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The effects of pre-harvesting operations on birds nesting in Oilseed Rape *Brassica napus*

Authors

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EXECUTIVE SUMMARY

The effects of pre-harvesting operations on birds nesting in oilseed rape were investigated in a study of 17 fields at Deeping St. Nicholas, Lincolnshire. Prior to harvest, rape was either swathed (i.e. cut) or sprayed with a desiccant (in this study either 'Reglone' or 'Roundup') to aid harvesting.

Seven species were recorded singing in rape on surveys between 1993 and 1996. Three of these: Sedge Warbler, Reed Warbler and Reed Bunting, and one further species, Linnet, were recorded nesting in rape in 1996. Reed Buntings were recorded nesting throughout fields, other species frequented the edges and a proportion of these birds may have nested in surrounding dykes and verges.

The median date of swathing in 1996 was 21 July and that of spraying 22 July. Swathed fields were harvested significantly earlier than sprayed fields on a median date of 29 July, compared with 5 August respectively. Nests of Sedge Warblers and second-brood Reed Warblers were largely confined to dykes and therefore were not affected by crop operations. Reed Buntings in the study area fledged their first broods by mid-July. Second broods fledged on a median date of 25 July, after pre-harvesting operations. No nests survived swathing (n = 5). In contrast all survived spraying (five with Reglone, one with Roundup). No nests or nestlings were lost after spraying, suggesting that exposure to the sprays was not detrimental in this small sample. In comparison to swathing, spraying gives 15 extra days for birds to fledge their young. Thus, this study suggests that over 50% of Reed Buntings' second broods may be saved by spraying crops rather than swathing them. Analysis of BTO Nest Record Cards in the region including and surrounding Lincolnshire, confirms that a substantial proportion of nests of the three species are likely to be active in the period between swathing and harvesting.

Reed Buntings, Sedge Warblers and Reed Warblers all used rape extensively to collect food for their young. Reed Buntings, however, used rape less after it was sprayed. In spite of possible changes in food availability, the feeding and growth rates of nestling Reed Buntings did not decrease after spraying.

It is concluded that oilseed rape offers a suitable habitat to nesting Reed Buntings and that a higher proportion of second broods survive treatment with a desiccant than swathing.

1. INTRODUCTION

Oilseed rape *Brassica napus* has become an increasingly common crop across the British Isles over the last 30 years (increasing in England and Wales from 24,000 to 362,000 ha between 1974 and 1992: Ministry of Agriculture, Fisheries and Food) and with its spread it has become increasingly attractive to several species of birds. The crop provides both food and nesting sites. The rape itself and the many invertebrates that the crop supports are eaten in the breeding season by, for example, Grey Partridge *Perdix perdix*, Blackbird *Turdus merula*, House Sparrow *Passer domesticus*, Greenfinch *Carduelis chloris*, Linnet *Carduelis cannabina* and Reed Bunting *Emberiza schoeniclus* (Davis, 1967; O'Connor & Shrubb, 1986; Lack, 1992). In winter, fields are used by Woodpigeons *Columba palumbus* and Skylarks *Alauda arvensis* (O'Connor & Shrubb, 1986; Lack, 1992). There has been limited study on the use of rape as a nesting habitat. A number of reports have been made of Sedge Warblers *Acrocephalus schoenobaenus*, Reed Warblers *Acrocephalus scirpaceus* and Reed Buntings singing from rape and Quail *Coturnix coturnix*, Pheasant *Phasianus colchicus*, Dunnock *Prunella modularis*, Grasshopper Warbler *Locustella naevia* and Corn Bunting *Miliaria calandra* have also been recorded in the crop during the breeding season (Bonham & Sharrock, 1974; Sharrock 1986; Bradbury *et al.*, 1990; Lack, 1992; Prŷs-Jones, 1993). Little evidence exists, however, to prove that any of these species actually nest in rape (British Trust for Ornithology (BTO) Nest Records Scheme (NRS); Bowey, K., pers. comm.), although it is strongly suspected.

The present study investigated the effects of pre-harvesting and harvesting operations on birds nesting in autumn-sown rape. Prior to the harvest in July and August, fields are either sprayed with herbicide or swathed to desiccate the crop prior to harvest. Swathing cuts the crop down to a height of 50 cm leaving bare stalks and lines of cut material. In contrast, sprayed rape is left standing until harvest approximately 14 days later.

The study aimed to determine which species nested in rape in a Lincolnshire study area, how the timing of their nesting related to the timing of the above pre-harvesting operations and the effects of these operations on nest survival, nestling growth and feeding behaviour.

2. METHODS

2.1 The Study Site

The study was conducted at Deeping St. Nicholas in the Lincolnshire fens (Grid Reference: TF11). This area is dominated by arable farming where wheat, linseed, sugar beet and peas are commonly grown in addition to rape. Hedgerows are largely absent and fields are often bounded by dykes and larger drains. Reeds *Phragmites australis* dominate the vegetation along drains, but in smaller dykes these grow together with nettles *Urtica dioica*, Willowherb *Epilobium* spp. and thistles *Carduus/Cirsium* spp. In addition to crops, two habitats were defined: dyke and grass (i.e. grass-dominated verges and sown set-aside).

2.2 Study Methodology

Fieldwork took place between May and August 1996, but was concentrated in late June and July at the time of pre-harvesting and harvesting operations. Three fields on Vine House and Deeping Fen Farms were intensively monitored. A car or a tractor was used to view bird activity from surrounding tracks and from a single tramline circuit through each crop. In addition, a number of fields on neighbouring farms were also monitored from tracks for signs of nesting activity.

2.2.1 Densities of Species Singing in Oilseed Rape

Surveys of singing birds on Vine House, Deeping Fen and neighbouring farms provided information on the densities of birds that potentially nested in rape each year from 1993. Each field was surveyed from a car or on foot once in May or early June. (Data were collected by PNW and were supplemented in 1996 by NHKB).

2.2.2 The Timing of Crop Operations

In July and early August fields were monitored daily to determine the dates of crop operations. Data are also provided on the dates of desiccant spraying on Vine House and Deeping Fen Farms each year from 1991.

2.2.3 The Timing of Nesting and the Effects of Crop Operations on Nest Survival

As many nests as possible were found and observed in order to determine the hatching and fledging dates of nestlings. Although some nests were not found, their approximate location was known (once hatched) through observation of food-carrying adults. Adults continued to feed their young after they had fledged and dispersed from the nest and it was possible in these cases to determine fledging dates by observing the adults' behaviour. Data on fledging dates were supplemented with information from nests outwith rape.

Analysis of BTO nest record cards determined the regional distribution of fledging dates of the three main species (Sedge Warbler, Reed Warbler and Reed Bunting) found nesting in rape in the field study. The region was defined as Lincolnshire, Norfolk, Suffolk, Cambridgeshire, Northamptonshire and Leicestershire and data were taken from 1962 to 1994 (no trends in average first egg laying date occur for these species (NRS data), so it was considered

appropriate to use NRS data from a wide range of years). Fledging dates were based on estimated first egg laying dates and known laying periods, incubation periods and fledging ages. Laying periods were four, three and three days for Sedge Warbler, Reed Warbler and Reed Bunting respectively, incubation periods 14, 11 and 13 days respectively and fledging ages 13, 11 and 10 days respectively (Cramp, 1992; Cramp & Perrins, 1994). Data on laying dates only included cases for which the date could be estimated to within ± 5 days.

The survival of nests through spraying, swathing and harvesting was also monitored. Daily nest survival rates (Mayfield, 1975) were compared pre- and post-spraying (see Johnson, 1979; Hensler & Nichols, 1981 for methods); data were combined for incubation and nestling stages due to the small number of nests found. The height of nests and their distance from the top of the crop were recorded to the nearest 5 cm to investigate whether the vertical position of nests within the crop may influence their survival.

2.2.4 The Effects of Crop Operations on Feeding Behaviour and the Growth Rates of Nestlings

Adults of each species were observed to determine the feeding rates of nestlings before and after fields were sprayed. Feeding rate was defined as the number of times that adults visited a nest during a 30 minute observation period (data were not included for nestlings of less than three days, which may be brooded almost continuously: Cramp, 1992; Cramp & Perrins, 1994). The habitats used for food collection were assessed by observing the destinations of adults on leaving the nest.

