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THE DIET OF PEREGRINE FALCONS IN RANKIN INLET, NORTHWEST TERRITORIES: AN UNUSUALLY HIGH PROPORTION OF MAMMALIAN PREY[1]

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Throughout their virtually world-wide range, Peregrine Falcons (*Falco peregrinus*) rely almost completely on the aerial capture of other birds (Cade 1960, Radcliffe 1980). Moreover, the Peregrine's reliance on a wide range of stable avian prey populations is believed to be responsible for the great stability of their breeding density and reproductive output (Newton 1979, Ratcliffe 1980).

In our study area near Rankin Inlet, Northwest Territories, Canada, however, Peregrine Falcons are not very stable in either breeding density or reproductive output. The number of successful pairs rose from a three-year mean of 13 to 21 and production of fledglings nearly doubled in conjunction with a 1985 peak in microtine rodent density (Court et al. 1988a, 1988b). The authors speculated that the microtine increase provided an abundant food resource that the Peregrine Falcons exploited to their reproductive advantage. A subjective appraisal of prey use during the microtine peak year indicated that both microtine rodents and arctic ground squirrels were being eaten (Court et al. 1988a).

We wanted to determine if mammals were a normal prey species for the Rankin Inlet Peregrine Falcon population. Therefore, in this paper, we quantitatively describe the diet of Peregrine Falcons of Rankin Inlet during two years of non-peak microtine abundance.

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METHODS

The study area surrounds the Inuit hamlet of Rankin Inlet (Keewatin Region, Northwest Territories, Canada) on the northwest coast of Hudson Bay. The area is tundra interspersed with rocky outcrops that form the cliffs used for nesting. July mean high and low temperatures are 13.1°C and 4.5°C. Peregrine Falcons arrive in late May and leave again in late September or early October. Laying is usually in the first 10 days of June, eggs hatch in mid-July, and young fledge from mid to late August. A complete description of the study area and the natural history of the population has been given elsewhere (Court et al. 1988a, 1988b).

During the nestling period, we collected pellets (the regurgitated, indigestible body parts of prey) and prey remains once each week from three nests in 1986, and from five nests in 1987. We made collections every three days from an additional two nests in 1986. We removed all prey remains prior to the first collection, and after each subsequent collection to prevent counting prey individuals twice.

Analysis of remains was similar to methods used by Mollhagen et al. (1972). We examined remains and dissected pellets from each collection, and recorded the number of each kind of identifiable body part. The minimum number of animals was equal to the greatest number of identical bones per taxon. If no countable items were found from a species, then we counted one individual for finding the hair or body feathers. Juvenile plumages enabled us to distinguish between age classes of most passerines and shorebirds.

TABLE 1. Prey remains collected at Rankin Inlet in 1986 and 1987.

Species	1986 Numbers	1987 Numbers	Average Weight	Source of Average Weight
Horned Lark (*Eremophila alpestris*)				
Adult	4	5	39	Maher 1980
Juvenile	4	3	30	Maher 1980
Lapland Longspur (*Calcarius lapponicus*)				
Adult	4	5	27	Maher 1964
Juvenile	0	3	23	Maher 1964
Snow Bunting (*Plectrophenax nivalis*)				
Adult	10	11	34	Maher 1964
Juvenile	6	4	31	Maher 1964
Water Pipit (*Anthus spinoletta*)	2	2	21	Dunning 1984
Robin (*Turdus migratorius*)	1	0	77	Dunning 1984
Unidentified Passerine				
Adult	12	3	32	Calculated[1]
Juvenile	20	7	30	Calculated[1]
Total passerines	63	43		
Dunlin (*Calidris alpina*)	0	2	57	Dunning 1984
Lesser Golden Plover (*Pluvialis dominica*)	2	3	145	Dunning 1984
Semipalmated Plover (*Charadrius semipalmatus*)				
Adult	1	2	47	Dunning 1984
Juvenile	0	2	47	Assumed[2]
White Rumped Sandpiper (*Calidris fuscicollis*)	0	1	45	Dunning 1984
Unidentified Shorebird				
Adult	8	3	50	Calculated[3]
Juvenile	2	1	50	Calculated[4]
Total shorebirds	13	14		
Oldsquaw (*Clangula hyemalis*)				
Adult	2	2	873	Dunning 1984
Juvenile	1	1	768	Calculated[4]
Parasitic Jaeger (Male) (*Stercorarius parasiticus*)	0	1	280	Maher 1974
Rock Ptarmigan (*Lagopus mutus*)				
Adult	2	2	525	Poole and Boag 1988
Juvenile	1	1	400	Poole and Boag 1988
Arctic Tern (*Sterna paradisaea*)	1	1	110	Dunning 1984
Rock Dove (*Columba livia*)	1	0	542	Dunning 1984
Peregrine Falcon Chick (*Falco peregrinus*)	0	2	300	estimated by author
Lemming (*Dicrostonyx groenlandicus*)	20	32	73	Banfield 1974
Arctic Ground Squirrel (*Spermophilus parryii*)	6	3	350	Poole 1987
Total number of prey individuals	110	102		

