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MICROTINES AND GROUND SQUIRRELS OF THE COASTAL PLAIN OF THE ARCTIC NATIONAL WILDLIFE REFUGE: NOTES ON DISTRIBUTIONS, DENSITIES, AND GENERAL ECOLOGY

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Key words: Microtine rodents, Microtus miurus, Microtus oeconomus, Dicrostonyx torquatus, Spermophilus parryii, Lemmus sibericus, population density, demography, habitat selection, predation, Arctic National Wildlife Refuge, north slope.

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Microtines and ground squirrels of the coastal plain of the Arctic National Wildlife Refuge: notes on distributions, densities, and general ecology.

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Abstract: A microtine rodent trapping survey was done at three locations across an altitude/coastal influence gradient in the Arctic National Wildlife Refuge from 31 May - 25 August 1984. Each location was trapped three times at monthly intervals. A similar trapping program was done in 1983. Densities of *Microtus oeconomus* decreased at the more inland study areas between years. *Dicrostonyx torquatus* and *Lemmus sibericus* species were more common towards the coast. *Microtus miurus* occurred only at the most inland study site. Analysis of raptor pellets indicated that *Dicrostonyx* and *Lemmus* populations at the two more coastal sites may cycle or fluctuate. These populations appear to be in the second consecutive low density year. Habitat selection and partitioning by microtines appears to occur at low densities. Distribution of arctic ground squirrels (*Spermophilus parryii*) depends primarily on suitable burrowing conditions and forage quality. Herbivory by, and predator use of microtines and ground squirrels suggests their integral importance in the arctic ecosystem.

Microtines and ground squirrels of the coastal plain of the Arctic National Wildlife Refuge: notes on distributions, densities, and general ecology.

Microtine rodents are extrmely important components of the tundra ecosystem as they may account for most of vertebrate herbivory on the tundra (Batizli et al. 1981) and are an important prey resource for a wide variety of predators. Arctic ground squirrels are also of considerable importance as prey animals as well as being interesting in terms of their habitat selection and population dynamics. The brown lemming (Lemmus sibericus), collared lemming (Dicrostonyx torquatus) and tundra vole (Microtus oeconomus) are the most common microtines of the coastal plain of the Arctic National Wildlife Refuge (ANWR). The singing vole (Microtus miurus) occurs primarily in the foothills and mountains, and the redbacked vole (Cleithrionomys rutilus) occurs only farther into the mountains at lower elevations (Bee and Hall 1956). Arctic ground squirrels occur throughout the ANWR and their distribution seems to correspond to that of permafrost free substrates suitable for burrows. The material presented in this report represents data from the second season (1984) of a two year study program, and also some comparisons with results from the first season (Babcock 1984). The objectives of the study were as follows:

1. Estimate the distributions and densities of ground squirrels and of all microtine rodent species occurring within the coastal plain of ANWR.

2. Determine habitat use and population dynamics of ground squirrels and microtine species.

3. Note predator use of microtines and ground squirrels.

Method and Materials

Study Areas

The second field season of the study was done from 31 May through 25 August 1984 and includes some information from and comparisons with the previous field season (2 June through 18 August 1983). The study sites were chosen to give a latitude/altitude transect across the coastal plain and to reflect differences between coastal and mountain influences. Transportation logistics also influenced site locations. The study sites were located on the Kongakut and Katakturak rivers and also near the Okpilak river delta (Fig. 1). Each study site was visited three times over the field season at approximately one month intervals; stays at each site lasted about ten days. See Babcock (1984) for detailed descriptions of study areas.

Microtine Trapping

In the first field season at each study site a live trapping grid was surveyed and staked using a compass and chain. Trap points were located a 10 m intervals on the 130 x 130 m grid, giving a total of 196 trap locations and a total grid area of approximately 2 ha. A large size (7.6 x 7.6 x 23 cm) folding Sherman live trap was placed near each grid point and was stuffed with indigenous vegetation as insulation. Traps were not baited. The grid was checked at 4-6 hr intervals (dependent on temperature and precipitation) for 5 days (120 hr). All captured animals were identified to species, sexed, weighed, and reproductive state/maturity was noted. Animals were marked using the toe clip method of Melchior and Iwen (1965). Each grid was run for a 5-day trapping period at monthly intervals for a total of three periods at each site. These grids were left marked over the winter and were used in the same way in the 1984 field season.

