Responses of wintering Brent Geese to human disturbance

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This paper describes the effects of human disturbance on Dark-bellied Brent Geese *Branta bernicla bernicla* wintering in Essex in 1973–1974 and 1974–1975 in terms of: (a) the restriction of feeding area; (b) the effects on feeding behaviour and flighting. The study was one of four interrelated studies of Brent Geese, initiated by the proposal to reclaim the Maplin Sands (an important Brent Goose feeding area) to build the third London airport.

Methods

The study area included all the coastline between the River Colne and Leigh Marsh in Essex (Figure 1). Seasonal changes in the numbers and precise distribution of geese were recorded on 1:25,000 outline maps, and also the nature and intensity of disturbance and local movements of geese. The amount of feeding time lost, and the extra time in flight, through disturbance were determined. An area was selected and observation begun 10 minutes after arrival, to allow the geese to settle, from at least 200 m away. Once a minute the number of geese present, the proportion of geese feeding, in eighths, and the number of geese in flight, were recorded. The time and estimated distance from the geese of every disturbance were also recorded within each minute.

A count or good estimate of the number of flying birds was made once every minute, and an estimate, in eighths, of the proportion of the flock that held their necks below horizontal. (Birds occasionally held their heads low for other reasons than feeding.) The accuracy of these estimates was checked in flocks of known size by counting accurately the number of birds with their heads down, immediately following an estimate in eighths. The latter method was found to give a reasonable estimate of the proportion of birds with heads down ($r = 0{\cdot}96$; $p < 0{\cdot}001$; Figure 2).

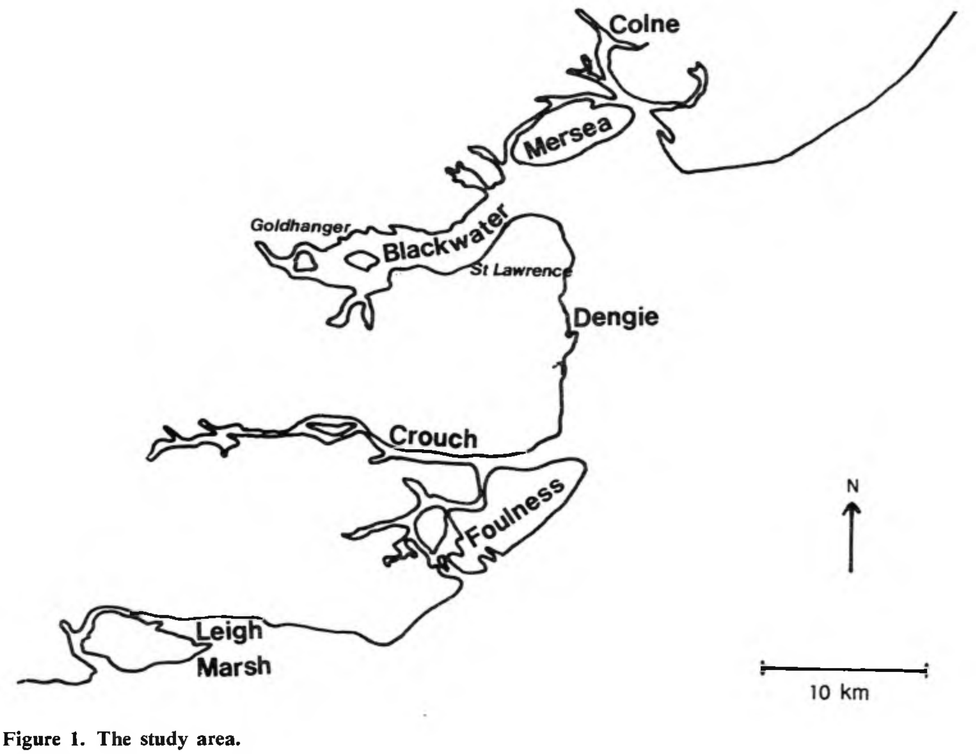

Figure 1. The study area.

