

BREEDING BIOLOGY AND PRODUCTIVITY
OF GEESE ON THE
YUKON-KUSKOKWIM DELTA, ALASKA*

Cooperative Study Agreement between
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Prepared by: Dennis G. Raveling, Associate
Prof. Wildlife Biology
Craig R. Ely, Graduate Assistant
James S. Sedinger, Graduate
Assistant
Div. of Wildl. & Fish. Biol.
Univ. of Calif., Davis 95616

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FOREWORD

The breeding biology of most goose species has been described. Investigations on the Yukon Delta by Mickelson (1975) and Eisenhauer and Kirkpatrick (1977) provide the baseline from which future studies can expand in this area. Three areas of investigation stood out as needs for more intensive research to provide a more thorough understanding of adaptations of geese to the short arctic summer and factors controlling their productivity.

1. Physiology and Nutrition - Geese arrive on the breeding grounds at the peak of their annual weight and fat cycle. These reserves are critical in terms of egg laying potential. More detailed study of the energetics of lipid and protein deposition and utilization were needed to quantify these factors which are related to the timing of nesting, and to both the evolutionary and proximate control of clutch size. Raveling studied these factors in Cackling Geese (Branta canadensis minima) at Old Chevak in 1974. Laboratory analyses have been completed and one manuscript has been accepted for publication (Raveling 1978 - appended). Two other manuscripts on these subjects are in rough draft form. In summary, these data provide quantitative estimates of the relative importance of stored reserves versus food required from the environment to support the activities of adults through the pre-laying, laying, incubation, and molting periods.

Reproduction is a stressful event. Female Cackling Geese weigh 1095 g at the time their eggs are hatching as compared to 1890 g when they arrive on the Delta and 1387 g when they initiate incubation. Fat deposits have declined from 28% to 3% and protein losses are also evident by the time of hatching.

Growth of goslings is rapid and must be accomplished before food supplies diminish in quantity or quality as autumn freezing begins. In addition to declines in clutch sizes in late springs, there is evidence that gosling survival is poorer in late than in early breeding seasons (Raveling and Lumsden 1978).

Needed are quantitative studies on the foraging behavior of geese in relation to availability and quality of food supplies which provide for gosling growth and restoration of body condition and the requirements of the stressful molt (Hanson 1962) in adults. The synchrony of new growth sedges and grasses with these energetically demanding activities needs to be documented in relation to annual variation and reproductive success.

2. Predation and Habitat Use - The four species of geese which occupy the Delta share the habitat by nesting in different niches. Related to these differences are variations in body size, density, and probably incubation behavior and responses to predators. Whitefronts (Anser albifrons) and Emporors (Anser canagicus) commonly nest on the mainland and presumably can defend their nests against foxes (Alopex lagopus and Vulpes fulva). Cacklers and Brant (Branta bernicla) are much smaller and are more dependent on island nesting situations. Brant and Cacklers, however, are more agile flyers and presumably better able to defend their nests against jaegers (Stercorarius parasiticus and S. longicaudus) and Glaucous Gulls (Larus hyperboreus). Correlated with these features are the more solitary nature of Whitefronts and Emporors contrasted to the high density, semi-colonial Cacklers and the colonial Brant.

While the above interrelationships seem intuitively obvious, we believe that more intensive study of the nesting success of these geese in relation to habitat type, nest site, and the density and behavior of predators is needed in order to properly understand the evolution of these behaviors. Data on the abundance of prey used by the predators are also needed as there is evi-

dence that the impact of predators on goose nests may be related to fluctuations in other prey. Understanding these interrelationships is necessary to understanding annual variations in density and nesting success of geese in different habitats. Predation may play an important role in limiting ranges and densities of geese.

3. White-fronted Goose Breeding Biology - We have the least amount of information about the breeding biology of Whitefronts of any of the geese in North America. Barry (1967) and Mickelson (1975) have provided descriptions. The secretive and dispersed nesting behavior of Whitefronts, along with their choice of a variety of upland nest sites difficult to find, have resulted in this relatively poor understanding. Attention must be devoted to Whitefronts to provide a comparative understanding of adaptations as well as providing the baseline for predicting variations in breeding success needed for understanding their population dynamics.

