An examination of the use of oilseed rape brassica napus oleifera, crops by the sedge warbler, crocephalus schoenobaenus in North-East England, 1995 - 1997

Keith Bowey

DEDICATION

For J.R.B. & A.B., who laid the foundations and J.S. - who finished off the pointing.

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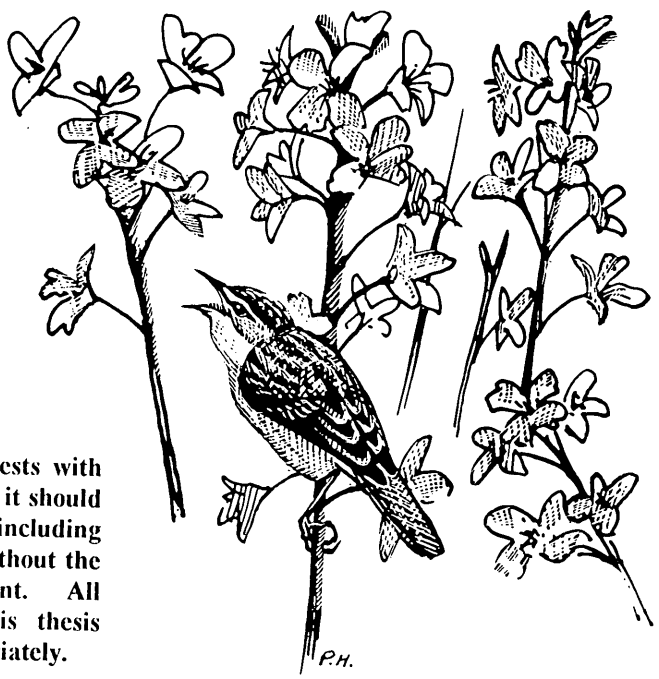

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FOREWORD

In a dynamic world of ever changing stresses upon the biosphere, birds are increasingly looked upon as a means by which large scale environmental changes might be monitored (Furness & Greenwood 1993). Change may be related to gross habitat manipulation or loss resulting from technical or agricultural innovation, or ascribed to the more indirect effects linked to changes in global weather patterns. In a world of shifting sands it is important for ecologists to try and understand how species respond to the effects of such change and how new habitats might sometimes offer new opportunities to some species.

CHAPTER 1 - INTRODUCTION

1.1 General Introduction

Farm land holds substantial populations of birds. It has been said that it is the largest of all habitats available to birds in Britain (O'Connor & Shrubb 1986). Bird population estimates indicate that it holds 50-100 million pairs of *circa.* 130 species (Moore 1980). "Much ecological research relating to the conservation of birds has been directed at studying natural and semi-natural habitats. There is however, now, a growing awareness that all areas of land may be important in contributing towards the maintenance of bird biodiversity - farm land included", (Lack 1992).

Recent declines in common bird species, especially those associated with the farmed landscape (RSPB 1996), have led ornithologists to question some of their long-held beliefs on habitat management and species protection. One conclusion increasingly drawn is that, in a more output-driven agricultural system, a greater emphasis should be placed upon an holistic approach to land management if the common wildlife, especially birds, of our wider countryside is to benefit. This approach is intended to complement the conservationist's traditional view focusing on reserve management and habitat protection programmes. Alongside the urgency with which these new ideas have been formed and adopted, has come an increasing awareness that some formerly derided elements of our farmed landscape are more important for birds than was previously believed. This applies to fields of oilseed rape *Brassica napus* ssp. *oleifera* (Burton *et al.* 1996, Watson & Rae 1998, Burton 1998, May 1998) and their use by sedge warblers *Acrocephalus schoenobaenus*, the subject of this thesis.

In recent decades, the ecology of the sedge warbler has been extensively studied in the British Isles (e.g. Catchpole 1972, 1973b, 1976a, 1976b, 1977, Green & Davies 1972, Bibby & Green 1981, 1983, Thomas 1984, Alker & Redfern 1996). The changing

fortunes of this species, amongst others, (Peach *et al.* 1991) has been used in developing the concept of integrated population monitoring (Greenwood *et al.* 1993). This research has concentrated on populations in the species' traditional habitats. Recent reviews of birds in farm land (Mellanby 1981, O'Connor & Shrubb 1986, Lack 1992) make little or no reference to sedge warblers and their association with rape; whilst some suggest that, within the farmed landscape, sedge warblers associate only with wetlands (Shaw 1988).

To date, there has been no published, systematic study of the use of oilseed rape by sedge warblers, despite the fact that, since 1974 (Bonham & Sharrock 1974), they have been known to use the crop. The growth in popularity, as a crop, of oilseed rape amongst land managers raises questions as to how important, relative to semi-natural vegetation, this habitat now is for a bird species, whose British population, has declined considerably in the last three decades (Marchant *et al.* 1990). This thesis documents the results of the first extensive, detailed study of the use of rape crops by the species.

1.2 The Aims of the Thesis

This thesis has two broad aims. First, it attempts to document, quantify and evaluate, the degree to which oilseed rape is used by sedge warblers in north east England. Second, it examines some aspects of the species' behavioural ecology in the crop and compares these with its behaviour in more traditional habitats.

1.2.1 Objectives

The study had three main objectives. To ascertain:

i) the degree of utilisation of oilseed rape crops by sedge warblers in a 138 km^2 area of north east England and to place this into a regional and national context. This was to be achieved via a survey of rape crops in the study area, and a desk top study to provide the regional and national contexts (the results of which are published elsewhere - Bowey *submitted*).

ii) whether the species chooses rape crops, preferentially, over adjacent agricultural habitats, for nesting and feeding (Bowey *in prep*);

iii) how aspects of the species' ecology in rape compared to those in typical habitats, namely its: territorial spacing; singing and song-flight behaviour; and, if proven to breed its breeding success and nesting strategy.

At the outset of this study, published sources (Bonham & Sharrock 1974, Bradbury *et al.* 1990) had shown sedge warblers might be found in rape. For this association to be established unequivocally it was felt necessary to prove:

i) a temporal association between sedge warblers and rape throughout the breeding season; i.e. greater than the transitory association observed for migrating birds, such as whinchat, *Saxicola rubetra* and rape (Bowey *in press*).

ii) that sedge warblers tracked (*sensu* Wiens 1989) changes in the location of the rape habitat between breeding seasons.

iii) that a rape field with sedge warblers in one summer, would not have birds the following year if a crop, other than rape, was grown in that field in the second year.

1.3 The Sedge Warbler

Range and Relationships

The Sedge Warbler *Acrocephalus schoenobaenus*, is a summer visitor to the British Isles, with a distribution extending into north-west Europe (Hagemeijer & Blair 1997), and east to Western Siberia (Harrison 1982, Flint *et al.* 1984). It is a long-distance, trans-Saharan migrant (Moreau 1972) wintering in tropical and sub-tropical zones of west and southern Africa (Cramp1992, Gibbons *et al.* 1993, McLachlan & Liversidge 1981, Curry-Lindahl 1981).

Essentially, it is monotypic (Snow 1971, Williamson 1983), with a body length of *circa.* 13 cm, a wing span of 17-21 cm, a lean weight of 11.2 g (Cramp1992) and a life expectancy of up to six years (Literak & Pikula 1996). Its identification and separation from closely related and similar species has been well covered in the literature (Williamson 1983, Bibby 1980, Porter 1983, Harris *et al.* 1989, Madge 1992). During the breeding season it is largely insectivorous (Witherby *et al.* 1958), though it has been recorded taking a wide range of food items, including some fruits (Cramp 1992).

History in Britain

Evidence of the species in Britain dates from Pennant 1776 (Harrison 1988), though it was probably widespread long before then (Holloway 1996). This assertion is based on the evidence of the species' many common names, e.g. "sedge bird" -18th century Surrey and Sussex; "chitter-chat" - a Northumbrian name (Lockwood 1984, Harrison 1988); "chattering Billy", "razzor grinder" and "pit sparrow" (Simms 1985, Greenoak 1997). It was described by Gilbert White, as early as 1769 (White 1788). Such cultural evidence confirms that it must have been a familiar bird during the 19th century (Holloway 1996).

Prior to the extensive drainage of lowland wetlands, especially in the eastern Fens (Godwin 1978, Rackham 1986), it would, in all likelihood, have been a more widespread and common bird in Britain, than at present (Harrison 1988).

Habitat Choice and British Distribution

Across its range it is found in "osiers and reedbeds, hedgerows, tangled vegetation, bushes and undergrowth on marshy ground, near water along ditches and in crops" (Vaurie 1959). Use of crops during the breeding season, at least on the continent, was recognised some time ago (Witherby *et al.* 1958) but in Britain the use of rape has been known only since the early 1970's (Bonham & Sharrock 1974). In Britain, with the exception of willow warbler *Phylloscopus trochilus*, it is the most widely distributed member of the *Sylviidae* (Gibbons *et al.* 1993). It is found, as a breeding bird, from the south coast, through Wales (Lovegrove *et al.* 1994), Ireland (Sharrock 1976, Hutchinson 1989), England and Scotland, to the Western Isles. It is scarce in the north-west highlands (Thom 1986) and is the only member of its genus regularly breeding in the northern isles (Gibbons *et al.* 1993); having increased in Orkney this century (Snow 1979). It has been recorded "singing" in Shetland (Berry & Johnston 1980) and was recently confirmed as a breeding species there (Sclater 1997). Essentially, it is a lowland species, rarely found breeding above 300 m a.s.l. (Thom 1986).

Status

Prior to the 1960's the species' population level in Britain was believed to be stable (Marchant *et al.* 1990), with some localised increases recorded this century, for example in the Outer and Inner Hebrides (Thom 1986). Since the Second World War extensive lowland drainage has been implicated in the decline of a number of wetland birds, like the sedge warbler (Williams & Bowers 1988). Since the mid-1960's the species has undergone considerable fluctuation in population level, the trend being one of decline, with some recovery since the mid-1980's (Marchant *et al.* 1990); recent reviews emphasising this (Stroud & Glue 1991, Andrews & Carter 1993, Carter 1995). So severe was the decline in the early 1980's that, in 1990, the species was listed as a Red

Data candidate species (Batten *et al.* 1990), although subsequently omitted from both red and amber lists (Gibbons *et al.* 1997). From a European perspective, it has declined considerably in the north-west, with an estimated overall decline of 12%, 1970-1990 (Tucker & Heath 1994), though there have been increases in some northern states, e.g. Finland.

Declines in Britain during the late 1960's (Sharrock 1976, Hutchinson 1989) were ascribed to the prolonged droughts experienced in its wintering area (Marchant *et al.* 1990); mirroring the decline of the similarly wintering whitethroat *Sylvia communis* (Winstanley *et al.* 1974). Further population crashes occurred, co-incident with a re-commencement of Sahel droughts, during the early to mid-1980's, (Marchant *et al.* 1990, BTO 1991); spring to spring survival of marked birds correlating with rainfall patterns in the Niger (Peach *et al.* 1991). Some reviews of historical information suggest that populations have been largely stable or marginally increasing (Gibbons *et al.* 1996).

Breeding densities of sedge warbler can be high in suitable habitats, up to 172 territories per km^2 (Thom 1986). The most recent national population estimates suggest 250,000 pairs (Gibbons *et al.* 1993), compared to 300,000 in the early 1970's (Sharrock 1976).

Migration

Spring migrants are noted in Britain from April (Riddiford & Findley 1981), rarely in late March in southern counties (Nightingale & Alsop 1992, Nightingale & Alsop 1996). Birds are routinely present into September, with small numbers in October (Riddiford & Findley 1981), but winter records are rare (Lack 1986). Extreme dates for its presence, in one African wintering area, were 26th May and 28th August (Aidley & Wilkinson 1987b). Locally, it is present from late April, supplemented by the arrival of birds throughout May and into June (pers. obs.), to early September (Unwin 1975-1979, Baldridge 1980-1986, Armstrong 1987-1995); adults leaving breeding habitats, and the region, during late July and early August (Durham Ringing Group 1988-1996). These dates tally with the national situation (Riddiford & Findley 1981). Locally, females

arrive some eight to ten days later than males (pers. obs.). A Scottish colour-ringing study suggested a similar difference between the sexes (Thom 1986). Peak autumn passage in Britain, occurs in early August (e.g. Ormerod 1990a), passage birds feeding in reedbeds especially on plum reed aphids *Hyalopterus pruni* when available (Bibby & Green 1981, Ormerod 1991). Locally, birds in August and September are usually birds of the year (Durham Ringing Group 1988-1996). Such migratory pulses, of similarly aged birds, adults earlier in the season than birds of the year, have also been shown to occur in some reedbeds further south in Europe (Basciutti *et al.* 1997). Southward migration can be relatively rapid, a bird ringed on Calf of Man was taken from a cat, in Shropshire 200 km away, 25 hours later (Wallace 1981).

Sedge Warblers in Rape

Earlier reviews of farm land birds (e.g. Nicholson 1951) make no mention of sedge warblers or oilseed rape. The species was first documented singing in rape in Bedfordshire, May 1974 (Bonham & Sharrock 1974). Prior to this, despite being found relatively frequently in agricultural areas, usually along hedges and ditches (Murton 1971), it was thought not to occur often in arable crops and never in rape. Subsequently, the use of rape fields by sedge warblers and other birds, has became much more common (Sharrock 1986, Bradbury *et al.* 1990, Watson & Rae 1998). Despite this increased documentation, Lack (1992) still asserted that "pied wagtail and sedge warbler are usually associated with wet areas" indicating that, even recently, the potential importance of rape to sedge warblers was not recognised.

1.4 Oilseed Rape

"Our countryside is like a multi-coloured chequerboard. Its chief characteristic is its attractive patchwork appearance, with an infinite variety of small odd shaped fields of brown ploughland or green pasture....", (Young 1943); to this pallete, yellow has been added.

Range and Relationships

Oilseed rape, has been used to refer to a number of crops but, in Britain, usually refers to *Brassica napus* ssp. *oleifera* (Anon. 1988, 1989). It is a yellow-flowered crucifer (*Brassicaceae*) i.e. cabbage family (Clapham *et al.* 1989) with glaucous-green, lyrate, pinattifid leaves, the inflorescence being an elongated raceme, carrying four-petalled flowers (Weiss 1983). Flower number varies from plant to plant, a dozen to double that; on average, 68% of these produce seed-bearing pods. It is self-fertile, though there may be some insect-related facilitation of fertilization (Weiss 1983). A crop of the temperate regions, rape grows best at temperatures below 25° C., is relatively frost and pH tolerant and grows on a wide variety of soil types (Weiss 1983). It may or may not be a cultigen and evidence, from chromosomal studies, suggests that the modern crop may be derived from the hybridization of swede rape *B. rapus* and wild cabbage, *B. oleracea* (Scarisbrook & Daniels 1986, Smart & Simmonds 1995).

History and Uses in Britain

Brassica napus has been widely grown in north-west Europe for centuries (Smart & Simmonds 1995). In India, it is known from Sanskrit records, 2000-1500 BC (Langer & Hill 1991) whilst in Britain, Brassica pollen has been recorded from Roman sites and rape pollen is known from the Anglo-Saxon settlement of Hungate (Godwin 1975). It has been grown since at least the 16th century, spreading to the Fens in Lincolnshire, during the 17th century drainages of that area (Ward *et al.* 1985).

The seed was originally used to produce oil for lamps (Langer & Hill 1991) but was replaced by animal fats, and then gas and electricity. It became a fodder plant; declining in popularity over the later part of the 19th and early 20th centuries (Kirk 1992). By the 1960's little was grown in Britain, its uses being restricted to some industrial lubricants (Kirk 1992). Modern varieties are increasingly used as a source oil for the production of "bio-diesel" (Smart & Simmonds 1995, Durham County Council 1997).

The decline in its popularity of cultivation was reversed in the early 1970's when the acreage grown increased dramatically (Table 1). The factors leading to this included a substantial increase in world market price and the guaranteeing of crop price in Europe, in order to reduce the import of vegetable oils (Moore 1987), under the European Economic Community's Common Agricultural Policy (Smart & Simmonds 1995). Simultaneously, there was an increased awareness that the use of rape as a break crop could reduce pest treatment costs and increase yield (Ward *et al.* 1985). Break crops are now used by most arable farmers, usually between winter cereals; wheat *Triticum aestivum*, and barley, *Hordeum vulgare* (Lack 1992) in a modern version of crop rotation. The principal factor making the crop popular with farmers was the system of financial inducements, available under the Common Agricultural Policy (Woods 1989). The economic impetus underpinning this growth in cultivation is illustrated by the market price, rising from *circa.* £35 per tonne,1969, to *c.* £50 by 1971-72; *c.* £70-80 by 1973; *c.* £100 by 1974 and to over £300 by 1983 (Eddowes 1976, Ward *et al.* 1985).

The area of land under cultivation to rape in England increased seventy four fold in the 15 years between 1970 and 1984 (Sharrock 1986). In the UK, between 1971/72 and 1981/82, the area grown increased by 1567% whilst, over the same period, wheat tillage increased by 40%, with barely any increase in barley; this was set against a slight decline in total arable crops, from 19,149,000 ha to 18,795,000 ha (Anonymous 1983) over the same period. By 1985, rape occupied a greater area than any other arable break crop (Ward *et al.* 1985). Increases continued into the mid-1990's (Anonymous/MAFF 1997), spreading north; over 10,000 ha being grown in Scotland by 1984 (Ward *et al.* 1985). By the mid-1990's, it had reached Shetland (pers. com. D. Okill).

In most recent reviews of birds in agricultural landscapes, rape's use by birds is not mentioned (Mellanby 1981, Woods 1989, Evans *et al.* 1996) though occasionally alluded to (Davis 1967). Most references to the use of rape by sedge warblers, and other birds, have come from observations published by amateur observers (Bonham & Sharrock 1974, Sharrock 1986, Bradbury *et al.* 1990). With the exception of a short enquiry by

the BTO (Burton *et al.* 1996, Burton 1998), for which the reed bunting *Emberiza schoeniclus* was the main study species, there have been few systematic studies of the topic.

1.5 Study Areas

All field work was conducted within the Metropolitan Borough of Gateshead, Tyne & Wear (Figure 1); latitude: 54° 53' to 54° 59' north; longitude: 1° 30' to 1° 50' west. The borough covers an area of some 138 km² (Gateshead M.B.C. 1995).

The Gateshead region, at the mid-latitude point of the sedge warbler's world breeding range (Murton & Westwood 1977), is geographically and ecologically varied, with a wide range of habitats (Bowey *et al.* 1993). It has an altitudinal range of *circa.* 250 metres; highest point, 259 m a.s.l. (H.M. Ordnance Survey 1987). Although it has an extensive urban area (population of 203,000 - Gateshead M.B.C. 1995) in the east, in the largely rural west considerable areas are acknowledged as being of "high wildlife and conservation value" (Nature Conservancy Council 1989), and contain many Sites of Nature Conservation Importance (Gateshead M.B.C. 1997b). Some 17% of its area is afforested (Bowey *et al.* 1993) and agricultural areas are comprised of: permanent pasture, with beef and dairy cattle, sheep and horses; as well as arable. The range of arable crops grown is limited, mainly winter cereals and rape; with some potatoes and spring rape (Gateshead M.B.C. 1995). Rape is widely grown, except along the northern boundary and in the main central and eastern conurbations. The use of rape by sedge warblers was studied across the whole of the borough.

The principal study site for birds in traditional habitats, was Shibdon Pond Local Nature Reserve (S.S.S.I.), located in the broad, glacially scoured flood-plain of the River Tyne, at Blaydon (54° 58' north, 1° 42' west), between 2-4 m a.s.l. It is a prime site for sedge warbler, holding annual maximum densities of between 121-181 singing males per km² in

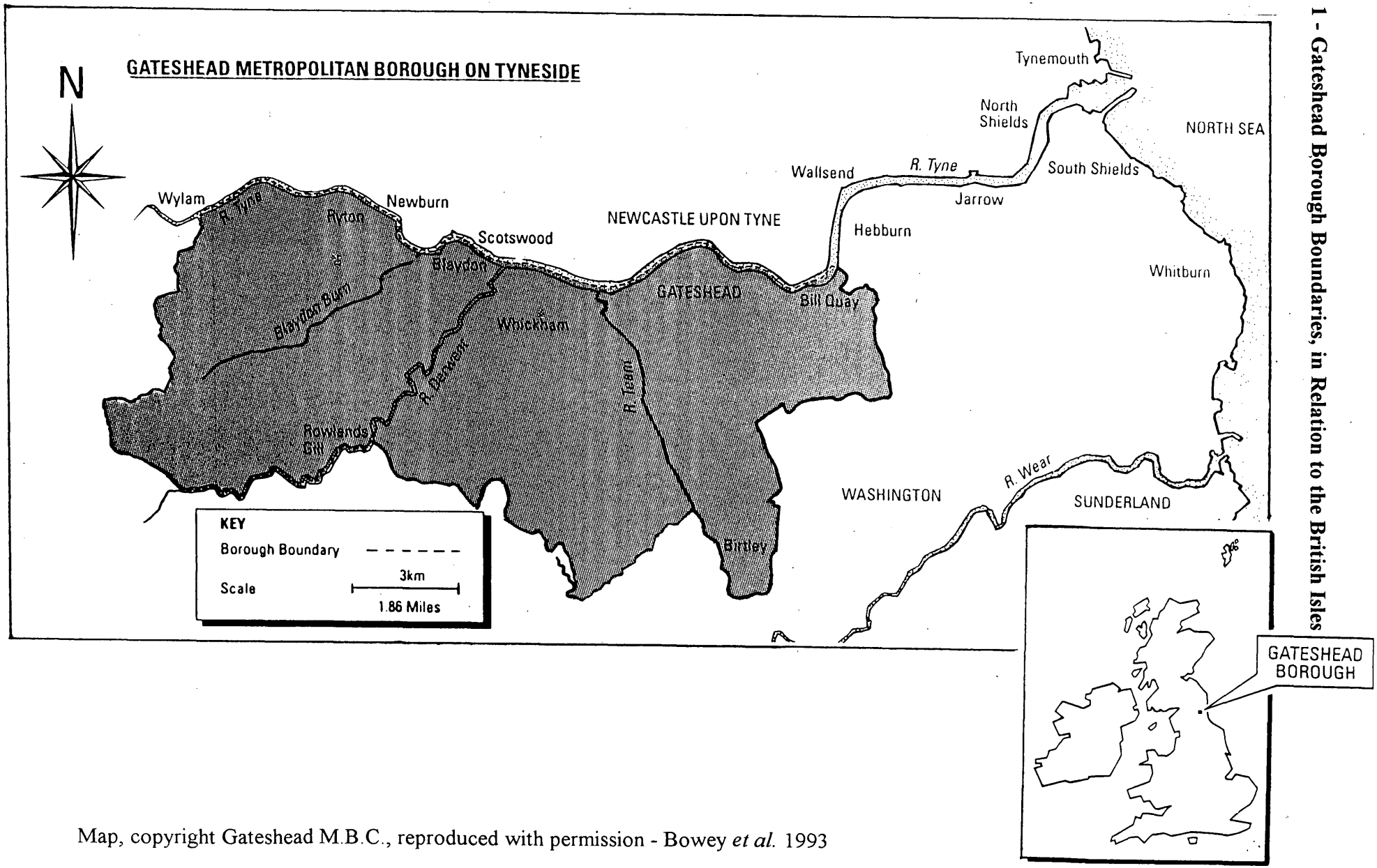


Figure 1 - Gateshead Borough Boundaries, in Relation to the British Isles

1988-1993 (Armstrong 1988-1993, Bowey unpub. data). The site is owned by Gateshead M.B.C. and leased to Durham Wildlife Trust (Gateshead M.B.C. 1997a). A nature trail, open to the public, allows easy access to all habitats used by sedge warblers. As public access is usual, birds are used to the presence of humans and are not disturbed by prolonged periods of observation (see Alker & Redfern 1996).

The reserve features a wide range of wetland and dry habitats often used by sedge warbler including: stands of *Typha latifolia*; *Glyceria maxima* reedswamp; common reed *Phragmites australis*; as well as marsh, with *Epilobium hirsutum* and *Juncus* spp.; willow *Salix* spp. and hawthorn *Crataegus* scrub. On the fringes of the reserve both Japanese knotgrass, *Reynoutria japonica*, and Canadian golden-rod, *Solidago canadensis* are utilised by sedge warblers as a nesting habitat. For the purpose of this thesis rank grassland areas, outside of the S.S.S.I., but occupied by sedge warblers, were considered an integral part of the study area, bringing the total area under scrutiny to 18 ha.

CHAPTER 2 - METHODS

2 General Methods

An extensive survey in Gateshead, of rape and all suitable sedge warbler habitat, as traditionally defined (Cramp 1992), was carried out during spring/summer 1995 and 1996, with limited additional field work in 1997. The presence/absence of birds was determined during surveys along the periphery of rape fields or, in the case of Shibdon Pond, along the 1.2 km Nature Trail. Analysis of results from intensive survey work in the contrasting habitats allowed for the development of a comparative study of the territorial density and behaviour of birds in rape and traditional habitats.

Surveys were conducted during the peak song-period for sedge warblers, late April to early June (Catchpole 1973a, Shaw 1988). The presence of sedge warblers was established by the registration of singing activity by males or, by visual observation. All registrations were logged and mapped, according to the observed activity of each bird (Williamson & Homes 1964).

Each extensively surveyed rape field was visited on at least three occasions over a three week period during the main song period, 1995 and 1996, to determine presence or absence of the species. A smaller sample of rape fields were similarly visited in 1997. Surveys were usually conducted between the hours of four and eight a.m. (B.S.T), the most productive period for singing males (Catchpole 1973a). Due to time constraints, approximately 35% of surveys had to be undertaken at other hours of the day, mainly before noon but with some afternoon (<5%) and evening visits (*circa.* 10%). As a result, there may have been a small reduction in the detectability of birds. However, this effect should have been, in part, compensated for by other visits to these sites at the peak time for song output. Assuming temporal song patterns to be similar between habitats, any observed reduction in detectability would have been similar as the timing of survey visits was standardised in both habitats.

Non-registration of sedge warblers in a visited field/habitat at any time during the survey visit was interpreted as absence. Survey work identified occupied fields, in which further intensive and behaviour based studies might be conducted. Due to the synchronised nature of sedge warbler's spring song (Bell *et al.* 1968, Catchpole 1973a) this work was concentrated in May and early June.

Repeat observations, over several days, of singing birds, allowed the construction of territory maps, territory densities being calculated using cluster analysis (Marchant 1983). Bell *et al.* (1968) determined that such Common Bird Census (CBC) methods might locate only 75% of sedge warbler territories; hence the reliance, in the intensive study, on supplementary, confirmatory details to indicate the presence of a breeding territory, e.g. the registration of birds undertaking breeding, pair-bonding or nest-building behaviour (Tomialojc 1980). That said, it has been determined that the sedge warbler is one of the easiest species to map accurately using CBC-type registrations (Fuller & Marchant 1985). Whilst accepting the constraints upon accuracy inherent in such methods for revealing sedge warbler presence in extensively surveyed rape crops (Dawson 1985), it is appropriate to use such an approach to investigate the species' territorial spacing and population density in intensively surveyed rape crops. Only areas with singing males were studied intensively, except for three fields, holding crops of winter wheat, barley and spring rape in 1995, and an area of agricultural habitat, holding winter wheat, in spring 1997 that had held rape in 1996.

