Barn Swallows and agriculture

Karl L. Evans and Robert A. Robinson

Rosemary Watts/Powell

ABSTRACT Much concern has been expressed recently regarding the population status of Barn Swallows *Hirundo rustica* in Europe. Analyses of long-term population datasets suggest that the UK Barn Swallow population has probably increased slightly in recent decades, but this overall picture masks regional variation. Long-term declines in eastern England may have occurred in response to the loss of preferred foraging habitat, i.e. grazed grassland. More local declines have occurred in other regions, probably in response to localised habitat changes and nest-site loss. Local, and perhaps also national, declines have taken place in other European countries as well. The loss of foraging habitats and nest-sites has been implicated in these trends. Although factors operating on the African wintering grounds may also have contributed to reduced population levels, evidence for this is limited.

Long-term monitoring schemes have revealed significant changes in the population and range sizes of many British birds. Species which occur on farmland have shown some of the most dramatic declines, and formerly abundant species such as Common Starling *Sturnus vulgaris* and House Sparrow *Passer domesticus* are now on the 'Red List' of Birds of Conservation Concern, alongside much rarer species such as Capercaillie *Tetrao urogallus* and Cirl Bunting *Emberiza cirlus* (Gregory *et al.* 2002). This would have been considered highly unlikely 50 years ago.

In continental Europe, similar declines in bird populations have occurred and, at the level of individual countries, these are correlated

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123. Barn Swallow *Hirundo rustica*.

with the extent of agricultural intensification (Tucker & Heath 1994; Donald *et al.* 2001a). Autoecological studies have identified particular changes in farming practices which have probably caused certain species to decline (Aebischer *et al.* 2000), including Corn Crake *Crex crex* (mechanised and earlier mowing), Sky Lark *Alauda arvensis* (loss of mixed farming and spring cereals), and Cirl Bunting *Emberiza cirlus* (loss of stubble fields and extensive pasture). Research has demonstrated that agricultural intensification is a pre-eminent cause of population declines but also that measures can be undertaken to reverse these declines, at least for some species. Research has also raised public awareness and concern, which, together with pressure from conservation organisations, has strongly influenced the UK Government's decision to use an index of bird populations as a measure of the quality of life and to pledge to reverse declines in farmland birds by 2020 (Anon. 1999).

Applied farmland bird research initially focused on arable systems and their associated species, and results suggested that reduced food supply, primarily grain and weed seeds, was a major causal factor of population declines (Donald *et al.* 2001b; Robinson & Sutherland 2002). As adults, species such as Yellowhammer *E. citrinella* and Corn Bunting *E. calandra* have exclusively seed-based diets, but nestlings require an invertebrate-rich diet, and it was suggested that decreasing invertebrate abundance in farmland habitats was also important. A loss of invertebrates may lead to bird population declines either because fewer offspring can be raised or because adult mortality increases, both of which reflect a trade-off between reproductive investment and survival. There is good evidence that reduced availability of invertebrate chick food has contributed to population declines in the Grey Partridge *Perdix perdix* (Potts 1986), and mounting evidence that many species have lower breeding success as a consequence of agro-chemicals reducing, albeit often temporarily, invertebrate abundance (Brickle *et al.* 2000; Morris *et al.* 2002).

The Barn Swallow *Hirundo rustica* breeds widely throughout the Holarctic and Palearctic regions and is often colonial (Turner 1994). Over 100 pairs have been recorded nesting in the same building, though most colonies are much smaller and solitary pairs are not unusual. The species formerly bred in caves and possibly tree holes, but now most pairs nest in man-made structures. Stone buildings and those which house livestock appear to be favoured. The species is entirely insectivorous and all but the