Data on feeding behaviour were supplemented with information from nests in dykes and fields immediately neighbouring rape.

Investigations were also made of the growth rates of nestling Reed Buntings (in nests within rape) before and after fields were sprayed. The mass and wing-length of nestlings were recorded daily until a maximum of eight days old. If disturbed after this nestlings may leave the nest prematurely.

3. RESULTS

3.1 Densities of Species Singing in Oilseed Rape and their Distribution

The densities of singing males of each species found during surveys of rape fields from 1993 to 1996 are shown in Table 3.1.1. Densities were not affected by the area surveyed, except perhaps in 1993 when the figure for Reed Bunting was high. Three main species were found in the crop: Reed Bunting, Reed Warbler and Sedge Warbler. Other species - Dunnock, Blackbird, Whitethroat *Sylvia communis* and Corn Bunting - were only recorded infrequently. The highest densities recorded were of Reed Buntings (1.53-3.57 per 10 ha) and Reed Warblers (2.02-2.47 per 10 ha), though the figures for the latter species and also those for Sedge Warbler (0-0.51 per 10 ha) may be overestimates. Whilst Reed Buntings may be found singing throughout a field, some species, such as Reed Warbler, are more commonly found near the edge (Figures 3.1.1 & 3.1.2). Both Reed and Sedge Warbler were most usually found singing along edges adjacent to dykes and it is probable that a high percentage of pairs nested in dykes rather than in rape. Indeed only one pair of Sedge Warblers was found nesting in rape (see Appendix 1). Reed Warblers were found in rape on their first nesting attempts, but only one pair was recorded nesting in the crop after this (nest 'B1': see Appendix 1). Most later nests were in reeds in the dykes.

3.2 The Growth of Oilseed Rape and the Timing of Spraying, Swathing and Harvesting in the Study Area

The oilseed rape in the study area in 1996 was planted in early September 1995. The crop was 100 cm high in the third week of May 1996 and 140 cm high when in flower in the second week of June. Thereafter vertical growth of the crop was negligible. Six rape fields were sprayed (by tractor) in the study area in 1996, the three on Vine House and Deeping Fen Farms with the diquat desiccant 'Reglone' (at a dosage of 3l/ha, with the addition of the wetter 'Agral') and three on a neighbouring farm with an alternative glyphosate herbicide 'Roundup' (at a dosage of 3l/ha, with the addition of the activater 'Frigate') (see Ivens, 1990). Eleven fields were swathed. Figure 3.2.1 shows the dates that rape fields were sprayed or swathed in the study area. The median date of spraying was 22 July ($n = 6$) and that of swathing 21 July ($n = 11$), a difference that was not significant (Mann-Whitney $z = 0.97$, n.s.). Figure 3.2.2 shows the dates that fields were harvested. The median date of harvesting of sprayed fields was 5 August, a median of 14 days after spraying ($n = 5$). Swathed fields were harvested a median of 9.5 days after swathing on a median date of 29 July ($n = 10$). (Harvest dates were unknown for one sprayed field and one swathed field). The difference in harvest dates was significant (Mann-Whitney $z = 2.84$, $P < 0.01$), as was the difference in the interval between pre-harvesting operations and harvesting (Mann-Whitney $z = 2.67$, $P < 0.01$).

The median dates that fields in the study area were sprayed each year from 1991 to 1995 varied from 8 to 28 July. The median of these dates was 19 July ($n = 5$), a similar date to that in 1996.

3.3 The Timing of Nesting and the Effects of Crop Operations on Nest Survival

3.3.1 The Timing of Nesting

Reed Bunting

In the study area in 1996 Reed Buntings laid their first clutches in the first half of May and young fledged in the first half of June. No nest losses were recorded in this first part of the breeding season and thus no replacement clutches were found (see Appendix 1). All later nests are assumed, therefore, to be second broods. Fledging dates for second broods are shown in Figure 3.3.1.1. Dates for three nests (two not followed to completion and one predated) are predictions based on known hatching dates and an average estimated fledging age of 9.93 days (n = 29 nestlings, SE = 0.20). Previous studies in Europe have found that Reed Buntings fledge at between 9 and 13 days (Cramp & Perrins, 1994). Data for three further nests on predictions based on observation of adults feeding behaviour. Nine of the 12 nests in this sample were within rape. The median fledging date for all second broods in the present study was 25 July (n =12, range = 20 July to 7 August).

Fledging dates for Reed Buntings in the defined region, determined from an analysis of nest record cards, are shown in Figure 3.3.1.2 (n = 273). Although this graph is likely to under-represent the frequency of late nests due to seasonal variation in observer effort (see Crick & Baillie, 1996), it gives an indication of the range of fledging dates that occurs. The median fledging date is in the first half of June, a small proportion of broods fledge after mid-July (i.e. during or after the time of pre-harvesting operations).

Other Species

In the present study Reed Warblers laid their first clutches in early June and chicks fledged in late June and early July (median date = 6 July, n = 7). At this time, pairs nested both in rape fields and dykes. As subsequent nesting attempts were largely confined to dykes, however (see 3.1), it was clear that most pairs were unaffected by cropping operations.

Fledging dates for Reed Warblers in the defined region are shown in Figure 3.3.1.3 (n = 780). The median fledging date is in early July; a sizeable percentage of broods do not fledge until after mid-July.

Only one pair of Sedge Warblers was recorded nesting in rape: a pair was seen carrying nesting material into a field on 17 July. Nests of this species too, therefore, were largely unaffected by cropping operations in this study.

Fledging dates for Sedge Warblers in the defined region are shown in Figure 3.3.1.4 (n = 119). The median fledging date is in mid-June; only the small percentage of second broods fledge after mid-July.

Only two other species were recorded nesting in rape in the present study. A pair of Whitethroats was seen carrying food to nestlings on 10 and 11 July and a Linnet pair was seen feeding nestlings on 20 July.

3.3.2 The Effects of Spraying and Swathing on Nest Survival

No nests were known to be destroyed by spraying. Five Reed Bunting nests found beforehand all survived spraying with desiccant (four with 'Reglone', one with 'Roundup'), whilst young from a sixth fledged on the day of spraying (with Reglone). One other Reed Bunting nest was found in a field which had been sprayed with Roundup three days earlier (see Appendix 1).

The daily survival rate of Reed Bunting nests in unsprayed (or unswathed) fields was 0.96 (51 nest-days, 13 nests). After spraying the rate was 1.00 (27 nest-days, 7 nests), an insignificant difference ($z = 1.44$, n.s.). Although the numbers of nests sampled were too small to provide much power to this test, the result does indicate that spraying did not have a detrimental impact.

In contrast, no nests were known to have survived swathing. All five nests observed - four Reed Bunting and one Linnet - were destroyed (see Appendix 1). No further nests were found in fields after swathing and observations of bird movements did not indicate the presence of any.

The vertical position of nests within the crop may influence their survival through pre-harvesting operations. Of 10 Reed Bunting nests, seven were on the ground and three (second brood nests) in bent-over canopies, 55, 90 and 110 cm from the ground and 30 cm from the top of the crop. Two canopy nests and three ground nests survived spraying. All four Reed Warbler nests (including one found post-fledging) were supported by rape stems. These were 65, 70, 75 and 75 cm from the ground and 70, 65, 55 and 75 cm from the top of the crop respectively.

No nests were known to be in rape fields at the time of their harvesting.

3.4 The Effects of Crop Operations on Feeding Behaviour and the Growth Rates of Nestlings

3.4.1 Food and Feeding Rates in Unsprayed and Sprayed Fields

Reed Bunting

Table 3.4.1.1 shows the habitats that adult Reed Buntings flew to from the nest to collect food. Excluding data from first brood nests, there was a significant difference in the frequency that rape was used before and after fields were sprayed ($X^2 = 4.23$, d.f. $= 1$, $P < 0.05$). Birds flew to rape more often before spraying (80.5% of 87 occasions) and less often afterwards (67.6% of 185 occasions). Rape was the main habitat used for food collection however, and of other habitats, only wheat (10.8% of all occasions) and dykes (7.7%) were used regularly.