Field observations were undertaken using 10 x 40 binoculars and a 20-60 zoom telescope, and were recorded on a hand-held, Sony dictaphone, for later transcription. Throughout the study it was assumed that all ringed and colour-ringed birds behaved in similar ways to those which had not been so manipulated (see Calvo & Furness 1992).

Statistical analysis of results was undertaken using Micro Soft Works spreadsheets and according to Fowler & Cohen (1994), with reference to Tabachnick & Fidell (1989).

The sedge warbler distribution maps were generated using "Recorder", a biological database package developed by English Nature.

In all analyses, the Null hypothesis, of no difference between groups, is invoked i.e. that data sets are drawn from similar populations or samples. Any observed differences between these samples are considered statistically significant at the 95% confidence level, i.e. where $p<0.05$. Hence, when data analyses indicates that $p<0.05$, the Null hypothesis has been rejected and it was considered that the data sets were not drawn from similar populations or samples.

CHAPTER 3

The Distribution of Sedge Warblers in Oilseed Rape, Gateshead 1995-1997, with a Comparison of the Species' Utilisation of This and Traditional Habitats

Introduction

The sedge warbler is widespread in north-east England (Kerr & Johnston 1991-1995, Day *et al.* 1995, Armstrong 1987-1995, Bell 1988-1996). Earlier this century it was considered a common summer resident, though declining due to wetland drainage (Temperley 1951). In general, its status remains unchanged over the last 20-30 years (Durham County Bird Report 1970-1973, Raw 1992), despite the fact that some mapping exercises (Gibbons *et al.* 1993) indicate local losses from as many as ten 10 x 10 km squares where formerly present (Sharrock 1976). Locally, it is a lowland bird, many occupied areas being situated along the main river valleys, with a population estimate of between 520 and 660 territories (Westerberg & Bowey 1999) in County Durham, southern Tyne & Wear and north Cleveland (i.e. vice-county 66).

Sedge warbler's choice of habitat is catholic, with an emphasis on "high marsh" (Fuller 1982). It includes: reedbeds, scrub and young forestry plantation (Parslow 1973, Simms 1985), although the latter is not documented by Avery & Leslie (1990). Traditional habitats include a variety of low, dense vegetation, scrub and ruderal habitats not exclusively near water but often located on wetland margins (Cramp 1992). Gibbons *et al.* (1993), state that they occasionally breed in "crops, like oilseed rape" but this habitat was not listed by Fuller (1982). This suggests that any widespread use of rape is a recent, or recently recognized, phenomenon. This is confirmed by studies of farm land bird communities in the 1960's and 1970's (Williamson 1967, Wylie 1976) which made no mention of the habit. Sedge warblers were first recorded using rape in Gateshead when three were singing at Fellside, Whickham, in May 1989 (pers. obs.); although anecdotal evidence suggests that birds may have been present in rape at Kibblesworth as early as 1987.

The major agricultural land uses in Durham are for mixed arable and pastoral systems, which cover almost 51.5% of land area (Clifton & Hedley 1995); rape is a widespread, commonly grown crop (pers. obs). In Tyne & Wear, the area covered by rape was too small to be documented up to 1980 but, by 1984, over 700 ha was grown (Ward *et al.* 1985), with over 380 ha of winter rape in Gateshead alone, by 1995 (Bowey unpub. data).

This chapter presents the results of quantitative surveys of the distribution and abundance of sedge warblers in rape and traditional habitats in Gateshead borough, in relation to a series of environmental variables.

Methods

The location of all rape crops in Gateshead borough was established via an extensive ground survey during early March-late April 1995. All arable fields in the borough were visited to identify their crop type and landowners of fields with rape were identified (Appendix 1), by local enquiry and cold calling of farmers listed in the Gateshead and South Tyneside telephone directory. Once contacted, access permission and arrangements were negotiated and land owners were kept in touch with the study's progress through mailings and personal seasonal reports. The location of crops in 1996 and 1997 was determined from information provided by landowners, supplemented by a limited ground survey to identify any overlooked crops. Adjacent fields of rape, separated by a boundary feature, such as a hedge, a ditch or vegetated hedge bank, were treated as different fields.

Presence/absence of birds was determined during extensive field surveys (see Chapter 2). A field was considered occupied if, at any stage of the survey period, a sedge warbler was recorded using the rape, for any purpose. To identify the environmental variables which might affect the use of rape crops by sedge warblers, the following were examined, in relation to the presence of birds:

i) Altitude - taken from Ordnance Survey (OS) 1:25,000 scale, Path-finder maps (H.M. Ordnance Survey 1989-1991), at estimated field centre, as a best fit between 5 m contour lines.

ii) Field area - measured, to the nearest one hundredth of a hectare, using a zero setting, compensation planimeter, on 1:10,000 maps (as a mean of five measured values). Where possible, areas were cross referenced to parcel numbers on Ordnance Survey maps, as a check to accuracy.

iii) Distance to nearest wetland - as the species is often associated with wetland margins the effect of distance from such habitats on presence in the crop was examined. Distance from crop edge to the nearest open water/wetland was measured using a miniature trundle wheel, on O.S. 1:25,000 Path-finder maps. Figures used were the mean of five measured readings, to the nearest 5 m.

iv) Distance to nearest traditional habitat known to have been occupied by sedge warblers in the previous five years, as in iii)

v) Distance to nearest rape crops in previous year - planting of rape is moved between fields from season to season. Hence, distance to nearest rape crop between growing seasons might affect the probability of occupancy by sedge warblers. Distance was determined by locating all the previous season's rape fields and measuring distance from field edge to edge, as in iii).

Additionally, habitat descriptions of areas adjacent to or abutting crop fields were determined in the field using the National Vegetation Classification for semi-natural habitats (Rodwell 1991), or by categorisation into three non-natural classes: urban, agricultural or plantation.

At certain rape field sites occupied by sedge warblers, an intensive study of territorial spacing and behaviour was conducted, to allow comparison with similar work undertaken in traditional habitat at Shibdon Pond. Four rape sites were chosen for potential intensive work, this work being completed in three of them. The criteria used to choose these sites were: that the sites would represent crops grown across a broad

Table 2 - Characteristics of Intensively Studied Areas of Oilseed Rape, Gateshead Borough 1995-1997

	Altitudinal Range (m)	Years Rape Present	Intensive Study	Crop Management
Barlow Fell	160-170	1995, 1996, 1997	1995	Rotation
Team Valley	15-25	1995, 1996, 1997	_	Rotation
Washingwell	75-115	1995, 1996, 1997	1996	Blocks Rotated
Winlaton Care Village	100-110	1997	1997	Blocking

Key:
Rotation - rape rotated, usually around four adjacent fields, on a four year cycle with other arable crops.
Blocks rotated - rape was moved around large areas of arable land between years, but usually within two to three field lengths of a previous year's crop.
Blocking - rape grown in blocks i.e. groups of fields, the crop was usually moved considerable distances between fields between years.

Results

Extent and type of rape cultivation in Gateshead borough

During 1995-1997, 185 fields of rape were recorded in Gateshead; six of these were of spring sown rape (3.24%), the remaining 179 of autumn sown, i.e. winter, rape. Only the latter is sufficiently developed in spring to provide suitable habitat for sedge warblers. Hence, survey effort was concentrated in this crop. Of the winter rape crops, 126 were surveyed for sedge warblers; 117 extensively (see Chapter 2) and 9 intensively (three per annum). In all surveyed winter rape fields, summed across three years, birds were absent from 53 (42%) and present in 73 (58%).

For summary details on the location of rape fields, the type and area of rape grown, and those used by sedge warblers, see Appendices 5 & 7.

Distribution of rape and its use by sedge warblers in Gateshead borough

Sedge warblers were recorded in rape, in all parts of the borough, wherever the crop was grown. Survey work in 1995 revealed that 40% of the 55 whole or partial tetrads (2x2 km) in Gateshead held sedge warblers, at a mean density of 3.73 singing males/occupied tetrad. Over the three seasons of the study, birds were recorded singing (in both habitat types) in 27 tetrads (49.1%) in at least one year (for annual breakdown and densities see Tables 3 & 4). Most rape was grown in the west and south of the borough and the crop was recorded in 25 tetrads (see Appendix 5); sedge warblers were known to be present in at least 76% of these. Over the three years of the survey only three tetrads held sedge warblers in both traditional and rape habitats, and in only one of these (in 1996) did birds occur in both types of habitat in the same tetrad, in the same year (Figure 2a).

The extensive survey of suitable sedge warbler habitats revealed a greater number of singing birds in Gateshead, in all years of the study, than previously realised. A borough population estimate of 40 singing birds had been made in 1993 (Bowey *et al.* 1993), prior to the realisation that many birds were using rape crops. In 1995 and 1996, 82 and

Figure 2a - Distribution of Sedge Warblers in Traditional and Rape Habitats, by Tetrad, in Gateshead, 1995-1997

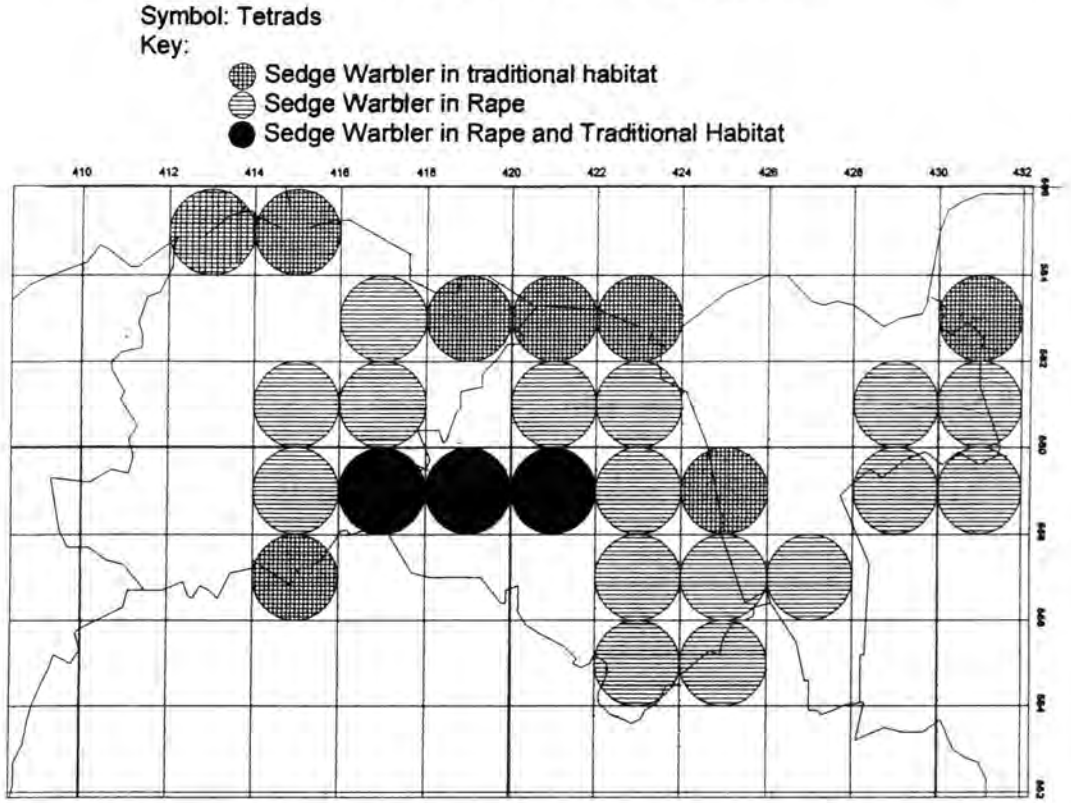
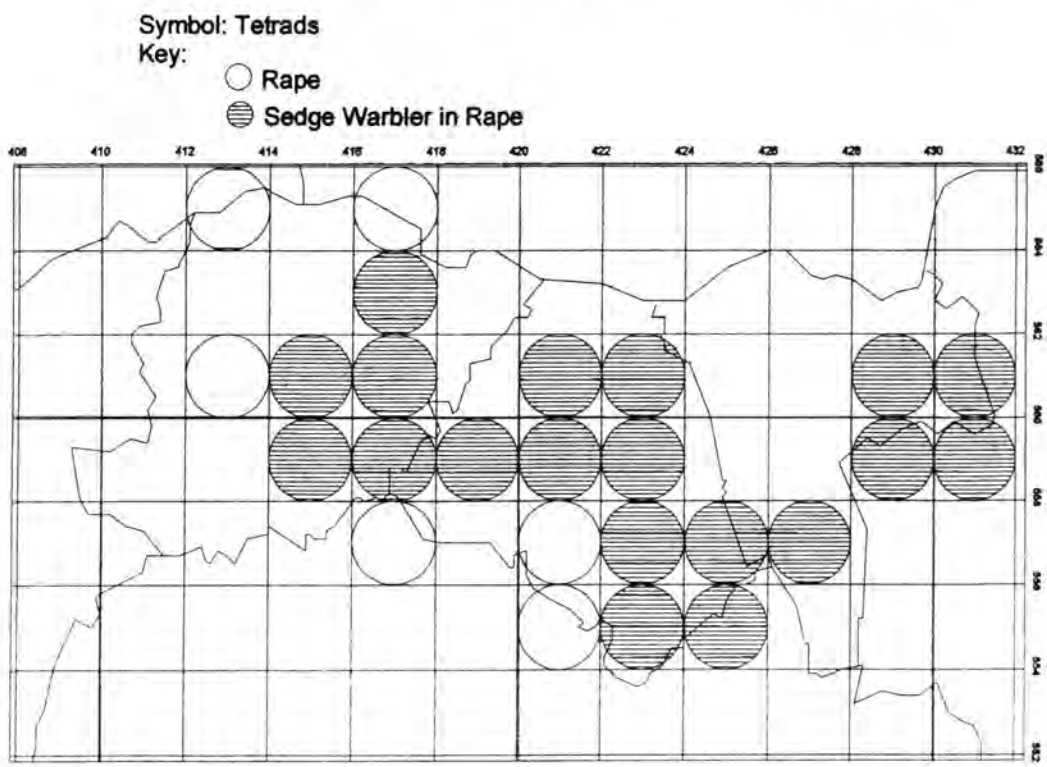


Figure 2b Distribution of Sedge Warblers in Rape, by Tetrad, in Relation to the Known Distribution of Rape in Gateshead, 1995-1997



Grid figures refer to the 100km and 1km grid reference codes of the National Grid

Table 3 - Presence of Sedge Warblers in Gateshead Borough by Tetrad, According to Habitat, 1995-1997

	In Rape Only No. of Tetrads		In Trad. Only No. of Tetrads		All Habitats No. of Tetrads	
1995	13	23.63%	9	16.36%	22	40.00%
1996	15	27.27%	5	9.10%	19	34.50%
1997	6	10.90%	5	9.10%	11	20%

No. of Tetrads Occupied 1995-97	**19**	**11**	**27**

Table 4 - Singing Sedge Warblers in Different Habitats in Gateshead Borough, 1995-1997

	1995	**1996**	**1997**
Shibdon Pond	18	16	17
Other Trad. Habitats	7	7	5
Oil-seed Rape	57	51	40
Total	**82**	**74**	**62**
Percentage of total in rape	69.51	68.92	64.52
Total in Trad. Habitats	25	23	22
Males in rape/occupied tetrad	4.39	3.4	6.67
Males/tetrad, all occupied tetrads	3.73	3.89	5.64

74 were found, with 57 and 51 in rape respectively - and in 1997 more than 60 (40 in rape), despite a reduction in the intensity and extent of fieldwork (Table 4).

In 1995 and 1996, 77% and 85% respectively, of all winter sown rape fields were surveyed as part of the extensive work. In 1997, however, only 37.5% of fields were similarly surveyed. Despite this unavoidable reduction in survey effort there was no significant difference between the observed number of singing sedge warblers, in any year of the study, and the three year mean of sedge warblers for the period, 1995-1997; $X^2 = 2.78$, d.f. 2, $0.25>p> 0.1$ (the proportion of surveyed fields occupied by sedge warblers is shown in Table iv, Appendix 7). Which means that in each year of the study the observed number of singing sedge warblers in Gateshead borough was, effectively, similar. This, despite potential seasonal variation in number and the known diminution of effort in 1997. If the annual totals of birds located were, broadly, comparable as observed, this suggests one of three explanatory scenarios: that all birds were found in each year but that, for some reason, less effort was required in 1997, than in 1995 and 1996, to achieve the same end; that the sedge warbler finding efficiency of the survey increased over the period; or, that the actual number of sedge warblers in rape had increased between 1995 and 1997, meaning more birds were found for less effort.

Sedge warblers were present in rape in 19 tetrads (34.5%), at some time between 1995-1997; 6 (10.9%) of these held birds in rape in all years (the proportion of surveyed fields occupied by sedge warblers in each year is shown in Table iv, Appendix 7). However, the reduction in fieldwork in 1997 may have depressed this latter figure, as many tetrads which held birds in rape in 1995 & 1996, were not extensively surveyed in 1997. In 1995 & 1996, in which survey effort was similar, 12 tetrads (21.8%) held birds in rape in both seasons. The tetrad distribution of sedge warbler in rape, and in relation to known distribution of rape, in Gateshead, 1995-1997, is shown in Figure 2b.

Timing and duration of use of rape crops by sedge warblers

Birds were recorded as being present in rape from early May through to early/mid-July in 1995 & 1996 (Table 5); but only until late June in 1997, when field work was curtailed due to poor weather. Singing birds were present in at least 45%, of extensively surveyed fields in all years (44.7% in 1995, 52.2% in 1996 and 45.8% in 1997, Table 7). In all 9 intensively surveyed rape crops, 1995-1997, birds were present throughout the breeding season, with birds present over the same period in at least 37.5% of the extensively surveyed crops which held birds. This indicates that occupation of rape crops throughout the breeding season, appears to be the norm whenever sedge warblers were noted as present in the rape.

Other habitats used by sedge warblers in Gateshead borough

A summary of habitats used by sedge warblers in Gateshead between 1995-1997 is given in Table 6a. The distribution of sedge warblers between the different habitats in Gateshead, 1995-1997, differed highly significantly from that which might have been expected had this distribution been a random one; $\chi^2 = 77.541$, d.f. =7, $p<0.001$, indicating that birds were not using all available habitats to the same degree.

Many traditional habitat types merged one into the other and therefore presented problems of boundary definition; but rape was always clearly delineated. In terms of the total numbers of birds located, rape was the most important habitat for sedge warblers in Gateshead in each year of the study. It held the largest number of singing males of any occupied habitat and formed the greatest area of occupied habitat. Over the three year period 67.9% (148) of all singing sedge warblers located (n =218) were found in rape (Table 4 & 6); 7.8% in scrub with rank herbage; 7.3% in wet fen; and, 6.8% in dry rank herbage. In total, 1995-1997, rape held more than eight times the number of singing sedge warblers of any other occupied habitat; a larger area of rape habitat being available to birds.

Due to difficulties in accurately estimating the total area of each available habitat across the whole study area, it was not possible to undertake a compositional analysis to

Table 6a - Habitats Utilised by Singing Sedge Warblers, Gateshead Borough 1995-1997

Habitat	1995	1996	1997	Total
Wet fen	7	5	4	16
Cereal crop	0	1	0	1
Dry rank herbage	5	4	6	15
Scrub/rank herbage	5	5	7	17
Oilseed rape	57	51	40	148
Hawthorn hedgebank	2	2	1	5
Willow scrub/fen	2	3	1	6
Reedbed	4	3	3	10
Total	**82**	**74**	**62**	**218**

Number of singing males; occupation by broad habitat type.

Table 6b - Territory Density of Singing Sedge Warblers in Intensively Studied Habitats in Rape and at Shibdon Pond, 1995-1997

Habitat	Singing Males/ha
Wet fen	1.23
Dry rank herbage	0.8
Scrub/rank herbage	0.75
Hawthorn hedgebank	0.33
Willow scrub/fen	1.67
Reedbed	16.67
Oilseed rape	0.77

determine the relative degree of habitat selection by birds. However, the density of singing males in intensively studied habitats, at Shibdon Pond and in rape (Table 17), was calculated and this is summarised in Table 6b. The data indicate that traditional habitats vary considerably in the density of birds found in them. Although only a very small area of reedbed was present this attracted, proportionally, many more birds than other habitats. Rape held a similar density of birds to some habitats, such as scrub/rank herbage, but lower than that found in wet fen. Nonetheless, the results indicate that oilseed rape is a frequently used habitat by sedge warblers. The greatest local concentration of birds, however was at Shibdon Pond, in traditional habitat. The habitat utilisation by sedge warblers in Gateshead, 1995-1997, is illustrated in Figure 3.

The evidence for presence of sedge warblers in extensively surveyed rape fields and the degrees of evidence for proof of breeding in those fields, is summarised (by field) in Table 7.

The density of singing males at Shibdon Pond and in rape fields is summarised in Table 19a. Three density figures were calculated for rape: i) for all surveyed fields, i.e. the absolute minimum density of birds in rape; ii) for fields occupied by sedge warblers; and finally, iii) for intensively studied sites (Table 17). The annual, mean density of singing sedge warblers (1995-1997) in occupied rape was 0.282/ha, s= 0.017, n=3.

What environmental factors influence the species' use of rape crops?

In order to test the influence of each investigated environmental variable on the occupancy of rape fields by sedge warblers, between the study years, the use of a two-way Analysis of Variance (ANOVA) was considered. However, as between year sample sizes were not equivalent and the size of the data sets in many of the cells of the analysis, were frequently less than five, the risk of committing a Type 1 error was increased, i.e. the rejection of the Null hypothesis when it should have been accepted. Hence, the use of ANOVA was rejected and alternative analytical methods were utilised.

Figure 3 - Percentage Habitat Utilisation by Singing Sedge Warblers (n=218), Gateshead Borough 1995-1997

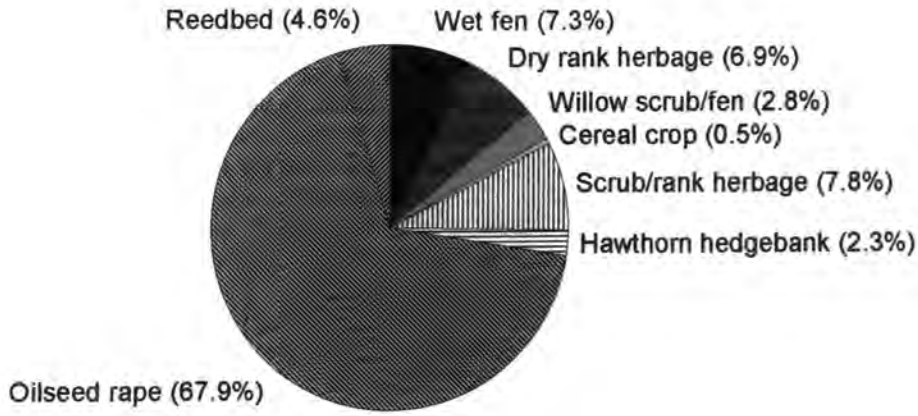


Table 7 - Sedge Warbler Occurrence and Field by Field Evidence of Breeding by Sedge Warblers in Extensively Surveyed Rape Fields, 1995-1997

Evidence	1995		1996		1997		Total
Area utilised by SW (ha)	164		152		99.07		414.5
No of SW singing	45		41		30		116
Mean no. of SW/occupied field	2.14		1.71		1.58		
SW density/ha of occupied rape	0.28		0.27		0.302		
No. of fields surveyed	47		46		24		117
No. of fields in which SW present	21	44.7%	24	52.2%	19	79.2%	64
No. of fields holding singing males	21	44.7%	24	52.2%	14	58.3%	59
No. of fields in which territories established	21	44.7%	24	52.2%	11	45.8%	56
No. of fields in which pairs present	6	12.8%	10	21.7%	5	20.8%	21
No. of fields in which nests found	1	2.1%	0		0		1
No. of fields in which fledged young recorded	1	2.1%	0		0		1

Key:
SW - singing sedge warbler
Percent. - % of surveyed fields

NB. Unlike 1995 & 1996, the figures for the presence of singing males and no. of territories established in fields in 1997, were not equivalent. This was as a result of limitations to the extent of fieldwork in that year. Consequently, presence of birds in some fields was registered by observation only and follow up visits, to establish territory establishment, or other evidence for proof of breeding, could not be undertaken in all cases.

i) Altitude

Both occupied and unoccupied fields spanned almost the whole altitudinal range of recorded crops; occupied fields ranged from 15-173 m a.s.l., unoccupied from 17-190 m a.s.l. The presence of birds in relation to the altitude of all extensively surveyed rape crops is summarised in Tables 8a & 8b.

The number of rape fields falling into each altitude category varied from season to season and, as a consequence, the mean altitude of surveyed fields varied from year to year (Table 8c). This was a product of the manner in which the crop was grown and not of survey methodology. Table 8d compares the percentage of surveyed rape fields in each altitude category with the percentage of all rape fields in those categories. In all years these figures were similar, indicating that the surveyed fields were representative, in respect of altitude range, of all rape fields.

The altitude of crops in Gateshead were distributed normally in all years of the survey (see Figure 4). In 1995 and 1996, the mean altitudes of occupied, extensively surveyed crops, 75.72 m a.s.l. (n= 21, s= 42.39) and 81 m a.s.l. (n=24, s=41.74) were significantly lower than those of unoccupied extensively surveyed crops, 132.5 m a.s.l. (n=26, s=46.72) and 117.64 m a.s.l. (n=22, s=48.12); t test = 4.23, d.f. 45, $p<0.01$ for 1995 and t test = 2.77, d.f. 44 $p<0.01$ for 1996. However, this effect was not evident in 1997, the mean altitudes being 107.2 m a.s.l. (n= 19, s=41.89) for occupied crops and 120 m a.s.l. (n=5, s=32.59) for unoccupied crops. During the study period no crop at over 173 m a.s.l. was occupied by sedge warblers; although in 1998 a crop at 242 m (the highest recorded locally) was occupied by singing birds (pers obs.).

Over the whole period of the study, there was a highly significant association between the presence or absence of sedge warblers in a rape field and the altitude category within which the field fell; contingency test, $\chi^2=19.26$, d.f. 6, $0.005<p<0.001$.

