Wildfowl (1973) 24:111–121

Behaviour and distribution of wild geese in south-east Scotland

I. NEWTON, V. M. THOM AND W. BROTHERSTON

The distribution of wintering Greylag *Anser anser* and Pink-footed Geese *A. brachyrhynchus* in Britain is governed by the presence of suitable roosting sites, such as estuaries and lakes, from which the birds fly to nearby farmland to feed. The same roosts and associated feeding areas are used year after year. This paper examines the dispersal of geese in south-east Scotland and, in particular, their choice of roosting and feeding sites. It forms part of a general study, more of which has been published elsewhere (Newton & Campbell, 1970, and 1973; Newton, Campbell & Allison, in press). The area involved, covering 24,000 km², extended from Pitlochry in the north to beyond Biggar and Kelso in the south, and from the east coast to beyond Stirling in the west (Figure 1). It included a representative selection of roosting and feeding sites, and held the bulk of the immigrant population of both species. In recent autumns, Icelandic Greylag in Britain have numbered about 60,000 individuals, and Pinkfeet about 70,000 (Boyd & Ogilvie, 1969, 1972).

Methods

The first detailed information on goose distribution in Scotland was built up over several years from extensive ground searches and aerial surveys by Wildfowl Trust staff, helped by local observers. This information, summarized by Atkinson-Willes (1963), formed the starting-point for our survey. From 1960, V.M.T. studied goose distribution around Perth. This was done partly at weekends, but also on other days, because her job took her to many farms in the study area, and provided further opportunity to find geese and question farmers (Thom & Murray, 1964). In 1952, W.B. (in Edinburgh) began watches at certain roosts, which came to

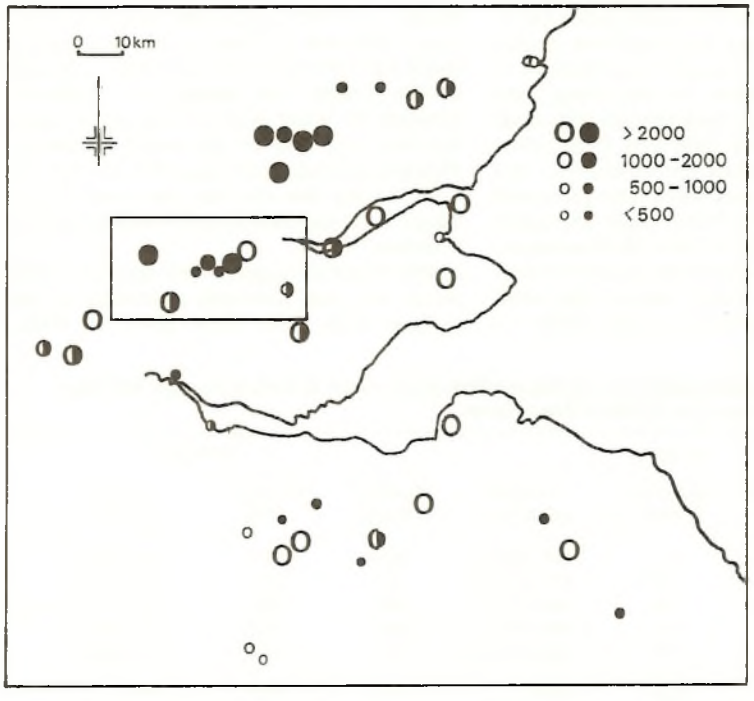

Figure 1. Map showing position of study area, and main roosting sites. Filled circles = Greylag; open circles = Pinkfoot; split circles = both species. Inset shows area covered by Figure 2.

occupy nearly every winter weekend for 20 years, and from 1955 also organized cooperative counts at all known roosts in the study area south of the Forth (Brotherston, 1964). He too noted feeding areas, but did not cover the ground systematically as did V.M.T., north of the Forth. In 1967–70 I.N. also searched systematically for feeding geese, and checked waters not already known to be used as roosts. This paper synthesizes all this information. Records accumulated for 20 years, but all roosting and feeding areas mentioned here were used regularly during 1966–70. Possibly some minor roosting and feeding areas were missed, but not enough to affect the overall conclusions.

Population

An estimated 37,000–46,000 Greylag were present in the study area in different Novembers 1966–70, with an average of 41,000, and an estimated 49,000–63,000 Pinkfeet, with an average of 58,000 (Boyd & Ogilvie, 1969, 1972). In different years, this represented 59–73% of the total immigrant Greylag in the country, and 64–93% of the total Pinkfeet. The large differences in numbers between autumns resulted partly from variations in the size of the total population, and also from annual variations in the regional distribution of geese within Britain. In the study area north of the Forth, both species were relatively numerous in 1968 and 1970, when much grain was shed before harvest, and less so in other years when little grain was shed. South of the Forth, grain and geese were most plentiful in 1969. In all autumns, the two species were about equally numerous north of the Forth, but to the south Pinkfeet greatly predominated (Table 1).

Behaviour

Most Pinkfeet arrived in Britain in late September and early October and left during April and early May. Most Greylag arrived during October and left from mid-March to mid-April. Thus the average Pinkfoot spent 30 weeks each year in Britain and the average Greylag 26. The difference was presumably because the Pinkfeet came direct from the highlands of Iceland, where the summer season was shorter than in the lowlands inhabited by Greylag.