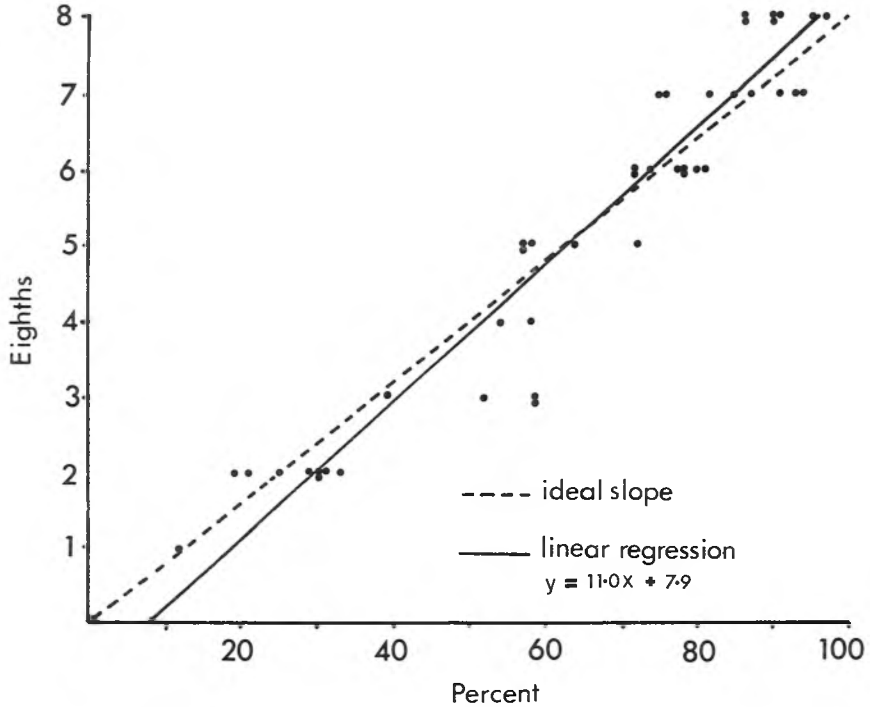

Figure 2. The relationship between estimates by eighths and percentage estimates by actual head counts of the proportion of geese with their heads down (feeding).

Sampling methods

Six sites, namely the Colne, Goldhanger and St Lawrence Bay (Blackwater), the Dengie Peninsula, Leigh Marsh, and Foulness, were chosen for quantitative study. This selection ranged from little disturbed to very disturbed sites and at times supported about two-thirds of the British and one-third of the world population of Brent in 1973–1974. In each area it was possible to spread watches evenly over the tidal cycle and fairly evenly between dawn and dusk, though there was a tendency to watch slightly more frequently between 09.00–11.00 hrs and between 14.00–16.00 hrs. Most data were collected between November and February. At Leigh and Goldhanger, comparative data were collected in early and late winter.

Estimation of feeding time lost as a result of disturbance

The effects of disturbance rarely lasted longer than 20 minutes after a disturbance ceased. Thus the percent of time spent feeding was estimated firstly when there had been no disturbance for at least 20 minutes, and secondly throughout disturbed and undisturbed periods. The difference between the two estimates gives a measure of the proportion of their time that geese were prevented from feeding by disturbance. This measure, unlike most measures, is unaffected by the extent to which birds compensated for disturbance by feeding more during undisturbed times. Such a measure was necessary because the extent of compensation could not be determined. The lost feeding time comprised disturbance flights, walking or swimming away from a feeding area, and simply head-raising.

Experimental disturbances

Goose flocks feeding on saltmarsh in North Norfolk were disturbed experimentally in February and March. Standard approaches were made on foot, wearing a bright red jacket. The distance between the observer and the nearest bird when the flock flew up was measured by pacing.

Results

Responses to disturbance

When mildly alarmed, Brent Geese put their heads up briefly, but quickly resumed feeding. When somewhat more alarmed, they stopped feeding for longer, sometimes walking away and calling. When severely disturbed they took flight, often resettling in the same place after disturbances by aeroplanes or loud noises, but usually leaving when disturbed by people on the ground. Geese re-alighted in dense flocks, gradually spreading out to feed, sometimes by further flighting away from the main group of birds. The disturbance behaviour of a flock may be determined by the behaviour of its most nervous members, since a few geese taking flight tended to cause the whole flock to follow. Adults with families spend more time with their heads raised. These 'sentinels', probably males, often first gave warning of potential danger, though they were not necessarily the first to fly.

Brent Geese were particularly susceptible to disturbance by aircraft, and any 'plane below about 500 m and up to 1·5 km away could put them to flight. Slow, noisy aircraft were especially harmful, and helicopters caused widespread panic. The geese were very slow to become habituated to aircraft, though at Leigh Marsh in January–February they did cease responding to the transport planes that took off regularly from Southend Airport. Other low-flying aircraft continued to cause disturbance throughout the winter (Table 1).

