Whinchat	All	297	11-May	13-May	14-May	15-May	16-May	17-May	19-May	19-May	20-May	22-May	23-May	24-May	26-May	28-May	29-May	1-Jun	6-Jun	10-Jun	15-Jun	2-Jul
Whinchat	non-SDA	18	26-Apr	28-Apr	30-Apr	2-May	5-May	7-May	10-May	11-May	13-May	15-May	16-May	25-May	3-Jun	6-Jun	9-Jun	15-Jun	16-Jun	23-Jun	6-Jul	12-Jul
Whinchat	SDA	279	14-Apr	20-Apr	22-Apr	26-Apr	30-Apr	2-May	2-May	6-May	10-May	13-May	17-May	19-May	21-May	22-May	25-May	2-Jun	10-Jun	17-Jun	19-Jun	24-Jun
Wren	All	70	21-Apr	26-Apr	29-Apr	1-May	2-May	5-May	10-May	10-May	12-May	15-May	16-May	21-May	25-May	3-Jun	7-Jun	12-Jun	16-Jun	21-Jun	29-Jun	12-Jul
Wren	non-SDA	5	26-Apr	28-Apr	30-Apr	2-May	5-May	7-May	10-May	11-May	13-May	15-May	16-May	25-May	3-Jun	6-Jun	9-Jun	15-Jun	16-Jun	23-Jun	6-Jul	12-Jul
Wren	SDA	6	14-Apr	20-Apr	22-Apr	26-Apr	30-Apr	2-May	2-May	6-May	10-May	13-May	17-May	19-May	21-May	22-May	25-May	2-Jun	10-Jun	17-Jun	19-Jun	24-Jun
Yellowhammer	All	11	4-May	5-May	7-May	9-May	13-May	17-May	17-May	17-May	19-May	21-May	27-May	3-Jun	6-Jun	9-Jun	12-Jun	15-Jun	17-Jun	19-Jun	4-Jul	20-Jul
Yellowhammer	non-SDA	5	17-May	17-May	17-May	17-May	17-May	20-May	24-May	27-May	31-May	3-Jun	5-Jun	8-Jun	10-Jun	12-Jun	15-Jun	22-Jun	29-Jun	6-Jul	13-Jul	20-Jul
Yellowhammer	SDA	6	3-May	4-May	4-May	5-May	6-May	7-May	8-May	9-May	12-May	15-May	18-May	21-May	25-May	30-May	4-Jun	9-Jun	11-Jun	14-Jun	16-Jun	19-Jun

Appendix 3 (continued)

