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Habitat requirements of golden plover

A pilot study

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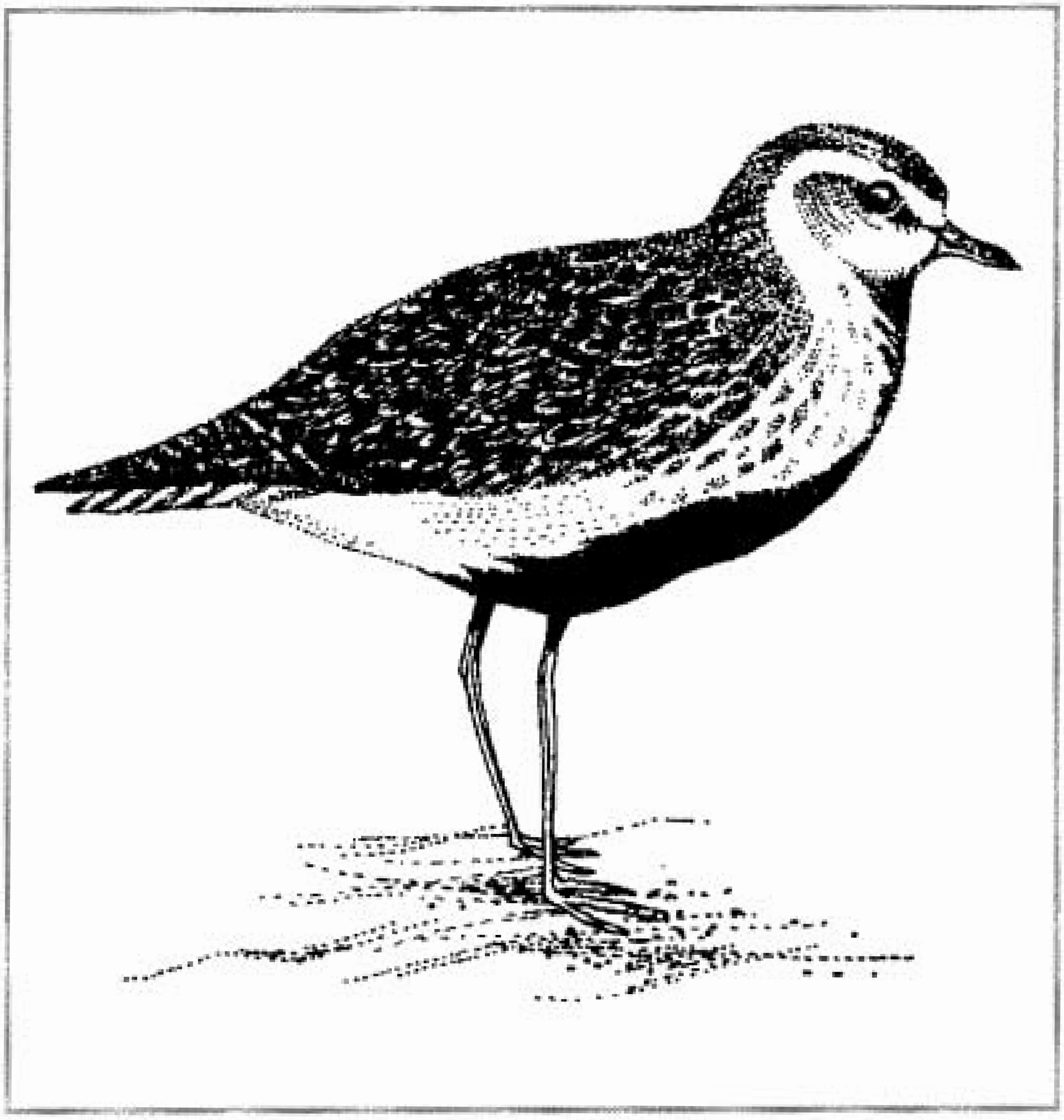

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HABITAT REQUIREMENTS OF GOLDEN PLOVER: A PILOT STUDY

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1. SUMMARY

1. This report details a pilot study on the habitat requirements of Golden Plover on the breeding grounds, to test different methods of measuring habitat selection and assess the feasibility of carrying out a larger-scale project.

2. Two study areas of different vegetation types within the Upper Teesdale region were chosen for the study, one at Chapel Fell and the other on the Widdybank NNR.

3. Nest finding, though labour intensive, was successful, with a total of 15 nests being located. Adults proved to be relatively easy to catch (with an c.80% success rate) and colour-ringing was highly suited for marking individuals (both adults and chicks)

4. Attachment of radio transmitters to adults by supergluing onto the back was found to be a suitable method, but problems with the low sensitivity of the system used meant that little useful data were collected. In future a more powerful system should be employed.

5. Radio telemetry of the chicks was very successful indeed. Five broods were tracked, two of those from hatching almost right through to fledging. Again supergluing the tags to the back was a suitable attachment method. The 0.8g. tags were appropriate for use right from hatching without any significant effect on the birds.

6. Home range sizes of both the adults and the chicks were variable between areas, ranging from 4.1 to 24.6 hectares. Maximum distances moved from the nest during the chick period were 660 m and 740 m for the adults and the chicks respectively.

7. Adults and chicks were recorded on very different habitat types. Adults tended to be located on *Eriophorum*-dominated habitats at Chapel Fell and on limestone grassland at Widdybank, whilst chicks appeared to show selection for damper *Juncus*-dominated marshy areas with adjacent cover.

8. Adult habitat selection was also studied by carrying out an extensive survey over the whole of the two study areas. This proved to be a useful technique to complement the detailed radio telemetry, and also to aid with the interpretation of wider scale survey results.

9. Some data were also collected on nest site selection and its consequences on breeding success. These suggested that nests associated with heather had higher survival rates but broods in these same areas were not so successful. Sample sizes however were small and further data would need to be collected to corroborate these findings.

10. We recommend that a more detailed study employing these techniquesshould be carried out at the earliest possible opportunity. It should additionally address the roles of food availability and cover in the birds' habitat selection.

2. CONTENTS

3. BACKGROUND

The Golden Plover is a species that breeds throughout the uplands of Britain but one that is thought to be declining in both range and numbers. Britain holds around 90% of the EC breeding population and has international responsibility to take special measures to conserve the species and its habitat, as it is listed on Annex One of EC Directive 79/409 on the Conservation of Wild Birds.

There has been much recent discussion amongst conservationists about management of Britain's uplands (see, for example, Usher & Thompson 1988). It has been suggested that heather moorland, managed for Red Grouse, *Lagopus lagopus*, should be encouraged, but little is known of the consequences of such a strategy for upland birds. At the same time, over-grazing (by sheep throughout the British uplands with the additional impact of Red Deer in the Scottish Highlands) is thought to be a major problem in the uplands, but again little is known of the impact that this activity has on upland bird numbers, distribution or productivity.

