Scottish Birds

Winter 1999

THE JOURNAL OF
THE SCOTTISH
ORNITHOLOGISTS'
CLUB

Vol. 20 No. 2 ISSN 0036 9144

Scottish Birds

The Journal of the Scottish Ornithologists' Club

Editor: Dr S da Prato
Assisted by: Professor D Jenkins, Dr J B Nelson, Dr I Bainbridge, Dr M Marquiss and R Swann
Business Editor: The Secretary SOC, 21 Regent Terrace Edinburgh EH7 5BT
(tel 0131-556 6042, fax 0131 558 9947).

Scottish Birds, the official journal of the Scottish Ornithologists' Club, publishes original material relating to ornithology in Scotland. Papers and notes should be sent to The Editor, *Scottish Birds,* 21 Regent Terrace, Edinburgh EH7 5BT.

Two issues of *Scottish Birds* are published each year, in June and in December. *Scottish Birds* is issued free to members of the Scottish Ornithologists' Club, who also receive the quarterly newsletter *Scottish Bird News*, the annual *Scottish Bird Report* and the annual *Raptor round up*. These are available to Institutions at a subscription rate (1997) of £36.

The Scottish Ornithologists' Club was formed in 1936 to encourage all aspects of ornithology in Scotland. It has local branches which meet in Aberdeen, Ayr, the Borders, Dumfries, Dundee, Edinburgh, Glasgow, Inverness, New Galloway, Orkney, St Andrews, Stirling, Stranraer and Thurso, each with its own programme of field meetings and winter lectures. The Waterston Library at the Club's headquarters at 21 Regent Terrace, Edinburgh EH7 5BT is the most comprehensive ornithological library in Scotland, and is available for reference during office hours (Monday to Friday, 0930-1630 hrs). (But please phone beforehand).

SOC annual membership subscription rates

	Direct Debit	Other methods
Adult	£18.00	£20.00
Family (2 adults and any children under 18) living at one address	£27.00	£30.00
Junior (under 18, or student under 25)	£7.00	£8.00
Pensioner/unwaged	£10.00	£11.00
Pensioner Family (2 adults living at one address)	£14.50	£16.00
Life	£360.00	£400.00
Life Family	£540.00	£600.00

All subscriptions may be paid by Direct Debit and Covenanted. Subscriptions paid by Direct Debit greatly assist the Club. Please ask for a Direct Debit form by phoning the Secretary at the above address.

Published by the Scottish Ornithologists' Club, 21 Regent Terrace, Edinburgh EH7 5BT
Printed by Meigle Print, Block 11, Units 1 & 2, Tweedbank Industrial Estate, Galashiels TD1 3RS

Raven population size and distribution on the Isle of Islay in winter

M MADDERS & F M LECKIE

The numbers and distribution of Ravens was studied on the Isle of Islay between October 1996 and April 1997. Survey work identified 35 Raven territories, of which 32 were occupied by breeding pairs in April. Territorial pairs were located in 2 additional areas where no suitable nest sites were apparent. Most territories were located around the coast, with the main concentration in the west and southwest, notably The Oa. The estimated breeding density across the whole island was 0.04 pairs km² ie close to the Scottish mean. Eight territories were monitored regularly throughout the winter. These territories were occupied continuously by Raven pairs.

The estimated size of the nonterritorial population, based on counts of Ravens at a communal roost, varied from 149 to 285 birds. Daytime sightings of Raven were clustered around 2 axes in the centre and northwest of the island. These axes intersected at the communal roost. Raven abundance in different parts of the island was investigated in relation to various measures of topography and habitat. When distance from the roost was taken into account, Raven distribution was best explained by the cover of improved grassland and proximity to the municipal refuse tip.

Introduction

In recent years, licences have been issued to shoot limited numbers of Ravens *Corvus corax* on the Isle of Islay, in response to a perceived increase in the Raven population and because they are widely believed to damage and kill domestic stock. This situation has given rise to concern among some conservationists that our knowledge of Raven ecology on Islay is insufficient for the effects of licensed killing on the Raven population to be predicted. This paper presents the results of research to estimate the size of the breeding and non breeding Raven population in 1996-7. A further aim of the study was to map the distribution of Ravens in winter, and relate Raven abundance to various measures of land cover and terrain.

Islay is located some 24km west of the Kintyre peninsula and covers approximately 615km² (Fig 1). Inland, it is characterised by unproductive bogs and mires, heaths and rough grasslands, improved and semi improved grasslands, arable habitat and even aged conifer plantations. The coastline measures c220km and comprises mainly steep rocky cliffs, dunelands and intertidal habitats. The island is exposed and affected by a maritime climate (Boyd 1983).

Methods

Territorial Raven population size

Systematic searches for territorial Raven pairs were carried out in October 1996 and April 1997. The whole coastline of Islay was walked during each survey period. All inland

crags, steep gullies and stands of mature woodland marked on 1:25000 scale OS maps were visited during April. Information on areas where breeding had been proven or suspected was sought from local ornithologists, land managers and stalkers. These areas were visited in both October and April.

Details of the number, location and behaviour of all Ravens seen were plotted on to 1:25000 scale maps. Crags and suitable trees (>3m tall with a trunk diameter at breast height > 0.5m) were scanned carefully for Raven nests. Territories were defined as follows:

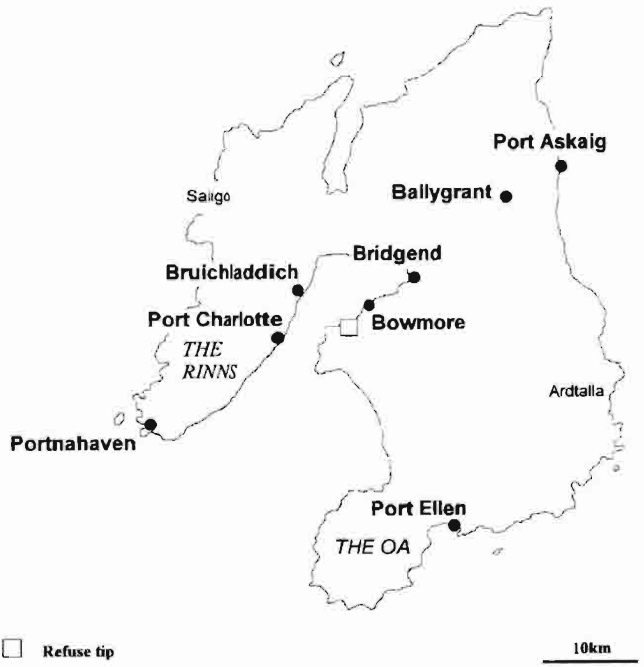
Breeding territories. Areas containing a nest, or cluster of nests, that were occupied by a pair of Ravens.

Apparently vacant territories. Areas containing one or more nests but which were apparently unoccupied by Ravens.

Non breeding territories. Areas where no nests were found in which territorial behaviour by a pair of Ravens was observed.

Follow up visits were made to all apparently vacant and non breeding territories, in order to confirm status. To test whether pairs roosted within their territories at night, a random sample of 8 breeding territories identified in October 1996 were visited at monthly intervals

Figure 1 ***Map of the Isle of Islay, showing place names mentioned in the text.***



until March 1997. During each visit, evidence of recent roosting (eg presence of Ravens at dawn / dusk, fresh faeces below roost ledges and branches) was recorded.

Non territorial Raven population size

The size of the non territorial Raven population was estimated from counts at a communal roost near Bridgend. A roost in this area had been known for at least 25 years. In 1996-97 it was located in tall mainly coniferous, trees at the edge of extensive policy woodland. Ravens were counted simultaneously from 2 vantage points (A and B), located 0.35km northwest and 1.25km south of the roost, respectively. Between them the vantage points afforded a comprehensive view of all the routes by which Ravens could enter or leave the roost area. Vantage point A was located at the same elevation as the tops of the trees used for roosting, whilst vantage point B was below tree top height. As a result, even quite low flying Ravens were silhouetted against the sky and therefore relatively easy to detect.

Two evening counts and one dawn count per month were undertaken. Counts were carried out during nil precipitation in a variety of wind conditions. Dawn counts were undertaken on the first suitable morning following a dusk count. Data from the April dawn count was excluded from analysis because count accuracy was probably affected by human disturbance. Evening counts commenced at least one hour before sunset and continued until no further Raven movements could be detected. On arrival, the observer at vantage point A counted any Ravens already present within the roost. Morning counts commenced one hour before dawn and continued until all Ravens had apparently left the roost. The roost was then entered in order to check that no further birds remained.

During counts, the number and flight direction of Ravens approaching or leaving the roost were recorded to the nearest minute. Observations from each vantage point were carefully synchronised so that the overall count could be adjusted to take account of any duplication. In cases where there was a discrepancy between observers in the number of Ravens involved in a particular movement, the higher figure was adopted. At dusk, Ravens that had flown to roost sometimes flew out again later, either to interact with incoming birds or forage briefly before returning to the roost. Birds leaving the roost in this way were deducted from the total.

A number of additional sites where local information and our own observations suggested that Ravens might roost communally were checked for evidence of occupation (eg faeces under potential roost trees / ledges, birds gathering at dawn / dusk). We made several observations in the late afternoon and early evening from various vantage points on the east coast of Islay, in order to confirm that Ravens from Jura did not routinely fly to roost at Bridgend.

Raven distribution

Information on the distribution of Ravens during daylight was gathered between October 1996 and April 1997 during 2 weekly systematic counts of wintering geese carried out by Scottish Natural Heritage. These were conducted from vehicles by teams of 2 observers following fixed routes within 6 areas (Fig 2). Between them, the routes covered virtually all roads and driveable tracks on the island. Each route was covered 13-16 times. Counters were asked to record the number and location of all Ravens seen on 1:25000 scale maps. Sightings were later transferred

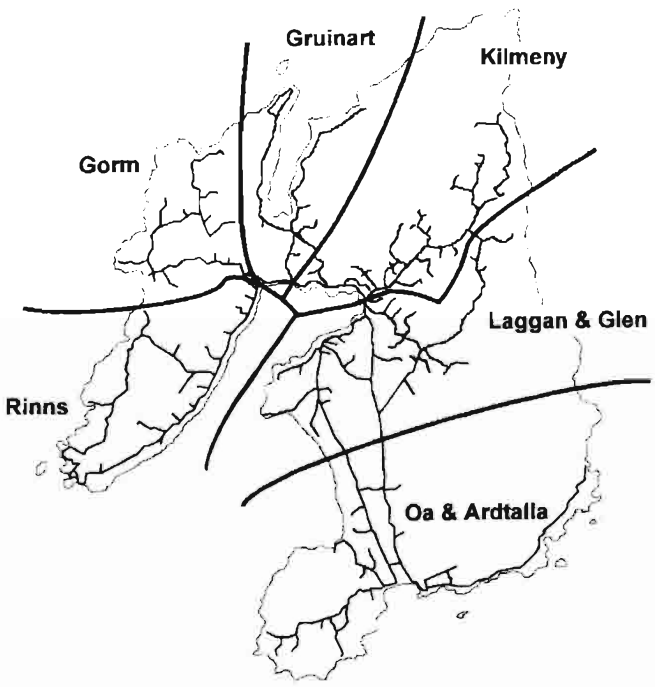
onto a map depicting the island as an array of grid cells, each cell representing 2x2km on the ground. Cells containing land which was >50% visible from the count routes ('observable cells') were determined in the field. The number of times each observable cell was surveyed (counting each cell once for every route) was calculated. Finally, an index of Raven abundance was determined, by dividing the number of Ravens recorded in each observable cell by the number of times that cell had been surveyed.

Habitat data were taken from a map of land cover compiled by Lyndsey Kinnes (Scottish Natural Heritage) using 1:24000 scale aerial photographs (Scottish Development Dept 1988), provisional soil maps (Macaulay Land Use Research Institute), 1:25000 Ordnance Survey maps and field surveys. Within each observable grid cell, the cover of 6 habitat types was recorded by eye to the nearest 5 percent. The habitat types recorded were:

1. Woodland.
2. Heaths, bogs and montane habitats.
3. Rough grasslands and bracken.
4. Improved grasslands.
5. Coastal dunes and cliffs.
6. Other, including marshes and anthropogenic features.

In addition, 3 topographic variables that were considered to have a possible influence on Raven use were recorded, measured at the centre point of each cell. These were altitude (m), distance from the communal roost (km),

Figure 2 ***Routes used to count wintering geese.***



and distance from the municipal refuse tip near Bowmore (km).

Results

Territorial Ravens

A total of 32 breeding territories, 3 apparently vacant territories and 2 non breeding territories were identified. Incubation was confirmed in all 32 breeding territories. On the basis of these observations, the density of breeding Ravens on Islay was estimated to be 0.04 territorial pairs km^{-2}. The distribution of breeding territories was predominantly coastal (Fig 3). Of 32 nests used in 1997, 75% were located on sea cliffs. The number of occupied nests per km of coast varied from 0.43 on The Oa to less than 0.07 along the south and north east coasts. Inland breeding territories were widely spaced. The mean nearest neighbour distance for 7 inland nests used in 1997 was 4.5km (range 2.4-8.2km). Five nests (16% of total) were located in trees, including Scots Pine, Beech and Oak. All tree nests were greater than1km from the coast.

Figure 3 ***Raven territories located on Islay in 1996-97.***

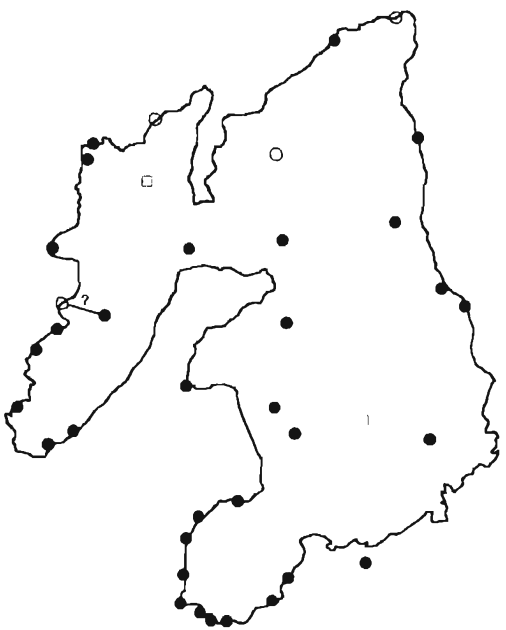
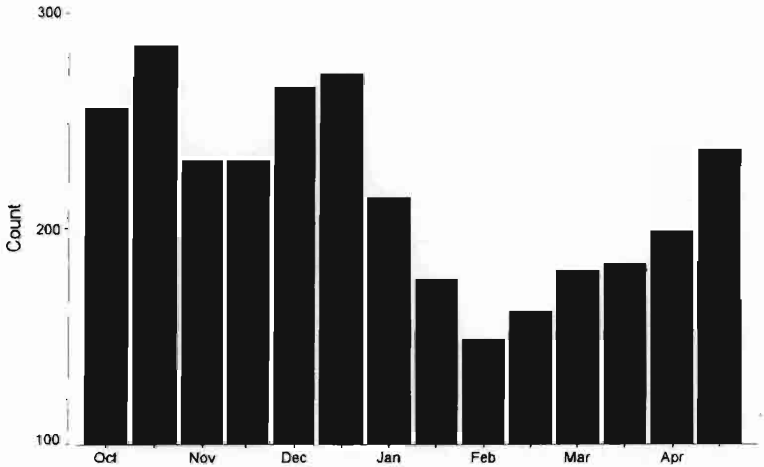


Figure 4 ***Numbers of Ravens entering the communal roost at dusk, 1996-97.***



Of the 8 territories selected for monthly monitoring, 7 were used for roosting by pairs of Raven throughout the winter. The remaining territory was used until February, when the pair disappeared and could not be relocated nearby. This territory was subsequently classified as vacant.

Non territorial Ravens

The number of Ravens counted entering the communal roost at dusk ranged from 149 to 285 (median 223.5, interquartiles 180-258.5, n = 14). From Oct-Dec numbers fluctuated between 230-280 birds (Fig 4). Numbers declined sharply in January, and only 149 Raven were present by early February. Thereafter, numbers increased steadily to nearly 240 by late April.

There was a high level of agreement in the number of Ravens counted at dusk and dawn in 5 out of 6 pairs of counts (Table 1). In the remaining pairing (Feb 9/10), 40% fewer Ravens were counted at dawn than the previous evening. However, it was strongly suspected that some birds had already left the roost before dawn observations began. Following dawn observations, no unaccounted Ravens were flushed when the roost was entered to check for birds remaining in the roost. Although this does not necessarily mean that all birds present in the roost at the beginning of dusk observations were visible from vantage point A, it is nevertheless reassuring.

Prior to roosting, up to 150 Ravens usually gathered at a hill summit 0.5km NW of the roost. These birds tended to enter the roost after most other Ravens, often in groups of 5-20 (exceptionally, 83). Of 1569 Ravens that flew directly to the roost, 49% comprised single birds and 37% were apparently paired. With the exception of a flock of 15 and another of 22, the remainder comprised groups of 10 or less. A consistently large proportion of birds approached the roost from the east, although a greater proportion arrived from the south and southwest on some count evenings (Fig 5). There was a statistically significant difference in the proportion of birds

Table 1 ***Numbers of communally roosting Ravens recorded during pairs of counts made at dusk and dawn.***

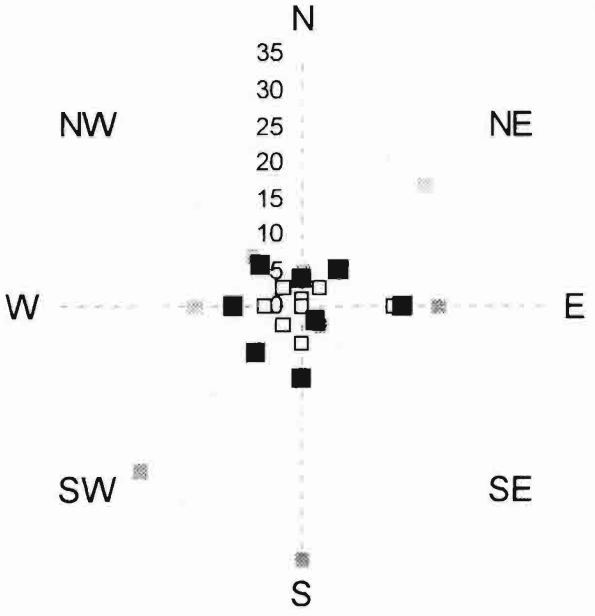
Date	Dusk	Dawn	Difference
21-23 Oct	256	251	-2%
25-26 Nov	232	256	+10%
6-7 Dec	266	263	-1%
5-6 Jan	215	242	+12%
9-10 Feb	149	90	-40%
10-11 Mar	181	170	-6%
		Mean*	12%

* *Ignoring direction of difference*

Table 2 ***Mean number of Ravens (±SE) recorded from 6 routes used to count wintering geese.***

Route	No of counts	No of Ravens	
		Mean	*± SE*
Gorm	16	13.88	*2.66*
Gruinart	13	11.54	*3.29*
Kilmeny	16	11.00	*2.58*
Laggan & Glen	15	26.47	*8.62*
Oa & Ardtalla	13	7.46	*1.59*
The Rinns	16	6.31	*2.25*

Figure 5 ***Flight direction of Ravens observed entering the communal roost at dusk on 14 evenings. The compass rose shows the number of birds that approached from each cardinal compass point as a % of the total that flew direct to the roost. Black squares identify the group median. Other squares indicate the upper (grey) and lower (open) quartiles.***



that approached from each cardinal compass direction (Kruskal-Wallis one way anova: X^2_7= 17.89, P = 0.012). Observations of Raven movements across the island early and late in the day were consistent with the assumption that Bridgend was the only communal roost site.

Distribution of Raven activity

A total of 1,143 Ravens were recorded from the routes used to count wintering geese. Ravens were recorded most often from the Laggan and Glen route, and least often from the Oa and Ardtalla, and The Rinns routes (Table 2). However, there was no statistically significant difference between routes in the number of Ravens recorded per count (K-W one way anova: x^2_5 = 8.38, P = 0.136, *ns*).