Within Britain, different roosts were not self-contained, and a continual shifting of birds from roost to roost around the country was confirmed by observations, counts and ringing. Recoveries of birds ringed near particular roosts came, within the next 3 months, from all parts of the winter range, but more often from near than far (Boyd, 1955, 1957, 1959). Movement took place on any date, not just in response to hard weather or food shortage. In general, geese concentrated in predominantly grain-growing areas in autumn, and in predominantly grass-growing areas in winter. As expected, day-to-day interchange was greatest between adjacent roosts, and in any one area certain pairs or groups of waters functioned as one, so that large numbers of geese at one site meant small numbers or none at the others. North of the Forth, two groups of waters in Strathmore acted more or less as two units for Greylag; and to the south Harperig/Threipmuir and Gladhouse/Portmore were each linked for Greylag, as were Fala/Gladhouse and Baddinsgill/Westwater for Pinkfeet.

The number of geese that used any one water was not normally restricted by its surface area. The small pond at Fala,

Table 1. Numbers (in thousands) of Greylag and Pink-footed Geese in study area, each November, 1966–70, based on Wildfowl Trust Counts

	Greylag			Pinkfoot		
	North of Forth	South of Forth	Total in study area	North of Forth	South of Forth	Total in study area
1966	39·3	1·7	41·0 (68%)	35·0	13·7	48·7 (64%)
1967	35·9	2·6	38·5 (73%)	44·0	16·3	60·3 (93%)
1968	41·8	2·6	44·4 (73%)	44·6	10·0	54·6 (84%)
1969	30·1	6·4	36·5 (59%)	44·6	16·8	61·2 (84%)
1970	41·5	4·8	46·3 (71%)	50·3	13·1	63·4 (88%)
Mean	37·7	3·6	41·3	43·7	14·0	57·6

The figures in brackets show the percent of the country's total population present in the study area each November.

which covered about 1 hectare, held for much of each season less than 2,000 geese, but occasionally up to 6,000–an average of one goose per 2·5 m². On large roosts geese did not spread evenly over the water surface, but remained as a flock in the lee of a shore or island, their position changing from night to night, according to wind direction. They preferred sheltered areas near gentle open shores, where they could walk out during darkness. In estuaries and coastal bays they usually stood on banks of sand or mud that were flooded for only a short time. They drifted on the water at high tide, and returned to the banks when the water dropped again. On waters regularly used by both species, the two kept in separate flocks.

As a rule both species roosted by night and fed by day. They left their roosts earlier with respect to sunrise, and returned later with respect to sunset, in mid-winter, when days were shortest, than in autumn or spring. On mixed roosts, Pinkfeet left earlier and returned later, on average, than did Greylag, though there was much overlap. In both, it often took more than an hour for all the flocks to leave a roost in the morning, and for them to assemble again in the evening.

After reaching a feeding area in the morning, the first party often circled once or twice before alighting, but the build-up was then rapid, with successive parties settling in without hesitation. After the dawn flight, the roosting assemblage usually split into several feeding flocks at varying distances and directions from the roost. During the day, groups of birds moved between flocks, and also between feeding and roosting places. Birds fed least around mid-day and, if water was not available in the fields, sometimes returned to the roost to drink and bathe. Greylags often accumulated steadily on their roosts from around mid-day and, in general, spent much more time on water than did Pinkfeet. To large and undisturbed waters, like Loch Leven, Pinkfeet occasionally returned to drink and bathe around mid-day, but otherwise they drank from pools on fields (if at all) and rested on special areas (see later), so that roosts remained deserted through the day.

Both species arrived at roosts in flocks, often from several different directions. On windy nights their arrival was often more prolonged and fragmented than on calm ones. The geese approached in level flight, sometimes rising when nearing the roost, then gliding or 'whiffling' (side-slipping and tumbling) down to the water surface. After the first flocks were in, later ones flew in without the hesitation often shown by first arrivals. There was usually a great clamour, redoubled whenever a fresh detachment came in. Then some time after the last flock had arrived, the noise steadily fell to a low level, which was maintained until about an hour before the dawn flight when it increased again. (This was confirmed by the 'water keepers' at several reservoirs, and by M. A. Ogilvie who spent many nights beside goose roosts.)

During the lighter half of the moon cycle some geese fed at night, more so in winter than in autumn or spring (Newton & Campbell, in press). When the moon rose early, the birds simply remained in the fields, but when it rose late, they roosted as normal and flew out again at night. After such light nights, any geese on the roosts at daybreak were often slow to leave. Some Greylag stayed till around noon, while Pinkfeet often flew to a resting area and did not feed for an hour or more.

Influence of shooting

Shooting and other disturbance had less effect on geese using large waters than on those using small ones. On the large Loch Leven, no consistent trends in numbers were detected after shoots, but small waters were frequently deserted for several days afterwards. Pinkfeet more often deserted a roost after shooting than did Greylag. Shooting also affected the time geese arrived at a roost and, when heavily disturbed, both species delayed their arrival till well after dark. In areas where shooting was especially heavy, geese also made maximum use of the moon for feeding. The limited disturbance on feeding areas was less important, because almost always the birds found alternative places nearby, and did not leave the district.

