

The return of the Red-billed Chough to Cornwall: the first ten years and prospects for the future

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Abstract In 2001, three Red-billed Choughs *Pyrrhonorax pyrrhonorax* settled on the Lizard peninsula and a successful breeding attempt followed in 2002. Since then, breeding has taken place each year and, by spring 2011, the population had increased to six pairs, which fledged a record-breaking 15 young. As part of the joint RSPB/Natural England Action for Birds in England Species Recovery Project for Chough and the RSPB/National Trust/Natural England Cornwall Chough Project, this population has been the subject of nest protection and targeted habitat management to maximise the chances of successful natural recolonisation. Monitoring has provided detailed information on the establishing population and will provide early warning of future problems. This paper updates Carter *et al.* (2003) and reviews the project, describes how the Cornish birds have performed during the last decade, offers comparisons with Red-billed Chough populations elsewhere in northwest Europe and speculates on what the future may hold.

Introduction

Population history and conservation priority

The Red-billed Chough *Pyrrhonorax pyrrhonorax* (hereafter referred to as Chough) has a wide but fragmented Old World distribution, from the European Atlantic coast right across to the Pacific. The isolated northwest European population involves a distinct subspecies, *P. p. pyrrhonorax*. The information available suggests that Choughs of this subspecies declined through the nineteenth century before showing signs of recovery during the first half of the twentieth (Owen 1988). Co-ordinated, systematic surveys during the second half of the twentieth

century suggest a further recovery (Johnstone *et al.* 2007), although few areas where the Chough became extinct have yet been recolonised. The current distribution of *P. p. pyrrhonorax* remains restricted primarily to south- and west-facing coasts of Scotland, Ireland, the Isle of Man, Wales, Brittany, and a few areas inland from these coastlines.

Southwest England is one of those areas where the Chough was lost in the nineteenth and twentieth centuries, with the last breeding records for Dorset in 1890, Devon in 1910, Somerset in 1916 and Cornwall in 1947 (Owen 1988). Historically numerous, particularly in Cornwall where they apparently exceeded 150 pairs around 1800 (Owen

1988), Choughs had begun to cause concern among naturalists by the late 1800s because of their population declines. Besides a reduction in suitable foraging habitat, persecution – trapping, shooting and egg-collecting – has been suggested as a contributory factor (Penhallurick 1978; Owen 1988). The Chough is closely associated with extensive livestock-rearing, since its invertebrate prey is often more abundant and accessible on grazed areas (Bignal *et al.* 1997), and changes in agriculture, including both the intensification and the abandonment of land, may thus have played a key role in its decline.

The Chough is Amber-listed in the UK and Isle of Man because of its declining status in Europe (Eaton *et al.* 2009; www.birdlife.org). More generally, Choughs in north-west Europe are vulnerable because of the small size of some of their populations, and the potential adverse effects of predicted reductions in livestock numbers through the reform of agricultural policy.

The importance of the population in southwest England

There are three important factors to mention here. First, although currently small, the southwest England population has the potential to increase enormously, given its previous breeding range (e.g. Penhallurick 1978). The current nucleus in Cornwall could also eventually lead to the recolonisation of other parts of southern England. Second, flying between populations in Wales, Ireland and

Brittany, a restored Chough population in Cornwall would help to facilitate gene flow between otherwise isolated populations. Even at very low levels, such interchange can help to maintain genetic variation, which may in turn help populations to adapt to long-term changes (Newton 1998). The population in Cornwall is therefore of significance in helping to maintain the health of the wider northwest European population. Finally, the ‘Cornish Chough’ is a spiritual symbol for Cornish people, linked to Cornwall through centuries-old mythological associations with King Arthur – it even appears on the Council’s coat of arms. The natural spectacle provided by such iconic wildlife is increasingly valued by human society (Fisher *et al.* 2009).



Richard Bedford

229. Red-billed Choughs *Pyrrhocorax pyrrhocorax* are accomplished aerial gymnasts; Cornwall, August 2010.

Want to see a Cornish Chough?

BOX 1



Andy Hay (rspb-images.com)

230. During the breeding season, members of the public can watch the antics of the founder Red-billed Chough *Pyrrhocorax pyrrhocorax* pair and their family at Southerly Point.

The public watchpoint at Southerly Point on the Lizard, where people can see the original pair during the breeding season, has attracted thousands of people every year since the first successful breeding there, in 2002. This is not a high-tech operation with nest cams and wide screens, merely involving a warden, some information about the project, and a telescope, but most people are enthralled by the story, and many will wait for hours for a glimpse of the birds as they fly in and out of their nesting cave.

The Cornwall Chough Project

In the decades after the Chough had become extinct as a breeding species in the southwest, birds were seen occasionally in the region, but the arrival of at least three in Cornwall in spring 2001, followed by a successful breeding attempt in 2002, caused great excitement (Carter *et al.* 2003). Since breeding Choughs had been absent from the southwest for over half a century, there was

also uncertainty about whether sufficient suitable foraging and nesting habitat was still available to allow the birds to survive and increase. There were other concerns too, including the potential for disturbance from the increasingly important tourism industry along the coast, the potential threat from egg-collectors and uncertainty about the future effects of inbreeding on population growth.