Of 203 2x2km grid cells containing land, 30% were classified as unobservable from the count routes and excluded from further analysis. These cells were mostly distributed in the northeast and southeast of the island and tended to be occupied by ground above 100m. All but 8 Ravens (0.6%) were recorded in grid cells classified as observable. Cells

Figure 6 ***Relative abundance of Ravens recorded during 2 weekly counts of wintering geese, 1996-97. Areas marked "X" were not visible from count routes.***

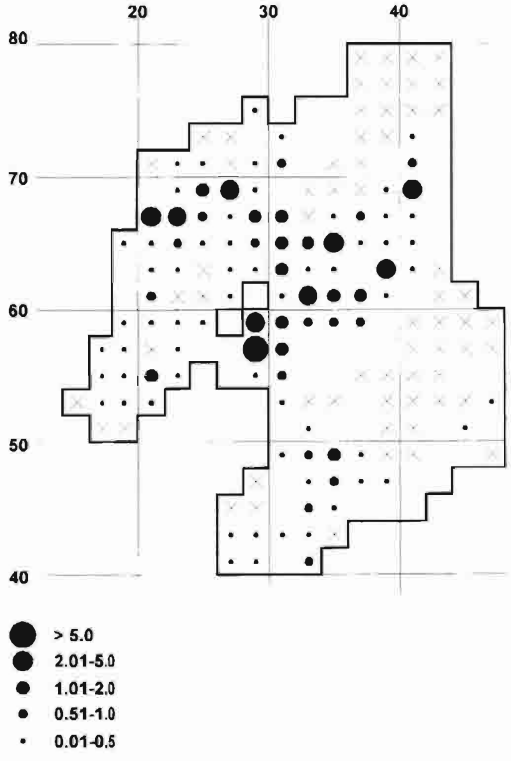


Table 3 ***Correlation coefficients between variables representing Raven abundance =and various measures of habitat and topography. Correlations with P<.001 are shown in bold. Variables were used in a multiple regression model to predict Raven abundance (see Appendix).***

	Index of Raven abundance	Altitude	Heath bog & montane	Improved grassland	Rough grass -land	Wood -land	Roost distance
Altitude	-0.19						
Heath, bog & montane	0.00	**+0.61**					
Improved grassland	**+0.42**	**-0.38**	**-0.37**				
Rough grassland	+0.18	**-0.30**	-0.18	**+0.43**			
Woodland	-0.08	-0.11	-0.17	+0.07	+0.20		
Roost distance	**-0.31**	+0.10	-0.09	**-0.30**	-0.16	-0.04	
Tip distance	**-0.35**	+0.24	+0.01	**-0.36**	-0.10	-0.05	**+0.55**

† Log transformed.

Table 4 ***Differences in habitat and terrain between 2x2km cells where Ravens were recorded, and where they were not. The table shows mean values (±SE).***

	Ravens recorded Mean	± *SE*	Ravens not recorded Mean	± *SE*
Percentage cover of:				
Woodland	8.1	1.5	9.6	1.9
Heath/bog	30.6	2.3	38.2	4.6
Rough grassland	13.9	1.0	11.7	1.1
Improved grass	18.5	1.3	6.3	1.0
Other habitats	8.5	0.8	7.0	1.1
Altitude (m)	57	71	5	1
Distance to roost (km)	11.0	13.1	0.6	0.8
Distance to refuse tip (km)	10.1	13.1	0.4	0.7

with most Raven sightings were distributed along 2 broad axes. These extended from Bridgend towards Saligo, and from the refuse tip towards Port Askaig, respectively (Fig 6). The axes intersected at the communal roost. This analysis indicated that Ravens were least abundant in the south of Islay and The Rinns.

Habitat and topographic variables differed between the observed cells in which Ravens were recorded and those in which they were not (Table 4). These differences were statistically significant in respect of improved grassland (Mann-Whitney U = 834.5, P < 0.0001) and distance from the refuse tip and roost (Student's t = 3.68, df. 139, P <0 .001 and t = 1.94, df. 139, P = 0.05, respectively). Other variables did not differ significantly between the 2 groups of cells (altitude: U = 1179.5, P = 0.41; woodland: U = 1917.5, P = 0.25; heath /bog /montane: U = 1920.5, P = 0.29; rough grassland: U = 1933.5, P = 0.31; other: U = 1891.5, P = 0.22).

After controlling for the effects of roost distance, variables representing the percentage cover of improved grassland and distance from the refuse tip were each found to have a significant effect on the number of Ravens recorded (see Appendix). The other variables tested did not have significant effects. Improved grassland was negatively correlated with roost and tip distance (Table 3). Despite this, improved grassland had a positive effect on the Raven index, whereas roost and tip distance each had negative effects. This suggests that the cover of improved grassland had a greater effect on Raven abundance as distance from the roost and tip increased. Taken together, the cover of improved grassland and distances from the roost and tip were relatively poor predictors of Raven abundance, between them accounting for only around one quarter of the variability in the Raven index.

Limitations of analysis

Few areas above 300m were visible from the count routes. It is possible that these areas were occupied regularly by Ravens that were not recorded. However, there is circumstantial evidence to suggest that this was not the case. Firstly, relatively few Ravens were seen flying over the skyline of ground within grid cells classified as unobservable. Second, few Ravens were encountered in upland areas during systematic searches for territorial pairs in October and April. Anecdotal information from stalkers and shepherds suggested that groups of up to 25 Ravens often made use of ephemeral food sources such as deer grallochs and carcasses, but that these birds were not present continuously.

Goose counters spent more time observing areas of improved grassland than other habitats, where there were fewer geese. It might therefore be expected that they were more likely to detect Ravens in improved grassland. Furthermore, an individual Raven may have been counted twice if it moved from view at one counting station to reappear at another counting station in the time it took to count a large goose flock. However, observers were highly experienced counters and aware of these potential sources of bias. Care was therefore taken to standardise search effort and take account of bird movements.

Discussion

The density of breeding Ravens on Islay does not appear to be exceptional in comparison with other parts of upland Britain. For example, Cross and Davis (1986) estimated there were 0.11 pairs km^2 in central Wales, ie 3 times the density on Islay. The density found in 11 Scottish studies reported by Ratcliffe (1997) ranged from 0.01 pairs km^2 in Sutherland to 0.10 pairs km^2 in Shetland, with a mean of 0.05 pairs km^2 (ie similar to that found in the present study). It is possible that we failed to identify some territories (especially inland), due to the difficulty of locating nests in wooded areas and the sometimes cryptic behaviour of territorial birds. However, all potentially suitable habitat was searched thoroughly, and we therefore consider that few territories were overlooked. Further survey in 1999 identified 2 additonal breeding territories that may have been occupied in 1997.

The large number of non territorial Ravens, many of which were paired and presumably seeking territories, suggests that the breeding population is close to the maximum that the island can support. The breeding population is probably limited by the availability of nest sites, especially inland where there are few trees or crags suitable for nesting. The

presence of 3 apparently vacant territories is consistent with studies elsewhere (eg Davis & Davis 1986, Ellis *et al* 1994), which have shown that all territories are seldom occupied in any one year. It is possible that the vacant territories found on Islay held insufficient food to maintain a resident pair of Ravens. This might be due to long term decline in territory quality, or to a temporary shortage of food in marginal territories. Alternatively, Ravens may have been victims of persecution by humans or territorial disputes with Golden Eagles *Aquila chrysaetos*. The latter is thought to account for the disappearance of Ravens in late winter from one of the 8 monitored territories.

We found no evidence that territorial Ravens used the communal roost, or that there were other communal roosts on Islay. Numbers at the roost were lowest in late winter, when it might be expected that the population as a whole was at its annual minimum due to winter mortality. However, numbers increased in early spring, indicating that birds which had roosted elsewhere, on Islay or beyond, began to enter the communal roost. Some pairs may have attempted to set up territories in late winter, when carrion was presumably relatively abundant, and then returned to the communal roost during spring as they lost interest in territorial behaviour and food became more ephemeral. Ratcliffe (1997) noted that, in some districts, non territorial birds become more dispersed in winter, and that single birds and pairs sometimes detached themselves from the main group. It is possible that some Ravens used one or more temporary roosts elsewhere on Islay during late winter. Although we found no evidence to support this, such behaviour has been noted in previous years (see Argyll Bird Report 1991). Alternatively, some non territorial birds may have left the island in late winter, and returned, or were replaced gradually during spring. The latter hypothesis is consistent with the findings of studies in Maine, US (Marzluff *et al* 1996), where the Raven population was shown to be extremely fluid, with groups moving large distances to establish new roosts in response to changes in food availability. If this occurs in Scotland, non territorial Ravens on Islay might be part of a population that covers most of Argyll and includes parts of Northern Ireland. However, this would require frequent large scale movements across the open sea, and current evidence suggests that this only occurs sporadically (eg Elliot 1989).

Roosts that consistently attract over 200 Ravens are scarce in Britain, although over 1,000 birds occupied one in north Wales in recent years (Ratcliffe 1997). In Argyll, roosts of up to 100 or so birds have been reported at Oban, Tobermory (Mull) and on the Kintyre peninsula (Argyll Bird Report 1987-92, 1996). Many of these roosts are associated with refuse tips. However, these roosts have a much larger hinterland from which to draw birds than the one at Bridgend. The size of the non territorial Raven population is of concern to stock managers, since the birds are potentially highly itinerant and communally roosting birds may share information on the location of food resources (Marzluff *et al* 1996). Thus, it might be possible for large numbers of Ravens to rapidly locate temporally and spatially restricted food sources, such as deer grallochs in winter or vulnerable young stock in spring. Similarly, concern has been expressed in some quarters that Ravens might affect bird species perceived to be of high conservation importance (eg some wading birds and seabirds, Chough *Pyrrhocorax pyrrhocorax*, and Hen Harrier *Circus cyaneus*), through the predation of eggs and young, and

disruption of nesting and foraging behaviour. However, there is as yet no unequivocal evidence for this.

It is important that losses of stock due to Ravens are rigorously investigated and quantified in order that current perceptions of predation, widespread among shepherds, can be tested. The non territorial population is large in relation to the size of the island, and these birds are probably most frequently involved in reports of stock losses. Ravens are wary birds and difficult to approach closely. As a result, licensed killing and illegal persecution may be directed mainly at territorial birds, which can be ambushed more easily near their nest sites.

Overall, the pattern of Raven distribution was associated with improved grasslands and distance from the refuse tip. The data suggest that territorial Ravens may have been relatively scarce in areas where overall abundance was greatest. This was probably because improved grasslands in general, and the refuse tip in particular, were located in low lying and treeless areas that provided few nesting opportunities. This is consistent with Davis & Davis (1986), who found that nonterritorial Ravens in central Wales tended to frequent places lacking nesting pairs. Non territorial Ravens may have simply avoided areas occupied by territorial pairs. However, we saw groups of non breeding Ravens close to nesting pairs on several occasions, with the resident birds apparently tolerating this intrusion.

Clearly, food resources are central to the question of why Ravens preferred improved grasslands. There are no published data on the diet of Ravens on Islay, and this should be a priority for future research. Elsewhere, Ravens feed on a wide range of prey, including sheep carrion, Rabbit *Oryctolagus cunniculus* and hare *spp*, small mammals, birds and various invertebrates (Ratcliffe 1997). Studies of winter diet based on analysis of regurgitated pellets have shown a preponderance of sheep (eg Bolam 1913; Newton, Davis & Davis 1982; Ewins, Dymond & Marquiss 1986) or lagomorph prey (eg Mattingley 1995; Marquiss & Booth 1986). On Islay, sheep carrion is more abundant in lowland pasture than elsewhere (D Carss, *pers comm*), and this is likely to be an important factor in explaining Raven distribution. It is also possible that foraging Ravens select improved grassland because invertebrate prey is abundant and carcasses of rabbits and hares are sometimes present.

It is widely believed that Raven numbers have increased throughout west Scotland in recent years. Possible reasons for this include increased availability of sheep and deer carrion, and increased scavenging opportunities at refuse tips. There are no reliable estimates of the size of the Raven breeding population on Islay prior to our study, although a partial survey in 1994 located c 20 territories (J Gordon, *pers comm*). Previous *ad hoc* counts of Ravens roosting communally near Bridgend indicate that at least 100 birds have roosted there since the early 1970s (M A Ogilvie, *pers comm*). However, the difficulties involved in accurately counting Ravens using the roost mean that earlier counts may have under estimated the number of birds actually present. Consequently, there is no conclusive evidence that the Raven population on Islay has increased, although it may have done so.

Conclusions

This study shows that the wintering Raven population on Islay comprises at least 64

territorial and up to 285 non territorial individuals. Territorial birds were mainly distributed around the coast, where nesting opportunities were greatest. Areas that were used most intensively by Ravens tended to be occupied by improved pasture habitats, or were located close to the refuse tip.

Acknowledgements

The data presented were gathered as part of a wider study of Raven ecology on Islay commissioned and funded by the Scottish Office Agriculture, Environment and Fisheries Department (SOAEFD) and Scottish Natural Heritage (SNH). We thank J Campbell (SOAEFD) and R McKenzie (SNH) for their support during this project. We are indebted to D Hayward, M A Ogilvie, C Cronin, R Lilley and the 1996-97 SNH goose counting team for assistance with fieldwork. Julia Welstead extracted the habitat data. The cooperation of Islay's farmers, landowners, estate managers and staff is gratefully acknowledged. M Marquiss and an anonymous referee suggested significant improvements to an earlier draft.

References

Argyll Bird Reports 1987-92 & 1996. Argyll Bird Club.

Bolam G 1913. *Wildlife in Wales*. Frank Palmer, London.

Boyd J M 1983. Natural environment of the Inner Hebrides – an introduction. In Boyd J M & Bowes D R (eds) *Natural environment of the Inner Hebrides*. The Royal Society, Edinburgh.

Cross A V & Daves P E 1986. *Monitoring of Ravens and land use in central Wales*. Unpublished report NCC.

Davis P E & Davis J E 1986. The breeding biology of a Raven population in central Wales. *Nature in Wales* 3: 44-54.

Elliot R E 1989. *Birds of Islay*. Christopher Helm, London.

Ellis P M, Okill J D, Petrie G W & Suddaby D 1994. The breeding performance of Ravens from a sample of nesting territories in Shetland during 1984-1993. *Scottish Birds* 17: 21-34.

Ewins P J, Dymond J N, & Marquiss M 1986. The distribution, breeding and diet of Ravens *Corvus corax* in Shetland. *Bird Study* 33: 110-116.

Marzluff J M, Heinrich B & Marzluff C S 1996. Raven roosts are mobile information centres. *Animal Behaviour* 51: 89-103.

Mattingley W A 1995. Winter diet of Ravens in Perthshire. *Scottish Birds* 18: 71-77.

Newton I, Davis P E & Davis J E 1982. Ravens and buzzards in relation to sheep farming and forestry in Wales. *Journal of Applied Ecology* 19: 681-706.

Ratcliffe D A 1997. *The Raven*. T & A D Poyser. London

Mike Madders, Carnduncan, Bridgend, Isle of Islay PA44 7PS
Fiona M Leckie, ITE, Hill of Brathen, Banchory, Kincardineshire AB31 4BY

Revised manuscript accepted August 1999

Appendix: Statistical regression of habitat and terrain variables on Raven abundance.

Least squares multiple regression was used to explain variation in the index of Raven abundance[2] (the continuous dependent variable). The independent variables were the percentage cover of 5 habitat types, altitude, and distances to (a) the communal roost, and (b) the refuse tip (see Table 3). The variable representing roost distance was forced into the regression equation, regardless of whether or not it was significant. This was justified because it was expected to be a nuisance variable with an important effect on Raven distribution. Other variables were entered using a forward selection procedure, with an F to enter value of 0.05 (entry) and 0.10 (removal). Scatterplots of residuals were inspected in order to check the data met the necessary assumptions.

The model selected 2 variables, representing distance to the refuse tip and percentage of improved grassland. Summary statistics are shown below.

	B	*Beta*	*T*	*Sig. T*
Roost distance	-0.005488	-0.074586	-0.785	0.4337
Tip distance	-0.020422	-0.222643	-2.391	0.0181
% improved grassland	0.011366	0.340916	4.351	0.0000
Intercept	0.442828		4.192	0.0000
			R^2 =	0.23

Thus, $\log y = 0.44 - 0.01^{\text{roost distance}} - 0.02^{\text{tip distance}} + 0.01^{\text{improved grassland}}$

With the variables representing roost and tip distance in the equation, R = 0.37, $F_{2,138}$ = 11.16, P < 0.0001. After the addition of improved grassland, R = 0.49, $F_{3,137}$ = 14.72, P < 0.0001.

[2] Log transformed.

Raven *Andy Dowell*

Barnacle Geese on the Solway: 1990-1996

J M BLACK[1,4], D PATTERSON[2,5], P SHIMMINGS[2,6] & E C REES[3]

There have been exceptionally large counts of Barnacle Geese wintering on the Solway Firth since 1994. The highest figure comes from 2 coordinated counts carried out during the 1996-97 winter, which gave an average of 23,000 birds. The possibility that the "extra" birds may have come from one of the other Barnacle Goose populations is considered. Ring resightings did not provide evidence for substantial immigration, but a short term movement of birds to the Solway Firth may have gone undetected due to the difficulty of reading rings on Rockcliffe Marsh. Mass autumn migration has occurred earlier in recent years but Barnacle Goose counts, both on the Solway Firth and in northeast Scotland, also indicate that some geese arrive later in the season. Moreover, it is possible that birds are still present on uninhabited islands off the west coast of Norway in autumn and early winter. This suggests that recent censuses on the Solway Firth have taken place prior to the arrival of the entire Svalbard population. More frequent coordinated censuses are needed to monitor any build up in numbers during the winter, and to describe any short term immigration from other populations.

Introduction

Record numbers of Barnacle Geese *Branta leucopsis* were counted on the Solway Firth during the 1996-97 winter. Two coordinated counts, carried out in December 1996 and March 1997, found an average of 23,000 individuals, a substantially higher figure than the 18,100 birds recorded during a more extensive coordinated census of the same area in October 1996. The coordinated census in the previous year came to only 12,700 (on 20 October 1995), although other counts in autumn and later in the season gave higher figures (Table 1). Normally estimates of population size, as determined by the coordinated censuses, give much smaller differences between years, averaging 668 birds (SE 113, n = 24 years), and ranging from 100-2,100 individuals, for consecutive seasons up to and including the 1993-94 winter. The first major rise in numbers occurred between the 1993-94 and 1994-95 seasons, with population estimates of 14,350 and 17,900 geese respectively. The largest increase recorded before 1994-95, when numbers rose from 8,400 in 1984 to 10,500 in 1985, was attributable to a massive recruitment of first year birds; 26% of the population (2,730 of the 10,500 geese recorded in 1985) were juveniles. The increases in 1994 and 1996 could not be explained by similarly exceptional breeding seasons, however, nor by exceptionally high survival rates in these 2 years (see below).

Table 1 ***Svalbard Barnacle Goose population parameters on the wintering grounds, 1990-1996. Asterisks denote calculated values (see text). Number of counts are indicated in parentheses. Final assessment indicates estimated population size determined by the coordinated censuses and coordinated counts.***

Year	Autumn assessment	Winter-Spring assessment	Final assessment	Proportion (%)of young: autumn(final)
1996-97	19,600[1]	23,000 (2)	23,000	12.1 (16.1)
1995-96	13,645[2] (2)	17,445 (2)	20,450*	15.7 (20.9*)
1994-95	13,450[2] (3)	17,900 (2)	17,900	7.3 (9.7*)
1993-94	14,350[2] (4)	10,900 (2)	14,350[3]	11.8
1992-93	13,200[1]	9,140 (2)	13,200	5.1
1991-92	13,300[1]	10,100 (4)	13,300	14.0
1990-91	12,100[1]	9,900 (6)	12,100	12.0

[1] = Coordinated autumn census across entire Solway. In 1996-97, an additional 1,500 birds thought to be from the Svalbard population, counted in other parts of Scotland at the time of the autumn census, are included in the autumn figures.
[2] = Mean of coordinated census total and of other autumn counts that exceeded numbers recorded during the census; ie favours higher value. In 1995-96, an additional 530 birds thought to be from the Svalbard population, counted in other parts of Scotland at the time of the autumn census, are included in the autumn figures.
[3] = A further 119 Barnacle Geese were reported to have "wintered in Norway in 1993"; from Myklebust et al *(1994). These were not included in the final assessment value.*

This paper documents the pattern of growth in the Svalbard Barnacle Goose population, and investigates the disparity in numbers in relation to the timing of the annual coordinated censuses, to determine if the censuses were being undertaken before all birds had arrived on the Solway Firth. It considers whether, as the Svalbard population grew, an increasing number of birds arrived later in the season, and also the possibility of immigration from one of the other Barnacle Goose populations in recent winters.

Background and counting techniques

The Wildfowl and Wetlands Trust (WWT) has been monitoring the size and breeding success of the Svalbard population of Barnacle Geese since 1959. Daily monitoring started in 1970, with twice daily counts from the tower at Eastpark Farm and annual co-ordinated censuses of the Solway Firth. The Svalbard population is one of 4 *Branta leucopsis* populations that occupy different breeding and wintering areas in western Europe. Its tendency to winter almost exclusively on the Solway Firth gives it one of the smallest ranges for any goose population in the world, making it easier to determine total population size through co-ordinated censuses of the birds in the wintering range.