most southerly of Palearctic breeding populations migrate southwards to spend the winter in sub-Saharan Africa. The species' behavioural ecology has been well studied (e.g. Møller 1994), its popularity as a study species reflecting a tolerance of disturbance at the nest and the ease with which nests can be found. Such traits, together with the Barn Swallow's insectivorous diet and anecdotal evidence for population declines, also render it a highly suitable species for study when investigating how agricultural intensification affects insectivorous farmland birds. Public empathy for the species, due in part to its association with summer, also generates the potential to use the Barn Swallow as a flagship species for farmland bird conservation. Recently, applied ecological research has been directed at describing Barn Swallow population trends and discovering the reasons for change. In this paper we summarise the results of this effort, focusing predominantly on the European breeding grounds, particularly the UK. We first summarise the evidence for population change and then discuss potential causes. Although we focus on the breeding grounds, we also assess whether changing conditions in the African winter quarters may influence population dynamics.

Fig 1. Spatial variation in Barn Swallow *Hirundo rustica* population density in the UK, derived from 2002 Breeding Bird Survey (BBS) data. Darker shades indicate areas where higher densities of Barn Swallows were recorded on BBS squares.

British status

Distribution

The Barn Swallow is one of Britain's most widely distributed species, with breeding recorded in over 90% of 10-km squares (Gibbons *et al.* 1993). Although common over much of the UK, only small numbers occur in the highlands and islands of Scotland, other upland areas, and in large cities. At a national scale its distribution changed little between the late 1960s and the late 1980s, although it gained a stronger foothold on some of the more remote Scottish islands during this period (Sharrock 1976; Gibbons *et al.* 1993).

More recent data on spatial variation in abundance are obtainable from the BTO/JNCC/RSPB Breeding Bird Survey (BBS). Counts, made in distance bands along line transects, from 2,200 sample squares, can be interpolated to produce indices of relative abundance across the country (Newson & Noble 2003). These confirm that Barn Swallows are still widely distributed across the UK, and that the overall pattern of abundance has not changed markedly since the late 1980s, though densities are currently rather low in parts of southeast England (fig. 1).

Population trends: results from the Breeding Bird Survey and Common Birds Census

On an historical timescale, Barn Swallow populations throughout Europe have probably increased dramatically since humans began to alter the landscape. Forest clearance would have increased the availability of the open habitats which swallows prefer for foraging, and buildings would have provided additional nest-sites.

The Common Birds Census (CBC) monitored British bird populations in farmland and woodland habitats from 1964 to 2000 (fig. 2; Marchant *et al.* 1990). The CBC index for Barn Swallow is quite variable, at least when compared with indices for other passerines of a similar size (Baillie *et al.* 2002). Such variability may obscure a long-term population trend, although there is no convincing evidence for a decline of the UK population as a whole since the mid 1960s. This overall pattern, however, conceals regional differences; populations in eastern England have declined markedly, whereas those in the west of Britain have tended to increase (Robinson *et al.* 2003). Furthermore, population indices tended to increase for mixed-farm plots, whereas populations did not

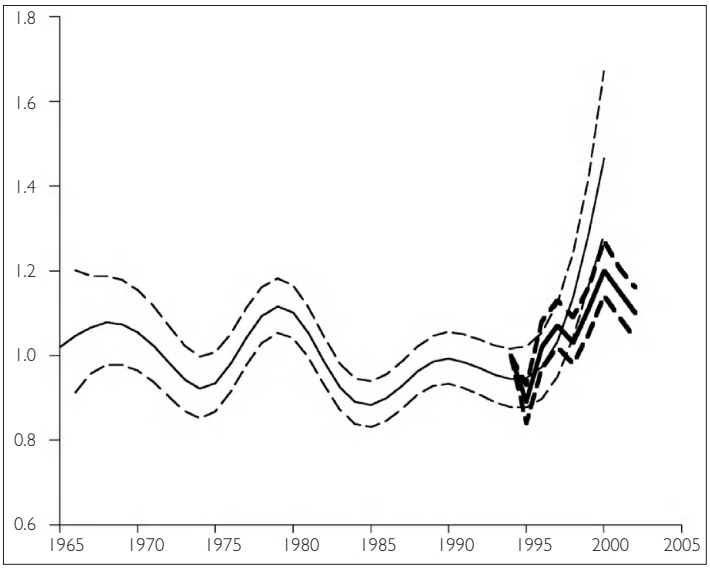

Fig. 2. Trends in UK Barn Swallow *Hirundo rustica* populations, from Common Birds Census plots (1965-2000, grey lines) and Breeding Bird Survey squares (1994-2002, bold black lines). Dashed lines indicate 95% confidence limits.

change significantly on farms which were predominantly either arable or pastoral.