To help address some of these issues, a



Tony Blunden

231. Red-billed Choughs *Pyrrhocorax pyrrhocorax* and grazing (here on the Lizard peninsula in Cornwall) go together like scones and clotted cream.

joint project involving the RSPB and Natural England (part of the Action for Birds in England programme) was established in 2001, with the National Trust joining the partnership as the wider Cornwall Chough Project in 2002. The project has three main objectives within the overall aim of maximising the success of the re-establishing population: (i) to create and manage foraging habitats where existing conditions are thought inadequate; (ii) to protect nesting pairs from disturbance and egg-collectors; and (iii) to monitor the population in order to help inform future decisions about conservation management.

Choughs have been the subject of much research in recent decades, which has shed light on aspects of diet (table 1), habitat preference (table 2), population ecology (e.g. Reid *et al.* 2009), and their sensitivity to human pressures in their current range (e.g.

Kerbiriou *et al.* 2009), all of which has helped to identify conservation priorities.

Diet and habitat preferences

Choughs feed largely on invertebrates throughout the year (table 1), locating them by probing in soil, gleaning from the soil surface and vegetation, and searching herbivore dung. Certain invertebrate groups often feature heavily in the diet at particular times of year, and the diet is supplemented at times by cereal grains from harvested fields and animal feeds (table 1). Although diet appears broadly similar throughout the UK, there are some regional differences, which reflect variation in habitat availability and agriculture.

Habitat selection by Choughs has been well studied in Britain & Ireland. Choughs feed preferentially in areas where prey is readily accessible (and presumably foraging most profitable), and most studies have

Table 1. Favoured food items found to occur in the diet of Red-billed Choughs *Pyrrhocorax pyrrhocorax* at different times of year. Sites are ranked by latitude.

Site	Period	Food	Source
Islay, Argyll	Oct–Apr	Cereals	McCracken <i>et al.</i> (1992),
	Jan–Apr	Dung flies (bibionids), cereals	
	Jan–July	Tipulids	McCracken & Foster (1993, 1994)
	spring, late summer and autumn	Dung invertebrates	
	summer	Variety of surface-active invertebrates	
	Nov–Mar	Beetles, ants, grain	
North Wales	Apr–Jul	Tipulids, adult and larval ground beetles, ants, cereal	Whitehead & Johnstone (2005)
	Oct–Nov	Tipulids, adult and larval ground beetles	
Bardsey, Caernarfonshire	Jul–Oct	Ants, beetles and tipulids	Roberts (1982)
	Nov–Mar	Kelp flies and sandhoppers	
Pembrokeshire	Apr–Jun	Beetles, moth larvae, tipulids	Meyer <i>et al.</i> (1994)
	Jul–Oct	Beetles, moth larvae, earthworms,	
	Nov–Feb	Beetles, grain, earthworms	
Cornwall	Mar–Jun	Beetles, tipulids, ants	This study
	all year	Tipulids	
	May	Moth larvae	
	May–Sep	Ants	
Ouessant, Brittany	Aug–Mar	Dung invertebrates	Kerbiriou & Julliard (2007)
	Jul–Oct	Ants and beetles	
	Nov–Mar	Tipulids, dung invertebrates, wild grains	
	Apr–Jun	Beetles and spiders	



Bob Sharples

232. A Red-billed Chough *Pyrrhocorax pyrrhocorax* next to non-native succulents on the Lizard peninsula. These plants threaten to smother native coastal-slope flora in places, and their spread is actively controlled.

feeding on cliff slopes and enclosed pasture, particularly where grazing and trampling (including by people) create short, open swards. This preference is apparent over a range of spatial scales. For example, Whitehead *et al.* (2005) found that at a larger scale (between fields) birds tended to select for management types with the shortest swards (2–3 cm), while at a smaller scale (within fields),

found that grazed areas with short swards (<7 cm) were favoured by foraging Choughs, including in Cornwall (table 2). Observations in Cornwall show that Choughs prefer

birds preferred patches with shorter swards and more friable soils than elsewhere – conditions that make finding food easiest.

During the breeding season, Choughs feed

Table 2. The most favoured habitats of Red-billed Choughs *Pyrrhocorax pyrrhocorax* at different times of year. Sites are ranked by latitude and, where possible, habitats are ranked by preference.

Site	Preferred habitat	Season	Source
Islay, Argyll	Grass pasture with short, open swards	Apr–Jun	Signal <i>et al.</i> (1996)
Islay, Argyll	Dune grass, cliff slope, acid grass	Jul–Sep	Madders <i>et al.</i> (1998)
	Acid grass, improved grass, neutral grass	Dec–Feb	
Islay, Argyll	Coastal dunes (pre-breeders)	All year	Reid <i>et al.</i> (2009)
	Newly cut silage (pre-breeders)	Jun–Aug	
Co. Donegal	Machair and maritime turf, short and often grazed	Mar–Jun	Robertson <i>et al.</i> (1995)
North Wales	Earth banks, paths, grazed coastal grass and heath	Apr–Jul	Whitehead <i>et al.</i> (2005)
Bardsey, Caernarfonshire	Close-cropped grass	All year	Roberts (1983)
Pembrokeshire	Cliffs, short-grazed old-grass, arable stubble	All year	Meyer (2001)
Ireland	Maritime grass, gorse-dominated grass, unimproved grass	Jun–Aug	Trewby <i>et al.</i> (2007)
	Maritime grass, semi-improved and improved grass	Sep–Nov	
	Semi-improved, improved and unimproved grass	Dec–Feb	
	Gorse-dominated grass, maritime grass, unimproved grass	Mar–May	
Cornwall	Paths, earth banks with short swards, short/grazed coastal grass	All year	This study
Brittany	Paths, rocky and short grass, short grass	Apr–Jul	Kerbiriou <i>et al.</i> (2006)

mainly within 300 m of the nest and the extent of good foraging habitat close to nesting sites has been shown to influence breeding success. Choughs breeding on Ouessant, Brittany, fledged, on average, one extra chick for every extra hectare with mean sward height of less than 5 cm within 300 m of their nest (Kerbiou *et al.* 2006).