Disturbance and exploitation of geese on the Solway Firth, where the saltmarshes were used as a firing range, resulted in the

Svalbard Barnacle Goose population declining in the early part of the century to only 300 birds by 1948 (Owen & Norderhaug 1977). The population responded to several conservation measures and increased in a step wise fashion over a 50 year period (Black 1998). Due to the increase in numbers, a proportion of the population has begun to nest and feed in areas that are beyond the limited traditional distribution (Owen *et al* 1987, Prestrud *et al* 1989, Black *et al* 1991). This has caused concern amongst local farming communities, both at staging sites and in the wintering range (Black 1998).

Methods used to count the geese have varied slightly over the years, mainly in response to the increasing number of birds wintering on the Solway Firth. In the early years of the study, total population size was determined by a coordinated census in October. Initially this involved counting geese at Caerlaverock, then visiting other sites in the area to check for additional birds. More systematic coverage of other sites was made from the mid 1980s, however, following the increase in population size to > 10,000birds in 1984 (Black 1998). The census now involves around 12 people counting birds at all major sites on the Solway Firth within a one-hour time period, with any goose movement between neighbouring sections being recorded and taken into account when determining the total numbers present. This is considered the most accurate way of assessing population size from the ground. From 1994-95 onwards, less extensive but more frequent coordinated counts were undertaken, in addition to the coordinated censuses, to verify census results and monitor changes in distribution. These counts ideally require 5 or 6 people covering all major sites used by the geese within a 2 hour time period, but with some less frequently used areas being omitted. Thus coordinated counts may miss a few goose flocks and, since a longer time period is involved, are more susceptible to double counting. Coordinated counts so far have been rather accurate, however; counts made in autumn 1995 and autumn 1996 were, on average, within 4% of the coordinated census figures recorded the following day.

The reassessment

The disparity in numbers between the 1995/96 and 1996/97 seasons could not be explained by a good breeding year with a large recruitment of goslings (Table 1), nor to a substantial reduction in adult mortality, which is already low (<10% per annum, see Pettifor *et al* 1998). Two further explanations therefore were considered, which might both be influencing the numbers recorded: mass immigration from one of the other 3 Barnacle Goose populations, and the possibility that the coordinated censuses were being conducted before all birds had arrived on the Solway Firth.

Potential immigration: the evidence

Each of the Barnacle Goose populations has a sample of marked birds, making it possible to assess the level of movements of birds between populations. Since the early 1990s, WWT has recorded more than 25,000 ring resightings of over 3,000 individuals on an annual basis; some 95-98% of marked individuals identified in one season are resighted in the next. Ring reading effort is greatest in the wintering grounds, particularly at Caerlaverock and Southerness, but annual expeditions to the spring staging grounds and biannual trips to the breeding grounds also have been undertaken.

The Russian and Baltic breeding populations, which winter in Germany and The Netherlands, were most recently estimated at 236,000 birds in January 1994 (B Gunter *pers comm*). Around 10,000 of these are from the Baltic breeding population, of which some 20% are ringed (K Larsson *pers comm*), giving c2,000 ringed birds in the Baltic breeding population in 1994. Of the remaining 226,000 Russian birds, approximately 89 should still be ringed, based on an annual mortality rate of 12% derived from 1978-84 data. Thus, only about 0.04% of the Russian birds were ringed in 1994. This gives an estimated 0.89% ringed birds for Barnacle Geese wintering in continental Europe. If the 5,000 extra birds seen on the Solway Firth in 1996-97 was due to immigration of geese from the continent, we would have expected to detect c1,000 extra rings if movement was mainly from the Baltic breeding population, 2 rings if they came from Russia, or 57 rings if there was a homogeneous mix of the 2 populations in the wintering range.

Given the high resighting rate for the 3,000+ ringed birds at Caerlaverock, it is likely that any new rings would have been read amongst geese using the reserve. Only 2 Baltic ringed birds were detected, however, and none of the birds ringed in Russia. The 2 Baltic breeding birds were first seen in the Svalbard population during the 1992-93 winter, and have been recorded on the Solway Firth each year since then. No other Baltic ringed birds have been identified in the Svalbard population, even during the 1994-95 winter, when the first substantial increase in numbers was recorded.

Studies of the Greenland breeding population of Barnacle Geese have included catching and ringing the geese wintering at RSPB Gruinart, Islay, in recent years. By 1994, 5% of 7000 birds at RSPB Gruinart were ringed, together with 1-2% of c20,000 geese wintering elsewhere on Islay. About 1 % of the remainder of this population (c18,000 geese in western Scotland and Ireland) have also been fitted with plastic rings (S Percival *pers comm*). We therefore would have expected to have recorded at least 50 extra rings on the Solway if the influx of 5,000 birds in 1996-97 was due to immigration from the Greenland population. Geese from the Greenland breeding population were recorded at Caerlaverock in 1965 (M A Ogilvie) and 1976 (M Owen), as were 5 birds in 1991-92, one in 1994-95 and 2 birds in 1995-96. Some immigration therefore seems to occur, but not on a scale that explains the recent population increase. The goose identified in 1976 remained in the Svalbard population, but all the other birds were recorded back on Islay the following winter (S Percival *pers comm*).

Thus, although some movement between populations has been recorded, the small number of birds identified on the Solway that had been ringed outside the range does not provide evidence for large scale immigration from the Baltic and Greenland populations. Difficulties in reading rings on the saltmarsh at Rockcliffe, however, means that the arrival of new birds to this part of the Solway would go undetected, particularly if it were for short periods late in the season. Some tentative support for the immigration hypothesis comes from counts of Barnacle Geese on Islay, which show that numbers there decline during the winter when the autumn population exceeds 20,000, and not when it falls below this level, but there were insufficient data for closer investigation of mortality or emigration with respect to initial population size (Choudhury & Owen 1993). Moreover, the

fact that few individuals in the Russian population carry rings means that we cannot readily dismiss the possibility of a large scale movement of these birds to the Solway Firth. The Russian population has been monitored closely in recent years so, if 5,000 birds were to move to Scotland for a prolonged period, the annual census of the Russian population would have indicted a phase of reduction or stability in numbers, rather than the continual increase in recent years (B Gunter *pers comm*). There remains the possibility that geese may arrive on the Solway Firth direct from Russian breeding grounds, but this is impossible to prove in the absence of a more extensive ringing programme.

Annual censuses

It was thought initially that the increase in goose numbers recorded during the 1990s could be attributed to the different counting methods used (described above), and particularly to bird movements influencing the coordinated count totals. The sustained increase between 1990-91 and 1996-97, however, indicates genuine growth resulting in a near doubling of the population over this period (Table 1). The high figures returned from the coordinated census in autumn 1996 confirmed 2 high coordinated counts made the previous spring, when an average of 17,445 birds were recorded in April. These counts awaited confirmation because the vast majority were recorded on Rockcliffe Marsh, which is a large expanse of saltmarsh and difficult to cover. The coordinated census in October 1995 had recorded only 12,700 birds, with coordinated counts at the time giving only slightly higher figures (averaging 13,115 with the census total; Table 1). Armstrong & McCaul (1995, 1996) had reported 2 high counts of the area in the previous winter, averaging 17,880 in February 1995. Two opportunistic (partial) counts by WWT also found an average of 15,100 in February 1995, which were similar to Armstrong & McCall's figures, but were again higher than WWT's coordinated census the previous autumn. The opportunistic and coordinated counts therefore indicated that, at least from 1994-95 onwards, good numbers of birds were arriving after the date of the coordinated census in autumn (Table 1). Lower mid winter and spring assessments before 1994-95 can be attributed to only parts of the Solway Firth being counted from mid winter onwards in earlier years.

Table 1 summarises the autumn and mid winter/spring counts, and indicates the final population estimate for each season, up to and including the 1996-97 winter. The coordinated census in autumn 1996 was 18,100. The coordinated counts obtained later in the year were averaged, giving a total of 23,000. This indicates that 4,900 birds arrived after the initial census. Certainly some 1,500 were recorded in other parts of Scotland in the third week of October, including: 800 at Loch of Strathbeg, 300 at Meikle Loch, 200 at Findhorn Bay, Moray, and 112 in the Montrose Basin. The proportion of juveniles also increased during the winter, from 12.1 % (n = 11,098 sampled in October) to 16.1 % (n=10,089 sampled in December and January), indicating the late arrival of some family parties. The proportion of juveniles recorded in 1994 and 1995 therefore was revised, adding the same proportional increase (of 33.06%) to the autumn values that had been observed between the autumn and mid winter estimates in the 1996-97 season. The final population estimate for the 1995-96 winter was also revised (Table 1), based on a population of 23,000 including 16.1%

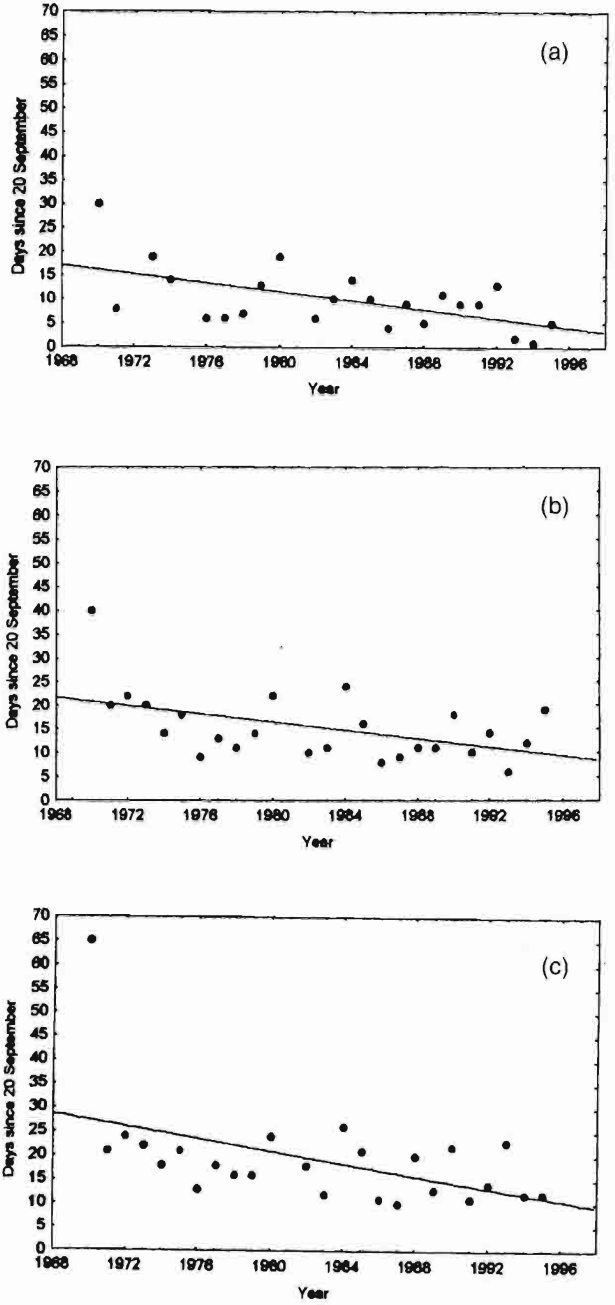


Figure 1 ***Arrival dates for Barnacle Geese at Caerlaverock:***
a) first 1000 birds
b) first 50% and
c) 75% of final population value.

juveniles in 1996-97, and an estimated annual survival rate of 94% (Pettifor *et al* 1998), since the spring 1995 counts were considered conservative and were made late in the season. Moreover, the difference in counts recorded in 1995-96 and 1996-97 had not been explained by mass immigration (see above), nor by observed breeding success.

Timing of arrival

What further evidence is there to support the suggestion that Barnacle Geese have been arriving later on the wintering grounds in recent years? The timing of autumn migration was investigated by plotting the arrival dates for the first 1,000 birds, and for the first 50% and 75% of the final population, each year from 1970 to 1996 (Fig 1). Results indicated that over this period most of the population arrived earlier, rather than later, at Caerlaverock ($r= -0.552$, $P<0.01$, $n=23$; $r=-0.482$, $P<0.02$, $n=25$ and $r= -0.470$, $P<0.02$, $n=25$ for the first 1,000 birds, first 50% and first 75% of the population respectively, Pearson correlations; Fig 1).Even when the exceptionally late 1970 season was excluded, the inverse correlation of arrival dates over time remained significant for the first 1,000 birds and for 75% of the population ($r= -0.431$, $P=0.05$, $n=22$; $r= -0.368$, $P=0.08$, $n=24$ and $r= -0\ 400$, $P=0.05$, $n=24$ in each case).

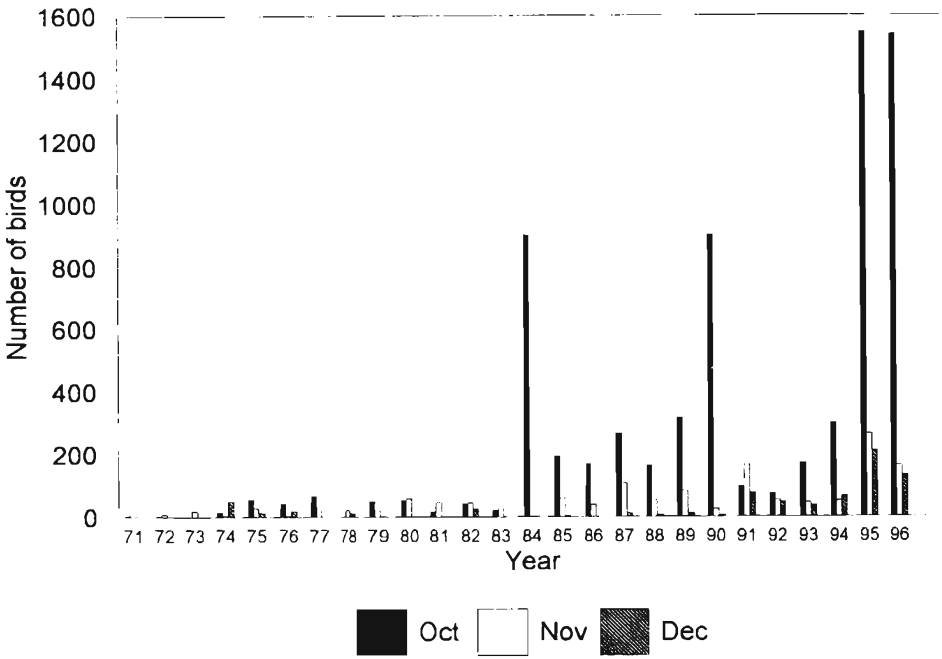
An assessment of the Wetland Bird Survey counts from November to March (ie months beyond the normal migratory period) indicates that the number of flocks in north eastern Britain outside the Solway Firth region has increased during the study period, with a mean of 5.8 (SD +/-3.87) other sites being used each year from 1971-1979 inclusive, 12.1 (+/- 3.93) other sites from 1980-81 to 1989-90 and 15.4 (+/- 3.82) other sites from 1990-91 to 1996-97. Moreover, the numbers recorded at these other sites has increased, particularly since 1984. At least 1,500 were still on migration in October 1995 and 1996, at the time of the coordinated census, and a few had still not arrived by December (Fig 2). This suggests that, although most of the Svalbard population has arrived earlier on the Solway Firth in recent years, there is an increasing tendency for some birds to lag behind and to trickle into the Solway during the mid winter months.

Conclusion

There have been exceptionally large counts and censuses of Barnacle Geese on the Solway Firth since 1994. Two coordinated counts returned an average figure of 23,000 birds in the 1996-97 winter. The low frequency of recording ringed birds from the other Barnacle Goose populations did not provide evidence for mass immigration, but it is possible that short term movements to Rockcliffe Marsh may have gone undetected.

Counts of Barnacle Geese during mid winter months in northeast Scotland indicate that birds have stayed at autumn migratory sites for longer periods in more recent years. Unknown numbers of birds may also be lagging behind on uninhabited offshore islands on the west coast of Norway. Delayed arrival or immigration is not unprecedented for the Svalbard population; G Harrison, counting the geese on the Solway Firth in 1964, reported that Barnacle Goose numbers at Rockcliffe Marsh in spring can, indeed, be higher than counts undertaken in autumn at Caerlaverock (Harrison 1974; see also Roberts 1966). More frequent coordinated censuses will be undertaken in future, with a view to monitoring any build up in numbers during the winter, and recording any short term immigration from other populations.

Figure 2 ***Number of geese recorded in northeast Scotland (excluding the Solway Firth) in October, November and December.***



The continued growth in the Svalbard population has been attributed to an increase in newly established colonies (Prestrud *et al* 1989), and to additional nests at long established colonies (Drent *et al* 1998). This, in turn, is linked with an increase in the breeding ratio (the proportion of successful breeders to potential breeders), and the proportion of juveniles seen in winter flocks (Pettifor *et al* 1998). There is some evidence to suggest, however, that increasing density in the breeding range is having a deleterious effect at some of the older breeding colonies (Black 1998). Several demographic changes have been noted, including an older age of first breeding, an increase in the number of non breeders, and an increase in gosling and adult mortality during migration. There is also evidence that the growth rate and final body size of geese reared at some colonies has declined over the study period - probably through increased competition for limited food on the brood rearing areas (Black *et al* 1998, Loonen *et al* 1997).

Acknowledgements

We thank WWT staff and volunteers for making coordinated counts and censuses

possible, in particular Steven Cooper, Carl Mitchell and Peter Williams, who helped to ascertain recent population sizes. Richard Phillips kindly prepared the figures and, with David Cope and Myrfyn Owen, made helpful comments on a draft of the text.

References

Armstrong R & McCaul C 1995. *Distribution of Barnacle Geese around the Solway Firth during the winter of 1994-5.* Report to SNH, Dumfries.

Armstrong R & McCaul C 1996. *Distribution of Barnacle Geese around the Solway Firth during the winter of 1995-6.* Report to SNH, Dumfries.

Black J M 1998. *Flyway conservation and management plan for the Svalbard Barnacle Goose population.* DN Report 22:1-100. Directorate for Nature Management, Trondheim.

Black J M, Deerenberg C & Owen M 1991. Foraging behavior and site selection of Barnacle Geese in a traditional and newly colonized spring staging area. *Ardea* 79: 349-358.

Black J M, Cooch E G, Loonen M J J E, Drent R H & Owen M 1998. Body size variation in Barnacle Goose colonies: evidence for local saturation of habitats. *Norsk Polarinstitutt Skrifter* 200:129-140.

Choudhury S & Owen M 1993. *Migratory geese wintering on Islay: assessing the impact.* Report to the Scottish Office. Wetlands Advisory Service Ltd., Slimbridge.

Drent RH, Black J M, Loonen M J J E & Prop J 1998. Barnacle Geese *Branta leucopsis* on Nordenskiöldkysten, western Spitsbergen - in thirty years from colonisation to saturation. *Norsk Polarinstitutt Skrifter* 200:105-114.

Harrison J M 1974. *Caerlaverock. Conservation and wildfowling in action.* WAGBI Conservation Publication, WAGBI.

Loonen M J J E, Oosterbeek K & Drent R H 1997. Variation in growth of young and adult size in Barnacle Geese *Branta leucopsis*: evidence for density dependence. *Ardea* 85:177-192.

Myklebust M, Byrkjeland S, Gylseth P H & Størkensen ØR 1994. Fugler i Norge 1994. Rapport fra Norsk faunakomite for fugl (NFKF). *Vår Fuglefauna* 18:303-322.

Owen M & Norderhaug M 1977. Population dynamics of Barnacle Geese *Branta leucopsis* breeding in Svalbard, 1948-1976. *Ornis Scandinavica* 8:161-174.

Owen M & Shimmings P 1992. The occurrence and performance of leucistic Barnacle Geese *Branta leucopsis*. *Ibis* 134:22-26.

Owen M, Black J M, Agger M C & Campbell C R G 1987. The use of the Solway Firth by an increasing population of Barnacle Geese in relation to changes in refuge management. *Biological Conservation* 39:63-81.

Pettifor R A, Black J M, Owen M, Rowcliffe J M & Patterson D 1998. Growth of the Svalbard barnacle goose Branta leucopsis winter population 1958-1996: an initial review of temporal demographic changes. *Norsk Polarinstitutt Skrifter* 200:147-164.

Prestrud P, Black J M & Owen M 1989. The relationship between an increasing population of Barnacle Geese and the number and size of their colonies in Svalbard. *Wildfowl* 40:32-38.

Roberts E L 1966. Movements and flock behaviour of Barnacle Geese on the Solway Firth. *Wildfowl* 17:36-45.