If the uplands are to be managed in a way sympathetic to the Golden Plover, then precise information on its habitat requirements must be known. Several previous studies have looked at its habitat use during the breeding season, notably in Norway (Byrkjedal 1989), but these have mostly concentrated on observing adult birds. Studies in Britain have shown that Golden Plovers tend to be associated with high altitude plateaux and avoid areas dominated by long grass and bracken, *Pteridium aquilinum* (Howarth *et al.* in press). Human disturbance may have an important influence on populations (Yalden & Yalden 1989), whilst afforestation has had a negative impact both through direct loss of habitat and through increased predation levels as the new forests provide refuges for predators (Thompson *et al.* 1988). None of these studies has, however, been able to focus on the question of the detailed habitat requirements of the species, mainly because of the difficulty in monitoring broods. Yalden (1991) was the first to try radio-tracking broods. He met with some success on a small scale but did not make any measurements of habitat use. The current study sought to establish whether it would be feasible to use radio-telemetry to tackle the question of the species' detailed habitat requirements at a sufficiently detailed scale to provide the information required for effective prescriptions for conservation management. As a feasibility study, the emphasis was placed on assessing the value of a number of techniques rather than obtaining a full series of replicate samples using any one of these.

4. AIMS

- ❑ to investigate the methods that could be used to measure habitat use by Golden Plover in the breeding season with particular emphasis on radio-telemetry.
- ❑ to investigate the feasibility of a larger research study to investigate habitat requirements of Golden Plover and produce recommendations for management.

4.1. Questions to be addressed:

- ❑ Which method (or combination of methods) is most appropriate for establishing which habitats Golden Plover require for successful breeding, how these requirements change through the breeding cycle and how they vary with environmental conditions?

- ❑ What further research would need to be a priority to produce recommendations for the management of upland areas to increase/maintain the numbers of Golden Plover that breed on them?

5. METHODS

5.1. Overview

The overall strategy of our approach to the problem of measuring Golden Plover habitat use was to tackle the question at different levels and compare the results obtained. The emphasis throughout was on instantaneous observation of the birds' habitat. We did not deal with the question of what the birds were doing on these habitats but rather sought to quantify the amount of time that they were spending on the habitats that were available to them. Four different approaches were taken to measuring habitat use, at varying degrees of detail:

- ❑ Radio-telemetry of broods to determine habitats used by chicks
- ❑ Radio-telemetry of adults
- ❑ Spot observation of ringed adults during each site visit.
- ❑ Extensive surveys of all the birds, their broods and nests on the two study areas.

5.2. Selection of study areas

Several criteria were used to select the areas for the 1992 field study. It was important that they should be typical upland areas with a reasonably high density of breeding Golden Plover. They also needed to support a diversity of vegetation patch types, so that the birds' detailed habitat preferences could be investigated. Two sites in Upper Teesdale were chosen, and were of contrasting habitat types. The Chapel Fell site (National Grid reference NY860340) was typical of many areas of heavily sheep-grazed moorland, dominated by *Eriophorum vaginatum* with only sparse cover of heather, *Calluna vulgaris*. It included many patches of *Nardus* dominated grassland, some dense stands of *Calluna*, and several areas of *Carex/ Juncus*-dominated flush and marsh. The second site, Widdybank Fell, (National Grid reference NY822298) was more typical of heather moorland managed primarily for Red Grouse, with a much greater heather cover and a mosaic of burnt patches of different age. It included several extensive patches of limestone grassland and calcareous flushes. It appeared to have a rather lower sheep grazing intensity than Chapel Fell.

5.3. Previous survey results

Some historical data were available for both sites. Chapel Fell was surveyed as part of an environmental impact assessment for a recent wind farm proposal. It was estimated that there were 11 pairs of Golden Plover within the current study area. Widdybank Fell, a National Nature Reserve, has been surveyed once every year since 1973 by the EN site manager. He estimated that around 12 pairs regularly bred within the current study area, with little variation between years (I. Findlay, pers. comm.). NCC's Upland Bird Survey also covered the latter site in the early 1980s and estimated a somewhat larger total of about 30 pairs (J. Barrett pers. comm.).

5.4. Nest finding

Nest finding was an essential priority, (i) to quantify nesting habitat, (ii) to measure breeding success (iii) for catching adults, and (iv) for marking chicks. Golden Plover nests are notoriously difficult to locate but we did succeed in finding a total of 15: 8 on Chapel Fell and 7 at Widdybank. It would have been likely that we would have found more if we had been able to start fieldwork earlier in the season, as many birds were well into incubation by the end of April (see Fig. 1). We used the search techniques recommended by Ratcliffe (1976), scanning 2-300m ahead whilst walking across the study area. Most nests were found by flushing incubating birds within a few metres.

Nesting habitat was recorded by measuring the vegetation in a 4 x 4 m^2 quadrat located with the nest at centre. The percentage cover of each species was estimated by eye, following the method of the National Vegetation Classification (Rodwell et al 1991). NVC classes were identified using the program MATCH (Malloch 1989).

When a nest was located the eggs were measured to estimate their state of development. The length and breadth of each egg were measured on the first visit, and weighed on all visits. Egg density for each visit was estimated using the standard equation below (where the constant is 0.507, Hoyt 1979):

$$Egg\ density = \frac{weight}{Constant \times length \times breadth^2}$$

Using these density data for nests of known hatching date, a standard curve of **egg density** against hatching date was constructed (Fig. 2). This was then used (a) to predict when nests would hatch, and (b) to estimate hatching date for nests that were lost before hatching.

Nest survival rates were calculated using the Mayfield (1961, 1975) method. Standard errors of these estimates were calculated using the method of Hensler & Nichols (1981). This enabled statistical comparisons to be drawn between sites, habitats and seasons.

5.5. Catching adults

We had considerable success trapping adults on the nest. We used a large heart-shaped walk-in trap (50 cm diameter, 50 cm high), placing the nest in one of the cups of the 'heart' and keeping the nest under observation as much as possible (though it was essential that we kept hidden from the birds and at a distance of at least 400m). In all we had about an 80% success rate, i.e. birds were trapped on about 80% of the occasions on which the trap was set. A total of 16 adults was marked with individual colour-ring combinations.

Four adults were fitted with 2.2g, SS-2 button cell radio-transmitters (supplied by Biotrack). These were glued with superglue onto the bird's back. The first transmitter was lost from the back within 24 hours, because of insufficient adhesion. The other 3 remained in place until at least the last observation of the bird, up to 6 weeks from attachment. It had been hoped that the transmitters might be used to measure both the birds' habitat use and their feeding activity. They incorporated a mercury tilt switch, the orientation of which would indicate feeding behaviour, enabling monitoring on a continuous basis. Though the initial problem with the transmitter falling off was overcome, the main fault was the poor reception distances, which were generally only about 400m. For future work more powerful transmitters and/or more sensitive receiving equipment will be required to enable the birds to be tracked more efficiently.