Large birds with a slow wingbeat such as Great Black-backed Gulls *Larus marinus*, Herons *Ardea cinerea* and Hen Harriers *Circus cyaneus* were also liable to put the geese to flight. Even Carrion Crows *Corvus corone* landing near a goose flock caused birds to raise their heads briefly. The intensity of response to aircraft and their slowness to habituate to them may have been partly a result of the visual resemblance of aircraft to large birds. Kestrels *Falco tinnunculus*, Merlins *F. columbarius* and Sparrowhawks *Accipiter nisus* did not always cause disturbance, though geese sometimes flew up when these raptors caused waders to give alarm calls.

At low tide, disturbance was caused by bait-diggers, bird-watchers, and people walking out to moored boats or shellfish beds. At high tide disturbance was often caused by people on the shore. There was a decrease during the winter in the distance at which people at Leigh and Goldhanger put Brent Geese to flight (Figure 3). Before New Year, about one-third of people approaching to within 100 m put birds to flight, whereas after New Year only 12% of people did so at this distance ($p < 0{\cdot}001$). In early winter it was not possible to approach the geese more closely than 50 m. In January–March however, twelve observations were made of

Table 1. The frequency of disturbing incidents that put some or all of the Brent Geese being watched to flight.

Place	Time of year	Total time watched (mins)	Mean time between disturbances (mins)	Number of disturbances by:— People on the ground (a)	(b)	(c)	Aircraft (d)	(e)	(f)	(g)	Loud noises (h)	(i)	(j)	Total
C	Jan–Mar	1179	147	1	1		1					4	1	8
G	Nov–Dec	1439	60	10	1	1	7			2			3	24
G	Feb–Mar	1428	179	2	1	1	4							8
G	Jan–Feb (weekends)	452	75	5									1	6
S	Feb–Mar, Nov	611	76	4			1	1	1		1			8
D	Nov–Mar	1958	218	2		3	4							9
F	Oct	581	290									2		2
L	Nov—Dec	862	32	14			4	6			3			27
L	Jan–Mar	947	118	1		2	4				1			8
L	Oct–Nov (weekends)	600	25	7		3	10	4						24
Totals:		167 h 37 m		46	3	10	35	11	1	2	5	6	5	124

C = Colne, G = Goldhanger, S = St Lawrence Bay, D = Dengie, F = Foulness, L = Leigh.
(a) on shore or seawall; (b) wildfowlers; (c) bait-diggers; (d) small propellor-driven aircraft; (e) transport aircraft; (f) jet aircraft; (g) helicopters; (h) boats with outboard engines; (i) army explosives; (j) gun shots.

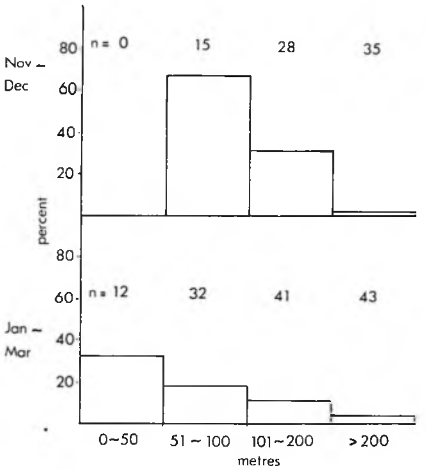

Figure 3. The distances at which people on the ground put Brent Geese to flight in early and late winter. Vertical scale shows percentage of disturbances that occurred at each distance.

people coming within this distance, and on only four occasions were the geese put to flight. At Leigh, geese sometimes stayed on the ground when people came as near as 20 m to them.

Experimental approaches to flocks of between 6 and 400 geese on the Norfolk saltmarshes showed that there was a tendency for larger flocks to take flight at greater distances ($r = 0{\cdot}67$; $n = 22$; $p < 0{\cdot}001$; Figure 4).

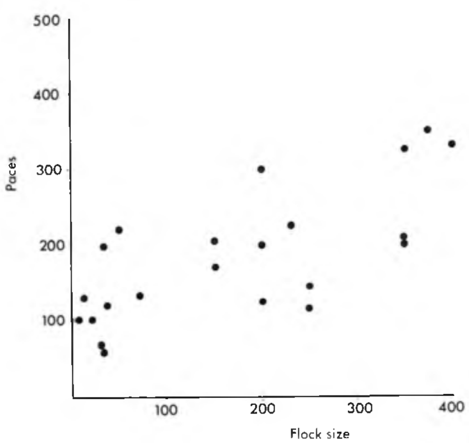

Figure 4. The distances at which flocks of different size were put to flight by experimental disturbances in north Norfolk in February–March 1974 and 1975.