[1] *The Wildfowl & Wetlands Trust, Slimbridge, Gloucestershire, GL2 7BT*
[2] *The Wildfowl & Wetlands Trust, Caerlaverock, Eastpark Farm, Dumfries, DG1 4RS*
[3] *The Wildfowl & Wetlands Trust, Martin Mere, Burscough, Ormskirk, Lancashire, L40 0TA*
[4] *Department of Wildlife, Humboldt State University, Arcata, California 95521-8299, USA*
[5] *Findon Cottage, Clashmore, Dornoch, Sutherland, IV25 3RG*
[6] *Postboks 97, N-8860 Tjotta, Norway*

Revised manuscript accepted September 1999

Barnacle Geese *Myrfyn Owen*

Breeding population estimates for Lapwing, Oystercatcher, and Curlew in Scotland: results of the 1998 BTO Lapwing Survey

A M WILSON & S J BROWNE

Volunteer fieldworkers surveyed 142 tetrads in Scotland for breeding Lapwings during spring 1998, 118 of which were surveyed for other wader species also. Breeding populations of 69,800 pairs of Lapwings, 36,200 pairs of Oystercatchers and 32,000 pairs of Curlews were estimated in Scotland. The Lapwing population estimate is slightly higher than that for England and Wales in 1998, suggesting that the British population may now be less than 140,000 pairs. The estimates for Oystercatcher and Curlew are conservative. This suggests that previous estimates of the British population of Curlews may be too low.

Introduction

Lapwings *Vanellus vanellus* have been known to be declining in the British Isles for several decades, especially in England and Wales (Shrubb & Lack 1991, O'Brien & Smith 1992). This decline appears to have accelerated recently in England and Wales where there was a 49% drop in numbers between 1987 and 1998 (Wilson *et al in press*). There is little evidence for such large declines in Scotland where the RSPB and SOC surveys revealed a non significant 13% decrease in numbers in the Scottish lowlands between 1992 and 1997 (Tharme 1998).

Since the Lapwing was once a common and widespread bird on lowland farmland, its decline is important since it may reflect wholesale changes in farming practice in both arable and pastoral farming areas. Against this background, the British Trust for Ornithology (BTO) organised a survey of breeding Lapwings in Scotland in 1998 in conjunction with the BTO/RSPB survey of Lapwings in England and Wales. The aim was to provide a baseline population estimate comparable with that made for England and Wales. There have been several estimates of breeding Lapwing numbers on Scottish lowland farmland in recent years (Galbraith *et al* 1984, O'Brien 1996) but there has not been an attempt to estimate the population of the country as a whole. During the survey, other wader species were also counted as some of these also have substantial breeding populations in Scotland.

Methods

Field methods followed those used in the Lapwing survey of England and Wales in 1987 and 1998 (Shrubb & Lack 1991, Wilson *et al in press)*, where volunteers surveyed a single randomly selected tetrad (2x2km square) in each 10km square of the national grid. In addition to counting Lapwings, observers were given the opportunity to count all other wader species, although this was optional.

As it was not feasible to achieve as high a level of coverage in Scotland, which is less densely populated with volunteer fieldworkers than England and Wales, it was decided to restrict the survey sample size.

This was done by selecting a higher number of random tetrads in regions where occupancy by Lapwings was high during the 1988-91 Breeding Atlas (Gibbons *et al* 1993), than in areas where occupancy was low. The stratification was done using the 29 BTO regions of Scotland, which are loosely based on the old counties of Scotland, or subdivisions thereof. A Regional Index of Lapwing Occupancy (Regindex) was calculated from the 1988-91 Breeding Atlas data as follows:

Regindex = tetrads where Lapwings were seen / tetrads visited.

It was thought that a survey sample size of 300 selected tetrads would be sufficient. The number of tetrads selected in each BTO region was calculated as follows:

Number of tetrads selected in each BTO region = (Regindex / Totindex) x 300.

Totindex equals the sum of Regindex across 29 BTO regions. One tetrad was selected randomly from each 10km square and then the appropriate numbers of tetrads was randomly chosen from these for each BTO region. This resulted in a total of 281 tetrads being selected, some of the initial 300 were excluded as they were entirely in the sea. The surveys were carried out on a single day during April, to coincide with the peak egg laying period of Lapwings. Apparently breeding pairs of waders were plotted on maps and the total number of pairs estimated for each of the 4 x 1km squares in the tetrad. Observers were asked to visit all suitable breeding wader habitat within the tetrad, most of which was covered by scanning with binoculars from roads and paths.

As wader densities are more likely to be affected by landscape features such as land use, gradient and altitude than by geographical location, it was decided to analyse the data using Institute of Terrestrial Ecology (ITE) Landscape Types (Bunce *et al* 1996). This system classifies each 1km square into one of 4 Landscape Types: Arable, Pastoral, Marginal Upland and Upland. As ITE Landscape Types are given by 1km square rather than by tetrad, it was decided to analyse the bird data on a 1km square level. Separate population estimates were made for each of 4 Landscape Types within each BTO region as follows:

Population = mean count within 1km squares covered x total number of squares

This resulted in population estimates for each BTO region and Landscape Type; 108 strata in all as some BTO regions do not contain all 4 Landscape Types. However, as coverage was sparse in some regions, populations were estimated for only 60 of the possible 108 strata. Population estimates for strata where no 1km squares were covered were made by calculating a mean density in each Landscape Type across all regions covered and multiplying this by the area of each Landscape Type in regions not covered. There was no systematic bias in those regions where coverage was low. The Pearson Correlation Coefficient between the number of tetrads selected and the number of tetrads covered was not significant (r=0.10392).

Ninety five percent confidence limits were derived using the proportionately random bootstrap method to produce the upper and lower 2.5 percentiles of the frequency distribution estimates derived from 999 repeated simulations (Greenwood 1991).

Results

A total of 142 tetrads was covered for the survey representing 513 x 1km squares (55 squares were entirely in the sea). The proportion of squares covered falling into the Pastoral and Marginal Upland squares closely reflected the proportion of those Landscape Types in Scotland, but Arable squares were over represented and Upland squares under represented. However, as estimates were calculated by Landscape Type, an uneven spread of squares would not bias the population estimates. While all observers counted Lapwings, 17% of observers made no attempt to count other wader species, resulting in a smaller sample size of 424 x 1km squares for other waders (Table 1). Oystercatcher *Haematopus ostralegus* and Curlew *Numenius arquata* were found in a high proportion of squares, although there was insufficient coverage of other wader species to produce population estimates.

Oystercatcher was found to be the most widely distributed wader species with breeding birds found in 21% of 1km squares, marginally more than Lapwing which was found in 20.1% of squares (Table 2).

Curlew was found in 19.3% of 1km squares but was the most widely distributed wader in Upland squares. Overall population estimates were 33,554 pairs of Oystercatcher, 64,408 pairs of Lapwing and 32,413 pairs of Curlew (Table 2).

The Uists in the Western Isles are well known for their especially high concentrations of breeding waders (O'Brien 1996) but, unfortunately, no squares were surveyed there as part of the 1998 BTO Lapwing survey. Populations of Oystercatcher and Lapwing have been well studied on the Uists where the most recent estimates were of 2,726 pairs of Oystercatchers and 5,410 pairs of Lapwings in 1993 (O'Brien 1996). The populations of both species may have actually increased on the Uists since then (Fuller & Jackson *in press*). As the Uists form less than 4% of the land area of the Marginal Upland Landscape Type, it is reasonable to assume that excluding these islands from the analysis would have little effect on the population estimate for that Landscape Type. Adding the Uist populations to the totals in Table 2 would give Scottish population estimates of around 36,200 pairs of Oystercatcher and 69,800 pairs of Lapwing. Since Curlew have only recently colonised the Uists and remain

Table 1 ***Numbers of 1km squares covered for the 1998 Lapwing Survey in each of the ITE landscape types in Scotland.***

Landscape type	Number of 1km squares in which Lapwings were surveyed (% of total)		Number of 1km squares in which other wader species were surveyed (% of total)		% of Scotland falling into each landscape type
Arable	123	(24)	119	(28)	16
Pastoral	62	(12)	61	(14)	13
Marginal upland	109	(21)	84	(20)	23
Upland	219	(43)	160	(38)	48

Table 2 ***Population estimates of breeding Lapwing, Oystercatcher and Curlew in Scotland in 1998.***

Species & Landscape type	% squares occupied	Pairs found	Density (pairs per 1km²)	Population estimate (pairs)	Lower 95% confidence limit	Upper 95% confidence limit
Oystercatcher						
Total	21.0	186	0.38	33,554	21,810	48,226
Arable	25.2	54	0.45	6,596	3,377	10,208
Pastoral	21.3	14	0.23	2,527	998	4,168
Marginal Upland	23.8	55	0.65	11,660	5,124	18,380
Upland	16.3	63	0.29	12,771	9,623	16,071
Lapwing						
Total	20.1	338	0.66	64,408	33,809	104,567
Arable	27.6	98	0.80	11,463	6,036	19,738
Pastoral	19.4	40	0.65	3,732	1,026	8,178
Marginal Upland	21.1	103	0.94	21,740	7,665	40,726
Upland	12.3	97	0.44	27,474	9,542	48,136
Curlew						
Total	19.3	180	0.42	32,413	22,083	43,085
Arable	15.1	27	0.23	2,628	1,055	4,248
Pastoral	21.3	22	0.36	3,046	1,017	5,130
Marginal Upland	23.8	59	0.70	12,265	6,025	19,281
Upland	19.4	72	0.33	14,474	10,033	18,789

scarce around 26 pairs were located in 1998 (Rabbitts 1999), no adjustment to the Curlew population estimate from Table 2 was necessary.

Discussion

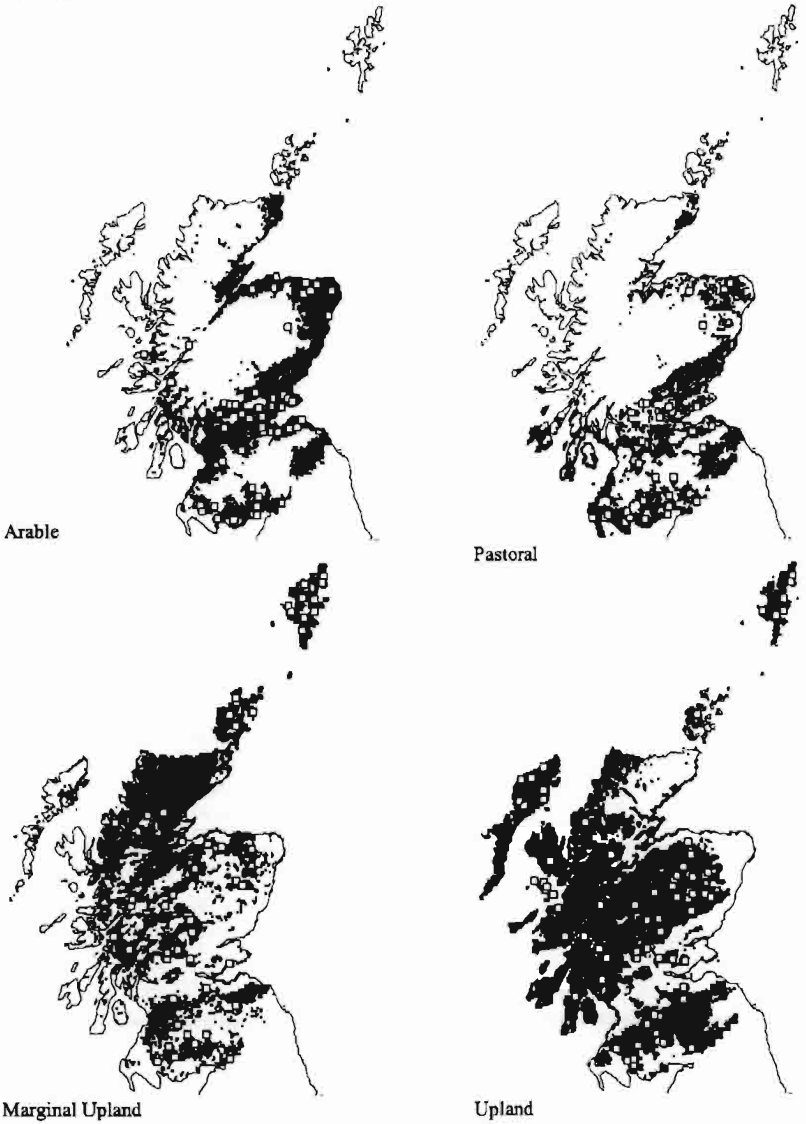
Population estimates for Oystercatcher, Lapwing and Curlew in lowland Scotland in 1992-93 were 82,500 pairs, 92,000 pairs and 35,000-55,000 pairs respectively (O'Brien 1996). The Scottish population estimates published here are lower than those for the Scottish lowlands in 1992-93 for all 3 species, although confidence limits overlap for Lapwing and Curlew. Populations of these waders showed no significant change in the Scottish lowlands between 1992-93 and 1997 (Tharme 1998) but Lapwings decreased by a statistically significant 28% on Breeding Bird Survey squares in Scotland between 1994 and 1998 while Oystercatchers decreased by a non significant 18% and Curlews by a non significant 10% over the same period (Noble *et al* 1999).

The 1992-93 estimates were derived from an RSPB/SOC survey of waders in lowland Scotland. The definition of lowland Scotland used in the RSPB/SOC survey was that from the Macauley Land Capability for Agriculture classification system and is impossible to compare with the 4 Landscape Types used in this paper. The Upland Landscape Type for example, includes most of the Scottish islands while the Marginal Upland Landscape Type also includes a large areas of lowland (Figure 1). The estimates of lowland populations from the RSPB/SOC survey was based on a definition of lowland Scotland covering 46.7% of the total area. The Arable and Pastoral Landscapes together make up just 29% of the total area of Scotland, so clearly, lowlands as defined by the Macauley system include considerable areas of Marginal Upland and Upland as defined by ITE Landscape Types. Since large parts of the Upland and to a lesser extent the Marginal Upland Landscape Types hold very low Lapwing densities, it could be argued that the RSPB/SOC survey did in fact cover a substantial proportion of the Scottish Lapwing population.

We suggest that the final estimate of around 69,800 pairs of Lapwings in Scotland from the 1998 BTO survey is not significantly biased. This total is more than the estimate of 63,000 pairs in England and Wales in 1998 (Wilson *et al in press*). This suggests that the British population of Lapwings is now less than 140,000 pairs - considerably less than the 185,000 -238,000 pairs estimated for 1988-91 at the time of the New Breeding Atlas (Gibbons *et al* 1993).

The population estimates for Oystercatcher and Curlew should, however, be considered too low. The estimate of 36,300 pairs of Oystercatchers is particularly low compared with the estimated 82,500 pairs in the Scottish lowlands in 1992/93 (O'Brien 1996). It should be noted that the RSPB/SOC surveys involved 3 visits to each 1km square and the estimates of Oystercatcher and Curlew numbers were taken as the maximum number on any one visit. The 1998 BTO survey involved just one visit, which would naturally lead to lower population estimates. Also, the BTO survey was designed specifically to locate breeding Lapwings and as such, underestimates of numbers of other species may have occurred for a number of reasons. Most importantly, the visits were timed to coincide with the peak period of nesting activity of Lapwings, which are earlier than that for Oystercatcher or Curlew (Cramp & Simmons 1983). It is also possible that observers put more effort into locating Lapwings than other waders and

Figure 1 ***Distribution of ITE Landscape Types and tetrads covered in the 1998 Lapwing survey. Black = Landscape type. White squares = tetrads covered in each Landscape type.***



they may have not surveyed some habitats that are unsuitable for Lapwings but are used by other species, notably shorelines and river channels which are favoured by Oystercatchers. It is also likely that some tetrads were not covered as they were deemed unsuitable for Lapwing, high moorland being one example.

Scotland does not appear to have suffered from the widespread loss of breeding waders on lowland farms that has been encountered in England and Wales, although there can be little doubt that large decreases have occurred in the more intensively farmed areas (Stan da Prato *pers comm*) and there is now good evidence of a decline in Lapwing numbers in Scotland during the 1990s (Noble *et al* 1999). However, due to the more rapid and long standing decline further south, Scotland holds an increasingly high proportion of the British population of several wader species, including over half the Lapwing population.

Since the estimate of 32,000 pairs of Curlews in Scotland in 1998 is undoubtedly too low, the most recent British population estimate of 33,000-38,000 pairs (Reed 1985) may be an underestimate since other parts of Britain, especially northern England also support large populations of breeding Curlews (O'Brien & Murray 1998, O'Brien *et al* 1998). Furthermore, Britain is estimated to support at least 35% of the European breeding population of this species (Piersma 1986), placing great importance on the Scottish population in particular.

The maintenance of mixed farming systems and traditionally managed grasslands are essential if numbers of these and other waders species are to be maintained. The designation of Environmentally Sensitive Areas in Scotland has the potential to benefit breeding waders (Picozzi *et al* 1996) but such schemes would have to become more widespread if the rapid decline in breeding Lapwing numbers evident in much of England is to be prevented from occurring throughout Scotland.

Acknowledgements

First and foremost we would like to thank the volunteer fieldworkers and regional organisers for completing the fieldwork. Many thanks to Simon Gillings, Su Gough, Dr Ian Henderson, Mark O'Brien, Dr Stan da Prato, Nicki Reed and an anonymous referee for many useful comments on drafts of this paper and Dr Rob Fuller and Dr Juliet Vickery for steering the BTO's Lapwing Survey from its inception. The 1998 Lapwing Survey in Scotland was funded by the Helen and Horace Gillman Trust and the BTO's Save Our Skylarks Appeal for research into farmland bird populations.

References

Bunce R G H, Barr C J, Clarke R T, Howard D C & Lane A M J 1996. ITE Merlewood land classification of Great Britain. *International Journal of Biogeography* 23:625-634.

Cramp S & Simmons K E L 1983. *The Birds of the Western Palearctic* Volume 3. Oxford University Press. Oxford.

Fuller R J & Jackson D *In press*. Changes in populations of breeding waders on the Machair of North Uist. Scotland, 1983-1998. *Wader Study Group Bulletin*.

Galbraith H, Furness R W & Fuller R J 1984. Habitats and distribution of waders on Scottish agricultural land. *Scottish Birds* 13:98-107.

Gibbons D W, Reid J B & Chapman R A 1993. *The New Atlas of Breeding Birds in Britain and Ireland: 1988-1991* T & A D Poyser, London.

Greenwood J J D 1991. Estimating the total number and its confidence limits. Appendix in Shrubb & Lack 1991. (see below).

Noble D G, Bashford R T, Marchant J H, Baillie S R & Gregory R D 1999. *The Breeding Bird Survey 1998. Report number* 4. British Trust for ornithology, Joint Nature Conservation Committee and Royal Society for the Protection of Birds.

O'Brien M & Smith K W 1992. Changes in the status of waders breeding on wet lowland grasslands in England and Wales between 1982 and 1989. *Bird Study* 39:165-176.

O'Brien M 1996. The numbers of breeding waders in lowland Scotland. *Scottish Birds* 18:231-241.

O'Brien M, Green M, Harris A & Williams I 1998. The numbers of breeding waders in Wales in 1993. *Welsh Birds* 2:35-42.

O'Brien M & Murray 5 1998. Estimating the breeding wader populations on farmland in northern England in 1993. *Wader Study Group Bulletin* 85:60-65.

Picozzi N, Cait D C & Cummins R P 1996. Breeding waders in the Cairngorm Straths ESA in 1995. *Scottish Birds* 18:197-204.

Piersma T 1986. Breeding waders in Europe: A review of population size estimates and a bibliography of information sources. *Wader Study Group Bulletin* 48, Supplement.

Rabbitts B 1999 (editor). Outer Hebrides (Western Isles) Bird Report for 1998.

Reed T 1985. Estimates of British breeding wader populations. *Wader Study Group Bulletin* 45:11-12.

Shrubb M & Lack P C 1991. The numbers and distribution of Lapwings nesting in England and Wales in 1987. *Bird Study* 38:20-35.

