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Distribution and behaviour of passerines around Peregrine *Falco peregrinus* eyries in western Greenland

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This paper describes the distribution and behaviour of passerine birds within 1 km of Peregrine Falcon *Falco peregrinus* eyries in western Greenland. Passerine populations were censused in 1983 around six cliffs occupied by nesting Peregrines and at six sites on the open tundra, and in 1984 at two unoccupied sites suitable for Peregrine nesting.

Four passerine species accounted for over 90% of birds seen. Within 400 m of Peregrine occupied cliffs, three species, Lapland Longspur *Calcarius lapponicus*, Northern Wheatear *Oenanthe oenanthe*, and Common Redpoll *Carduelis flammea*, were found in lower than average abundance while the fourth, Snow Bunting *Plectrophenax nivalis*, was found in increased abundance. Our indirect tests suggest that Peregrine presence, rather than direct predation, was responsible for the distributions of the first three species. The Snow Bunting, however, behaviourally adapts to Peregrine presence in order to exploit nesting habitat available at the cliff base.

These results contrast strongly with those reported by other Arctic workers, where increased abundances of potential prey were observed in close proximity to nesting Peregrines.

Several investigators, citing anecdotal evidence, have reported that, in Arctic regions, the density of one or more potential prey species decreases with distance from active Peregrine *Falco peregrinus* nests (see Cade 1960 for review). This distribution of potential prey has been explained as either (1) selection of nest sites by Peregrines to put them in areas of high prey abundance, or (2) a commensalistic relationship, whereby the prey take advantage of the Peregrine's aggression toward nest predators. As part of an investigation of nest site selection by Peregrines in western Greenland, we studied the distribution and density of the four most common passerines (Burnham & Mattox 1984, Meese 1984): Lapland Longspur *Calcarius lapponicus*, Northern Wheatear *Oenanthe oenanthe*, Snow Bunting *Plectrophenax nivalis*, and Common Redpoll *Carduelis flammea*, to determine if these were similar near Peregrine nest sites and across the open tundra. These four species constitute the bulk of the Greenland Peregrine's diet (Burnham & Mattox 1984).

Methods

We employed the variable-strip transect method (Emlen 1971, Burnham *et al.* 1980, Burnham *et al.* 1981) to collect data on distribution, density (Burnham *et al.* 1980), and habitat use of the four commonest passerine species. Our study area was located at the widest strip of ice-free land in western Greenland, near Sondre Stromfjord (see Fig. 1). In this area, members of the Greenland Peregrine Falcon Survey have been locating Peregrine nest sites since 1971 (Burnham & Mattox 1984). Our data were collected between 10 and 26 July 1983, with additional observations made in August 1984.

Three 1-km transects were established at each of six cliffs occupied by nesting Peregrine Falcons (eyrie

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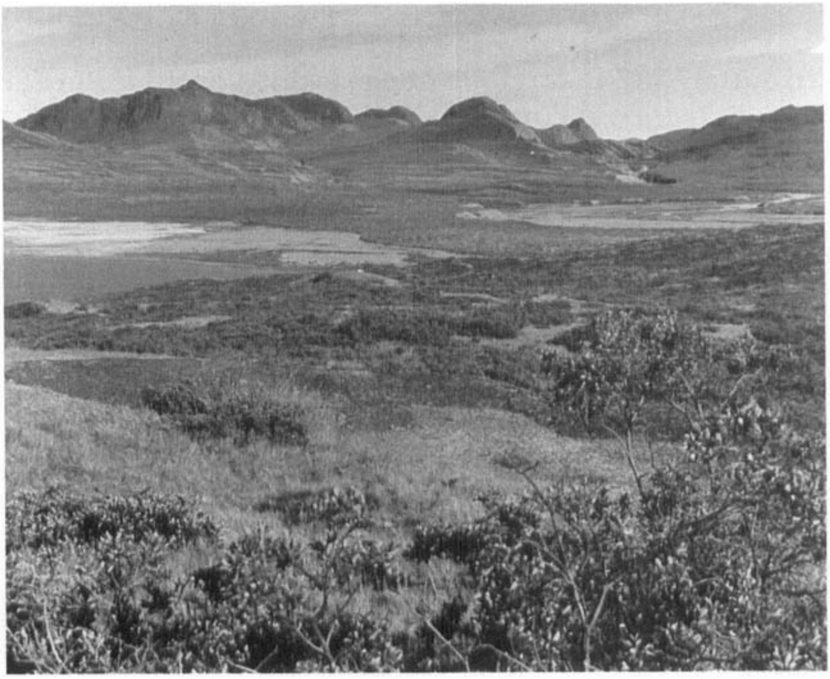