Table 8a - Recorded Occupation of Extensively Surveyed Rape Crops by Sedge Warblers, According to Altitude (m a.s.l.) of Field, 1995-1997

	1995			1996			1997			Total		
Altitude	n	Absent	Present	n	Absent	Present	n	Absent	Present	n	Absent	Present
<30	5	1	4	5	1	4	2	0	2	12	2	10
31-60	6	1	5	4	2	2	1	0	1	11	3	8
61-90	9	4	5	17	4	13	1	1	0	27	9	18
91-120	8	4	4	5	4	1	14	3	11	27	11	16
121-150	6	4	2	6	4	2	2	0	2	14	8	6
151-180	12	11	1	7	5	2	4	1	3	23	17	6
181-210	1	1	0	2	2	0	0	0	0	3	3	0
Total	**47**	26	21	**46**	22	24	**24**	5	19	**117**	53	64

Table 8b - Percentage Occupation of Extensively Surveyed Rape Crops by Sedge Warblers, According to Altitude of Field, 1995-1997

	1995			1996			1997			Total		
Altitude	%	Absent	Present	%	Absent	Present	%	Absent	Present	%	Absent	Present
<30	10.6	2.1	8.5	10.9	2.2	8.7	8.3	0	8.3	10.3	1.7	8.5
31-60	12.8	2.1	10.6	8.7	4.3	4.3	4.2	0	4.2	9.4	2.6	6.8
61-90	19.1	8.5	10.6	36.9	8.7	28.3	4.2	4.2	0	23.1	7.7	15.4
91-120	17	8.5	8.5	10.9	8.7	2.2	58.3	12.5	45.8	23.1	9.4	13.7
121-150	12.8	8.5	4.2	13	8.7	4.3	8.3	0	8.3	12	6.8	5.1
151-180	25.5	23.4	2.1	15.2	10.9	4.3	16.7	4.2	12.5	19.7	14.5	5.1
181-210	2.1	2.1	0	4.3	4.3	0	0	0	0	2.6	2.6	0
Total		55.3	44.7		47.8	52.2		20.8	79.2		45.3	54.7

Table 8c - Mean Altitude (m a.s.l.) of Extensively Surveyed Rape Fields, 1995-1997

	Mean	n	s
1995	107.04	47	52.79
1996	98.52	46	48.1
1997	109.83	24	39.83

Key:
s = standard deviation

Table 8d - Percentage of Rape Fields in Each Altitude Category, 1995-1997

Altitude Category	1995 Surveyed Fields	1995 All Fields	1996 Surveyed Fields	1996 All Fields	1997 Surveyed Fields	1997 All Fields
<30	10.6	8.5	10.9	9.3	8.3	12.5
31-60	12.8	10.2	8.7	7.4	4.2	7.8
61-90	19.1	16.9	36.9	37	4.2	12.5
91-120	17	16.9	10.9	9.3	58.3	37.5
121-150	12.8	15.3	13	13	8.3	15.6
151-180	25.5	28.8	15.2	20.4	16.7	14.1
181-210	2.1	3.4	4.3	3.7	0	0

ii) Field area

The size of winter rape fields varied considerably, the largest surveyed field being more than 33 times the size of the smallest; mean size was 5.75 ha, n=179, s=3.86, mean size of all surveyed crops was 5.48 ha, n=126, s=3.71, see Appendix 7. The presence of birds in relation to measured area of extensively surveyed rape fields is summarised in Tables 9a & 9b.

The number of rape fields falling into each area category varied considerably less, from year to year, than those in the equivalent classification by altitude. Table 9c compares the percentage of surveyed rape fields in each area category, with the percentage of all local rape fields in the same categories. In all years of the study these figures were similar, indicating that the surveyed fields were representative, in terms of area, of all rape fields in the borough. The mean size of occupied rape fields varied from year to year, due to the fact that different fields and numbers of fields, were in cultivation with rape each year. Mean size of occupied rape crops throughout 1995-1997, was 6.27 ha (n=64, s=4.14), that for unoccupied was 4.35 ha (n = 53, s=2.37). In two of the three study years, mean occupied field size was greater than the mean size of rape fields in the borough and, in all years, it was greater than the mean size of surveyed crops; see Table 10. In all three years, mean size of occupied crops was greater than that of unoccupied crops, suggesting that field size may have some determining influence on which fields sedge warblers use, but in no instance was this effect statistically significant.

An analysis of (log 10) transformed data, on mean field size, found that there was no significant difference between the mean size of occupied and unoccupied fields in 1996, t test = 1.94, d.f 44, $p>0.05$. The difference between the variances of the respective transformed data sets in 1995 and 1997 was too great to allow a comparison of mean field size for those years (F tests at p=0.05; 1995, F=2.4,v_1 20, v_2 25; 1997, F=3.6, v_1 4, v_2 18).

Table 9a - Recorded Occupation of Extensively Surveyed Rape Crops by Sedge Warbler, According to Field Area, 1995-1997

	1995			1996			1997			Total		
Area (ha)	n	Absent	Present	n	Absent	Present	n	Absent	Present	n	Absent	Present
<3	11	7	4	12	10	2	6	3	3	29	20	9
3-4	13	8	5	17	7	10	8	1	7	39	16	22
5-6	10	7	3	6	1	5	7	1	6	23	9	14
7-8	5	2	3	6	3	3	2	0	2	13	5	8
9-10	3	2	1	2	1	1	1	0	1	6	3	3
11-12	2	0	2	2	0	2	0	0	0	4	0	4
13-14	0	0	0	0	0	0	0	0	0	0	0	0
15-16	2	0	2	0	0	0	0	0	0	2	0	2
>17	1	0	1	1	0	1	0	0	0	2	0	2
Total	47	26	21	46	22	24	24	5	19	117	53	64

Table 9b - Percentage Occupation of Extensively Surveyed Rape Crop by Sedge Warbler, According to Field Area, 1995-1997

	1995			1996			1997			Total		
Area (ha)	%	Absent	Present	%	Absent	Present	%	Absent	Present	%	Absent	Present
<3	23.4	14.9	8.5	26.1	21.7	4.3	25	12.5	12.5	24.8	17.1	7.7
3-4	27.7	17	10.6	37	15.2	21.7	33.3	4.2	29.2	32.5	13.7	18.8
5-6	21.5	14.9	6.4	13	2.2	10.8	29.2	4.2	25	19.7	7.7	12
7-8	10.6	4.3	6.4	13	6.5	6.5	8.3	0	8.3	11.1	4.3	6.8
9-10	6.3	4.3	2.1	4.3	2.2	2.2	4.2	0	4.2	5.1	2.6	2.6
11-12	4.3	0	4.3	4.3	0	4.3	0	0	0	3.4	0	3.4
13-14	0	0	0	0	0	0	0	0	0	0	0	0
15-16	4.3	0	4.3	0	0	0	0	0	0	1.7	0	1.7
>17	2.1	0	2.1	2.2	0	2.2	0	0	0	1.7	0	1.7
Total		55.3	44.7		47.8	52.2		20.8	79.2		45.3	54.7

Table 9c - Percentage of Rape Fields in Each Size Category, 1995-1997

Area (ha)	1995 Surveyed Fields	1995 All Fields	1996 Surveyed Fields	1996 All Fields	1997 Surveyed Fields	1997 All Fields
<3	23.4	18	26.1	27.8	25	20.3
3-4	27.7	26.2	37	37	33.3	32.8
5-6	21.5	22.9	13	13	29.2	31.3
7-8	10.6	14.8	13	11.1	8.3	6.25
9-10	6.3	9.8	4.3	5.6	4.2	4.7
11-12	4.3	3.3	4.3	3.7	0	3.1
13-14	0	0	0	0	0	0
15-16	4.3	3.3	0	0	0	0
>17	2.1	1.6	2.2	1.9	0	1.6

Table 10 - Summary of Mean Crop Size, 1995-1997

	1995			1996			1997		
	Size (ha)	n	*s*	Size (ha)	n	*s*	Size (ha)	n	*s*
All Crops	6.32	61	3.9	5.08	54	3.6	5.77	59	3.99
All Surveyed Crops	5.99	50	4.1	5.27	49	3.7	4.8	27	2.19
Extensively Surveyed Crops	5.99	47	4.1	5.27	46	3.7	4.8	24	2.15
Unsurveyed Crops	7.8	11	2.6	3.19	5	0.8	6.57	32	4.95
Occupied Crops	7.29	21	5.1	6.21	24	4.2	5.21	19	2
Unoccupied Crops	4.79	26	2.2	4.13	22	2.5	2.98	5	1.79

s = standard deviation
n = number of crops

Despite the apparent consistency of association, over the three year period, between larger field size and occupation by sedge warblers, there was no significant statistical evidence to confirm such an association between the presence or absence of sedge warblers in rape fields and the size category into which the field fell; contingency test, X^2=13.99, d.f. 8, p>0.05.

iii) Distance to nearest wetland

The occupancy of rape crops in relation to distance from the nearest water/wetland is shown in Table 11a & 11b. This distance varied greatly, from zero, where water/wetland was on or within the crop boundary, to 850 m. The nearest water was usually a drainage ditch and in only 7.7% of the 117 extensively surveyed crops was the nearest wetland adjudged suitable for nesting sedge warblers. The distance from all rape crops to the nearest non-rape sedge warbler habitat was, almost invariably, greater than that measured to the nearest water/wetland and, in some cases, was considerable (Tables 12a & 12b), e.g. 3.44 km.

In all years of the study the mean distance from water/wetland of unoccupied rape fields was greater than that of occupied fields. Over the whole period, 1995-1997, the mean distance from occupied fields to nearest water/wetland was 198.59 m (n=64, s=196.43); from unoccupied crops 310 m (n=53, s=200.01).

There was no evidence of a statistical association between the presence or absence of sedge warblers in rape fields and the distance from water/wetland at which the field was located; contingency test, X^2=13.36, d.f. 8, p>0.1.

The data on mean distance from nearest water/wetland, which were not normally distributed, were transformed (log 10) and subsequent analysis showed a highly significant difference between the mean nearest distance of occupied and unoccupied fields from water/wetland in both 1995, t test = 2.69, d.f 44, p<0.01, and 1996, t test= 3.03, d.f. 44, P<0.01. No such association was evident for 1997, t test = 0.129, d.f. 24,

Table 11a - Recorded Occupation of Extensively Surveyed Rape Crops by Sedge Warbler, According to Distance to Nearest Water/Wetland, 1995-1997

	1995			1996			1997			Total		
Distance (m)	n	Absent	Present	n	Absent	Present	n	Absent	Present	n	Absent	Present
0-99	9	2	7	16	5	11	7	1	6	32	8	24
100-199	7	3	4	9	4	5	7	2	5	23	9	14
200-299	7	4	3	6	3	3	2	0	2	15	7	8
300-399	7	6	1	6	2	4	3	1	2	16	9	7
400-499	7	5	2	3	3	0	1	1	0	11	9	2
500-599	8	4	4	4	3	1	1	0	1	13	7	6
600-699	0	0	0	2	2	0	2	0	2	4	2	2
700-799	0	0	0	0	0	0	0	0	0	0	0	0
800-899	2	2	0	0	0	0	1	0	1	3	2	1
900-999	0	0	0	0	0	0	0	0	0	0	0	0
>1000	0	0	0	0	0	0	0	0	0	0	0	0
Total	47	26	21	46	22	24	24	5	19	117	53	64

Table 11b - Percentage Occupation of Extensively Surveyed Rape Crops by Sedge Warbler, According to Distance to Nearest Water/Wetland, 1995-1997

	1995			1996			1997			Total		
Distance (m)	%	Absent	Present	%	Absent	Present	%	Absent	Present	%	Absent	Present
0-99	19.1	4.3	14.8	34.8	10.9	23.9	29	4.2	25	27.4	6.8	20.5
100-199	14.9	6.4	8.5	19.6	8.7	10.9	29.2	8.3	20.8	19.7	7.7	12
200-299	14.9	8.5	6.4	13	6.5	6.5	8.3	0	8.3	12.8	6	6.8
300-399	14.9	12.8	2.1	13	4.3	8.7	12.5	4.2	8.3	13.7	7.7	6
400-499	14.9	10.6	4.3	6.5	6.5	0	4.2	4.2	0	9.4	7.7	1.7
500-599	17	8.5	8.5	8.7	6.5	2.2	4.2	0	4.2	11.1	6	5.1
600-699	0	0	0	4.3	4.3	0	8.3	0	8.3	3.4	1.7	1.7
700-799	0	0	0	0	0	0	0	0	0	0	0	0
800-899	4.3	4.3	0	0	0	0	4.2	0	4.2	2.6	1.7	0.9
900-999	0	0	0	0	0	0	0	0	0	0	0	0
>1000	0	0	0	0	0	0	0	0	0	0	0	0
Total		55.3	44.7		47.8	52.2		20.8	79.2		45.3	54.7

Table 12a - Recorded Occupation of Extensively Surveyed Rape Crops by Sedge Warbler, According to Distance to Nearest Known Occupied Sedge Warbler Traditional Habitat, 1995-1997

	1995			1996			1997			Total		
Distance (m)	n	Absent	Present	n	Absent	Present	n	Absent	Present	n	Absent	Present
0-299	0	0	0	2	1	1	0	0	0	2	1	1
300-599	3	2	1	5	2	3	0	0	0	8	4	4
600-899	6	4	2	2	2	0	1	0	1	9	6	3
900-119	8	4	3	6	2	4	10	1	9	24	7	17
1200-1499	11	7	4	12	8	4	3	1	2	26	16	10
1500-1799	9	6	3	5	2	3	2	0	2	16	8	8
1800-2099	4	1	3	7	4	3	1	1	0	12	6	6
2100-2399	3	1	2	1	0	1	3	0	3	7	1	6
>2400	3	1	2	6	1	5	4	2	2	13	4	9
Total	**47**	26	21	**46**	22	24	**24**	5	19	**117**	53	64

Table 12b - Percentage Occupation of Extensively Surveyed Rape Crops by Sedge Warbler, According to Distance to Nearest Known Occupied Sedge Warbler Traditional Habitat, 1995-1997

	1995			1996			1997			Total		
Distance (m)	%	Absent	Present	%	Absent	Present	%	Absent	Present	%	Absent	Present
0-299	0	0	0	4.3	2.2	2.2	0	0	0	1.7	0.9	0.9
300-599	6.3	4.3	2.1	11	4.3	6.5	0	0	0	6.8	3.4	3.4
600-899	12.8	8.5	4.3	4.3	4.3	0	4.2	0	4.2	7.7	5.1	2.6
900-119	17	8.5	8.5	13	4.3	8.7	41.7	4.2	37.5	20.5	6.8	14.5
1200-1499	23.4	14.9	8.5	26	17.4	8.7	12.5	4.2	8.3	22.2	13.7	8.5
1500-1799	19.1	12.8	6.4	11	4.3	6.5	8.3	0	8.3	13.7	6.8	6.8
1800-2099	8.5	2.1	6.4	15	8.7	6.5	4.2	4.2	0	10.3	5.1	5.1
2100-2399	6.4	2.1	4.3	2.2	0	2.2	12.5	0	12.5	6	0.9	5.1
>2400	6.4	2.1	4.3	13	2.2	10.9	16.7	8.3	8.3	11.1	3.4	7.7
Total		55.3	44.7		47.8	52.2		20.8	79.2		45.3	54.7

p>0.05, although the sample size of unoccupied crops in this year, five, was small. In all years there was no significant difference in the variances of the mean distance in data sets from occupied and unoccupied fields: F tests; 1995, F=1.93,v_1 20 v_2 25, i.e. p>0.05; 1996 F=1.58, v_1 4 v_2 18, i.e. p>0.05; 1997, F=1.11,v_1 18, v_2 4 i.e. p>0.05.

In 1995 & 1996, the mean nearest distances from previously occupied sedge warbler traditional habitat (which were normally distributed, see Figure 5) was greater for occupied rape fields than for unoccupied fields; 1995, 1538.23 (n=21, s=630.55), 1315.5 (n=26, s=541.4); and 1996, 1610.96 (n=24, s=836.29), 1342.54 (n=22, s=642.65). In 1997 however, the mean nearest distance of unoccupied crops from such habitat was greater than for occupied crops, 1943.6 m (n=5, s=689.01) as oppose to 1429.22 m (n=19, s=585.15), for occupied fields. However, in none of these years was the difference between the mean distance of occupied and unoccupied rape fields and occupied sedge warbler habitats significant:

1995 t=0.42, d.f. 45, p>0.1; (F=1.36,v_1 20 v_2 25, i.e. p>0.05);

1996 t=1.21, d.f. 44, p>0.1; (F=1.69, v_1 23 v_2 21, i.e. p>0.05);

1997 t=1.69, d.f. 22, p>0.1; (F=1.39,v_1 4 v_2 18 i.e. p>0.05).

On analysing the relationship between the presence and absence of sedge warblers in rape fields and the distance at which those fields were located from traditional habitat occupied by sedge warblers, over the three years of the study, there was found to be no statistically significant association; contingency test, χ^2=11.1, d.f. 8, p>0.1.

iv) Distance to nearest rape crop in previous cropping year

The presence of sedge warblers in relation to nearest distance from the previous year's rape crop is summarised in Table 13a & 13b. The greater the distance a rape crop was located from the previous year's crop the lower the probability of its attracting sedge warblers (see Figure 5b).

Figure 5 - Annual Distribution of Rape Fields into Distance from Sedge Warbler Habitat Category, 1995-1997

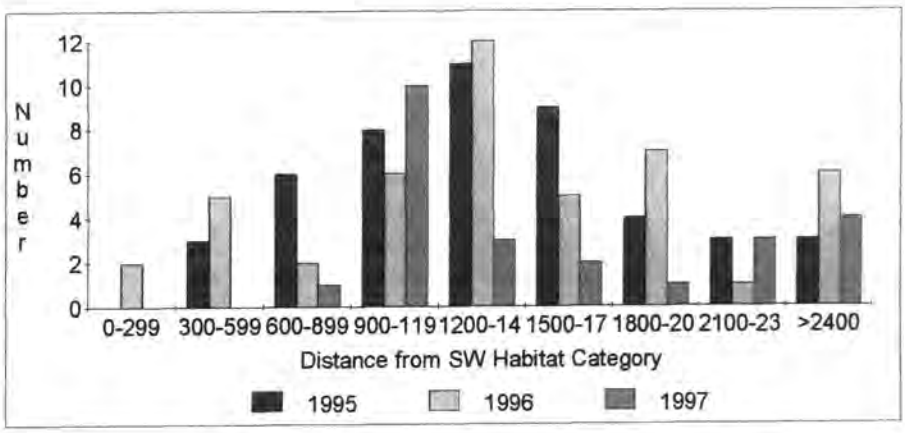


Figure 5b - Occupation of Extensively Surveyed Rape Crops by Sedge Warblers, According to Distance from Nearest Rape Crop in the Previous Breeding Season, 1995-1997

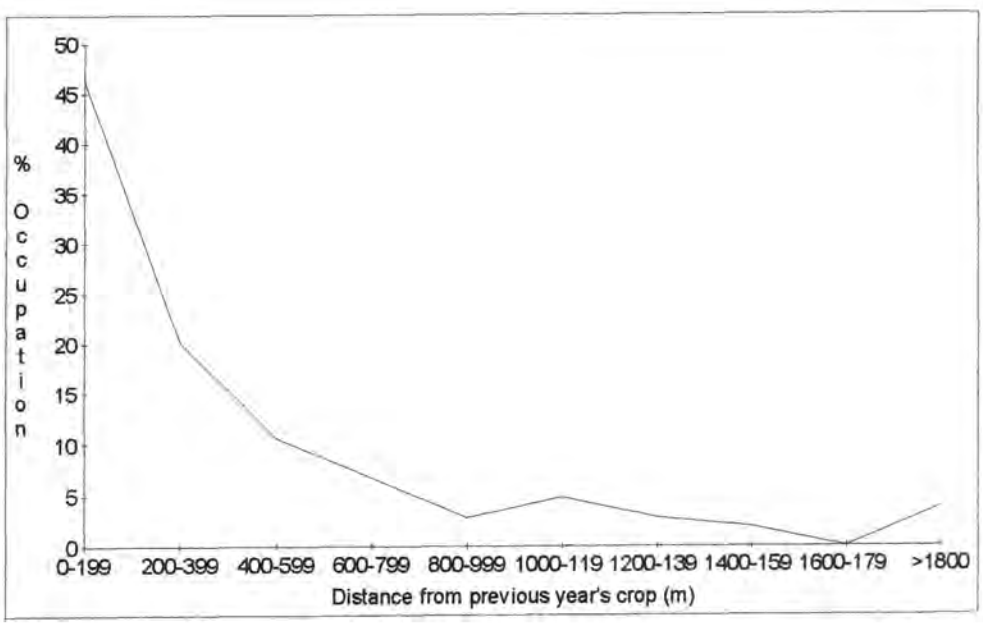


Table 13a - Recorded Occupation of Extensively Surveyed Rape Crops by Sedge Warblers, According to Distance from Nearest Rape Crop in the Previous Breeding Season, 1995-1997

	1995			1996			1997			Total		
Distance (m)	n	Absent	Present	n	Absent	Present	n	Absent	Present	n	Absent	Present
0-199	9	2	7	25	10	15	14	2	12	48	14	34
200-399	6	1	5	10	5	5	5	0	5	21	6	15
400-599	7	3	4	2	1	1	2	0	2	11	4	7
600-799	1	1	0	3	1	2	3	3	0	7	5	2
800-999	2	2	0	1	1	0	0	0	0	3	3	0
1000-1199	4	4	0	1	0	1	0	0	0	5	4	1
1200-1399	3	3	0	0	0	0	0	0	0	3	3	0
1400-1599	2	2	0	0	0	0	0	0	0	2	2	0
1600-1799	0	0	0	0	0	0	0	0	0	0	0	0
>1800	0	0	0	4	4	0	0	0	0	4	4	0
Total	**34**	18	16	**46**	22	24	**24**	5	19	**104**	45	59

Table 13b - Percentage Occupation of Extensively Surveyed Rape Crops by Sedge Warblers, According to Distance from Nearest Rape Crop in the Previous Breeding Season, 1995-1997

	1995			1996			1997			Total		
Distance (m)	%	Absent	Present	%	Absent	Present	%	Absent	Present	%	Absent	Present
0-199	26.5	5.9	20.1	54	21.7	32.6	58.3	8.3	50	46.2	13.5	32.7
200-399	17.6	2.9	14.7	22	10.9	10.9	20.8	0	20.8	20.2	5.8	14.4
400-599	20.6	8.8	11.8	4.3	2.2	2.2	8.3	0	8.3	10.6	3.8	6.7
600-799	2.9	2.9	0	6.5	2.2	4.3	12.5	12.5	0	6.7	4.8	1.9
800-999	5.9	5.9	0	2.2	2.2	0	0	0	0	2.8	2.8	0
1000-1199	11.8	11.8	0	2.2	0	2.2	0	0	0	4.8	3.8	1
1200-1399	8.8	8.8	0	0	0	0	0	0	0	2.8	2.8	0
1400-1599	5.9	5.9	0	0	0	0	0	0	0	1.9	1.9	0
1600-1799	0	0	0	0	0	0	0	0	0	0	0	0
>1800	0	0	0	0	8.7	0	0	0	0	3.8	3.8	0
Total		52.9	47.1		47.8	52.2		20.8	79.2		43	56.7

Table 14 - Mean Distance Of Rape Crops from Nearest Previous Year's Rape Crop, 1995-1997

Occupied	**1995**	**1996**	**1997**
Mean distance (m)	228.19	190	129.74
n	16	24	19
s	169.07	279.44	161.02
Unoccupied	**1995**	**1996**	**1997**
Mean distance (m)	848.5	536.14	422
n	18	22	5
s	453.05	719.43	382.5

s = standard deviation
n = number of crops

The annual mean distance of occupied and unoccupied fields from the previous year's nearest rape crops is summarised in Table 14; the equivalent figures for the whole period 1995-1997 were, occupied crops 189.95 m (n=59, s=217.03), unoccupied crops 648.4 m (n=45, s=599.96). In 1995, the mean nearest distance of occupied crops from previous year's rape was less than 27% of that for unoccupied crops; 228.19 m compared to 848.5 m, suggesting that the probability of rape crop occupancy by sedge warblers, might be related to this distance. Indeed, in 1995 no field, occupied by sedge warblers, was located at more than 470 m from a 1994 crop of rape and during the whole period of study only five fields (n=59) occupied by sedge warblers were located at more than 500 m from the previous year's nearest rape crop.

There was a highly significant association between the presence or absence of sedge warblers in rape fields and the distance at which they were situated from the nearest rape crop in the previous year; contingency test, χ^2=30.3, d.f. 9, $p<0.001$. The closer a rape field was located to the previous year's crop the more likely it was to attract sedge warblers.

All habitats abutting surveyed rape crops were classified (Rodwell 1991). Seven were identified, four fitted NVC descriptions, these were: W21, W24, W23 and W16 (see Appendix 6), with a further three defined as: plantation woodland, agricultural and urban. The most widely encountered habitat, abutting 89.7% of all surveyed rape crops, was W21: *Crataegus monogyna-Hedera helix* scrub, i.e. hawthorn hedge. Although the presence of a hedge around a rape field was both a common and widespread habitat feature, the absence of a hedge appeared to have no effect on the presence of sedge warblers in rape; of eleven crops, around which there was no hedge in 1995, six showed no evidence of sedge warblers but birds were present in the other five (χ^2 = 0, d.f. 1 with Yates' correction, $p>0.25$). Habitat information is summarised in Table 15. The pattern of occurrence of sedge warblers in rape, in relation to adjacent habitat features, 1995-1997, did not differ from random, χ^2 = 8.774, d.f. 6, $0.25>p>0.1$; indicating that there

Table 15 - Occupation of Rape Fields by Sedge Warbler According to Habitat Abutting Crop, 1995-1997

	1995			1996			1997			Totals		
Habitat	**n**	**Absent**	**Present**	**n**	**Absent**	**Present**	**n**	**Absent**	**Present**	**n**	**Absent**	**Present**
W21	47	24	23	40	18	22	26	4	22	113	46	67
W24	18	5	13	42	18	24	27	5	22	87	28	59
W16	9	3	6	4	0	4	4	1	3	17	4	13
W23	1	1	0	1	1	0	0	0	0	2	2	0
Plantation	5	1	4	7	3	4	3	3	0	15	7	8
Agricultural	3	2	1	8	4	4	3	1	2	14	7	7
Urban	4	3	1	3	1	2	0	0	0	7	4	3

For habitat descriptions see **Appendix 6**

was no discernible association between the presence/absence of sedge warblers in rape fields and the habitat abutting the field.

Breeding behaviour and territory density at intensively studied sites in traditional habitats and in rape

The Use of Traditional Habitats at Shibdon Pond

During 1995-1997, 60 sedge warbler territories (51 singing males) were identified at Shibdon Pond (Table 16), a mean of 20/annum (s=2.646). It is believed that all established territories were located in each year of the study, but success of breeding could not be proven in all of these. Successful breeding (young fledged) occurred in at least 31 (50.8%) of these. The incidence of apparently unmated males at Shibdon Pond was 27.7%, 17.7% and 18.2% of all recorded singing males in 1995, 1996 & 1997 respectively; a mean of 21.2%, n=3, s=5.63. The mean density of singing sedge warblers (1995-1997) at Shibdon Pond was 0.93/ha.

A small number of males set up second territories (Alker & Redfern 1996). This phenomenon was recorded in each field season and is clearly more common than previously documented e.g. by Hollom (1985) and Cramp (1992); *cf.* Alker & Redfern (1996). In the 60 territories, nine males (17.6%), the identities of which were known through colour-ringing, established second territories. At least six of these successfully attracted females. Of these, three (i.e. 5.9% of all singing males), one in each field season, successfully reared young with the second female. In all documented cases, the second territory was not established until the first female was either in the late nest-building stage or on eggs.

At Shibdon Pond the period of occupancy by sedge warblers, extended from: 27th April to 15th September 1995; 21st April to 18th September 1996; and, 27th April to 28th September 1997. Ringing and observation of birds at this location indicate that most records of birds after mid-August probably referred to passage birds (pers obs).

