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Greylag Geese on Tiree and Coll, Scotland: Status, Habitat Use and Movements

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Abstract.—Regular counts of Greylag Geese (*Anser anser*) on the islands of Tiree and Coll, Argyll, Scotland have taken place since 1982. In the last 20 years, there has been a ten-fold increase with numbers leveling out since 2000 at ca. 4,000 geese. Breeding productivity, measured as percentage young in August flocks and brood sizes, was comparable to Greylag Geese on other Hebridean islands. Sightings of 1,002 individuals banded since 1998 were largely restricted to the islands, although six birds were recorded in other parts of northwest Scotland where re-sighting probability was low, indicating dispersal to new areas. The large difference between annual productivity and estimated mortality rates, coupled with the leveling-off of counts, suggested that moderate numbers might be emigrating. Greylag Geese fed primarily on silage fields and improved permanent pastures throughout the winter. Goslings remained with their parents until early April, when the adults moved to relatively remote, uncultivated land to breed. During the non-breeding season, the average flock size decreased from 70 to 22 birds. Winter home ranges of breeding adults and goslings were smaller than those of non-breeding adults and geese in their second winter, suggesting that social groups within flocks were out-competed from the preferred feeding areas and, as a result, may be more likely to disperse and colonize new areas. Geese showed individual and specific preferences for restricted parts of potential feeding areas. These basic elements of flock dynamics need to be understood when selecting management options. Current management, involving wide-scale shooting and scaring, requires provision of adequate feeding refuges to prevent dispersion of the grazing conflict to other areas, both within and beyond the two islands. Received 28 April 2004, accepted 17 July 2004.

Key words.—Greylag Goose, *Anser anser*, Isles of Tiree and Coll, numerical increase, habitat use, winter home ranges, dispersal.

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The remaining native Greylag Goose (*Anser anser*) population of Scotland, at the end of the nineteenth century, became restricted remnants of its previous distribution, isolated in the extreme north and west of the country. This is probably a result of persecution, which reduced numbers to their lowest levels in the first half of the twentieth century (Berry 1939). A small degree of dispersal from the remnant stock was sufficient to colonize areas in a restricted band from Colonsay in the Inner Hebrides, along the west coast of Scotland and as far north as the northern isles (Mitchell 1999). The total native Hebridean Greylag Goose population currently numbers 10,000 birds and although the species can be legally harvested in the open season, it can only be shot in the closed season under licence (Mitchell 1999).

The recent increase in numbers of resident Greylag Geese on the islands of Tiree and Coll, Argyll is the subject of considerable

discussion among the residents and conservationists and led, in part, to the development of a goose management scheme for the islands in autumn 2003. According to local people, geese have only been regularly present in the summer on Tiree in the last 30-40 years (I. MacDonald, pers. comm.). There appear to be no historical records of breeding prior to the early twentieth century, although after an increase during the 1940s, post-breeding numbers reached 50-100 birds (Owen *et al.* 1986). In 1938, a pair bred on Coll for the first time in many years (MacDougall 1938), and further records suggest numbers slowly increased from that time (Boyd 1958, Sharrock 1976).

Madders (1992) documented an increase in the number of Greylag Geese from 200-300 birds in the early 1980s to 1,340 birds in 1990/91. This paper provides census data from 1990 to 2002 and describes monthly habitat use in 2000-03. Data on

breeding success and movements of individual geese are also provided for the period 1998-2003.

STUDY AREA

The islands of Tiree and Coll are the most westerly of the Scottish Inner Hebrides, centered at 56°32' N and 06°42' W. They lie 11 km northwest of Mull and 15 km west of Ardnamurchan Point, the westernmost part of the Scottish mainland (Fig. 1). Both islands are about 19 km long and 5-6 km wide, and they are separated by a rocky sound, some 3 km wide in which, lies the satellite island of Gunna. The two islands are rather flat, reaching 141m at the highest point and, as a result of the level topography, are poorly drained and hold numerous wetlands of various sizes, ranging from permanent lakes of one km² in area to seasonal pools. Rearing of livestock dominates the agriculture of both islands, and there are extensive grassland habitats ranging from heavily fertilized silage fields to unimproved grasslands. Near the coast, the latter are dominated by wind-blown shell-sand rich in calcium, and form herb-rich swards known locally as "machair". Inland grasslands tend to be more acidic as they are less influenced by shell-sand. They are dominated by coarser grasses and Heather (*Calluna vulgaris*) and are known locally as "sliabh".