Brent Geese learned the dangers associated with particular places. For example at the Colne salting, much used by wildfowlers, geese in February could not be approached within 500 m, whereas the same geese could be approached to within 150 m on the Colne mudflats. Similarly, they were more easily disturbed when on novel feeding areas, such as fields behind the sea wall. For example, during an undisturbed 90 minute watch of birds feeding on winter wheat at Dengie on 8th January 1974 (soon after they started feeding over the sea wall), 34% of the time was spent feeding, compared with a mean of 59% on intertidal areas at Dengie. Large boats rarely caused disturbance, being generally in deep water. Even when they did come close, in the Colne estuary, the birds ignored them. Yachts, too, rarely disturbed Brent Geese, but small boats with noisy outboard engines caused them to take flight.

Brent Geese quickly become habituated to most sounds. Unexpected ones, such as nearby gun shots from wildfowlers, usually put the geese to flight. Similarly, the first shots of the day at the Colne Army ranges caused geese to leave the saltings for the mudflats. They quickly returned however, and ignored all subsequent firing that day. At Foulness, the extremely loud but regular bangs made during weapon testing caused little reaction after the first weeks. Brent Geese fed undisturbed 50 m from passing trains at Leigh Marsh.

When disturbances occurred very frequently, birds appeared to become more easily disturbed on subsequent occasions. For example, three people walking on the *Zostera* beds at Leigh in November approached Brent Geese three times in the space of one hour. At the first approach, the birds flew up when the people were about 200 m away, at the second approach 600 m, and on the third at 800 m.

Effects of disturbance on distribution and movements

Brent Geese were not totally excluded by disturbance from any large areas with suitable food. Geese avoided heavily disturbed feeding sites in early winter but used all such areas later, as food stocks became depleted elsewhere. At Leigh Marsh, for example, the geese at first avoided the area around the north-east corner of Two Tree Island, close to the town of Leigh, a cockle processing depot, a car park, and the railway. In the second half of November, however, only the disturbed parts of the *Zostera* bed remained

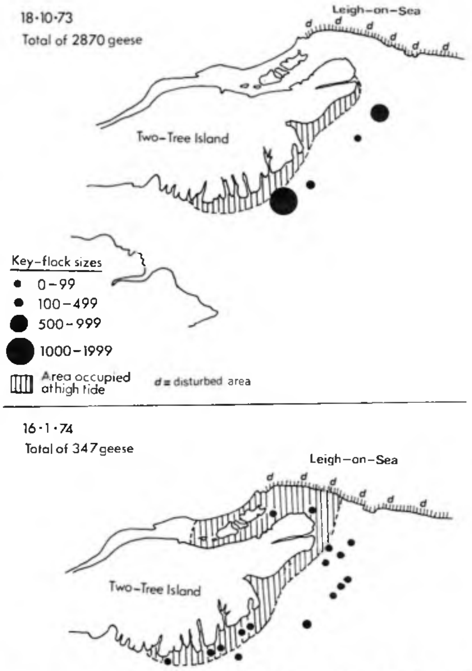

Figure 5. The distribution of Brent Geese at Leigh Marsh before and after habituation to disturbance by people on the shore at Leigh-on-Sea.

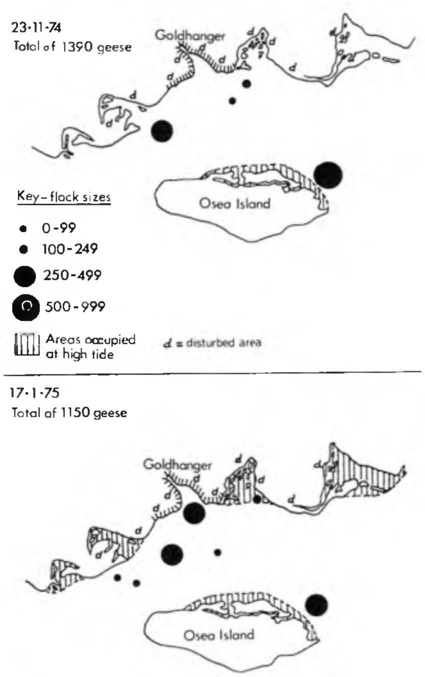

Figure 6. The distribution of Brent Geese in the north Blackwater before and after habituation to disturbance by people on the northern shore.

green and the birds started to feed there (Figure 5). A similar pattern occurred in the north Blackwater (Figure 6), and in all the other major feeding areas where there was disturbance from the shore. The geese only penetrated narrow creeks without all-round visibility when other areas had been depleted of food (Figure 7).