Choughs respond to changes in grazing regime by switching feeding sites (e.g. Ausden & Bateson 2005) and breeding success is related to local changes in grazing (McCanch 2001). This is important because it shows that suitable management close to nest-sites can increase foraging opportunities and improve breeding success. The converse is also true – for example, a lack of grazing, owing to restrictions on cattle movements, in favoured fields near the longest occupied nest-site in Cornwall resulted in the birds having to travel much farther to find suitable foraging areas.

Habitat suitability in Cornwall

Based on our knowledge of Chough foraging habits, habitat suitability of land within 250 m of the sea was mapped for long stretches of the Cornish coast (400 km in total) during the winters of 2006/07 and 2007/08 (Mucklow & Croft 2008). This showed that for coastal slopes and adjacent fields combined only 13% of habitat was thought to be of highest suitability for Choughs, with short swards being maintained by grazing on 9% and by weather and

salt spray on the remaining 4% (table 3). Areas of highest suitability were often highly fragmented, and where birds were regularly brought into contact with people using coastal footpaths. The fact that Choughs readily reoccupy nest-sites many years after they have been vacated suggests that the birds have a very clear search image of what constitutes a good site, and there are striking examples of this at reoccupied sites in Cornwall. With knowledge of historical nest-sites, roost sites used by paired pre-breeding birds (often subsequently used as nest-sites) and habitat suitability, conservation efforts in Cornwall have been efficiently targeted to the places most likely to be used by breeding Choughs in the short term. This process, of identifying the most suitable habitat for Choughs, is now being extended to the north Devon and Somerset coasts to establish a chain of ‘key areas’, based on historical occurrence and current habitat suitability (along with need and scope for improvement; Davies *et al.* 2011). A number of Choughs ringed in Wales have been reported on the Somerset and north Devon coasts in recent years, and these key areas will facilitate the linking of Chough populations in Cornwall and south Wales in the longer term.

At the ten nest-sites occupied recently in Cornwall, habitat was assessed as below maximum suitability if there were no short swards (<5 cm) within 300 m of nest-sites and if there was evidence that the adults travelled farther than this to forage while

Table 3. The availability of habitats of different suitability for Red-billed Choughs *Pyrrhocorax pyrrhocorax* along the Cornish coast in the winters of 2005–07. Areas given are in hectares.

Importance to Choughs	Habitat	Unenclosed coastal strip (%)	Adjacent enclosed fields (%)
Highest	Grazed unimproved and semi-improved coastal grass (average sward <5 cm), grazed coastal heath, weather-maintained coastal grass (average sward <5 cm), bare ground, rocky outcrops	644 (12.6)	636 (14)
Less high	Grazed improved grass (average sward <5 cm), spring cereal stubbles in winter	0	1,625 (35.7)
Lower	Rank coastal grass (average sward >5 cm), gorse, scrub, ungrazed heath, Bracken, ungrazed improved grass, ungrazed dune systems, Hottentot Fig <i>Carpobrotus edulis</i> (invasive non-native), winter arable crops, bare ploughed fields	4,470 (87.4)	2,291 (50.3)
Grand total		5,114 (100)	4,552 (100)

breeding. Of the ten sites, only two met the criteria for maximum suitability in all years occupied. This suggests that the land near nests is often not of the highest suitability for Choughs and also shows that its management is rarely constant over time.

Some management changes are very marked. For example, when livestock are removed, either temporarily or permanently, swards in most habitats quickly become too tall and dense for Choughs to find soil-invertebrate prey easily, and unsuitable vegetation types may become established, such as Bracken *Pteridium aquilinum* and scrub. However, more subtle changes may also make sites less suitable for foraging Choughs during the breeding season, such as the seasonal use of grazing breaks to benefit flowering plants and the removal of livestock

during peak coastal footpath use. Consequently, encouragement of landowners to manage sympathetically for Choughs near to nest-sites needs to be constant, so that beneficial practices are established and maintained, especially during the breeding season.

Since the extent to which land management can be changed was anticipated to be small, specific targets (in terms of improving habitat) have not been set, but rather any maintenance or increase in highly suitable habitat near current or potential nest-sites is a success. This can be encouraged through agri-environment agreements that include options designed to benefit Choughs, such as using hardy, traditional breeds of cattle and ponies throughout the spring and summer, keeping these out in winter where practical, and having a network of suitably grazed enclosed fields adjacent to the coast where the birds can forage away from busy footpaths. In this way, the Cornwall Chough Project has influenced the management of some fields within 300 m of most nest-sites since 2001, although benefits have not always been maintained in successive years and, in some cases, other negative changes have taken place nearby.