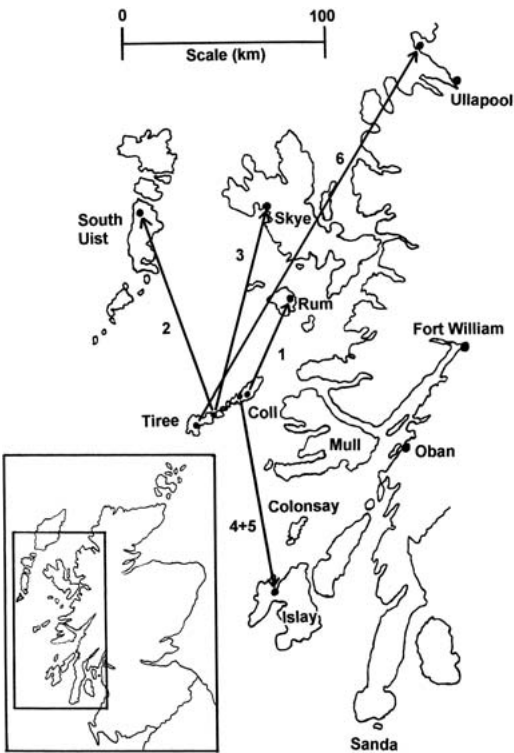


Fig. 1. Map of the west coast of Scotland, showing the islands of Tiree and Coll, Argyll, plus movements of banded Greylag Geese away from the two islands. Inset shows location of study area within Scotland.

METHODS

Systematic counts of Greylag Geese on Tiree/Coll were undertaken infrequently during the 1980s. A complete field-by-field census of geese on Tiree has been undertaken up to five times each winter since 1991, with additional regular complimentary counts on Coll (Fig. 2). Since 1996, the location of each goose flock was noted together with habitat coded as: arable, silage, improved permanent pasture, rough grazing including machair and sliabh, freshwater wetlands or coast. During July/August, geese were aged using plumage characteristics as either adult or gosling. Where families were identified, brood size was recorded.

In 1998, 1999, 2000 and 2002, Greylag Geese were rounded up when the geese were flightless. Adults were marked with plastic neck collars engraved with three alphanumeric codes. Goslings were marked with engraved plastic leg bands. In addition, each bird was sexed and fitted with a metal BTO band. Marked geese were released in groups and family cohesion was maintained (Bowler 2003). A total of 1,002 geese was banded comprising 850 on Tiree, 142 on Coll and ten birds on Gunna.

Sightings of marked geese were made while undertaking ground counts and opportunistically at other times. Details were recorded on the social status of the individual, whether the individual was part of a family unit, and habitat type. Re-sightings of marked birds from areas beyond the two islands came from independent observers and from the British Trust for Ornithology (BTO). Records of marked geese recovered during shoots, were received from Argyll Estates and from individual farmers and crofters.

Home range analysis using sightings of individually marked geese in the non-breeding period between August and March inclusive was undertaken using CalHome (Kie *et al.* 1996). Geese were classified as either adults with young or adults without young (i.e. of unknown age when marked), goslings in their first winter, or geese in their second winter. To avoid pseudo-replication of sightings of males and females belonging to a pair, only data for males were analyzed. Similarly, only one member of a group of siblings (again, a male) was chosen. Ranges were based on all live sightings within a single non-breeding season (August to March) and covered all habitat types. Home ranges were calculated us-