Figure 1. Portion of study area near Sondre Stromfjord, Greenland. Peregrines utilize cliffs for nesting. See Methods for habitat descriptions.

samples), and at six sites where cliffs suitable for Peregrine nests did not exist (tundra samples). Location of the first transect at each site was randomly determined by spinning a pencil on a map and using a compass to find the indicated direction. The other transects were then offset 120° with respect to the first (H.W. Steinhoff, pers. comm.). Each transect was measured in ten intervals of 100 m (Fig. 2) and the position of each bird in its interval was noted. Each transect was walked once. Direction of travel (i.e. toward or away from the eyrie) was varied to account for the potential for bird distribution to be an artifact of observer presence.

Vegetation was described by general community type. Nine habitat types were recognized, according to the classification of Böcher *et al.* (1968): (1) arctic–subarctic steppe (a dry grass–sedge community), (2) herbslopes (moist meadow-like community with many species), (3) dwarf-shrub heath (low woody vegetation), (4) willow copse (*Salix* spp. dominated community, 1/2 to 2 m high), (5) fell-field (windy localities with scattered plants), (6) barren ground (exposed rock lacking vegetation), (7) fen/marsh (community of grass-like meadow and marsh plants), (8) pond/lake/river/fjord (any permanent body of water), and (9) grassland slopes (dense vegetation of grasses or grass-like plants, rich in mosses and lichens). A sample of the percent occurrence of each habitat type was made by recording the habitat in which the observer stood at the end of each 100 m transect interval and at the common origin of the three transects (Fig. 2).

Results

For transects conducted within 1 km of Peregrine Falcon eyries, the number of birds observed in each 100 m interval of transect was found to differ significantly from that expected had the birds been distributed evenly from the nest site to a distance of 100 m from the nest ($\chi^2_9 = 70{\cdot}9$, $P < 0{\cdot}001$). No departure from a random distribution was recorded in the tundra sample ($\chi^2_9 = 13{\cdot}78$, $P > 0{\cdot}1$). There was a trend for more birds to be seen far from eyries than near eyries (Spearman rank correlation, $r_s = 0{\cdot}876$, $n = 10$, $P < 0{\cdot}001$). In an attempt to define more precisely 'near' versus 'far' as distance categories from an eyrie, a sequential chi-square test was performed

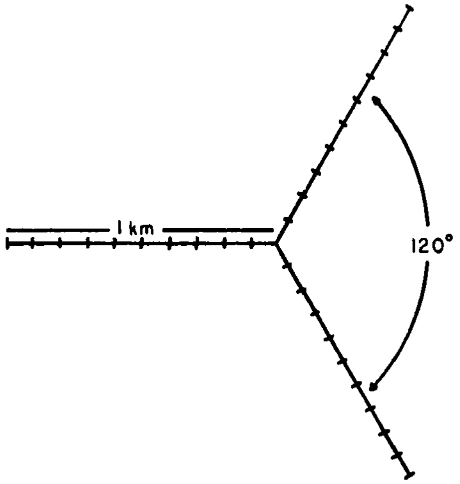

Figure 2. Transect design indicating 100 m segments. In eyrie samples the origin of the 3 lines would indicate location of a Peregrine eyrie. (see text for explanation of 'eyrie' and 'tundra' samples).

on all possible 'near' and 'far' groupings to obtain a minimim chi-square value, i.e., the best estimate of the borderline between near and far groups (Mood *et al.* 1974, pp. 256–257). This test indicated 0–400 m as the 'near' category and greater than 400 m as the 'far' category ($\chi_1^2 = 47{\cdot}8$, $P < 0{\cdot}001$).