Approach

The summer of 1977 was the initiation of our study of the above problems. Rather than disperse to different areas or to enlarge study areas, we concentrated for the most part in the study area used by Raveling in 1974 where background information was available. A team approach was used to study the area more intensively to enable more studies to be undertaken simultaneously on the same area. The following reports describe our initial progress in this 5-year cooperative study.

BREEDING BIOLOGY OF GEESE

The tundra of the Yukon-Kuskokwim Delta supports nearly the entire breeding population of Cackling Geese and most of the Emperor Geese and the Pacific Flyway White-fronted Geese. We have initiated a study to further define their reproductive strategies to correlate their reproductive success with weather, habitat, and predation. Data on reproductive potential and anticipation of nesting success are needed for understanding and managing population levels of these species.

METHODS

We arrived at Old Chevak on 5 May 1977. Arrival and relative abundance of birds were noted daily as were observations of weather conditions and the progress of the spring thaw (habitat availability). We moved to our tent camp on 20 and 22 May. The location of the study areas which were searched for nests are indicated in Fig. 1.

Nest Searching

Initial searches were conducted during the egg laying period by examining favorable sites in order to obtain a sample for which precise dates of nest initiation were known and to assess the impact of early predation before down was added to nests (in area A-Fig. 1). When all nests found contained complete clutches, the entire study area (A, B, C) was systematically searched by walking around the edge of each pond and to every island in each pond. The edges of all sloughs and marsh-pingo rims were searched for White-front nests. Selected nests were revisited to determine hatching dates to allow for back-dating of nest initiation by allowing for incubation time and egg laying rate based on data from Mickelson (1975). All nests were revisited to determine hatching success. Area D served as a control and was searched only once late in the incubation period (28 June) and again after hatching had occurred. Searches in area D were restricted to shorelines and islands.

Nesting Data

Data collected on each nest included: habitat (upland pond, lowland meadow pond, marsh, slough bank); site (island, shore, peninsula); distance to water and approximate size of island; number of islands in pond; clutch size; relative amount of down; presence of adults. When the order of laying could be determined from differential staining on the eggs, the eggs were numbered. Some eggs were weighed to the nearest gram on a Pesola spring scale and lengths and widths were measured with a vernier caliper.

Evidence of predation was noted and attributed to foxes if tracks were visible or no trace of egg shells could be found. If egg shells remained at or near the nest, they could usually be attributed to predation by jaegers based on their appearance. Destroyed nests on islands surrounded by water were attributed to avian predators even if no shells remained.

Location of each nest was marked on an aerial photograph (2.5 inches = 1 mile).

Behavior

The behavior of some incubating geese and activity of predators was observed from observation towers (see Fig. 1 for locations).

Predators

Foxes seen and den sites located were marked on aerial photos. Numbers

Figure 1. Location of study areas. OCH = Old Chevak. A, B, C = primary search areas. D = control area. E = brood observation area.