Influence of snow and ice

Seldom, if ever, were all localities frequented by geese under snow at the same time and, while many birds concentrated temporarily in snow-free areas, others stayed where they were. Shallow snow seemed not to influence the foraging of either species, but deep snow restricted the choice of areas available. Both species fed from large grass tussocks at such times, on fresh shoots and rootlets, and Greylag also ate protruding turnips. Both species spent

more time than normal resting during snow periods and less in trying to feed. When a roost froze over, but food remained available locally, geese usually rested on the ice, either on their feet or bellies. It was often possible to see how many had spent the previous night on a site from the castles of droppings left behind.

Roosting sites

Several factors combined to make a site safe and acceptable to geese for roosting. These included not only the degree of actual disturbance, but also various intrinsic features which conferred safety, like situation, area, openness, distance from centres of human activity, and so on. The extent to which any particular roost was used seemed to depend mainly on the balance between its intrinsic attractiveness and the level of actual disturbance. The extensive mud flats of Montrose Basin, for example, were highly attractive to geese, yet little used because of great disturbance by wildfowlers. On the other hand, Dupplin Loch was basically unattractive because of its small size and woodland setting, but was so undisturbed that at times it held more geese than any other site in Britain. To judge from the reactions of geese, the most important disturbances were, in order of importance, low flying aircraft, shooting, human presence, and unfamiliar and prominent objects like oil drums and scarecrows. Geese soon learned to associate danger with particular places, and the same birds were more wary at one place than at another. The main roosts of the two species in the study area are given in Table 2, and all the sites at which geese were seen to roost in Appendix 1.

(a) *Coastal and estuarine sites*

Some favoured roosting sites were on estuaries and coastal mud and sand flats, which were flooded for a minimum period each day, yet where no enemy could approach undetected. A total of nine large mud or sand flats was available in the area, in or near estuaries; at seven, Pinkfeet predominated, and at two Greylag (Table 3). The smallest mud flat used by geese for roosting covered about 3 km², but the area of a site was less important than the distance it spread from shore. Greylag, in their favourite sites, could get up to 1 km off shore, but Pinkfeet liked to get even further out, and on Abertay Sands and Dog Bank in the Tay regularly stood up to 3 km off shore. The only smaller areas of coastal mud which geese frequently used were cut off on all side by water. Both species roosted

Table 2. Main roosts of Greylag and Pink-footed Geese in the study area

	Greylag	Pinkfoot
Strathmore	Lochs Rescobie, Balgavies, Forfar Kinnordy, Lintrathen, Clunie, Marlee and Stormont, Monks Myre, 'Bloody Inches'.	Montrose Basin, Lochs Forfar and Rescobie
Firth of Tay	Mugdrum island	Three sites in the estuary
Strathearn	Drummond Pond, Pitcairnie Loch, three sites on river	Dupplin Loch
Strathallan	Carsebreck	Carsebreck, Loch Mahaick
Ochil Hills	Glenfarg Reservoir	Glenfarg Reservoir
Kinross Plain	Loch Leven	Loch Leven
Eden area	—	Edenmouth, Cameron Reservoir
Forth Valley	Flanders Moss, Lake of Menteith, Inches near Alloa, Grangemouth	Flanders Moss, Lake of Menteith, Grangemouth, Aberlady
Pentland Hills	Harperig and Threipmuir Reservoirs	Cobbinshaw, Baddinsgill and Westwater Reservoirs
	—	
Moorfoot Hills	Gladhouse Reservoir, Portmore Loch	Gladhouse Reservoir, Fala Moor
Lammermuir Hills	Watch Reservoir	Hule Moss
Lanark Hills	—	Upper Cowgill and Culter Reservoirs
Lower Tweed Valley	Hoselaw Loch	

Table 3. Use of coastal and estuarine sites for roosting by geese in the study area

	Approximate area (km²) exposed at low tide	Used by
Montrose basin*	7	Pinkfeet, rarely Greylag
Tay (1) Abertay sands	3	Pinkfeet
(2) Dog/Carthegina banks	26	Pinkfeet, some Greylag
(3) Mugdrum and nearby banks	1·5	Greylag, some Pinkfeet
Edenmouth*	6	Pinkfeet
Forth (1) Tyninghame*	3·5	Pinkfeet
(2) Aberlady Bay	4	Pinkfeet, rarely Greylag
(3) Grangemouth Flats*	10	Pinkfeet, some Greylag
(4) Inches at Alloa*	0·7	Greylag, some Pinkfeet

*Those thus marked are much disturbed by wildfowlers, are now used less than at the turn of the century, and mainly after the end of the shooting season. Edenmouth is also disturbed by low-flying aircraft.

on Mugdrum Island and its associated sand banks in the Tay, and on certain islands in the Forth near Alloa.

In both Tay and Forth, several sites were used, but Pinkfeet predominated at the safer seaward ones, and Greylag further inland. Thus Abertay Sands near Taymouth were used only by Pinkfeet, Dog and Carthagina Banks further upstream mainly by Pinkfeet, and Mugdrum and its associated sand banks yet further up mainly by Greylag. Likewise in the Forth, Tyninghame Sands and Aberlady Bay were regularly used only by Pinkfeet, Grangemouth mainly by Pinkfeet, and the upstream sites around Alloa mainly by Greylag. Furthermore, at Grangemouth, where a harbour divided the flats, Pinkfeet mostly used the larger eastern sector, and Greylag the smaller western one. The only suitable site on the Eden (at the mouth) was used almost exclusively by Pinkfeet, as was Montrose Basin on the Angus coast.