As many as possible of the ringed and radio-tagged birds were located during each of the daily visits to the sites. On a few occasions the sites were visited twice in the same day but there was always a minimum time interval of 8 hours between the visits to ensure that the data gathered were independent. The birds' positions were plotted onto a visit map, together with the habitat that they were using, ignoring records when the observer had caused any disturbance before the bird was located. Notes on the birds' behaviour were made to give additional information about the stage of the breeding cycle, and particularly whether the behaviour was indicative of a parent attending a brood (Ratcliffe 1976). These data on the ringed adults were then used to estimate brood survival rates, using the same Mayfield method as for the nest survival rates.

5.6. Radio-tracking chicks

Radio-tracking of the chicks proved to be very successful. Five broods were marked in all. All of the radios were attached to chicks in the nest within a few hours of hatching; as once they had left the nest they became extremely difficult to locate. The 0.8g SS-2 button cell transmitters (supplied by Biotrack) were superglued to the chick's back. There was no indication at all of any problems to the birds resulting from carrying the transmitters. Some initial problems with the loss of the transmitter through insufficient adhesion were encountered but these were overcome by better gluing. One or two chicks were chosen per brood, taking the heaviest one/two. The signal from the transmitters could be received at distances of 30-100m but the reception was highly variable and dependent on topography. Once tagged, the marked broods were searched for at least daily. For each location they were mapped and the exact habitat they occupied was identified. Our success rate at location was about 85% (as the signal was occasionally completely blocked, for example, when the chicks were buried deep in hummocks or rushes). The lengths of time for which each brood was tracked and the fates of the radios are summarised in Table 1.

Table 1: Outcome of radio broods

Nest id	Dates	Time tracked	Fate of radio
CF1	30 May - 17 June	19 days	Battery flat/ Fledged
CF3	27 May - 30 May	4 days	Predated
CF7	24 June - 30 June	7 days	Bad weather
WD3	18 June - 29 June	12 days	Battery flat/ Fledged
WD5	13 June - 17 June	5 days	Bad weather

The vegetation types used by the broods were identified in the same way as the nesting habitat. Up to five 4 x 4 m^2 quadrats were located in each of the types in which the radio broods were found, and the percentage cover of each species was estimated by eye. The program MATCH was then used to identify the NVC class of these communities.

5.7. Extensive survey

The whole of each study area was surveyed each day when weather conditions allowed. All birds seen were mapped, and their habitat noted to give a further measure of habitat use. As with the nest-searching, the study area was scanned 2-300m ahead of the observer, to minimise the chance that the birds were responding to the presence of the observer. Golden Plovers have been reported as responding at distances of about 200 m (Yalden & Yalden 1989). Though less precise than the observations of marked birds, this extensive survey did have the advantage that it provided a larger sample size.

These survey data were also used to plot a map of the territories in each area, using the standard Common Birds Census technique, and hence to estimate the population. It will also be possible to analyses this data set to examine the implications for the interpretation of survey data from less frequent site visits (as, for example, in the Upland Bird Survey).

5.8. Quantifying habitat availability

The vegetation types on whole of the two study sites were mapped using a combination of previous survey data (Jones 1973, Owen & Tapper 1984), aerial photographs, large scale maps and our own ground survey. These were mapped where possible to the NVC class but some separation and regrouping of some classes was necessary (see results).

6. RESULTS

6.1. Background data

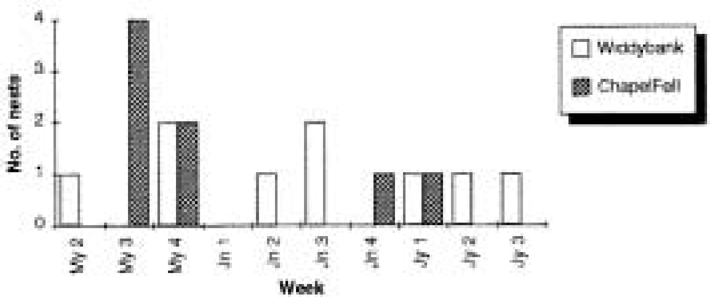
6.1.1. Populations of Golden Plover in the study area

We estimated that the Chapel Fell study area held 13 breeding pairs of Golden Plover, and the Widdybank Fell study area 16 breeding pairs. When the area of each is taken into account this gave almost identical breeding densities (5.4 pairs per km^{-2} at Chapel Fell, 5.3 pairs per km^{-2} at Widdybank). These values actually comprise an estimate of the number of territories occupied during the study. The total number attempting to breed may have been several pairs higher, as there were several cases in which it was apparent that a territory used by one pair early in the season was utilised by another later on. Such sequential breeding by Golden Plover has been noted in other studies (Parr 1979).

6.1.2. Timing of season

The timing of the Golden Plover season in Upper Teesdale is summarised in Fig. 1 that shows the distribution of the estimated first egg date. The season appeared to be somewhat earlier at the Chapel Fell site but lack of data from the first part of the season could have meant that there had been some pre-visit failures during early April when there was a period of snow cover (I. Findlay pers. comm.). Peak laying was recorded around the second week of April but the season extended right through summer with latest nest laid during the third week of June. The general pattern was one of laying from mid-April, hatching from mid-May, and a mixture of incubating and brooding adults from then on through to end of study period in mid-July.

Fig 1. Timing of Golden Plover hatch

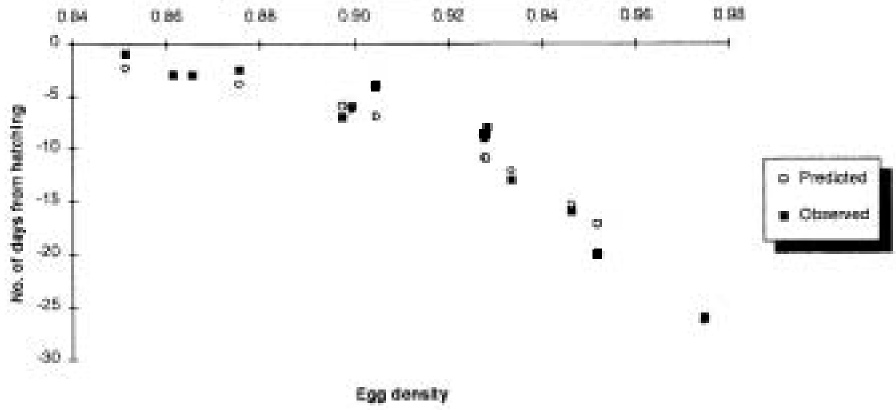


6.1.3. Egg density curve data

A standard curve of the estimate of egg density against the number of days from hatching (Fig. 2) was plotted, using data from the 11 nests for which the date of hatch was known from direct observation. The curve fitted to this graph enabled estimates to be made of the timing of the remainder of nests for which hatch date was not known, as long as the eggs had been measured. The equation derived was:

$$\textit{Number of days to hatch} = 41.8 \times \textit{Egg density}^{17.9}$$

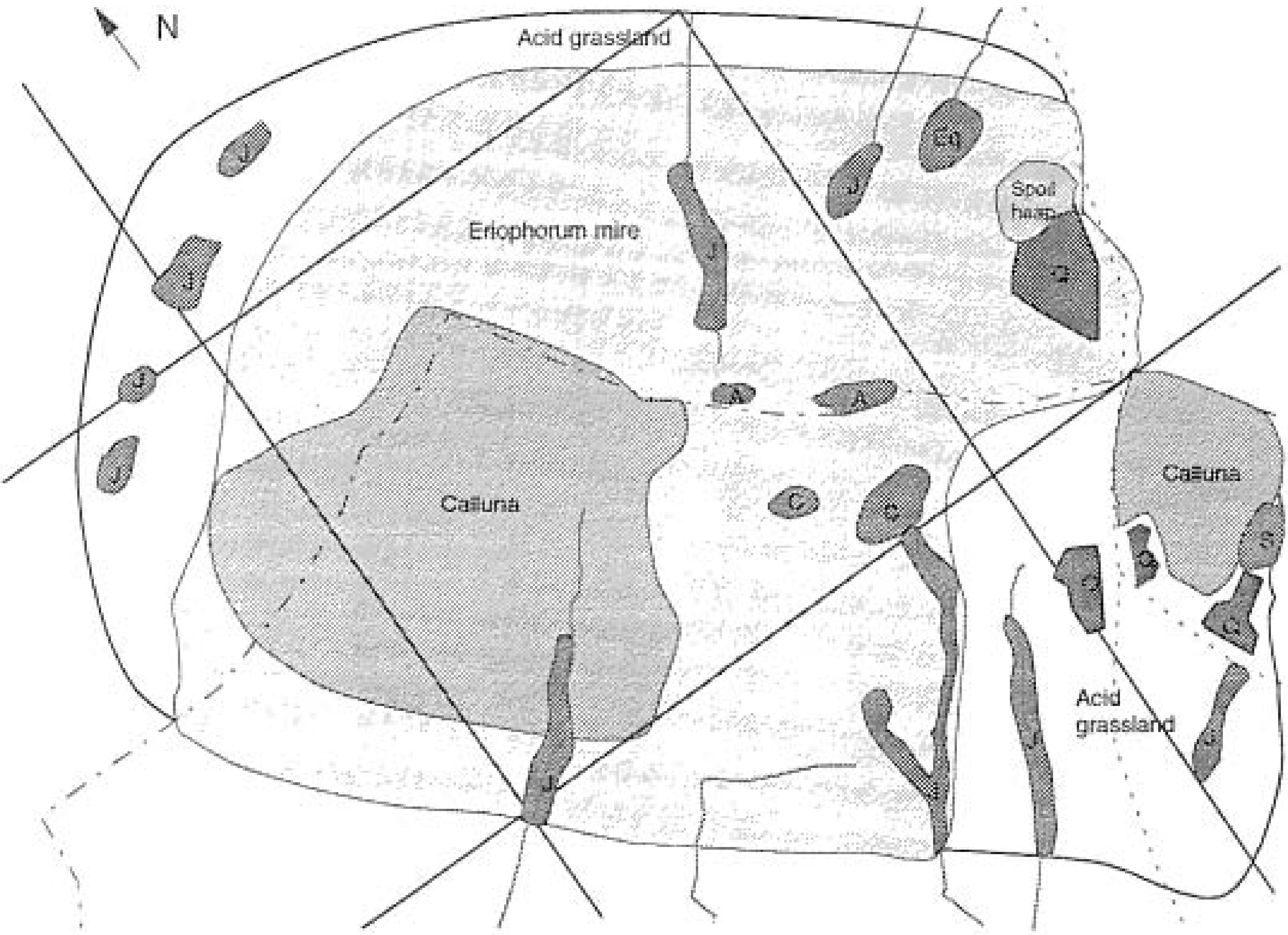
Fig. 2 Golden Plover egg density curve



6.1.4. Habitat availability at the two sites

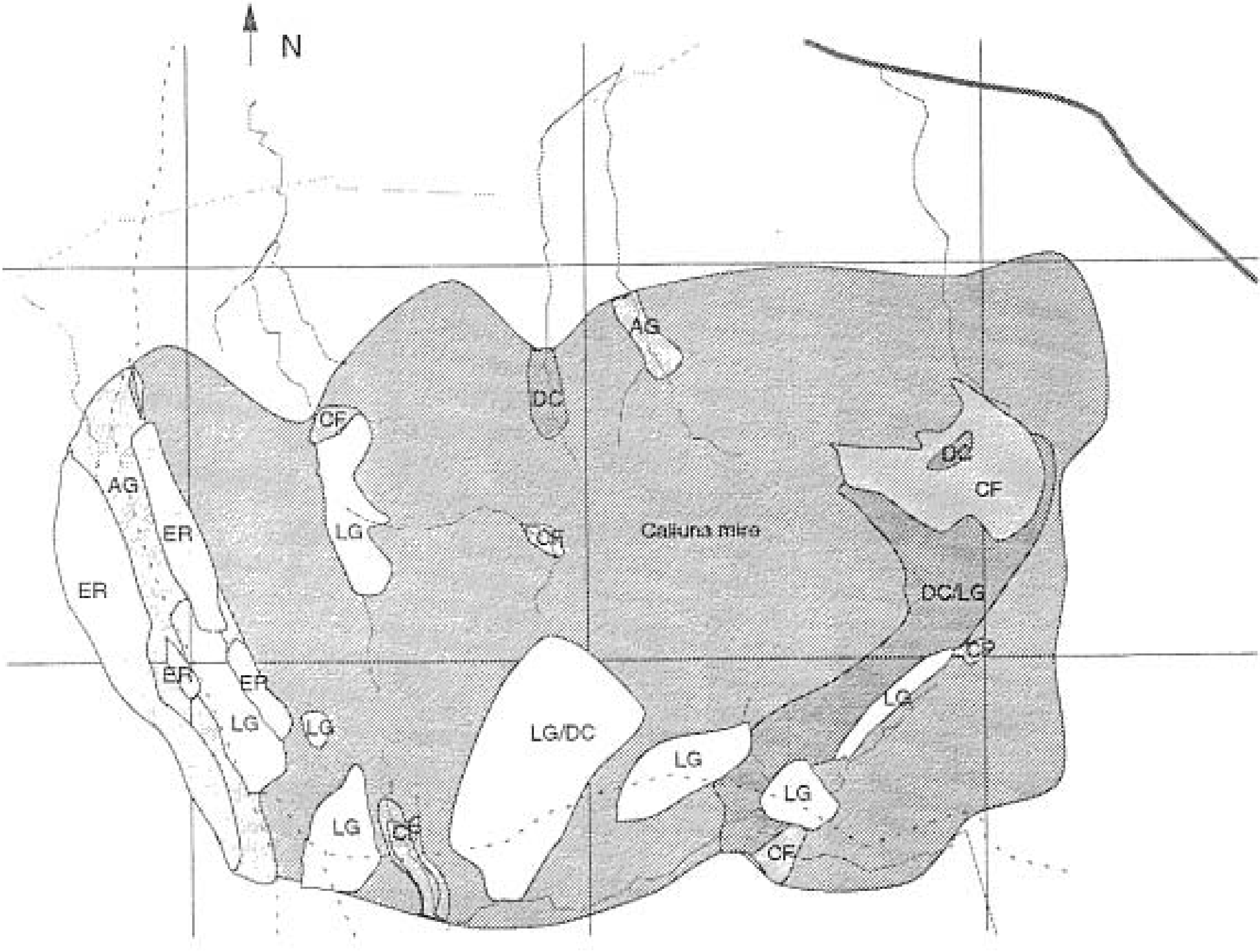
The total area of different habitats available to the birds at each site is mapped in Figs. 3 and 4 and summarised in Tables 2 and 3 for Chapel Fell and Widdybank respectively. Vegetation types have been kept as close to the NVC classes as possible.