			Date by which X% had started laying																			
		N	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
Black-h. Gull	All	404	26-Apr	30-Apr	30-Apr	2-May	5-May	5-May	7-May	9-May	9-May	10-May	10-May	11-May	11-May	12-May	13-May	14-May	17-May	17-May	19-May	30-May
Black-h. Gull	non-SDA	85	5-May	5-May	5-May	5-May	5-May	7-May	10-May	10-May	10-May	10-May	12-May	12-May	12-May	13-May	13-May	13-May	13-May	25-May	30-May	30-May
Black-h. Gull	SDA	319	26-Apr	28-Apr	30-Apr	1-May	2-May	5-May	6-May	8-May	9-May	9-May	10-May	11-May	11-May	11-May	13-May	17-May	17-May	17-May	17-May	24-May
Curlew	All	3	8-Apr	8-Apr	9-Apr	9-Apr	10-Apr	10-Apr	11-Apr	11-Apr	12-Apr	12-Apr	13-Apr	13-Apr	14-Apr	14-Apr	15-Apr	16-Apr	16-Apr	17-Apr	17-Apr	18-Apr
Curlew	SDA	3	8-Apr	8-Apr	9-Apr	9-Apr	10-Apr	10-Apr	11-Apr	11-Apr	12-Apr	12-Apr	13-Apr	13-Apr	14-Apr	14-Apr	15-Apr	16-Apr	16-Apr	17-Apr	17-Apr	18-Apr
Hen Harrier	All	77	2-May	2-May	6-May	8-May	11-May	11-May	12-May	14-May	16-May	18-May	19-May	21-May	22-May	24-May	28-May	30-May	31-May	31-May	5-Jun	19-Jun
Hen Harrier	non-SDA	33	2-May	6-May	8-May	11-May	11-May	12-May	13-May	19-May	19-May	19-May	21-May	22-May	24-May	28-May	29-May	31-May	31-May	2-Jun	3-Jun	19-Jun
Hen Harrier	SDA	44	29-Apr	2-May	5-May	7-May	10-May	11-May	11-May	13-May	15-May	16-May	18-May	18-May	20-May	22-May	24-May	29-May	30-May	31-May	8-Jun	17-Jun
Lapwing	All	11	15-Mar	16-Mar	17-Mar	17-Mar	19-Mar	21-Mar	21-Mar	21-Mar	24-Mar	26-Mar	1-Apr	6-Apr	6-Apr	6-Apr	7-Apr	8-Apr	9-Apr	10-Apr	13-Apr	16-Apr
Lapwing	non-SDA	2	15-Mar	17-Mar	18-Mar	19-Mar	20-Mar	22-Mar	23-Mar	24-Mar	25-Mar	27-Mar	28-Mar	29-Mar	30-Mar	1-Apr	2-Apr	3-Apr	4-Apr	6-Apr	7-Apr	8-Apr
Lapwing	SDA	9	16-Mar	17-Mar	18-Mar	19-Mar	21-Mar	21-Mar	21-Mar	22-Mar	24-Mar	26-Mar	30-Mar	4-Apr	6-Apr	6-Apr	6-Apr	8-Apr	9-Apr	11-Apr	14-Apr	16-Apr
Linnet	All	3	10-May	13-May	16-May	19-May	22-May	25-May	28-May	31-May	3-Jun	6-Jun	9-Jun	12-Jun	15-Jun	18-Jun	21-Jun	24-Jun	27-Jun	1-Jul	4-Jul	7-Jul