Although the CBC produced highly detailed and valuable data on bird abundance, it suffered from two main drawbacks as a national population monitoring tool. First, survey sites were not located randomly and the scheme did not monitor upland populations well, although the results were representative of much of lowland England (Marchant *et al.* 1990). Second, survey effort was intensive, requiring ten visits each year, which limited the number of sites covered. In addition to these general drawbacks, other factors cast doubt on the CBC's ability to monitor the national Barn Swallow population accurately. Colonies in towns and villages were poorly covered, though analyses show that trends do not differ on sites with human habitation from those without (Robinson unpubl.). Furthermore, because Barn Swallows nest colonially, defending territories of just a few square metres around their nest (Møller 1994), the territory-based mapping technique of the CBC was not ideal for this species. Nevertheless, the trends from plots in which birds were recorded as present, compared with those on which actual nests were counted, do not differ (Robinson *et al.* 2003).

The BBS was introduced in 1994 to overcome these problems, with a survey design requiring just two visits to a randomly chosen 1-km square per year (with an additional visit to record habitat details; Raven *et al.* 2003). This allows many more volunteers to participate, and over 2,000 squares are now surveyed each year. BBS data demonstrate that, between 1994 and 2002, Barn Swallow populations showed a statistically significant increase of 10% over the UK as a whole. The national pattern, however, hides much regional variation. Populations in the west of Britain have increased significantly, those in the north have shown no overall change, and those in the south and east have tended to decline (table 1). These patterns closely resemble those shown by the CBC indices over a longer time period.

Trends in local populations are also quite variable. Forty-seven CBC plots have been surveyed in at least 20 years since the inception of the scheme in 1964, and the indices for these show that swallow numbers declined significantly on 11 plots, increased significantly on eight, but that there was no significant change on the remaining 28 (Robinson unpubl.).

Other surveys

Eight English sites at which breeding Barn Swallow numbers had been recorded previously, mostly from the 1960s or 1970s, have recently been resurveyed (Evans *et al.* 2003c; table 2). Each site was relatively large, at least 8 km^2, and thus observed population changes were unlikely to reflect local redistribution of birds, as between-year fidelity to a local area is high. Population counts were achieved by surveying all potential nest-sites and counting the number of pairs directly, either through ringing studies or by counting the number of active nests, defined as those which were being prepared for egg-laying or contained eggs/chicks. Numbers increased at four sites, but decreased at the remaining four sites; there was some evidence that populations were increasing in the north and west but declining elsewhere.

European population trends

Declines in Barn Swallow populations have been reported across much of Europe (Tucker & Heath 1994). In general, the largest declines have been in northwest Europe, while populations in many eastern European countries appear to have remained stable, or are fluctuating with no overall trend. There is great uncertainty about the accuracy of information from many countries, however, since it is frequently based on expert opinion rather than derived from extensive, long-term monitoring schemes. There is also strong evidence for marked regional variation in population trends within some countries, particularly in northwest Europe. In the future, population and demographic data on swallows should be much improved as a consequence of the work of the EURING Barn Swallow project, initiated in 1997, the aims of which include monitoring the size and breeding performance of Barn Swallow populations across Europe.