(b) *Rivers*

Further up river, Greylag occasionally roosted on bare islands or on shingle banks in mid-stream, or on wet ground and flood pools at the edge. The river at such points was also fairly wide, with low banks devoid of trees. All three rivers in the area which offered these facilities were used. Favoured roosts on the Earn included the flood pools at Innerdunning, Dalreoch, and Netherfordun; on the Tay the Inches near Meikleour and the islets south of Pitlochry; and on the Clyde the Haughs near Quothquan (Lanark). Pinkfeet were seen at no such sites, but used the extensive sheets of water which occasionally resulted from flooding on the Clyde south of Libberton. This was especially true when nearby still waters were frozen.

(c) *Lakes and reservoirs*

Ordnance Survey Maps (scale 1/63,360) show a total of 165 ponds, lochs and reservoirs in the study area, excluding pools on mosses discussed below. Many such sites were too disturbed, in too narrow and steep-sided valleys, surrounded by trees, too far from feeding areas, so high that they were often frozen, or otherwise unsuitable as roosts. For the remainder, the surface area of water had an obvious influence on whether a site was used. Only 22% of

Table 4. Use of ponds, lakes and reservoirs for roosting by geese in the study area (mossland pools excluded—See Appendix 2)

Area of water (km²)	Total available	Used by Greylag	Used by Pinkfeet	Used by both species	Used by neither species
< 0·1	99	20	2	0	77
0·11–0·20	29	18	4	2	9
0·21–1·00	31	23	13	8	3
> 1·0	6	5	5	4	0
Totals	165	66	24	14	89

ninety-nine waters less than 10 ha in area were used by geese, but this proportion increased with increasing area, and all waters extending over more than 100 ha were used. The two species differed in the water areas they accepted. Greylag used the largest number, including both small and large waters, but Pinkfeet used mainly waters more than 20 ha in surface area (Table 4). Thus, of 128 waters of less than 20 ha in area, thirty-eight were used by Greylag and only six by Pinkfeet, but of thirty-seven larger waters, twenty-eight were used by Greylag and eighteen by Pinkfeet ($P < 0{\cdot}01$). Further, only twelve of the thirty-seven large waters in the area were used by both species together, the remaining twenty-five by one or other, so here again the species tended to separate.

(d) *Moorland pools*

Many roosts were centred on small pools on remote, damp, moors (or mosses). Because of the nature of the ground, such sites were seldom disturbed and all provided a wide view. Geese roosted on the pools themselves or on ground nearby. The map showed nineteen such mosses, with suitable pools, in our area. One of these was used by Greylag alone for roosting, four by Pinkfeet alone, and another two by both species (Appendix 2). Three of the most important Pinkfoot roosts in the area were on east Flanders Moss (Perthshire), Fala Flow (Midlothian) and Hule Moss (Berwickshire). For daytime resting, Greylag used at least another two such sites, and Pinkfeet another four. Also, Pinkfeet rested by day on at least eight other mosses, which lacked permanent water, and Greylag roosted on Cranley Moss (Lanark) when flooding created pools.

In conclusion, the two species differed in their favourite roosting places. Pinkfeet preferred extensive estuarine mud flats, large lochs and reservoirs, and remote mosses; Greylag used these sites to some extent, but also used smaller waters and rivers. In general, sites used by Pinkfeet offered greater security and freedom from disturbance than did many of the sites used by Greylag. This does not explain why Greylag avoided many of the safer sites, unless to avoid Pinkfeet already there. On shared roosts, the two species normally kept to different areas, and flighted independently.

The extent to which any particular roost was used seemed to depend partly on the number of alternatives available, on the relative degrees of security they offered, and the extent of recent disturbance at each. In practice, the numbers of geese at many sites fluctuated greatly from night to night, especially during the shooting season. Appendix 1 gives some idea of the maxima for the different sites recorded during our study, but adding them together would give a figure far in excess of the total geese in the area at any one time.

Rest stations

When feeding several kilometres from a roost, or when the roost offered only a small sheet of water, geese usually adopted areas of moor or rough grass as 'rest stations' from which they commuted to feeding areas nearby. These rest stations were constant from year to year, but not necessarily used throughout a season. Their siting appeared to result partly from the need to be near feeding areas and partly from the need for safety. Sites were often centred on a wide stretch of damp moorland or near the summit of a rounded hill in farmland, but always provided a wide view over surrounding land. The farmland ones were usually as far as possible from a road. One could not approach geese on such sites without being seen. Of twenty-three regular Pinkfoot rest stations found, twelve were on mosses, six on large grassy fields on hillsides, four on offshore sand banks or islands, and one in a damp field. Of twelve Greylag rest stations found, three were on mosses, two on islands, and seven on damp riverside fields (Appendix 3).

Rest stations were used much more by Pinkfeet than by Greylag and possibly helped Pinkfeet to exploit successfully feeding areas distant from roosts. After leaving a roost in the morning, Pinkfeet sometimes flew to a rest station and then, using it as a base, flew to and from the fields throughout the day. At evening, too, Pinkfeet often assembled on a rest station before going to roost. They then approached the roost in much poorer (and possibly safer) light than if they had flown there direct. This behaviour was especially prevalent when the roost offered only a small expanse of water, like the pond on Fala Moor. As a rule each Pinkfoot roost had one or more rest stations associated with it.