Table 16 - Sedge Warbler Breeding Activity at Shibdon Pond L.N.R., 1995-1997

	1995	1996	1997
No. of territories	21	17	22
No. of singing males	18	16	17
Pairs present	12	13	16
Males attempting second territory establishment	3	1	5
Successfully bigamous males	2	1	3
Apparently unmated males	5	3	4
Incidence of attempted double brooding	3	4	1
Successful double brooding (young fledged)	3	2	1
Mininum no. of successful nests (young fledged)	11	10	10

All nests located were followed through to success/failure. In some territories nests were not located, although recently fledged young were noted in some of these.

Sedge Warblers in Rape in Gateshead Borough

During 1995-1997, 4 areas of rape were examined as part of the intensive survey in Gateshead. In three of these groups of fields: Barlow Fell, Washingwell and Winlaton Care Village, full intensive surveys were carried out in 1995, 1996 and 1997, respectively (Table 17). Also, in three of the areas, Barlow Fell, Washingwell and Team Valley, comparison was made between years to look at site/rape fidelity in each year of the study period (Table 18). In all years of the study sedge warblers utilised the rape fields in each of these areas and, in all cases, established territories only in rape.

In each year of the intensive survey three fields were examined and, in every case, all of these fields were utilised by sedge warblers. A total of 32 territories, comprising 30 singing males, were documented - a mean, for the three sites of 10.67/annum (n= 3, s=1.15). It is believed that most established territories in these areas, in each year of the intensive study, were located but due to the nature of the rape crops, establishing the outcome of breeding was more difficult than in traditional habitats and it is conceivable that a small number of territories may have gone undetected. Evidence for apparent bigamous behaviour by males in rape was gathered on two occasions; i.e. 2 of 30 singing males (6.7%). Firstly, a colour-ringed bird, on Barlow Fell in 1995 and second, at Washingwells Farm in 1996. Although second females were observed to have been attracted to both of these males' territories, in neither instance was the outcome of the breeding attempt known. No evidence was obtained to prove successful double-brooding by birds in rape, although one pair unsuccessfully attempted this on Barlow Fell in 1995. The incidence of apparently unmated males at intensively studied rape sites in 1995, 1996 & 1997 was, respectively, 8.3%, 10% and 10%, a mean of 9.43%, n=3, s= 0.98. Less than 50% of the mean value observed for Shibdon Pond.

At intensively studied sites the period of occupancy by sedge warblers, extended from 7th May to 12th July (Barlow Fell 1995), and 10th May to 10th July (Washingwell 1996); although birds were increasingly difficult to locate after the end of the song period.

Table 17 - Sedge Warbler Occupancy and Territory Density in Intensively Studied Rape Fields, Gateshead 1995-1997

	Fields in study	Fields occupied	Area of rape in study (ha)	Territories established	Known pairs	Nest-building recorded	Young fledged	Territory density
(1) Barlow Fell 1995	3	3	11.34	12	7	Yes	Yes	1.06
(2) Washingwell 1996 *	3	3	16.01	10	7	Yes	Yes	0.62
(3) Winlaton Care Vill. 1997	3	3	15.55	10	4	Yes	Not known	0.64

No. of pairs indicate only those known to be present, and should therefore be considered an absolute minimum.

1) Rape fields at Barlow Fell were managed on a simple rotation,
2) Washingwell had large blocks of rape rotated,
3) At Winlaton Care Village, rape was grown under the non-rotating block system.

* 12 singing sedge warbler were located in the Washingwell area during 1996 but the intensive survey work covered only 10 territories (see Table 20).

Table 18 - Sedge Warbler Breeding Activity in Three Areas of Rape Fields, 1995-1997

Barlow Fell	***1995**	**1996**	**1997**
No. of Territories	12	3	3
Known Bigamous males	1	0	0
Incidence of double brooding	1	0	0
Documented nests (young fledged)	1	0	0

Team Valley	**1995**	**1996**	**1997**
No. of Territories	8	9	4
Known Bigamous males	0	0	0
Incidence of double brooding	0	0	0
Documented nests (young fledged)	1	0	0

Washingwell	**1995**	****1996**	**1997**
No. of Territories	7	12	10
Known Bigamous males	0	1	0
Incidence of double brooding	0	0	0
Documented nests (young fledged)	0	2	0

The Barlow Fell and Team Valley rape fields were managed on a simple rotation whilst at Washingwell, large blocks of rape were rotated between years.

Due to difficulties in locating non-singing birds, the outcome of breeding attempts in rape, other than where successful nests were found, was unknown. Hence, the number of nests documented should be considered an absolute minimum.

* intensive study site
** intensive study on ten of the twelve territories

Breeding strategies in different habitats

Polygyny was recorded in sedge warblers in both rape and traditional habitats. Although only a minority of males at Shibdon Pond attempted to attract a second female (17.6% of singing males), of those adopting the strategy, a large proportion, 66.7%, were successful, at least 33.3% rearing additional young from these unions. On the three occasions it was documented, males successfully reared young in both of their territories and, on two occasions, males successfully reared three broods in a season (*cf.* Alker 1992). Evidence of bigamous behaviour amongst males in rape was gathered from only a small number of individuals, on two occasions; in one instance, by a colour-ringed bird. Observations, which suggested that this bird was feeding young in its first territory, when still singing in its second, indicate that establishment of the second territory was not related to the loss of a mate or the failure of a first breeding attempt.

The mean date for re-commencement of song, indicative of an attempt to establish a second territory, for male sedge warblers in rape was 8th June (n=2), some 7 days later than for males at Shibdon Pond, i.e. 1st June (n=6). The attempt at double-brooding in rape, from 12th July, was later than similar attempts at Shibdon Pond, these usually commenced in the last few days of June (n=8).

Territory density at intensively studied rape sites

Ostensibly, singing sedge warblers at Shibdon, occurred at a density almost 3.3 times greater than that observed in occupied, extensively surveyed rape crops, Table 19a. A study in Lincolnshire over the period 1994-1996 (Burton *et. al* 1996) also identified sedge warblers in rape, but at lower densities than the present extensive study (Table 19b).

However, the mean territory density figure for rape at intensively studied areas e.g. Barlow Fell, 1995; Washingwell, 1996; and, Winlaton Care Village, 1997 (Table 17), was much higher, indicating that the extensive method employed did not inefficiently locate all sedge warblers present in rape. The mean figure for these intensively studied

Table 19a - Density (per ha) of Singing Sedge Warblers in Traditional and Rape Habitats, Gateshead 1995-1997

	Traditional	Rape Fields	
	Shibdon Pond	Surveyed crops	Occupied crops
1995	0.97	0.156	0.275
1996	0.86	0.169	0.27
1997	0.97	0.263	0.302

Table 19b - Density (per 10 ha) of Singing Sedge Warblers in Rape from Two Studies; Gateshead 1995-1996 and Lincolnshire 1995-1996

	Burton et al. 1996	Number of SW	Area (ha)	KB Study	Number of SW	Area (ha)
1995	0.44	10	225.4	1.56	45	288.36
1996	0.51	12	235.5	1.69	41	242.49

N.B. Table 20b includes two sets of data, one from the present study 'KB' and for comparison, one from a BTO enquiry in Lincolnshire, Burton *et al.* 1996.

Table 19c - Density (per 10ha) of Singing Sedge Warblers at Intensively Studied Rape Sites, Gateshead Borough, 1995-1996

	KB Intensive	Number of SW	Area (ha)
1995	10.6	12	11.34
1996	6.2	10	16.01

Key:
SW - singing sedge warbler

sites was 0.77 territories/ha (s=0.248), i.e. 81.7% of that determined for the high quality, traditional habitats at Shibdon Pond. Assuming that the intensively studied fields were representative of the extensively surveyed set of fields, this suggests that the extensive survey method may have only located some 37% of all singing sedge warblers in rape. A summary of known breeding activity (Sharrock 1976) by sedge warblers in all rape fields surveyed, both extensive and intensive 1995-1997, is given in Table 20.

Table 20 - Evidence of Sedge Warbler Breeding Activity in Oilseed Rape in both Extensively and Intensively Surveyed Fields, Gateshead Borough 1995-1997

	1995	1996	1997
No. of fields surveyed	50	49	27
Mininum no. of fields in which SW present	24	27	22
No. of singing males recorded	57	51	40
Mininum no. of territories established	26	38	24
Mininum no. of pairs known to be present	9	27	12
Males known to have established second territory	1	1	0
Successfully bigamous males	1	1	0
Apparently unmated males*	1	0	0
Incidence of double brooding	1	0	0
Successful double brooding (young fledged)	0	0	0
Nests present (nest found or evidence of nest-building)	3	13	4
Nests found	1	2	0
Mininum no. of broods known to have fledged	2	2	0

All nests located were followed through to success/failure. In many territories nests were not/could not be located due to the dense nature of the rape habitat.

* Apparently unmated males, i.e. territory established, but no evidence of female or other breeding activity, and no change to pattern of song.

Discussion

The study established that, in Gateshead, the use of rape by sedge warblers is now both common and widespread, as it is in the vice-county of Durham (Durham Bird Club 1974-1996). Whilst the description of the sedge warbler as a bird of wetland margins remains true, since all Durham's principal wetlands hold the species (Unwin 1975-1979, Baldridge1980-1986, Armstrong 1987-1996, Bell 1988-1993), birds using rape crops may now outnumber those in traditional habitats (Westerberg & Bowey 1999). This is certainly true for Gateshead borough. In this area, during 1995-1997, rape was widely available to sedge warblers. Out of *circa.* 320 arable fields, approximately 18.6% were devoted to the crop in any one year.

If occupation levels of rape by sedge warblers are assumed to be similar across lowland Durham to that observed from the extensive survey in Gateshead, i.e. a mean of 4.82 males/occupied tetrad 1995-1997; this is equivalent to 18.3 males/occupied 10 x 10 km square, suggesting a lowland vice-county population estimate of *circa.* 530 males in rape, per annum, 1995-1997.

The reasons for the effect of altitude, at which rape was grown, on the presence of birds in rape, whilst proven statistically, are unclear in their manifestation. Altitude may influence crop development rates, and therefore height and structure, which may, in turn affect the presence of sedge warblers. In traditional habitats sedge warblers are principally lowland birds (Thom 1986), this would suggest that the species is therefore less likely to utilise rape crops at higher altiturdes. Undoubtedly, the higher the location of crops the lower the probability of occupation by sedge warblers, yet crops at considerable altitudes, over 165m, held successfully breeding birds in 1995 and fields at even greater altitudes (e.g. >240 m a.s.l.) have been known to hold singing birds in the borough (pers. obs.). Perhaps sedge warblers' usual altitudinal range is dictated by their habitat preferences and the availability of such habitats at higher elevations?

Examining the apparent increase in survey efficiency, as indicated by the location of more sedge warblers in rape for less effort, for example, in 1997, it is conceivable that the actual number of sedge warblers in rape in Gateshead may have increased over the 1995-1997 period (the amount of rape grown varied between 274.3 and 385.42 ha, see Table i, Appendix 7). If inter-crop distance between seasons is the principal determining factor for presence/absence of sedge warbler in rape then such an increase might be related to the change in the mean inter-crop distance over the period. This declined from 848.5 m in 1995, to 536.1 m in 1996 and 422 m in 1997. This suggests that as inter-crop distance declined the probability of any single crop having sedge warblers increased, leading to a greater number of crops holding the species. This observation might easily be understood should sedge warblers reared in rape return to their natal area and the same habitat in which to breed.

At intensively studied rape sites, males set up territory at a mean density of 0.77/ha 1995-1997, compared to a mean of 0.93/ha at Shibdon Pond, see Table 19a. Densities equating to 121-181/km^2 have previously been calculated for the best areas of this site (Bowey unpub. data); which compares favourably with studies of high quality habitat, e.g.172 males/km^2 (Thom 1986), 2000 pairs/50 km^2 (Hagemeijer & Blair 1997). The density of singing male sedge warblers in rape in a Lincolnshire study (Burton *et al.* 1996) varied between 0.37 and 0.51 birds/10 ha, 1994-1996. The density of singing birds in Gateshead, 1995-1997, ranged from 1.6-2.69/10 ha for all extensively surveyed crops (Table 19a), up to 10.6/10 ha, for the highest calculated density at intensively studied sites, e.g. Barlow Fell in 1995 (Table 17). The comparable territory densities from the two studies are summarised in Table 19b. It is clear that more sedge warblers are found in rape when more intensive survey methods are used, the greater frequency and duration of visits leading to a higher detection rate. A similar result would be obtained should more intensive survey lead to double recording of birds. However, the repeat registration of singing birds, in the same locations in fields of rape, often at the same time as a territorial neighbour, indicates that such factors were not evident in the present study. It would appear that not all sedge warblers in rape are located by

extensive survey methods. In the light of this evidence, it would seem reasonable to assume that the calculated density of singing males for intensively surveyed crops most closely corresponds to the true density of birds in rape, as this method will have missed fewer birds. Assuming the mean density of sedge warblers at intensively studied sites, i.e. 0.77 males/ha 1995-1997, was representative of all rape crops occupied by sedge warblers in Gateshead, then an estimate of the actual number of sedge warblers in rape can be made. The area of extensively surveyed occupied rape in Gateshead 1995-1997, was 414.5 ha. If this was occupied at a density of 0.77 males/ha (as observed from the intensive survey work), the actual number of male sedge warblers in rape in Gateshead would have been 319.2 (i.e. 106.4/annum, 1995-1997), the observed figure was 148 (49.3/annum). If these assumptions are correct, the observed figures of rape occupation, as derived from the extensive survey methodology, may be only 46% of the actual number of singing males present. This indicates that the actual occupation of rape by sedge warblers is even greater than that shown by the extensive element of this and other studies.

Even in intensively studied areas of rape some birds may have gone undetected. For example, on Barlow Fell, 1995, a pair of sedge warblers were discovered feeding two fledged young on 5th July, in an area of crop previously visited 24 times, without any suggestion of birds being present in this immediate area. The development of the fledglings' feather tracts and their dependant nature, led to the conclusion that they were recently fledged (Harrison 1980). It was extremely unlikely that they had entered the crop from a territory outside the crop, as no birds had previously been noted in that vicinity and, being dependant upon the parents, they remained in this area over the following week. This suggests that territory establishment, mate acquisition and onset of breeding in rape can be rapid and, effectively, invisible even to an observer making regular, detailed survey visits (see Morton 1986).

Birds in rape adopted similar strategies of double-brooding and polygny (Tables 7a & 7b) to those in traditional habitats. Double brooding in the sedge warbler is "a relatively

rare phenomenon in Britain" (Cramp 1992) but it was noted on a number of occasions at Shibdon Pond during the study. No evidence was obtained for successful double-brooding in rape, although this has been reported (Watson & Rae 1998). In the case of the pair in rape, which were known to have attempted a second brood, the pair were observed for a period of 11 days, as they tended dependant fledged young. The birds, first found on 5th July 1995, when the juveniles were calculated to be c.15-16 days old were observed over the subsequent period with adults tending the young; by 7/8th, the young were, at least in part, feeding themselves. By 12th, the male had begun to re-establish himself in territory with advertising song and there was aggressive interaction between male and juveniles; which were now independent. Next day the male and female were observed together, undertaking behaviour indicative of copulation and nest-material gathering, the juveniles were not noted. This breeding attempt was curtailed by harvest of the crop on 27th July.

Polygyny in the sedge warbler is probably more common than previously realised (Alker & Redfern 1996) and it was found to occur in sedge warblers in both rape and traditional habitats. The fact that polygyny was proven in consecutive years at intensively studied rape sites suggests that such behaviour may be typical of some males in rape, as it would appear to be for males in traditional habitats.

The distance between rape crops between seasons appears to account, in many instances, for the presence of sedge warblers in rape, the closer the crops the greater the probability of occupation. Despite this, birds are occasionally found in crops regardless of distance from a previous crop. Examples of this include: fields at Thornley, 1995 and Warren's Haugh, 1996. The first included four fields which, in 1995, constituted the largest block of rape in the borough, the size of the block may have been sufficient to attract migrating birds. The Warren's Haugh crop was located in a river valley, less than 200 m from a wetland which occasionally attracts sedge warblers. Birds may have moved into the crop from there or chanced upon it whilst migrating along the valley (Mead 1983, Berthold 1994). The mean size of rape fields and the presence of sedge warblers in them may be

linked, although there was no statistically significant association. This might be explained by the way in which sedge warblers are distributed in rape. If sedge warblers occurred in rape fields at a uniform density, then they would be more likely to occur in large fields, as larger fields would have a greater probability of holding a territory. Alternatively, it would seem reasonable to presume that the larger a field or tract of habitat, the more obvious it is to a migrating bird. This might be particularly significant for a brilliantly coloured crop such as rape, which, in flower, even at night, has a high degree of luminosity. One might speculate that the larger the area of rape, the greater the chance of the crop attracting sedge warblers, as suggested by the results. The likelihood of sedge warbler occupancy may be related to the size of the block of crop grown. Crops occurring in large blocks, even at a distance from those of previous years, appeared to have a higher chance of attracting birds. One study in a range of crop types (Piironen *et al.* 1985), found that five of 27 species increased their number with field size, 12 decreased and 10, amongst them sedge warbler, showed variable results.

The influence of the close proximity of rape in the previous year on the presence of sedge warblers in the following year was, in some instances, very evident. For example, in one group of five crops, in which the mean distance, from the nearest rape in 1994, was 1266 m (s=102.57), no sedge warblers were recorded in 1995. The following year, when crops where were grown in adjacent fields, sedge warblers were recorded (although only in one of three fields, two probably being too poorly developed to hold the species; mean height 39 cm, n=2, s=1.41). Birds were present again in this area in 1997, when rape was grown in fields within 25 m of the 1996 rape and 150 m of the nearest 1995 crop. Crops at Winlaton Care Village in 1997, might have been expected to be less likely to hold sedge warblers, as they were an example of blocked crops (see Chapter 4). However, all of these fields were within 600 m of 1996's nearest rape field, two being within 460 m distance.

Using the observed nearest distances of occupied crops from the previous year's rape, a predictive model could be constructed to test future observations against the hypothesis,

"the distance between rape crops in consecutive years should have no effect on the presence or absence of sedge warblers in any particular rape crop". The critical distance, at which sedge warbler occupancy of a following year's rape field is determined, for the purposes of this model, might be derived by employing a logistic regression analysis of the 1995-1997 data.

An overview of 1995-1997 data suggests that the probability of rape occupancy by sedge warblers increases under 500 m distance from the previous year's nearest rape crop. This assertion is based on the fact that amongst all surveyed rape fields, 91.5% of those holding sedge warblers were located at less than 500 m from the previous year's rape, whilst 51.1% of those fields not registering birds were located at over 500 m distance (see Figures 6a & 6b).

In 1996, the presence of birds in some surveyed crops, located at less than 500 m from the previous year's rape, i.e. those which might have been expected to hold birds, may have been affected by that season's poor spring weather, through April and into mid-May (BTO 1997). In that year, spring weather delayed migration and reduced the breeding success of many migratory birds, including sedge warblers (Glue 1997, Balmer & Peach 1997). Locally, it slowed the development of rape crops by as much as five weeks (Bowey unpub. data) in some areas of the borough and some crops were so poorly developed that it was judged doubtful whether they could tenant sedge warblers during May. For example, the heights of the ten, least well-developed crops in 1996 were all under 60 cm (range 38-56 cm, mean height 47.3 cm); all were located at less than 200 m from the nearest 1995 rape crop. As no surveyed rape crop, with a height of less than 106 cm, was occupied by sedge warblers at any time during 1995-1997, the consequences for occupancy of these crops are obvious (see Chapter 4, for discussion of crop height and structure).

Sedge warblers usually associate strongly with habitat edges in their traditional habitats (Fuller 1982), which are often productive foraging areas for birds (Odum 1993). In an

Figure 6a - Nearest Distance (m) to Previous Year's Rape Crop, For Rape Fields Occupied by Sedge Warblers, 1995-1997

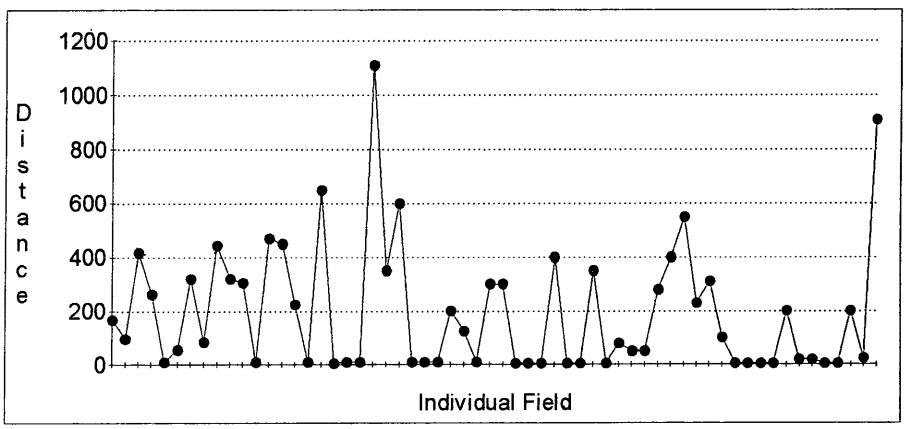
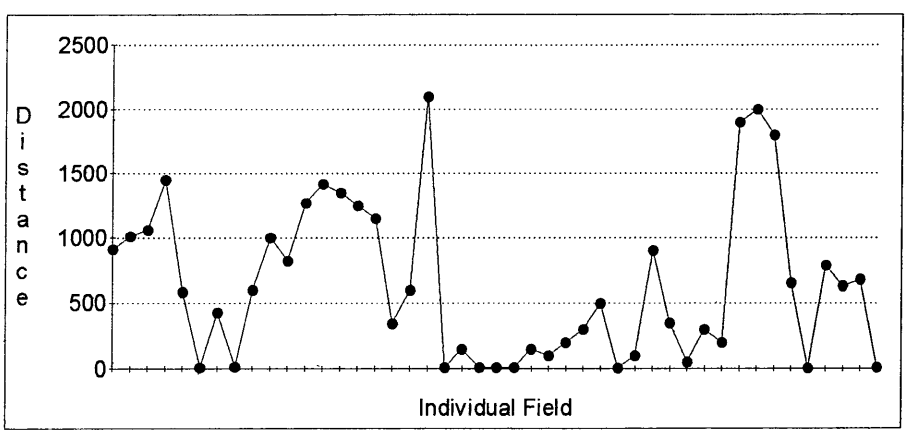


Figure 6b Nearest Distance (m) to Previous Year's Rape Crop, For Rape Fields Not Occupied by Sedge Warblers, 1995-1997



effectively, uniform habitat, such as rape, ecotones are at a premium; this effect is exaggerated in larger fields, having a smaller amount of edge in relation to field area. If the presence of ecotones was of importance in territory selection, one might predict that birds would be found close to the edges of crops and would favour smaller fields (see Shaw 1988). Observations indicate however, that sedge warblers are not restricted to the edges of rape crops, and that they may favour larger fields (Table 9a & 9b).

In a review of BTO data (Lack 1992), for 55 common, farm land species in the breeding season; sedge warbler was listed as "nesting and feeding mainly by ponds or streams" and figured in a list of six being "more or less dependant upon water". Of three species "mainly nesting and feeding in fields", sedge warbler was not amongst them. The current study indicates that sedge warblers associate strongly with fields of rape, can be found extensively in the crop and that their presence there is not dependant on the close proximity of water (see Tables 11a & 11b). Studying the ecological expansion of reed bunting *Emberiza schoeniclus* into drier habitats, Bell (1969) postulated that this species first moved into such habitats from traditionally inhabited, adjacent wetland. The manner by which sedge warblers first came to use rape crops is unknown, but there is no evidence from the present study to suggest any positive association between the proximity of wetlands and the presence of the species in rape. Indeed, it frequently occupies rape at large distances from the wetland habitats considered typical for it.

The nature of the habitat adjacent to rape had no influence on the presence of sedge warblers in the crop. O'Connor & Shrubb's (1986) assertion that hedges are one of the most important farm land habitat features for birds did not appear to apply to sedge warblers in rape, although birds occasionally forage in them (Bowey *in prep*) and routinely collected nest materials in the hedge bottoms (pers. obs.). Many farm land habitat features listed as being of importance in determining the number of territory holders in farm land (Shaw 1988), appeared unimportant to sedge warblers in rape. In his Scottish study, Shaw found only one species, tree sparrow *Passer montanus*, strongly associated with areas of arable. The present study clearly illustrates the strong link

between sedge warblers and arable land, more specifically, land upon which rape is grown.

The pivotal importance of patchiness in the ecology of individual animals' populations and communities is now widely recognised (May & Southwood 1990). The modern landscape of Britain, as experienced by a small passerine, such as a sedge warbler, is a patchy one; Bernstein *et al.* (1991) describe, "A typical habitat in lowland Britain.... and consisting of a mosaic (whose elements are often in the range of a few hectares in size) of woodland, hedgerows, cereal fields and pastures". This accurately describes the nature of sedge warbler's principal habitats, whether they be wetland or rape. Within the time span of the majority of sedge warblers' lives, a maximum of six years (Literak & Pikula 1996), most wetland habitats will persist in the same locality. By contrast, rape fields will, in most cases, not persist; they might be considered patchy, in both spatial and temporal terms.

The results show that rape was, easily, the most important habitat for singing sedge warblers in Gateshead over the period 1995-1997, and that sedge warblers frequently use it. Birds do not, however, occur in all rape crops. The main factors determining presence in rape seem to relate to the inter-year, between crop distance, i.e. the continuation of the crop in a given farmed area between breeding seasons, although altitude, probably through its effect on crop development, can also influence occupancy. If rape is occupied by sedge warblers in one year, then nearby crops (i.e. those closer than 0.5 km) have a higher probability of occupancy the following year. The further removed crops are from one another between seasons, the reduced likelihood of their occupation by sedge warblers. The greater spatial dis-continuity of the rape habitat between seasons appears to lead to a reduced probability of birds finding crops in the area in which they nested or were hatched, in the previous year. Such patterns might be easily explained if the, previously documented, between-year site faithfulness of males (Alker & Redfern 1996) also applied to birds in rape. Such birds would, presumably, return to breed in the nearest suitable habitat to that of the previous year, and their, or their neighbours' offspring, i.e. first calendar year birds, would, most likely, return to the

nearest available habitat within their natal area. Perhaps those birds which are found occupying rape crops at some distance from the previous year's crops are the rape-hatched young of the previous year from crops in the general vicinity but which have become somewhat disorientated? Such a theory might be tested be setting up an extensive colour-ringing and re-capture programme of birds in rape.

CHAPTER 4

Seasonal, Crop Structure and Crop Management Associations Between Sedge Warbler and Oilseed Rape, Gateshead Borough 1995-1997

Introduction

Oilseed rape is grown mainly as winter rape, a biennial plant sown in August or September of the year preceding harvest. It flowers from May to June, depending on location (Kirk 1992); locally, flowering has been noted from late April until early June (pers. obs.). During harvest the seeds have to be dried prior to removal from the plant for processing. This is done in one of two ways, using a chemical desiccant or the crop is cut and dried naturally; swathing. It is then collected and the seeds removed for oil extraction (Ward *et al.* 1985).