Opportunistic snap trapping was done at each visit to each site (using Museum Special traps) to collect stomachs for dietary analysis. The various microtine species were trapped in a variety of habitats in attempts to sample from a broad population of each species. Reproductive and demographic information was also gathered from snap trapped animals. Quantitative vegetation sampling was done in each habitat that was trapped.

Raptor and jaeger pellets were collected from the Katakturuk and Okpilak study areas during the 1983 and 1984 field seasons. The pellets were analyzed to aid estimates of the proportion of microtine species at these areas. Only skulls found in pellets were used, since the pellets were of variable age and condition.

Ground Squirrel Collecting

Squirrels were collected with a shotgun during each visit to each site, and reproductive, weight and age information was gathered. Squirrel stomachs were collected and stored in 80% ethanol for later dietary analysis. Squirrels were collected from the same specific area during each visit and quantitative vegetation sampling was done on the collecting areas.

Quantitative Vegetation Sampling

Vegetation was systematically sampled on each live trapping grid and also on areas where squirrels were collected and where snap trappings of microtines were done. A circular 0.25 m^2 quadrat was placed at regular intervals and all species occurring within the quadrat were assigned a cover class based on percent canopy cover. In 1983, vegetation was sampled at each point of the live trapping grids and these quadrat samples were arranged to refine the broad vegetation community type of the grid area into more narrowly defined microhabitat classes. These microhabitat classes on the grids were compared for indications of differential trapping success which would indicate microhabitat preferences of the microtines species.

On areas where snap trapping or squirrel collection was done, vegetation quadrats were placed at 10 m intervals along a transect and species cover classes were recorded. This information will be used to calculate an index of relative biomass of the plant species and in conjunction with diet analysis of the resident animals may give an indication of the food plant preferences of the different rodent species.

Results and Discussion

Microtine rodents of the north slope have been studied extensively at Barrow (Pitelka 1973, Batzli et al. 1981) and also at Atquasuk (Batzli and Jung 1980)