Feeding areas

Geese fed on only a small part of the farmland in the study area. Usually each roost

had several associated feeding areas, which varied from a single field to tracts of several square kilometres (Figure 2). (A feeding area was considered separate when it was more than 0·5 km from the next, otherwise the two were classed as one.) Adjacent unsuitable terrain limited the extent of most feeding areas. In general, geese fed most in extensive flat or slightly undulating country, with few trees and hedges, and avoided hummocky or well timbered terrain, with small fields and tall hedges, which restricted their view. They also avoided areas which, though topographically suitable, were much disturbed. Pinkfeet were more extreme in their preferences than Greylag, and often flew further from their roost to feed. We have tried to quantify this last difference in the study area by calculating the proportion of the total feeding area of the two species which lay at various distances from the nearest roost (Table 5). Analysis was restricted to the area north of the Forth where feeding areas were best known. In this area 90% of the Greylag's total feeding ground was within 5 km of a roost, and only 2% more than 10 km away compared with 66% and 15% for the Pinkfoot. About 1% of the Pinkfoot's feeding areas were more than 20 km from a roost. (The difference between the species is significant at the 0·1% level.) No account was taken of the extent to which the two species used feeding areas at different distances, nor the fact that geese did not invariably fly to the nearest roost from a particular feeding area.

Spatial separation of the two species

Differences in roosting sites and flighting distance tended to separate the two species and reduced the extent to which they fed on the same ground. Also Greylag generally preferred to be near rivers and Pinkfeet on extensive open areas, however far from water. North of the Forth, geese of one species or the other fed over about 351 km² of land, Greylag alone over 151 km², Pinkfeet alone over 153 km², and the two species together over only 47 km². Hence only 13% of the total goose country was used by both species.

Changes this century in the distribution of geese in the study area

Because of the sporting value of geese, their distribution over the years was well documented (Baxter & Rintoul, 1953; Harvey-Brown, 1906; Millais, 1901; Muirhead, 1895; Nash, 1935). Both species seem to have been increasing in Britain at least since 1880. The evidence up to 1930, mostly based on memory records, was given by Berry (1939), but since 1950 counts organized by the Wildfowl Trust have confirmed the trend (Boyd & Ogilvie, 1969, 1972). Throughout, moreover, the increase has been most marked in Scotland.

Not only did numbers rise at established roosts, but new sites were also occupied, mainly inland. The spread inland was probably encouraged by: (1) increased disturbance at coastal sites resulting from greater public wildfowling, aircraft and military activities (Berry, 1939); (2) construction of reservoirs (= roosts) in areas lacking natural lakes; (3) removal of trees and hedges, creating open spaces attractive to geese in inland areas formerly unsuitable; and (4) more autumn ploughing near the coast rendering much ground useless to geese thereafter, and improved management of grass in the uplands providing better feeding there than formerly (Brotherston, 1964).

The main coastal sites occupied in 1875–1900 were Montrose Basin (Pinkfeet), Inner and Outer Tay (both species), Edenmouth (both species), Grangemouth Flats (Pinkfeet), Aberlady Bay (both species) and Tyninghame (Pinkfeet). The main inland sites were Loch Leven (both species), Cobbinshaw Reservoir (Pinkfeet), Hule Moss (Pinkfeet), Coldingham Moss (Pinkfeet), Flanders Moss (both species), two unspecified mosses in Lanarkshire (Pinkfeet), and Fala Flow (Pinkfeet). The Pinkfoot was thus most widespread, roosting at fourteen sites (eight inland), compared with the Greylag's five (two inland). At that time, the Greylag shared all its roosts with the Pinkfoot, which always outnumbered it. Today the Pinkfoot has twenty-five major roosts (nineteen inland) in the same area, and the Greylag twenty-nine (twenty-eight inland); north of the Forth, both species are about equally numerous, but to the south the Pinkfoot still predominates, less so than in 1950. Now the Greylag shares only nine of its twenty-nine main roosts with the Pinkfoot, so the two species are also more segregated than formerly. The disappearance this century of Pinkfeet from Coldingham can be attributed to the destruction of the moss by ploughing, but Greylag have recently adopted the ponds remaining.