Frequency and intensity of disturbances putting geese to flight

In 168 hours of observation of geese at the selected sites, human disturbance that caused some birds to fly occurred on average once every 81 minutes. Forty-eight percent of disturbances were by people (mostly on the shore), 39% by aircraft (mostly small propellor-driven planes), 9% by loud noises and 4% by small boats. Figures for the separate study sites are given in Table 1. Leigh Marsh, early in the winter, was the

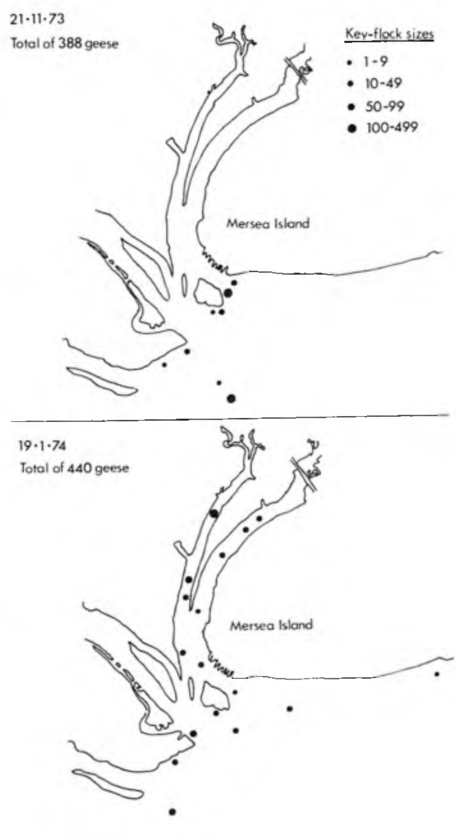

Figure 7. The distribution of Brent Geese near Mersea Island, illustrating the penetration of narrow creeks in late winter.

most disturbed study area, disturbances occurring about once every 30 minutes. This was about twice the frequency of the Blackwater estuary. Dengie, the Colne and Foulness were relatively undisturbed. Aircraft and people on the shore caused flighting in all areas except Foulness, where Army restrictions largely prevented these sources of disturbance. Bait-diggers caused some flighting at Goldhanger, Dengie and Leigh, and boats at Leigh and St Lawrence. Flighting was caused by gun shots on the Colne and Blackwater and by Army explosions on the Colne and Foulness.

Disturbances by aircraft on average caused about twice as many geese to take flight as disturbances by people ($d = 5{\cdot}3$; $p < 0{\cdot}001$; Table 2), largely because the area affected by an aircraft tended to be larger than that affected by a person on the ground. Taking into account their lesser frequency, aircraft caused about 1·6 times as much disturbance as people.

Table 2. The relative effectiveness of people and aircraft at putting geese to flight.

	Mean percentage of geese taking flight	No. of observations
People	38 ± 4·7	51
Aircraft	77 ± 3·6	30

Feeding time lost

Geese lost time from feeding by disturbance in all areas throughout the winter except at Leigh in late winter (Table 3). Over all areas, disturbance prevented geese from feeding for an average of 3·5% of their time. The greatest losses of feeding time were at weekends at Leigh and Goldhanger.

When the tide was out, there was a large area in which displaced Brent Geese could resettle, and so feeding could be resumed very quickly. Around high tide however, the available feeding space was relatively crowded and more likely to be disturbed. Disturbed geese then tended to fly out and sit on the water, only returning to feed when the disturbance had passed. A significantly greater amount of feeding time was lost per disturbing incident in the six hours around high tide than in the six hours around low tide ($p < 0{\cdot}001$, Mann-Whitney U-test). Thus walkers on the shore at high tide caused a greater loss of feeding time than bait diggers at low tide.