Although a range of habitat and management types can at times provide good foraging sites (table 2), management for Choughs often focuses on the creation of short swards through grazing. Grazing is sometimes considered detrimental to other species/communities, although many UK Biodiversity Action Plan (BAP) species associated with the coastal fringe have similar habitat requirements to those of Choughs (Lamacraft & Muirhead 2007; Rylands 2011). Choughs were absent from Cornwall when the county's SSSI network was designated, but JNCC guidance on site selection for species outside their main range provides a



Mike Barker

233. Abandoned mine workings, such as this adit, provide good nest-sites for Red-billed Choughs *Pyrrhocorax pyrrhocorax* in Cornwall.

mechanism for their consideration in the future. Consequently, as SSSIs are reviewed, Choughs should be considered as additional feature species, complementary to existing coastal species and habitat features that are maintained in favourable condition by active grazing regimes. Natural England has embraced Choughs within their current range in Cornwall as a target species within the Higher Level Stewardship scheme.

Human pressures

A concern in parts of Cornwall is the potential for disturbance by people using coastal paths, even though their trampling can create good foraging habitat. Choughs are sensitive to chronic levels of disturbance; on Ouessant, Kerbiriou *et al.* (2009) were able to link disturbance to the reduced survival of young, which in turn affected population growth. In that study, Choughs selected areas with short swards created by high visitor numbers, but survival of young was lowest when tourist numbers were greatest because inexperienced birds had trouble finding sufficient food when disturbed frequently. Anecdotal observations in Cornwall suggest that even adults move away from preferred feeding areas when visitor pressure is high, from April to October. It is too early to say yet whether this level of disturbance could affect population growth in Cornwall.

Persecution – egg-collecting, trapping and shooting – has been suggested as a contributory factor in the historical decline of the Chough (Owen 1988). Egg-collecting is, sadly, still an annual occurrence in Wales and nests in Cornwall receive 24-hour protection during the incubation period to minimise this threat (and, more generally, to reduce distur-

bance). In the last decade, nest-protection teams have foiled at least two egg-collecting attempts, and prevented many incidents of disturbance to birds at nests (both accidental and deliberate). On a more positive note, nest protection has also provided the opportunity to show Choughs to the public (box 1).

Progress in Cornwall

Population establishment

The breeding population of Choughs in Cornwall has been surveyed annually using the methods outlined in Johnstone *et al.* (2007). In summary, breeding records are assigned to one of three categories: possible (e.g. single birds or pairs recorded), probable (e.g. carrying nest material, courtship-feeding) and confirmed (e.g. faecal sacs or chicks seen). The Cornish population has



Ian Benallick

234. A UK BAP species that needs similar conditions to Red-billed Choughs *Pyrrhocorax pyrrhocorax*, Perennial Centaury *Centaurium scilloides* was rediscovered in 2010 in grassland near Land's End, an area also frequented by Choughs. Cattle are maintained here through an agri-environment agreement.

increased steadily since 2000, with six probable or confirmed breeding pairs and six pre-breeders (immatures) in 2010 (fig. 2). Probable/confirmed breeding behaviour has been recorded at ten different sites since 2001 and young have fledged successfully from four of these.

Choughs have recolonised other parts of their former range in recent decades and it is interesting to compare rates of increase between the different populations. Following the species' loss there in the late 1800s, a pair was recorded on Anglesey in 1953, then three pairs a decade later, and 37 pairs by 2002. In Gower, one pair returned in 1990 and was still present, together with a further three possible pairs, in 2002. Colonsay, in Argyll, was recolonised in the late 1960s, had one pair in 1982, nine in 1992 and 14 in 2002 (see Johnstone *et al.* 2007). In these cases, recent colour-ringing has shown some interchange between these newly established and adjacent

populations (e.g. Haycock 2002, Reid *et al.* 2003). The increase in Cornwall compares well with these examples, and similar natural interchange remains possible. However, not all colonisation attempts have been as successful, and there are several sites in Scotland and Northern Ireland where populations have not increased, despite years of breeding by single pioneer pairs (Johnstone *et al.* 2007).

Movements and flocking

All the chicks fledged in Cornwall in the past decade have been colour-ringed, which has enabled their progress to be followed in some detail. Since 2002, an average of 271 records per year of colour-ringed birds have been received, and in around two-thirds of cases individual birds could be identified.

Normally, Choughs first breed when 2–3 years old (Reid *et al.* 2003) and before then the immatures, or pre-breeders, associate in