Fig. 3 Chapel Fell habitat map



KEY:
J Juncus effusus flush
A Eriophorum angustifolium pools
C Carex marsh
Eq Equisetum marsh
S Scirpus cespitosus flush
Q Quarry

Fig. 4 Widdybank Fell habitat map



KEY:
LG Limestone grassland
CF Calcareous flush
DC Dry Calluna heath
AG Acid grassland

Table 2: Vegetation types at Chapel Fell (total area = 2.4 km²)

Habitat	Area (km²)	% of area	NVC equivalent
Calluna/Eriophorum moor	0.77	32%	M19a
Eriophorum moor	0.98	41%	M20a
Eriophorum/ Nardus/ Deschampsia heath	0.43	18%	U2/U5
Juncus effusus flush/hag bottom	0.17	7%	U6
Carex marsh	0.02	1%	M6
Eriophorum angustifolium pools	0.02	1%	M3
Spoil heap	0.02	1%	U1e

Table 3: Vegetation types at Widdybank Fell (total area = 3.0 km²)

Habitat	Area	% of area	NVC equivalent
Recently burnt *Calluna* moor	0.3	10%	M19
Calluna/Erica tetralix moor	0.27	9%	M19a
Older (>15 yrs) *Calluna* moor	1.05	35%	M19b
Dry *Calluna* heath	0.39	13%	H12
Limestone grassland	0.45	15%	CG8/9/10
Eriophorum heath	0.15	5%	M20
Nardus grassland	0.15	5%	U5
Calcareous flush	0.18	6%	M10
Juncus effusus flush	0.03	1%	U6
Sphagnum pools	0.03	1%	M2

6.2. Evaluation of techniques for measuring habitat use

6.2.1. Radio-tagged chick home ranges and habitat selection

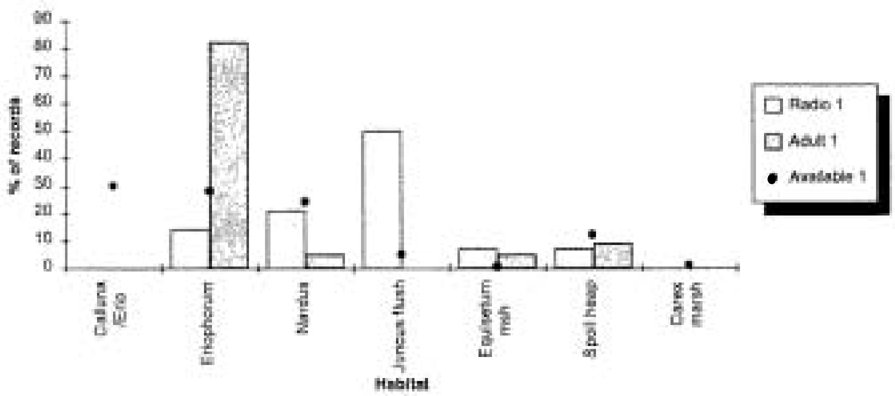
The home range sizes, median daily movement rate and median distance moved from the nest of each of the radio-tagged broods are given in Table 4. All home range areas were calculated using the minimum polygon method. For the broods in which two chicks were tagged an average of the two was taken, though on no occasion were the chicks separated by more than 50m. The main points to note are that (1) there was considerable variation in the movement and hence home range size of these broods and (2) though broods were capable of moving a considerable distance very quickly they generally tended to remain within a few 100m of their nest. The results seem to suggest that broods at Chapel Fell move further and have larger home ranges. There were significant results between the movement rates and the distances moved from the nest of the different broods (Kruskall-Wallis tests gave P=0.031 and P=0.042 for the two parameters respectively) but only between the one less mobile brood (WD3) and the rest.

Table 4: Home range size, movement rate and dispersal from the nest of the radio-tagged broods.

Brood	Home range (ha.)	Movement rate ($m.d^{-1}$): median	maximum	Distance from nest: median	maximum
CF1	11.6	110	380	270	740
CF7	13.3	330	450	200	710
WD3	4.1	50	150	90	160
WD5	(1.5)	210	400	220	350

The habitat used by each of the radio-tagged chicks is illustrated in Figs. 5 to 8. The percentages of observations of the brood and its attendant parent have been plotted together with the percentage of the habitat available to them within a 740 m radius (the greatest distance that any brood was observed to move from its nest, see Table 4). Thus it was possible to assess directly the degree of selection that the birds were exhibiting. These results are summarised further in Tables 5 and 6, which shows each of the major habitat types each and parent were positively selecting (+), avoiding (-) or showing no preference (.). Some additional observations were made of marked adults whose chicks were not radio-tagged. Data have been included for three individuals for which detailed measurement of habitat use was possible. Chi-squared tests were used to assess these preferences, with the 5% level taken as the significance threshold. The null hypothesis tested was that the birds used the habitats in the same proportion as they were available to them (within a 740 m radius of the nest).