Several roosts in the study area have

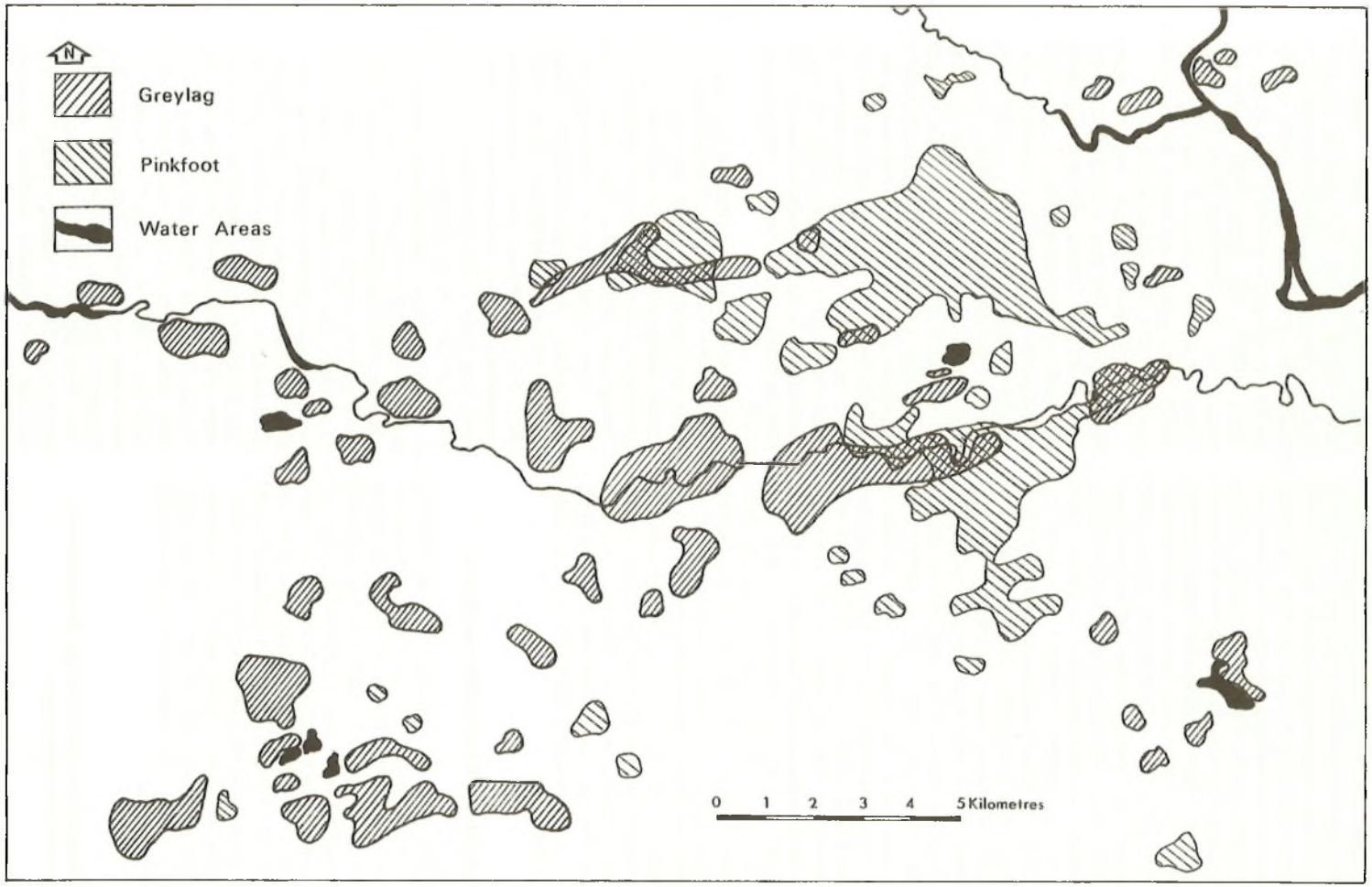

Figure 2. Part of the study area, showing the separation of feeding areas of Greylag and Pink-footed Geese.

Table 5. Extent of total feeding area of geese lying at different distances from roosts

	Distance from nearest roost (km)				
	0–2	2–5	5–10	10–20	20–30
% Greylag feeding area	49	41	8	2	0
% Pinkfeet feeding area	24	42	19	14	1

*Greylag alone fed over 151 km² of the study area north of the Forth, Pinkfeet alone over 153 km², and both species together over 47 km².

experienced fluctuating usage by geese over the years associated with changes in disturbance. Coastal sites, being public, were generally more disturbed than inland ones, the more so in recent years because of increased mobility of wildfowlers. At the Tay and Forth Estuaries military operations were also involved (Berry, 1939; Brotherston, 1964). Some coastal sites, with public access, such as Montrose, Eden, Grangemouth and Tyninghame, which were formerly important, are now little used until after the shooting season each year. Likewise the use of Cobbinshaw by Pinkfeet has declined since shooting increased there, while Harperig was largely deserted by Greylag for a time in favour of Threipmuir under the same conditions. On the other hand, the use of Aberlady Bay increased again after it became a nature reserve in 1952 (Brotherston, 1964). These changes provide circumstantial evidence for the importance of disturbance in influencing goose-distribution.

One last point worthy of comment is the increased importance to both species of reservoirs and other artificial lakes. Nowadays eight of the twenty-nine main Greylag roosts in the study area, and nine of the twenty-five Pinkfoot ones, were on man-made waters.

Conclusions

Potential limits to the distribution of geese in the study area were set by the location of suitable roosting sites in or near farmland, where all feeding was done. Within this framework, the distribution of the birds was then influenced mainly by disturbance, which banished or reduced them in certain areas and led to their increase in others. The degree of safety offered by an area was influenced by two types of factors. First were those imposed by the environment. For roosting, coastal and estuarine sites were intrinsically the most attractive to geese because they were the most extensive and open, while inland, large waters were more attractive than small ones. For feeding, open, flat or slightly undulating country, with a minimum of trees and hedges, was preferred to hummocky, well timbered country, with small fields. Second, actual disturbance, caused by shooting, human presence and other factors, superimposed its own pattern on that set by topography. The extent to which a particular roost or feeding area was used seemed to depend on the balance between its intrinsic attractiveness and the degree of actual disturbance. Lastly, while geese clearly linked disturbance with particular sites, the degree of overall shooting probably also affected the minimum requirements for roosting and resting areas, a heavily shot population using only the safer of a range of sites and a lightly shot population accepting others.