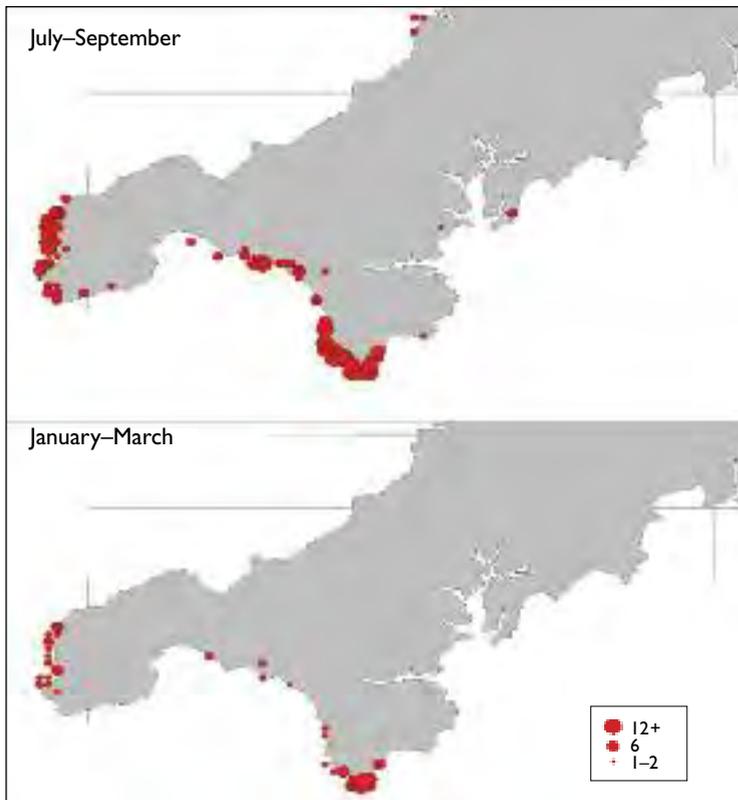


Fig. 1. The sizes and distribution of Red-billed Chough *Pyrrhocorax pyrrhocorax* flocks in Cornwall at different times of year. Data are for 2007 onwards; top = late summer (Jul–Sep), bottom = late winter (Jan–Mar). The sizes of symbols show maximum group size per 1-km square in each season. The grid is at 10-km intervals.

flocks throughout the year. These flocks typically comprise between a quarter and a third of the total population (Johnstone *et al.* 2007) and it has been suggested that joining a flock confers advantages to these pre-breeding birds – for example, opportunities to learn from older pre-breeders how and where to forage at different times of year (Bignal *et al.* 1997), and to select mates and gain breeding sites (Blanco & Tella 1999). Often, flocks of pre-breeders feed and roost at a small number of important sites that are used repeatedly over many years, and young Choughs will

travel large distances to reach them. The use of such sites peaks in late summer and early autumn, as on Islay (Argyll), for example (Reid *et al.* 2009).

After the chicks have fledged in June, Cornish adults typically disperse along the coastal fringe with their still-dependent young, often travelling tens of kilometres from the nest-site. By August, the young are independent and most adults have returned to the area immediately around their nest. Pre-breeders may remain within or close to their parents' territory, even feeding with them at times; alternatively, if other pre-breeders are in the vicinity, they often form a flock that ranges more widely (fig. 1). The maximum flock size so far recorded in Cornwall is 16, in November 2008, which included some breeding adults. Cornish pre-breeders that survive their first few months of independence have sometimes travelled over 60 km from their natal site by late summer, often in the company of siblings or other pre-breeders. In contrast, in late winter, flocks tend to be smaller and less wide-ranging (fig. 1). These post-breeding movements contain behaviours seen in Choughs elsewhere, suggesting the emergence of a similar social structure.

Favoured flock feeding sites in Cornwall have included fields where cattle have been wintered outside, and tourist spots where trampling (or mowing) has created very short swards – including a golf course! In addition, pre-breeders have been seen regu-



Claire Mucklow

235. A nestling Red-billed Chough *Pyrrhocorax pyrrhocorax* in Cornwall, being ringed and colour-ringed.

larly in late winter feeding for hours at a time in spring barley stubble close to the coast. Food here may include invertebrates, as by this time spilt grain is likely to have been much depleted by other seed-eating birds.

Recruitment and breeding

Five Choughs bred in Cornwall have now been recruited into the breeding population and have fledged chicks themselves. The median age at which they reached probable or confirmed breeding status was two (range 1–3), with chicks first successfully fledged by adults of a median age of three (range 2–4). This is at the lower end of the range found in the well-studied Islay population (Reid *et al.* 2003), likely reflecting the low population

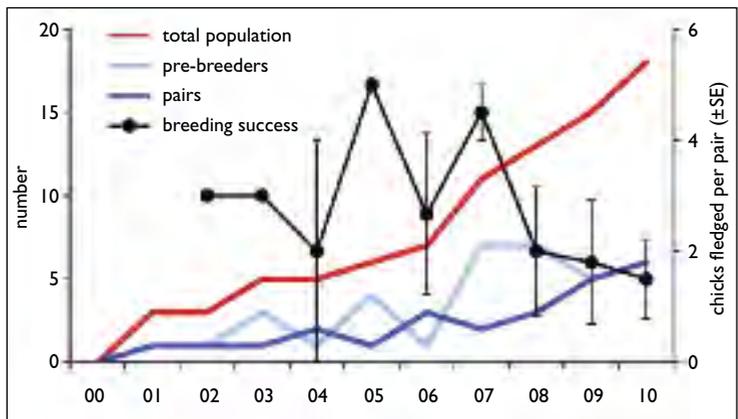


Fig. 2. The population trajectory of different components of the Cornish Red-billed Chough *Pyrrhocorax pyrrhocorax* population, along with mean breeding success based on the given number of pairs.

density in Cornwall, where competition for partners along with nest-sites and foraging habitat is low. Surprisingly, in 2009, one first-year female got as far as hatching a single chick, although this did not survive to fledge. Single chicks within broods of four and five have also failed to fledge in the last two years at another nest. Choughs generally start incubation after the third egg is laid, resulting in one or two of the chicks being smaller than the others (Bignal *et al.* 1997). These may starve if the parents are unable to provide sufficient food for all their young (an example of a brood-reduction strategy). Chick deaths at this stage are probably frequent in Choughs, but tend to go unrecorded in populations where monitoring is less intensive.