Fig. 5 Radio brood habitat use (CF1)



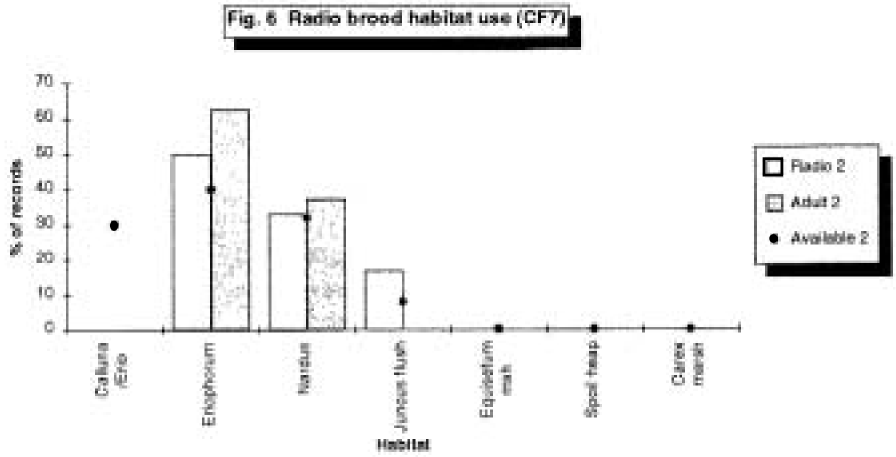


Fig. 6 Radio brood habitat use (CF7)
% of records
Habitat
Calluna /Erio
Eriophorum
Nardus
Juncus flush
Equisetum mah
Spoil heap
Carex marsh
Radio 2
Adult 2
Available 2

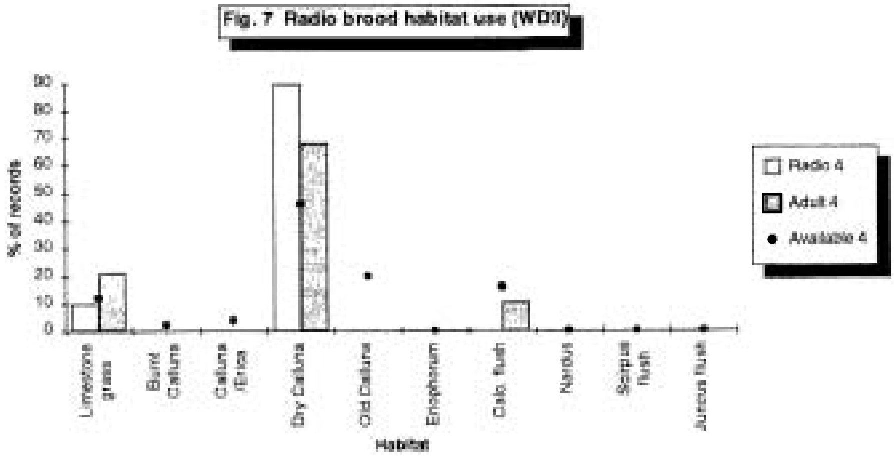


Fig. 7 Radio brood habitat use (WD3)
% of records
Habitat
Limestone grass
Burnt Calluna
Calluna /Erica
Dry Calluna
Old Calluna
Eriophorum
Calc. flush
Nardus
Scirpus flush
Juncus flush
Radio 4
Adult 4
Available 4

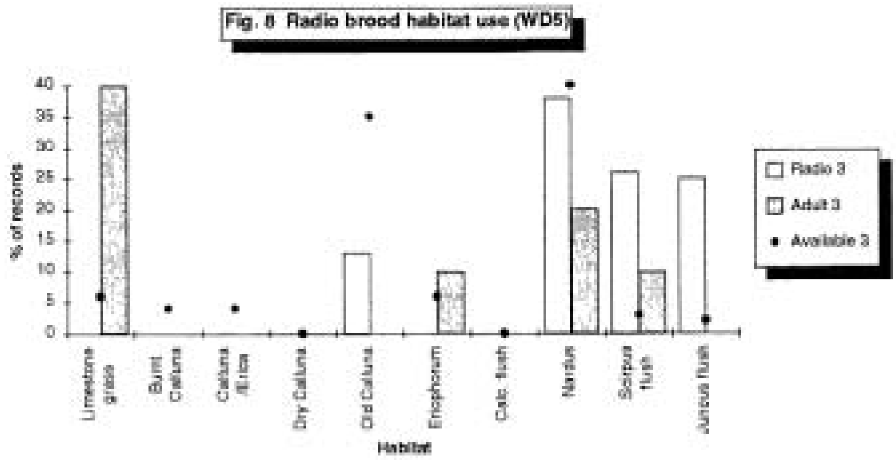


Fig. 8 Radio brood habitat use (WD5)
% of records
Habitat
Limestone grass
Burnt Calluna
Calluna /Erica
Dry Calluna
Old Calluna
Eriophorum
Calc. flush
Nardus
Scirpus flush
Juncus flush
Radio 3
Adult 3
Available 3

Table 5: Summary of habitat selection by radio broods and their ringed parents at Chapel Fell

Habitat	CF1 chick	CF1 adult	CF7 chick	CF7 adult	CF3 adult	CF6 adult
Calluna/Eriophorum moor	-	-	-	-	+	-
Eriophorum moor	-	+	+	+	+	+
Eriophorum/ Nardus/ Deschampsia heath	.	-	.	.	-	.
Juncus effusus flush/hag bottom	+	-	+	-	.	.
Carex marsh	.	.	.	.	.	+
Eriophorum angustifolium pools	.	.	.	.	.	.
Spoil heap	.	.	.	.	.	.

Table 6: Summary of habitat selection by radio broods and their ringed parents at Widdybank Fell

Habitat	WD3 chick	WD3 adult	WD5 chick	WD5 adult	WD1 adult
Recently burnt Calluna moor	.	.	.	.	+
Calluna/Erica tetralix moor	.	.	.	.	.
Older (>15 yrs) *Calluna* moor	.	.	-	-	-
Dry *Calluna* heath	+	.	.	.	.
Limestone grassland	.	+	.	+	+
Eriophorum heath	.	.	.	.	.
Nardus grassland	.	.	.	-	.
Calcareous flush	-	.	.	.	.
Juncus effusus flush	.	.	+	.	.
Sphagnum pools	.	.	.	.	.

Thus some chicks showed a preference for *Juncus* flushes, and for dry *Calluna* in one brood at Widdybank. They avoided stands of *Calluna* bog at both sites. They were located on very different habitats to their parents. Simultaneous records of the attending parents showed them to have no such preference for the same rushy patches and in some cases positively avoided them. These adults seemed rather to select *Eriophorum* moor at Chapel Fell and limestone grassland at Widdybank. They did, however, show the same general avoidance of mature heather-dominated bog as their broods. These adult data were however only collected in detail during the chick-rearing period and not through entire breeding season, so these results should be treated with caution and not taken as a measure of the total habitat requirement of the breeding adults. No attempt was made to collect information concerning adult activity, so it is not known whether, for example, adults have different habitat preferences for feeding and chick-guarding. It is clear though that the habitats used by the broods and their parents are very different, and any study of habitat use must be able to measure chick requirements as well as those of adults.