[1] The average of the identified species weights, weighted by their abundance in the sample.
[2] Juveniles were assumed to have the same weight as the adults. Ricklefs (1973) lists 3 species of shorebirds, all of which have asymptotic weights identical to the adult weights.
[3] The average of the identified species weights weighted by their abundance in the sample. The Golden Plover data were not used for this calculation as the unknown individuals could not have belonged to this species.
[4] Calculated by multiplying the adult weight by 0.88. The correction factor is the ratio of asymptotic weight to adult weight for the Mallard (*Anas platyrynchos*) (Ricklefs 1973).

We separated the data into four categories based on size (large vs. small) and class (avian vs. mammalian). We did not use finer categories because numbers of individuals within each species were often quite small. The small birds category consisted of prey of mean body weight 200 grams or less, and the large birds category of prey of mean body weight over 200 grams. Mammalian prey were divided into two categories: microtine rodents and the much larger arctic ground squirrels (*Spermophilus parryi*). For each category and year, we calculated percent individuals and percent of total prey biomass. Prey biomass was baesd on mean body weights reported in the literature (Table 1).

RESULTS

Data from 1986 and 1987 were combined when calculating percent individuals and percent biomass, because no differences between years could be found (contingency table, G = 6.445, P = 0.09, df = 3).

Small birds (64%) were the most important contributor to percentage of individuals, followed by microtines (25%), large birds (8%), and arctic ground squirrels (4%). The most important contributors to percent biomass were large birds (43%), followed by small birds (25%), microtines (18%), and arctic ground squirrels (15%).

Passerines (78.5%) were the most numerous individuals within the small bird class, followed by shorebirds (20%), and Arctic Terns (*Sterna paradisaea*, 1.5%). Forty-four percent of the passerines, and 18% of the shorebirds were juveniles. Horned Larks (*Eremophila alpestris*), Lapland Longspurs (*Calcarius lapponicus*) and Snow Buntings (*Plectrophenax nivalis*) were the most frequently identified passerines, while Lesser Golden Plovers (*Pluvialis dominica*) and Semipalmated Plovers (*Charadrius semipalmatus*) were the most frequently identified shorebirds (Table 1).

Passerines (62%) were also the most important contributors to small bird biomass, followed by shorebirds (34%), and Arctic Terns (4%). Forty-two percent of the passerine biomass, and 13% of the shorebird biomass consisted of juveniles.

Within the large bird category, we found six Oldsquaw (*Clangula hyemalis*), six Ptarmigan (*Lagopus mutus*), two Peregrine Falcon chicks, one Rock Dove (*Columba livia*), and one Parasitic Jaeger (*Stercorarius parasiticus*). As percent biomass, this translated into 54% Oldsquaw, 31% Ptarmigan, 6% Peregrine Falcon, 6% Rock Dove and 3% Jaeger.

The appearance of Peregrine Falcon chick remains always coincided with the disappearance of a sibling, therefore we have assumed that they were siblings that died, or were killed, in the nest. Cause of death was not determined, because only bones and feathers were found.

Twenty-nine percent of prey individuals and 33% of the prey biomass were mammalian. Microtine remains (25%) were found more frequently than Arctic ground squirrel remains (4%), but microtines (18%) and ground squirrels (15%) were similar in percent biomass. Microtines remains were not separated by species, but only four species occur in the area: (*Dicrostonyx groenlandicus, Lemmus sibiricus, Clethrionomys gapperi*, and *Microtus pennsylvanicus*). All ground squirrel remains were of juveniles. The use of mammals was not restricted to a few nests, microtines were found in all nests, and ground squirrels were found in eight out of 10 nests. All microtine individuals except one were identified from the pellets, while virtually all avian individuals were identified from remains.