Habitat choice in the sedge warbler has been found to be related to the structural complexity of vegetation (Thomas 1984) and, in rape, this is related to height since the density of side branches and leaves increase as the plant grows taller (pers. obs.). Crop height is an easily measurable variable, indicative of structure, which might affect the use of the crop by the species.

This short chapter summarises information gathered on crop growth and management features which might have influenced settlement by sedge warblers in particular fields in spring.

Materials & Methods

The Effect of Crop Structure and Floristic Composition of Rape Crops on the Presence of Sedge Warblers

In May 1995, as sedge warblers were arriving in rape (a time which approximates to the time of maximum local crop development, i.e. just after flowering, - Weiss 1983), the height of each of 50 study crops was measured using a metal, extendible tape. Mean

height was calculated along a 100 m transect, at the mid-point of the field, measurements being taken at each 10 m interval from the crop edge. Height was measured at right angles from ground level to the apical tip of the plant. Two other key elements of structure and floristic composition were recorded:

i) A simple measure of three dimensional complexity i.e. density of ground emergent rape stems, per m^2. This was calculated for eight fields; four with sedge warblers and four without, from counts of stem density in ten number, $1m^2$ plots, which were randomly chosen between crop edge and centre. These were taken after harvest, when cut stems were most easily counted. The crops were chosen to represent size and altitudinal range of surveyed crops.

ii) The identity of all vascular plants observed on routine survey visits, between May and June, in 20 fields; ten with sedge warblers and ten without. The crops were chosen to be representative, in terms of size and altitudinal range, of all surveyed crops.

Additionally, throughout the study period, all species of vascular plant encountered in rape were identified (Hubbard 1976, Rose 1981, Fitter *et al.* 1984, Clapham *et al.* 1985). A full species list was made (Appendix 8).

Crop Management and Sedge Warblers in Rape

To determine how crop management might affect the presence/absence of sedge warblers, the following management procedures were investigated:

i) planting regime and harvesting dates;

ii) crop variety;

iii) crop treatments and harvesting.

Information was gathered from landowners via a crop management questionnaire in autumn 1995 (for example, see Appendix 2). This was supplemented by circulation of

further questionnaires, on variety of rape grown, to a number of landowners in 1997, followed by telephone interview, as necessary.

Association Between Sedge Warblers and Oilseed Rape: Site and Habitat Fidelity Between Years

Site and habitat fidelity of sedge warblers was investigated in three selected areas. These were chosen after determining the presence of sedge warblers in rape in 1995 and ascertaining that rape would be grown in the same areas, but not necessarily the same fields, in each subsequent year of the study. These areas were, (Grid references taken at approximate centre of study area):

i) Barlow Fell, NZ157602;

ii) The Team Valley, NZ257569;

iii) Washingwell, NZ217600.

These areas illustrated two of the three crop management regimes employed in Gateshead. In i) and ii) the crops were rotated but, in the latter, the rape was grown on the blocking principle and the blocks moved around a large area of arable from one season to another; hence, crops were rarely more than two to three field lengths from a previous year's crop.

Over the three study seasons, visits were made to these sites at least twice in every period of 7 days; with seven periods each season. If time allowed, more visits were made and, in some seasons, e.g. 1996 at Washingwell, data were collected as part of the intensive survey (see Chapter 3). The locality of all singing birds was mapped according to crop/habitat each year. To determine whether sedge warblers occupied non-rape crops the year after the growth of rape, fields at Washingwells Farm, which had supported sedge warblers in rape in 1996 were surveyed, using the same methodology, in spring 1997 when they were planted with different crops.

Throughout, first arrival dates i.e. first registration date of singing sedge warblers, in all habitats were documented

Results

The Effect of Structural and Floristic Composition of Rape Crops on Presence of Sedge Warblers

i) Height and structure of the crop

The height of rape, early to mid-May 1995, varied between 0.99 m and 1.51 m; mean height being 1.22 m (n = 50 fields, s= 0.121). Table 21 summarizes occupation of rape according to mean height.

The mean height of rape crops unoccupied by sedge warblers, 1995, was 1.178 m (n=26, s= 0.111), and for occupied crops, 1.257 m (n=24, s=0.119). Occupation of rape crops by sedge warblers was found to be associated with mean height of the crop; taller crops having a greater probability of attracting sedge warblers (t- test = 2.414, d.f. 48, $p<0.05$).

The stem density of rape plants, in eight sampled crops, is shown in Table 22; mean density was 80.8, (n=8, s=2.462). The mean density of rape plants, per m^2, in crops with sedge warblers in 1995 was 80.65 (n=4, s=1.771) and for crops without sedge warblers 80.95 (n=4, s=3.309). There was no significant difference between the mean stem density of occupied and unoccupied crops: F tests; 1995, F=3.49, v_1 3 v_2 3, $p>0.05$; t=0.266, d.f. 6, $p>0.05$.

ii) The presence of other plants amongst the rape

Other than rape, 19 species of vascular plants were recorded in the 20 surveyed fields. The relative abundance of the thirteen commonest plant species, i.e. those occurring in at least 15% of the fields, is shown in Table 23.

Table 21 - Occupation of Rape Crops, by Sedge Warblers, According to Height (m) of Crop, May 1995

Field Name/No.	Mean Height	SW Presence	Field Name/No.	Mean Height	SW Presence
Cut Thorn 1	1.114	No	Marshal L. Fm.	1.21	Yes
2	1.128	No	Thornley 1	1.238	Yes
3	1.093	No	2	1.3	Yes
4	1.11	No	3	1.293	Yes
Pockerley Fm B. 1	1.243	No	4	1.288	No
2	1.118	Yes	5	1.473	No
3	0.991	No	Barlow Lane 1	1.36	Yes
Birtley 1	1.258	No	2	1.238	No
2	1.22	Yes	3	1.4	No
Ravesnw.	1.505	Yes	W.Byremoor 1	1.138	No
Whinnel Hill 1	1.078	Yes	2	1.083	No
2	1.14	Yes	3	1.215	No
Kibblesworth	1.2	Yes	4	1.193	No
Long Acre 1	1.348	Yes	5	1.108	No
2	1.373	Yes	Team Vall. 1	1.16	Yes
3	1.118	No	2	1.07	Yes
Barlow Fell 1	1.26	Yes	3	1.06	Yes
2	1.288	Yes	4	1.088	No
3	1.28	Yes	5	1.188	Yes
Lead Rd. 1	1.135	No	Stella 1	1.44	Yes
2	1.17	No	2	1.348	Yes
3	1.18	No	3	1.348	No
Sherburn Tow. 1	0.998	No	Leam Lane 1	1.263	Yes
2	1.175	No	2	1.43	Yes
3	1.208	No	Winter Wheat	0.633	No
4	1.14	No	Winter Barley	1.04	No
			Spring Rape	0.5	No

Table 22 - Sedge Warbler Presence/Absence in Rape in Relation to Density (stems/m²) of Rape Plants, 1995

Crop	Stem Density	SW Presence
Barlow Fell 1	79.5	Yes
Barlow Fell 2	81.2	Yes
Team Valley 1	82.9	Yes
Team Valley 2	79	Yes
Lead Road 1	83.1	No
Lead Road 2	80.4	No
Sherburn Towers	76.5	No
Cut Thorn 1	83.8	No

Table 23 - Presence and Relative Abundance of the Thirteen Commonest Vascular Plants in 20 Rape Fields, 1995

Plant species	No. of Fields Present	Percentage Present
Galium aparine	13	65
Capsella bursa-pastoris	20	100
Stellaria media	20	100
Tripleurospermum maritimum	10	50
Senecio vulgaris	6	30
Fumaria officinalis	18	90
Veronica persica	15	75
Sinapsis arvensis	4	20
Euphorbia helioscopia	7	35
Viola tricolor	3	15
Lamium purpureum	19	95
Myosotis arvensis	3	15
Poa annua	9	45

Table 24 summarises information on the presence of sedge warblers in 1995 in relation to the presence/absence of the 13 commonest vascular plants found in 20 surveyed rape fields.

Table 25 documents the level of coincidence between the presence of sedge warblers and the absence/presence of each of these plant species. There was no apparent association between the presence of any particular species of plant and the presence of sedge warblers in rape fields. The level of coincidence between sedge warbler presence and plant presence varied between 28.6% and 66.7%, except for one species, which was found in only three fields; sedge warblers being present in all of these (i.e.100% coincidence). For seven of the 13 plant species, the degree of coincidence varied by less than 10% on either side of 50%. Similar results were obtained for plant absence. For six of the 11 plant species absent from surveyed fields, sedge warblers coincidence varied by less than 10% around 50%. Of the 13 commonest vascular plants in rape, all thirteen were present in crops holding sedge warblers whilst 12 of these were present in crops without sedge warblers. Of those rape fields in which the plants were not present, sedge warblers were present in 10 and absent in 10.

A range of vascular plants were found growing in rape crops in Gateshead (see Ward *et al.* 1985), a total of 34 species were identified (see Appendix 8). There was, however, little variation in the range of plants between fields. A small number of species, e.g. chickweed *Stellaria media* and shepherd's purse *Capsella bursa-pastoris*, were ubiquitous. Most species recorded were annuals and might be described as "arable weeds" (Clapham *et al.* 1985).

In comparison with nearby cereal crops, a wide range of vascular plant species were found in rape. Of three non-winter rape fields examined in spring 1995: winter barley, winter wheat and spring rape, only in spring rape were any species of broad-leaved, vascular plants found and, in both barley and wheat, no species of plant, other than the crop, were recorded.

Table 24 - Sedge Warbler Presence in Relation to Presence of Common Vascular Plants in 20 Rape Crops, 1995

Plant species	No. of fields present	Plant present Sedge Warbler Present	Absent	No. of fields absent	Plant absent Sedge Warbler Present	Absent
Galium aparine	13	8	5	7	5	2
Capsella bursa-pastoris	20	10	10	0	0	0
Stellaria media	20	10	10	0	0	0
Tripleurospermum maritimum	10	4	6	10	4	6
Senecio vulgaris	6	4	2	14	6	8
Fumaria officinalis	18	8	10	2	0	2
Veronica persica	15	8	7	5	3	2
Sinapsis arvensis	14	1	3	6	10	6
Euphorbia helioscopia	7	2	5	13	9	4
Viola tricolor	3	1	2	17	8	9
Lamium purpureum	19	10	9	1	1	0
Myosotis arvensis	3	3	0	17	10	7
Poa annua	9	5	4	11	5	6

Coincidence of 13 species of common vascular plants, with sedge warblers in 20 surveyed rape fields; no. of fields sedge warbler recorded in, according to plant species presence and absence

Table 25 - Coincidence of Sedge Warbler Presence in Rape in Relation to the Presence/Absence of Thirteen Common Vascular Plants in 20 Surveyed Rape Crops, 1995

Plant species	No. of fields present	Level of SW coincidence with plant sp. presence	No. of fields absent	Level of SW coincidence with plant sp. absence
Galium aparine	13	61.0%	7	71.4%
Capsella bursa-pastoris	20	50.0%	0	n/a
Stellaria media	20	50.0%	0	n/a
Tripleurospermum maritimum	10	40.0%	10	40.0%
Senecio vulgaris	6	66.7%	14	42.9%
Fumaria officinalis	18	44.4%	2	0.0%
Veronica persica	15	53.3%	5	60.0%
Sinapsis arvensis	14	25.0%	6	62.5%
Euphorbia helioscopia	7	28.6%	13	69.2%
Viola tricolor	3	33.3%	17	47.1%
Lamium purpureum	19	52.6%	1	100.0%
Myosotis arvensis	3	100.0%	17	58.8%
Poa annua	9	55.6%	11	45.5%

Key:
n/a - not applicable

Crop management and variety, and the presence of sedge warblers

Rape had been grown in the Gateshead area for at least 15 years prior to the current study (Bowey unpub. data) however, only small amounts of the crop were present until the mid-1980's, when it became increasingly popular (Ward *et al.* 1986). Details of the oilseed rape grown, and the 126 fields surveyed, in Gateshead, 1995-1997, is summarised in Appendix 7.

i) Three regimes of rape production were identified: simple rotation; block-cropping; or, a rotation of blocks. The first involved the rotation of four crop types over a four year cycle and was the most widely practised by farmers in Gateshead (i.e. 56.3% of all fields, 1995-1997). Such systems, in modern farmed landscapes, result from the adoption of 'set-aside' (see Appleby 1995) and usually involves: winter barley, rape, winter wheat and a season of set-aside. The second system involves moving a single crop type around extensive blocks of land over the four year rotation; this system covered 39 fields of rape over the study period. The third mimicked the smaller rotation, but on a larger scale; only 16 fields over the three year period were managed under this system. The resultant distance between rape crops in consecutive years was in the order of 200-800 m rather than the 10-200 m more usually experienced in the first rotational system.

Sedge warblers were recorded in rape grown in all systems, in each year of the study but most regularly from fields in the simple rotational system (Table 26). There is a highly significant association between the presence of sedge warblers in rape and the regime under which the rape is managed, $\chi^2 = 23.07$, d.f. 2, $p<0.001$. In particular, birds are more likely to be present in fields in the simple rotation system ($\chi^2=8.12$, d.f. 1, $0.005<p<0.001$) and birds most likely to be absent from fields in the blocked system ($\chi^2=7.17$, d.f. 1, $0.01<p<0.005$).

ii) Landowners grew nine varieties of rape 1995-1997. Sedge warblers were recorded in all varieties during the study; the frequency of occupancy of each variety by sedge warblers is summarised in Table 27. The extent to which each variety was grown varied

Table 26 - Presence/Absence of Sedge Warblers According to Cropping System, 1995-1997

	1995		1996		1997		Total '95-97	
	Present	Absent	Present	Absent	Present	Absent	Present	Absent
Rotated Crops	20	8	20	12	13	2	53	22
Blocked Crops	3	14	3	9	4	0	10	23
Rotated Blocks	1	0	4	1	5	3	10	4
Total	24	22	27	22	22	5	73	49

from year to year, although Apex was overall the most popular. The three most popular varieties 1995-1997, were: Apex, Bristol and Falcon (Table 28) these made up 80.6% of the known crop area, the remaining six varieties, collectively, making up less than 20%. The varieties: Comanche, Gazelle and Lizard, together, amounted to only four crops over the study period.

iii) All surveyed rape crops were swathed (i.e. cut) and left to dry naturally so this could have no bearing on presence/absence of birds (Ward *et al.* 1985). In 1997 one landowner used desiccants on an unsurveyed crop, the only known instance of this practice in Gateshead. Typical swathing dates in 1995-1996 fell between 23rd and 28th July. By early August almost all crops were harvested. Swathing date is critical for birds with nests or nestlings in a crop, as the cutting and upheaval of harvest would, almost certainly, destroy nests and dependant young (Burton *et al* 1998).

Sedge warblers were recorded in rape crops, regardless of whether these had been treated for pests prior to birds arrival (e.g. for slugs) or later, through May and into early June (e.g. for cabbage aphid or flea beetle), Table 29. There was no significant association between whether a crop was treated and the presence/absence of birds in it (χ^2=3.97, d.f. 4, p>0.25).

Are sedge warblers site-faithful or faithful to arable habitat between years?

During the three year study, the only arable crop which consistently held sedge warblers was oilseed rape (Table 6a). In spring 1995, three non-rape crops adjacent to rape crops holding sedge warblers were surveyed, these consisted of: winter wheat and winter barley on Barlow Fell, and spring rape in the Team Valley (see Table 21). At no time during the survey were sedge warblers recorded in any of these fields. The work at Barlow Fell, Team Valley and Washingwell, 1995-1997, showed that in each year, at each location, birds were present only in rape; birds moving with the crop as it moved between seasons. The evidence for proof of breeding, and the breeding strategies adopted by birds at these sites, is summarised in Table 18.

Table 28 - Percentage Composition of Rape in Gateshead, of the Three Most Popular Varieties of Rape, 1995-1997

Variety	By No. of Fields	By Area (ha)
Apex	37.11%	33.62%
Bristol	23.71%	33.35%
Falcon	17.52%	13.59%

The survey of 20.76 ha of winter wheat at Washingwell, in the same area which had held 12 sedge warbler territories in rape, at a density of 0.58/ha, in 1996 revealed no evidence of sedge warblers at any time during 1997 (Table 30). The habitat in this area remained similar between seasons with the exception of the removal of a section of hedge, *circa.* 80 m in length, between two fields. In 1997, sedge warblers were, however, present in the nearest adjacent rape crop to the 1996 crops; some 250 m to the west. This suggests that sedge warblers "follow" rape around a farmed area, apparently tracking the mobile habitat between years (see Wiens 1989). It is, however, unknown whether such tracking involves the same individuals between years.

Arrival patterns of sedge warblers in rape and traditional habitats

First detection dates for singing male birds in rape crops are summarised in Table 31; those for Shibdon Pond and V.C. 66 are summarised in Table 32. Dates are expressed by using 1st May as equivalent to "1", 10th May = "10", etc. Therefore, 1st June = "31" plus 1, i.e. "32". Mean first detection date for males at Shibdon 1995-1997, was 25th April, and in rape, 2nd May; a seven day difference between habitats. Poor spring weather in May 1996 delayed migration and mean first detection date in rape was six days later, 21st May 1996 (n= 27) than in 1995 i.e.15th May (n=22).

Females are unobtrusive in behaviour (pers. obs.) and may go unobserved, perhaps for a period of several days after arrival. The best clues to female presence are male behaviour (Catchpole 1973a). Hence, documented dates for first arrival of females (Table 32) are unlikely to be as accurate as those for males

Table 30 - Singing Sedge Warblers at Washingwells Farm 1997, Oilseed Rape in 1996

			No. of Singing Males per Seven-day Visit Period.							
Visit Period	**No. of Fields**	**Area (ha)**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total territories**
Rape 1996	4	20.76	0	1	9	9	6	9	5	12
Winter Wheat 1997	3	20.76	0	0	0	0	0	0	0	0

Table 32 - Sedge Warbler First Documentation Dates in Rape and Traditional Habitats, Gateshead 1995-1997; in Relation to First Documentation Dates in County Durham

		Shibdon Pond	Rape	Earliest in County Durham
1995	First male	27/04	02/05	21/04
	First female	18/05	23/05	*
	Mean (male)	*	15/5 (n=22)	*
1996	First male	21/04	03/05	20/04
	First female	27/05	22/05	*
	Mean (male)	*	21/5 (n=27)	*
1997	First male	27/04	02/05	19/04
	First female	10/05	11/05	*
	Mean (male)	*	11/5 (n=21)	*

Discussion

Prior to this study it might have been postulated that sedge warblers were associating with some other feature of the farmed landscape independent of rape. However, the current work illustrates both the association of birds with rape through the breeding season and between breeding seasons, regardless of other habitat features. Sedge warblers clearly associate strongly with rape, this assertion is corroborated by a short study (Robertson 1990) which determined that, in only one of 23 cases, did sedge warblers occur in the same field the year after rape, should the crop be changed to another arable crop.

Crop height, which is governed by crop development and is related to its structure, appears to be associated with the presence of birds in rape, the mean height of occupied crops being 7.9 cm more than that for unoccupied crops. Taller crops are more likely to have sedge warblers present. Rape grows to between 0.8 and 1.5 m in height (Weiss 1983), mean height in Gateshead in 1995 being 1.22 m. At such heights, within the normal developmental range of the crop, height has little bearing on its structural development, this latter factor probably has a greater determinant influence on the species' use of rape (Thomas 1984). Below a certain critical height, at which the required complex structure of inter-locking stems, leaves and flowers, is not developed, then crop height will undoubtedly become a significant factor in determining sedge warblers' use of rape. This critical height has yet to be determined, although during this study no crop of less than 1.06 m in height held birds.

The density of rape plants within a field might conceivably affect its use by sedge warblers however, there was very little variation in plant density in the measured crops. The emergent plant density was largely determined by seed drilling density, which was prescribed by yield maximisation guide-lines, provided by agricultural seed merchants. Meteorological conditions, substrate type, local shading and drainage factors can also affect plant density on the small scale. Crop stem density was similar in all measured

crops as land managers sow at similar rates hence, with little variation between fields, the presence of birds in rape is not influenced by this factor.

Shaw (1988) stated that the number of plant species present on farm land was most strongly, and inversely related to the amount of arable land present, however rape appears to hold more species of vascular plant than other arable crops. The presence of sedge warblers in rape does not appear to be linked to the presence of any of these plants. The weedy nature of rape is probably related to the more open nature of the crop early in the season, but is also a function of the manner in which the crop is managed (Ward *et al.* 1985). It is not usually considered a key revenue generating crop hence, many land managers use less intensive processes than for winter cereals. Reduced expenditure on pest control may lead to a consequent increase in the level of invertebrate number and plant biodiversity within the crop; the potential benefits for birds using the crop are obvious.

Ward *et al.* (1985) stated that chickweed, *Stellaria media*, is probably the most widespread, broad-leaved weed in rape, and is considered a pest by farmers. Other plants widely found are field speedwell *Veronica persica*, scentless mayweed *Tripleurospermum maritimum*, pineappleweed *Matricaria matricarioides*, and red dead-nettle *Lamium purpureum* (Ward *et al.* 1985). All were widespread in rape in Gateshead, as were groundsel *Senecio vulgaris*, poppy *Papaver rhoeas*, and shepherd's purse *Capsella bursa-pastoris*. Ward *et al.*(1985) described these as "frequently encountered in the autumn", however all were amongst the commonest of spring plants. It is conceivable that the ever present, shepherd's purse may be important to sedge warblers as it adds structural complexity to some crops, forming a second strata of vegetation under the rape (pers. obs.).

Planting regime and between season field plan, has a considerable effect on whether sedge warblers are present in rape crops. It is these processes which largely determine

inter-crop distance between years which, is strongly influential in determining the presence of sedge warblers in any particular rape crop.

The three cropping regimes of rape: simple rotation; block-cropping; or, a rotation of blocks led to different degrees of predictability about the presence of rape in a farmed area, over a period of time. In a simple rotation, the crop is usually present at no more than one or two fields distance (i.e. 10-200 m) from a previous year's crop whilst crop blocking leads to a large degree of unpredictability about the presence of rape in one area between seasons (distances between crops, 450-2500 m). Any bird returning to a field in which it had bred or been reared would not, necessarily, find rape in that area the following year under the blocking system. The least practised system in Gateshead, rotated blocks of rape over four years, was used by only one farmer, around an area abutting Washingwell Woods. This led to a relatively high degree of predictability about the presence of rape between years, in the context of one farmed area, although distances between crop edges between seasons were, on average, greater than in the simple rotation (i.e. 200-800m).

Rape crops without sedge warblers one year, but having rape grown adjacent to them the following year, had an increased probability of attracting sedge warblers in the subsequent year. This might be explained by late-in-the-season use of the crop by randomly dispersing juveniles, from local breeding sites in rape, prior to migration. Same season recaptures of juveniles ringed in Gateshead (Durham Ringing Group 1988-1996) indicate that juveniles from traditional habitats, disperse relatively short distances, to feed in similar habitats to those in which they were hatched, prior to migration (see Mead 1983, Berthold 1994); e.g. juveniles from Shibdon re-captured in the Derwent Walk Country Park, 4.15 km south-south west. If this also applies to birds reared in rape then it provides a mechanism by which potentially new areas of rape might be discovered and, subsequently, exploited for breeding. If just a small proportion of first calendar-year birds, which would usually return to breed in their natal area, instead, return to the area in which they fed prior to migration the previous autumn, then this

might also offer a mechanism by which the spread of the rape utilisation habit might occur across an area of arable land.

The apparent tracking of rape between seasons has considerable implications for the species in respect of niche utilisation. For instance, rape-nesting sedge warblers could occur sympatrically with wetland birds yet be spatially and, considering that birds in rape prey on a different suite of insects (Bowey *in prep*), trophically segregated from them (after Odum 1971). Such separation, through habitat choice, should lead to a much more widespread exploitation of available habitat, but it may also restrict gene flow between such sympatric populations; over time such barriers to gene flow might have considerable evolutionary implications.

The crop variety grown and the pest control treatments undertaken did not appear to influence the presence of birds; although the manner of application of the latter, might influence breeding success. Although rape variety grown has no apparent influence upon the presence of sedge warblers in the crop, the level of unpalatable glucosinolates (Kirk 1992), which, unlike plant structure, varies according to variety, may have a bearing upon its use by some insect species, and therefore affect the levels of available prey to birds. However, most invertebrate species found in the crop (Bowey unpub. data.) are either Brassica specialists (Kirk 1992) or generalists, both of which can accommodate high levels of these chemicals.

Much work has been done on ecological isolation, competition and niche separation in warblers of the genus *Acrocephalus*, in both winter range (Lack 1971), and the breeding season (Catchpole 1973b, Catchpole & Leisler 1986) as well as on the resource partitioning of passage birds (Ormerod 1990b). It might be postulated that the widespread use of rape by sedge warblers (Bowey *submitted*) imposes a greater degree of niche separation between some populations of this species than exists between it and its close congener, the reed warbler *Acrocephalus scirpaceus*, in some wetlands; despite

CHAPTER 5

Capture by Tape-luring and Biometrics of Sedge Warblers in Rape and Traditional Habitats

Introduction

Territorial male sedge warblers react aggressively to an intruding male or a recording of a male in their territory (Catchpole 1973a). Hence, aggressively reacting males can be caught in appropriately positioned mist-nets close to the sound source of an intruding song (Catchpole 1977). The sexes are, effectively, similar in plumage and external characteristics, although some males can be separated by their whiter, less creamy toned underparts (Cramp 1992). During parts of the breeding season, in the hand sex determination is made possible by the presence of a cloacal protuberance (males) or a brood patch (females), (Svensson 1992).

Methods

Whenever possible sedge warblers, regardless of habitat, were caught and rendered individually identifiable using a unique combination of up to three plastic colour rings and a standard, engraved, magnesium-aluminium alloy ring, internal closed diameter 2.3 mm, (British Trust for Ornithology 1984).

The tape-lure used consisted of: a one minute loop cassette, with a recording of a singing sedge warbler; played on a portable Walkman cassette player, amplified through a battery operated, 3 watt speaker for up to 30 minutes. The speaker was suspended in vegetation within one metre of a 6 m, three panel mist net (mesh size, 38 mm) in the territory of a singing sedge warbler. In rape, the net was set along tractor "tram lines" (to minimise crop trampling), in traditional habitats in vegetation close to the subjectively judged middle of the singing male's territory. All tape-luring and colour-ringing activities, 1995-1997, were registered with and licensed by the BTO.

Table 33 - Summary of Results of Tape Luring of Sedge Warblers, 1995-1997

	Trad. Habitats	Rape
No. of males caught	16	5
No. of males attempted	26	21
No. of females caught	6	0
No of hours of luring	28	22.5
% of attempted males caught	61.5	23.8
No. of males/hour	0.57	0.222

Discussion

The responses of male sedge warblers to the tape lure varied according to habitat but the tape luring results indicate that males were caught more frequently for similar effort in traditional habitats than in rape. Typically, a male in a traditional habitat territory (Thomas 1984, Catchpole 1972), might be caught more easily than those in the more uniformly structured habitat of rape. It is conceivable that this merely reflects a difference in efficiency of mist-netting with a tape lure between the two habitats, rather than a difference in behaviour on behalf of the birds. However observations of male behaviour indicate that this is not the case.