6.2.2. Adult home ranges and habitat selection

Table 7 summarises the data collected on the adults' home range size and distance moved from the nest during the chick-rearing period. Home ranges were, as with the broods, generally larger at Chapel Fell, and most records were within a few 100m of the nest. None were seen further than 660m from the nest. Though the difference in the distance moved from the nest is statistically significant (Kruskal Wallis test, P=0.002) this significance disappears when the WD3 adult is excluded from the analysis.

Table 7: Home range size and distance moved from the nest by attending adults during the chick-rearing period.

Adult (nest id)	**Home range (ha.)**	**Distance from nest: median (m)**	**maximum (m)**
CF1	24.6	320	660
CF3	21.1	210	440
CF6	12.6	230	470
WD1	14.2	190	390
WD3	13.1	110	270
WD5	7.1	240	380

6.2.3. Nesting habitat

Tables 8 and 9 summarise the selection of habitats for nesting within each of the two study areas. Though the sample sizes are not large enough to do any meaningful statistical tests for habitat selection they have been included as they do give an indication of a trend. At Chapel Fell the nests appear to be located in relation to overall availability of habitat, apart from avoidance of wetter habitats. At Widdybank the birds appeared to be more selective, avoiding old mature heather and open limestone grass (there were no such comparable habitats to avoid at Chapel Fell). Possible consequences of such habitat selection are examined in the breeding success section below and later in the discussion.

Table 8: Nesting habitat selection at Chapel Fell

Habitat	Number of nests	% of nests	% of area
Calluna/Eriophorum moor	3	38%	32%
Eriophorum moor	3	38%	41%
Eriophorum/ Nardus/ Deschampsia heath	2	25%	18%
Juncus effusus flush/hag bottom	0	0%	7%
Carex marsh	0	0%	1%
Eriophorum angustifolium pools	0	0%	1%
Spoil heap	0	0%	1%

Table 9: Nesting habitat selection at Widdybank Fell

Habitat	Number of nests	% of nests	% of area
Recently burnt *Calluna* moor	1	14%	10%
Calluna/Erica tetralix moor	1	14%	9%
Older (>15 yrs) *Calluna* moor	0	0%	35%
Dry *Calluna* heath	1	14%	13%
Limestone grassland	0	0%	15%
Eriophorum heath	1	14%	5%
Nardus grassland	0	0%	5%
Calcareous flush	2	29%	6%
Juncus effusus flush	0	0%	1%
Sphagnum pools	0	0%	1%

6.2.4. Extensive survey

Figs. 9 and 10 show the proportion of observations of Golden Plover made during the extensive surveys on each of the habitats available to them, at Chapel Fell and at Widdybank respectively. At both sites the birds showed strong selection for certain habitat types. Chi-squared goodness of fit tests using the null hypothesis that the birds were distributed randomly with respect to habitat throughout the season were highly significant: $\chi^2 = 116.3$ (9 df) at Chapel Fell and $\chi^2 = 397.3$ (21 df) at Widdybank.

Fig. 9 Golden Plover habitat use: Chapel Fell

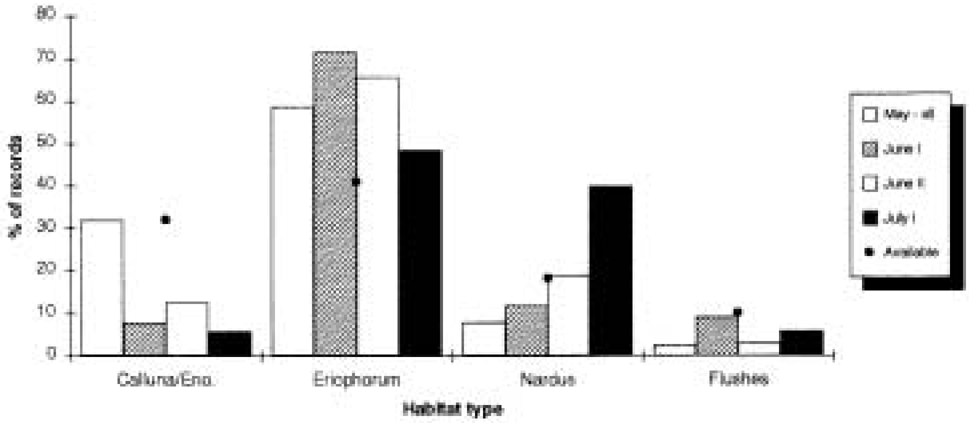
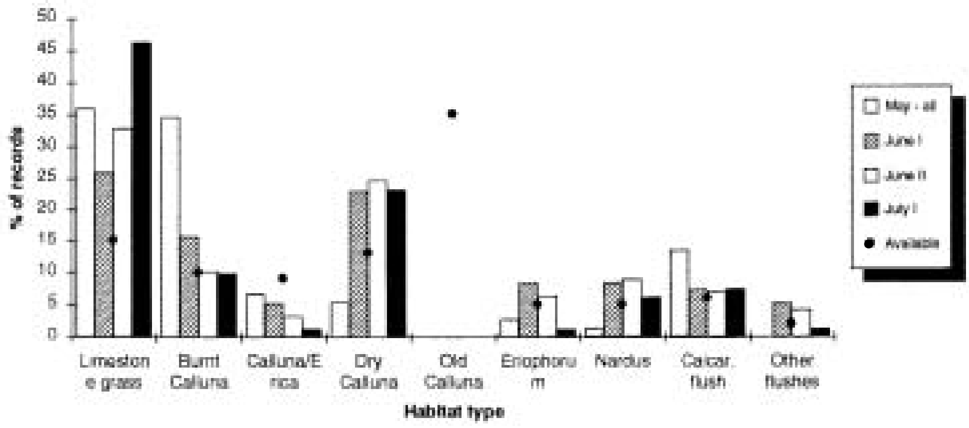


Fig. 10 Golden Plover habitat use: Widdybank Fell



These figures also illustrate the seasonal changes in habitat use through the season. The main points to note are that:

(1) Early in the season before any chicks had hatched, birds at Chapel Fell were using the various habitats in a pattern roughly proportionate to their availability. At Widdybank during this period there was strong selection for patches of recently burnt heather.

(2) From June onwards, when there was a mixture of incubating, chick-rearing and failed breeders at both sites, there was a decline in the use of most of the heather dominated habitats and a corresponding increase in the numbers found on grassy areas, though the dry *Calluna* heath at Widdybank was also used extensively, particularly where it occurred as a mosaic with the limestone grassland.