Linnet	SDA	3	10-May	13-May	16-May	19-May	22-May	25-May	28-May	31-May	3-Jun	6-Jun	9-Jun	12-Jun	15-Jun	18-Jun	21-Jun	24-Jun	27-Jun	1-Jul	4-Jul	7-Jul
Meadow Pipit	All	15	1-May	5-May	6-May	6-May	7-May	8-May	8-May	8-May	8-May	9-May	9-May	10-May	14-May	28-May	4-Jun	8-Jun	8-Jun	10-Jun	14-Jun	22-Jun
Meadow Pipit	non-SDA	4	8-May	8-May	8-May	8-May	8-May	8-May	9-May	14-May	18-May	23-May	28-May	1-Jun	6-Jun	8-Jun	8-Jun	8-Jun	8-Jun	8-Jun	8-Jun	9-Jun
Meadow Pipit	SDA	11	29-Apr	5-May	5-May	6-May	6-May	6-May	7-May	8-May	8-May	9-May	9-May	9-May	11-May	13-May	22-May	1-Jun	6-Jun	11-Jun	16-Jun	22-Jun
Merlin	All	84	25-Apr	30-Apr	1-May	3-May	4-May	5-May	6-May	7-May	8-May	8-May	9-May	9-May	10-May	11-May	12-May	12-May	13-May	16-May	21-May	31-May
Merlin	non-SDA	22	27-Apr	30-Apr	2-May	3-May	4-May	4-May	4-May	7-May	8-May	9-May	9-May	9-May	10-May	11-May	12-May	13-May	15-May	18-May	25-May	30-May
Merlin	SDA	62	25-Apr	30-Apr	1-May	3-May	3-May	5-May	6-May	7-May	7-May	8-May	8-May	9-May	9-May	10-May	12-May	12-May	12-May	14-May	19-May	31-May
Peregrine	All	72	26-Mar	31-Mar	2-Apr	4-Apr	6-Apr	7-Apr	9-Apr	9-Apr	10-Apr	10-Apr	12-Apr	13-Apr	14-Apr	15-Apr	16-Apr	17-Apr	20-Apr	25-Apr	1-May	14-May
Peregrine	non-SDA	13	31-Mar	3-Apr	5-Apr	6-Apr	6-Apr	7-Apr	8-Apr	9-Apr	10-Apr	10-Apr	10-Apr	11-Apr	13-Apr	14-Apr	14-Apr	14-Apr	15-Apr	16-Apr	23-Apr	3-May
Peregrine	SDA	59	26-Mar	30-Mar	2-Apr	3-Apr	6-Apr	7-Apr	9-Apr	9-Apr	10-Apr	12-Apr	12-Apr	14-Apr	14-Apr	16-Apr	17-Apr	19-Apr	20-Apr	26-Apr	30-Apr	14-May
Raven	All	522	23-Feb	25-Feb	28-Feb	2-Mar	4-Mar	5-Mar	6-Mar	8-Mar	9-Mar	10-Mar	11-Mar	12-Mar	13-Mar	14-Mar	15-Mar	17-Mar	18-Mar	23-Mar	28-Mar	18-Apr
Raven	non-SDA	104	24-Feb	26-Feb	29-Feb	1-Mar	2-Mar	4-Mar	6-Mar	7-Mar	7-Mar	8-Mar	10-Mar	12-Mar	12-Mar	12-Mar	13-Mar	16-Mar	17-Mar	23-Mar	1-Apr	18-Apr
Raven	SDA	418	22-Feb	25-Feb	28-Feb	2-Mar	4-Mar	6-Mar	7-Mar	8-Mar	9-Mar	10-Mar	11-Mar	12-Mar	13-Mar	15-Mar	16-Mar	17-Mar	18-Mar	23-Mar	27-Mar	13-Apr
Ring Ouzel	All	3	26-Apr	26-Apr	26-Apr	27-Apr	27-Apr	27-Apr	27-Apr	27-Apr	28-Apr	28-Apr	2-May	6-May	10-May	14-May	18-May	22-May	26-May	31-May	4-Jun	8-Jun