In Denmark, the national point-count survey shows a long-term decline in numbers and many localised surveys also reveal decreases, some of which are particularly marked (Thellesen 2000). In Switzerland, annual national surveys between 1983 and 1998 suggested that Barn Swallow populations declined by approximately 75% (Schmid *et al.* 2001), and although this trend is not statistically significant, intensive localised surveys show that significant declines occurred in areas such as Lake Constance and Zurich (Bauer & Heine 1992; Böhning-Gaese & Bauer 1996; Weggler & Widmer 2000). Local data from southern Finland suggest a decline of about 80% between 1936 and 1984 (Tiainen *et al.* 1985), although annual transect surveys between 1978 and 1995 suggest that the population is now stable, albeit with large fluctuations (Väisänen *et al.* 1998). Long-term declines have

Table 1. Regional variation in Barn Swallow *Hirundo rustica* population trends in the UK, 1994-2002, revealed by the Breeding Bird Survey. Figures marked with an asterisk are statistically significant (P<0.05); data from Raven *et al.* (2003).

	% change	lower 95% confidence interval	upper 95% confidence interval
UK	+10.1*	+4.0	+16.0
Scotland	-5.1	-20.0	+13.0
Wales	+39.0*	+16.0	+66.0
Northern Ireland	+12.5	-18.0	+55.0
England	+9.0*	+3.0	+16.0
Northwest	+3.5	-11.0	+20.0
Northeast	+20.3	-6.0	+54.0
Yorkshire	+23.1	0	+52.0
East Midlands	-5.0	-23.0	+17.0
East	-25.6*	-36.0	-13.0
West Midlands	+8.9	-10.0	+32.0
Southeast	-9.9	-23.0	+5.0
Southwest	+41.9*	+24.0	+62.0

Table 2. Long-term Barn Swallow *Hirundo rustica* population trends at eight sites that were recensused between 1998 and 2000. Data from Evans *et al.* (2003c). 'Population' indicates estimated number of pairs.

site	county	baseline year	baseline population	resurvey year	resurvey population	population index
South Brewham	Somerset	1967	25	1999	59	2.36
Healy	Northumbria	1968	30	2000	60	2.00
Sedberg	Cumbria	1964	133	1998	181	1.36
Stanford	Norfolk	1977	138	2000	171	1.24
Blithfield	Staffordshire	1964	74	1999	59	0.80
Didcot	Oxfordshire	1975	74	1999	27	0.36
Holbeach	Lincolnshire	1981	28	1999	5	0.18
Berney Arms	Norfolk	1964	64	1999	9	0.14

also been reported in the French Alps (Archaux 2002) and from German villages and rural areas (Jeromin 1999; Berthold 2003). We are aware of only one European study reporting a stable population, that along the lower River Dyje in the Czech Republic (Hubalek-Zdenek 1997), and no studies which report increasing populations, although this may partly reflect a publication bias towards studies reporting declines.

Agricultural intensification – a driver of population change?

In the UK, one of the most obvious effects of agricultural intensification has been the polarisation of arable and pastoral farming systems (Robinson & Sutherland 2002). Prior to the 1960s, most farms were obliged to employ a mixed system, as crop production required manure from livestock, while grain was partly used to feed livestock during the winter. The advent of synthetic fertilisers and pesticides enabled farmers in drier eastern regions to specialise in the production of more profitable arable crops. Conversely, farmers in upland and western regions of the UK, with soil types less suitable for cultivation, concentrated on rearing livestock. A major implication of such polarisation has been the loss of habitat heterogeneity, both within farms and at a larger scale, which has had detrimental effects on many bird species (Benton *et al.* 2003).