Direction of travel along the transect did not confound these results, as the three transects done in reverse (i.e. from 1 km away moving toward the eyrie) exhibited the same pattern of fewer birds near eyries ($\chi_1^2 = 11{\cdot}5$, $P < 0{\cdot}005$).

Three species, Lapland Longspur, Northern Wheatear, and Common Redpoll, were found in significantly higher numbers more than 400 m from Peregrine eyries ($\chi_1^2 = 49{\cdot}23$, $P < 0{\cdot}005$; $\chi_1^2 = 10{\cdot}2$, $P < 0{\cdot}005$; $\chi_1^2 = 7{\cdot}27$, $P < 0{\cdot}01$, respectively; Table 1) while Snow Buntings were observed in greater abundance less than 400 m away ($\chi_1^2 = 8{\cdot}41$, $P < 0{\cdot}005$; Table 1). The number of birds observed in front of and below eyries was not significantly different from that observed behind and on the sloping back side of cliffs (Mann-Whitney $U_{7,9} = 40{\cdot}5$, n.s.)

Table 1. *Distribution, by species and distance, of birds within 1 km of Peregrine eyries. LL = Lapland Longspur, CR = Common Redpoll, NW = Northern Wheatear, SB = Snow Bunting.*

Distance from eyrie (m)	Species				
	LL	CR	NW	SB	Total
0–100	0	1	4	7	12
100–200	0	1	2	1	4
200–300	1	0	5	2	8
300–400	4	0	7	3	14
400–500	8	3	15	0	26
500–600	11	3	9	0	23
600–700	11	5	4	1	21
700–800	25	7	17	0	49
800–900	15	1	11	3	30
900–1000	23	0	6	1	30
Total	98	21	80	18	217

Table 2. *Number of birds (% of total) seen in each habitat and percentage ground cover of habitats in each distance category. Zero to 400 m constitutes the 'near' category, more than 400 m the 'far' category. See text for habitat descriptions.*

	Near		Far	
Habitat	No. Birds (%)	No. Samples (%)	No. Birds (%)	No. samples (%)
Steppe	0	3 (4)	3 (2)	4 (4)
Herbslopes	0	1 (1)	0	0
Heath	5 (13)	28 (36)	80 (45)	45 (42)
Willow copse	15 (39)	11 (14)	57 (32)	13 (12)
Fell field	13 (34)	15 (19)	24 (13)	10 (9)
Barren ground	4 (11)	5 (6)	0	0
Fen/marsh	0	0	6 (3)	2 (2)
Lake/pond	0	11 (14)	0	31 (29)
Grass/slopes	1 (3)	4 (5)	9 (5)	3 (3)

To account for the possibility that the observed distribution was a function of reduced amount of certain habitats near Peregrine occupied cliffs, habitat samples taken within 400 m of eyries were compared to those taken more than 400 m away. Chi-squared analysis of those habitat types with an expected sampling frequency of 5 or more (Cochran 1954) showed no significant difference between percentage occurrence of the four major terrestrial habitat types ($\chi^2_3 = 3{\cdot}57$, n.s.). These habitats accounted for 85% of all habitat samples taken and 89% of all birds seen within 1000 m of cliffs (Table 2).

In 1984, single transects were walked at each of two cliffs suitable for Peregrine nesting (i.e., with sufficient height, southern aspect, numerous ledges) but with no Peregrines present. The numbers of birds observed at these cliffs (10 at one site, 14 at the other) were significantly greater than those from Peregrine occupied cliffs (Mann–Whitney U-test: $U = 34_{2,16}$, $P < 0{\cdot}01$). Although extensive habitat sampling was not done at these two sites, no differences in available habitats were noted; hence, it is not felt that differences in habitat alone could account for the increased abundance of birds below these two cliffs.