6.3. Additional data

6.3.1. Nest and brood success

As the sample sizes from this preliminary work were relatively small, the analyses of nesting and fledging success are inevitably limited. Some comparisons were possible however, allowing some insight into the consequences of the birds' habitat selection. Table 10 shows a summary of the clutch size, daily nest survival rate (and hence overall nest survival rate) and daily brood survival rate (and hence overall brood survival rate). The incubation period was taken as 30 days (Nethersole-Thompson, in Cramp *et al.* 1983) for the calculation of the overall nest survival rate, and the fledgling mortality period as 14 days, as no brood losses were recorded after the chicks were 14 days old.

Table 10: Summary of breeding success data.

	Mean clutch size (s.e.)	Daily nest survival rate (s.e.)	Overall nest survival rate	Daily brood survival rate (s.e.)	Overall brood survival rate
Total	3.50 (0.19)	0.9458 (0.0004)	18.9%	0.9583 (0.0004)	55.1%
Chapel Fell	3.57 (0.20)	0.9658 (0.0006)	35.2%	0.9531 (0.0007)	51.1%
Widdybank Fell	3.40 (0.40)	0.9423 (0.0010)	16.8%	0.9688 (0.0009)	64.1%
Early	3.67 (0.21)	0.9690 (0.0005)	38.9%	0.9670 (0.0004)	65.0%
Late	3.33 (0.35)	0.9348 (0.0013)	13.2%	0.9333 (0.0021)	38.1%
Heather	3.60 (0.40)	0.9808 (0.0004)	55.9%	0.9167 (0.0032)	29.6%
Other	3.43 (0.20)	0.9316 (0.0011)	11.9%	0.9722 (0.0004)	67.4%

The main points to note are:

(1) **Clutch size** showed no significant differences (at the 5% level) for any of the comparisons (though there was a trend of smaller clutches that followed that for lower nest success).

(2) **Nest survival rate** was greatest in nests associated with *Calluna*, those started earlier in the season and those at Chapel Fell (though there was insufficient information available to be able to separate these factors).

(3) **Brood survival rate** was higher in habitats without *Calluna* at Widdybank, and also for earlier nests.

The cause of breeding failure was identified in several cases. Two of the five nests lost were predated by mustelids (which leave a characteristic hole in part of egg only and remove the contents, L. Waddell pers. comm.), one probably by a hedgehog, (shell smashed and scattered around the nest), whilst the other two were unknown as the whole clutch disappeared. Cold wet weather conditions appeared to be the major cause of brood mortality. Two of the four known brood losses occurred during such conditions.

7. DISCUSSION

The project achieved all of its main aims in demonstrating that it would be feasible to carry out fieldwork on a larger-scale to examine the habitat requirements of breeding Golden Plover. We successfully located a sample of nests, caught and individually marked adults, and radio-tagged and tracked chicks. Radio-tracking of adults was not successful but the experience gained meant that this problem can now be resolved with more powerful and more sensitive equipment.

The sites chosen were typical of many Golden Plover sites in northern England, with density of just over 5 pairs per km^2 (Ratcliffe 1976). They would be well suited to further work on Golden Plover, particularly as marked populations have now been established.

In addition to assessing the various methods to measure habitat use, some interesting preliminary results about Golden Plover habitat use were also obtained. Most notably, radio-tracking of chicks showed them to be using very different habitats to their parents. Chicks were generally recorded (a) in/near cover and (b) near open feeding areas, and there were several cases of strong selection for marshy patches such as *Juncus* flushes. The use of these habitats was not detected at all by the observation of the adults. It is possible that the methods may have slightly over-emphasised the importance of cover. All spot observations were made walking through Golden Plover territories rather than by distant continued observation, so it could be argued that the observer may have had some effect on the results. However, in most cases where the chicks were observed simultaneously they usually crouched immediately when disturbed. Therefore it is thought that these data do genuinely reflect habitat use by the chicks. Casual records when observing broods from a distance suggested the same results. Clearly radio-transmitters are absolutely essential to enable measurements of chick habitat requirements to be made. Those used in this study proved to be highly suitable as they gave excellent results. With rapidly developing technology it will soon be possible to have a higher powered transmitter that will last for the whole of the chick period.

Observation of marked adults complemented the data obtained from radio-tracking the broods. It showed major differences in habitat use by adults and their broods. Data on time budgets of the adults' behaviour is needed to identify their exact feeding habitat requirements as opposed to those of their brood. This should be a priority for further work. Effective radio-transmitters on the adults would provide an excellent means to construct time budgets, determine location, and assess which habitats are being used, all on a continuous basis.

The extensive survey work gave a useful overall picture of the populations in the two areas. It enabled measurement of overall habitat use and put the detailed results into a wider, more general context. It proved possible to quantify adult habitat use during the nesting period and through chick-rearing.

Some additional data were gathered which suggested some hypotheses about the consequences of habitat selection on the birds' breeding success. Though this was only a preliminary study, and the results inevitably have comparatively small samples, they do still show some interesting trends. It appears that Golden Plover have a requirement for a number of different types of habitat, including camouflage and cover for nests and broods, and open feeding areas with high food availability for adults and broods. Thus it appears to be a species that thrives in a habitat mosaic rather than blanket cover of a single habitat type.

There is scope for some further analysis of the data collected so far. The complex interrelationship of spatial habitat and bird data would be well suited to more detailed examination using a Geographical Information System. It is intended to set up the data on an ARC/INFO system in the near future. The work also has considerable implications for the interpretation of survey data. This too will be examined in more detail in the near future.

Two particular areas of investigation should be a priority for incorporating into a fuller study of habitat selection in Golden Plovers:

1) The role of food availability in habitat selection

There is a need to quantify the availability and the reliability of the birds' food source. We have successfully measured habitat occupancy but need more information about the use that they make of those areas. For example, do the adults obtain adequate food in the habitats for which they have been recorded or do they make forays into food-rich areas such as flushes to satisfy their dietary requirements?

2) The role of cover in habitat selection

Both nests and chicks require cover from predation, and the chicks may have an additional requirement for a suitable micro climate. Does inadequate vegetation cover for the chicks lead to higher risk of predation and /or exposure? Experiments with artificial clutches would provide information on predation rates in different habitat types.

In conclusion this work has shown that it is possible to study the detailed habitat requirements of Golden Plover, and a longer-term research project should be able to gather sufficient information to be able to predict the consequences of habitat change and availability on Golden Plover populations, and produce prescriptions for upland management. Many of the factors are likely to also be of relevance to other upland birds, and further studies should perhaps investigate additional species. The Curlew, *Numenius arquata*, would be an excellent candidate, as an upland bird that differs apparently in its habitat requirements, is easy to census, its nests are relatively easy to locate and has not been well studied in Britain's uplands. Longer-term work would also provide the opportunity to look at the effect of habitat availability on other aspects of the birds' population dynamics, such as the rates of return and survival.

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