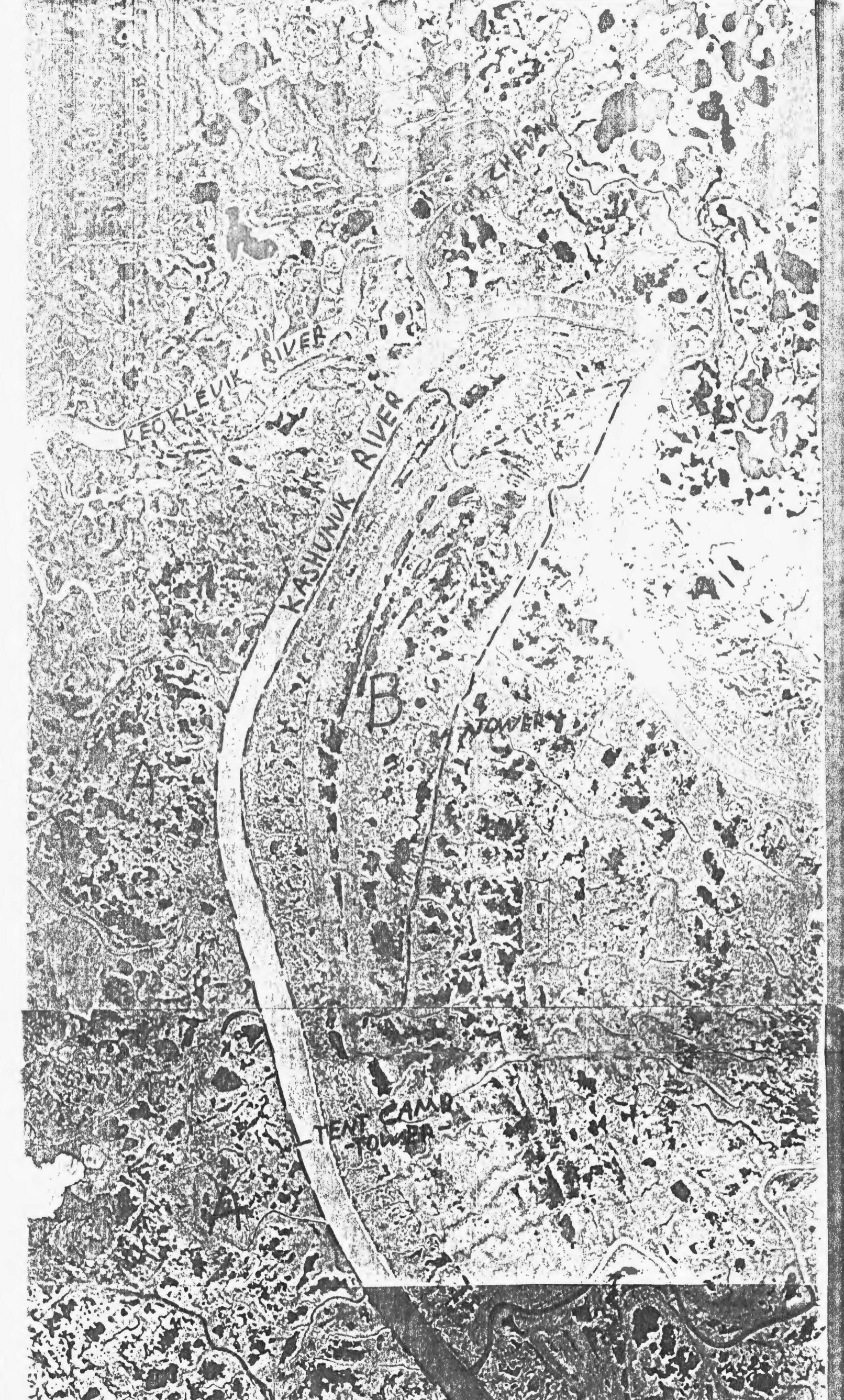
KEOKLEVIK RIVER

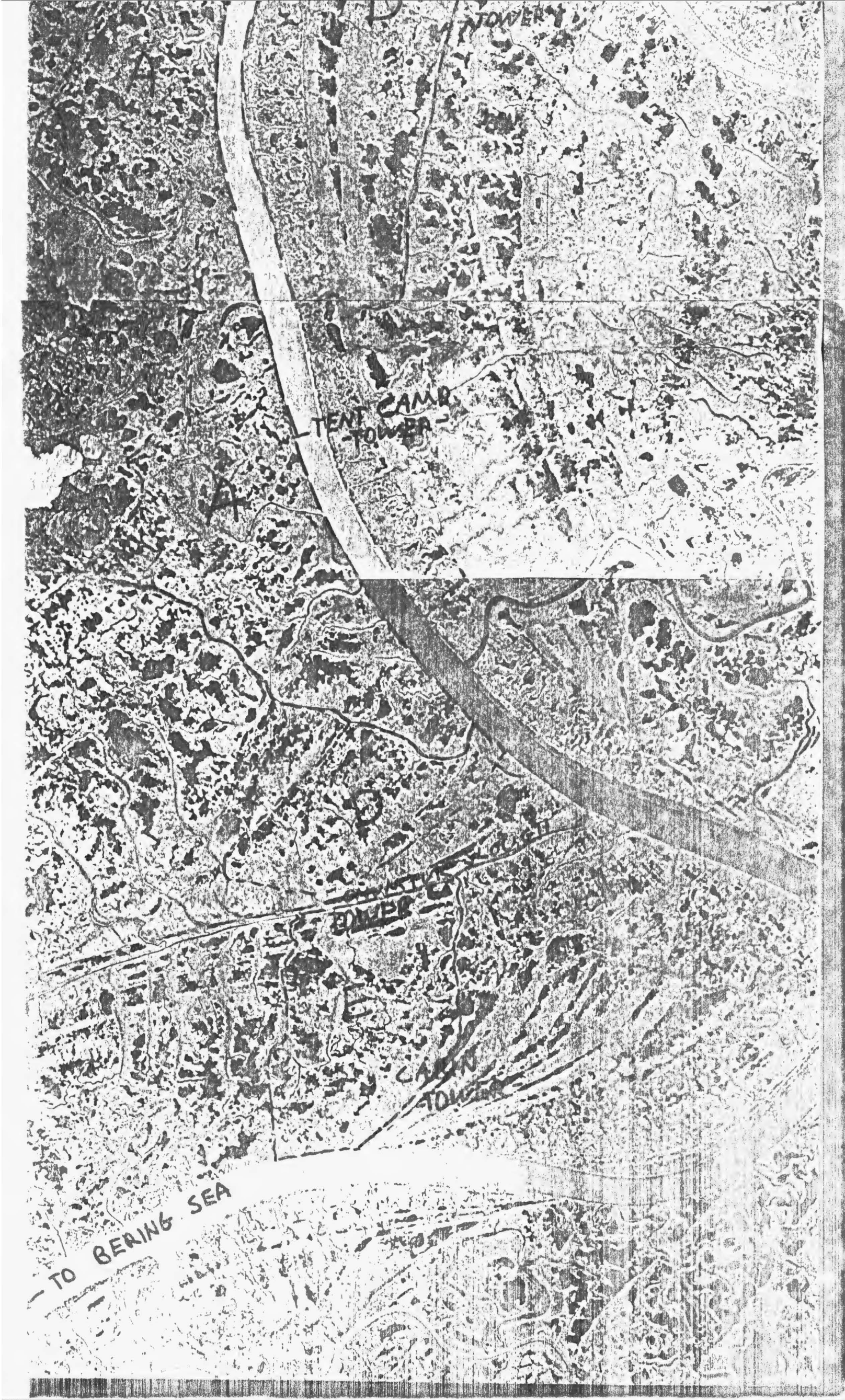
KASHUNUK RIVER

B

TOWER

TENT CAMP
TOWER





TOWER

TENT CAMP
TOWER

DIVER
CAMP TOWER

TO BERING SEA

and locations of jaegers, Short-eared Owls (Asio flammeus), and Snowy Owls (Nyctea scandiaca) seen while nest searching were recorded. Time spent afield, and approximate number of miles walked when not nest searching, were recorded to relate to number of predators (and prey) seen.

Ptarmigan Abundance

The numbers of Willow Ptarmigan (Lagopus lagopus) seen per mile walked and their status (flock, pair, single) were recorded between 10-13 May. These counts occurred when flocks were just breaking up and pairs were obvious. By 22 May, territorial male Ptarmigan, which were still mostly white, were obvious against the dark pingos. Females had become secretive. At this time, the number of territorial males was plotted on an aerial photograph in area A (22-29 May).

Microtine Trapping

One hundred, unbaited snap traps were set in Microtus oeconomus runways and examined once per day between 23 May and 3 June and 1-24 July. Traps were in different habitats within 100 yards of the Kashunuk River near our tent camp (Fig. 1). Traps were moved when captures declined to none or one.

Fake Nests

At the time of goose hatching, 36 artificial nests were created by using 2 chicken eggs per nest in Area B on 3 July. Eighteen sites were at actual (9) or simulated (11) White-front nests along slough banks and 18 were at actual (8) or simulated (10) Cackling Goose nests along pond edges, especially at sites which had been islands but were then connected to the mainland by receding water levels (N = 12). Brant down was added to constructed "Cackler" nests and White-front or Emperor Goose down was added to constructed "White-front" nests to simulate their normal appearance. Eggs in all nests were covered with nest material and down as normally accomplished by geese when they leave their nests when undisturbed. The presence of possible predators was noted at the time the nests were constructed and checked 6 days later.