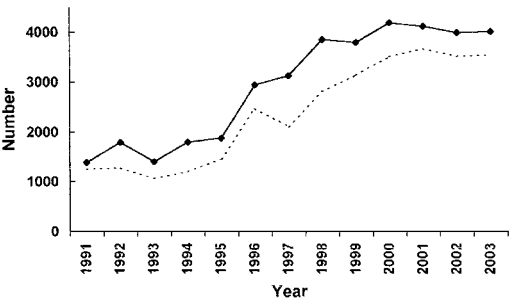


Fig. 2. Counts of Greylag Geese on Tiree and Coll, 1991-2003. Data represent the highest count total for each year for the two islands combined when both islands were counted within the same month. (Dashed line represents Tiree figures only).

ing both within- and between- island sightings, which effectively treated the islands as one bio-geographical unit. This view is justified as geese are regularly seen both flying across the 3-km wide Gunna Sound that separates the two islands and visiting the islet of Gunna in between. The ranges were derived using the adaptive kernel (Kie *et al.* 1996) to include the area in which 75% of sightings were seen. The ranges data were not all normally distributed and differences between social groups were evaluated using Mann-Whitney *U*-tests. Results are reported as mean \pm SE, where N is sample size.

RESULTS

Status

Numbers. Winter numbers on Tiree/Coll increased from *ca.* 670-920 individuals in 1985-87 (Stroud 1989) to *ca.* 4,000 in 2000-03 (Fig. 2). The rate of increase between 1991 and 1998 was 25.5% per annum, but declined to 4.3% per annum between 1998 and 2000, and numbers did not change between 2000 and 2003. Spring counts were lower than during the winter months and maximum annual counts occurred in August-December. This may partly have reflected the effects of shooting in the open season, combined with the movement of paired adults to remote breeding areas away from managed grasslands in spring and, perhaps, to areas beyond Tiree and Coll.

Breeding success. Annual breeding productivity defined as the proportion of young birds in the post-breeding count on Tiree in August/early September ranged between 18% and 43% in 1998-2003 (mean 30% \pm 3.2, N = 6), with an average production of 928 \pm 96 goslings per year (Table 1). Annual mean brood size varied little between years on Tiree with an average of 3.68 \pm 0.06 goslings per family in the period 1998-2003 (Table 2). By combining data on brood size

recorded during the summer with the proportion of young estimated in August/September, it was possible to estimate the number of successful breeding pairs (Table 2). There was an average of 251 \pm 23 successful breeding pairs each year on Tiree between 1998 and 2003.

Shooting bags. Greylag Geese were shot during the open season (1 September–1 February) by shooting parties organized by Argyll Estates on Tiree, and by crofters and farmers protecting their crops on both islands in the open season and under license in the closed season on Coll. A concerted effort was made by Argyll Estates to reduce numbers in the 1998 shooting season and some 700 geese were shot. Approximately 265 geese were shot annually on Tiree by visiting shooting parties in 1999-2003 (Table 2). The number of geese shot by islanders during these years was not known, but was thought likely to be less than a hundred birds per annum. Of the 1,002 geese banded since 1998, 153 were known to have died by May 2004, of which 130 (85%) were shot and killed, five (3%) struck overhead wires, two (1%) were hit by vehicles, one (a gosling) was predated by a Great Black-backed Gull (*Larus marinus*) and 15 (10%) died of unknown causes.

Habitat Use

During the breeding season, the geese were concentrated in remote areas of sliabh, away from roads and buildings. Nests have been found in heather, on rocky knolls, in rough unimproved grassland and on hummocks in mires. Molt concentrations occurred on both large and small lochs, as well

Table 1. Post-breeding statistics for Greylag Geese on Tiree 1998-2003 (annual breeding productivity is defined as the percentage of young in the August/September counts).

Date	Count	Aged	No. young	(%) young	Estimated young
22 Aug 1998	2807	1670	565	33.8	948
29-30 Aug 1999	2890	1673	497	29.7	858
29-30 Aug 2000	3522	680	173	25.0	881
28-29 Aug 2001	2921	1758	763	43.3	1268
2-3 Sept 2002	2800	1710	311	18.2	510
25-26 Aug 2003	3544	1917	598	31.2	1106

Table 2. Estimated number of successful breeding Greylag pairs on Tiree 1998-2003 together with shooting bag totals (data collected from shooting parties).