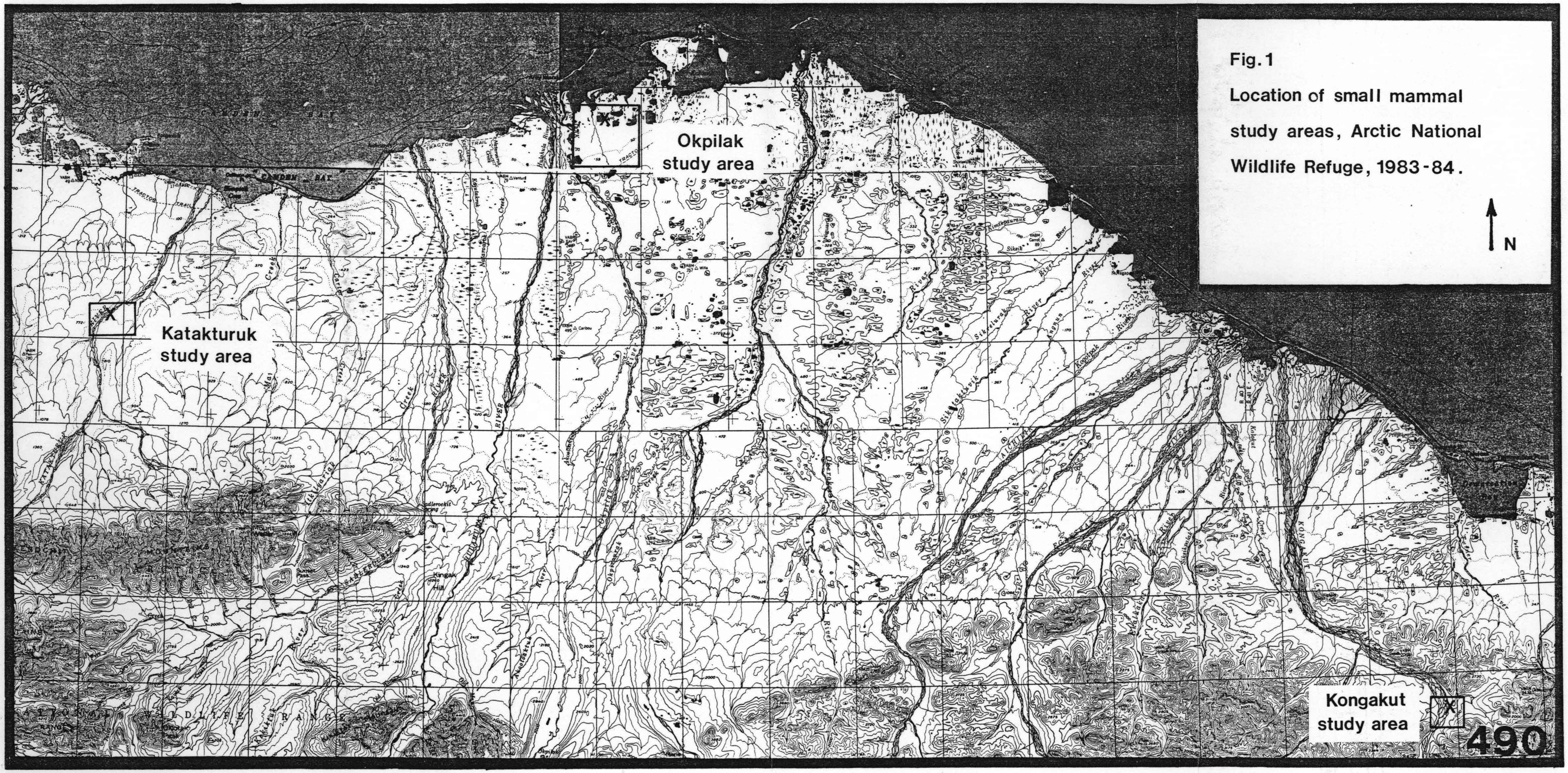

Fig. 1

Location of small mammal study areas, Arctic National Wildlife Refuge, 1983-84.

and Prudhoe Bay (Feist 1975). General distributions and ecological notes on microtines were recorded by Bee and Hall (1956). There are only a few detailed studies in the literature from other locations on the north slope. Some information on microtine species of the coastal plain of ANWR is summarized by Babcock (1984).

Four species of mircotines were captured over the 1984 season and approximate densities and habitat use relationships were calculated. The species differ widely in abundance both geographically and temporally. Captures on the live trap grids of all species of microtines combined were lower in 1984 compared to the capture success of 1983 (Table 1). The largest decrease in microtine density between the seasons was on the Kongakut grid where the 1983 high of about 15 trappable animals per ha declined to 1.5 trappable animals per ha.

Table 1. Number of captures for all microtine species on live trap grids in 1983 and 1984 seasons (Number of individuals in parentheses).

		Trapping Period		
Study Area	Year	1	2	3
Kongakut	1983	28 (19)	43 (20)	54 (31)
	1984	1 (1)	2 (2)	6 (3)
Kaktakturuk	1983	24 (12)	17 (12)	36 (19)
	1984	14 (5)	6 (3)	3 (2)
Okpilak	1983	8 (3)	16 (11)	4 (3)
	1984	3 (2)	6 (3)	6 (5)

On the Katakturuk gird, microtine density appeared to decrease across the 1984 season while at the coastal Okpilak grid densities remained fairly uniform across the season and between years (Table 1). Snap trapping in 1984 accumulated 1043 trap-nights at the Kongakut area, 699 at Katakturuk and 1082 at the Okpilak area yielding captures (for all microtine species combined) of 66, 45, and 114 respectively. For comparison, at Kongakut there were 0.63 captures and at Okpilak 1.11 captures per 10 trap-nights. Microtus oeconomus was the only species captured on the Katakturuk and Kongakut live trap grids in 1984, and this species was the most common both on and off the Okpilak grid. Only 2 Lemmus were captured on the Okpilak grid in 1984.