Breeding success has been measured, using two comparable methods, for a number of Chough populations in northwest Europe (fig. 3). At a mean of 2.55 chicks fledged per probable/confirmed pair during 2001–10, breeding success in Cornwall is high compared with other populations (fig. 3), and has included three broods (involving two different pairs) where five chicks were fledged (it is rare for Choughs to lay more

than five eggs; Bignal *et al.* 1997). Although success has been lower in more recent years (fig. 2), this may reflect the fact that more inexperienced two- and three-year-old birds have joined the breeding population. Reid *et al.* (2003) found that breeding success peaked when females were 6–9 years old, so it is hoped that these inexperienced Cornish youngsters will go on to breed more successfully in future seasons.

Chicks can be sexed in the nest (using biometrics – this method has an accuracy of more than 95% in the Welsh population). Since re-establishment, the brood sex ratio has been approximately equal, with 57% of fledged young being males. Through the information obtained from sexing young birds in the nest, it has been discovered that, on two occasions, a ‘pair’ exhibiting all the signs of preparing to breed has, in fact, involved two males (although the unlikely combination of incorrect sexing and infertility could not be ruled out). On the second occasion, the closely bonded ‘pair’ has been together since 2008 and builds a nest annually, despite contact with unpaired pre-breeding females. This poses a dilemma for

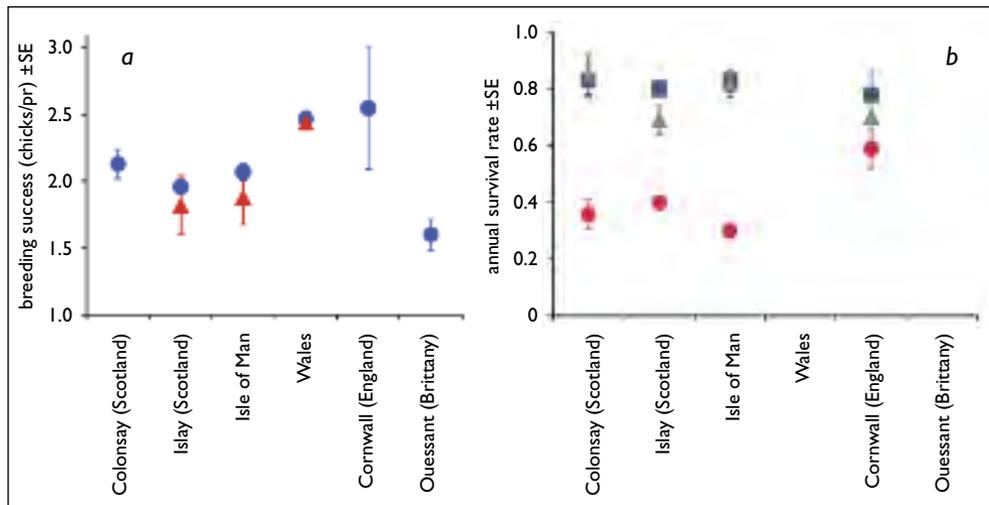


Fig. 3. Demographic rates of northwest European Red-billed Chough *Pyrhcorax pyrrhcorax* populations, ranked by latitude. (a) Breeding success was based on (i) all breeding attempts (Scotland, Isle of Man and Ouessant) or (ii) sites with probable or confirmed breeding status (Wales and Cornwall). Points are means for the maximum number of years available (blue circles) or for the 1982 national census (red triangles, all method ii). That the figures for Scotland, the Isle of Man and Wales are similar for the two methods lends weight to their comparability. (b) Survival probabilities calculated using the MARK program: red circles = 1st-year, grey triangles = 2nd-year and blue squares = older. Sample sizes are >50 except for Cornwall, where $n=25$ for breeding success and $n=55$ for survival. Sources: Bullock *et al.* (1983), Reid *et al.* (2009), Cross & Stratford (unpubl. data).

Table 4. Known causes of death of Red-billed Choughs *Pyrrhocorax pyrrhocorax* fledged in Cornwall. Fledglings become pre-breeders when they leave family groups, and adults when they display evidence of probable or confirmed breeding.

Cause of death	Number of cases			Evidence
	Chicks or fledglings	Pre-breeders	Adults	
Peregrine Falcon <i>Falco peregrinus</i>	0	2	2	Observation and post-mortem
Large gull or corvid	6	0	0	Observation
Dog or fox	0	0	1	Post-mortem
Electrocution	0	1	0	Post-mortem
Heart failure	1	0	0	Post-mortem
Total	7	3	3	

reporting population statistics. Including the same-sex pair increases the population size (from five to six pairs in 2010), but reduces mean breeding success (from 1.8 to 1.5 chicks per pair). Here we have counted birds as pairs if they show behaviours qualifying them for probable or confirmed breeding status (e.g. nest-building), as would be the case if ringing and sexing did not take place.