Year	Mean brood size	Number of broods checked	Estimated number of young (from Table 1)	Estimated number of breeding pairs	Shooting bag total
1998	3.69	116	948	257	700
1999	3.63	134	858	236	240
2000	3.60	175	881	245	250
2001	4.00	122	1268	317	335
2002	3.56	110	510	143	290
2003	3.58	155	1106	309	208

as on headlands and islets. A molting flock was recorded in the late 1980s on the islet of Gunna and this was perhaps the principal molting site then (Stroud 1989), although numbers using this site subsequently have been few and variable.

During the non-breeding season, from August to March, Greylag Geese on Tiree were mostly recorded on silage fields (36%) and improved permanent pastures (33%, Fig. 3). Only 1.5% of geese were recorded on

arable fields in this period, highlighting in part, the very small area of arable crops grown on the island. Some 24% of geese were recorded on rough (mostly unimproved) grazing land with 7% on machair and 17% on sliabh. There was no significant difference in the proportion of habitat used during the eight-month period except for arable, the use of which declined from 4.3% of geese in August to 0.6% in March ($r_s = -0.91$, $P < 0.05$, $N = 6$). Average flock size outside of the breeding season decreased from over 70 birds in October to below 30 by March (Fig. 4, $r_s = -0.98$, $P < 0.05$, $N = 8$).

Movements and Home Ranges

Of the 1,340 fields within the study area, 539 (40%) never held geese during 1998-2002. These tended to be close to houses and roads, although some seemingly suitable fields were avoided. Of 801 fields in which geese were recorded, some fields held a disproportionately large number of geese. Ten fields (1.2% of the fields holding geese) accounted for 10.1% of geese. Others rarely held geese, with 600 fields (62.4% of the

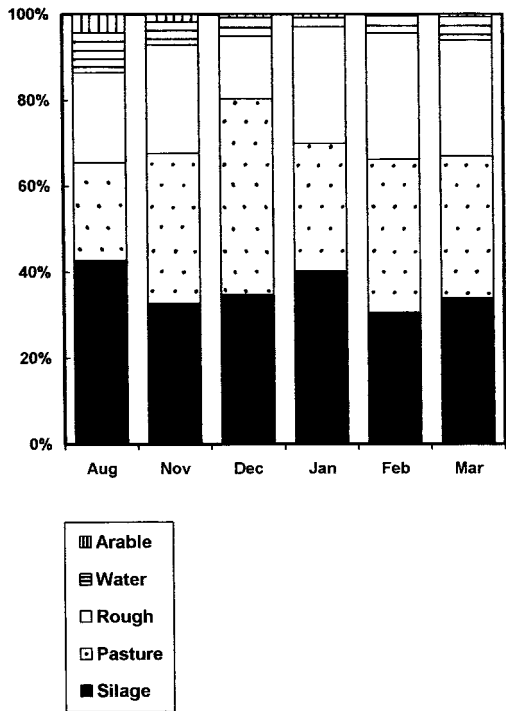


Fig. 3. Use made of five main habitats by Greylag Geese on Tiree during the period August-March. Data are presented as a mean monthly percentage of all-island counts conducted between 2000 and 2003 (N = 3 for all months).

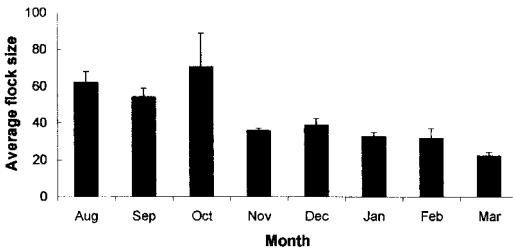


Fig. 4. Average flock size during the non-breeding season, August to March inclusive (mean plus SE bar, N = 268, 227, 116, 250, 207, 261, 190 and 291 respectively).

fields holding geese) accounting for only 33.7% of recorded flocks (Fig. 5). Banded individuals showed an even higher degree of attachment to certain fields. Banded geese were seen in 476 fields. Ten fields (2.1% of fields holding banded geese) accounted for 47.8% of sightings. However, others also rarely held geese, with 275 fields (57.8% of fields holding banded geese) accounting for only 11.3% of banded birds (Fig. 5), reflecting a bias towards fields close to banding locations.