Differences in roosting, feeding and flighting habits between the species could be attributed largely to the greater wariness of the Pinkfoot and its stronger reaction to disturbance. For roosting, it used places which were especially safe, either because of their intrinsic characteristics, or because they were remote and otherwise free from disturbance. The avoidance of some of these sites by Greylag is puzzling, unless to avoid Pinkfeet. On shared roosts, the two species normally kept apart, and several times this century Greylag segregated completely from Pinkfeet when an alternative roost in an area became available (Brotherston, 1964). Last century all the Greylag roosts were shared by Pinkfeet, but now that more waters are occupied, less than one-third of the Greylag roosts are shared (Appendix 1).

Aknowledgments

We are grateful to A. Allison & C. R. G. Campbell for allowing us to incorporate their observations of geese, and to H. Boyd, Dr. D.

Jenkins, Professor G. V. T. Matthews, M. A. Ogilvie & L. Young for their comments on the manuscript.

Summary

In southeast Scotland immigrant Greylag and Pink-footed Geese fed entirely on farmland (including grassland), where their distribution was governed by the location of suitable roosts, from which they flew to restricted feeding areas nearby. Continual movement took place between different roosts, and peak numbers occurred in different months in different districts.

Pinkfeet preferred the safer of a range of sites for roosting, including estuaries, large lakes and reservoirs, and remote moorland pools, while Greylag also used less safe sites, including small ponds and rivers. Of forty-five major goose roosts in the study area, only nine were used regularly by both species, the rest by one or other. On shared roosts the two species kept apart.

Pinkfeet were also more particular in their choice of feeding areas, and often foraged further from their roosts than did Greylag. Greylag rarely flew more than 5 km to feed, but Pinkfeet regularly more than 10 km, and occasionally more than 20 km.

Differences in roosting and flighting habits led to spatial separation of the two species on farmland and, of the total goose country in the study area, only 13% was occupied by both species together, the rest by one or other.

Within limits set by the location of suitable roosting and feeding areas, the distribution of geese, was influenced mainly by disturbance, especially shooting.

References

Atkinson-Willes, G. L. 1963. *Wildfowl in Great Britain.* London: HMSO.

Baxter, E. V. & Rintoul, L. J. 1953. *The Birds of Scotland.* London & Edinburgh: Oliver & Boyd.

Berry, J. 1939. The status & distribution of wild geese & wild duck in Scotland. *Int. Wildf. Inquiry*, Vol. 2. Cambridge: Univ. Press.

Boyd, H. 1955. The role of tradition in determining the winter distribution of Pinkfeet in Britain. *Wildfowl Trust Ann. Rep.* 7:107–22.

Boyd, H. 1957. Recoveries of British-ringed Greylag Geese. *Wildfowl Trust Ann. Rep.* 8:51–4.

Boyd, H. 1959. Greylag Geese in Britain in Winter. *Wildfowl Trust Ann. Rep.* 10:43–58.

Boyd, H. & Ogilvie, M. A. 1969. Changes in the British wintering population of the Pink-footed Goose from 1950 to 1975. *Wildfowl*, 20:33–46.

Boyd, H. & Ogilvie, M. A. 1972. Icelandic Greylag Geese wintering in Britain in 1960–1971. *Wildfowl*, 23:64–82.

Brotherston, W. 1964. The numbers & behaviour of geese in the Lothians and Berwickshire. *Wildfowl Trust. Ann. Rep.* 15:57–70.

Harvie-Brown, J. A. 1906. *A Fauna of the Tay Basin and Strathmore.* Edinburgh: David Douglas.

Millais, J. G. 1901. *The Wildfowler in Scotland.* London.

Muirhead, G. 1895. *The Birds of Berwickshire.* Edinburgh: David Douglas.

Nash, J. K. 1935. *The Birds of Midlothian.* London: Witherby.

Newton, I. & Campbell, C. R. G. 1970. Goose studies at Loch Leven in 1967/68. *Scot. Birds* 6:5–18.

Newton, I. & Campbell, C. R. G. (1973) Feeding of geese on farmland in east-central Scotland. *J. appl. Ecol.* 10: (in press).

Newton, I., Campbell, C. R. G. & Allison, A. In press. The food of Greylag & Pinkfooted Geese in east-central Scotland. *Bird Study*,

Thom, V. M. & Murray, C. 1966. Grey geese in Perthshire. *Trans. Proc. Perth. Soc. Nat. Sci.* 11:38–42.

Dr I. Newton, The Nature Conservancy, 12 Hope Terrace, Edinburgh, EH9 2AS.
Miss V. M. Thom, 19 Braeside Gardens, Perth.
W. Brotherston, 22 Rutland Square, Edinburgh EH1 2BB

Appendix 1. Sites on which geese were known to roost in the study area, 1966–70. A: usual maximum number more than 2,000; B: 1,000–2,000; C: 500–1,000; D: less than 500.

Greylag

O.S. map 49: Haughs of Tay south of Pitlochry (D), Dowally Loch (D), Craiglush Loch (D), Loch of the Lowes (D), Butterstone Loch (D), Loch Benachally (D), Loch Clunie (A), Kings Myre (D), Broomhill Pond (A), Bloody Inches (A), Marlee Loch (B), Dykeside Moss (D), Fingask Pond (D), Stormont Loch (A), Hare Myre (D), Monks Myre (A), Lintrathen Loch (C), Long Loch (D), Redmyre (D), Airntully Pools (D).

O.S. map 50: Kinnordy (C), Forfar Loch (B), Rescobie/Balgavies Loch (B), Monikie Reservoir (D), Duns Dish (C).