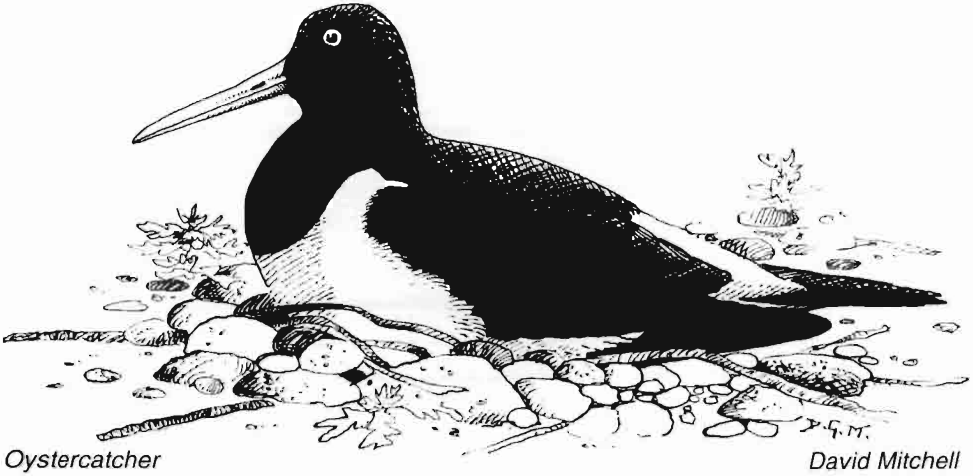
Tharme A 1998. RSPB SOC Lowland breeding wader survey of mainland Scotland 1997. *Scottish Bird News* 52:13. The Scottish Ornithologists' Club.

Wilson A, Vickery J & Browne S. The numbers and distribution of Lapwings nesting in England and Wales in 1998. In press. *Bird Study.*

A M Wilson, British Trust for Ornithology, The Nunnery, Thetford, Norfolk, IP24 2PU.

S J Browne, Game Conservancy Trust, Fordingbridge, Hampshire, SP6 IEF

Revised manuscript accepted September 1999



Oystercatcher *David Mitchell*

Bird numbers in an Aberdeenshire glen in March-June 1987-99

D JENKINS & A WATSON

Singing birds were counted in March-June 1987-99 by mapping territory locations. Birchwood held more birds per hectare than Pine or scrub, and woodland beside short grassland held most. Big areas of woodland or scrub had more species, but fewer birds per hectare, than smaller areas. Permanent pasture held more Lapwings than Oystercatchers, and arable land similar numbers of both. All species fluctuated in number from year to year, but 3 showed long term declines and 10 long term increases. Decline and recent increase in 3 other species were associated with stream pollution from acidification and later improvement in stream quality. Year to year change was related negatively in Wrens to snowfall (ie fewer after much snowfall), in Robins and Stonechats to the number of mornings with snow lying, and in Mistle Thrushes and Oystercatchers to frost. Several species, including Dunnock and Song Thrush, reported as declining in the UK, did not do so on the study area. Both it and nearby wintering areas lacked the profound farm and forestry changes typical of most of the UK.

Introduction

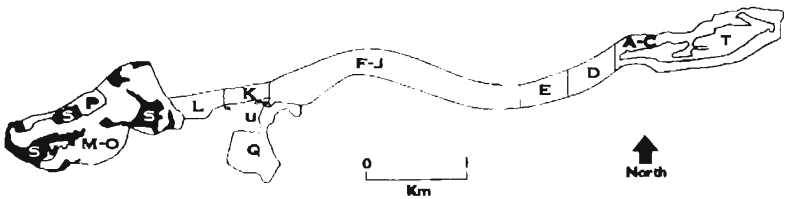
For 13 years the same observer (DJ) mapped singing birds in a narrow glen not subject to intensive farm and forestry practices. The aims were to record bird species and numbers in different habitats and to detect possible trends in numbers. Little is known of these topics in Scottish glens, save for grouse and raptors. Because hard winters can reduce bird numbers (Greenwood & Baillie 1991) and the study area is snowier and frostier than most parts of the UK, we compared changes in numbers with local records of snow and frost. Other workers' research on water acidity and invertebrates in our study area provided an opportunity to compare their data with stream bird numbers. As in most studies of bird numbers, our data are indices, not censuses.

Study area

This was 40 km west south west of Aberdeen in a narrow glen bottom of the Water of Feugh, a tributary of the River Dee. It lay over granite, the parent material for the glacial deposits and soils. Moorland above it was used for deer and grouse shooting, and some sheep in summer. It ran 9km along the Water of Feugh and Burn of Corn at 134-280m altitude. Five routes, each a day's walk, totalled 12 km, divided into 15 sections of 500m length and 7 other areas, which alone or combined formed habitat areas A-V (Fig 1, Appendix).

All Pine was Scots *Pinus sylvestris*, for brevity called Pine below, and all Birch *Betula pendula*. Many trees regenerated after 1945, as shown by maps, aerial photographs, and a survey in 1985 (Watson & Hinge 1989), but

Figure 1 ***Study area showing habitat areas A-C, D, E, F-J etc described in the Appendix. The study area comprised 15 x 500m sections A to O, and 7 other areas P and Q to V, which alone or combined formed habitat areas A-C, D etc.***



checks since 1985 showed no material change during the period of the present study. Most woodland and all scrub were natural, with more tree and scrub species, more varied age and understorey, and less bare ground than modern plantations. Understorey plants were mainly Gorse *Ulex europaeus*, Broom *Cytisus scoparius*, Bracken *Pteridium aquilinum*, Heather *Calluna vulgaris*, Blaeberry *Vaccinium myrtillus* and some Juniper *Juniperus communis*. Natural pinewood grew north of A-E, K and L, and south of A-D, and planted Pine and Larch *Larix decidua* north-east of A.

Young trees grew on all areas except fields, but browsing and fire prevented regeneration locally. Rabbits *Oryctolagus cuniculus*, Roe Deer *Capreolus capreolus* and Red Deer *Cervus elaphus* grazed all areas, with many Rabbits in fields. Sheep and cattle grazed M-O's fields all years, Q's in summer, and T's irregularly. Fires burned 2-3 ha of heather on F-J in March 1991 and 1996, after which a Wheatear *Oenanthe oenanthe* sang in 1996 and probably nested in 1999. Some scrub was cut on negligibly tiny parts of E and S.

Methods

Birds studied in all areas and years

DJ considered the Common Birds Census (CBC, Marchant 1983) unsuitable for this study in a long narrow area running through many habitats. While walking slowly with many stops, he plotted on 1:10 000 maps the locations of all singing birds heard up to 150m on either side, on each of 5 walk routes. The 300m width broadly coincided with the glen bottom. Some farmland was wider, but open terrain and few birds made it feasible to cover all of it. He began each walk within an hour of dawn in March-April and at 0600 in May-July. Mostly he walked the road from Finzean Sawmill west to Ballochan, but covered A-C and M-O by circuits. He used a telescope to check walk counts on M-O's fields and to count on Q's fields from a vantage point.

He walked each route on 4-5 days in 1987, 8-12 in 1988, and c17 annually in 1989-99 by weekly counts in 1 March-30 June. Even the 4-5 greatly exceeded the 2 now recommended (BTO 1996) for the Breeding Bird Survey (BBS), and the usual 17 exceeded the 10 which is the minimum of the CBC, so fieldwork was more time consuming than in the BTO national surveys. Also, the timing within an hour of dawn or at 0600 in summer was more stringent.

We regarded a species as territory holding if song was heard in 3 or more weeks in the same 500m section of a walk route. In a

preliminary account of the early years, Jenkins (1995) based each species' spring/summer total on the highest number repeated on at least 3 days on each route (eg 4, 6 and 5 would give 4), assuming that transients caused the peak of 6. This assumption could not be tested, and some routes covered several different habitats. Here, therefore, we use a different method: the highest spring/summer count for each species in each of the 15 sections and 7 other areas. It gives some confidence that totals by both methods are closely related, eg in Wren *Troglodytes troglodytes*, Robin *Erithacus rubecula*, Willow Warbler *Phylloscopus trochilus*, Blue Tit *Parus caerulea* and Chaffinch *Fringilla coelebs* (n = 13 years, r_s = 0.72 - 0.88, P < 0.02 - < 0.001).

Birds not studied in all areas and years

Notes below Table 1 show data on species not counted in all areas and years. No counts were made of: Siskins *Carduelis spinus*, often seen over all habitats but rarely heard singing; Crossbills *Loxia* spp in years when all were in flocks in June; the mainly crepuscular or nocturnal Tawny Owl *Strix aluco*, Woodcock *Scolopax rusticola* and Snipe *Gallinago gallinago*; Pheasants *Phasianus colchicus* and Grey Partridges *Perdix perdix* because gamekeepers released them; and Carrion Crows *Corvus corone* and Magpies *Pica pica* because keepers killed them. Apart from Kestrel *Falco tinnunculus*, Buzzard *Buteo buteo* and perhaps Sparrowhawk *Accipiter nisus*, raptors nested outside the area, and were counted by other observers. From 1992 the landowner forbade entry to wood P, but from nearby fields the observer noted birds singing in P, except Goldcrests *Regulus*

Table 1 ***Annual total number of territories, based on numbers of singing passerines, lekking Blackcock*** **Tetrao tetrix,** ***duck pairs, and nest sites in a gull colony to nearest 5.***

	87	88	89	90	91	92	93	94	95	96	97	98	99
Mallard	5	10	8	4	8	2	7	6	6	4	4	4	3
Goosander	5	7	8	5	9	4	5	2	5	4	2	1	2
Black Grouse*	37	28	19	26	17	26	24	23	28	21	20	18	16
Oystercatcher	10	11	15	14	13	12	14	11	11	9	5	7	7
Lapwing	12	13	13	15	19	22	15	16	17	15	9	9	11
Curlew	14	16	17	19	13	18	9	11	10	15	12	13	11
Common Sandpiper	1	1	3	3	0	0	2	0	0	2	1	0	0
Common Gull	30	30	50	55	25	15	10	5	5	0	0	0	0
Cuckoo	7	5	7	10	5	7	7	2	6	3	3	3	2
Tree Pipit	0	3	1	2	0	4	2	2	1	0	0	3	2
Meadow Pipit†	+	+	+	19	+	+	+	16	13	19	15	20	23
Grey Wagtail	3	9	14	15	7	7	7	3	5	4	6	14	11
Pied Wagtail	4	3	4	10	7	6	6	9	11	11	11	15	13
Dipper	5	6	8	6	9	4	6	4	3	5	7	10	9
Wren	23	46	58	76	40	64	59	43	51	43	63	81	92
Dunnock	9	10	10	15	15	12	14	23	16	6	9	23	24
Robin	27	17	37	46	35	43	40	32	44	29	55	76	76

Redstart	7	4	5	8	5	6	2	5	5	5	7	9	5
Whinchat	11	13	11	12	12	14	9	10	10	15	11	17	13
Stonechat	0	1	3	7	4	4	5	6	9	1	7	8	5
Blackbird	3	4	5	6	6	2	2	3	4	2	5	4	3
Song Thrush	16	6	21	13	23	18	12	12	13	10	12	23	28
Mistle Thrush	10	7	13	9	13	12	11	8	7	7	6	15	12
Willow Warbler	56	56	53	63	68	59	48	49	68	65	68	97	106
Spotted Flycatcher	3	3	5	8	4	6	10	5	15	10	5	16	16
Long-tailed Tit	0	4	4	2	4	4	2	2	0	3	3	3	1
Blue Tit	3	5	8	15	14	10	11	11	15	15	19	24	16
Great Tit	4	5	9	19	11	13	9	14	16	12	18	21	22
Treecreeper	10	5	7	3	8	11	10	12	12	7	9	14	14
Chaffinch	59	60	70	72	78	70	64	71	69	69	69	91	110
Yellowhammer	8	4	6	7	8	3	5	3	5	5	2	3	5
Goldcrest except P	0	0	0	3	0	1	5	2	4	1	12	12	13
Coal Tit except A-C	5	5	7	6	10	8	2	7	14	14	9	17	13
Greenfinch except P	0	0	1	1	2	0	1	2	2	2	3	2	4

** In the early 1990s a secondary lek became established nearby but outside the study area, and birds abandoned the study area lek in May 1999 after flooding.*

† *Birds present but not counted.*

Others: Redshank Tringa totanus *1 in 1991 and 95; Short-eared Owl 1 in 89 and 92; Great Spotted Woodpecker* Dendrocopus major *1 in 89, 93 and 95, 2 in 96 and 97, and 5 in 98; Skylark* Alauda arvensis *1 in 90 and 95; Sand Martin* Riparia riparia *3 in 95, 7 in 96; and 6 in 99; Wood Warbler* Phylloscopus sibilatrix *2 in 92 and 96; Chiffchaff* Phylloscopus collybita *1 in 99; House Sparrow* Passer domesticus *1 in 97, and 2 in 98 and 99; Linnet* Carduelis cannabina *2 in 90, 1 in 92 and 95, 4 in 98 and 10 in 99; Redpoll* Carduelis flammea *2 in 90, 1 in 91 and 98; Crossbill 1 in 97 and 3 in 98; Bullfinch* Pyrrhula pyrrhula *1 in 94 and 2 in 98. Others present each summer but counted only in a few years were Woodpigeon* Columba palumbus *12 in 98 and 9 in 99; Swallow* Hirundo rustica *in buildings 3 in 88, 7 in 98, and 6 in 99; Jackdaw* Corvus monedula *12 in 97 and 15 in 98; and Starling* Sturnus vulgaris *3 in 90, 4 in 93 and 96, 6 in 97, 10 in 98 and 2 in 99. Former residents were Red Grouse* Lagopus scoticus *on F-J until the mid 1980s and Grey Partridges on fields.*

regulus and Greenfinches *Carduelis chloris* which were not loud enough.

Of 35 species recorded irregularly, we regard those heard singing in only 1-2 weeks as not territory holding. A few Green Woodpeckers *Picus viridis*, Pied Flycatchers *Ficedula hypoleuca* and others sang in more than 3 weeks, but are excluded below because no females were seen. A pair of Short-eared Owls *Asio flammeus* that nested nearby in 4 years often hunted the area, and Wheatears sang on the area at times though mostly nesting outside.

Weather

Mr F Sheridan ran a station for the Meteorological Office at Bridge of Dye at 160m, where weather resembled that on our study area 7 km to the west. From his readings at 0900 daily we obtained maximum and minimum air temperature, precipitation, snow depth, and snowfall since the previous morning. We calculated the longest run of days with snow lying all day, given that snow one morning must lie all day if snow is lying next morning in the absence of a fresh fall. Because this proviso did not always apply, the longest run is a minimal value.

The range of November-April values for cumulative snowfall was 14-110 cm, mornings with snow 4-34, longest run 1-10, and cumulative frost 58-168 day °C below 0° (e g treating -2° on one morning as 2, and -1° next morning as 1, adding to 3 day °C below). Snowfall was related to the number of mornings with snow and *ln* longest run (r = 0.81 and 0.78, $P < 0.002$ and < 0.003), and the last 2 were related ($r = 0.94$, $P < 0.001$). Cumulative frost was poorly related to snowfall, mornings with snow, and *ln* longest run (r = 0.10, 0.21, and 0.14), as expected because frost often occurs without snow during winter anticyclones.

Table 2 ***Mean annual densities (number of territories of each species per 100 ha) in 10 woodland or scrub areas A-C to V, mean total density of all species, and number of species, with densities rounded to nearest whole number except in cases <0.5.***

	A-C	D	E	F-J	K	L	P	S	U	V
Area size in ha	30	15	15	75	5	10	6	30	1	2
Woodpigeon"	8	7	10	1	30	25	17	0	0	0
Green Woodpecker	0	1	0	0	0	0	0	0	0	0
Great Spotted Woodpecker	2	2	0	0.1	0	0	0	0	0	4
Tree Pipit	4	2	1	0.1	0	0	0	0.3	0	0
Wren	52	25	38	23	32	37	13	22	131	39
Dunnock	2	2	8	7	2	6	5	17	38	39
Robin	52	25	30	10	29	31	41	9	123	19
Redstart	15	4	1	0	2	2	0	0	0	0
Whinchat	0	0	2	15	0	0	0	3	0	0
Stonechat	0	0	1	6	0	0	0	0	0	0
Blackbird	10	1	0	0.2	0	2	1	1	0	0
Song Thrush	14	7	9	3	17	15	12	11	38	35
Mistle Thrush	10	6	4	0.2	14	13	13	5	46	31
Wood Warbler	1	1	0	0	0	0	0	0	0	0
Willow Warbler	45	33	50	22	59	47	87	27	115	73
Goldcrest	0.3	4	5	0.3	14	10	28	3	15	15
Spotted Flycatcher	15	6	4	0.1	6	15	1	0	15	0
Long-tailed Tit	6	2	2	0	0	2	1	0	0	0
Coal Tit	17*	14	11	1	25	17	22	0	8	15
Blue Tit	29	7	2	1	5	7	1	2	23	0
Great Tit	25	8	4	2	5	7	5	3	31	0

Treecreeper	19	8	1	1	8	12	5	0	0	8
Jackdaw+	42	0	0	0	0	0	0	0	0	0
Starling+	11	2	0	0	0	0	2	3	0	0
House Sparrow	1	0	0	0	0	0	0	0	0	0
Chaffinch	75	37	36	16	62	55^	110	27	177	119
Greenfinch	6	0	0	0	0	0	57	0	0	0
Linnet	0	0	0	0.2	0	0	0	1	0	0
Redpoll	0	0	0	0.1	0	1	0	1	8	0
Crossbill	0.3	1	0	0	0	0	0	0	0	4
Bullfinch	0.3	0	1	0.1	0	0	0	0	0	0
Yellowhammer	1	0	0	0	0	2	3	14	31	0
Total density	462	198	222	108	306	306	426	146	792	400
No. of species	27	23	20	22	15	19	19	17	14	12

*" 1998 and 99, * 1988-99 bar 1990, ^ 1988-93, and + 1998, 99 and some data in other 1990s years.*

The number of species was related to the area's size in ha (both ln, n = *10, r = 0.64, P = 0.045). The number of species per ha varied 48-fold in different areas. It was related negatively to the area's size (both* ln, r = *-0.99, P < 0.0001), i e more species per ha on small areas. Total density (the mean number of birds of all species per 100 ha) was related to area size and to number of species per ha (all* ln, r = *-0.80 and 0.85, P = 0.006 and 0.002). These relationships did not depend on the small 1ha area U and 2ha V, and still held when the analysis excluded both areas.*

Results

Number and density of species summering in woodland or scrub, and size of habitat areas

The number of species in woodland or scrub ranged from 12 on the small area V to 27 on the big A-C (Table 2). Big areas held more species but lower total densities (notes below Table 2).

Passerine density in woodland and wader density on farmland

Passerine density (the mean number of passerines per 100 ha) in Birch area A-C exceeded that in other woodland and scrub (Table 2). Area A-C had a higher density than D in all 13 years (Wilcoxon paired ranks T = 0, P < 0.003), and likewise A-C than K. Peak density was at U, a streamside hardwood belt with short grassland round it. Some species had high density in any woodland beside short grassland, eg Willow Warbler and Chaffinch at P, U and V. Greenfinches were at high density in Cypresses at P.

Permanent pasture on Q held more Lapwings *Vanellus vanellus* than Oystercatchers *Haematopus ostralegus*, but arable land on M-O had similar numbers of both (Table 3). Arable land held more Oystercatchers per unit area than on Q's pasture. Both species reared young in both habitats.

Fluctuations in numbers

All species fluctuated over the years (Table 1), Tree Pipits *Anthus trivialis* and Long-tailed Tits *Aegithalos caudatus* from 0 to 4, and Stonechats *Saxicola torquata* from 0 to

Table 3 ***Annual number of occupied Oystercatcher and Lapwing sites per 100 ha (rounded to nearest whole number) on area Q's permanent pasture and M-O's arable land including leys.***

	87	88	89	90	91	92	93	94	95	96	97	98	99	Median
Pasture, 26ha														
Oystercatcher	8	8	8	4	8	4	8	8	4	4	4	8	8	8
Lapwing	23	19	19	19	23	35	27	31	31	27	15	11	12	23
Arable, 49ha														
Oystercatcher	16	16	25	20	20	16	20	16	18	14	8	8	10	16
Lapwing	12	16	16	20	27	27	16	16	18	16	10	12	16	16

Most occupied Lapwing sites held pairs, but Oystercatcher sites often held singletons due to temporary absence of a partner feeding on farmland down Feughside and in nearby glens outside the study area.

On Q's pasture, Lapwing density exceeded that of Oystercatchers (n = 13 years, Wilcoxon paired ranks test, P = 0.0002). Area M-O had similar density of both. Lapwing density on Q tended to exceed that on M-O, but not significantly so. Oystercatcher density on M-O exceeded that on Q (P = 0.0004).

Area T's 14 ha of pasture (in 2 years barley) held no breeding Oystercatchers in 1987, 1997 and 1999, 2 in 1993, 3 in 1990 and 1992, and one in other years, and no Lapwings. Pastures of 1 and 1.2 ha below K and L, both overlooked by trees, had no waders.