The proportion of time spent in food-seeking activity in daylight in 1973–1974 was probably close to the maximum possible. Undisturbed birds with their heads up, although counted as not feeding, were usually foraging (walking to the next patch of food). Very few birds were seen resting, except when the tide completely covered the feeding grounds. The proportion of time spent feeding in *Enteromorpha* areas was smaller than on *Zostera* areas in 1973–1974 ($p < 0{\cdot}05$, Mann-Whitney U-test). This was largely because birds on *Enteromorpha* spent a greater proportion of their time foraging, not because they rested more. Geese on *Zostera* in early winter spent a much greater proportion of time feeding in 1973–1974 than in 1974–1975 (Table 3). The difference was due to birds in the latter

Table 3. The feeding time lost as a result of disturbance.

Place	Months	Year	% Time feeding, no disturbance (A)	% Time feeding, overall (B)	% Time disturbance, prevented feeding (A–B)	Time watched mins
Colne, mudflats	Feb–Mar	1973	41·8	41·1	0·7	235
Colne, saltings	Feb–Mar	1973	91·1	90·3	0·8	209
Goldhanger	Nov–Dec	1973	64·3	61·2	3·1	519
Goldhanger	Feb–Mar	1974	50·0	48·0	2·0	581
Goldhanger	Jan–Feb (weekends)	1974	51·9	44·8	7·1	295
St Lawrence Bay	Feb–Mar, Nov	1973	67·8	63·3	4·5	501
Dengie	Mar, Nov, Dec Jan–Feb	1973 1974	59·3	57·3	2·0	435
Foulness	Oct	1973	82·4	80·5	1·9	581
Leigh	Nov–Dec	1973	79·3	74·4	4·9	862
Leigh	Jan–Mar	1974	62·7	62·9	+0·2	697
Leigh	Oct–Nov (weekends)	1974	53·3	41·6	11·7	600

season resting at low tide, and may have been related to the small number of young birds. Later however, birds fed throughout the tidal cycle.

Brent Geese fed at night throughout the winter, sometimes in cloudy weather, and on quite sparse *Enteromorpha*, for example in the Blackwater in January and February. However, geese appeared not to feed so intensely at night as during the day, mostly feeding at mid-tide as the water lifted the food off the mud.

Extra time spent in flight

A flight was considered to be due to disturbance when there was a clear causal connection between a disturbing incident and a flight of geese, and also when birds flew back to their feeding grounds after disturbance had passed. In the absence of disturbance, Brent Geese spent an average of 1·1% of their time in flight (Figure 8). The total time spent flying was highly correlated with the amount of flying caused by disturbance ($r = 0{\cdot}93$; $n = 11$; $p < 0{\cdot}001$). In the Blackwater and at Leigh Marsh, disturbance caused the amount of flying to more than double, and at Leigh at weekends in early winter, Brent Geese spent an extra 5·5% of their time in flight. Over all areas and times of year, disturbance caused an extra 1·7% of time to