Microtus miurus (singing vole): This species was captured only at the Kongakut study area. It occurred commonly in restricted habitats and these habitats tended to be scattered throughout the area. M. miurus was found at higher elevations, especially ridge slopes that were moist, vegetated with shrub willows and forbs, and that had other than directly south facing aspects. In snap trapping transects down slope, M. miurus and M. oeconomus were trapped in distribution exclusive of each other, with M. miurus using only the upper slope and M. oeconomus only the more poorly drained, flatter and more sedge dominated end. Murie (1954, pp. 117-118) and others have noted that M. miurus collects vegetation in the fall and uses these food storage piles as a winter food resource. Several fresh storage piles were collected on 25 August from the Kongakut/Caribou Pass area. These piles appeared to be unfinished, and ranged in weight from 8 to 94 gm dry weight. Lupinus arcticus contributed most weight to the piles, followed by Hedysarum spp., and then shrubs (Salix spp.). Storage piles remaining from the previous winter were also noted to contain large proportions of Lupinus and other forbs. At Tulik Lake in the central Brooks range, M. miurus storage piles were seen to consist almost entirely of Equisetum spp. (Heikki Hentonnen, pers comm.). Densities of M. miurus appeared to be reduced from 1983 levels, dropping from 1.17 captures per 10 trap-nights to 0.62 captures per 10 trap-nights. Sex ratios of captured animals were even in 1983, but in 1984 the sex ratio was significantly skewed with 9 females and 2 males captured.

Microtus oeconomus (tundra vole): This species tends to use a broad variety of habitats and can be found in association with Lemmus and Dicrostonyx. Batzli and Jung (1980) have described M. oeconomus as a generalist herbivore where it occurs with these lemming species. Tundra voles do however tend to select forage from both woody dicotyledonous and graminoid plant groups. In 1984 highest densities of M. oeconomus were found in areas dominated by almost pure stands of Eriophorum angustifolium. In one such stand of sedges at a lake outflow area at Okpilak, densities were relatively high (1.65 captures per 10 trap-nights), perhaps due to the high nutritional quality of the vegetation in that specifc location. Abundant waterfowl fecal material collected at the lake outflow and appeared to be fertilizing the vegetation in the vicinity. In feeding trials with captive animals the below ground carbohydrate storing portions of the Eriophorum stems were consumed preferentially over the leaf and upper stem. M. oeconomus was trapped on all live trap girds and was collected in habitats away from the grids at each area. The 24 individuals trapped on all combined grids in 1984 had significantly skewed sex ratio of 20 males: 4 females, (x^2 =10.667, $0.001<P<0.005$). The 1983 sex ratio for 83 live trapped animals did not deviate significantly from even. A major factor probably contributing to this change in density and demography was the low accumulation of snow on the ANWR over the winter of 1983 - 1984. Light and patchy snow cover would tend to reduce the amount of protective and suitably insulated winter habitat, and winter mortality due to exposure and predation was likely to have been high. In 1984 there is evidence that the animals snap-trapped at Kongakut were subject to some nutritional stress compared to the animals from Okpilak. The litter sizes of snap trapped young of the year females were calculated by number of embryos or placental scars. Animals from Kongakut had significantly smaller litter sizes than those from Okpilak (Student t-test, one tailed; t = 5.30, $P<<0.001$). Stearns (1977) suggests that genetic, social and behavioral components, in addition to nutrition, may influence litter size in rodents.

Dicrostonyx torquatus (collared lemming): The collared lemming has been reported to have a dietary specialization for deciduous woody dicotyledons, especially Salix pulchra (Batzli and Jung 1980). Dicrostonyx were captured at all three study areas, but densities were low (probably less than two per ha) and appeared to be less than densities estimated from 1983 trapping.

Lemmus sibericus (brown lemming): The brown lemming has been studied extensively, with emphasis on cyclic changes in its population density. At Barrow, peak densities of up to 225 individuals per ha have been recorded, dropping to lows of 0.02 per ha with 3 to 6 years between peaks (Batzli et al. 1981). Causes for the cycle have been ascribed to climatic, nutritional (Schultz 1964, Pitelka 1973), predation (MacLean et al. 1974) and even endocrine, genetic, and social factors (Chitty 1967, Krebs et al. 1973). Clearly, no one factor is the driving force of this phenomenon, but all may contribute in varying degrees.

Relatively few _Lemmus_ were captured or collected at Okpilak in 1983, but in 1984, 20 individuals were snap-trapped from the same _Eriophorum_ stand at a lake outflow where highest _M. oeconomus_ desities occurred. Only 5 individuals were captured at Katakturuk in both seasons combined and none were seen or captured at Kongakut.