9. The amplitude (highest value divided by lowest) was 8 in Blue Tits, 4.7 in Treecreepers *Certhia familiaris*, 4.5 in Redstarts *Phoenicurus phoenicurus*, 3 in Blackbirds *Turdus merula*, 1.9 in Whinchats *Saxicola rubetra* and Chaffinches, and 1.8 in Meadow Pipits *Anthus pratensis*.

We tested changes over the 13 year period by comparing the number singing with the year, treating 1987 as one, 1988 as 2 etc. They were related positively (increase) in Pied Wagtails *Motacilla alba*, Robins, Stonechats, Willow Warblers, Spotted Flycatchers *Muscicapa striata*, Blue Tits, Great Tits *Parus major* and Treecreepers (r_s =0.59 to 0.91, $P < 0.05$ to < 0.001). Goldcrests and Coal Tits *Parus ater* also increased ($r_s = 0.84$ and 0.74, $P < 0.001$ and < 0.01, excluding Goldcrests on P and Coal Tits on A-C because of no counts in some years). Wrens increased with year, though not significantly ($r_s = 0.52$, $P < 0.1$).

Goosanders, Oystercatchers, Common Gulls *Larus canus* and Cuckoos *Cuculus canorus* declined with the year (r_s = -0.64 to -0.93, $P <$ 0.05 to < 0.001), and Curlews *Numenius arquata* and Yellowhammers *Emberiza citrinella* though not significantly (r_s = -0.54, $P < 0.1$). The gull colony increased to 55 nest sites in 1990 but declined to none in 1996-99.

To find whether numbers changed in relation to winter weather, we used proportionate change in each species (one year's number

divided by the previous year's number). We compared this with the intervening winter's cumulative snowfall, number of mornings with snow lying, longest run of successive days with snow lying all day, and cumulative minimum air frost. Proportionate change in 5 species was strongly related to the intervening winter's factors of snow or frost. Because the weather factors were inter related, we used multiple regression to determine for each species which weather factor accounted best for the variation in proportionate change. The longest run of days with snow lying all day accounted best for variation in Wrens, the number of mornings with snow lying in Robins and Stonechats, and cumulative frost in Oystercatchers and Mistle Thrushes *Turdus viscivorus* (Table 4, Fig 2).

For other species, proportionate change showed only weak associations with the weather factors. Frost was negatively associated with proportionate change in Song Thrushes and Chaffinches (r = -0.43 and -0.42, $P > 0.16$), and the number of mornings of snow negatively with proportionate change in Great Tits (r = -0.44, P = 0.16). Most associations were negative, as expected from Greenwood & Baillie (1991), but some positive. All were far from significant. Even with species in Table 4, the variation accounted for by all the weather factors was only 27-48%, bar 84% in Oystercatcher.

Jenkins (1995) saw fewer stream birds in the early 1990s than previously, and Grey Wagtails and Dippers bred poorly. After

Table 4 ***Proportionate change in the number of singing birds on the study area from one summer to the next in relation to the intervening winter's number of mornings with snow lying, longest run of days with snow lying all day, and frost (cumulative number of day degrees with minimum air temperature below 0°C). Each value under a weather column shows the percentage of the variation in proportionate change that is accounted by that weather factor.***

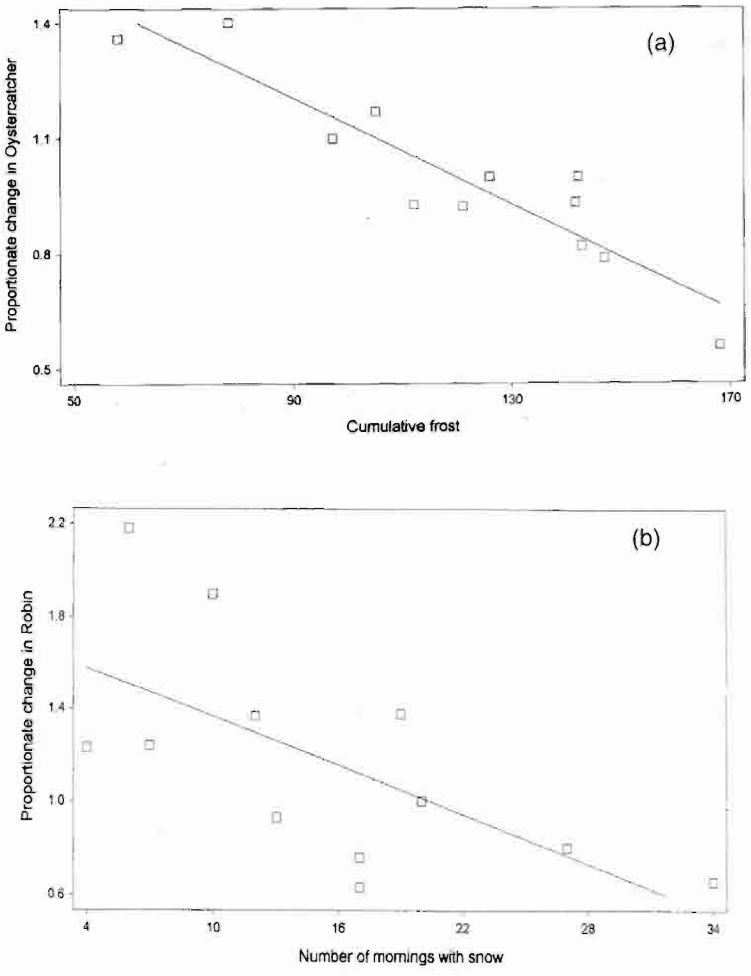
	Snow mornings	Longest run	Frost	*P*
Oystercatcher			84^	< 0.0001
Wren		27		0.049
Robin	41			0.015
Stonechat	48			0.011
Mistle Thrush			43	0.012

Data were transformed (ln) for proportionate change except in Oystercatcher. From multiple regression, data for each species show the adjusted R^2 under whichever weather factor accounted best for the observed variation in proportionate change (i.e. the highest R^2), and n = 12, bar 11 in Stonechat. Incorporating the other weather factors contributed 0 extra to R^2 in Oystercatchers, Robins and Mistle Thrushes. Incorporating the longest run contributed an extra 10% in Stonechats.

^ Scottish Oystercatchers winter south of Scotland (Goss-Custard 1996), but many inland breeders return in February to lower Deeside, frosty winters may coincide in Deeside and further south, and many died in lower Deeside during hard frost and snow in March 1980 (Watson 1980).

The 4 passerines were not seen on the study area in mid December-mid February save in mild winters.

Figure 2 ***Proportionate change in numbers from one spring/summer to the next, and weather factors in the intervening November to April inclusive, a) in Oystercatcher in relation to cumulative frost (total of day° of minimum air temperature below 0°C), and b) in Robin in relation to number of mornings with snow lying. The fitted regression line is shown.***



Common Sandpipers *Actitis hypoleucos* increased from a pair in 1987 and 1988 to 3 in 1989 and 1990, he saw none for 2 years, but later 2 in 1993 and 1996, and one in 1997. Grey Wagtails increased from 3 singing in 1987 to 15 in 1990, declined to 3 in 1994, and increased to 14 in 1998 and 11 in 1999. Dipper numbers were high in 1989-91, low in 1992-95, and high again in 1998 and 1999. Proportionate change in Grey Wagtail and Dipper was unrelated to snow or frost, but stream acidity may explain their changes in numbers (*see* Discussion).

Discussion

Number of species breeding in woodland or scrub, their density, and habitat area

The number of species was positively related to the size of the area of woodland or scrub, thus fitting the species/area relationship of more species on big areas (MacArthur & Wilson 1967).

The total number of birds per 100 ha was negatively related to the size of woodland or scrub areas. This is a common result when comparing densities in different studies, possibly due to observers choosing small patches because these have high density, or to small patches involving big edge effects where birds use ground outside (Gaston *et al* 1999). The former does not apply in our study, but the latter is inevitable in any small area. Small woodland areas P, U, and V lay beside fields and short grassland where some birds foraged after flying from the woodland. All 3 were narrow, where edge effects are bound to exceed those in square or circular areas. This is not a criticism of narrow areas, for it is realistic to expect square and circular areas to have higher local density at their edges than at their centres.

In woods further up Deeside, densities of selected species varied greatly between areas and years (D Jenkins and J Conroy, species Tables in Buckland *et al* 1991). The data are not strictly comparable with ours because their years differed (1980-84) and their Glen Tanar Pine and Crathie Birch are ancient woods. Most densities of selected species in ancient woods exceeded those in our more recent woods, by up to 2-4 times for the more abundant species. Total densities in ancient birch exceeded those in ancient pine (French *et al* 1986), and in ancient woods exceeded those in our woods by 1.2-fold in Pine and 2.6-fold in predominant Birch.

Proportionate change in numbers from one summer to the next

Snow or frost accounted well for proportionate change in numbers in Wrens, Robins, Stonechats, Mistle Thrushes and Oystercatchers. In the BTO data for England during more than 2 decades up to 1987-88, proportionate change in Wrens and Robins, and in several other species not in Table 4, was related to the number of days with snow (Greenwood & Baillie 1991). These authors suggested that other weather factors including frost appeared less important than snow, but did not analyse bird numbers and frost, and their measure of frost was the number of days with a grass minimum temperature below 0°C (ie not frost severity). Like us, they found that proportionate change in some species showed insignificant associations with snow, including a few associations with a positive sign.

Because hard winters in Deeside and England usually coincide, one might expect proportionate change in bird numbers in Deeside and England to be similar. The BTO sent us their CBC data for some species in

1987-95 for Scotland and 1987-96 for England, thus covering most years of our study. Because our data are not exactly comparable with BTO data, for instance because some BTO observers and sites changed between years, our analyses are tentative. Correlations in Dunnock *Prunella modularis* and Robin, where the BTO gave us data as examples, were very weak ($n = 9$ years with BTO Scottish data, $r = 0.18$ and 0.04). In the case of migrant species which winter in Africa, Deeside and UK birds may share migration and wintering grounds, but correlations between our data and BTO data in Willow Warbler and Spotted Flycatcher were again very weak ($r = 0.26$ and -0.41 with BTO UK data, and -0.02 and -0.004 with BTO Scottish data, $n = 10$ years with UK data and 9 with Scottish). Presumably our area was atypical of the lowland habitats which predominate in CBC plots, and certainly its lack of intensive farm and forestry practices fits this (below).

Decline and recovery of stream birds in relation to acidity

Soulsby *et al* (1997) measured acidity and invertebrate abundance in the Water of Feugh at Ballochan in the study area. An initial rise in acidity followed by a fall may explain the decline of stream birds noted by Jenkins (1995), and their later partial or intermittent recovery. Acidification in the early and mid 1980s coincided with declines of aquatic invertebrates, but in 1983-94 the acidity decreased and Mayflies *Ephemeroptera* increased in the Feugh and other Deeside streams over granite.

Comparison with national long term trends

Blue Tits increased on the study area over the 13 years, as in the CBC in the UK over 25 years (Marchant *et al* 1999). However, Lapwing, Dunnock, Song Thrush *Turdus philomelos*, Willow Warbler, Spotted Flycatcher and Goldcrest showed no obvious decline as reported for the UK (Gibbons *et al* 1993, Marchant *et al* 1999) and the last 3 species increased. Counts in a wood near Edinburgh also show no Dunnock decline (Smith & Appleton 1998), and data from the BBS show no decline of Song Thrush and Willow Warbler in Scotland (Anonymous 1999). Our study area lacked the heavy use of insecticide and herbicide which typify the UK and which especially affected southern England where most CBC plots have been sited. Because many species not seen in winter on our study area are known to winter on farmland and woodland at lower altitudes in Feughside and the Dee valley (Jenkins, unpublished), it might be argued that they might be affected there by intensive agriculture. However, these lower areas lie on infertile soils of class 3 or poorer, where stock rearing dominates farming (Black 1985). Because of the lack of intensive arable cropping, there has been far less pesticide use and other intensification there than on fertile arable soils in east Scotland and England. The study area's habitats remained broadly unchanged during the study, not subject to intensive forestry practices, intensive farming, or transfer of moorland to woodland or farm grassland. Hence the study area's birds form a useful 'control', compared with those on land more affected by the profound farm and forestry changes over much of the UK in recent decades.

Acknowledgements

We thank E Cameron for help with maps, R J Fuller, I Newton and S R D da Prato for comments, F Sheridan for weather data, J Watson for Fig 1, A M Wilson for BTO data, and landowners, gamekeepers and farmers for cooperation.

References

Anonymous 1999. The BBS perspective on Scottish breeding birds 1994-1998. *Scottish Bird News* 55: 3-4.

Black H L 1985. Agricultural land use beside the River Dee. *The Biology and Management of the River Dee* (ed D Jenkins) pp. 94-99. Institute of Terrestrial Ecology, Huntingdon.

British Trust for Ornithology 1996. *Breeding Bird Survey 1996 Instructions*. Thetford, Norfolk.

Buckland S T, Bell M V & Picozzi N 1991. *The Birds of North-East Scotland*. North-East Scotland Bird Club, Aberdeen.

French D D, Jenkins D & Conroy J W H 1986. Guidelines for managing woods in Aberdeenshire for song birds. In *Trees and Wildlife in the Scottish Uplands* (ed D Jenkins) pp 129-143. Institute of Terrestrial Ecology, Huntingdon.

Gaston K J, Blackburn T M & Gregory R D 1999. Does variation in census area confound density comparisons? *Journal of Applied Ecology* 36: 191-204.

Gibbons D W, Reid J B & Chapman R A 1993. *The New Atlas of Breeding Birds in Britain and Ireland*: 1988-1991. Poyser, London.

Goss-Custard J D (ed) 1996. *The Oystercatcher: from Individuals to Populations*. Oxford University Press, Oxford.

Greenwood J J D & Baillie S R 1991. Effects of density-dependence and weather on population changes of English passerines using a non-experimental paradigm. *Ibis* 133, supplement 1: 121-133.

Jenkins D 1995. Changes in numbers of some common birds in the Forest of Birse, 1987-1994. *North-east Scotland Bird Report* 1994: 66-71.

MacArthur R H & Wilson E O 1967. *The Theory of Island Biogeography*. Princeton University Press, Princeton.

Marchant J H 1983. *BTO Common Birds Census Instructions*. British Trust for Ornithology, Tring.

Marchant J, Sanderson F & Glue D 1999. Changes in breeding bird populations, 1997-98. *BTO News* 220: 10-14.

Smith B & Appleton G 1998. Every woodland tells a story. *Scottish Bird News* 51: 5.

Soulsby C, Turnbull D, Hirst D, Langan S J & Owen R 1997. Reversibility of stream acidification in the Cairngorm region of Scotland. *Journal of Hydrology* 195: 291-311.

Watson A 1980. Starving Oystercatchers in Deeside after severe snowstorm. *Scottish Birds* 11: 55-56.

Watson A & Hinge M 1989. *Natural Tree Regeneration on Open Upland in Deeside and Donside*. Institute of Terrestrial Ecology, Banchory.

Long-tailed Tit *Andrew Dowell*

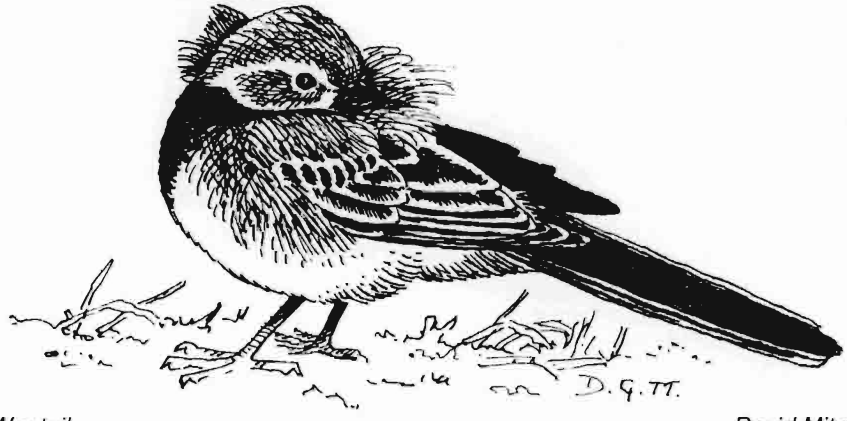
Appendix. Description of areas A-C to V, with the number of tree species in parentheses.

A-C Mostly mature Birch, understorey mainly Bracken (20)
D Birch and westwards mostly Pine, Gorse, Heather, Blaeberry and Bracken (7)
E Mature Pine and westwards Heather, Blaeberry, Bracken, young Pine, Gorse, Broom (14)
F-J Heather and Bracken with Gorse, Broom, Dog Rose *Rosa canina* and rushy flushes (8)
K Mostly mature Pine with much Larch (3)
L Mature Larch, understorey of Bracken and some Gorse (15)
M-O Rotating cereal, leys/hay and Turnips, and some permanent pasture (0)
P Planted mature Larch and Pine, and cypress *Chamaecyperus* (8)
Q Pasture since 1970 (0)
S Mainly grazed Grass with Gorse, Broom and Bracken, and trees scattered or in groups (14)
T Pasture (barley in 2 years) surrounded by A-C (0)
U Streamside belt, mainly Birch, Alder and Willow, with Broom, Gorse and Dog Rose (10)
V Mature planted Pine and Larch with some Broom and Gorse (9)

All areas bar P had streamside Alders, Willows and Birches, and all bar K, L and P had flushes with tall Rushes *Juncus* spp. All woodland had open glades, and A-C, K, L, P, S, U and V were near grass fields. The avenue of dense Cypresses in P was thinned after 1991. The linear R was the Water of Feugh and Burn of Corn. The study area included all the main tract of Birch in A-C and all the glen's farmland.

David Jenkins, c/o Department of Zoology, University of Aberdeen AB24 3TZ
Adam Watson, c/o Institute of Terrestrial Ecology, Banchory AB31 4BY

Revised manuscript accepted September 1999



Pied Wagtail *David Mitchell*

Breeding success of Red-throated Divers on Orkney Mainland, 1973-1998

C J BOOTH

The breeding success of Red-throated Divers on 8 hill lochans in the West Mainland of Orkney was monitored over a period of 26 years (1973-1998). Of a total of 201 breeding attempts, 58% were successful with 0.73 young and 1.23 young being fledged per attempt and successful attempt respectively. Comparing data for the 2 periods 1973-1985 and 1986-1998, no significant difference in breeding success could be detected in terms of number of breeding attempts, proportion of successful breeding attempts or the numbers of young fledged.

Introduction

In Britain the Red-throated Diver *Gavia stellata* breeds only in Scotland and Northern Ireland but the numbers in the latter province are probably less than 10 pairs (Gibbons, Reid and Chapman 1993). In Scotland the majority of breeding pairs are found in the Northern and Western Isles with others in the north and west of the mainland (Gibbons *et al* 1997). The favoured nesting habitats are the banks of small moorland lochs but some pairs nest on the shores of larger lochs.

The purpose of this paper is to document the breeding success of Red-throated Divers on 8 hill lochans in the West Mainland of Orkney during the 26 years between 1973 and 1998. Red-throated Diver nesting success in Britain is reported to have declined over the 15 year period 1980 to 1995 (Crick *et al* 1997) and in consequence the species is included on the 'medium alert' list prepared by the British Trust for Ornithology.

Study area

The lochans are situated in blanket bog on moorland in the West Mainland of Orkney, at heights of between 180 and 200 metres above sea level. The furthest distance between 2 lochans is 7 km and the shortest 400 metres and they are sited from 3.5 to 5 km from the sea. The areas of the lochans range from 0.011ha to 0.042ha and the depth varies between 0.5 and 1.5 metres. There is very little plant growth.

Methods

Human disturbance at nesting lochs of Red-throated Divers can affect breeding success (Booth 1982). In order to minimise disturbance from monitoring, no attempts were made to find nests with eggs. In May, each lochan was observed from a distance to establish if pairs were present. Further visits were undertaken in early July and then in early August to assess, again from a distance, the presence

Table 1 ***Annual breeding success 1973-1998.***

Year	No of pairs attempting to breed	No of successful attempts	No of young fledged	No of young fledged per attempt	No of young fledged per successful attempt
1973	8	7	7	0.87	1
1974	8	6	7	0.87	1.16
1975	8	6	9	1.12	1.5
1976	8	5	6	0.75	1.2
1977	8	2	2	0.25	1
1978	8	4	5	0.63	1.25
1979	8	6	6	0.75	1
1980	8	6	9	1.12	1.5
1981	8	5	6	0.75	1.2
1982	8	3	5	0.63	1.66
1983	8	4	4	0.5	1
1984	8	5	7	0.87	1.4
1985	8	5	7	0.87	1.4
1986	8	5	5	0.63	1
1987	8	4	7	0.87	1.75
1988	8	5	7	0.87	1.4
1989	7	4	5	0.71	1.25
1990	7	5	7	1	1.4
1991	7	4	4	0.57	1
1992	7	6	7	1	1.16
1993	7	3	4	0.57	1.33
1994	8	2	3	0.37	1.5
1995	8	2	4	0.5	2
1996	7	5	5	0.71	1
1997	7	3	3	0.42	1
1998	8	5	7	0.87	1.4
1973-98	201	117	148	0.73	1.23

of young and adult birds. If the lochan appeared deserted a search of the bank was carried out for signs of a nesting scrape. When young were present, their age was estimated and another visit made a few days before it was thought that they would fledge. A full grown young bird, showing no obvious sign of down, was recorded as fledged and the pair as being successful. The presence of a definite nesting scrape was considered to be a nesting attempt, although it was just possible that no eggs were ever laid. To look for a possible decline in breeding success, data were grouped into the 2 time periods, 1973-1985 and 1986-1998. Tests for significant differences were then undertaken

using chi-square analysis and, if $p > 0.5$, differences were taken to be not significant (Fowler and Cohen, BTO Guide No 22).