Survival rates and mortality

Thanks to an army of volunteer Chough watchers and sightings sent in by members of the public, the 55 colour-ringed birds that have fledged in Cornwall have so far generated over 2,000 resightings. These have allowed calculation of annual survival rates of different age classes, which can be compared with estimates for other populations using the same method (fig. 3). In Cornwall, the annual resighting rate was 100% from one breeding season to the next, i.e. no colour-ringed birds had gone missing and then reappeared more than a year later. Although confidence limits are still relatively large because of the small number of individuals involved, first-year survival so far seems markedly better than in other populations, while second-year and adult survival rates are similar to those recorded elsewhere.

Surprisingly, it appears that young first-year males are surviving better than females (69% compared with 44%; fig. 4), although the survival rate of first-year females is still good. The reasons for this are currently unclear. It is possible that young females are roaming farther from their natal site than

males and are therefore exposed to greater risks. More resighting data are needed to confirm this, however (and any records of colour-ring combinations of Choughs in England are very welcome¹).

This difference between the sexes in annual survival is reflected in an increasing bias at present towards males across age groups. The uneven sex ratio will have prevented the population growing as fast as it could have, and it will be interesting to see if this effect remains should numbers and range become larger in the future.

As a consequence of the active public interest in the fortunes of Choughs in Cornwall, four dead birds have been reported. Post-mortem analysis has shown that all four were in good condition at the time of death. The deaths of a further nine have been observed in the field (table 4); most of these were fledglings, and thus at an age at which they are particularly inexperienced and vulnerable. The causes of death, mainly by predation, are not unexpected nor a particular cause for concern.

The threat from inbreeding?

Some birds reared in Cornwall in recent years are now breeding with each other. Since the population has only three founding individuals, this has inevitably led to a degree of inbreeding. Assuming that the founder birds were all unrelated, which is by no means certain, the mean inbreeding coefficient of 0.061 for chicks hatched in 2010 shows that inbreeding levels are moderate (Marr *et al.* 2006). Inbreeding in birds can result in lower

¹ Please send any records of colour-ringed Choughs to: cornishchoughs@rspb.org.uk

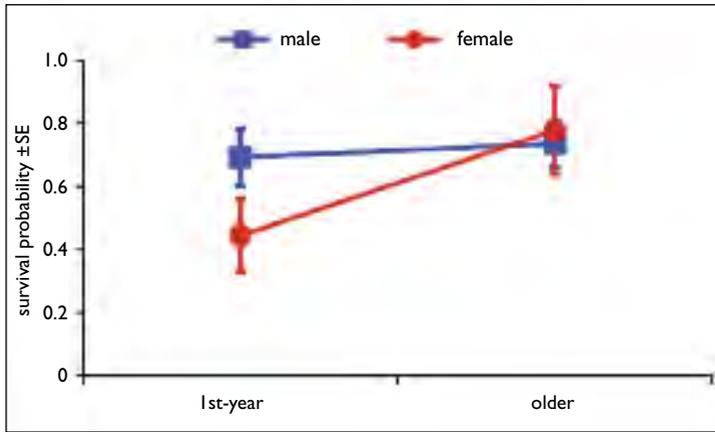


Fig. 4. Male first-year Red-billed Choughs *Pyrrhocorax pyrrhocorax* in Cornwall survived better than first-year females, although female first-year survival was still typical of other populations (fig. 3) (males, n=31; females, n=22). Two chicks with indeterminate sex characteristics were not included, and both died during their first year. Annual resighting rate was 100%.

hatching and fledging success, and survival, although the effects vary greatly among different species and negative effects are by no means certain (Newton 1998; Marr *et al.* 2006). In this respect, it is notable that Choughs on the Breton island of Belle Isle persisted for several decades at a level of 7–10 pairs before increasing to 17–19 pairs by 2002 (Kerbiriou 2005), despite being just as isolated from other Choughs as those in Cornwall are. If inbreeding does begin to affect the

Cornish population adversely in the future, then rapid population growth up to then, combined with occasional new individuals joining the population from other areas, will help.

We are confident that so far all nest-sites in Cornwall have been found each year, so that when a new, unringed Chough joined the population in February 2011 (now resident near Land’s End), it could only be a new immigrant. This is

good news for the population’s future, and illustrates Cornwall’s strategic position in terms of movements between northwest European Chough populations.

Conclusions and future prospects

This project is a good example of evidence-based conservation. Habitat assessments and targeted management have been based on previous studies of habitat preference and foraging behaviour, and comprehensive