Of the 1,002 birds marked on Tiree and Coll between 1998 and 2002, six (0.6%) were recorded away from the islands, with movements noted up and down the west coast of Scotland reaching as far south as Islay (90 km to the south) and as far north as Wester Ross (190 km to the northeast, see Fig. 1 and Table 3). Sightings of individual birds revealed regular movements between Tiree and Coll, and many Coll breeders visited Tiree during the winter (Fig. 6). In addition, one bird banded in Iceland and five birds banded on the Uists (80 km to the north) were recorded during the study.

The average home ranges of Greylag Geese between August and March was smallest for adults with young or goslings in their first winter (<7 ha) and largest for adults without young and geese in their second winter (>16 ha, Fig. 7). Adults with young had significantly smaller home ranges than adults without young ($U = 114$, $P < 0.05$, $N = 22, 24$), geese in their second winter ($U = 48$, $P < 0.05$, $N = 22, 11$) and goslings ($U = 19$, $P < 0.05$, $N = 22, 14$). There was no significant difference in home range size between

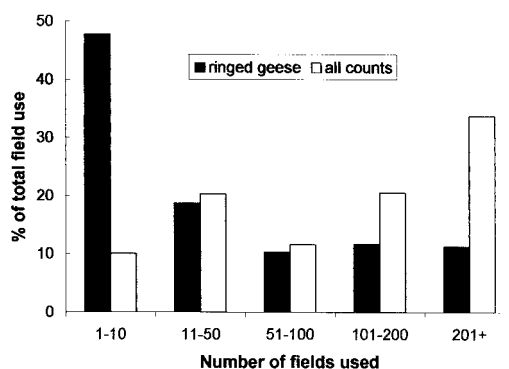


Fig. 5. The proportion of total field use on Tiree accounted for by the number of individual fields for banded geese in 1998-2003 ($N = 2101, 824, 453, 515$ and 498 respectively for the five categories) and for all geese in 2000-03 ($N = 82, 255, 280, 445$ and $1,208$).

adults without young and birds in their second winter ($U = 128$, n.s.). Banded goslings remained with their parents until early April and mean brood size of 13 families banded in 2002 declined from 2.8 in August to 2.1 in March 2003.

DISCUSSION

Status

The 4,000 Greylag Geese on Tiree and Coll represent 40% of the native stock breeding in the north and west of Scotland (Mitchell *et al.* 2000). Numbers increased rapidly between the early 1980s and 1998, but stabilized after 1999, coinciding with a period of greater shooting effort (Table 2). This pattern in numbers fits a logistic growth curve, with rapid expansion from a slow start, followed by

Table 3. Movements of banded Greylag Geese from Tiree and Coll.

No. on Fig. 1	Band code	Band site	Banding date	Age at banding	Last seen Tiree/Coll	Off-island record	Dates seen off-island	Seen again Tiree/Coll
1	AND	Coll	Jul 1999	Gosling	29 Mar 2000	Kinloch, Rum	22 Mar 2002 13 Nov 2002	
2	BBB	Tiree	Jul 1999	Gosling	Jul 1999	West Gerinish South Uist	25 Oct 2001 found dead	
3	BNP	Tiree	Jul 2002	Gosling	12 Nov 2002	Loch Caroy, Isle of Skye	16 Sep 2003 dead (shot)	
4	E10	Coll	Jul 1998	Adult	29 Aug 1999	Islay	14 Oct 1999	18 Feb 2000
5	E11	Coll	Jul 1998	Adult	24 Mar 1999	Islay	14 Oct 1999	5 Apr 2000
6	H70	Tiree	Jul 2000	Adult	2 Apr 2003	Achiltibuie, Wester Ross	6-7 Aug 2003	29 Sep 2003