Reed Buntings fed their young between two and eight times in a 30 minute period. This rate varied according to the age of nestlings (Figure 3.4.1.1), though not according to their number:

Number of feeds per 30 minutes $= 1.90 + 0.41$ Age (days)

Data for six nests before fields were sprayed ($r^2 = 0.53$; t (age) = 4.01, d.f. = 14, $P < 0.01$; t (number) = 0.54, n.s.).

For nests in fields after spraying, the number of feeds per 30 minute period also varied according to age (Figure 3.4.1.2) and at a similar rate ($F_{1,49} = 0.07$, n.s.):

Number of feeds per 30 minutes = 1.75 + 0.45 Age (days)

Data from five nests ($r^2 = 0.31$; t = 3.99, d.f. = 35, $P < 0.001$).

Allowing for the effect of nestling age, there was no difference in the feeding rate before and after fields were sprayed (using residuals from the first equation: Mann-Whitney z = -0.73, n.s.).

The rate of feeding also varied between the sexes: the female of a pair fed nestlings more often in a 30 minute period than the male ($z = 3.10$, $P < 0.01$, $n = 69$).

Other species

Table 3.4.1.2 shows the habitats that adult Reed Warblers flew to from the nest to collect food. Only rape (53.4% of occasions) and dykes (38.4%) were used extensively. Birds flew to rape as frequently after spraying as before ($X^2 = 0.61$, d.f. = 1, n.s.).

Data for Sedge Warblers came entirely from pairs that nested in adjacent dykes (Table 3.4.1.3). Rape (60.0% of occasions) and dykes (25.7%) were the main habitats used for food collection. One pair of Whitethroats that nested in rape also used the crop for feeding (Table 3.4.1.3).

There was a significant difference in the use of rape, dykes and 'other habitats' for food collection by Reed Buntings, Reed Warblers and Sedge Warblers in the pre-spraying period ($X^2 = 50.03$, d.f. = 4, $P < 0.001$). Reed Buntings flew to rape more often than other species and less often to dykes, whilst Reed Warblers flew to dykes more often than rape.

Reed Warblers fed their young between five and 16 times in a 30 minute period, Sedge Warblers between seven and ten times. It was not possible to determine if feeding rates varied according to nestling age or number for these species.

Species that were seen to use rape as a feeding habitat but which were not proven to nest there are recorded in Appendix 2.

3.4.2 The Effect of Spraying on the Growth Rates of Nestling Reed Buntings

The relationship between the mass and age of nestling Reed Buntings is shown for five broods in Figure 3.4.2.1. The growth of the nestlings followed a gentle S-shaped curve (see also Blümel, 1982), and was almost linear from the third to sixth days (nestling age was estimated for the three broods found in the latter stages of growth). Due to the curvilinear nature of mass increase and the small samples involved it was not possible statistically to compare daily

growth rates before and after spraying. As Figure 3.4.2.2 shows, however, the daily growth in mass of the sample broods was not visibly affected by spraying.

Figure 3.4.2.3 shows the relationship between wing-length and age for the same five Reed Bunting broods. The increase in wing-length also followed an S-shaped curve, though was almost linear from the third to eighth days. The daily growth in wing-length of the sample broods was not visibly affected by spraying (Figure 3.4.2.4).

4. DISCUSSION

Seven species were recorded singing in rape in surveys of the study area: Dunnock, Blackbird, Sedge Warbler, Reed Warbler, Whitethroat, Reed Bunting and Corn Bunting. Sedge Warbler, Reed Warbler, Reed Bunting and, in addition, Linnet were recorded nesting in 1996. The former three species have been reported singing in rape previously (Bonham & Sharrock, 1974; Sharrock 1986; Bradbury *et al.*, 1990; Lack, 1992; Prŷs-Jones, 1993) and Linnet commonly feed in the crop (Davis, 1967; O'Connor & Shrubb, 1986). It is probable that densities of birds recorded in the crop overestimated the numbers that nested there: males often sang from the edges of fields but may have nested in surrounding dykes. Only one pair of Sedge Warblers were seen to attempt to nest in rape and most Reed Warblers nested in dykes after their first broods. Only Reed Buntings were recorded commonly singing and nesting in the centre of fields. Surveys were timed to estimate the densities of birds on their first nesting attempts. As only a proportion of Reed Buntings, Reed Warblers and Sedge Warblers had second broods, densities at this time would have been lower.

A regional analysis of nest record cards revealed that most Reed Buntings and Sedge Warblers and a large proportion of Reed Warblers fledge their broods by the third week of July, the average date for the spraying and swathing of rape. (We cannot be certain of the proportions because late season nests are under-recorded by the Nest Record Scheme.) For Reed Bunting and Sedge Warbler, only second brood nests would be affected by these and subsequent harvesting operations. Between 43 and 47% of Reed Bunting pairs (Cramp & Perrins, 1994), between 17 and 32% of Reed Warblers and only a small percentage of Sedge Warblers (Cramp, 1992) have second broods. However, Bibby, (1978), suggests that nearly all pairs of the latter two species have at least two nesting attempts per year (by modelling the probability of nest failure and the liklihood of repeating). In this study, however, Sedge Warblers and Reed Warblers rarely nested in rape at this time and thus only Reed Buntings were affected by crop operations. Second brood Reed Buntings fledged an average of three days after spraying and four days after swathing.

No nests survived swathing, whilst, in contrast, all survived spraying. Nests on the ground potentially could survive swathing if missed by vehicle wheels and deposits of cut material, but would be highly exposed to predators afterwards. Seventy percent of Reed Bunting nests in rape were on the ground; pairs only nested in the crop canopy if it was bent-over and thus more supportive. All of four Reed Warbler nests found in rape were suspended between stems around 70 cm up; few Reed Warblers nest on or near the ground (Catchpole, 1973). Over half of Sedge Warbler nests, however, may be on or near the ground (Catchpole, 1973).

Nests in fields that are sprayed could be destroyed by machinery during the operation or, possibly, could be lost following exposure to the spray. Daily survival rates of Reed Bunting nests in rape did not change after spraying, suggesting that sprays were not deleterious to eggs or nestlings. Indeed the only nests lost were to predators before spraying, one possibly to a Grass Snake *Natrix natrix* which was seen closeby immediately prior to predation. Two individual nestlings died before spraying, but none were lost afterwards. The interval between spraying and harvesting allowed the successful fledging of broods in the fields.

Reed Buntings (and Sedge and Reed Warblers) used rape extensively to collect food for their young. The use of rape by Reed Buntings, however, decreased after spraying, suggesting that the desiccation of the crop had led to a reduction in their invertebrate food (see Cramp & Perrins, 1992). In spite of this, the feeding and growth rates of nestling Reed Buntings did not change after spraying, indicating that adequate food was still obtainable from the crop and neighbouring habitats. Only if Reed Buntings nested in the centre of much larger areas of rape, could the dessication of the crop potentially affect their ability to collect food.

Oilseed rape is clearly suitable to the Reed Bunting, both for nesting and for foraging. The expansion of the crop in Britain has provided the species with an important new habitat at a time when its population has declined steeply (Marchant *et al.*, 1990) and its range has correspondingly contracted (Prŷs-Jones, 1993). Although many Reed Bunting nests are lost to agricultural operations (Crick *et al.*, 1994), first broods in rape are relatively safe. Over 50% of second brood nests may be destroyed by swathing, however. This study suggests that the use of a desiccant will avoid this destruction.

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Species	1993	1994	1995	1996
Dunnock	0	0	0.13 (3)	0
Blackbird	0	0.04 (1)	0	0
Sedge Warbler	0	0.44 (10)	0.51 (12)	0.37 (6)
Reed Warbler	2.47 (9)	2.09 (47)	2.21 (52)	2.02 (33)
Whitethroat	0	0	0.04 (1)	0.06 (1)
Reed Bunting	3.57 (13)	1.60 (36)	2.12 (50)	1.53 (25)
Corn Bunting	0	0.09 (2)	0.13 (3)	0.06 (1)
Total	6.04 (22)	4.26 (96)	5.14 (121)	4.04 (66)
Area (ha)	36.4	225.4	235.5	163.5

Table 3.1.1 Densities of singing birds in oilseed rape (birds/10 ha).

* Figures in parentheses are total numbers of birds observed.