The observed response of some males in rape crops to the tape lure was to relocate, by 20 m or so, and to carry on singing. Comparable behaviour, on the part of territorial male sedge warblers in traditional habitats, was observed on only one occasion, in spring 1997. In this instance, a bird being tape lured in a dense *Typha latifolia* bed, moved some 15 m due east in response to the tape and sang vigorously from its new adopted spot. Perhaps territories in rape, at least before pair-bonding, are more flexible, birds showing a greater willingness to accommodate incoming territorial males, than their counterparts in traditional habitats. On eight occasions, when tape-luring in rape, the target male accommodated the apparent intruder in this manner. Sedge warblers have been recorded doing this to accommodate the later arriving reed warbler *Acrocephalus scirpaceus* when in territory in *Phragmites* reedbed (Catchpole 1973b).

The occurrence of such behaviour by males in rape might relate to a paucity of territory delineating features in the crop; one 20 m^2 square block of rape looking and, presumably, performing ecologically, much like the next 20 m^2 block. If food is readily available in the crop (see Bowey *in prep*) this might serve to reduce the need for territorial conflict (Krebs & Davies 1981). Competition for mates however would not be diminished by the structure of the habitat. Indeed, this might serve to elicit the opposite effect. Where territories are situated in structurally diverse habitats, variations in height and form,

presumably, offer birds obvious physical reference points with which to delineate their territorial boundaries, outside of which a male might be less likely to stray. Hence, the accommodation of an intruder or tape lure would be less likely in traditional, structurally diverse territories, as observed. This might explain the observed greater success of tape luring in such habitats.

Birds at Shibdon were 3.54 times more likely to be caught, for similar trapping effort than those in rape; males only, were 2.57 times more likely to be caught. In 28 hours of tape-luring effort, for every male caught in traditional habitats, 0.375 females were caught. Assuming that females were present in similar proportions to males in rape as in traditional habitats, one might expect 0.301 females to be caught for each male in 22.5 hours of effort in rape. No females were caught in rape.

A number of explanations for the lower capture rate of females can be postulated. Males are principally responsible for territory defence (Catchpole 1973a) hence they are more likely to approach the tape and be caught. Females are less attracted and show less antagonistic behaviour to the tape and there is a greater likelihood of them being either not yet present or otherwise engaged, e.g. feeding for egg production, nest building or incubating eggs, at the time of tape-luring. Alternatively, females may get caught for a number of reasons: investigating the song of an 'intruder' male, for the possibility of re-pairing or sneaking extra-pair copulations, from an apparently, high quality male (Davies 1987).

The biometric and body condition data indicated that there was no difference in size or body condition indicators between males caught in rape and those at Shibdon, which suggests that there were no discernible differences in the physical quality of males. It is possible that birds inhabiting rape crops are inexperienced, perhaps first-summer, birds. However, there are no published morphological characters which allow reliable determination of age in sedge warblers, after post juvenile moult (Ginn & Melville 1983,

Jenni & Winkler 1994). Hence, in spring, even birds in the hand, could not be accurately aged, so this theory could not be investigated.

CHAPTER 6

Song Behaviour of Sedge Warblers Utilising Rape Crops and Traditional Habitats, 1995-1997

Introduction

For most song birds, song is crucial in attracting a mate and establishing a territory (Campbell & Lack 1985). Hence, the study of a species' song may be key in revealing aspects of its habitat utilisation and mate acquisition (Carthy 1979). The song of the sedge warbler, "Garrulous, hurried and erratic" (Nicholson & Koch 1936), can be loud and is clearly species specific (Catchpole 1973a) and, depending on climatic conditions, it can be heard at considerable distances (pers. obs.). The song is composed of a variety of harsh, chattering, churring phrases, interspersed with high pitched, sweeter notes with some mimicry. Males appear to have individually distinctive songs, with no stereotypical sequences of notes and phrases, and no finite length to repeating patterns (Catchpole 1973a). Sedge warbler song is considered unusual in its extreme elaboration and function, its purpose being almost solely for mate attraction. Song usually terminates after successful pairing (Catchpole 1973a). Separation of vocalizations, into songs and calls is well defined in *Acrocephalus* warblers (Catchpole 1973a), and the distinct nature of sedge warbler song allows for easy identification and location during the song period, regardless of habitat. Song is usually delivered from a prominent perch, e.g. a willow or hawthorn, and this, with the birds' pale underparts, makes them visually and acoustically obvious (Catchpole 1972). Visual advertising is further enhanced by song-flights, in which song is co-ordinated with the elaborate flight (Catchpole 1973a, Baker 1997). In order to discover whether males in rape and traditional habitats differed in their song delivery a study of two elements of this behaviour was undertaken.

Methods

i) Total song activity. Each song incident was documented according to place and time, and classified into one of three delivery methods, each of which was readily

Results

Locating singing sedge warblers in traditional and rape habitats

Advertising song can carry considerable distances in open agricultural country. Given the right conditions, males in rape could be heard at over 0.5 km distance (pers. obs). Males were recorded singing at all hours of the day and night in rape and traditional habitats (pers. obs). On 25th June 1995, two males, at Shibdon, sang between 2309hrs and 0130hrs on 26th; both had females on nests.

Sedge warbler song delivery in rape and traditional habitats

During the 1996 field season 1403 song incidents were registered, 1390 being classified into a song category. Total song incidents recorded in 1997 were 1755, all being classified (Tables 35a & 35b). The method of song delivery differed highly significantly between traditional and rape habitats in both 1996: $\chi^2 = 314.19$, d.f. 2, $p<0.001$, and 1997, $\chi^2 = 153.22$, d.f. 2, $p<0.001$. Males in rape undertook a greater number of song flights, whilst birds in traditional habitats sang from perched or concealed locations to a greater degree.

Active song periods in different habitats

All documented song incidents, 1996-1997, were grouped into seven-day date periods. The time spent listening for song in both habitats and each 7-day period was standardised in 1996. However, this was not possible in 1997, when bad weather conditions and other factors meant that standardisation could only be achieved in the early part of the season; no observations being made in rape after 16th June. The pattern of song activity through the season in 1996 & 1997, in traditional and oilseed rape habitats, are illustrated in Figures 7a & 7b and 8a & 8b (song incidents by date period are summarized in Appendix 9). In both years there was a peak in the number of song incidents in late May and early June, with a second, minor peak, regardless of habitat, around the end of June.

Tables 35a - Summary of Classifiable Song Incidents in Different Habitats, 1996

	Concealed	Perched	Song-flight	Total
Traditional habitats	153	235	48	436
% of total for habitat	35.09%	53.81%	11.01%	
Rape	47	431	476	954
% of total for habitat	4.93%	45.18%	49.89%	
All song incidents	200	666	524	1390
% of total	14.38%	47.91%	37.70%	

Tables 35b - Summary of Classifiable Song Incidents in Different Habitats, 1997

	Concealed	Perched	Song-flight	Total
Traditional habitats	483	700	191	1374
% of total for habitat	35.15%	50.95%	13.90%	
Rape	39	197	145	381
% of total for habitat	10.24%	51.71%	38.06%	
All song incidents	522	897	336	1755
% of total	29.74%	51.11%	19.15%	

Song Incident - defined as a discrete observation of a singing bird, during which the bird was under observation, or its location known, for the whole period of the delivered song. If the bird changed position during song delivery, from a concealed location to a perched position, this was considered a new song incident.

Figure 7a - Sedge Warbler Song Incidents, by Habitat 1996

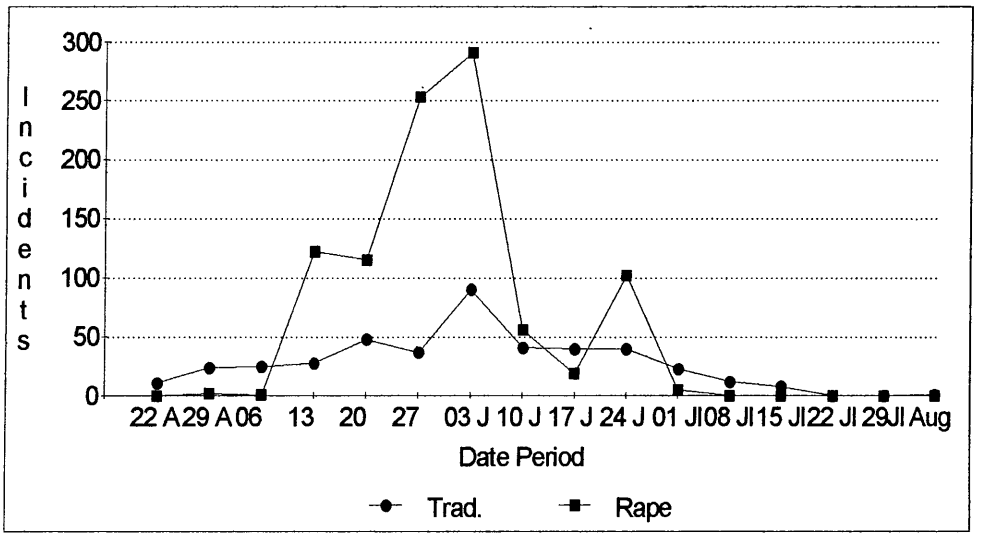


Figure 7b - Sedge Warbler Song Incidents, All Habitats 1996

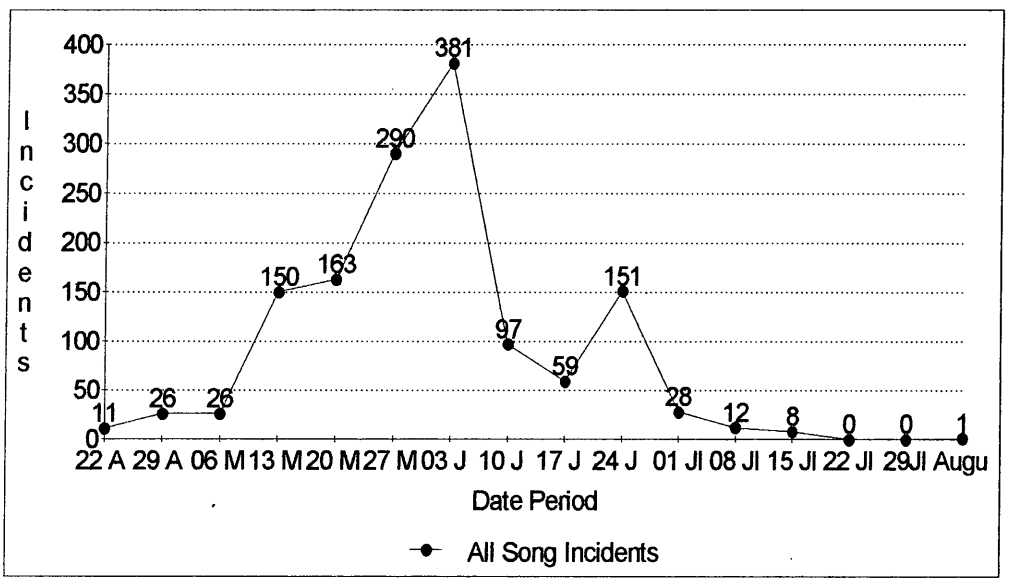


Figure 8a - Sedge Warbler Song Incidents, by Habitat 1997

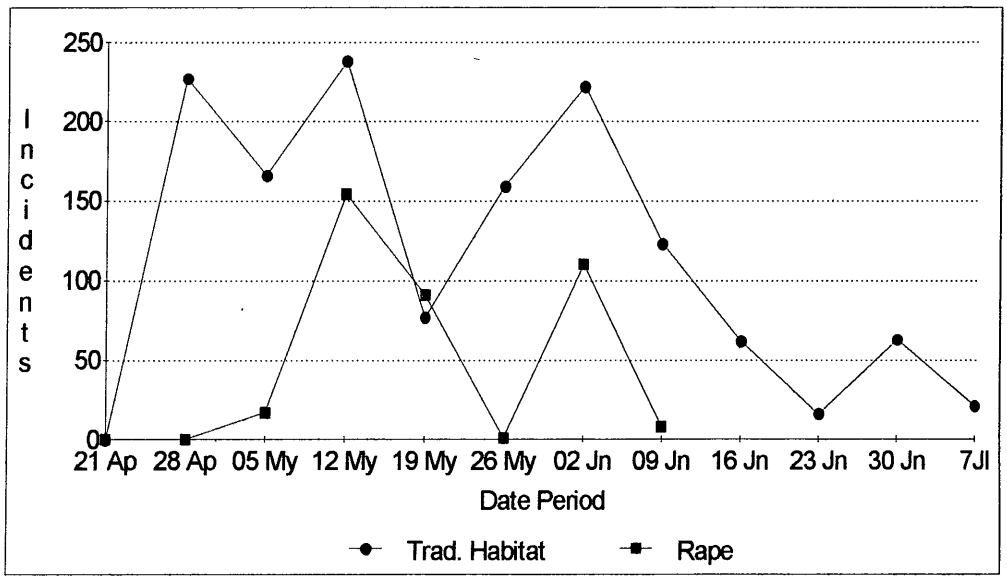
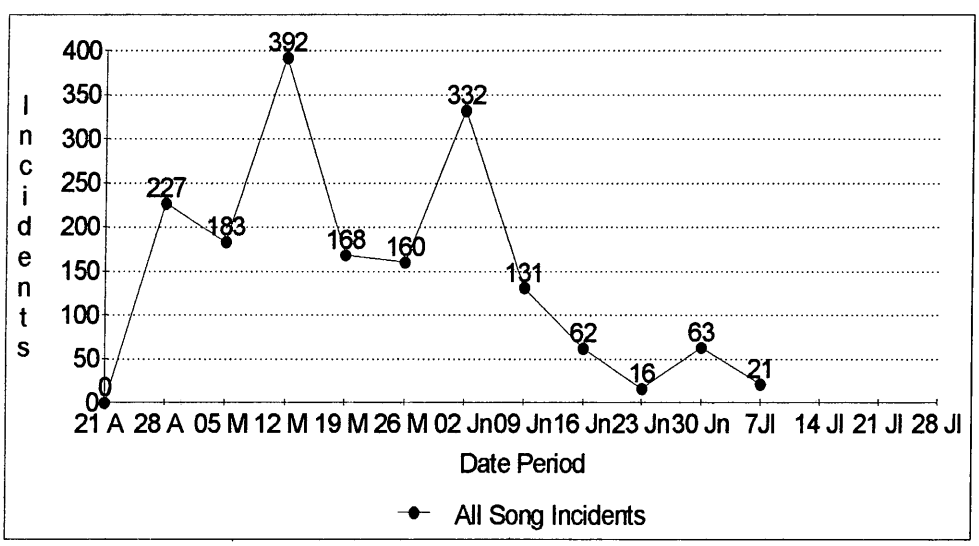


Figure 8b - Sedge Warbler Song Incidents, All Habitats 1997



During both 1996 and 1997, the principal song period of birds in rape was more concentrated than for birds in traditional habitats. In 1996, in rape, most song was concentrated between 6th May and 17th June, with a peak between 27th May-3rd June. In traditional habitats song was more evenly spread, with a smaller peak of activity, also concentrated in the 3rd June date period. In such habitats, song activity was recorded in 14 of the 16 date periods but only 10 in rape. Of all song incidents in rape, 80.85% (n=781) occurred in the four, seven-day date periods between 13th May and 9th June, compared to 46.45% (n =203) over the same period in traditional habitats. In 1997, of 11 date periods, song was registered in 10 in traditional habitats and 6 in rape; 93.43% (n=356) of all song incidents in rape occurred in the four, seven-day date periods between 12th May and 8th June, compared to 62.73% (n =862) in traditional habitats.

Date attributable records of sedge warblers in rape, throughout Durham (Durham Bird Club 1986-1995, Steele 1986-1995), showed that birds have been recorded singing from 4th May-28th July (Table 36). Including unspecified to date records (i.e. those attributed to month only), 67.44% of records referred to May, 19.77% June and 12.79% July (n=86).

Song flight rates in different habitats

The rate of song-flighting, according to habitat 1995-1997, is summarised in Tables 37a to 37c. The number of song flights, each year were standardised, across habitats, according to unit observation time, and compared amongst: rape, traditional habitats and rape modified by the presence of perches. In all years the observed differences in song flight rate between all habitats was found to be highly significant: 1995, $\chi^2 = 64.35$, d.f.1, with Yates' correction, $p<0.001$; 1996, $\chi^2 = 143.42$, d.f. 2, $p<0.001$; and, 1997, $\chi^2 = 247.71$, d.f. 2, $p<0.001$. The highest rates of song-flighting were found in rape, the song-flight rates were lower in rape modified by the presence of perches and lowest in traditional habitats (in which there were usually abundant perches).

Table 36 - Percentage Singing Activity of Sedge Warblers April-August, 1996-1997

	April	May	June	July	August	Total Song Incidents
1996 - Traditional	8.05	31.72	48.51	9.89	1.83	435
1996 - Rape	2.64	44.86	49.07	3.42	0	966
1997 - Traditional	16.52	46.58	35.57	1.53	0	1374
1997 - Rape	0	69.03	30.97	nil	nil	381
Total 1996 and 1997 - Rape	0.15	55.98	43.5	0.37	0	1347
DBC records, rape (1986-1995)	0	73.23	12.68	14.08	0	71

Key:
Nil - no observations in period.
Song activity is shown as a percentage of total observed song incidents according to habitat.

'DBC records', extracted from the Durham Bird Club's database (DBC 1974-1996, Steele 1986-1995), are not directly comparable to data from the present study. They are featured here in order to provide a regional context for the Gateshead data. This data set includes all date attributable records of singing sedge warblers in rape, in County Durham, 1986-1995.

Table 37a - Mean Rate of Song Flighting in Different Habitats 1995

	Trad. Habitats	Rape	Rape plus Perch
S/flights per minute	0.2	1.16	0
No. of s/flights in sample	4	109	0
Observation period (min)	21	94	0
No. of birds monitored	2	5	0

Table 37b - Mean Rate of Song Flighting in Different Habitats 1996

	Trad. Habitats	Rape	Rape plus Perch
S/flights per minute	0.208	0.866	0.757
No. of s/flights in sample	30	305	56
Observation period (min)	144	352	74
No. of birds monitored	9	19	4

Table 37c - Mean Rate of Song Flighting in Different Habitats 1997

	Trad. Habitats	Rape	Rape plus Perch
S/flights per minute	0.281	1.045	0.357
No. of s/flights in sample	110	116	10
Observation period (min)	392	111	28
No. of birds monitored	15	11	4

Discussion

Song attracts attention to the singing bird, usually for territorial defence or mate attraction (Campbell & Lack 1985). This activity inflicts costs, physical or physiological upon the individual, e.g. higher energy expenditure through song-flighting (Pennycuik 1972), an increased risk of predation or territorial conflict (Cade 1979, Krebs & Davies 1981). During the initial song period males were easily located, however, once females arrived and pairs become established, they were rarely heard (Simms 1986) though occasionally seen; this applied to both habitats studied.

Unsurprisingly, male sedge warblers in rape exhibit many similar song behaviour traits to those in traditional habitats i.e. they deliver song throughout the day, but mainly between dawn and mid-morning, with another peak of activity from late afternoon through to evening, and they use a number of song delivery methods, including song-flights. They do however, differ in the manner of song delivery, indulging in a higher rate of song-flighting, per unit time of high intensity song, than males in traditional habitats. In traditional habitats, the sedge warbler's song period is well synchronised across the population, the peak occurring in the first half of May, (Catchpole1973a). Males in rape have a more contracted song period, it being even more closely synchronised than that of birds in traditional habitats.

The amount of song output by males in both habitats declined dramatically after the arrival of a female; in many instances birds simply ceased singing (Catchpole 1973a) and birds were undoubtedly more difficult to locate, especially in rape, after the song period terminated (pers. obs). However, in all years of the study some males, often those arriving late, e.g. Shibdon Pond in 1996, 1997, and in rape on Barlow Fell in 1995, continued singing well into the season. This may have been due to an inability to attract a mate but in some instances it was known that some males were attempting to establish second territories and attract further mates (pers. obs). This latter peak of song activity has been noted in previous studies (Catchpole 1972, 1973b) and may be related to

double-brooding attempts, replacement clutches, males attempting to attract a second mate (Alker & Redfern 1996), or a combination of all three.

Birds in rape sang less often from concealed situations and indulged in a greater number of song-flights than birds in structurally more varied, traditional habitats. Concealed singing might minimise the risk from avian predators, whilst perched song and song-flighting might bring greater risk (Armstrong 1947). The reverse is likely to be true in respect of the efficiency of mate attraction; the principal purpose of sedge warbler song (Catchpole 1973a). The more obvious a male, e.g. higher rates of song-flighting, the greater the likelihood of a passing female noticing him; increasing his chance of pairing. Such short-burst, physical activity, uses considerable glycogen reserves (Pennycuik 1972), the increased respiratory demand having consequent energetic and dietary implications for birds (Philipson 1966). Assuming all other factors, e.g. female availability, are equivalent males in rape, with higher levels of song-flighting, will expend more energy and require more food than birds in traditional habitats to achieve mate acquisition.

Song flights, which are more complex in structure but not necessarily longer than perched song (Catchpole 1976a), have significant ecological importance to male sedge warblers. It seems reasonable to assume that the observed habitat-related differences in song delivery and song flight rate, are manifested by significant ecological differences between the habitats. It has been shown (Kroodsma 1976, Catchpole 1980, Catchpole *et al.* 1984) that male birds with larger song repertoires are more likely to elicit pairing with females, this may induce earlier breeding and increase the potential for successful breeding. Perhaps males in rape, exhibiting higher rates of song-flighting, are similarly benefited in their relations with females?

Where rape is modified by the presence of tall features, e.g. hedgerows, then the rate of song-flighting is also modified (see Table 36a-c). In these situations the features are often used as song-perches (pers. obs.). Tall features may be important to birds in

extensive areas of uniform low vegetation (Sharrock 1976), indicating that the rate and frequency of song-flighting may be largely determined by the structural composition of the habitat. The fact that the presence of tall features can modify the rate of song-flighting in rape suggests that this behaviour is largely dependant on the structure of the vegetation in and around that area of crop which constitutes the bird's territory. This could be tested experimentally, by manipulating the number of high perches within the territories of males in rape and comparing the before and after rates of song-flighting.

Any potential increase in predation risk, through increased song-flighting in rape, might be offset, by the relative lack of cover for stealth orientated hunters, such as sparrowhawk *Accipiter nisus* (pers. obs.). By contrast, traditional habitats provide more cover for such predators; in this case, reduced song-flighting may have some adaptive value in reducing predation risk. The result, a selective advantage for males exhibiting reduced song flighting and concentrating on perched song (or choosing territories with tall song perches). In both habitats, a trade off between differing ecological imperatives may occur; the importance of attracting a mate and the more immediately important issue of avoiding being eaten. For the strategy, of increasing one's obviousness to predators and incurring greater energetic demands in song delivery, to be successful in evolutionary terms, then the reproductive advantages attained by males in rape must offset the potential risks and any costs incurred by the individual.

For males in rape, perched and song-flights appear to be used for mate attraction (see Catchpole 1973a) whilst concealed, and some perched, song appeared to be geared towards territorial defence. This assertion is based on observations of rival males during territorial conflict and of their responses to tape lures (pers. obs.). Birds in rape, behaved in a similar manner to those in traditional habitats towards intruding males, but appeared less willing to react in the aggressive manner documented by Catchpole (1973a) to tape lures (pers. obs.). This may mean that birds in rape are more willing to accommodate intruders. Perhaps having less obvious landscape features within their territories, the territorial boundaries are more fluid and they require further, visual cues,

to release full aggression against an intruder - cues which are not readily available in rape.

Because of the range of information transmitted through bird song, its functional interpretation can be problematic (Armstrong 1963) but it is clear that the pattern of song delivery (concealed, perched and song-flights) differed quantitatively between rape and traditional sites (Tables 35a & 35b). Such differences may incur or confer different costs and benefits upon the birds using the habitats and these may relate to energetic demand or to factors such as access to females.

There is a correlation between mating systems and the complexity of song structures, more complex structures often being associated with polygynous mating strategies (Kroodsma 1977). The song of the sedge warbler is one of the most complex and variable of all oscines (Catchpole 1976a), which may indicate a certain pre-adaptation towards polygyny. If males with more elaborate songs are the first to attract females (Catchpole 1980), then quicker pair establishment, earlier mating and increased reproductive output might follow (see Perrins 1970) - this might be tested in the field by using sonagrams to investigate the structure of song delivered by males in rape and relating this to their speed of mate acquisition and subsequent breeding history. Successful bigamy was observed in both traditional and rape habitats during this study (see Chapter 3) and it is conceivable that higher rates of song flighting, prompted by the habitat structure of rape, may result in a race for female acquisition, in turn leading to earlier mating; freeing males to search for another mate. Such behaviour would encourage a greater synchronicity in song period early in the season; as observed amongst birds in rape.

Catchpole (1976b) has suggested that sexual selection may have played an important role in the evolution of the extreme length and variability of sedge warbler song; an "acoustic Peacock's tail". Perhaps evolution is now also shaping the manner of song delivery, according to the habitat in which it is delivered?

The ultimate reason for rape males' greater song-flighting remains unclear, although it may relate to the need to acquire a mate quickly and initiate breeding as soon as possible in a habitat which, due to harvest, has a limited period in which this activity can occur. The immediate problem for the male is to draw attention to himself in a structurally uniform habitat; the solution, increased song-flighting. Birds do not appear to have difficulty in obtaining prey in rape crops (Bowey *in prep*) so rape is, one presumes, capable of meeting the energetic demands of birds adopting this strategy. If females were less numerous in rape than in other habitats males may also have to sing more to attract one. Although such an imbalance in the sexes might explain some of the gender-related anomalies in the tape luring data, observational work suggested that there was no apparent lack of females in rape. For example, at least 50% of all recognised territories in intensively studied fields were known to hold pairs of birds and the real figure would, in all likelihood, have been higher.

It would appear that, the race for a mate, amongst male sedge warblers in rape is adapted to habitat. In rape, breeding has to be accomplished quickly, to allow for successful fledging of young within the relatively, short window of opportunity prior to harvesting. Greater song synchronicity may also increase male competition for females, further increasing the need for song-flights. The structure of bird song has been shown to be correlated with habitat (Morton 1975, Hunter & Krebs 1979), it would appear that, for sedge warblers in rape, the manner of song delivery is also modified by habitat. A clear case can be made for the observed behaviour of singing males in rape being adaptive. Lacking perches to sing from, the most obvious males, i.e. those song-flighting, are quickest to attract mates and consequently maximise their potential to be, reproductively, more successful.

CHAPTER 7

Nesting Behaviour and Reproductive Success of Sedge Warblers in Rape Crops and Other Habitats, Gateshead 1995-1997

Introduction

In choosing a suitable nest site a female sedge warbler must balance a number of considerations: the nest needs secure anchorage; it should be high enough to be safe from ground predators yet, hidden by vegetation in order to be safe from aerial predators and nest parasites (Honza *et al.* 1998). Hence, females need a habitat with enough structural rigidity for nest anchorage, vegetation for cover and nest material available to maximise their chance of rearing young from that nest.