A wealth of evidence suggests that Barn Swallows benefit from livestock production. First, the species prefers to nest in buildings which contain livestock (Møller 1983). Second, foraging birds prefer grassland, particularly grazed grass, to arable land, probably as a consequence of the diverse and abundant aerial invertebrate fauna associated with grazed grass (Evans 2001; Ambrosini *et al.* 2002). Any agricultural developments that reduce the availability of grazed grass, such as housing cattle indoors for longer periods, may lead to local population declines. Third, the cessation of livestock farming at a farm scale has been shown to cause Barn Swallow populations to decline, largely as a consequence of lower recruitment of young birds into the breeding population, but also because of decreases in breeding success (Møller 2001). In eastern parts of the UK, it is likely that the loss of livestock farming and grazed grassland has caused Barn Swallow populations to decline. Higher densities in western and northern parts of the UK (Robinson *et al.* 2003) may, however, reflect a simultaneous increase in the acreage of pasture in these areas, which could have more than compensated for declines in the east, and generated the apparent overall increase in the total UK population. Although other factors are also relevant for explaining swallow population trends, changes in the extent of grazed grassland appears to be the single most important one and, looking at Europe as a whole, it is clear that dramatic changes are likely to occur in eastern Europe as a consequence of the expansion of the EU and subsequent promotion of western-style intensive agriculture.

Karl Evans

124. Traditional farm buildings, especially ones with livestock, are a particular favourite for nesting Barn Swallows *Hirundo rustica*. The piles of droppings under a nest-site in the roof (as shown here) can provide a good clue to what stage the nesting attempt is at.

Other aspects of intensification may also have influenced Barn Swallow populations. In poor weather, foraging Barn Swallows increase their use of vegetated field boundaries, owing to the increased availability of prey relative to field centres during such conditions (Evans *et al.*

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125. Farm ponds provide easy access to mud for nest-building and are also an important source of food during inclement weather; their loss is one aspect of farm modernisation which has been detrimental to Barn Swallows *Hirundo rustica*.

2003a). Changes in farming practice have led to widespread loss of hedgerows and although this situation is slowly being improved, there are still significantly fewer hedgerows than in the past (Haines-Young *et al.* 2000). In addition, the location and type of hedgerows will have changed. Most new hedgerow planting is now along roads, and structural and floristic diversity are much lower here than in mature, established hedgerows, which in turn affects their insect communities. It appears likely that such habitat modification will have reduced the ability of farmland to sustain Barn Swallows during prolonged periods of adverse weather, perhaps particularly so in eastern England, where hedgerow loss has been most severe (Evans *et al.* 2003a). Similarly, farm ponds, which formerly provided high-quality foraging habitat, particularly during inclement weather, are now rare in the modern agricultural landscape.

There is growing evidence that farmland invertebrate populations are declining and that this is linked to intensification (Wilson *et al.* 1999; Benton *et al.* 2002). Although it is difficult to identify the particular aspects of intensification causing these declines, and no single factor is likely to be solely responsible, important candidates include loss of marginal habitats and weedy plants, increased mowing and cutting of grass, and increased use of agricultural chemicals (Donald 1998; Wilson *et al.* 1999; Vickery *et al.* 2001).

Applications of agro-chemicals during the breeding season reduce invertebrate abundance and cause some birds to shift their feeding territories (Brickle *et al.* 2000; Morris 2002). Barn Swallows feed on aerial invertebrates, which have great dispersal powers and are thus likely to recolonise sprayed fields rapidly; swallows also prefer to forage over grazed fields (Ambrosini 2002), which receive fewer chemical applications than arable ones. This may explain why studies have failed to detect a negative short-term response to chemical applications in Barn Swallows, despite other species exhibiting such responses (Morris 2002). Increased use of agro-chemicals is likely, however, to contribute to a general reduction of invertebrates, which may reduce the ability of farmland to support breeding swallows. More specifically, the use of anti-worming agents such as ivermectin (often sold as Ivomec or Heartgard) in livestock can reduce the abundance of dung-feeding inverte-

Karl Evans

Karl Evans

126 & 127. Barn Swallow *Hirundo rustica* nests. The rough texture of stone, particularly in combination with another anchorage point, provides swallows with ideal sites on which to build their nests.