DISCUSSION

Birds were the most frequently taken prey type in the Rankin Inlet Peregrine Falcon population, as they are in all studied Peregrine Falcon populations (Ratcliffe 1980). Most temperate and tropical Peregrine Falcons rely on prey species that we would class as large (Ratcliffe 1980, Czechura 1984, Tabotan 1984, Vasina and Straneck 1984), but in Rankin Inlet, small birds were the most frequently eaten. Small birds seem to be the most important prey for all tundra-dwelling populations (Burnham and Mattox 1984, Falk et al. 1986, Moore 1987, Poole and Bromley 1988). Court (1986) has suggested that the hunting of small birds is facilitated by the lack of trees on the tundra.

Neither Rock Doves nor American Robins (*Turdus migratorius*) inhabit the Rankin Inlet area, so their occurrence in the collections is remarkable. A blizzard in May of 1986 was accompanied by many extra-limital bird sightings (e.g., European Starlings (*Sturnus vulgaris*), Yellow-Rumped Warblers (*Dendroica coro-*

nata), Bank Swallows (*Riparia riparia*) and Barn Swallows (*Hirundo rustica*)). Perhaps these unusual bird species, the Rock Dove and the American Robin included, were blown north by this blizzard.

Peregrine Falcon siblings as prey are also somewhat unusual, but have been reported previously (White and Cade 1971, Court et al. 1988a). We do not know if the deaths were the result of siblicide, or if the chicks died and were then eaten.

Court et al.'s (1988a) work in Rankin Inlet indicated that microtines were being eaten at only 50% of the nests, compared to 100% of the nests we examined, but pellet analysis was not part of their study. In fact, pellets provided a much different picture of prey use than did prey remains; all but one microtine rodent were identified from the pellets. Reports of arctic Peregrine Falcon diets based solely on remains should therefore be viewed with caution.

About one third of the prey biomass was mammalian. Because evidence of microtines almost always came from pellets and falcons usually digest bones (Yalden and Yalden 1985), our estimate of microtine biomass was probably minimal. Either way, the proportion of rodents in the diet of the Rankin Inlet Peregrine Falcons is very high compared to other populations. Perhaps the lack of tree cover helps Peregrine Falcons prey on rodents as well as small birds.

Other tundra-dwelling Peregrine Falcons might therefore be expected to eat microtines as well, but mammals were not reported as prey in the central N.W.T. (Poole and Bromley 1988) or in Alaska (Hunter et al. 1988). They may have missed evidence of microtine predation, because they did not examine pellets. Dement'ev and Gladkov (1966) stated that in the U.S.S.R., tundra-dwelling Peregrine Falcons eat birds 'with extremely rare exceptions.' White and Cade (1971) reported the use of arctic ground squirrels and microtines by Alaskan Peregrine Falcons, but found that they accounted for less than 1% of the individuals identified. White and Cade (1971) did not state whether or not they examined pellets, so their results are hard to evaluate. Peregrine Falcons nesting in Greenland don't eat microtines because the ranges of Peregrine Falcons and microtines are completely disjunct (Burnham and Mattox 1984, Falk et al. 1986). There are, however, anecdotal reports of other tundra-dwelling Peregrine Falcons using mammals as food. Fischer (1967) cited two studies in Siberia that reported 28 to 50% mammals in Peregrine's diets, and Peregrine Falcons from the Yamal Peninsula in the U.S.S.R. will take "substantial numbers of lemmings" in some years (Cramp and Simmons 1980). Bertram et al. (1934) and Cade (1960) reported anecdotal evidence of Peregrine Falcons taking microtine rodents in Norway and the N.W.T. respectively.