O.S. map 54: Lake of Menteith (B), Loch Rusky (D), Flanders Moss (A), Muir Dam (D), Airthrey Loch (formerly D), Braco Pond (D), Loch Monzievaird (D), Loch of Balloch (D), Cowden Loch (D).

O.S. map 55: Drummond Pond (A), Carsebreck Ponds (A), Glendevon Reservoirs (D), Meallbroden Loch (D), Gartmorn Dam (D), Peppermill Dam (D), Pitcairnie Pond (A), Craigluscar Reservoir (D), Bertha Loch (C), Loch Glow (D), Glenfarg (B), Loch Leven (A), Loch Fitty (D), Loch Ore (D), Earn-Nether Fordun (C), Earn-Dalreoch (B), Earn-Inverdunning (C), Tay-Mugdrum Island (A), Tay-Dog/Carthegina Banks (C) Harperleas Reservoir (D), Ballo Reservoir (D), Holl Reservoir (D), Forth-Alloa Inches (C)j

O.S. map 56: Loch Lindores (C), Dunshelt Moss (C), Carriston Reservoir (D), Clatto Reservoir (D), Kilconquhar Loch (D), Carabee Pond (D).

O.S. map 61: Springfield Reservoir (D), Grangemouth Flats (C), Crosswood Reservoir (D), Crane Loch (D).

O.S. map 62: Harperig Reservoir (D), Threipmuir (C), Portmore Loch (D), Gladhouse Reservoir (B), Allanshaws Reservoir (D).

O.S. map 63: Stobsheil Reservoir (D), Watch Reservoir (C), Coldingham Ponds (D), Hirsel Lake (D).

O.S. map 64: Hoselaw Loch (C).

O.S. map 68: Cranley Moss (D).

O.S. map 70: Yetholm Loch (D).

Pinkfoot

O.S. map 49: Redmyre Moss (D).

O.S. map 50: Forfar Loch (A), Rescobie Loch (A), Montrose Basin (C).

O.S. map 54: Lake of Menteith (B), Flanders Moss (A), Loch Mahaick (A).

O.S. map 55: Carsebreck Ponds (A), Glendevon Reservoirs (D), Peppermill Dam (D), Dupplin Loch (A), Clevage Moor (D), Glenfarg (C), Loch Leven (A), Loch Fitty (D), Loch Ore (D), Tay-Mugdrum Island (A), Tay-Dog/Carthegina Banks (A), Tay-Abertay Sands (A), Harperleas Reservoir (D), Ballo Reservoir (D), Forth-Inches near Alloa (D).

O.S. map 56: Edenmouth (C), Cameron Reservoir (A).

O.S. map 61: Springfield Reservoir (D), Grangemouth Flats (C), Cobbinshaw Reservoir (C), Crane Loch (D), Bowmuir (D).

O.S. map 62: Westwater Reservoir (A), Baddinsgill Reservoir (A), Gladhouse Reservoir (A), Fala Flow (A), Aberlady Bay (A).

O.S. map 63: Hopes Reservoir (D), Tyninghame (D), Hule Moss (A).

O.S. map 68: Loch Lyock (D), Floods on Clyde, Quothquharn (B), Upper Cowgill Reservoir (C), Culter Reservoir (D).

Appendix 2. Mosses and moors used for roosting and resting by geese. G: Greylag; P: Pinkfoot.

Areas with ponds used for roosting: Bowmuir (P), Crane Loch (P), Dunshelt (G) Fala Flow (P), Flanders Moss (PG), Hule Moss (P), Redmyre (PG).

Areas with ponds used for resting: Auchterhead Muir (P), Clevage (P), Cranley Moss (G) Dykeside (G), Kippen Muir (P), Rossie Moor (P).

Areas without ponds used for resting: Auchencorth Moss (P), Esperson Moss (P), Toxside Hill Moss (P), Cocksmuir (P), Middleton Muir (P), Methven Moss (P), Muir of Orchill (P), Sherriffmuir (P).

Appendix 3. Rest stations of geese in study area. G: Greylag; P: Pinkfeet.

Strathmore: Rossie Moor (P), Redmyre (GP), Wester Essendy Farm (G).

Strathtay: Tentsmuir Point (P), Abertay Sands (P), Mugdrum Island (GP).

Strathearn: Methven Moss (P), Bachilton Farm (P), Pow Water (G), East Fordun Farm (G), Bogtonley Farm (P), Denmarkfield River Shingle (G), Milton of Forteviot Farm (G), Lauchie Farm (P), Kilspindie Farm (GP), East Forden Farm (G).

Kinross Plain: St Serfs Island, Loch Leven (P).

Eden Area: Dykeside Moss (G).

Forth Valley: Kippen Muir (P), Flanders Moss (GP), Sherriffmuir (P), Muir of Orchill (P).

Moorfoot Hills: Toxsidehill (P), Esperton Moss (P), Middleton Moss (P), Cakemuir Hill (P), Auchencorth Moss (P), Halflow Kiln Farm (P), Cocksmuir (P).

Lanark Hills: Cranley Moss (G).

E. E. Jackson

Plate IV. Diving ducks on land. Above: a male Canvasback *Aythya vallisneria* shows that it can maintain a horizontal posture despite its far-back legs. Below: a pair of Ring-necked *Aythya collaris* unusually have erected crests (part of the courtship) while ashore.

Philippa Scott