brates, with consequent adverse effects on species such as Red-billed Chough *Pyrrhocorax pyrrhocorax* (McCracken 1993; Edwards *et al.* 2001). No studies have investigated whether anti-worming treatments reduce aerial invertebrate abundance but, at least in Oxfordshire, the majority of such treatments seem to be applied to livestock that are not milked, and which are kept in fields away from dairies and other farm buildings where swallows nest (KLE unpubl.). Barn Swallows typically forage within a few hundred metres of their nest (the mean distance being c. 200 m; Bryant & Turner 1982) and are thus unlikely to use fields containing treated livestock. The use of anti-worming agents is perhaps unlikely to have dramatically reduced food availability for breeding Barn Swallows, but may have contributed to overall declines in invertebrate populations. It could also, arguably, affect productivity if pre-breeding adults and fledglings were foraging over larger areas.

In 2004, the BTO will run a survey of Barn Swallows in the UK, to obtain a national picture of habitat choice by foraging birds during the breeding season. The survey will gather data from between 2,000 and 4,000 randomly allocated points to determine patterns of habitat selection for birds foraging over arable and pastoral farmland. It should enable the factors influencing the current distribution of Barn Swallows and the direction and magnitude of localised population changes to be established more precisely.

Andy Harmer/Windrush

128. Barn Swallow *Hirundo rustica*.

Non-agricultural factors

Factors operating on the breeding grounds, but not directly related to agricultural intensification, may also influence Barn Swallow population trends. Nest-site loss is perhaps the most likely candidate. Robinson *et al.* (2003) found no relationship between regional CBC trends and an estimate of building redevelopment over a similar time period, but Evans *et al.* (2003c) found a strong correlation between the magnitude of population decline and nest-site loss within eight large English study sites. Studies in Switzerland and Germany have also demonstrated that the magnitude of Barn Swallow population decline is positively correlated with nest-site loss (Jeromin 1999; Weggler & Widmer 2000). The changing structure of villages, such as the demolition of outside toilets and the increasing tendency to secure sheds and other outbuildings, thus denying swallows access, may have contributed to population declines. The loss of farm buildings, as small farms are merged into larger units, may have further contributed to nest-site loss. This may be particularly important in southeast England, where the rate of redevelopment of old buildings has been greatest and Barn Swallow populations are declining the most.

Climatic change, particularly the trend towards warmer and drier summers, may also have affected breeding opportunities for Barn Swallows, either because mud is less readily available for nest building and/or because drier conditions may reduce invertebrate abundance (Frampton *et al.* 2000). Although the lower swallow population densities in southeast Britain, which is generally drier than the rest of the country, offer some support for this hypothesis, we consider that climate change is unlikely to contribute significantly to Barn Swallow declines in the UK. Most of the spatial variation in swallow density in the UK appears to be unrelated to climatic conditions, and areas of Europe which are much more arid than southeast England support large and stable Barn Swallow populations.

Factors operating in non-breeding regions

European Barn Swallows occur widely throughout sub-Saharan Africa in winter. In southern Africa, birds from many European regions (central and eastern Europe, the UK and Scandinavia) have been recorded wintering together; in central and eastern Africa, populations appear to be more segregated, with those breeding in western Europe having more westerly wintering locations (reviewed in Evans *et al.* 2003b). Most Barn Swallow mortality occurs during the winter, and is apparently independent of breeding population size (Møller 1989).

Karl Evans

129. The continued intensification of grassland management, such as increased silage production to feed cattle which are housed indoors, could have disadvantageous consequences for Barn Swallows *Hirundo rustica*.

Karl Evans

130. Grazing by cattle delivers many benefits to Barn Swallows *Hirundo rustica*, not least by increasing prey abundance and diversity.

Populations in decline, owing to European agricultural intensification, may thus be further affected by environmental change on the wintering grounds.

Barn Swallows have been recorded foraging over various habitat types in winter but they appear to shun heavily forested areas in preference for more open habitats, such as fresh water and savannahs (Fry *et al.* 1988). Clearance of dense tropical forest may thus favour the species and create local range expansions. There is, however, some evidence that winter diets largely comprise insects which feed upon woody vegetation; this raises the possibility that any loss of tree cover from semi-open habitats, such as bushy savannah, may be disadvantageous to wintering Barn Swallows (Evans *et al.* 2003b). Climate change may, however, be a factor promoting increasing tree cover in South African savannahs (van Jaarsveld & Chown 2001).