Microhabitat Selection by Microtines

Vegetation sampling was done on all three live trapping grids and sample quadrats corresponded to each grid point/trap location. This quantitative assessment of plant species presences and their cover class values was analyzed using a dichotomously branching sorting computer program (Cornell Ecology Program Series 1979). This program arranged the total set of samples for each grid into classes based on similarity of vegetation. This method provides a more objective classification of samples into microhabitat classes than could be done by inspection. On each grid, samples tended to be arranged across a moisture gradient, with more xerophyllic species groupings on one end and hydrophyllic species groupings on the other. The total set of samples from each grid was divisible into three or four microhabitats. These microhabitats exist as mosaics with xeric and hydric types often occurring in close proximity due to the poygonization of the tundra landscape. Since permafrost lies close to the soil surface, small changes in microtopography can strongly influence the amount of ground water available to plants. It should be realized that the microhabitat classes are based on continuum of samples, and the cut-off points between them are not totally distinct.

Microhabitats of the three live trap grids are characterized by the following plant species and conditions:

Kongakut

- hydric: _Eriophorum angustifolium_, _Salix glauca_, _Carex aquatilis_.
- mesic: _Salix arctica_, _Arctostaphylos rubra_, _Cassiope tetragona_.
- xeric: _Dryas integrifolia_, _Tofieldia coccinea_, _Carex nardina_, _Lichen_ spp.

Katakturuk

- hydric: _Eriophorum angustifolium_, _Carex aquatilis_, _Pedicularis verticillata_, _Carex saxatilis_.
- mesic: _Carex bigelowii_, _Salix reticulata_.
- xeric: _Saussurea angustifolia_, _Astragalus umbellatus_, _Hedysarum hedysaroides_.

Okpilak

- hydric: Large sized _Carex aquatilis_ and _Eriophorum angustifolium_, _Eriophorum russeolum_, _Juncus biglumis_; Polygon troughs.
- subhydric: _Salix reticulata_, _Carex bigelowii_, _Carex misandra_; polygon low centers and shallow troughs.
- subxeric: _Salix pulchra_, _Polygonum viviparum_, _Carex bigelowii_; rims of polygons.
- xeric: _Cassiope tetragona_, _Saussarea angustifolia_, _Luzula_ spp., _Lichen_ spp.; high polygon rims and mounds.

Using this assignment of each trap location into a microhabitat class it was possible to test for differential capture frequency between vegetation classes. There was significant selection of certain microhabitat classes over others on all grids though not in both seasons. On the Kongakut grid, where only M. oeconomus was captured, there was strong selection ($P<0.001$) for the hydric microhabitat in 1983, but no significant selection in 1984 (Table 2). The combined years showed strong selection as in 1983, and it may be that 1984 results are confounded by low sample size. At the Katakturuk grid, considering only M. oeconomus, there was no significant differential selection in 1983, but selection for wet (hydric) microhabitat was significant (0.010 P 0.025) in the 1984 season (Table 3). On the Okpilak grid in 1983, considering the combination of all microtine species, there was significant selection (0.001 P 0.005) for the dry microhabitats (xeric and subxeric; Table 4). In 1984, captures for all species showed no significant selection, although the combined years did ($0.025<P<0.05$). At Okpilak, when both years are combined and captures are broken down by species, there is significant selection of the dry mircrohabitats by Dicrostonyx ($0.005<P<0.0001$) and significant selection of the wetter microhabitats by M. oeconomus ($0.010<P<0.025$; Table 5). Captures of Lemmus were too few to calculate significance. Batzli and Jung (1980) suggest that the food habits of M. oeconomus may overlap with Dicrostonyx, but it appears that at Okpilak, with the densities seen in 1983 and 1984, this overlap may be insignificant and strong interspecific competition is probably avoided.

Table 2. Kongakut live trap grid, X^2 test of capture frequency in 3 microhabitat classes.