Results

Only one pair of divers was found nesting on a lochan in any one year. At 6 of the lochans, nesting was attempted in each year of the study. Of the other 2 lochans, one was abandoned from 1989-93 and the other 1996-97(Table 1). The clutch size of Red-throated Divers ranges from one to 3 eggs (Cramp 1977) but fledged broods of only one and 2 young were recorded on the monitored lochans. The total number of young reared to fledging annually varied from 2 to 9, whilst the number of young reared per breeding attempt ranged from 0.25 to 1.12 and for successful attempts from 1.0 to 2.0 (Table 1). Overall there were 31(26%) broods of 2 young and 86(74%) of 1 young.

A comparison of the breeding success in the 2 periods of the study showed no significant differences (Table 2).

Discussion

It can be expected that there will be some annual variation in breeding success but Table 1 shows that there are large variations from year to year in chick output from the monitored lochans (with peak productivity x 4.5 lowest). Only 2 young were reared in 1977, a time when egg collectors were particularly active in Orkney. Several clutches were thought to have been taken from the study lochans and this probably accounted for the very poor breeding success in that year. In a 10 year study in Shetland, a variation in the annual breeding success of Red-throated Divers was also found (Okill and Wanless 1990). The results from the Shetland study suggested less variability from year to year but this could be partly explained by different monitoring methods and because some failures may have been missed.

Overall there were fewer breeding attempts (97 compared to 104) during the second period of the present study and a lower proportion were successful (54.6% compared

Table 2 ***Breeding success in the periods 1973-1985 and 1986-1998.***

Parameter	Period 1973-1985	Period 1986-1998	Significance of difference
No of breeding attempts	104	97	ns
No (%) of successful breeding attempts	64 (61.5%)	53 (54.6%)	ns
No of young fledged	80	68	ns
No of young fledged per breeding attempt	0.77	0.7	ns
No of young fledged per successful breeding attempt	1.25	1.28	ns

to 61.5%. See Table 2). However, the observed differences between the periods are not statistically significant and are within the range attributed to chance variation. Therefore, there is no evidence of a decline in the breeding success of this monitored population in the West Mainland of Orkney over the period 1973 - 1998. This is in contrast to the trend noted for Red-throated Divers in Britain (Crick *et al* 1997).

Acknowledgements

I am very grateful to Dr Peter Reynolds for his help with the statistics and his comments on an earlier draft of this paper and to Dr Paul Heppleston for additional comments and advice. Dr S da Prato and an anonymous referee made further improvements.

References

Booth C J 1982 Fledging success of some Red-throated Divers in Orkney. *Scottish Birds* 12:33-38.

Cramp S (ed) 1977 *The Birds of the Western Palearctic* Vol 1. Oxford University Press, Oxford.

Crick H Q P, Baillie S R, Balmer D E, Bashford R I, Beaven L P, Dudley C, Glue D E, Gregory R D, Marchant C H, Peach W J and Wilson A M 1997. *Breeding Birds in the Wider Countryside: their conservation status* (1972 - 1996) BTO Research Report No 198. BTO, Thetford.

Fowler J & Cohen L *Statistics for Ornithologists.* BTO Guide No. 22.

Gibbons D W, Bainbridge I P, Thorne A P and Ellis P M 1997. The status and distribution of the Red-throated Diver *Gavia stellata* in Britain in 1994. *Bird Study* 44:194–203.

Gibbons D W, Reid J B and Chapman R A 1993. *The New Atlas of Breeding Birds in Britain and Ireland, 1988-1991.* T & A D Poyser.

Okill J D and Wanless S 1990. Breeding success and chick growth of Red - throated Divers *Gavia stellata* in Shetland 1979 - 1988. *Ringing & Migration* 11:65–72.

C J Booth, 34 High Street, Kirkwall, Orkney, KW15 1AZ.

Revised manuscript accepted September, 1999

Red-throated Diver *Andrew Dowell*

Persecution of birds of prey in north Scotland 1912-69 as evidenced by taxidermists' stuffing books

HENRY McGHIE

Persecution of raptors and owls was studied using the records of an Inverness based firm of taxidermists covering the period 1912-1969. A total of 767 birds of 14 species were submitted from north Scotland; many constitute hitherto unknown records of rare species. The numbers of birds submitted increased until 1930 and declined thereafter. The numbers of birds submitted were analysed in relation to vice county, land use and season. Persecution was most intense in East Ness but was also high in East Ross and East Sutherland. Records of Hen Harrier were analysed to chart the recolonisation of mainland Scotland by this species in the 1940s.

Introduction

The sporting estate developed as a major land use in Scotland from the beginning of the 19th century, when land vacated by the Highland Clearances was developed with wealth generated by the Industrial Revolution and the Agricultural Improvements (Prebble 1974, Temperley 1951, Brown 1976). The persecution of birds of prey was a routine part of land management and the populations of all birds of prey were reduced to varying degrees, with the possible exception of Kestrel *Falco tinnunculus* (Newton 1972). This persecution contributed towards some of the most drastic changes in the Scottish avifauna, and culminated in the extinction of 5 species of raptor as breeding birds in Scotland; bird of prey populations reached their nadir around the turn of the present century (Ritchie 1920, Baxter & Rintoul 1953). In spite of the importance of these changes to the ecology of the Highlands there is little quantitative information available. Information for the 19ths century is largely based on estate vermin lists, which some workers have considered to be subject to exaggeration (Pearsall 1952, Brown 1976, Nethersole-Thompson in Ratcliffe 1980) and other sources for this period relied on patchy or speculative information (eg Harvie-Brown and Buckley 1895). Declines in persecution in the present century are inferred from declines in gamekeeping which occurred after each of the World Wars, and the spread of many birds of prey into areas from which they were formerly extinguished (Watson 1977, Ratcliffe 1980, Tapper 1992), but few actual numbers of birds killed or rates of population increase are published (Newton 1972, 1979).

There were 2 large firms which offered a taxidermy service in the Highlands in the first part of the 20th century: John Macpherson & Sons (1887-1976) and Macleay's (c1850-1960s). Both of these firms were based in Inverness although a number of small firms operated for short periods both in Inverness and Dingwall. Macpherson's,

the larger of the 2 main firms, employed a resident taxidermist from 1912-67 and a visiting taxidermist from 1967-70; the firm remained open for business during both World Wars and was the only firm in operation after 1954. The taxidermists' records from Macpherson's were donated to Inverness Museum and Art Gallery in 1976; these consist of large ledgers or stuffing books which contain the details of every bird and mammal submitted for work and cover the period 1912-69. Each record consisted of the species, the date of submission and the name and postal address of the submitter; some entries were annotated as to the condition of the skin with regard to damage.

Methods

Records of raptors and owls (*Falconiformes* and *Strigiformes*) were extracted from the stuffing books for Caithness, Sutherland, Ross-shire, Inverness-shire, the Outer Hebrides and Skye on a Watsonian vice county basis. These were the counties which were naturally served by Inverness, and as very little taxidermy work was undertaken away from the Highland capital the bulk of work would have been likely to make its way there; Orkney and Shetland were excluded as there were firms providing a taxidermy service there in the earlier part of the 20th century. Whilst it was not implicit from the stuffing books that the birds submitted died as a result of persecution several lines of evidence indicated that this was indeed the case: the monthly pattern of submission of birds differed from the natural seasonal pattern of mortality (Newton 1979); the majority of birds were submitted by sporting estates or estate workers, and comments relating to damage generally referred to broken legs which would be consistent with birds having been trapped. Taxidermists' identifications were taken at face value.

It can be demonstrated for carnivores (McGhie and Moran *in prep*) that the majority of specimens were procured from the same area (same or adjacent 10km square of the National Grid) as that from which they were submitted and within one calendar month of the date of submission, with decomposition being an obvious consideration; the same situation was assumed to apply to birds of prey. One bird, a Red Kite *Milvus milvus*, was submitted from the same named locality, outside the area under study, as that from which it had been procured and 4 days later (*Scottish Naturalist* 1929). Stuffed birds, particularly birds of prey, were formerly much more popular than they are at present and Macpherson's often purchased birds from submitters to be sold as stock; it is likely that no ceiling was set by the firm which would limit the numbers of birds submitted and the stuffing books record all items which were submitted whether work was carried out or not.

The localities from which birds were submitted were traced using standard atlases (listed in references). Each locality was classified as being typified by upland, lowland or mixed land management practices in the early part of this century. The 'upland land use' class was defined as land managed primarily as grouse moor and/or deer forest in a locality ('locality' defined as circle of 3km radius centred on the place from which birds were submitted) with negligible or no agricultural land other than sheepwalk; the 'lowland land use' class was defined as land used solely for agriculture; localities which contained a combination of the aforementioned 2 classes were classified as being of 'mixed land use' class. Upland, mixed and lowland land use occupied approximately 60%, 30% and 10% respectively of the area under study. Areas

of lowland land use were restricted to the Firthlands; areas of mixed land use extended up straths and glens and around the coast, whilst the remainder consisted of land under predominantly upland land use. Estate forest plantations (State forests were largely developed after the Second World War) were most widespread in the 'mixed land use' class, but still common in the 'lowland land use' class. Birds submitted on the first of a calendar month were allocated to the previous month for analysis, as they would have been unlikely to be submitted for preservation on the same day as that on which they were procured, given the remoteness of the majority of localities from Inverness.

Results

Records relating to a total of 767 individual birds of prey of 14 species of diurnal raptors and 5 species of owl from the area under study were detailed within the stuffing books. Of these, 766 could be related to the locality of origin, 766 to the year and 760 the month of submission; records were well distributed throughout the area. Of these, 6 species of diurnal raptors were regular breeders within the area (Golden Eagle *Aquila chrysaetos*, Buzzard *Buteo buteo*, Sparrowhawk *Accipiter nisus*, Peregrine *Falco peregrinus*, Kestrel, Merlin *Falco columbarius*) as were 4 species of owl (Barn Owl *Tyto alba*, Tawny Owl *Strix aluco*, Long-eared Owl *Asio otus*, Short-eared Owl *Asio flammeus*). Three species were irruptive winter visitors (Rough-legged Buzzard *Buteo lagopus*, Gyrfalcon *Falco rusticolus*, Snowy Owl *Nyctea scandiaca*), 4 were rare migrants (Marsh Harrier *Circus aeruginosus*, Montagu's Harrier *Circus pygargus*, Honey Buzzard *Pernis apivorus*, Hobby *Falco subbuteo*) and 2 were formerly widespread breeders which had been confined to small areas (Hen Harrier *Circus cyaneus*) or wholly extinguished (Osprey *Pandion haliaetus*) as a result of earlier persecution but again established themselves during the period under study (status from Baxter and Rintoul 1953). The *Scottish Naturalist* was checked for details of each of the rarer species which were found in the stuffing books, but the only bird which was detailed was the Red Kite mentioned above; the birds mentioned within the stuffing books therefore constitute new records.

The numbers submitted of each of the regularly breeding species, with the exception of Barn Owl, increased between 1912-29 and declined thereafter (Table 1). More than 40% of the total numbers of each of these species were submitted between 1920-29; high numbers (>20% of totals) of six of the regularly breeding species continued to be submitted in the period 1930-39, during which period the greatest numbers of Barn Owl were submitted (31% of total). The numbers of birds submitted dropped dramatically after 1930-39 and dwindled thereafter until the period covered by the stuffing books drew to a close: less than 10% of the total numbers of each of the regularly breeding species were submitted between 1950-69. Only Montagu's Harrier, Hen Harrier, Osprey and Gyrfalcon had significant numbers submitted after 1930-39.

The greatest numbers of 9 of the 10 regularly breeding species (all except Short-eared Owl) were submitted from East Ness (vice county 96). The proportion of birds being submitted from East Ness declined steadily however: 47% of birds were submitted from the vice county in 1913-19, falling to 36%, 28%, 23% and 23% in the '20s, '30s, '40s

Table 1 ***Numbers of birds of prey submitted to Macpherson's 1912-69.***

Species	1912-19	1920-29	1930-39	1940-49	1950-59	1960-69	Total
Golden Eagle	45	73	25	6	9	3	161
Peregrine	31	63	26	9	2		131
Buzzard	18	51	23	11	4	1	108
Sparrowhawk	15	29	13	2		3	62
Kestrel	13	17	7	2	4		43
Merlin	7	14	6	2		1	30
Hen Harrier	1	3	2	3	2		11
Gyrfalcon		3		3		1	7
Rough-legged Buzzard	2	6					8
Osprey				2			2
Honey Buzzard			1				1
Marsh Harrier		1					1
Montagu's Harrier				1			1
Hobby		1					1
Tawny Owl	25	38	9	7	1	1	81
Barn Owl	15	14	16	4	1	2	52
Long-eared Owl	17	23	9				49
Short-eared Owl	4	6	4		1		15
Snowy Owl			3				3
Totals	193	342	144	52	24	12	767

and '50s respectively. Comparatively small numbers of all species, with the exception of Barn Owl, were submitted from Skye and only Gyrfalcon was submitted in a high proportion from the Outer Hebrides (Table 2). The commoner farmland species (Buzzard, Sparrowhawk, Kestrel, Barn Owl, Tawny Owl and Long-eared Owl) were mainly submitted from East Ross and East Ness although significant numbers were also submitted from East Sutherland. Large numbers of Barn Owl were also submitted from Skye. Three species (Hen Harrier, Short-eared Owl and Snowy Owl) were submitted in the greatest numbers from Caithness. Three of the 4 rare migrant species were only submitted from East Ness (Honey Buzzard, Marsh Harrier, Hobby) with the other being submitted from East Ross (Montagu's Harrier), whilst Rough-legged Buzzard was mainly submitted from East Ness and East Sutherland. Golden Eagle and Peregrine were submitted in the greatest numbers from East Ness (Table 2) and in greater numbers from each named locality within this vice county (Table 3), although large numbers of Golden Eagle were also submitted from West Sutherland and West Ross localities. A total of 12 peregrines were submitted from one named East Ness locality between April - June in 7 years between 1915-38, with 2 birds being submitted to Macpherson's together in April 1924, 1928 and 1938; low numbers of Peregrine were

Table 2 ***Numbers of birds of prey submitted to Macpherson's from each vice county.***

Species	Caiths	W Suth	W Ross	W Ness	Skye	O Heb	E Suth	E Ross	E Ness	Total
G Eagle	6	23	18	6	3	1	21	23	60	161
Peregrine	19	3	15	9	5	3	11	20	46	131
Buzzard	1	4	9	4	7	3	17	29	34	108
Sparrowhawk	3		9	2			6	11	31	62
Kestrel	4	2	3	2	3	1	1	11	16	43
Merlin	6	1	4		3	3	3	3	7	30
Hen Harrier	6						1	1	3	11
Gyrfalcon		1			2				3	6
Rough-legged Buzzard	1						3	1	3	8
Osprey		1							1	2
Honey Buzzard									1	1
Marsh Harrier									1	1
Montagu's Harrier							1		1	
Hobby									1	1
Tawny Owl	3	2	7	5	8		5	16	35	81
Barn Owl	1	1	8	7	11		1	7	16	52
Long-eared Owl	4	1	2		2	2	4	12	22	49
Short-eared Owl	7	1			1	3	2		1	15
Snowy Owl	3									3
Total	64	40	75	35	45	16	75	135	281	766

submitted from West Sutherland (Tables 2 and 3). Of 19 instances where 2 birds were submitted together between March - August, 5 instances were of Golden Eagle (one from East Ross and 4 from East Ness), 8 instances were of Peregrine (one each from West and East Ross and 6 from East Ness), 3 instances were of Sparrowhawk (2 from East Ross and one from East Ness), one instance was of Kestrel (from East Ross) and 2 instances were of Merlin (from East Sutherland and East Ness).

The greatest numbers of birds were submitted from localities typified by mixed and upland land use (Table 4 and 5). Very few birds were submitted from localities which did not agree with their published habitat requirements; for example, only 2% of Golden Eagle were submitted from areas of lowland land use, with which the species is not associated (Table 4). This further indicated that the majority of birds were submitted from the areas in which they had been procured. Two species, Golden Eagle and Peregrine, were mainly submitted from areas of upland and mixed land use (96% and 92% respectively); the majority (>50%) of Hen Harrier, Merlin, Kestrel, Barn Owl, Tawny Owl and Short-eared Owl were submitted from areas with mixed land use, as were high numbers (>40%) of Buzzard, Sparrowhawk and Long-eared Owl. Significant numbers of Sparrowhawk (37%),

Table 3 ***Number of years in which Golden Eagle and Peregrine were submitted to Macpherson's from each named locality.***

Species and vice county	Number of Localities	Number of years in which birds were submitted from an individual locality				
		1	2	3	4	7
Golden Eagle						
Caithness	6	6				
W Suth	16	11	5			
W Ross	14	11	2	1		
W Ness	6	6				
Skye	2	2				
O Hebrides	1	1				
E Suth	15	12	2	1		
E Ross	13	8	2	2	1	
E Ness	42	30	10	2		
Total	115	87	21	6	1	
Peregrine[1]						
Caithness	10	7	1	2		
W Suth	3	3				
W Ross	11	9	2			
W Ness	8	8				
Skye	4	4				
O Hebrides	3	3				
E Suth	9	8	1			
E Ross	10	9	1			
E Ness	26	20	5			1
Total	84	71	10	2		1

Notes: 1 Records for areas typified by upland or mixed land use from Feb-Sept only to exclude non breeding birds.

Kestrel (35%), Long-eared Owl (43%) and Tawny Owl (36%) were submitted from localities typified by lowland use given the restricted area of this land use type.