Changes within particular habitat types, such as farmland, may be more influential. Numerous incentives promote the intensification of African farming systems, including attempts to increase agricultural exports, reduce food imports and prevent the exhaustion of soil nutrients (Larson & Frisvold 1996; McCalla 1999). To realise those aims, fertiliser application rates in sub-Saharan Africa need to be approximately 50 kg/ha, a similar amount to that used in the UK in 1960; but they were only 11.5 kg/ha in 2000 (Larson & Frisvold 1996; World Resources Institute 2003). Most British Barn Swallows winter in South Africa where fertiliser use is much higher (48 kg/ha), but rates were double this 20 years ago. Across sub-Saharan Africa, pesticide application rates are presently six times lower than current UK rates. It thus appears that agricultural intensification in Africa is currently proceeding at a slow rate and is unlikely to exceed the levels witnessed in the UK in the early 1960s, when farmland bird populations were largely stable. While changes in farming practices in Africa will almost certainly have negative effects on biodiversity, they are arguably unlikely to pose a major threat to wintering Barn Swallow populations.

Many Afro-Palearctic migrants have been adversely affected by drought in the Sahel (Marchant 1992), and Barn Swallows are certainly affected by variations in rainfall: their range has shifted in response to changing rainfall patterns (Mead 1970); drought reduces body mass and the speed of moult (van den Brink *et al.* 2000); and winter mortality rates in a Danish population are negatively related to winter rainfall (Møller 1989). Decreased rainfall in African wintering quarters might thus reduce European Barn Swallow populations, although

it appears that the species was not greatly affected by the Sahelian drought, perhaps because Barn Swallows only migrate through the area rather than winter there.

Recent large-scale trapping (for food) at a major winter roost in Nigeria resulted in an annual harvest of around 2.2-5.6% of 40 million Barn Swallows. This may have threatened some European Barn Swallow populations, with data from ring recoveries suggesting that French populations may have been particularly vulnerable. Initiatives and development schemes to persuade hunters to cease trapping, including the provision of alternative protein sources, helped to alleviate this threat. It may now have disappeared, as very few Barn Swallows used this roost site during the 2002/03 winter; birds have probably relocated to alternative sites (Micheloni 2003).

Conclusions

The current European Barn Swallow population is probably much higher than it was before humans caused large-scale habitat change, but recent declines, both local and national, have been reported from many European countries, particularly in the west, although these reports are partly based on anecdotal evidence. In the UK, there is evidence of a slight increase in the total population in recent years, but also of localised declines, notably in eastern England. These are probably a consequence of agricultural intensification, especially increased arable cultivation and the associated loss of livestock. Loss of nest-sites may have also contributed to declines in some areas. Conditions on their African wintering grounds may affect swallows, but there is currently no good evidence that recent changes have generated population declines, although future climate change may be a cause for concern. Agri-environment schemes often contain provisions to promote the maintenance of livestock grazing, for example by encouraging mixed farming in areas which are predominantly arable, and such schemes may also deliver benefits to Barn Swallows.

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Karl Evans

131. Loss of marginal farmland habitats may have contributed to general declines in invertebrate abundance, reducing food availability for Barn Swallows *Hirundo rustica*

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Karl L. Evans, Oxford University Farmland Bird Group, EGI, Oxford University, South Parks Road, Oxford OX1 3PS*
Robert A. Robinson, BTO, The Nunnery, Thetford, Norfolk IP24 2PU

** current address: BIOME Group, Sheffield University, Western Bank, Sheffield S10 2TN*

J. Lawton Roberts/Windrush

132. Adult and juvenile Barn Swallows *Hirundo rustica* gather above the farm before beginning the trip to wintering grounds in Africa.