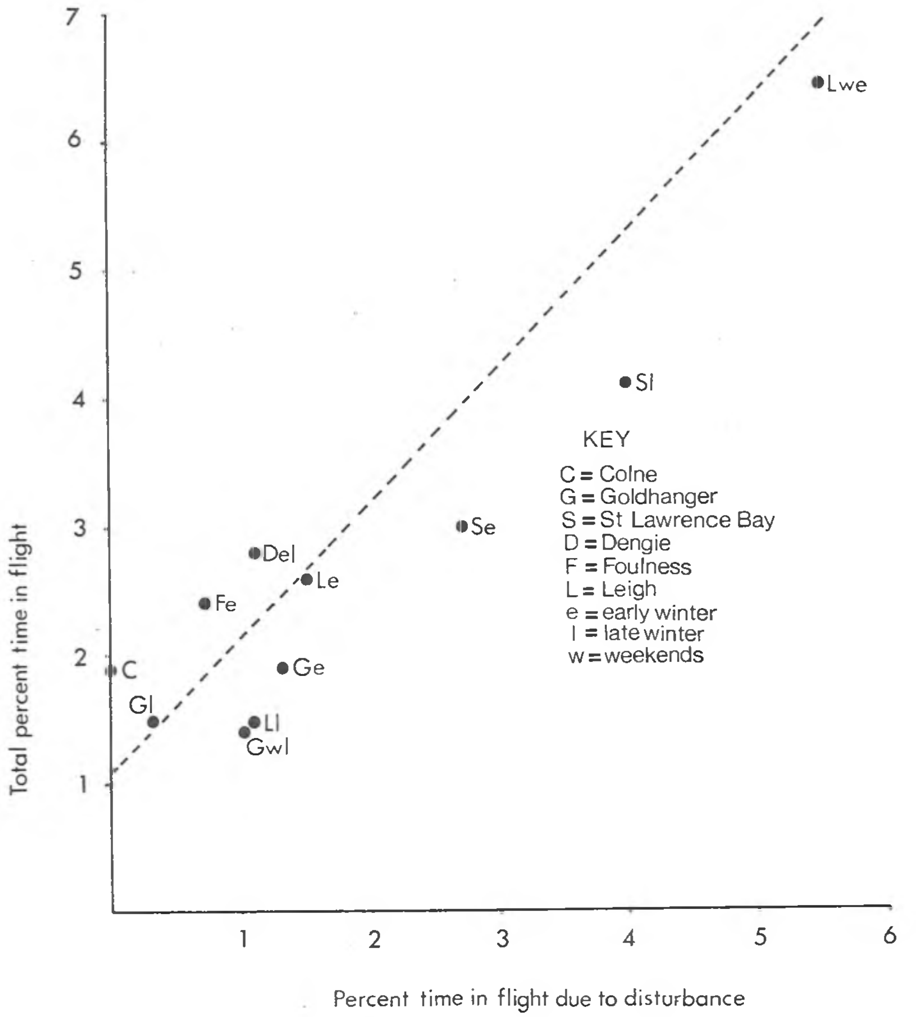

Figure 8. The relationship between the amount of flying due to disturbance and the total amount of flying.

be spent in flight.

On some occasions, disturbance caused birds to make 'normal' flights to other feeding areas earlier than they would otherwise have done. This partly compensated for the effects of disturbance. Thus, the amount of flying not due to disturbance tended to decrease as the amount of disturbance flying increased ($r = 0{\cdot}71$; $n = 10$; $p < 0{\cdot}01$; Figure 9).

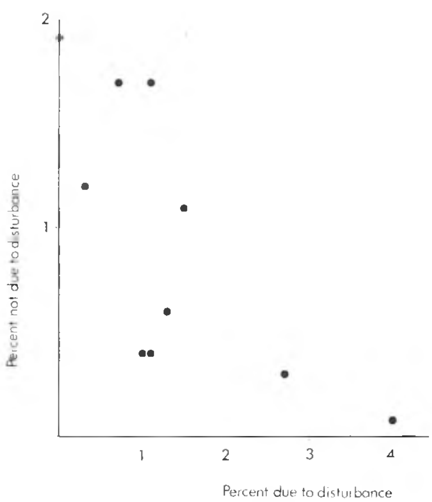

Figure 9. The relationship between the amount of flying due and not due to disturbance.

Discussion and conclusions

Restriction of feeding area

At high bird densities, feeding rates in some wader species may be depressed (Goss-Custard 1970). It is probable that similar effects occur in Brent Geese, and these could be made worse through the restriction of feeding area by disturbance. However, since this restriction occurred in early winter when there was still plenty of food, the effects were probably slight.

Feeding areas with restricted visibility were at first avoided but were used when other areas had been eaten out (for example around Mersea Island). Narrow estuaries in Suffolk and Essex, such as the Orwell, Stour and Crouch, supported proportionally fewer geese than other feeding areas, and were the only Essex feeding areas that were under capacity in 1973–1974 (K. Charman, pers. com.). This was probably a result both of restricted visibility and of the greater 'edge effects' in small feeding areas. An additional cause could be the reduced tolerance of larger flocks to disturbance. Apparently the maximum as well as the mean distance at which geese were disturbed increased with increasing flock size. Thus small flocks may have tolerated conditions in narrow estuaries better, and reducing disturbance therein would therefore not necessarily greatly improve their holding capacity for Brent Geese.

Effects on feeding behaviour and flighting

Disturbance would be harmful if it consistently resulted in birds losing more energy (through extra flying and lost feeding time) than they were able to make up by food intake. Disturbance was most intense at Leigh Marsh and the Blackwater. For example, at Leigh on weekends in 1974–1975, geese were prevented from feeding for 11·7% of their time and an extra 5·5% of time was spent in flight. On weekdays the figures were 4·9% and 1·5% respectively. Ringing results have shown that some individual Brent Geese may stay in one area, and so experience intense disturbance, for 3–4 months at a stretch (A. St Joseph & T. Bennett, pers. com.). The low digestive efficiency of geese (Owen 1972) and the restriction of feeding by the tide suggests that Brent Geese are likely to spend most of their available time feeding. Except in early winter 1974–1975, Brent Geese appeared to feed in daylight hours as intensively as tide and food availability allowed. Similarly, Rudge (1970) described Brent Geese on Foulness as spending an increasing proportion of their time feeding as the *Zostera* becomes depleted, spending all of the, shorter, days on the *Zostera* beds by mid-November. From about mid-November onwards it therefore seems unlikely that Brent Geese could have compensated for intense disturbance except by feeding more at night. Pink-footed *Anser brachyrhynchus*, Greylag *A. anser* and White-fronted *A. a. albifrons* Geese are known to increase their nocturnal feeding when intensive daytime shooting occurs (Newton & Campbell 1973; Owen 1972).