During mid-June to late July all known sedge warbler territories at Shibdon Pond and in rape were searched for the presence of breeding birds and nests (Bibby 1978, Harrison 1982, Hollom 1985). The principal aim was to obtain proof of breeding in rape and to compare breeding behaviour and reproductive success in the different habitats.

Methods

Areas containing nests with young were identified by observation of adults carrying food to suitable, dense vegetation. General nesting areas were located by a process of triangulation after noting adult behaviour and points of entry to vegetation. This was followed by a systematic hand search of the identified area. Nests were marked with a small (10 mm x 15 mm) white, paper flag on a stem of vegetation, one metre due east of the nest, to facilitate re-location and minimise the risk of damage through trampling. Nests and their contents were examined and documented, allowing breeding success of all nest found to be calculated and compared. First egg dates and laying periods were calculated retrospectively, for all nests discovered, using published criteria for ageing nestlings (Harrison 1980).

At the end of the breeding attempt, nests were removed, dissected and a range of details collected and measured. These included:

i) Identification (where possible) of nesting materials (Hubbard 1976, Clapham *et al.* 1989);

ii) Dried weight of nest. Nests were allowed to dry in a well ventilated, unheated area, for up to one week, until they reached a constant weight. They were then weighed using a zero'ed 50 g Pesola spring balance;

iii) Height of nest from substrate to base and lip of nest;

iv) The plants into/around which the nest was built and which formed the structural anchorage of the nest.

v) Height of vegetation in six territories, in which the earliest arriving females were recorded, in May 1997 at Shibdon. The highest vegetation was measured and overall cover estimated, from mean height (ten measured values) over a 10 by 10 m area.

All occupied nests were observed between "dawn plus one hour" and "dawn plus three hours", from concealed vantage points (a portable, net hide being used to aide observation and minimise disturbance) close enough to ensure accuracy of observation. The number of visits by parents, with food, to each nest was recorded over known time periods when nestlings were between 6 and 9 days old (British Trust for Ornithology 1984) and mean provisioning rates calculated from a minimum of three observation periods per nest. This was done for all nests in rape and a sample of three nests at Shibdon Pond, 1995-1996. In addition, all nestlings were rendered individually identifiable using a single bi-coloured plastic ring and a BTO metal ring. Only one colour-ring was used on pulli to minimise handling time and any impact of the presence of rings on adult behaviour and nestling survival.

Results

Success of sedge warblers nests in rape crops and traditional habitats

The first proof of successful breeding by sedge warblers in rape in Britain was obtained during 1995 (Bowey *in press*). On 20th June, a pair of sedge warblers were discovered feeding young in a nest in rape, at an altitude of *c.* 15m a.s.l. On 23rd, the nest was found, and the five nestlings were estimated to be four to five days old (Harrison 1982), the calculated hatching and first egg dates being, 18th June and 29th May respectively (see Table 38); one unhatched egg was present. Nestlings usually fledge after 13-14 days in the nest (Hollom 1985).

In 1996, on 1st July, a further sedge warbler nest was found in rape at Washingwells Farm, with another located in a nearby ditch, between two crops of rape, on 5th July; the male in this territory usually sang from the rape. Both nests successfully fledged young; three and five respectively. This latter instance was the only indication, during the three year study, that birds holding territory in rape may build nests outside the crop.

No unsuccessful nests were found in rape, but the dense nature of the habitat mitigates against this happening either by chance or as a result of systematic search. Successful nests were located only by watching adults carrying food. If nests failed before the nestling stage, there would be no such clues as to their location, hence they would be extremely unlikely to be found.

Data from local nests, at Shibdon Pond, 1995-1996, gave a mean clutch size of 4.6 (n=8, s=0.74) (Table 39). The 1995 data from Shibdon, gave a clutch size range of 4-6, median 5 (n=3, s=1).

Nesting success in relation to habitat

All monitored nests, 1995-1996, regardless of habitat, successfully fledged young. There was no significant difference in mean clutch size ($F=4.214, v_1\ 2\ v_2 7$, $p>0.05$; $t = 0.069$,

Table 38 - Calculated First Egg Dates at Sedge Warbler Nests, All Habitats, 1995-1996

Traditional habitats	First Egg Date
Nest 1	23rd May 1995
Nest 2	5th June 1995
Nest 3	26th May 1995
Nest 4	29th May 1996
Nest 5 *	8th July 1996
Nest 6	4th June 1996
Nest 7	6th June 1996
Nest 8	31st May 1996
Transitional**	
Nest T1	13th June 1996
Rape	
Nest 1	26th May 1995
Nest 2	9th June 1996

* The late date of this nest suggests that it may have referred to a replacement clutch or a second brood.

** Transitional - nest located in ditch, between two crops of rape

d.f. 9, p>0.05),or the mean production of fledged young from nests located in rape and those in traditional habitats (F=1.39,v_1 1 $v_2$7, p>0.05; t = 0, d.f. 9, p>0.05), although sample sizes were small (Table 40) .

All losses of young, in all nests studied, were incurred at the hatching stage, regardless of habitat. There was no loss of nestlings from any monitored nest, in any habitat, and the mean hatching and fledging rates at all nests were equivalent. This indicates that nest visits had similar effects on nests in all habitats, there being no discernibly deleterious impact on the success of monitored nests.

The mean dates, for registration of first fledged young, 1995-1997, were: 23rd June (n=3, s= 4) in traditional habitats and 6th July (n=2, s=4.242) in rape; a difference of 13 days (Table 41). Recently fledged young aré more difficult to observe in rape than traditional habitats and consequently these dates may include an observer bias, which would have the effect of making the data from rape appear later than those from traditional habitats. The earliest date for observation of fledged young over the three year period was 19th June (1997) at Shibdon Pond. The earliest fledged birds were observed in rape was 3rd July, 1995 (Table 41).

Nest construction in rape and traditional habitats

i) Nest dissection showed that nests in rape are constructed mainly from materials collected outside of the crop, although they contained some materials derived from within the crop. The bulk of nest materials comprised: fine grasses (largely *Festuca* and *Bromus*); unidentified plant stems; unidentified moss; and, spider webs, with some feathers and occasional other items such as pieces of paper and plastic (*cf.* Cramp 1992). Materials were usually collected in the vicinity of the nest site (pers. obs.) i.e. within 10m, in traditional habitats. The only plant growing in rape (excepting rape itself), recorded as being used in construction of rape nests was cleavers *Galium aparine*, but this occurred in only small amounts, in a single nest. Nests were anchored in a range of

Table 40 - Reproductive Success According to Nesting Habitat, 1995-1997

	Trad.	s	n	Rape pairs	s	n	Rape	s	n
Mean clutch size	4.625	0.744	8	4.667	1.528	3	4.5	2.121	2
Mean Nestlings hatchec	4	1.195	8	4.333	1.155	3	4	1.414	2
Mean Young fledged	4	1.195	8	4.333	1.155	3	4	1.414	2

Key:
'Trad.' - traditional habitats
'Rape pairs' - birds nesting in or around rape crops
'Rape' - birds nesting in the rape crop
s = standard deviation

Table 41 - First Observed Dates of Fledged Sedge Warbler Young (First Broods) 1995-1997

	Traditional Sites	No of. Broods	Rape Only	No of. Broods
1995	23/06	11	03/07	2
1996	27/06	10	09/07	1
1997	19/06	10	n/o	0
Mean '95-97	23/06		06/07	

Key:
n/o - no observations

Table 42a - Physical Details of Sedge Warbler Nests, Traditional Habitats, 1995-1996

	Height from Substrate to Rim (cm)	Base (cm)	Weight (g)	Plants	Anchorage
Nest 1	24.5	20	10.8	*Juncus effusus*	*Juncus effusus*
Nest 2	34	29	11.4	*Solidago canadensis*	*Solidago canadensis*
Nest 3	40	35.5	12.3	*Reynoutira japonica*	*Reynoutira japonica*
Nest 4	45	39.5	14.7	*Juncus effusus*	*Juncus effusus*
Nest 5	39.5	35	11.2	Rank grasses/herbage	*Glyceria maxima/Cirsium vulgaris*
Nest 6	22.5	17.5	9.9	*Solidago canadensis*	*Solidago canadensis*
Nest 7	33	28.5	13.9	*Solidago canadensis*	*Solidago canadensis*
Nest 8	24	19	12.1	Rank grasses/herbage	*Deschampsia cespitosa*

Table 42b - Physical Details of Sedge Warbler Nests, Rape Habitats, 1995-1996

	Height from Substrate to Rim (cm)	Base (cm)	Weight (g) Rape	Distance from Crop Edge (m) Total		Plants	Anchorage
Transitional							
Nest T1	33.4	28.5	0	11.3	2.5	Rank grasses Urtica diocia	*Rubus fruticosus*
Rape							
Nest 1	66	61	15.2 (38.4%)	39.6	11	*Brassica napus*	*Brassica napus*
Nest 2	67	61.5	17.9 (41.5%)	43.1	21	*Brassica napus*	*Brassica napus*

Key:
Plants - species of plant in which the nest was located
Anchorage - species of plant which formed the basal anchorage of the nest and around which it was built.
Weight (g) - of nest materials
Distance (m) - from edge of rape crop to nest location

plant species in traditional habitats but only rape was used for this purpose in rape crops (Table 42a & 42b).

ii) The mean, dry, weight of nests in rape was 41.4g (n=2, s=2.475), (Table 42b), that of nests in traditional habitats 12g (n=8, s=1.596). The mean dry weight of nest materials derived from the rape crop, for these nests was 40% (n=2), (Table 43); i.e. 60% of total weight of nest material for rape nests found was collected outside the crop. Hence, 24.8g (60% of mean weight of rape nests) of nest materials was collected outside the crop. So the mean weight of materials collected by rape nesting females outside the crop was about twice the total weight of materials collected by females in traditional habitats.

iii) Data relating to the height of nests above substrate, according to habitat, is summarised in Table 44. The mean height of nests in rape was 0.665 m (n = 2, range 66-67 cm, s=0.707) and in traditional habitats: 0.328 m (n = 8, range 24-45 cm, s=8.45). The difference between the mean height (substrate to rim) of nests in rape and traditional habitats was highly significant; F and t tests, $t = 15.58$, d.f. 8, $p<0.01$; the median height of nests in rape and traditional habitats was also significantly different, $U=0$, $p<0.05$, Mann-Whitney *U*-test.

iv) Nests, in traditional habitats, were found to be built, principally, in dense vegetation with a strong, three dimensional structure (cf. Thomas 1984, Cramp 1992). Apparently of importance to nest-building females was the presence of a firm structure to which the nest could be suspended or anchored (pers. obs.). Of eight nests located, 1995-1996, five were anchored on the lignified stems of the previous year's vegetation; two were located in evergreen species, e.g., rushes *Juncus spp.*; and, one was resting on a tussock of tufted hair-grass, *Deschampsia cespitosa* (see Table 42a). Nests in rape were built in similarly dense vegetation, the rape itself, but were even more difficult to locate than those in traditional habitats (pers. obs.). The nest found on 23rd June 1995, was only located in the crop after a prolonged period of observation and hand searching,

Table 43 - Mean Nest Weight (g), 1995-1996

	Traditional	n	s	Rape	n	s
Mean nest weight 1995	11.5	3	0.76	39.6	1	0
Mean nest weight 1996	12.36	5	1.96	43.1	1	0

Table 44 - Sedge Warbler Nest Height (cm) According to Habitat, 1995-1996

	Traditional habitats	Rape	Site Between Rape Crops
Mean height (substrate to base)	28	61.25	28.5
Range of heights, to base	17.5-39.5	61-61.5	n/a
s	8.4	0.354	n/a
Mean height (nest rim)	32.81	66.5	33.4
s	8.45	0.707	n/a
Range of heights, to rim	22.5-45	66-67	n/a
No. of nests	8	2	1

Key:
s - standard deviation
n/a - not applicable

amounting to over 6 hours of total search time. Rape plants formed the structural anchorage of both nests found in rape.

v) Height of vegetation (see Table 45). Although traditional territories often contained tall elements of vegetation, e.g. *Phragmites*, which provided song posts for males, the overall nature of vegetative cover was often patchy (pers. obs.), offering only variable cover for nest location. This has obvious negative implications for a prospecting females, limiting the number of suitable nest sites available to her. On arrival, prospecting females appear to be drawn to areas of vegetation with strong vertical structural features, usually comprising of vegetational elements retained from the previous year's growing season (pers. obs.), such as: reedbeds of *Phragmites australis*; docks *Rumex spp.*, rosebay willowherb *Chamenerion angustifolium* and, at Shibdon Pond, Canadian golden rod *Solidago canadensis* and Japanese knotgrass *Reynoutria japonica* (pers. obs.).

Do nestling provisioning rates differ in rape and traditional habitats?

Observed mean provisioning rates (visits with food/hour), of 6-9 day-old nestlings, by adults in rape and traditional habitats were, 11.65, s=0.685, and 10.48, s=2.211 respectively (Table 46). There was no significant difference between the observed median or mean provisioning rates of young in nests in either habitat; U=3, p>0.05, Mann-Whitney U-test; t = 0.636, d.f.4, p>0.05, t test.

Discussion

The documentation of nests in rape in 1995 and 1996, proved that sedge warblers breed in rape. Considering the utilisation of the rape crops by sedge warblers, across Britain (Bowey *submitted*) it is reasonable to assume that such breeding records are not isolated incidents but represent the normal use of rape by the species.

An analysis of nest record data (Bibby 1978) gave an average first egg date of 7-17th May for birds in traditional habitats. Five eggs is the usual clutch size in Britain (Bibby 1978); but this is greater further north, e.g. Finland (Raitasuo 1958).

The problems of finding a suitable location for nest-building are perhaps most marked for the female sedge warbler in traditional habitats in early May, where the greatest structural rigidity and vegetative cover are to be found low down. However, choosing such a location might expose a nest to later attack by a ground predator. If sound anchorage is available higher up, this is likely to be offset by a lack of cover. By contrast, females arriving in rape at this time find that the plant has already reached close to its maximum height (0.99-1.5 m, Table 27) and that it offers the complex, three-dimensional structure, important for nesting sedge warblers (Thomas 1984); as well as abundant vegetative cover for nest site location. Height of nest location varies from one foot to four or five feet above the ground, exceptionally 12 feet (Witherby *et al.* 1958). This study showed that the mean height of all nests was well within this range but that rape nests were located at greater heights than those in traditional habitats. Both nests found in rape were situated in the upper portion of the plant, well hidden by foliage and stabilised by an anchorage of rape stems and surrounding seed pods, in the lower portion of the flower raceme. However, the height at which nests are built may be a function of plant height and structure rather than a selection of height by the female sedge warbler, i.e. the most suitable part of the rape plant in which to build a nest, at the time of nest site selection, is at this height, rather than the observed height of nest location being the most favoured one at which to build a nest.

The selection of rape for nest-building by females, instead of traditional habitats, was well illustrated by observations made on 7th June 1996, at Birtley. A female, accompanied by a male, at 1127hrs, was collecting nest material amongst a bed of lignified rosebay willowherb, in a hedge bank between two rape crops. In this location there were ample stems, from the previous year for nest anchorage, however, the female chose to enter the adjacent rape, with materials, incorporate these into a nest, before returning to collect more material in the same locality (pers. obs.). The habitat in which the female was collecting nest materials is one in which the species has been observed to nest successfully locally (pers. obs.).

Oilseed rape offers sedge warblers a good solution to their nest siting dilemma, of stability of nest versus access to predators. The crop provides firm anchorage, dense leafy cover, at a greater height than that provided by traditional sites at the same stage of the growing season, when nest-building commences. Some studies of *Acrocephalus* spp. have suggested that vegetative density of nesting habitat may be an important factor influencing fledgling survival (Ille & Hoi 1995) and here, once again, rape may prove to be advantageous to the sedge warbler. Nests in rape were difficult to locate, primarily as a result of the uniformity and dense nature of the habitat; choosing to nest in effectively featureless habitats, away from trees and bushes, might reduce nest predation or cuckoldry (Oien *et al.* 1996) and birds nesting in less accessible places may have better breeding success (Nice 1957, Craighead & Stockstead 1961). In a study of 2000 nest record cards, ground predators were implicated in the failure of 30.4 % of sedge warbler nests to which a cause of failure was ascribed (Bibby 1978). Some studies suggest nest predation rates are lower in farm land than in woodland (O'Connor & Shrubb 1986) and others (Martin 1993) indicate that ground nesting species in scrub and grassland habitats suffer greater nest predation than those in open habitats. Hence, height of nest and the structure of the surrounding habitat may be of considerable importance to nesting sedge warblers. Nests in rape were built at relatively higher positions than traditional nests.

The response of rape-nesting adults to an unidentified ground predator was observed in 1996. Birds became alarmed and then, in concert, followed the predator through the crop, perching on the stems, contact and alarm-calling constantly; accompanied by agitated body movements and tail cocking (Mellor 1981). This behaviour was maintained for a period of some ten to twelve minutes until it was obvious that the birds had followed the predator from the immediate area of the nest. Similar behaviour has been noted in response to weasels *Mustela nivalis* in traditional habits (pers. obs.) and the observer elicited a similar response from a nesting pair whilst lying under rape, searching for a nest, at Washingwell, 1996. In this instance, the pair moved to within one metre of the intruder, alarm calling and mobbing (Campbell & Lack 1985).

There were many fewer observations of females collecting nest materials in traditional habitats than in rape (Table 47), no doubt as a result of the fact that it is easier for them to find materials closer to the nest in such habitats, without being observed. In such cases they do not have to fly long distances or to emerge from cover to find materials and are, therefore, less likely to be noted (pers. obs.). Birds in rape must break cover to collect materials outside of the crop. This strategy exposes them to a greater risk of predation, but such behaviour must also have energetic consequences for rape-nesting females. Inevitably, they make a greater number of material gathering journeys as they build a larger nest (Table 42a & 42b), and, in most circumstances, have to fly greater distances to collect nest material. Conceivably, females collect nest materials from other plants in the rape crop, though neither field observation, nest dissection or vegetation survey provided any evidence to support this possibility.

Rape-nesting females, like most *Acrocephalus* warblers, are solely responsible for nest construction (Collias & Collias 1984) and have to find much of their nest material outside of the crop. This was confirmed by field observations of females collecting nest material in hedge banks and uncultivated margins of rape fields and then entering the crops with them (Table 47). Average territory size of sedge warblers in traditional habitats has been calculated at 1072 m^2 (Thomas 1984) and 1811 m^2 (Catchpole 1972).

Table 47 - Observed Nest-building Forays by Sedge Warblers, According to Habitat, 1995-1997

	Oilseed Rape			
	Outside of Crop	Male in Attendance	Inside Crop	Male in Attendance
1995	5	5	0	0
1996	21	17	1	1
1997	7	7	1	1
Total	33	29	2	2

	Trad. Habitats			
	Outside of Territory	Male in Attendance	Inside Territory	Male in Attendance
1995	0	0	3	3
1996	0	0	10	8
1997	1	1	8	8
Total	1	1	21	19

NB. For the purpose of the study, a territory was defined as that area in which the male of the pair had been noted singing, was aggressively active against intruding birds and in which it was usually to be found (Campbell & Lack 1985, Alker & Redfern 1996).

Assuming that nests were located centrally within these, and that a female finds most of her nest materials within the territory, then the maximum distance a female would have to fly for such an activity would be between 18.47 m and 24 m; most forays would be considerably less than this. The mean distance from the crop edge for nests in rape, and therefore the minimum distance such females in rape were obliged to fly to find most of their nest material was 16 m (n=2). This is 66.67% of the maximum distance for an average female in Catchpole's (1972) study. From an admittedly small sample of rape nests, females appear to build larger nests, suggesting that rape-building females are likely to use more energy in constructing a nest than similar birds in traditional habitats. This, at a time in the reproductive cycle, when the additional weight of reproductive organs or developing eggs may materially increase the female's energetic costs of locomotion and she will be requiring considerable energy for egg production (Ricklefs 1974). Combined, this would suggest that nesting in rape might not be the most energetically efficient strategy for female sedge warblers, assuming that all rape-nesting birds build similarly sized nests - the motivating factors for such behaviour are, at present, obscure.

Bibby (1978), calculated that the overall success rate of sedge warbler nests was 56%. In the current study, all nests monitored produced young, regardless of habitat. The reproductive success achieved in the sample of rape nests (Table 40) however, indicates that, if the postulated increased energetic demands for females in rape are real, then this did not negatively impact upon their production of eggs or the subsequent fledging of young from rape nests. This, in turn, suggests that nesting in rape may somehow compensate for any extra energetic demands incurred by the female during nest-building. The costs may be overcome, as previously suggested, for singing males, by a greater abundance of energetically rich food. Alternatively, any such energetic debts incurred by females in rape during nest-building, may not be large enough to reduce her reproductive potential. Furthermore, it is conceivable that the use of rape may confer upon birds some other reproductive benefit not identified in this study. Such a benefit may not be

accrued directly by the individual but in terms of selective advantage, e.g. through an increased survival of the females' rape-reared offspring into subsequent generations.

Nest-building in rape may also have negative, energetic consequences for males, for, after pair bonding, the male spends considerable time accompanying the female; presumably guarding against extra pair copulations (Birkhead 1979); males in such situations expend much energy shadowing females (Ettinger & King 1980). If the male follows the female on most nest gathering forays, as observed, he too will be expending larger amounts of energy than a similar male in traditional habitats.

Sedge warblers, when feeding young, collect much prey outside their territorial boundaries (Lack 1946); this has been estimated to be as much as 82% of all items (Catchpole 1972). This was the case for birds at Shibdon Pond, which repeatedly foraged in rewarding pieces of habitat considerable distances from the nest, e.g. beds of water cress, *Nasturtium rorippa* (pers. obs.). Rape did not appear to produce such rich in prey hot-spots and birds dispersed from the nest in a scattered fashion, but often flew a considerable distance from the nest, into the rape, before returning with prey (pers. obs.). Birds feeding young in rape often dropped into the cover of the rape some distance from the nest and moved towards it under cover of the vegetation (pers. obs), contrary to some published accounts of adult behaviour at the nest (Simms 1985). As a result of this secrecy, calculated provisioning rates for rape (Table 46) may be less accurate than those for traditional habitats, where parental observation at the nest was more easily undertaken.

A number of factors might severely limit breeding success in rape, paramount amongst these is timing of harvest (Lack 1992). This activity, at the wrong stage of the nesting cycle - nestlings being extremely unlikely to survive the process of swathing - would determine breeding success or failure. This study, however, proves that crop management need not preclude the successful use of rape for nesting. Both rape crops in which nests were found during the study, and from which young successfully fledged,

had been treated with an application of pesticide during the nesting cycle. The Team Valley crop, 1995 (five young fledged), was treated, in the latter part of May, for flea beetles, this application occurring just prior to the incubation phase (first egg date for this nest, 29th May). The Washingwell crop, 1996 (three young fledged) was treated on 29/5/96 for pollen beetles, when the female would have been prospecting for nest sites if not already nest building (first egg date calculated as 9th June).

During territory selection there may be a difference, between sexes, in the selection criteria by which assessment of a suitable site and habitat is made within rape crops, i.e. there may be conflict between the sexes (see Krebs & Davies 1981). For instance, it may be advantageous for a female to minimise her energy requirements during nest construction, in order to maximise egg production from the available energy resources. In such a scenario, she might choose a territory with habitat edge (and therefore nest material) close to the chosen nest site. By contrast, males may prefer to hold territory in the best area for mate attraction and for feeding himself and potential offspring. This poses the question, should a female mate with a male without access to the crop edge? If she does, this might impact negatively upon the energetics of nest building, requiring her to fly further and also increase her risk of predation. On a number of occasions during this study, nest-building females, carrying nesting materials, were observed entering rape crops, accompanied by males, at considerable distances from the crop edge e.g. 40 m and more (pers. obs.).

CHAPTER 8

Conclusions and Closing Remarks, Sedge Warblers and Oilseed Rape

The increase in the area of rape grown in recent decades is only one of a suite of dramatic changes which have occurred in the British countryside, "perhaps the most apparent in visual terms....before 1973....cultivation of this crop was negligible" (Blunden & Curry 1985).

The rapid colonisation of oilseed rape over recent decades by sedge warblers is, without doubt, a significant development for this species. The present study has shown that the species is not only widespread in locally studied rape fields but, at intensively studied sites, it can occur at densities which are equivalent to, or not a great deal less than (i.e. 82.7%), the densities found at high quality traditional sites nearby. It is clear that the species is not merely a passage visitor to rape, but spends the whole breeding season in the crop. Successful breeding in rape was confirmed during the study, in 1995, when Britain's first sedge warbler nest in rape was discovered. Not only do sedge warblers nest in rape but they exhibit a very strong habitat fidelity towards the crop. In any given farmed area, birds follow rape around it, from field to field, between years. This suggests that returning birds, perhaps breeders from the previous year, or young hatched in local crops, may return to the same area, in subsequent years, to breed. Further colour-ringing studies should confirm this. In such a scenario, birds are more likely to find crops in a farmed area if the rape is grown within a relatively short distance of fields which birds had previously occupied. This was confirmed by an element of the study which showed that when the crop was changed to winter wheat, in fields which had held sedge warblers in rape the previous year, the fields attracted no sedge warblers. Although the nearest rape crops (*c.* 250 m) did attract birds. Sedge warblers are very highly selective of habitat in the agricultural landscape, rape being used, in this study, almost to the exclusion of any other habitat. It would seem that inter-crop distance, between years - which is largely dependant on crop rotation plan - is of prime influence

in determining sedge warbler presence in any chosen field of rape. As this inter-crop distance increases, the probability of rape occupation by sedge warblers decreases. By and large, sedge warblers in rape appear to behave in a similar manner to those in wetland and marginal habitats. Indeed, the highly complex, dense structure of rape is very reminiscent of the nature of the habitat-edge ecotypes, so frequently occupied by the species. Indeed, it may be that the vegetation structure, and its immediate availability to sedge warblers at the time they return to Britain in spring, is largely responsible for the species' adoption of the crop. Some differences in behaviour, of males in relation to the manner in which song is delivered in rape, and possibly in females, in the effort they invest in nest construction, were identified by the study. However, although the levels of activity undertaken by both males and females in rape suggest considerably higher energy expenditure by the individual birds than in traditional habitats, the breeding success of rape nests, relative to those monitored in traditional habitats, was unaffected.

Oilseed rape is often perceived as emblematic of the intensification of British agriculture since the Second World War, and the consequent loss of wildlife (Pye-Smith & Rose 1984). Yet, in many modern agricultural landscapes, in which hedgerows and associated flora have disappeared, the crop is now a significant nectar/pollen source for bees and other insects (Moore 1987, Bowey 1996). Clearly, it is also important for some bird species. Indeed, so abundant is rape in cultivation that, even in wild situations, it is now the commonest member of the *Cruciferae*, often being found along roadsides and field edges (Mabey 1996). The rate at which modern farming has changed is illustrated by the fact that, within a decade of being introduced as a modern crop, rape had grown to be the fourth most widely grown arable crop in Britain (O'Connor & Shrubb 1986). Such rapid change has, potentially, huge negative impacts for bird populations yet, it would appear, the sedge warbler may have been one of the first species to successfully adapt to this new habitat and benefit from the opportunities it presented.