Discussion

Our results show increasing abundance of potential prey with increasing distance from Peregrine eyries. These accord with the results of Geer (1978), who found reduced abundances of Great Tits *Parus major* and Blue Tits *P. caeruleus* near the nests of Sparrowhawks *Accipiter nisus* in England, and Eng & Gullion (1962), who found a 'circle of suppression' of Ruffed Grouse *Bonasa umbellus* numbers within a half-mile (0·8 km) radius of Goshawk *Accipiter gentilis* nests in Minnesota.

However, this contrasts strongly with accounts from other Arctic areas, where potential prey were found in greater abundance in close proximity to nesting Peregrines. Turner (1886) and Suschkin (1908, cited in Cade 1960) believed that Peregrines were selecting nest sites based on locally abundant prey resources. Our data are based on transects conducted during the passerines' incubation and nestling stages. It is possible that Peregrines hunted extensively in the vicinity of their eyries before our data were collected, thereby significantly reducing the number of passerines close to the cliffs and producing the observed distribution. However, intensive observations made throughout the breeding season in the same area by Harris & Clement (1975) indicated that Peregrines infrequently hunted close to their cliffs.

Ratcliffe (1980) reviewed much of the published data on hunting ranges of Peregrines and concluded that inland Peregrines rarely hunt within 1 km of their eyries unless the eyrie is located within a concentrated prey base, e.g., a seabird colony. Also, Peregrines typically hunt utilizing a high-speed dive on flying prey (Salomonsen 1950). This tactic is ideal for prey located below the eyrie but would not be as appropriate for prey above and behind it. Because the distribution of birds on the sloping back sides of eyries was not significantly different from that below, we believe that the presence of the falcons, rather than direct predation, is mostly responsible for the observed distribution; we see no evidence that Peregrines are selecting eyries based on a locally abundant prey base. On the contrary, it appears that three of the four passerines actively avoid settling near Peregrine-occupied cliffs.

The presence of nest robbers may be a factor influencing avian distributions, perhaps leading to commensalism, as has been hypothesized by several previous workers in Arctic areas (Peterson 1948, Kessel & Cade 1958, Buturlin 1933 and Grote 1934 cited in Cade 1960, Ogilvie 1976). Under this hypothesis, an advantage would accrue to a species which settled near another if the second species was defensive against potential nest predators. The Arctic Fox *Alopex lagopus* is known to prey heavily on passerines in Arctic areas (Hussell & Holroyd 1974, Pattie 1977), yet Harris & Clement (1975) observed Arctic Foxes living at the base of one of the two Peregrine eyries they studied but do not report harassment of the foxes by falcons. Thus, although there is a potential for nest robbing, the Peregrines do not provide protection against at least one nest predator, eliminating the potential advantage of nesting near Peregrines to avoid fox predation.

An interesting result of this work was the finding of two different behavioural responses to Peregrine presence. We believe that this difference is mostly explained by passerine nesting habitat preference. Lapland Longspur, Northern Wheatear, and Common Redpoll nest in heath or willow (Salomonsen 1950), abundant habitats scattered across the tundra (see Table 2); all appeared actively to avoid settling near Peregrine occupied cliffs. Thus they could reduce their chances of being preyed upon by allowing themselves sufficient time to find cover if a Peregrine should attack from its eyrie.

Snow Buntings, however, were significantly more abundant near cliffs than away from them. Snow Buntings nest in rock piles and other stone structures (Salomonsen 1950), a habitat infrequently found but one which occurs in abundance below cliffs. Salomonsen (1950, p. 545) reported that the entrances to Snow Bunting nests were too narrow to permit entry by Arctic Fox, in accordance with Harris & Clement's (1975) finding that Peregrines do not provide protection against this nest predator. In order to exploit the rock piles at cliff bases while limiting its availability as prey, Snow Buntings fly unusually close to the ground, 'hugging' every rise and dip in the landscape (pers. obs.). Thus, instead of relying on avoidance via increased distance, they adapt behaviourally by changing their flight style, making capture more difficult for an avian predator. MacIntyre (1914, 1960 cited in Ratcliffe 1980) reported that pigeons nesting near Peregrines in Britain used the same tactic to avoid capture.

The question of why an increased abundance of potential prey is found in proximity to Peregrine nests in some areas while the reverse is true in western Greenland is an interesting one and deserves further study.

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