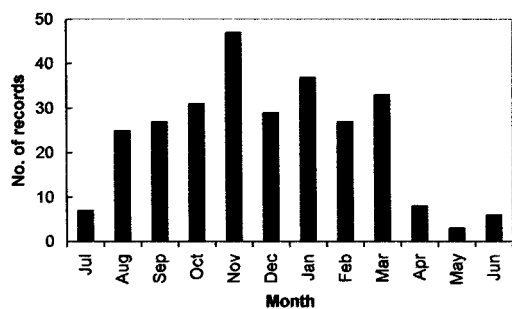


Fig. 6. The number of Coll-banded Greylag Geese observed by month on Tiree 1998-2003 (repeat records of individual birds within a month have been omitted).

an equally rapid leveling off. Recent increases in the numbers of Greylag Geese on islands with managed grasslands, such as the Uists in the Scottish Outer Hebrides, are thought to be partly due to greater breeding success and recruitment (Mitchell and Sigfusson 1999), resulting from an increase in the quality and quantity of improved pasture since the 1960s (Paterson 1991) and also reduced persecution during the close season. The rapid expansion in numbers on Tiree and Coll is thought likely to relate, at least in part, to an intensification of grass management on the islands, combined with an increase in the total area of managed grassland since the early 1980s (Harrison and MacLeod 2004). New varieties of grass grown on the islands have higher protein content and digestibility, and offer a longer growing season, enabling a higher carrying capacity of stock (Harrison

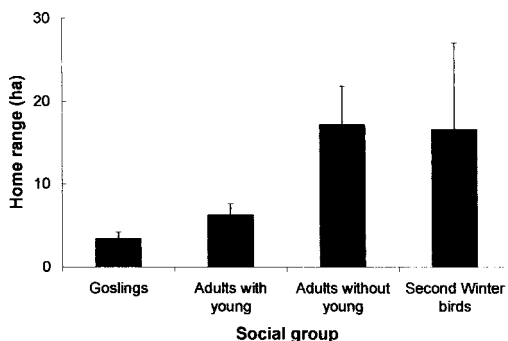


Fig. 7. Home ranges of banded birds of different social groups within feeding flocks of Greylag Geese on Tiree and Coll in the non-breeding season (August-March inclusive) for the period 1998-2003 (mean plus SE bar, $N = 14, 22, 24, 11$ respectively for the four social groups).

and MacLeod 2004). However, although numbers of geese were low prior to this agricultural intensification, they were already beginning to increase, suggesting that they had not yet reached equilibrium with grass conditions at that time. The rapid increase in goose numbers may be coincidental in time with intensification of grassland management.

Amongst populations of geese that undergo lengthy migrations between breeding and wintering areas, mortality rates on the migratory flights may be high, particularly for birds in the first year of life and during adverse weather (see Owen 1980). For example in 1986, 35% of Barnacle Geese (*Branta leucopsis*) died between the age of four weeks in Spitsbergen and arrival on their Scottish wintering grounds (Owen and Black 1989), whilst mean brood size amongst White-fronted Geese (*Anser albifrons*) in 1984 fell from 3.65 after fledging in Greenland to 2.84 on their wintering grounds in Islay (Fox 2003), although this may have included hunting mortality at staging areas in Iceland. The absence of migration mortality in the current study means that hunting accounted for most of the post-fledging mortality (85% of known deaths of banded birds), and such mortality is likely to be additive given the apparently low natural mortality rates. However, it seems unlikely that current numbers are being maintained by the continued moderate shooting pressure alone, since the number of young produced each year is roughly three times the number that are known to be shot. Causes of pre-fledging mortality were largely predation by gulls and road casualties, and accounted for 0.01% of young per week from the end of June until fledging in August 2001 ($N = 190$ broods; Bowler 2003).

The apparent threshold of 4,000 birds could be interpreted as the islands' carrying capacity, although this figure would be higher in the absence of shooting, while the possible density-dependent mechanisms responsible for establishing this threshold and how and when they operate within the goose life cycle remain unknown.