Habitat	Rape	Grass	Dyke	Beet	Wheat	Unknown	n
First brood	67 (85)	9 (11)	1 (1)	0	2 (3)	0	79
Second brood pre-spraying	70 (80)	2 (2)	11 (13)	1 (1)	3 (3)	0	87
Post-spraying	125 (68)	0	15 (8)	9 (5)	33 (18)	3 (2)	185
Total	262 (75)	11 (3)	27 (8)	10 (3)	38 (11)	3 (1)	351

Table 3.4.1.1 Habitats used by Reed Buntings for food collection.

* Figures in parentheses are percentages of observations. First brood data are taken from six nests between 9 and 25 June 1996 inclusive, second brood data from 11 July. Pre-spraying data are from 10 nests, including two in fields adjacent to rape. Data were insufficient to test if habitats used by these birds were different from those that nested in rape. Post-spraying data are from five nests.

Habitat	Rape	Grass	Dyke	Beet	Wheat	Unknown	n
Pre-spraying	147 (54)	7 (3)	100 (37)	0	6 (2)	11 (4)	271
Post-spraying	9 (43)	0	12 (57)	0	0	0	21
Total	156 (53)	7 (2)	112 (38)	0	6 (2)	11 (4)	292

Table 3.4.1.2 Habitats used by Reed Warblers for food collection.

* Figures in parentheses are percentages of observations. Pre-spraying data are from 11 nests, those post-spraying from two nests. Figures include data from six nests in dykes adjacent to rape, as comparatively few pairs nested in the crop. Data were insufficient to test if habitats used by these birds were different from those that nested in rape.

Habitat	Rape	Grass	Dyke	Beet	Wheat	Unknown	n
Sedge Warbler	42 (60)	0	18 (26)	10 (14)	0	0	70
Whitethroat	9 (90)	0	1 (10)	0	0	0	10

Table 3.4.1.3 Habitats used by other species for food collection.

* Figures in parentheses are percentages of observations. Data for both species are from the pre-spraying period. Data for Sedge Warblers are from two nests in dykes adjacent to rape. Data for Whitethroat are from one nest in rape.

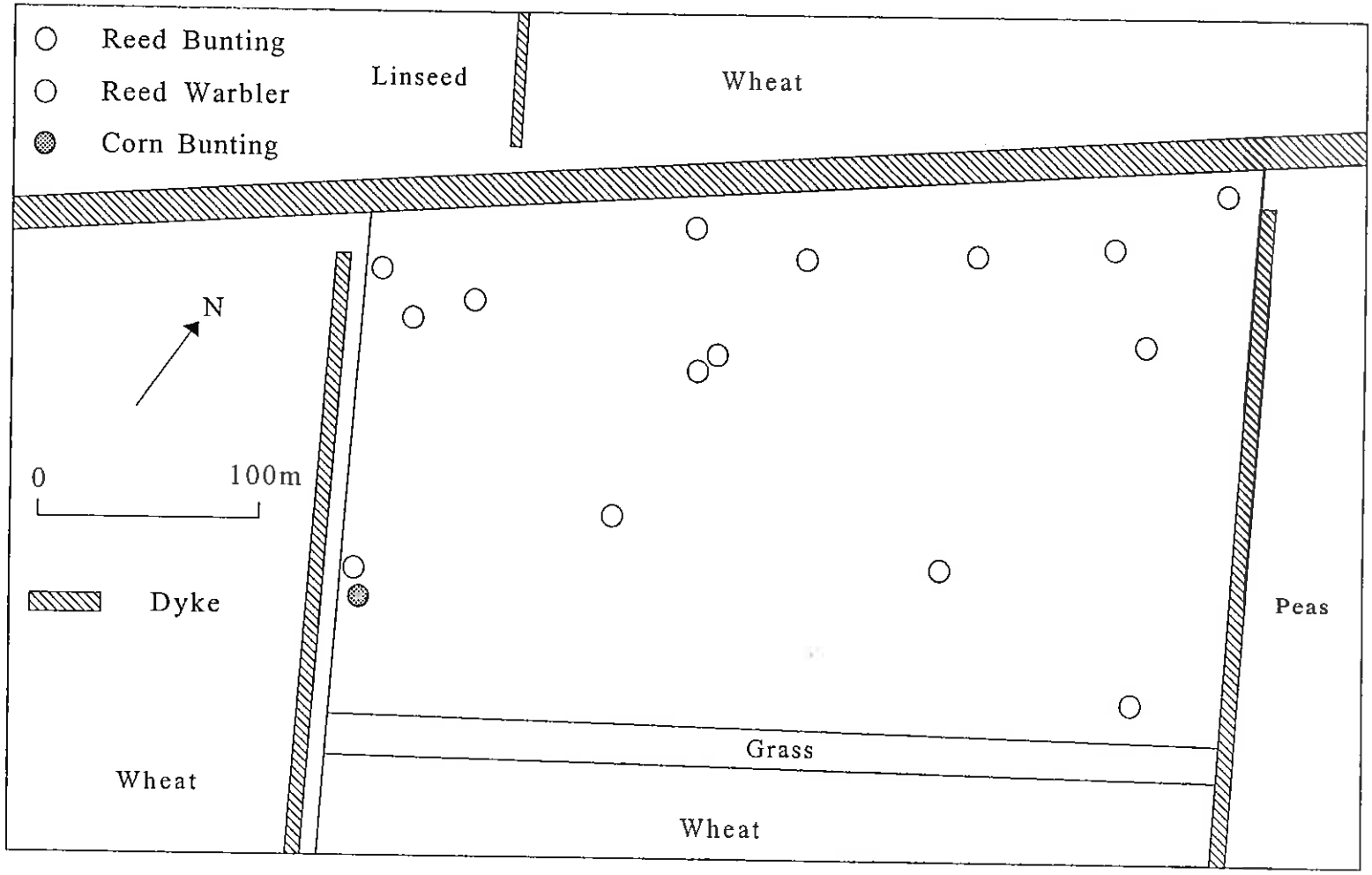

Figure 3.1.1 The distribution of singing birds in rape field 'B' on 10 June 1996.