The seasonal pattern of submission varied between species and in relation to land use (Tables 4 and 5). In areas dominated by grouse moor and deer forest, the majority of Golden Eagle (53%), Peregrine (87%), Kestrel (100%) and Merlin (76%) were submitted between March-August. The majority of Sparrowhawk (60%) were submitted between September - February, whilst Buzzard was submitted in roughly equal numbers in spring/summer (40%) and autumn/winter (60%), with a slight peak in March-April and a slight low in July-August. In areas of lowland land use the majority of Peregrine were submitted between July-

August (60%) and January-February (20%) and Merlin were submitted between January-April (75%) and September-October (25%). Buzzard, Sparrowhawk and Kestrel were submitted more evenly throughout the year from agricultural land than in areas of grouse moor/deer forest. Areas of mixed land use generally showed patterns of submission intermediate between those from land managed as grouse moor/deer forest and agricultural land. All owls, except Short-eared Owl, were submitted in greater numbers

Table 4 ***Numbers of birds of prey submitted to Macpherson's in relation to land use.***

Species	Total	Lowland (10%)[1]		Mixed (30%)		Upland (60%)	
		Mar-Aug	Sept-Feb	Mar-Aug	Sept-Feb	Mar-Aug	Sept-Feb
		Percentage of each species					
Golden Eagle	161	2	2	24	21	32	19
Peregrine	131	4	4	29	18	39	6
Buzzard	108	9	18	14	30	11	18
Sparrowhawk	62	23	15	18	29	6	9
Kestrel	43	23	12	23	28	14	
Merlin	30	7	7	37	23	20	6
Tawny Owl	81	10	26	15	41	4	4
Barn Owl	52	8	8	18	46	10	10
Long-eared Owl	49	16	27	16	27	4	10
Short-eared Owl	15		7	40	46		7
		Number of each species					
Hen Harrier 1913-39[2]	8		1		4	1	2
Hen Harrier 1940-69[3]	8			4	2	2	
Gyrfalcon	5	1		2		2	
Rough-legged Buzzard	8			2	1	1	4
Osprey	2			1		1	
Honey Buzzard	1				1		
Marsh Harrier	1						1
Snowy Owl	3				3		

Notes: 1 Figures in brackets are approximate percentage of the total land area which each land use type occupied

2 Includes 2 birds from Morayshire (see Table 6)

3 Includes 2 birds from Morayshire and one from Aberdeenshire (see Table 6)

Table 5 ***Monthly pattern of submission of birds of prey to Macpherson's in relation to land use.***

Species	Land use type	Total	Jan-Feb	Mar-Apr	May-Jun	Jul-Aug	Sept-Oct	Nov-Dec
			Percentage of total submitted					
Golden Eagle		160	13	30	23	6	12	17
Peregrine	Lowland	10	20	10	10	30	30	
	Mixed	62	13	24	24	13	8	18
	Upland	59		37	50		8	5
Buzzard	Lowland	29	28	10	10	14	21	17
	Mixed	47	19	15	9	9	19	30
	Upland	30	17	20	17	3	26	17
Sparrowhawk	Lowland	23	4	13	22	26	13	22
	Mixed	29	4	10	21	7	41	17
	Upland	10			10	30	30	30
Kestrel	Lowland	15	7	27	27	12	27	
	Mixed	22	9	9	18	18	14	32
	Upland	6		34	16	50		
Merlin	Lowland	4	25	50			25	
	Mixed	18		28	11	22	28	11
	Upland	8	12	25		51	12	
Tawny Owl		81	24	10	6	11	21	28
Barn Owl		52	35	21	8	6	17	13
Long-eared Owl		49	22	12	12	12	22	18
Short-eared Owl		15	13		7	33	20	27
			Number of birds submitted					
Hen Harrier 1912-39[1]								
	Lowland	1					1	
	Mixed	4	1				2	1
	Upland	3	1	1				1
Hen Harrier 1940-69[2]								
	Lowland	0						
	Mixed	6		1	2	1	1	1
	Upland	2			2			
Gyrfalcon		6	1	5				
Rough-legged Buzzard		8	3	3				2
Osprey		2			2			
Honey Buzzard		1				1		
Marsh Harrier		1					1	
Snowy Owl		3						

Notes: 1 Includes 2 birds submitted from Morayshire (see Table 4)

2 Includes 2 birds submitted from Morayshire and one from Aberdeenshire (see Table 4)

during September-February; the more migratory Short-eared Owl was also submitted in high numbers between July-August.

The seasonal pattern of submission of Hen Harrier differed before and after 1946 (Table 6). Prior to 1946, of 8 records where the month of submission was known, 6 (75%) were submitted between Oct-Jan, one was submitted in Feb and one was submitted in March and none were submitted between April-August. After 1946, of 9 records, one was submitted between Oct-Jan, one was submitted in Feb, and 7 (78%) were submitted between April-August. This difference was statistically significant when records for Sept-Feb and Mar-Aug were compared for the 2 periods (chi-squared, 1 degree of freedom, $P<0.01$).

Discussion

Two factors affected the numbers of birds submitted: persecution pressure and the population size of each species. In addition to this, species varied in their desirability as trophies (and consequent financial value): it was not surprising that the 2 species submitted in the greatest numbers, namely Golden Eagle and Peregrine, were those generally considered to be the most 'majestic'. Rare species such as Hobby, Montagu's Harrier and Honey Buzzard, whilst not generally considered to be particularly 'majestic', would have been desirable as curiosities. Thus, different proportions of the numbers of each species which fell into human hands would have been likely to be submitted for preservation. As a result of

Table 6 ***Details of all Hen Harriers submitted to Macpherson's.***

Locality	Vice county	Date of submission	Land use type	Sex/Age
Feshie Bridge	East Ness	30/1/15	Mixed	
Edderton	East Ross	12/10/21	Lowland	
Dumphail	Moray	25/11/21	Upland	
Stanstill	Caithness	18/12/26	Mixed	
Pitcroy, Blacksboat	Moray	5/3/27	Upland	
Kildonan	E Sutherland	14/2/29	Upland	Male (imm)
Bettyhill	Caithness	20/10/30	Mixed	
Leys	East Ness	1934	Lowland	Male
Forss	Caithness	16/12/40	Mixed	Male
Clashindarroch	Aberdeenshire	23/5/46	Upland	Male
Dallas	Moray	8/6/46	Mixed	
Dallas	Moray	25/4/47	Mixed	Male
Berriedale	Caithness	26/5/47	Mixed	
Halkirk	Caithness	20/8/48	Mixed	
Islay		11/2/49	Mixed	Female
Lochindorb	East Ness	18/5/54	Upland	Male
Islay		22/7/56	Mixed	Male
Pentland	Caithness	6/10/59	Mixed	Female

Notes: 1 Recorded as having "both legs broken"

this, the numbers submitted of each species were not directly comparable with each other, but intraspecific comparisons between different areas and different time periods were considered permissible. The high proportion of Hen Harrier, Merlin, Short-eared Owl and Snowy Owl submitted from Caithness, and of the more familiar farmland species from the Firthland vice counties may reflect the higher numbers of these species found there, whilst the low proportion of Peregrine which were submitted from West Sutherland possibly reflects the low density which occurs in that vice county (Ratcliffe 1980). The different seasonal patterns of submission of Peregrine and Merlin in areas of differing land use were probably related to the seasonal presence of these species in these areas (Table 5).The high numbers of Golden Eagle and Peregrine, both species which would have been valuable as mounts, which were submitted give some idea of the intensity of persecution which the populations of these and probably other species underwent, even allowing for the fact that not all birds of prey which fell into human hands would have been fit for preservation (see especially Table 3).

Persecution of birds of prey was reduced during the years of the 2 World Wars as gamekeepers were called up for service, allowing some species to increase (eg Newton 1972, Watson 1977, Ratcliffe 1980). Changes in social structure following each of the World Wars resulted in declines in gamekeeping: there were 23,056 gamekeepers in Britain in 1911, 13,350 in 1920 and 4,391 in 1951 (Tapper 1992) and this would have presumably resulted in declines in persecution. The numbers of birds submitted were thus more closely related to overall levels of persecution and not related to the species' population sizes for the period 1913-1950. The exception to this may have been the Barn Owl: the different pattern of submission of this species, peaking in the 1930s, may have been due to widespread declines of this species in the 1920s which Blaker (1933) and Shawyer (1998) attributed to climatic factors. Birds of prey did not receive complete legislative protection until 1954 with the Protection of Birds Act, although Sparrowhawk was not included until the Act was amended in 1968; the Protection of Birds Order for Inverness-shire (1951) was important enough to everyday life as to occupy 2 pages of the Inverness Courier, complete with the Gaelic name of each species. The 1954 Act was widely regarded as ineffective and unenforceable, particularly in remote upland areas where the bulk of persecution occurred and illegal persecution continues to the present time (eg Etheridge *et al* 1997, Scottish Raptor Study Groups 1997). Ineffective or not, the Act had the effect of driving persecution underground, thus putting an end to the usefulness of the stuffing books as a tool for examining persecution; declines in the numbers of birds submitted were already well underway by 1954, however persecution pressure was greatest in East Ness, particularly the grouse moor districts of Strath Errick, the Monadhliath and Strathspey. The greater numbers of birds submitted, the higher numbers of Golden Eagle and Peregrine submitted from each named locality and the high proportion of instances where 2 individuals of the same species were submitted at the same time all suggest greater persecution pressure in East Ness. Persecution pressure was also high in East Ross and East Sutherland where there are large amounts of agricultural land and forests adjacent to formerly important grouse moors, and where many large estates have

their seats. The lower numbers of birds which were sent in from Skye, the Outer Hebrides and the western vice counties reflect the lower intensity of gamekeeping which existed in these areas and particularly the low amount of grouse moor; management of deer forest did not include the intensive persecution of birds of prey associated with grouse moor (see Brown 1976).

Persecution of birds of prey would most likely have been by shooting and trapping, with pole traps and traps set at nests, and with poison baits. The seasonal patterns of submission of different species reflect the different methods of persecution used: in areas of grouse moor and deer forest many birds were submitted during the early breeding season, especially Golden Eagle and Peregrine, which suggests that they were either trapped or shot at nest sites; this method of persecution was possibly more widespread in these areas than elsewhere, and the use of relatively small numbers of traditional nest sites would have made these 2 species especially vulnerable. The higher incidence of 2 birds being submitted together from grouse moor and deer forest also suggests that breeding birds were being targetted in these areas. Owls were mainly submitted during the autumn and winter months, when long hours of winter darkenss may have made them more susceptible to persecution than during the breeding season.

Two species detailed in the stuffing books, namely Osprey and Hen Harrier, underwent significant changes in status during the period under study. Osprey recolonised Scotland in the 1950s after an absence of almost 40 years although individuals had been seen with increasing frequency since the end of the Second World War (Brown and Waterson 1962). The records of Hen Harrier contained within the stuffing books are of special interest: Hen Harrier was probably extinguished as a breeding species in mainland Scotland by the beginning of the 20th century and there were very few confirmed records of breeding up until the Second World War, after which time the species recolonised the mainland. Campbell (1957), Blake (1961) and Watson (1977) all speculated that the Hen Harrier was already established by the 1940s although they held different opinions as to the extent to which recolonisation had taken place by 1946. Three lines from the stuffing books suggest that there was indeed a great increase during or shortly after the Seond World War (Table 6). Firstly, Hen Harrier was the only species, excepting very rare migrants, which was submitted in significant numbers after 1940 and the numbers submitted of each of the regularly breeding species were already in sharp decline by this time. Secondly, the fact that Hen Harrier was not being submitted before 1946 when all other birds of prey were undergoing heavy persecution suggests that they were not breeding in any numbers although Campbell (1957) considered that it bred intermittently in the northern Highlands but does not provide any evidence. Thirdly, the change in the species status around the time of the Second World War is most clearly illustrated by the difference in the seasonal pattern of submission before and after 1946: prior to 1946 Hen Harrier was only submitted during the winter of pre breeding period. (February-March) whilst after 1946 it was most frequently submitted during the breeding season (April-August). Watson (1977) speculated that the recolonisation of the mainland had advanced considerably by 1946 because of the widely scattered nature of the first breeding records after the Second World War, but Etheridge *et al* (1997)

calculated that Hen Harrier populations can rapidly recover following the cessation of persecution. The recovery of the Hen Harrier is normally attributed to declines in gamekeeping during and after the war, and to poorer heather burning practices leading to an increase in suitable nesting habitat. It is interesting to note that Hen Harrier was not submitted from the Outer Hebrides, where it was known to breed during the period under study (Watson 1977), although small numbers of other species were submitted for preservaton at this time (Table 3). The Hen Harrier persisted as a British species only in the Outer Hebrides, where it was preserved, and in Orkney, and the evidence of the stuffing books corroborates this. Nethersole-Thompson (in Watson 1977) knew of Hen Harriers nesting in Moray in 1945, and the 1946 and 1947 records in the stuffing books may refer to this locality.

The stuffing books provide an insight into a time of different values, when birds of prey were regarding as vermin and the conservation movement was in its infancy. They are fascinating natural and social history documents and other workers are encouraged to make use of sources of historical data such as these while this is still possible.

Acknowledgedments

I am very grateful to Inverness Museum and Art Gallery for allowing me to work on their collections and to Stephen Moran (Assistant Curator Natural Sciences) for his help and advice.

References

Anon 1996. *Road Atlas of Great Britain*, Automobile Association.

Anon 1964 *Road Atlas of Great Britiain*. Bartholomew and Son, Edinburgh.

Baxter E V & Rintoul L J 1953 *Birds in Scotland*. Oliver and Boyd, Edinburgh.

Blake E 1961 Return of the Hen Harrier. *Scottish Field*, February issue.

Blaker G B 1933 The Barn Owl in England. *Bird Notes and News*. 15:169-192.

Brown L 1976 *Birds of Prey*. Collins New Naturalist. London.

Brown P & Waterston G 1962 *The Return of the Osprey*. Heinemann. London.

Campbell L W 1957 The Rarer Birds of Prey: their present status in the British Isles. *British Birds* 50:4.

Etheridge B, Summers R W & Green R E 1997 The effects of illegal killing and destruction of nests by humans on the population dynamics of the Hen Harrier *Circus cyaneus* in Scotland. *Journal of Applied Ecology* 34:1081-1105.

Harvie-Brown J A & Buckley T E 1895 *A Vertebrate Fauna of the Moray Basin*, David Douglas, Edinburgh.

Newton I 1972 Birds of Prey in Scotland: some conservation problems. *Scottish Birds* 7:5-23.

Newton I 1979 *Population Ecology in Raptors*. T & A D Poyser, Berkhamsted.

Pearsall J A 1952 *Mountains and Moorlands*. Collins New Naturalist, London.

Prebble J 1963 *The Highland Clearances*. Penguin, Harmondsworth.

Ratcliffe D A 1980 *The Peregrine Falcon*. T & A D Poyser, Calton.

Ritchie J 1920 *The Influence of Man on Animal Life in Scotland*. Cambridge University Press, Cambirdge.

Scottish Raptor Study Groups 1997 The illegal persecution of raptors in Scotland. *Scottish Birds* 19:65-85.

Shawyer C 1998 *The Barn Owl*. Arlequin Press, Chelmsford.

Tapper S 1992 *Game History: an ecological perspective*. Game Conservancy Council, Fordingbridge

Temperley G W 1951 The Natural History of Raasay. *Scottish Naturalist* 63

Watson D 1977 *The Hen Harrier*. T & A D Poyser, Berkhamsted.

Henry A McGhie, Nurse's House, West Road, Muir of Ord, Ross-shire IV6 7TD

Revised manuscript accepted October 1999

Golden Eagle chasing winter plumaged Ptarmigan *David Mitchell*

SHORT NOTES

Recolonisation of the Isle of May by Sandwich Terns during 1999

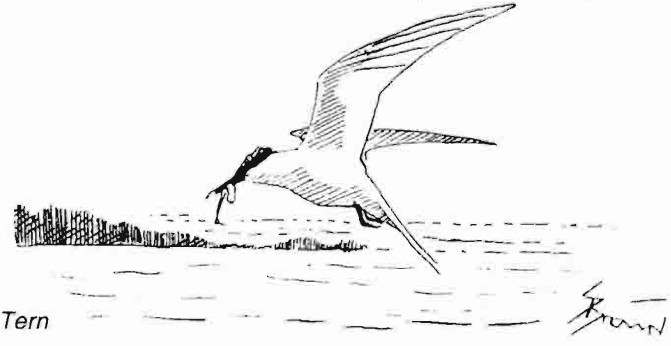
The recolonisation of the island by Sandwich Terns *Sterna sandvicensis* was the most noteworthy event of the 1999 breeding season on the Isle of May. Sandwich Terns have not bred on the island in numbers since 1956 with only one record in the interim of a single pair raising one chick in 1990. In the past 2 seasons large numbers of Sandwich Terns have been present around the island throughout the season and, in 1998, 3 birds laid eggs very late in the season before abandoning them. In 1999 birds returned in good numbers with 291 individual birds noted in the colony on the evening of June 25th The first incubating birds were noted on 20 June with 3 birds sitting, and large numbers were present displaying. This is quite a late date for first laying and would tend to indicate that these birds were either inexperienced younger birds or had attempted to breed elsewhere earlier in the season and had failed. The maximum number of sitting birds was counted on 4 July with 110 birds on eggs. The birds formed a tightly packed sub-colony within the Arctic/Common Tern nesting area at the summit of the island around the Beacon. The first chick was noted on 21 July.

On 11 August chicks began to move around the colony as part of a large creche with 87 large chicks counted. The group was extremely mobile, and moved east across the island despite rocky terrain and large nettle patches. They crossed Holyman's Road into the Burrian area and moved on to the seaward rocks from 12th when chicks moved below the tideline. Chick numbers had reduced to 4 or 5 by the next day, with most chicks assumed washed away or predated by gulls, and by the 14th no chicks could be found.

This is a welcome return of a breeding species which previously bred on the island in good numbers, with a population of 1400-1500 pairs in 1946 (Eggeling, W J 1985 *The Isle of May.*), and despite the disastrous end to the season it is hoped that the colony will continue to grow and succeed in fledging chicks in future seasons.

Darren Hemsley, 3 Carselea Road, Invergowrie, Dundee DD2 5AW

Revised mansucript accepted August 1999



Sandwich Tern *Steven Brown*

Interactions between breeding Choughs and Fulmars on Islay

The Isle of Islay holds a significant proportion of the Scottish Chough *Pyrrhocorax phyrrhocorax* population but recent surveys suggest that the numbers of Choughs on the island are declining (Madders *et al* 1998 Distribution and foraging habitat preferences of Choughs on the Oa peninsula, Islay. *Scottish Birds* 19:280-289). Several reasons for the decline have been put forward but it seems likely that there is no one cause, rather a number of factors combine to reduce the breeding population.

I have visited Islay every year for the last 20 years and have known certain Chough sites to be successful year after year. More recently, 2 particular sites have failed despite adults being present throughout the breeding season. These nests are on a stretch of coastline comprising low cliffs with numerous long and narrow gullies (up to 50m long and 5-10m wide). The nests themselves are situated towards the inland end of two of the larger gullies in inaccessible caves. While walking along this coastline in June 1998 I noticed that many of the gullies, including those containing the Chough nests, were inhabited by several (up to 15) pairs of nesting Fulmars *Fulmaris glacialis*. These, I know, were not present 12 years ago and were not recorded in the 1986 seabird survey on Islay (M Ogilvie *pers comm*).

On the same walk I observed that both pairs of Choughs were present around their nesting gullies and at each site I witnessed interactions between the Choughs and Fulmars. The Choughs seemed keen to get into their nest sites but as they attempted to fly in, aggressive aerial attacks from the nesting Fulmars deterred them. Having seen these birds running the gauntlet to get to their nests, I was not surprised that they had failed to rear young in recent years. Similar interactions have been recorded in Wales where, in 1997, Fulmars trampled a Chough nest containing eggs and prevented the Chough from returning (A Cross *pers comm*).

My observations suggest there has been an increase in the Fulmar population on Islay although no recent surveys have been carried out. There are many sites where the 2 species seem able to breed successfully in close proximity. However, it is possible that problems are associated with specific topographic features (eg gullies) where the approaches Choughs use to reach their nests are limited.

If Fulmars continue to spread and colonize more of the rocky coastline there is a risk that they will have an impact on other Chough pairs and thus add to the factors already contributing to the decline of Choughs on Islay.

Derek Hayward & Sian Davies, Logwood Cottage, Mealbank, Kendal, Cumbria LA8 9DJ

Revised manuscript accepted August 1999

Advice to contributors

Authors should bear in mind that only a small proportion of the *Scottish Birds* readership are scientists, and should aim to present their material concisely, interestingly and clearly. Unfamiliar technical terms and symbols should be avoided wherever possible and, if deemed essential, should be explained. Supporting statistics should be kept to a minimum. All papers and short notes are accepted on the understanding that they have not been offered for publication elsewhere and that they will be subject to editing. Papers will be acknowledged on receipt and are normally reviewed by at least 2 members of the editorial panel and, in most cases, also by an independent referee. They will normally be published in order of acceptance of fully revised manuscripts. The editor will be happy to advise authors on the preparation of papers.

Reference should be made to the most recent issues of ***Scottish Birds*** for guidance on style of presentation, use of capitals, form of references, etc. **Papers should be typed on one side of the paper only, double spaced and with wide margins and of good quality; 2 copies are required and the author should also retain one.** We are happy to accept papers on computer discs; however, please state the type of word processing programme used. Contact Sylvia Laing on 0131 556 6042 if you wish further information on this. Headings should not be underlined, nor typed entirely in capitals. Scientific names in italics should normally follow the first text reference to each species unless all can be incorporated into a table. Names of birds should follow the official Scottish list (*Scottish Birds* 1994 Vol 17:146-159). Only single quotation marks should be used throughout. Numbers should be written as numerals except for one and the start of sentences. Avoid hyphens except where essential eg in bird names. Dates should be written:...on 5 August 1991.....but not on the 5th (if the name of the month does not follow). Please do not use headers, footers and page numbers. Please note that papers shorter than c700 words will be treated as short notes, where all references should be incorporated into the text, and not listed at the end, as in full papers.

Tables, maps and diagrams should be designed to fit either a single column or the full page width. Tables should be self explanatory and headings should be kept as simple as possible, with footnotes used to provide extra details where necessary. Each table should be on a separate sheet. Maps and diagrams should be either good quality computer print outs in black and white (please do not use greyscale shading) or in black ink and be camera ready, but drawn so as to permit reduction from their original size.

Scottish Birds

Volume 20 Part 2 December 1999

Contents

Published by the Scottish Ornithologists' Club,
21 Regent Terrace, Edinburgh EH7 5BT.