Average annual breeding productivity defined as the proportion of juveniles in August was slightly higher on Tiree and Coll (30.2%)

than on the Uists in 1986-1994 (mean = 26.8%; Mitchell 1999), although mean brood size was similar (3.67 and 3.68 young respectively). Reproductive output in north and west Scotland is higher than that of migratory populations. For example, the long term (1970-1995) mean for the proportion of young in the autumn Iceland population of Greylag Geese was 17.7% with an average brood size of 2.24 young (Mitchell and Sigfusson 1999), although this was measured after an 800 km migration across the Atlantic Ocean.

Habitat Use

Greylag Geese feed on roots, tubers, green leaves and stems, flower heads and fruits obtained from marshes, loch margins and farmland, including pasture. In this study, the habitat use was similar to that of Greylag Geese on the Uists (Paterson 1991), where they fed chiefly on various grasses and on areas of ripening cereals, especially Rye (*Secale cereale*) and Oats (*Avena strigosa*), or stubble. Use made of arable land was lower in the current study, largely as a result of the relatively small amount of arable crops grown on Tiree (23 ha in 2002). The decline in use made of arable land on Tiree between August and March, is presumably related to the steady reduction in the availability of this resource as the stubbles were ploughed back in during the winter. Other studies have demonstrated seasonal changes in the diet of Greylag Geese apparently responding to, and in part driven by, seasonal changes in the habitats available (e.g. Newton and Campbell 1973; Bell 1988; Stenhouse 1996). The recorded decrease in flock size during the non-breeding season may have partly related to changes in food availability, such as the decline in arable crops, but other factors such as disturbance from shooting and long distance movements may also be important.

Individual Greylag Geese were concentrated on relatively few fields and crofts, agreeing with similar studies elsewhere. Wilson *et al.* (1991) demonstrated individual and specific preferences for restricted parts of potential feeding areas for White-fronted Geese in Wexford, Ireland, while Hearn and Mitchell

(1995) reported that of 1,474 fields checked for Pink-footed Geese (*Anser brachyrhynchus*) in Perthshire, Scotland, only 14% were used, and of these, ten fields accounted for 25% of all recorded flocks. On Tiree and Coll, the degree of attachment to individual fields was not so pronounced, presumably as a result of a higher concentration of geese in a smaller area or on a more homogenous habitat.

Movements and Home Ranges

Despite comprehensive checking of winter goose flocks on Tiree and Coll, only one out of 3,000 Greylag Geese marked in Iceland between 1996 and 2000 has ever been recorded there (in February to April 2002), indicating that Icelandic birds do not winter on the islands. Of 500 geese marked on the Uists (see Mitchell 1999), five have been recorded on Tiree and Coll, including one, which stayed to breed on Tiree. These movements add weight to the suggestion that Tiree and Coll may have been colonized by birds from the Uists (Mitchell 1993). Moreover, none of the 300 geese marked with neck collars in Sutherland in 1995-96 have been recorded on Tiree and Coll (F. Symonds pers. comm.).

Of the six Tiree/Coll banded birds seen away from the islands (Table 3), three left the islands within their first to third years of life, whilst three of the departures occurred in March/April and are therefore suggestive of movements to new breeding areas. To date, no banded birds have been found breeding away from Tiree/Coll, although the low levels of band-reading effort elsewhere and the remote nature of breeding sites, render detection of such birds unlikely.

The Tiree and Coll stock of Greylag Geese appear to be mostly sedentary, making relatively frequent short movements within the two islands, but only infrequent movements elsewhere. Re-sighting probabilities off the islands are small because of low observer coverage, so the six records of banded birds away from Tiree and Coll to date may be indicative of more frequent long distance movements. The difference between annual productivity and estimated mortality rates is large in some

years which, given the thorough count coverage and recent leveling off of counts, suggests that a large number of geese may leave the islands each year.