		Microhabitat Class (percent of grid area)			
		Wetter ⟵	⟶	Drier	
	Year	Hydric (31.1%)	Mesic (37.3%)	Xeric (31.6%)	Totals
Observed	1983	58	34	33	125
number of	1984	3	2	4	9
captures	combined	61	36	37	134
Expected	1983	38.91	46.55	39.54	125
number of	1984	2.80	3.35	2.85	9
captures	combined	41.70	49.90	42.63	134
X^2 test	1983	13.831 ($P<0.001$)			
Statistic*	1984	1.022 (not significant)			
(Significance)	combined	13.548 ($0.001<P<0.005$)			

*Critical level ($\alpha = 0.05$) = 5.991 with 2 degrees of freedom.

Table 3. Katakturuk live trap grid, X^2 test of capture frequency (M. oeconomus only) in 3 microhabitat classes.

	Year	Microhabitat Class (percent of grid area) Wetter ⟷ Drier: Hydric (12.8%)	Mesic (52.0%)	Xeric (35.2%)	Totals
Observed number of captures	1983	12	37	25	74
	1984	8	10	6	24
	combined	20	47	31	98
Expected number of captures	1983	9.44	38.51	26.05	74
	1984	3.06	12.49	8.45	24
	combined	12.50	51.00	34.50	98
X^2 test Statistic* (Significance)	1983	0.794 (not significant)			
	1984	9.182 ($0.010<P<0.025$)			
	combined	5.169 (not significant))			

*Critical level ($\hat{\alpha}$ = 0.05) = 5.991 with 2 degrees of freedom.

Table 4. Okpilak live trap grid, X^2 test of capture frequency (for all species combined) in 4 microhabitat classes.

	Year	Microhabitat Class (percent of grid area) Wetter ⟷ Drier: Hydric (24.0%)	Subhydric (25.5%)	Subxeric (34.2%)	Xeric (16.3%)	Totals
Observed number of captures	1983	5	5	6	12	28
	1984	7	2	4	1	14
	combined	12	7	10	13	42
Expected number of captures	1983	6.71	7.14	9.57	4.57	28
	1984	3.36	3.57	4.79	2.29	14
	combined	10.07	10.71	14.36	6.86	42
X^2 test statistic* (significance)	1983	14.480 ($0.001<P<0.005$)				
	1984	5.491 (not significant)				
	combined	8.474 ($0.025<P<0.05$)				

*Critical level ($\hat{\alpha}$ = 0.05) = 7.815 with 3 degrees of freedom.

Table 5. Okpilak live trap grid, X^2 test of capture frequency by species (both seasons combined) in 4 microhabitat classes.

	Species	Hydric (24.0%)	Subhydric (25.5%)	Subxeric (34.2%)	Xeric (16.3%)	Totals
		Microhabitat Class (percent of grid area) Wetter ⟵⟶ Drier				
Observed number of captures	Dicrostonyx	2	4	3	8	17
	M. oeconomus	10	1	5	5	21
	Lemmus	0	2	2	0	4
	All species	12	7	10	13	42
Expected number of captures	Dicrostonyx	4.08	4.34	5.81	2.78	17
	M. oeconumus	5.04	5.36	7.18	3.43	21
	Lemmus	not enough captures to perform valid test				4
	All species	10.07	10.71	14.36	16.86	42
X^2 test statistic* (significance)	Dicrostonyx	12.248 (0.005<P<0.001)				
	M. oeconomus	9.808 (0.010<P<0.025)				
	All species	8.474 (0.025<P<0.050)				

*Critical level (α=0.05) = 7.815 with 3 degrees of freedom.

Predator Use of Microtines

Microtines are prey for all mammalian predators of ANWR and they are primary prey of short-tailed weasels (*Mustela erminea*) and least weasels (*Mustela nivalis*). Weasel predation may contribute to the cyclic densities fluctuations of lemmings by accelerating mortality in the crash phase of the cycle (MacLean et al. 1974). Most of this predation appears to occur in winter. One short tailed weasel was captured on the Okpilak grid in 1983 and two least weasels were captured in the Kongakut area in 1984. At each study area recent winter nests were examined for evidence of predation. Depredated nests contain fur, bones and often stomachs of animals that were preyed upon within the nest, and usually the nest has been lined with microtine fur as additional insulation by the weasel. The Okpilak area had the highest incidence of nest predation, followed by Kongakut and Katakturuk (Table 6). The actual incidence of predation is probably somewhat higher, since microtines build new nests through the winter as old ones are fouled.