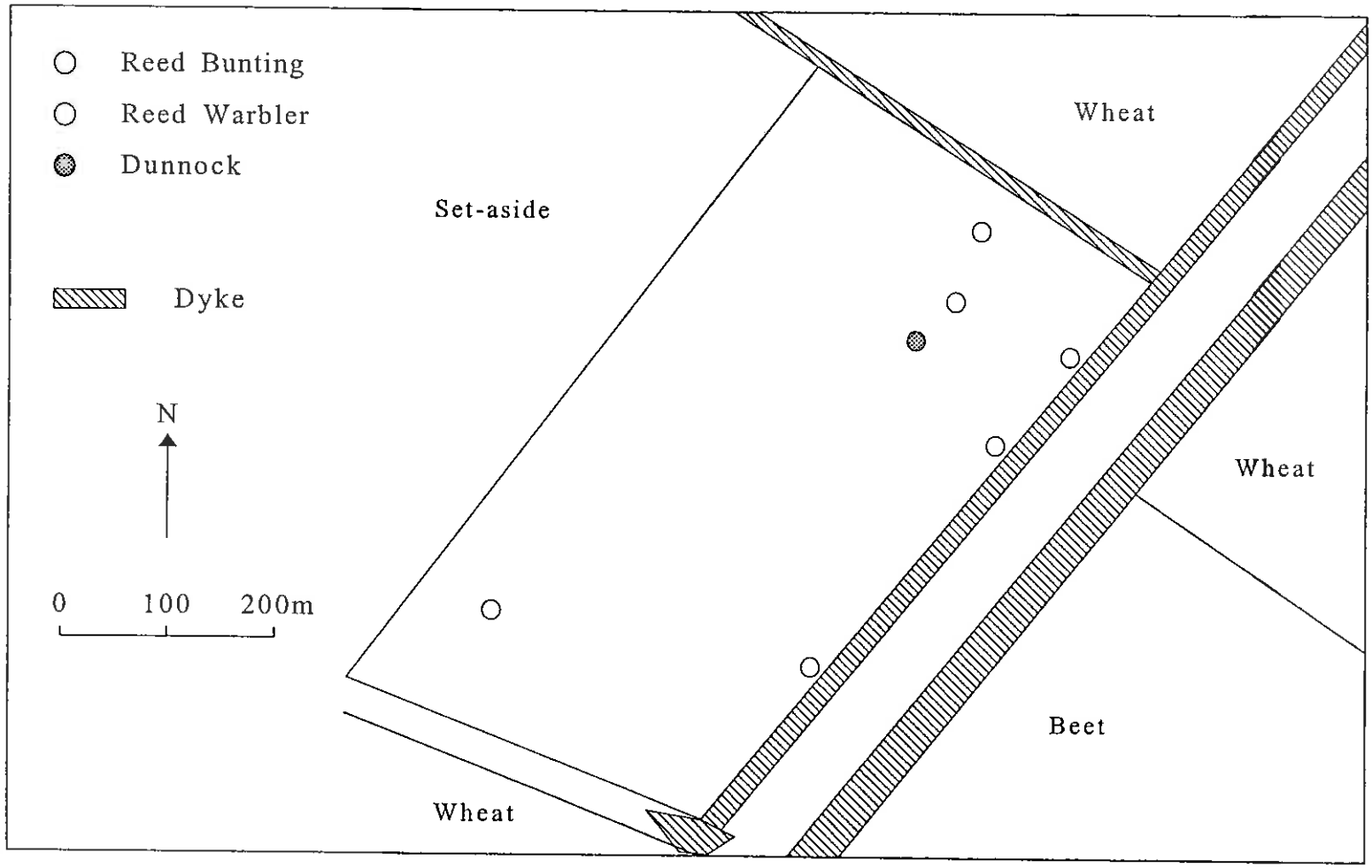

Figure 3.1.2 The distribution of singing birds in rape field 'I' on 12 June 1996.

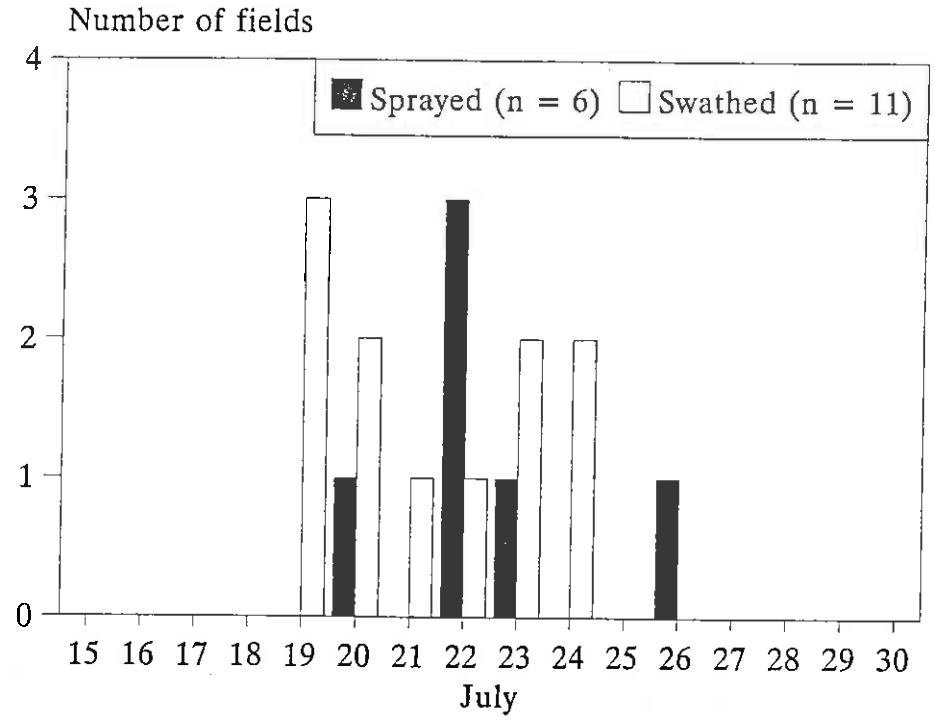

Figure 3.2.1 Spraying and swathing dates of fields in the study area in 1996

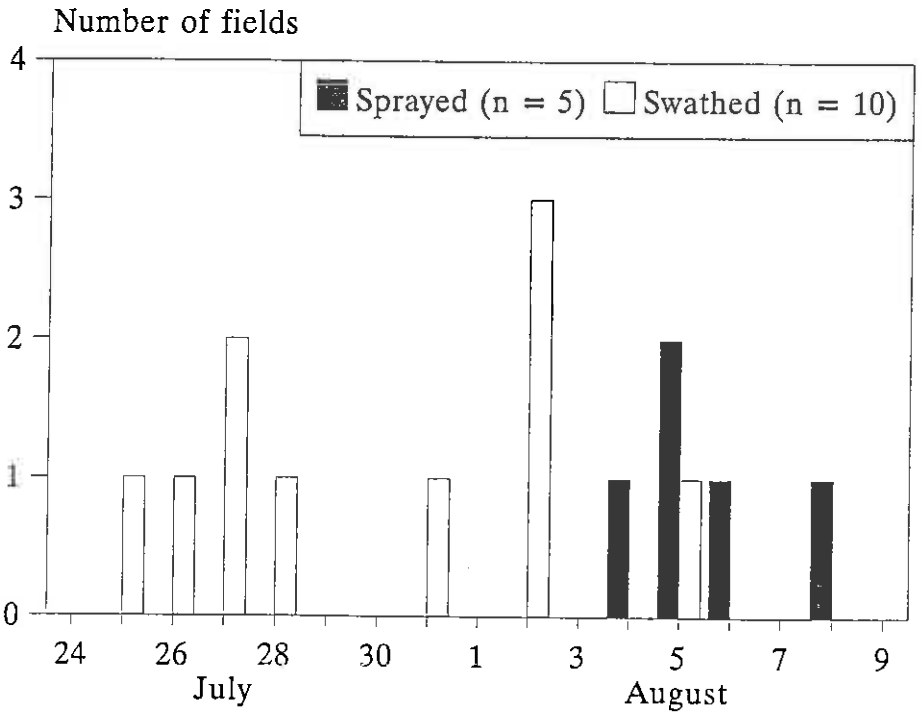

Figure 3.2.2 Harvest dates of sprayed and swathed fields in the study area in 1996