Recently, Greylag Geese have started to breed in increasing numbers on other Inner Hebridean Islands including Islay, Colonsay, Mull and its satellite islands (see Fig. 1). Breeding was first noted at Loch Gruinart on Islay in 1997 and by 2003, some 50 pairs were estimated to be breeding on the island, while the post-breeding flock at Loch Gruinart doubled from 316 in 1999 to 600 in 2003 (M. Ogilvie in litt.). Three pairs bred for the first time on Colonsay in 1986 and by 2002, the island held a resident population of 200 birds (Jardine 2002). Some 200 birds occur around the coasts of Mull, including the Treshnish Isles, plus a further 200 on the Argyll mainland including increasing colonies on islands in sea lochs (Craik 2002). It is likely, although not proven, that this spread in breeding range has involved birds dispersing from Tiree and Coll. The timing of colonization and the rapid increases observed could relate to high levels of emigration from Tiree and Coll during the period of most rapid growth in numbers (1995-99), since vagrancy in some bird species increases in years with high breeding success (Veit 1997). This may explain the low number of records of banded geese away from the islands, since banding only began in 1998. A similar pattern of increased dispersal from the rapidly increasing Greylag Goose numbers in the Uists in the early 1980s might also explain the initial rise in numbers on Tiree and Coll. The effect of disturbance from increased shooting effort on the emigration rates from such rapidly expanding populations is unknown but possibly significant.

Tiree/Coll geese had small home ranges during the non-breeding period (August to March) compared to results of other studies. For example, Barnacle Geese wintering on the Solway estuary in southern Scotland had a median home range (corresponding to 85% of cluster polygons) of 254 ha at one site and 558 ha at another (Phillips *et al.* 2003), compared to an average of just 5-17 ha for Greylag Geese on Tiree/Coll. This dif-

ference reflects the small size of the islands, which by definition constrains the possible home ranges of the geese, whilst those on the Solway had a much larger area of suitable habitat in which to feed and roost.

It would be expected that the breeding adults and goslings had similar home ranges, since family cohesion was strong and banded goslings remained with their parents until early April. This agrees Owen (1980) reported that family units persist in many goose species through the first winter and regularly up to the point when paired adults begin strengthening their bond in early spring. The larger home ranges of breeding adults, compared with goslings, may reflect early movements of some adults away from winter feeding areas to more remote breeding locations. The small home ranges of families of Greylag Geese (goslings and adults with young) suggest that, in the absence of man-induced scaring schemes, the geese returned to fields where they had already fed safely, such fidelity resulting in particular fields being used to a larger than expected extent.

The larger home ranges of geese in their second year and of adults without young agrees with Giroux and Patterson (1995), who found that the home ranges of unpaired adult Pink-footed Geese in northeast Scotland in winter were twice as large as those of juveniles. Such social hierarchy and dominance of preferred feeding areas by families is well established in winter goose flocks (Black and Owen 1988). Low-ranking geese are out-competed from the higher quality feeding sites by established pairs and families (Black *et al.* 1992) and may therefore be more likely to make relatively long sea-crossings to new potential breeding areas elsewhere.

Management Implications

Numbers have leveled out at *ca.* 4,000 birds, following a drop in the rate of increase after 1998. Hunting at the present rate, combined with other currently unknown density-dependent factors, appears to be keeping numbers in check but would appear to be insufficient to reduce goose numbers below their present level.

Little is known about the population dynamics of geese on these islands and to this end, a period of more intensive band-reading effort was initiated on Tiree in September 2003 with the aim of developing a basic population model (Cope *et al.* 2004). This is timely as a goose management scheme was introduced on the islands in autumn 2003 with the aim of reducing goose damage to the most vulnerable crops.

That individual Greylag Geese appear to be restricted to discrete flocks with distinct home ranges on a small number of fields on Tiree and Coll is an important consideration for management. Targeted shooting/scaring may move birds from vulnerable crops to a wide range of fields seemingly available for feeding. It is important that the scheme includes sacrificial crops and/or refuge areas where geese can feed undisturbed in order to prevent a dispersion of the grazing problem. Similarly, the small home ranges of successful breeding adults suggest that increased disturbance to flocks may have a greater impact on non-breeding birds. Without sufficient refuge areas, there is a risk that this may cause an even greater proportion of the non-breeding birds to disperse from the islands, leading to increasing agricultural conflict elsewhere. Alternatively, this could be viewed as a positive management tool for repopulating areas of the species' former range.

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