The extensive movement of Brent Geese on to farmland in recent winters (Bennett & St Joseph 1974) suggests that intertidal food resources became depleted. This was probably a consequence of the very large population (41,000 in Britain in 1973–1974; Ogilvie 1974) and the prior removal of many of the Dutch feeding grounds through reclamation (Ogilvie & Matthews 1969). Past occurrences of inland feeding by Brent

Geese and Black Brant *B. b. nigricans* have all been associated with food shortage; during the *Zostera* disease of the 1930s (Moffitt 1942; Morzer Bruijns & Timmerman 1968), poor food growth in 1951–1952 (Leopold & Smith 1953) and in the cold winter of 1962–1963 (Rudge 1970). Weights of Brent Geese in the Foulness/Blackwater area decreased from a mean of 1,248 g (n = 101) in January–February 1974 (about 9%; $p < 0{\cdot}01$) (A. St Joseph & T. Bennett, pers. com.). In 1933–1935, during the *Zostera* disease, some Brent Geese in the Netherlands weighed as little as 500 g (Morzer Bruijns & Timmerman 1968). Similarly, White-fronted Geese that had died of starvation in January 1963 were 42% lighter than the average for normal winters (Beer & Boyd 1964). Thus, weight loss of Brent Geese in winter may be indicative of food shortage, but a mean weight loss of only 9% is unlikely to result in any deaths. Nevertheless, poor winter food supplies may also result in reduced breeding performance in geese, for example in Black Brant (Cottam, Lynch & Nelson 1944) and Barnacle Geese *B. leucopsis* (Cabot & West 1973).

If Brent Geese were losing weight through food shortage, any disturbance could not be compensated for. Food shortage probably occurred in January–March, by which time the geese had become used to the proximity of people, though not to 'planes, which caused more than half of all flighting. Moreover geese feeding on farmland were more wary and more easily put up than when on mudflats.

Although the overall impact of disturbance is probably not very serious at present, it is worrying that the two most disturbed areas, Leigh Marsh and the Blackwater, are also the two most important feeding areas in Britain in terms of goose numbers, apart from Foulness (K. Charman, pers. com.). It is especially important that increases in disturbance should not occur in these two areas. Zonation in the use of coastal areas in Essex may soon be required. For example, people could be discouraged from walking close to the shore at high tide in certain areas, whilst yacht marinas, bait-digging, oyster beds, etc., could be concentrated in areas less important for wildfowl. The restriction of low-flying aircraft is even more important, since Brent Geese are so slow to become habituated to them. Ideally, aircraft should not fly below 500 m over estuaries.

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Summary

An assessment is given of the effects of human disturbance on the distribution and behaviour of Dark-bellied Brent Geese *Branta bernicla bernicla* wintering in Essex.

Disturbed areas and places with poor visibility were avoided in early winter, but were used later when other areas became depleted of food. Geese became partially habituated to the proximity of people and to some loud noises, but not to small low-flying aircraft.

The areas which contained the most geese apart from Foulness, namely Leigh Marsh and the Blackwater estuary, were also the most disturbed. Here, disturbance at weekends prevented geese from feeding for up to 11·7% of their time, and caused the time spent in flight to increase as much as sevenfold. Overall levels of disturbance were much lower than this, and would probably have been unimportant so long as adequate food was available on which geese could feed in undisturbed times, and at night. However, a shortage of food probably prevented complete compensation for the effects of disturbance.

Disturbance could be greatly reduced by restricting access to the sea wall in certain areas around high tide, and by controlling the numbers of low-flying aircraft.

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A feeding flock of Barnacle Geese *Branta leucopsis*. The birds with their heads up may be on the look out for danger, or obtaining information on food availability, see pp. 15–20. (*Philippa Scott*).