Table 6. Microtine winter nest predation at 3 study areas in 1984.

Study Area	Total Nests Examined	Nests Disrupted by Predation Number	%
Kongakut	37	5	13.5
Katakturuk	29	2	6.9
Okpilak	74	18	24.3
All combined	140	25	17.9

Microtines are also of considerable importance to avian predators in the ANWR, most notably snowy owls (Nyctea scandica) and jaegers (Stercorarius spp.). At Barrow and other northern Alaskan locations breeding densities and fledging success of snowy owls and jaegers have been reported to increase with increases in microtine densities (Maher 1970, Maher 1974, Pitelka 1974). Clutch size of rough legged hawks also appears to be related to availability of microtines (Harrison 1978, p. 91). Only one snowy owl was seen in each season at the Okpilak area, although they were a common visitant and were seen hunting there in 1982 (Spindler and Miller 1983). A pair of rough legged hawks nested on the Katakturuk bluff in 1983, laying three eggs (two chicks were surviving on 10 August) and in 1984 one chick was in the nest on 12 July but was not seen on 11 August. Jaegers nested at both Okpilak and Katakturuk in both seasons. Raptor and jaeger pellets were collected from the Okpilak and Katakturuk areas in 1983 and 1984. Proportions of Lemmus and Dicrostonyx skulls in pellets from the two areas were not significantly different, but the proportion of M. oeconomus skulls was significantly higher ($P<0.001$) at Katakturuk (Table 7). M. oeconomus comprised only 2% of skulls from Okpilak, but 18% from Katakturk, although the impression from two seasons of trapping was that lemmings were outnumbered by M. oeconomus at both sites. The inference that can be drawn from these data is that most avian predation occurs when populations of lemmings are high relative to M. oeconomus and that the lemming populations at Okpilak and Katakturuk are cyclic or at least fluctuate widely in density.

Table 7. Chi square contingency table comparing proportions of Lemmus, Dicrostonyx, and M. oeconomus skulls in raptor and jaeger pellets from the Okpilak and Katakturuk study areas.

Study area	Lemmus	Dicrostonyx	M. oeconumus	Totals
Okpilak 1983				
Observed	51	100	3	154
Expected	48.95	89.75	15.30	
X^2 value	0.086	1.171	9.888	
Katakturuk 1983 & 1984				
Observed	45	76	27	148
Expected	47.05	86.25	14.70	
X^2 value	0.890	1.218	10.292	
Totals	96	176	30	302
Totals X^2	0.175	2.389	20.180	22.744
(Significance)	(n.s.)	(n.s.)	(P 0.001)	(P 0.001)

X^2 test statistic critical value = 5.991 with 2 degrees of freedom, ($P<0.001$).

Ground Squirrels

Spermophilus parryii (arctic ground squirrel) were collected in 1984 from all three study areas. Stomachs were preserved for analysis of diet and comparison of diets with estimates of plant species biomasses from the collection areas. At the Kongakut area squirrels lived in extensive colonies on the river bluffs and in rock outcrops at higher elevations. The Katakturuk and Okpilak colonies were limited to river bluffs and dunes. The sex ratios of collected animals were not significantly different from even at all areas. The mean weight of squirrels from Kongakut was 725g, Katakturuk 500g, and Okpkilak 667g. Although these weights are statistically different, the difference is probably not valid because of sampling bias towards smaller (young of the year) individuals later in the season. Young of the year began to disperse from their natal colonies (Carl 1971) about 1 July at Kongakut, and on 11 August the first animals were seen across the river from the Katakturuk bluff colonies. At Okpilak on 17 August and subsequent days a squirrel was seen on the VABM Mars pingo, at least 4 km from the nearest perennial colony. A few observations of feeding squirrels were made at each area, and in all cases the chosen forage was forbs and other herbaceous plants or plant parts.

Grizzly bears (Ursus arctos) were seen digging in squirrel colonies at Kongakut and Okpilak in 1984, and in both cases bears appeared to have achieved success in catching squirrels. Evidence of grizzly predation on the Katakturuk colonies was also common in August. All large raptors are known to take ground squirrels and golden eagle (at Kongakut) and rough legged hawks (at Katakturuk and Kongakut) were seen hunting over colonies throughout the season.

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