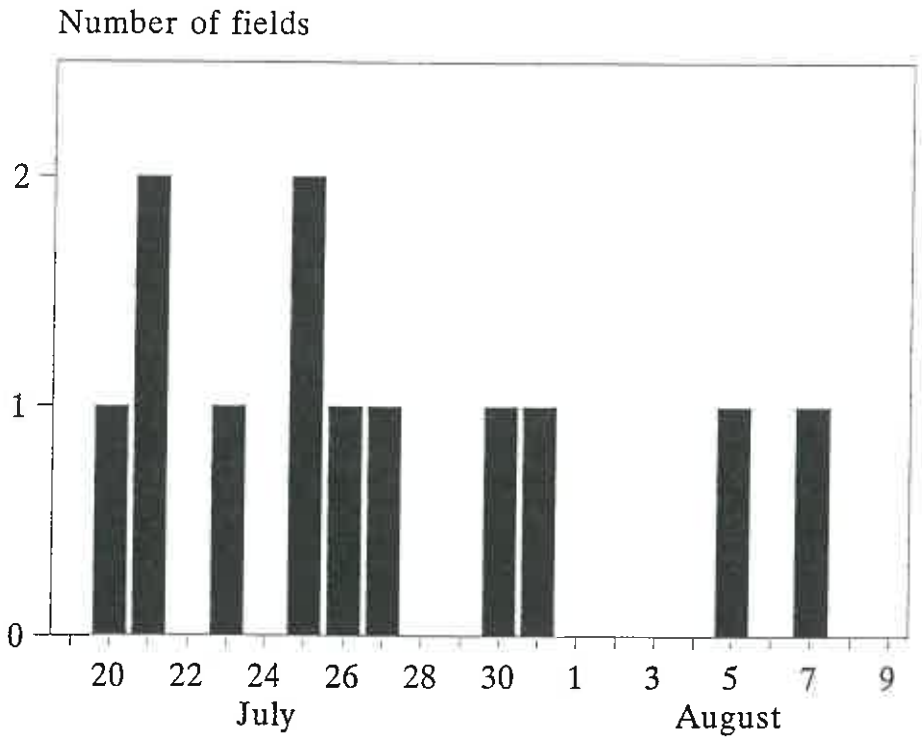

Figure 3.3.1.1 Fledging dates of second brood Reed Buntings

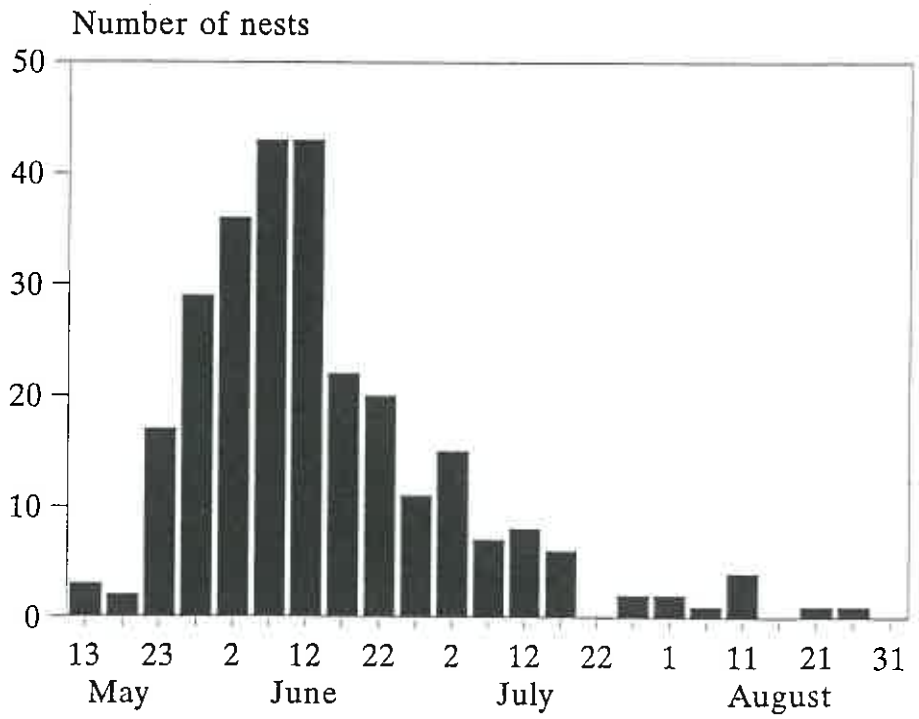

Figure 3.3.1.2 Fledging dates of Reed Buntings in the defined region, determined from an analysis of nest record cards

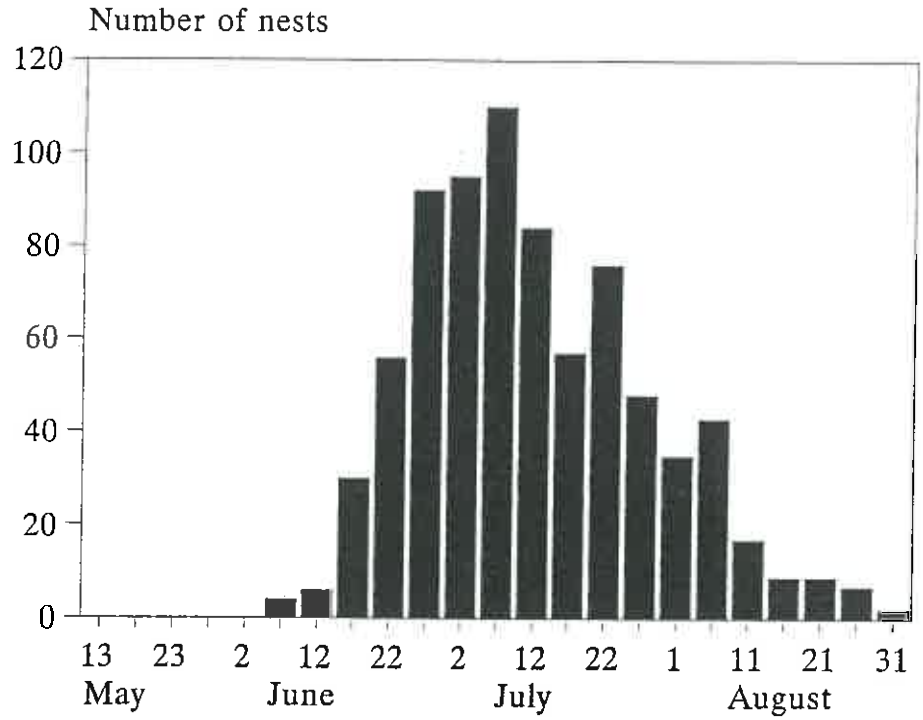

Figure 3.3.1.3 Fledging dates of Reed Warblers in the defined region, determined from an analysis of nest record cards

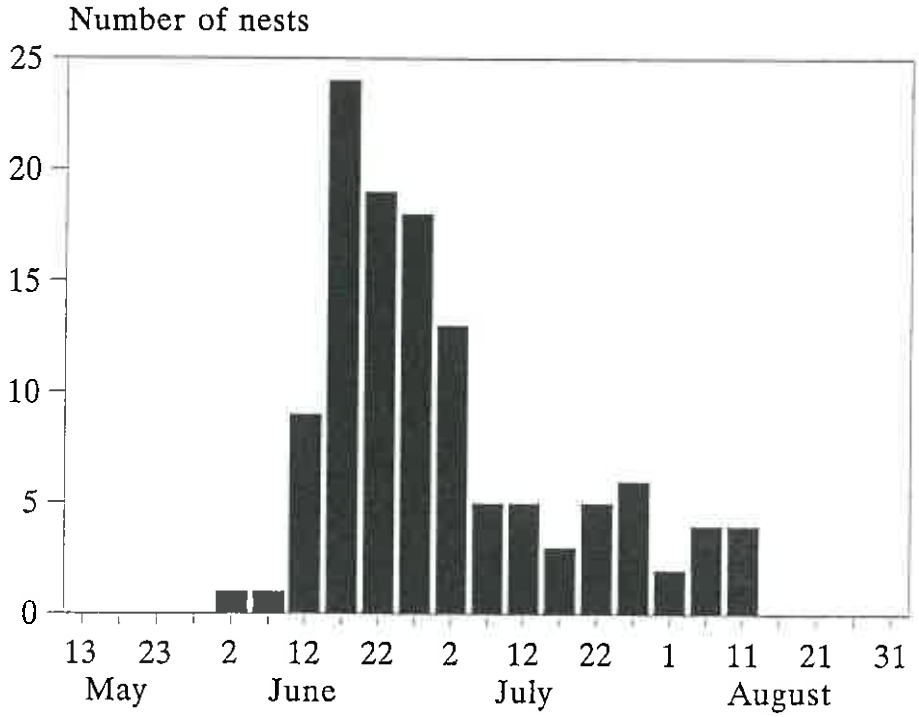

Figure 3.3.1.4 Fledging dates of Sedge Warblers in the defined region, determined from an analysis of nest record cards

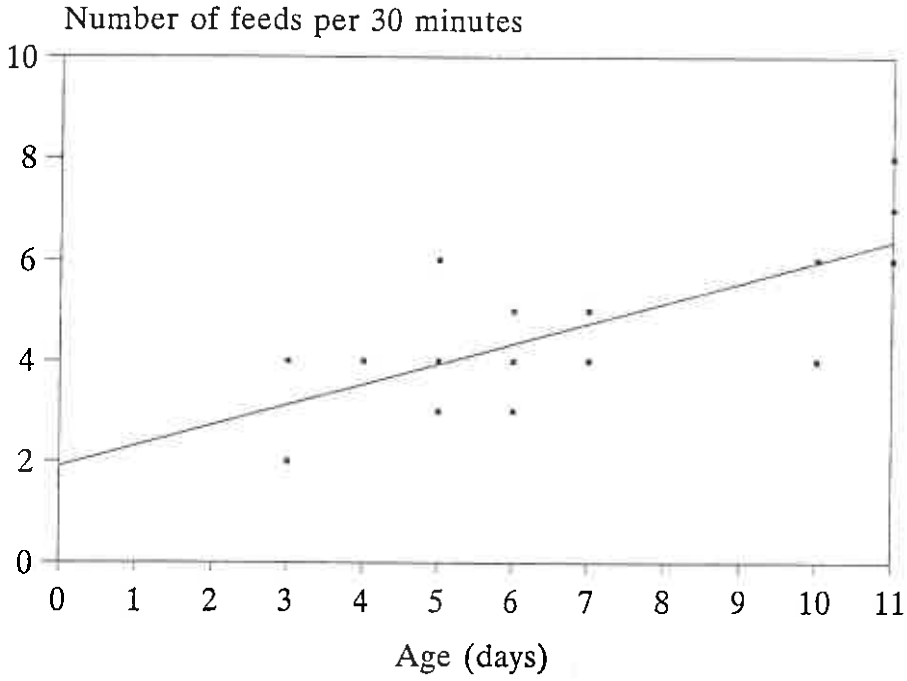

Figure 3.4.1.1 The relationship between feeding rate and nestling age for Reed Buntings nesting prior to spraying