Appendix 4 Full list of percentiles for first egg-laying dates derived from ringed pulli. Combinations where there are no records are excluded.

			Date by which X% had started laying																		
		N	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
Ring Ouzel	SDA	3	26-Apr	26-Apr	26-Apr	27-Apr	27-Apr	27-Apr	27-Apr	27-Apr	28-Apr	28-Apr	2-May	6-May	10-May	14-May	18-May	22-May	26-May	31-May	4-Jun	8-Jun
Stonechat	All	14	2-Apr	7-Apr	17-Apr	20-Apr	24-Apr	28-Apr	29-Apr	2-May	10-May	14-May	18-May	31-May	7-Jun	11-Jun	11-Jun	12-Jun	13-Jun	23-Jun	3-Jul	12-Jul
Stonechat	non-SDA	3	6-Apr	8-Apr	11-Apr	14-Apr	16-Apr	19-Apr	21-Apr	24-Apr	27-Apr	29-Apr	3-May	6-May	10-May	14-May	17-May	21-May	24-May	28-May	1-Jun	4-Jun
Stonechat	SDA	11	9-Apr	17-Apr	20-Apr	22-Apr	25-Apr	28-Apr	5-May	12-May	14-May	15-May	29-May	11-Jun	11-Jun	11-Jun	12-Jun	12-Jun	20-Jun	27-Jun	5-Jul	12-Jul
Wheatear	All	50	30-Apr	1-May	2-May	3-May	3-May	5-May	5-May	6-May	8-May	9-May	9-May	10-May	10-May	11-May	12-May	13-May	14-May	14-May	19-May	26-May
Wheatear	non-SDA	9	30-Apr	30-Apr	30-Apr	30-Apr	30-Apr	1-May	2-May	3-May	4-May	5-May	7-May	9-May	10-May	11-May	11-May	12-May	13-May	14-May	14-May	14-May
Wheatear	SDA	41	1-May	2-May	2-May	3-May	5-May	5-May	6-May	7-May	8-May	9-May	9-May	10-May	10-May	12-May	12-May	13-May	14-May	18-May	19-May	26-May
Whinchat	All	57	11-May	15-May	17-May	17-May	18-May	19-May	19-May	20-May	21-May	24-May	25-May	27-May	28-May	11-Jun	12-Jun	13-Jun	17-Jun	19-Jun	21-Jun	25-Jun
Whinchat	non-SDA	15	8-May	12-May	17-May	17-May	17-May	18-May	19-May	19-May	20-May	20-May	20-May	20-May	21-May	23-May	25-May	26-May	27-May	27-May	1-Jun	13-Jun
Whinchat	SDA	42	14-May	16-May	17-May	17-May	19-May	19-May	21-May	22-May	25-May	27-May	28-May	7-Jun	12-Jun	12-Jun	14-Jun	17-Jun	19-Jun	19-Jun	21-Jun	25-Jun
Wren	All	11	14-Apr	19-Apr	20-Apr	20-Apr	25-Apr	30-Apr	1-May	1-May	2-May	3-May	4-May	4-May	5-May	5-May	5-May	5-May	6-May	6-May	7-May	8-May
Wren	non-SDA	3	20-Apr	22-Apr	23-Apr	24-Apr	25-Apr	26-Apr	28-Apr	29-Apr	30-Apr	1-May	2-May	3-May	3-May	4-May	5-May	5-May	6-May	7-May	8-May	8-May
Wren	SDA	8	13-Apr	17-Apr	21-Apr	24-Apr	28-Apr	1-May	2-May	3-May	3-May	4-May	4-May	4-May	5-May	5-May	5-May	5-May	5-May	6-May	6-May	6-May
Yellowhammer	All	1	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May
Yellowhammer	SDA	1	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May	16-May

Appendix 4 (continued)

Species	N	Date by which X% had started laying																			
		5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
Black Grouse	32	19-May	19-May	20-May	21-May	22-May	22-May	22-May	22-May	23-May	23-May	23-May	24-May	24-May	24-May	25-May	26-May	28-May	30-May	3-Jun	13-Jun
Curlew	34	26-Apr	28-Apr	28-Apr	29-Apr	1-May	2-May	4-May	8-May	8-May	10-May	10-May	11-May	14-May	17-May	17-May	24-May	27-May	27-May	28-May	5-Jun
Dunlin	16	2-May	4-May	5-May	8-May	9-May	11-May	13-May	13-May	15-May	16-May	17-May	18-May	18-May	22-May	26-May	28-May	28-May	2-Jun	7-Jun	7-Jun
Golden Plover	20	14-Apr	17-Apr	19-Apr	21-Apr	25-Apr	28-Apr	29-Apr	30-Apr	1-May	4-May	7-May	8-May	13-May	22-May	24-May	25-May	26-May	28-May	28-May	1-Jun
Hen Harrier	62	27-Apr	2-May	3-May	6-May	8-May	9-May	12-May	13-May	14-May	17-May	18-May	20-May	22-May	23-May	24-May	27-May	31-May	1-Jun	7-Jun	16-Jun
Lapwing	1013	18-Mar	26-Mar	29-Mar	31-Mar	3-Apr	6-Apr	9-Apr	12-Apr	14-Apr	17-Apr	19-Apr	23-Apr	27-Apr	1-May	6-May	11-May	16-May	22-May	27-May	12-Jun
Raven	51	1-Mar	1-Mar	1-Mar	7-Mar	7-Mar	7-Mar	7-Mar	7-Mar	7-Mar	7-Mar	7-Mar	7-Mar	7-Mar	7-Mar	10-Mar	14-Mar	14-Mar	14-Mar	14-Mar	14-Mar

Appendix 5 Full list of percentiles for first egg-laying dates derived from RSPB Wales data.