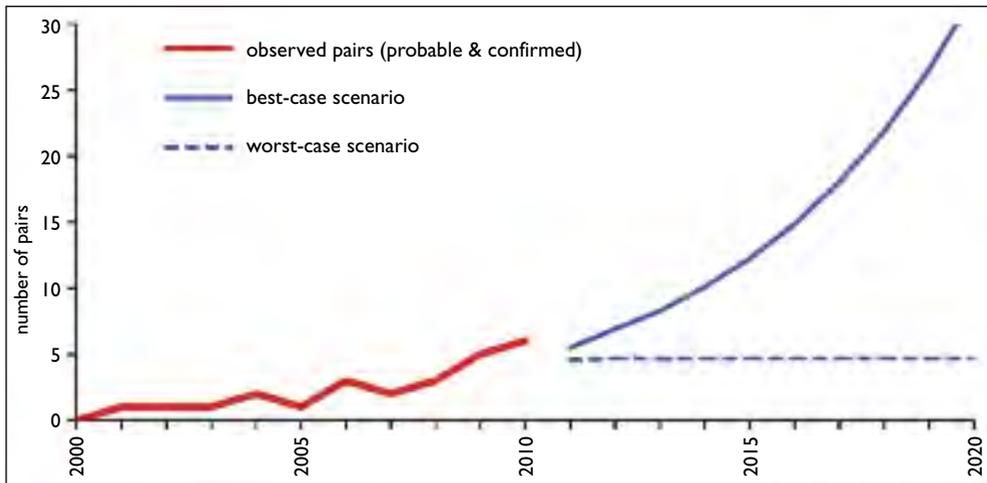


Fig. 5. Observed number of Red-billed Chough *Pyrrhocorax pyrrhocorax* pairs to 2010 (including same-sex pairs), and predicted population trajectories from 2011 for numbers of females of breeding age (2+ years) for different values of demographic rates. ‘Best-case scenario’ is equal sex ratio, pooled sex survival rates (1st-yr = 0.59, 2nd-yr = 0.70) and 2001–10 mean breeding success (2.55). ‘Worst-case scenario’ is observed mean proportion female (0.43), female-specific survival rate (1st-yr = 0.44, 2nd-yr = 0.78) and 2010 mean breeding success (1.50). In both cases, adult survival was 0.78.

Returning Choughs bring economic benefits

St Just School



236. 'Choughs take the biscuit' in a local schools' competition run by Cornwall-based Warrens bakery. Sales helped to fund a 'Chough Club' for children from St Just Primary School.

The economic benefits that Choughs may have brought to local communities are less visible but an equally important aspect of their return. A study using questionnaires in 2004, only a few years after their return, showed that people came from all over the UK to see Cornish Choughs, bringing some £180,000 into the local economy. More than a decade ago, the only place you would see a Chough in Cornwall was on coats of arms and a few pub signs. Today, Choughs are appearing as company

logos, on merchandise, feature frequently in local and national media, and have even inspired a novel. Hopefully, such economic benefits and 'spin-offs' will become permanent services provided by a healthy coastal environment, with Choughs as its flagship.

population monitoring is keeping an eye not only on the numbers of birds present, but also on the demographic processes that can warn of future problems. However, because there was no formal trial design, we cannot be sure how much the interventions have helped the population to do as well as it has.

We have seen from other areas that Choughs can establish self-sustaining populations from very small beginnings, and it is hoped that events in Cornwall are just the start of a recolonisation of suitable coastal habitats throughout southwest England and perhaps even farther afield. Knowing how quickly the population might increase (and its extinction risk decline) helps us to plan for the project's future. Although the sample sizes are still small, making sophisticated population viability analyses unreliable, we have used a simple deterministic population model to show best- and worst-case scenarios for the data available. This suggests a population perhaps as large as 30 breeding pairs by 2020, although the worst-case scenario shows no population growth at all (fig. 5). More data will help to refine the accuracy of such forecasts.

The return of this most Cornish of birds has also brought a revival of interest in the Chough as a cultural symbol for Cornish

people, and financial benefits for Cornwall too (box 2); these, we hope, like the Chough, will be here to stay.

Next steps

The Cornwall Chough Project will continue to support the re-establishment of a self-sustaining population of Choughs in southwest England through natural colonisation by carrying out the following actions.

We shall continue to protect nests from disturbance and egg-collectors. As numbers and range have increased, we have developed a strategic approach, directing manpower to the sites at most risk and using technology, where appropriate, to help us combat these threats.

Where appropriate, we shall continue to work with landowners, using agri-environment schemes to increase the availability of suitable habitat within the Chough's range, targeted at current and historical nest-sites and other favoured feeding areas, for example in West Penwith, where Choughs were historically numerous, but where the spread of Bracken and scrub through the abandoned ancient field system makes much of the area of little value to them and many other BAP species at present. More widely and where necessary, we will target suitable

management to key areas along the north coast of Cornwall, Devon and Somerset to facilitate links between the Cornish and Welsh populations, and work with conservation partners in Wales to support Chough conservation around the Severn.

Population monitoring will continue – at the time of writing, monitoring just completed for 2011 suggests that there are again six pairs, along with four pre-breeders, which is great news following the hardest winter for decades. The next UK Chough survey is scheduled for 2014, and adequate coverage in southwest England, bolstered by records from this project, is essential. As known inbreeding becomes routine, monitoring of breeding success is important. This can help to identify the reasons behind any decrease in breeding success, separating the effects of inbreeding from (for example) that of age and breeding experience. Colour-ringing to monitor pre-breeder survival, movements and relatedness of future pairs will continue, complementing information on population size and breeding success, to maximise our ability to detect problems early.

Choughs have returned to Cornwall and the stories of each individual bird are giving us an unparalleled view of how recolonisation happens. However, key questions remain inadequately answered by the current small sample sizes. For example, has it been a case of gap-year girls risking it all to explore while the home boys hang around their usual haunts that has led to a shortage of eligible females, and is this preventing the population from growing as fast as it could? Only time and hard work from lots of organisations, farmers and volunteers, will tell. We hope that the next ten years will be as dramatic and fascinating as the first!

Acknowledgments

We would like to extend our thanks and gratitude to all those who have supported Choughs and the work of the Cornwall Chough Project and its partners over the last decade, and in particular the many volunteers and farmers who have become involved in helping to secure the future for this most Cornish of birds.

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