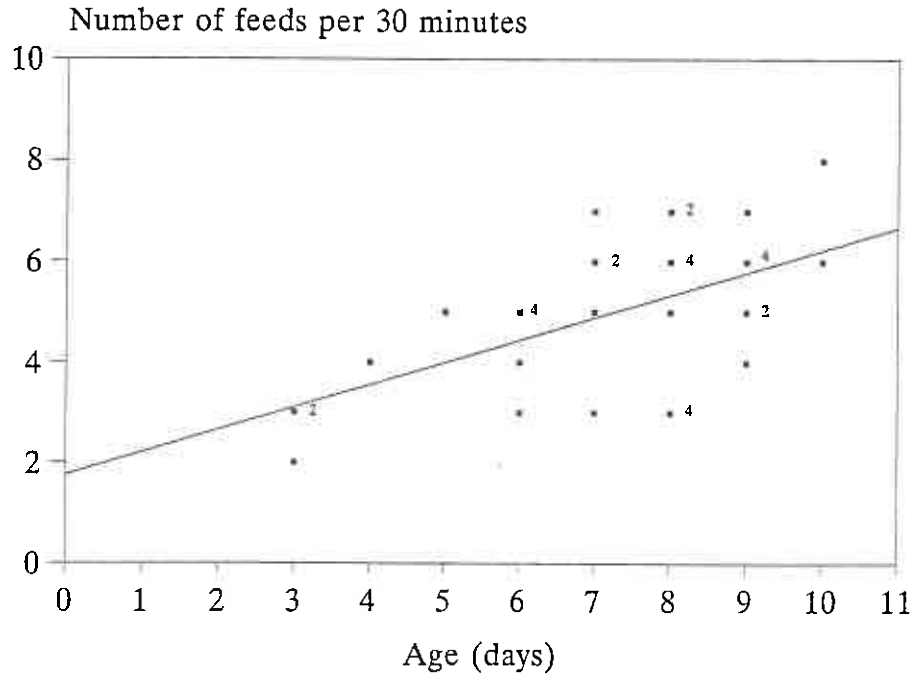

Figure 3.4.1.2 The relationship between feeding rate and nestling age for Reed Buntings after spraying

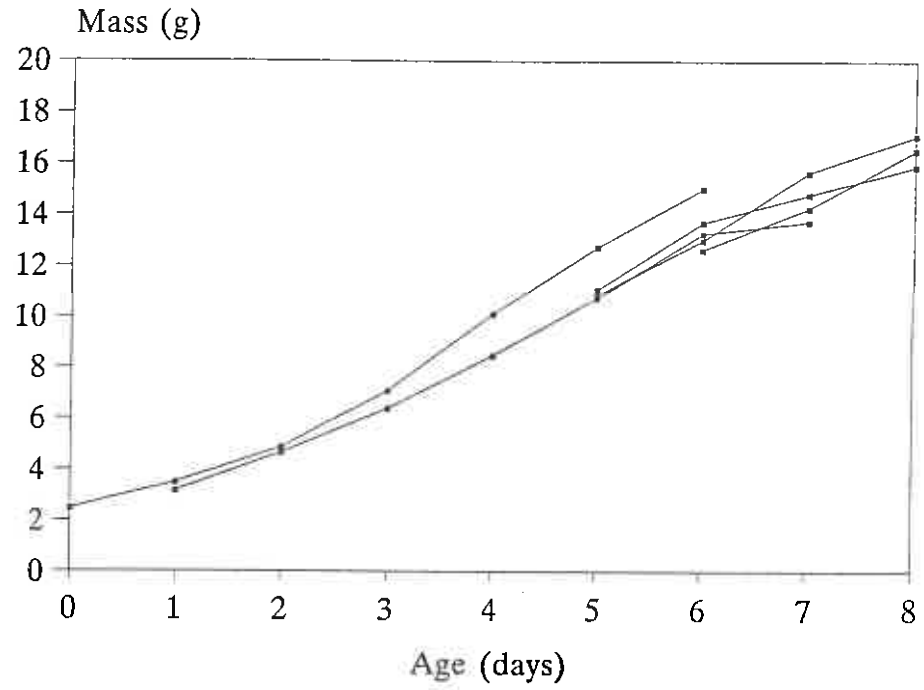

Figure 3.4.2.1 The relationship between mass and age in nestling Reed Buntings. Data are means from five broods.

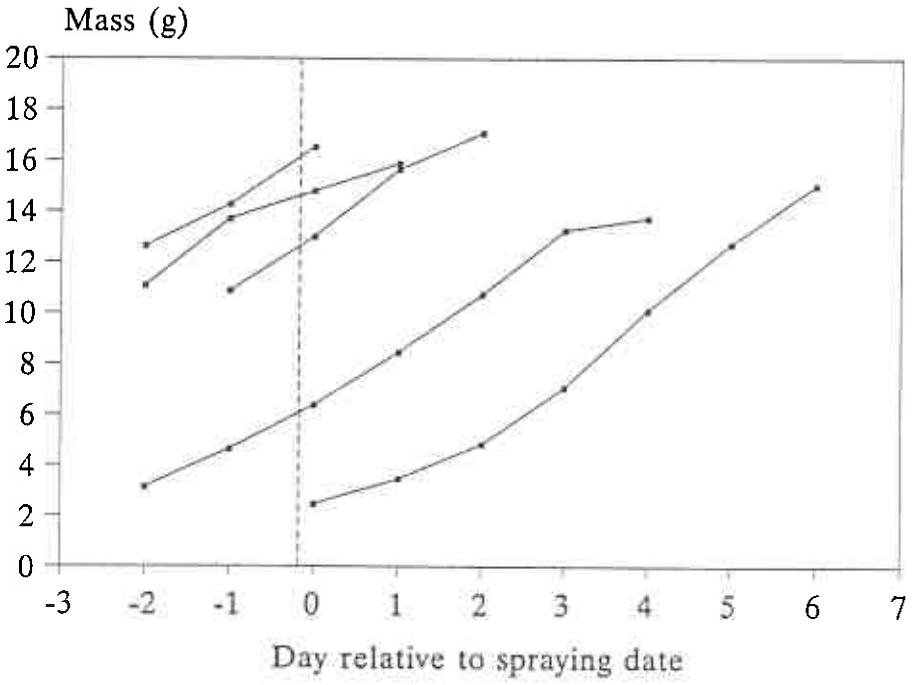

Figure 3.4.2.2 Daily mass changes of nestling Reed Buntings before and after spraying. Data are means from five broods.

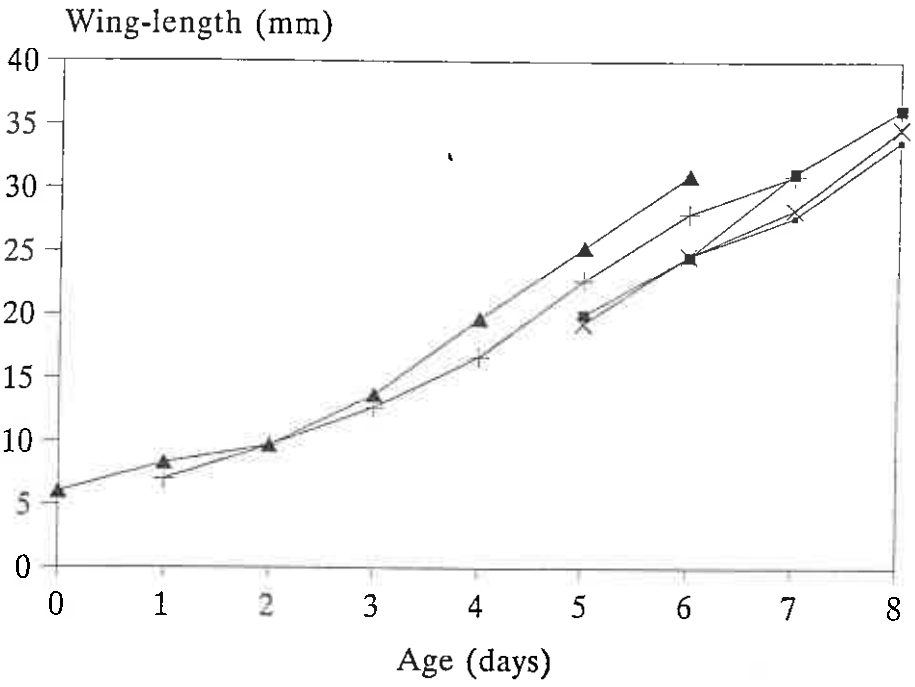

Figure 3.4.2.3 The relationship between wing-length and age in nestling Reed Buntings. Data are means from five broods.