Microtine abundance is known to fluctuate widely in arctic areas and was probably not at peak density in the Rankin Inlet study area in 1986 and 1987. Although we did not conduct microtine censuses, changes in their abundance were crudely monitored by examining numbers of Rough-legged Hawk and Snowy Owl (*Nyctea scandiaca*). The Rough-legged Hawk (*Buteo lagopus*) breeds in the tundra regions of North America, Europe, and Asia, and preys mainly on microtine rodents. Throughout its range, breeding density and

reproductive performance are determined locally by variations in microtine densities (Hagen 1969, White and Cade 1971, Galushin 1974, Andersson and Wiklund 1987, Poole and Bromley 1988). In Rankin Inlet, there were 27 laying pairs of Rough-legged Hawks in 1985, but never more than 12 in the years 1981 to 1984, 1986 and 1987 (Court et al. 1988b, unpublished data for 1987). Numbers of Snowy Owls are also known to track microtine abundance (Cade 1960, Hagen 1969, Miller et al. 1975). We recorded the number of owls seen while in the field from 1985 to 1987; we saw 24 owls in 1985, comapred to one in 1986 and one in 1987. Therefore microtines in the study area were probably at peak density in 1985, and at lower densities in the other years.

The relatively high prevalence of microtine rodents in the Peregrine's diet in 1986 and 1987 is therefore remarkable, and suggests that microtines may have been even more important as prey items in 1985 when their availability was at a peak. Ratcliffe (1980), Hunter et al. (1988), and Thiollay (1988) found that prey abundance is an important consideration in Peregrine Falcon prey selection, and the Prairie Falcon (*Falco mexicanus*), which is the Peregrine Falcon's closest relative (Schmutz and Oliphant 1987), has been found to increase its use of a favored rodent species in years of high rodent abundance (Steenhof and Kochert 1988). Therefore, the microtine contribution of 18% to prey biomass in years of low microtine abundance suggests that they are an important prey species for the study population. The importance of microtine rodents in the diet lends support to Court et al.'s (1988b) hypothesis that the 1985 increase in Peregrine Falcon population size and production of young was influenced by microtine abundance.

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PITCH PRODUCTION IN CAROLINA CHICKADEE SONGS[1]

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Key words: Song production; pitch change; species recognition; Carolina Chickadee; Parus carolinensis.

The fee-bee song of the Black-capped Chickadee (*Parus atricapillus*) consists of two clearly whistled notes, the first *fee* slightly higher in pitch than the second *bee* (Dixon and Stefanski 1970, Ficken et al. 1978). Weisman et al. (1990) reported that frequency relationships in Black-capped Chickadee songs represent simple transformations of constant ratios between adjacent notes across the frequency range of the species. That is, both the frequency sweep (glissando) during the *fee* note and the change in frequency from *fee* to *bee* have constant frequency ratios among and within individuals.

Whereas the perception of absolute pitch is related to the frequency of a sound, the perception of relative pitch by pitch interval is related to the frequency ratio between adjacent sounds (Hall 1980). Weisman et al. (1990) presented four kinds of evidence in favor of relative pitch production in Black-capped Chickadees: (i) distributions of the absolute pitches of *fee* and *bee* overlap extensively; (ii) the absolute pitches of the notes are highly predictable from one another, i.e., highly correlated with each other and with values predicted from one another; (iii) the pitch interval ratios between the start and end of *fee* and between *fee* and *bee* are

much less variable than the absolute pitches of the notes; and (iv) when individual birds shift the absolute pitches of their song notes, they maintain constant species-typical pitch intervals.

Carolina Chickadees (*P. carolinensis*) are closely-related congeners (Braun and Robbins 1986, Gill et al. 1989), who also sing clearly whistled notes in their territorial songs. Ward (1966) and Smith (1972) described the song of the Carolina Chickadee as a series of alternating high and low pitched notes. A variety of song types are observed, which appear to vary across geographical regions (Ward 1966). We here examine relationships among the absolute pitches in two song types of Carolina Chickadees to determine whether they show relative pitch constancies similar to those observed in the songs of Black-capped Chickadees.

METHODS

We recorded the songs of 23 Carolina Chickadees within a 10-km radius of Duke University, Durham, North Carolina in May 1990. Most birds sang more than one song type; we recorded six song types of which two were by far the most frequent in our area (see A and B in Fig. 1). We obtained at least five exemplars of song A from 19 birds, and five exemplars of song B from 11 of these same birds. We obtained five exemplars of song B from four additional birds, who did not sing song A in our recordings, raising our sample of song B to 15 birds. Individuals were identified by territory location and recorded in a single session, with all territories separated by at least ½ km, to insure that all recorded birds were different individuals.