The reasons for sedge warbler's original adoption of rape as a habitat remains unclear, but may relate to recent declines in wetland habitats (Ratcliffe 1977) and the coincident

increase in acreage of rape. Female sedge warblers might be attracted to rape because it fulfils many of their main requirements for nesting. It provides a dense habitat with a large degree of structural complexity, and large population densities of invertebrate prey (unpub. data).

It is conceivable that the habit of rape usage first developed because some males were excluded from optimal habitats by territorial interactions with fitter birds (Krebs 1971), i.e. the crop, being sub-optimal as a habitat, was acting as a refuge from territorial competition. Should space be available, young birds settle in optimal habitat, regardless of the habitat in which they were reared (Krebs & Perrins 1977). This would suggest that sedge warblers reared in rape, were it a sub-optimal habitat, might be expected to gravitate towards traditional habitats whenever possible. At present there is no evidence of where rape-reared sedge warblers subsequently breed, though this point might be clarified by further ringing studies. If the sub-optimal habitat scenario was true, one might anticipate reduced breeding success of birds in rape. However, the data available from the present study indicated that this was not the case.

Oilseed rape is a habitat widely utilised by sedge warblers (Bowey *submitted*), capable of supporting breeding birds. Furthermore, females were noted in a large proportion of established territories, so many males were apparently capable of attracting mates (Norman 1994). Comparing body condition data suggests that there is no discernible difference in these criteria between males in traditional and rape habitats. All of these facts indicate that rape is not a sub-optimal habitat for sedge warblers, or one that is used by poorer quality birds.

Sedge warbler males in traditional habitats exhibit a high degree of between year site fidelity, this has been confirmed by local ringing data (DRG 1988-1996). If birds bred in rape show a similar degree of habitat fidelity, and if they return to breed in rape near to where they were reared there would, presumably, be a tendency for the habit to spread across the huge area of potential rape habitat e.g. over 300,000 ha of rape in England

and Wales in 1995 (Anonymous/MAFF 1997), as it spread from its early 1970's base in the south of England.

If the reproductive output of birds in different habitats varies consistently with habitat, perhaps as a result of habitat quality or the individual fitness of birds using the habitat, it would be expected that this would have consequences for the population dynamics of a species (e.g. Holmes *et al.* 1996). Prior to this study it might have been postulated that rape was functioning as a sink (Pulliam & Danielson 1991) into which breeding sedge warblers disappeared, without any reproductive output for their efforts (Shrubb 1990). The results of the present study suggest that this is not the case for rape-utilising sedge warblers. The widespread nature of the habit and the fact that source populations, in traditional habitats (Pulliam 1988), are not necessarily located close to rape, may indicate the reverse. That rape is now an important breeding habitat for sedge warblers is indisputable and, in the Gateshead area at least, rape holds greater numbers of birds than do traditional habitats.

After late July, when winter sown rape is harvested, the habitat is no longer available to birds, although it is conceivable that spring sown rape could be used for feeding after this time. Such a loss of habitat need not be a difficulty for birds as, by this time in the season, many adults have already commenced migration. Similarly, such an abrupt loss of rape, as a result of harvest, will be less critical for sedge warblers than for a similar passerine species obliged to moult prior to migration, e.g. willow warbler, for the former does not undergo wing moult in Britain (Ginn & Melville 1983) - primary moult, in October-December, is co-ordinated with winter quarter rainy seasons (Aidley & Wilkinson 1987a). Hence there are no energetic conflicts, with regards energy partitioning in the post-breeding season, all energy reserves can be allocated to preparation for migration, as oppose to feather renewal.

Occasionally, observed changes in the monitored populations of some species have been ascribed to mass immigration (Summers-Smith 1989), however most population change

can be explained by other means (Greenwood *et al.* 1993). It would appear that the large scale use of unmonitored rape fields, by sedge warblers, occurred over the period 1970-1995 with relatively little documentation and almost unnoticed by ornithologists. If this was a relocation of birds from traditional habitats, might such a movement have contributed to the observed declines of the species at monitored sites in the 1980's (Peach *et al.* 1991) - regardless of the loss and degradation of traditional sedge warbler habitat across the United Kingdom (Blunden & Curry 1985)?

Traditionally, sedge warblers were considered birds of wetland and wetland margins (Parslow1973, Harrison 1988, Holloway 1996), recent ornithological literature (Baker 1997) and field guides (Gosler 1991b, Johnson 1992, Heinzel *et al.* 1995), continue to describe them thus, although there are increasing references to its use of rape (Perrins 1990, Gibbons *et al.* 1993). However, the actual extent to which the species uses the crop is still not yet fully appreciated by most observers.

Cereal farm land has been considered a poor habitat for song birds. Territory densities, for all species in this habitat being between 21 (Fuller 1984) and 28-38 pairs/km^2 (Shaw 1988). The equivalent figures for sedge warblers, from intensively studied rape sites in the present study, i.e. 77 territories/km^2, far exceed these. This indicates that arable land with oilseed rape is likely to hold considerably greater numbers of farm land birds than arable land generally, and many more than has been previously recognised.

Previously, the sedge warbler has been identified as one which was at risk (Batten *et al.* 1990, Gibbons *et al.* 1997), and it is a potential bird of conservation concern. Further loss of wetlands might seriously affect the species, hence, its utilisation of a widespread agricultural habitat is of potentially great interest in terms of its conservation. Future changes to the Common Agricultural Policy, were these to reduce the amount of oil-seed rape grown (Woods 1990), might also impact considerably on sedge warbler numbers.

SUMMARY

Sedge warblers were highly selective of habitat in the agricultural landscape; rape being used almost to the exclusion of any other. Birds were widely distributed in rape, in Gateshead 1995-1997, and showed a high degree of between-year habitat fidelity. They were recorded in rape in 19 of 55 tetrads and 67.9% (n=148) of all singing males found (n =218) were in rape. At intensively studied sites, birds set up territory in rape at a mean density of 0.77/ha, compared to 0.93/ha in high quality traditional habitats nearby.

Birds were proven to breed successfully in rape; a small number of monitored nests not differing in mean number of fledged young produced from those in traditional habitats. Nests in rape were, constructed, primarily, from materials collected outside the crop; a small sample indicated that these were heavier and positioned higher from the ground than nests in traditional habitats.

The principal environmental variable governing the presence of sedge warblers in rape crops appeared to be the distance between rape crops between years. The probability of occupation decreased as this distance increased and this distance was largely determined by the land manager's chosen crop rotation plan. The height of rape, which may influence crop structure, also appears to effect the likelihood of occupation by sedge warblers; at no time was a crop of less than 106 cm occupied.

Tape-luring revealed that males in rape were more difficult to catch than those in other habitats, the reasons for this, at present, remain unclear. Examination of body condition indicators of males, revealed no differences between birds in rape and traditional habitats.

An enquiry into song behaviour revealed that, in rape, males exhibit: higher rates of song-flighting; greater numbers of song flights; and, a greater synchronicity of song period than in traditional habitats. Song delivery is modified where the rape is influenced by the presence of higher perches.

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APPENDICES

Contents

APPENDIX 1

List of Landowners in Gateshead Allowing Access on to Land with Rape Crops for Purposes of Study 1995 to 1997

All addresses are located in Tyne & Wear unless stated.

Mr Armstrong	Sherburn Towers Farm, Rowlands Gill,
Messrs Askew	c/o West Grange Fm, Kibblesworth,
Mr Boon	North Farm, Urpeth, Chester le Street, Co. Durham
Messrs Bullerwell	c/o South Farm, Barlow, Blaydon upon Tyne
Mr Cheesborough	Heddon Haughs, Heddon on the Wall, Newcastle
Mr Lowrison	Stephens Hall Fm., Greenside, Ryton
Mr Marr	Old Ravensworth, Lamesley, Gateshead
Mr Oates	Trench Hall, Ravensworth Estate, Whickham
Mr Philipson	North Farm, Barlow, Rowlands Gill
Mr Quigley	Lintz Garth Farm, Burnopfield, Rowlands Gill
Mrs Wigham	Hollin Hill Farm, Rowlands Gill

APPENDIX 2

Questionnaire Circulated to all Landowners in Late 1995 to Determine the Methods of Crop Management

Rape Crop Questionnaire (Sedge Warblers in Rape).

This questionnaire is designed to provide me with details of the history and management of the crops in which I have been searching for Sedge Warblers during the summer of 1995. It has been designed to take as little of your time as is possible to fill in. If you do not have the information to answer any of the questions, an educated guess will suffice. If you cannot answer any particular question then do not worry, just fill in what you can. The information on the maps (especially regarding previous crops) is of particular importance to me.

If you have any comments or observations regarding my work, birds or other wildlife in the rape crops, which you feel may be of interest to me, feel free to add them to the comments section. If you would like to speak to me about any aspect of my study, feel free to give me a bell on (01207) 545427 home, or (01207) 545212 at Thornley Woodlands Centre, for a chat.

Your Name.

Address.

1) What type of rape do you grow (please tick)?

Winter.....

Spring.....

2) a. What variety of rape do you grow?.....

b. Are there any special features of this variety which made you choose it (e.g. low in glucosinolates)?.....

3) When did you sow the 1995 rape crop (approximately)?.....

4) When did you harvest the 1995 rape crop?.....

5) Did you artificially desiccate the crop before harvesting ? YES/NO

6) Was the crop "swathed" and left to dry naturally? YES/NO

7) How long did the crop "lie" before being collected?.....

8) Did you treat your rape crops for any pests in 1995? YES/NO

9) If answer to 7) is YES, for which pests (could you please indicate which ones - please tick - and the approximate time of application of any treatment?)

Date/Time of Year

Flea Beetle.....

Cabbage Aphid.....

Slugs.....

Weevil.....

Other (please specify).....

10) Could you indicate, on the map provided, all fields in which you grew rape during 1995, (please write **"95"** in the middle of each rape crop on the map - if you need more maps pleas contact me!)

11) Could you indicate what crop was in these fields, in which you grew rape during 1995, during the previous year i.e. in 1994, please mark the field with the symbol indicated in brackets?

Rape = (**R**), Set-aside = (**S**), Cereals = (**C**) - Winter Barley = (**WB**), Winter Wheat = (**WW**), Spring Cereal = (**SCW or SCB**), Other (please specify)

12) a. Did you have any rape crops, during 1994, in the vicinity (half of one kilometre radius) of the fields in which you grew rape during 1995?

YES/NO

b. If YES, where (please mark on map with **r94**) ?

13) For how many years have you grown rape in or around the area of your 1995 rape fields, as shown by you on the map? Please tick or indicate the approximate time, if you can say precisely please do so, in "other" section.

1-3 Years.....

3-5Years.....

More.....

First rotation.....

Other.....

12) Could you show, on the map (write **"96"** in the middle of the field, please), where you intend to grow oil-seed rape in 1996?

13) Would you be willing for me to undertake further survey work around your crops during 1996? YES/NO

14) Any Other Comments:

Once again, many thanks for your time in completing this questionnaire, the information provided is of enormous importance to my study.

Please return, in envelope provided, with the completed maps, to Keith Bowey: 3, Alloy Terrace, Highfield, Rowlands Gill, Tyne & Wear, NE39 2ND.

Telephone (01207) 545427 or (01207) 545212 at Thornley Woodlands Centre.

APPENDIX 3

Body Condition Data for all Male Sedge Warblers Caught, 1995-1997

The table summarizes all data referring to body size and condition of all sedge warblers trapped during the study period, 1995-1997.

Ring Number	Fat Score	Pec. Muscle	Wing mm	Weight g	Time of capture (BST)	Date	Habitat
J306793	2	2	68	11.1	08:15	04/05/95	Shibdon
F784454	2	2	68	11.6	20:40	05/05/95	Shibdon
J306646	0	2	68	10.7	07:00	21/05/95	Shibdon
K026655	0	1	68	11.8	07:05	21/05/95	Shibdon
K026660	0	2	68	11.5	07:05	21/05/95	Shibdon
J465703	1	1	66	10.8	14:30	26/05/95	Shibdon
J465706	0	2	68	11.2	15:25	16/06/95	Shibdon
Not ringed	0	0	68	?	16:07	06/07/95	Shibdon
J465757	3	1	68	12.1	14:45	03/05/97	Shibdon
J465758	2	1	66	11.3	09:35	11/05/97	Shibdon
J465761	2	1	70	11.8	09:15	15/05/97	Shibdon
J465764	1	2	65	11.2	15:20	31/05/97	Shibdon
J465765	1	1	66	11.3	16:19	31/05/97	Shibdon
K992372	0	1	67	11.3	09:40	22/06/97	Shibdon
J465726	1	1	67	10.7	08:47	03/05/97	Shibdon
J306786	1	1	67.5	11.8	?	15/05/97	Shibdon
J465702	0	2	68	11.6	07:15	24/05/95	Rape
J465704	3	2	68	12	17:30	26/05/95	Rape
J465705	0	1	67	11.2	09:15	04/06/95	Rape
J465759	2	2	69	11.5	05:30	13/05/97	Rape
J465760	0	1	68	11.4	05:15	15/05/97	Rape

APPENDIX 4

Descriptions of Habitats used by Sedge Warblers, Gateshead Borough 1995-1997

Habitat descriptions:

Wet fen: inundated ground with tall herbaceous plants e.g. *Glyceria maxima* and *Typha latifolia*.

Cereal crop: winter wheat.

Dry herbage with rank grassland: usually tall herbs e.g. *Chaemonerion angustifolium* with grasses such as *Deschampsia cespitosa*, *Arrhenatherum elatius* and *Dactylis glomerata*.

Scrub, with tall herbage: usually hawthorn *Crataegus monogyna* dominated scrub with tall herb communities often with large numbers of umbellifers.

Oilseed rape: *Brassica napus oleifera*.

Hawthorn hedge bank (i.e. hedge and associated flora): hawthorn *Crataegus monogyna* dominated linear scrub with associated species such as elder *Sambuca nigra*, bramble *Rubus fruticosa agg.* and rank grassland dominated by false oat grass *Arrhenatherum elatius*.

Willow scrub with fen/marsh: scrub dominated by *Salix* spp. with associated tall herb communities characteristic of inundated ground e.g. *Epilobium hirsutum* and *Juncus effusus*.

***Phragmites* reedbed with fen/marsh**: *Phragmites australis* mixtures of other tall fen and wetland herbs e.g. *Glyceria maxima*, *Typha latifolia*, *Epilobium hirsutum* and *Juncus effusus*.

APPENDIX 5

Location of Rape and Study Fields, Gateshead Borough, 1995-1997

The grid references of all 126 surveyed rape fields are listed against, field name and year of survey. All grid references refer to 100 km square "NZ" of the national grid. The location of all known rape in Gateshead is mapped according to tetrad, Figure A.

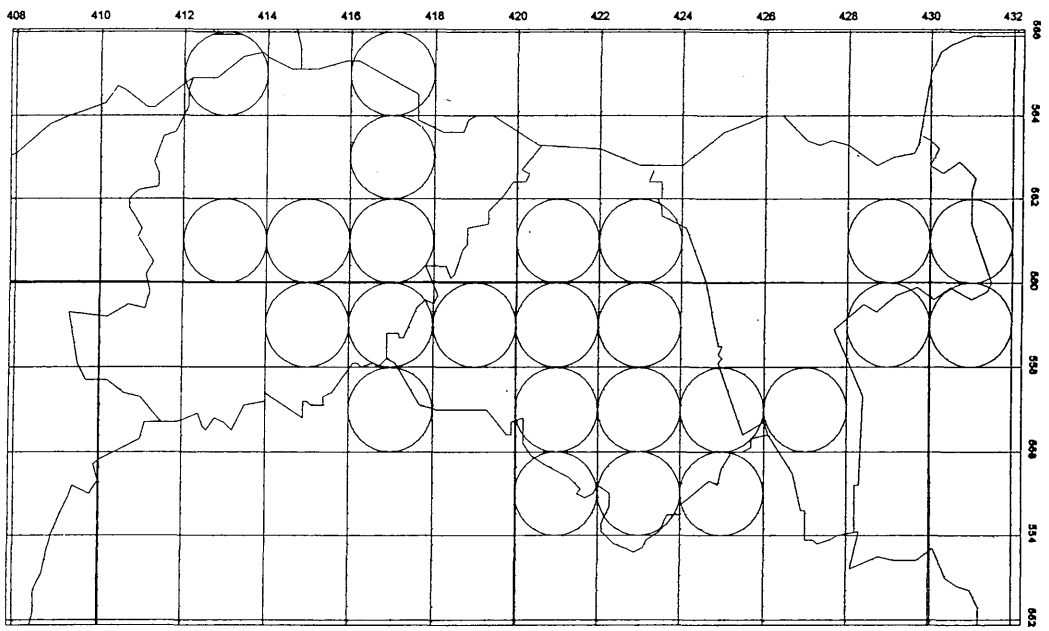
1995	Grid Ref
Cut Thorn 1	187583
2	186585
3	186583
4	183583
Pock Fm B. 1	227557
2	227555
3	228554
Birtley 1	277565
2	278564
Ravensworth	237587
Whinnel Hill 1	226567
2	227565
Kibblesworth	234567
Long Acre 1	266573
2	268574
3	270575
Barlow Fell 1	155604
2	158603
3	147598
Lead Rd. 1	133616
2	128612
3	134609
Sherburn Tow. 1	158598
2	163616
3	164620
4	164595
Marshal L. Fm.	214596
Thornley 1	175611
2	177613
3	176614
4	173613
5	172615
Barlow Lane 1	155604
2	158603
3	147598
W.Byremoor 1	182574
2	183575
3	184578
4	179575
5	179574
Team Vall. 1	257565
2	258566
3	257568
4	257571
5	254570
Stella 1	167638
2	165639
3	166641
Leam Lane 1	298604
2	296603

1996	Grid Ref
Clara Vale	128647
Washingwells 1	220604
2	222606
3	222604
4	225604
Fellside Rd 1	185578
2	185582
3	191584
Lead Rd 4	134615
5	132612
6	131611
Norman's Riding	164613
Brockwell	160617
Hollinhill Lane 1	163601
2	163598
3	166599
Barlow Village	155606
Barlow Fell W.	151602
Barlow Fell Asht.	157602
Barlow Fell Thorn	160601
Warren's Haugh	171587
Gibs. Orangery	173586
Gibside 1	178586
2	176584
3	174583
T.V. Moor Mill L.	253567
Team Valley 6	256571
7	255573
Uplands House 1	276561
2	278563
3	280564
Kibblesworth HH	238572
Kibbles. Cooper	236559
Kib. Grange 1	234562
2	232562
Riding Lane 1	243553
2	242550
3	238548
Bog Hill	233546
Ravensworth Park	233587
Spen Banks	156593
Ryton Westf. 1	146647
2	145646
3	146645
Leam Lane 3	299603
4	300598
5	295602
6	293599
Watergate	217605

1997	Grid Ref.
Washingwells 5	217605
6	215604
7	217601
Bucks Hill 1	213602
2	214601
Broom Lane 1	211602
2	209601
Whaggs Lane	210600
Low Thornley 1	173603
2	171602
3	169603
4	168602
Hollinhill Lane 4	166600
5	167601
Barlow Fell 4	154602
Barlow Fell Reservoir	152600
Barlow Fell, South FM	157608
Barlow Fell, Plantation	161605
T.V. Moor Mill L 2.	253568
Team Valley 5	255569
Whinnel Hill 3	230565
Kibblesworth HH 2	240570
Kibblesworth 2	233566
Winlaton Care Village	168612
2	169612
3	171612
Fellside 4	189584

Figure A - Distribution of Rape, by Tetrad, Gateshead Borough 1995-1997

Symbol: Tetrads
Key:
○ Rape



Grid figures refer to the 100km and 1km grid reference codes of the National Grid

APPENDIX 6

Habitat Types Abutting Rape Fields, 1995-1997

All habitats prefixed "W" are defined by Rodwell (1991), as part of the National Vegetational Classification.

W21: *Crataegus monogyna-Hedera helix* scrub;

W24: *Rubus fruticosa- Holcus lanatus* under-scrub;

W23: *Ulex europaeus-Rubus fruticosa* scrub;

W16: *Quercus spp.-Betula spp.-Deschampsia flexuosa* woodland;

Plantation: plantation woodland, broad-leaved or coniferous;

Agricultural: agricultural fields without hedged boundaries, arable or pasture;

Urban: built-up habitats, sometimes with gardens.

APPENDIX 7

Oilseed Rape and Landscape in Gateshead 1995-1997

During 1995-1997, 179 fields of winter rape were recorded in Gateshead (see Table i). Of these, 126 were surveyed for sedge warblers, 117 during the extensive survey and nine, intensively, see Table ii). All surveyed fields of rape were situated at between 15 m and 195 m a.s.l. (rape occupation by sedge warblers, in relation to altitude, is dealt with in Chapter 3). The total area of winter rape grown in Gateshead borough over the study period was 1000.06 ha (Table i); mean, 333.35 ha/annum (n=3, range: 274.3-385.42 ha, s= 78.574).

Table i) Number of Fields and Area (ha) of Oilseed Rape (Winter/Spring) Grown in Gateshead 1995 - 1997

		Winter Sown Rape			Spring Sown Rape				
	Total	Area	Number Surveyed	Percentage Surveyed	Total	Area	Number Surveyed	Percentage Surveyed	Total Area
1995	61	385.42	50	82	4	47.5	1	25	432.92
1996	54	274.3	49	90.7	0	0	0	0	274.3
1997	64	340.34	27	42.2	2	9.2	0	0	349.54
Total	179	1000.06	126	70.4	6	56.7	1	16.7	1056.76

The mean size of winter rape crops was 5.75 ha (n=179, s=3.86), but field size varied considerably; mean size of surveyed rape fields was 5.46 ha (n=126, range 0.7-23.47 ha, s=3.63).

Table ii) Intensity of Survey of Winter Sown Rape Crops in Gateshead, 1995 - 1997.

	Rape Crops Present				Surveyed Crops			
	Area (ha)	No. of crops	Mean Size	*s*	Area (ha)	No. of Fields	Mean Size	*s*
1995	385.42	61	6.32	3.94	299.65	50	5.99	4.13
1996	274.30	54	5.08	3.59	258.47	49	5.27	3.71
1997	340.34	64	5.77	3.99	129.61	27	4.80	2.19
Total	1000.06	179	n/a	n/a	687.73	126	n/a	n/a

Key: n/a - not applicable, *s* = standard deviation

The total area of winter sown rape occupied by sedge warblers during 1995-1997, was 457.4 ha (Table iii); an annual mean of 152.42 ha (n= 3, s=32.95).

Table iii) Percentage Occupation, by Sedge Warblers of Surveyed Rape Fields, by Area (ha) and Number of Fields, Gateshead Borough, 1995-1997

	Area (ha)	% by area of crops	% area of surveyed fields
Occupied	457.4	45.50%	65.45%
Unoccupied	230.33	24.00%	34.55%
Unsurveyed	312.33	30.50%	n/a

Table iii) summarizes the relative areas of oilseed rape, surveyed, occupied and unoccupied by sedge warblers 1995-1997.

Table iv) Percentage Occupation of Surveyed Rape Fields by Sedge Warblers in Gateshead Borough, Year by Year - 1995-1997

Surveyed rape fields 1995-1997, n=126

	1995	1996	1997	Mean
% of surveyed fields occupied	48%	55.10%	81.50%	**57.90%**

APPENDIX 8

Vascular Plant Species Found Growing in Rape Fields, Gateshead Borough 1995-1997

The following is a list of all vascular plants (34 species) identified as growing in rape crops, in Gateshead borough during the present study.

Galium arvense	cleavers
Capsella bursa-pastoris	shepherd's purse
Stellaria media	chickweed
Tripleurospermum maritimum	scentless mayweed
Senecio vulgaris	groundsel
Fumaria officinalis	common fumitory
Veronica persica	field speedwell
Sinapsis arvensis	charlock
Sisymbrium officianle	hedge mustard
Rorippa sylvestris	creeping yellow-cress
Euphorbia helioscopia	sun-spurge
Viola tricolor	wild pansy
Lamium purpureum	red-dead nettle
Myosotis arvensis	field forget-me-not
Matricaria matricarioides	pineapple weed
Lamium alba	white dead-nettle
Galeopsis tetrahit	hemp nettle
Cirsium arvense	creeping thistle
Cirsium vulgare	spear thistle
Anchusa arvensis	bugloss
Antthriscus sylvestris	cow parsley
Heracleum sphondylyum	hogweed

Sonchus oleraceus	smooth sow-thistle
Sonchus asper	prickly sow-thistle
Chenopdium alba	fat-hen
Gernaium dissectum	cut-leaved cranesbill
Corydalis claviculata	climbing corydalis (invading from nearby woodland)
Papaver rhoeas	poppy
Poa annua	annual meadow grass
Agropyron (Elymus) repens	common couch (twitch grass)
Avena fatua	wild oats
Hordeum murinum	wall barley
Hordeum vulgare	barley
Triticum aestivum	wheat

APPENDIX 9

Sedge Warbler Song Activity According to Seven-day Date Period, 1996 and 1997

Tables iv) and v) summarise the recorded song activity of sedge warblers through the breeding season, in all habitats, during 1996 and 1997 respectively.

Table iv) Song Activity According to Seven-day Date Period, 1996

Date Period	Trad. Habitat		Rape		All Song Incidents	
22 Ap	11	2.52%	0	0	11	0.78%
29 Ap	24	5.49%	2	0.21%	26	1.85%
06 My	25	5.72%	1	0.10%	26	1.85%
13 My	28	6.41%	122	12.63%	150	10.69%
20 My	48	10.98%	115	11.90%	163	11.62%
27 My	37	8.47%	253	26.19%	290	20.67%
03 Jn	90	20.59%	291	30.12%	381	27.16%
10 Jn	41	9.38%	56	5.80%	97	6.91%
17 Jn	40	9.15%	19	1.97%	59	4.21%
24 Jn	40	11.21%	102	10.56%	151	10.76%
01 Jl	23	5.26%	5	0.52%	28	2%
08 Jl	12	2.75%	0	0	12	0.86%
15 Jl	8	1.83%	0	0	8	0.57%
22 Jl	0	0	0	0	0	0
29Jl	0	0	0	0	0	0
August	1	0.23%	0	0	1	0.07%
Total	436		966		1403	

Table v) Song Activity According to Seven-day Date Period, 1997

Date Period	Trad. Habitat		Rape		All song Incidents	
21 Ap	0		0		0	
28 Ap	227	16.52%	0		227	12.93%
05 My	166	12.08%	17	4.46%	183	10.42%
12 My	238	17.32%	154	40.42%	392	22.37%
19 My	77	5.60%	91	23.88%	168	9.57%
26 My	159	11.57%	1	0.26%	160	9.12%
02 Jn	222	16.16%	110	28.87%	332	18.92%
09 Jn	123	8.95%	8	2.10%	131	7.46%
16 Jn	62	4.51%	n/o		62	3.53%
23 Jn	16	1.16%	n/o		16	0.91%
30 Jn	63	4.59%	n/o		63	3.59%
7Jl	21	1.53%	n/o		21	1.19%
14 Jl	n/o		n/o		n/o	
21 Jl	n/o		n/o		n/o	
28 Jl	n/o		n/o		n/o	
Total	1374		381		1755	

Key: n/o - no observations