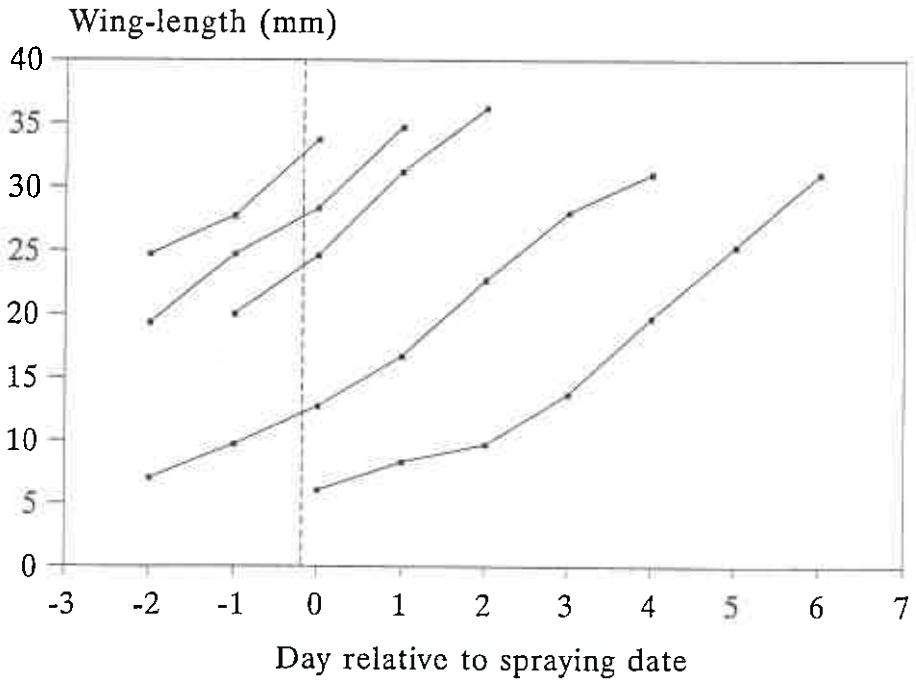

Figure 3.4.2.4 Daily wing-length changes of nestling Reed Buntings before and after spraying. Data are means from five broods.

Appendix 1

Histories of nests in oilseed rape

Each nest is given a two figure code indicating the field it was in and its number. Fields A, B, C and H were sprayed on 26, 23, 20 and 22 July respectively and fields E, I and J swathed on 23, 19 and 21 July respectively.

Sedge Warbler

C1	17 July	Pair building

Reed Warbler

A1	4 July	Pair feeding 3 young in nest (9 days old)
	5 July	Pair feeding 3 young in nest
	6 July	Pair feeding young out of nest; nest empty
A2	6 July	Pair feeding 1+ young in nest
	8 July	Pair feeding young out of nest
B1	9 July	Pair building
C1	26 June	Pair feeding 3 young in nest (7 days old)
	27 June	Pair feeding 3 young in nest
C2	3 July	Pair feeding 3 young in nest (9 days old)
	4 July	Pair feeding young out of nest; nest empty
E1	3-5 July	Pair feeding 1+ young in nest
	7 July	Pair feeding young out of nest
E2	4 July	Pair feeding 1+ young in nest
	5 July	Pair feeding young out of nest

Whitethroat

E1	10-11 July	Pair feeding 1+ young in nest

Linnet

J1	20 July	Pair feeding 1+ young in nest
	21 July	Nest destroyed by swathing; no activity seen

Reed Bunting

A1	19-25 July	Female on 4 eggs
	26 July	Hatched: 3 young, 1 unhatched egg
	27 July - 1 August	Pair feeding 3 young in nest
B1	9-10 June	Female on 1 + eggs
	25 June	Pair feeding young out of nest
B2	9 June	Pair feeding 2+ young (10 days) in and near nest
	10 June	Pair feeding young out of nest; nest empty
B3	16-19 July	Pair feeding 1+ young in nest
	21 July	Pair feeding 1+ young out of nest
B4	9 July	Female on 1+ eggs
	17-22 July	Pair feeding 1+ young in nest
	23 July	Pair feeding young out of nest
B5	9 July	Female on 1+ eggs
	17 July	Pair feeding 4 young (5 days) in nest
	18-21 July	Pair feeding 4 young in nest
	22-24 July	Pair feeding 3 young in nest
	25 July	Pair feeding young out of nest; nest empty
B6	16-17 July	Pair feeding 1+ young in nest
	18 July	No activity seen; presumed predated
B7	21 July	Pair feeding 3 young (1 day) in nest
	22-27 July	Pair feeding 3 young in nest
	28-29 July	Pair feeding 1 young in nest and 1+ out
	30 July	Pair feeding young out of nest; nest empty
B8	22 July	Pair feeding 5 young (5 days) in nest
	23-25 July	Pair feeding 5 young in nest
	26 July	Pair feeding young out of nest; nest empty
C1	10 June	Pair feeding 4 young (11 days) in nest
	11 June	Pair feeding young out of nest; nest empty
C2	10 June	Pair feeding 3 young (10 days) in nest
	11 June	Pair feeding 3 young in nest

C3	18 July	Pair feeding 4 young (6 days) in nest
	19-20 July	Pair feeding 3 young in nest
	21 July	Pair feeding young out of nest; nest empty
E1	23 May	Pair mating and female building
	8 & 10 June	Female on 1+ eggs
E2	7-10 July	Female on 5 eggs
	11 July	Hatching: 3 young, 2 eggs
	16 July	Empty, predated
E3	20-21 July	Female on 1 + eggs
	24 July	Nest destroyed by swathing; no activity seen
E4	21-22 July	Female on 1 + eggs
	24 July	Nest destroyed by swathing; no activity seen
E5	23 July	Pair feeding 1+ young in nest
	24 July	Nest destroyed by swathing; no activity seen
H1	22-23 July	Female on 1+ eggs
	24 July	Female returning to nest; stage unknown
H2	25 July	Pair feeding 4 young (5 days) in nest
	26-30 July	Pair feeding 4 young in nest
	31 July	Pair feeding young out of nest; nest empty
I1	12 June	Pair feeding 1+ young in nest
I2	19 July	Pair feeding 1+ young in nest
	20 July	Nest destroyed by swathing; no activity seen

Appendix 2

Species which used oilseed rape for feeding (excluding those which nested in the crop)

Moorhen *Gallinula chloropus*	Only once recorded in rape
Pheasant	Frequently recorded in rape
Black-headed Gull *Larus ridibundus*	Two recorded feeding from the top of rape in flight
Stock Dove *Columba oenas*	Occasionally recorded in rape
Woodpigeon	Frequently recorded in rape
Turtle Dove *Streptopelia turtur*	Occasionally recorded in rape
Skylark	Only once recorded in rape
Yellow Wagtail *Motacilla flava*	Occasionally recorded in rape
Dunnock	Frequently recorded in rape, both feeding and singing
Blackbird	Frequently recorded in rape, both feeding and singing
Goldfinch *Carduelis carduelis*	Only once recorded in rape
Greenfinch	Frequently recorded in rape
House Sparrow	Only once recorded in rape
Yellowhammer *Emberiza citrinella*	Only once recorded in rape