RESULTS AND DISCUSSION

Weather and Spring Thaw

Snow and ice cover was 90-95% complete upon our arrival on 5 May. The snow melt was affected by two major factors (predominate overcast and precipitation followed by a freeze) in 1977. Overcast conditions (mostly or complete) prevailed on 22 of the 27 days we were present in May and all of the first 10 days of June. These conditions prevented high temperatures, but also buffered cold spells. Snow fell on 14 days and rain on 7 days between 5 and 31 May. Snow occurred on one day and rain on 6 days of the first 10 days of June. The water content of the snow was high, but the progress of the melt was slow.

Winds blew most of the snow off the upland on 9-10 May and 11-13 May, surface melt water was common on sloughs and ponds, but snow over winter ice was still 3 feet deep. Extensive rotting winter ice on ponds was noted on 18 May and by 21 May, riverside marshes were contributing copious amounts of runoff onto river ice.

Flooding of lowland meadows was extensive between 22-24 May. A hard freeze stopped the runoff between 25-27 May. Thereafter, melt and runoff

was slow, but steady through 1-2 June. On 2 June, we estimated that 60% of lowland ponds were still unavailable for nesting because of high water. Ice and high water still covered upland ponds. Most lowland ponds and island nest sites became available on 2-4 June and islands on upland ponds became available for nesting from 7-10 June. By 12 June, all ponds were judged to be suitable for nesting. Ice cleared from the Kashunuk River on 14-15 June.

Arrival of Geese

The first Cackling Geese were seen on 7 May and a minor influx was noted on 12-13 May. A major arrival at Old Chevak occurred on 18-19 May. The first Emperor Geese were seen on 6 May, but no minor arrival was noted. They became common on 16-20 May. White-fronted Geese were scattered and evident upon our arrival and considered common after 8 May. No migration peak was discerned.

Nest Initiation

The first nests of Cackling Geese were on ponds connected to river-side drainages that cleared of ice and meltwater the earliest. The peak of laying was 3-4 June (Table 1), which coincided exactly with the first major availability of islands in lowland meadow ponds. About 82% of Cackler nests were initiated within 8 days (1-8 June). Analysis of nest initiation by habitat type remains to be accomplished, but it was obvious that nests in upland tundra ponds were initiated later than those in lowlands (which predominated in the sample in Table 1). Thus, the peak of nest initiation in 1977 was 16-17 days after the major arrival of Cackling Geese.

The first White-fronted Goose nests (Table 1) were begun at the time of the first major melt and runoff before ponds were available. They apparently were prevented from nesting during the freeze on 25-28 May, but began again as the runoff proceeded again. Peak of nest initiation occurred between 30 May and 4 June with 81% of nests initiated within 9 days (28 May - 6 June).

Approximately 92% of Emperor Goose nests were begun in 10 days (1-10 June), but a pronounced peak was lacking (Table 1). Although more Emperor Geese initiated nesting on 1-2 June than Cackling Geese, the majority were from 1 to 6 days after the peak of Cackler nest initiation.

Data on nest initiation by habitat type have yet to be analyzed, but these should be revealing as to the variation observed within and between species.

Nest Sites (Table 2)

Islands were the site of 91% of Cackling Goose nests, but, because much of our study area was in a low-lying flood plain (area B - Fig. 1), a large number (27%) of these sites became connected to shore soon after egg laying as meltwater receded. Emperor Geese nested in relatively equal proportions on islands, on shore sites near ponds, and along slough banks. White-fronts most commonly selected shore and slough bank sites.

The nature of shore nests varied between Emperor Geese and White-fronts. Emperors selected peninsulas and their nests were close to pond edges. Many White-front shore nests were next to tiny, temporary melt pools which dried, or nearly dried, before hatching and were not used by other geese. The location of slough edge nests also varied between species. Emperor Geese most commonly nested near the heads of the sloughs where they were narrow and shallow and near ponds. White-fronts more commonly selected sites away from ponds where the sloughs were wider, deeper and more heavily vegetated with Elymus and were closer to where they drained into the Kashunuk River.

Table 1. Dates of initiation of nests (first egg) of geese.

Species	N	Percent of nests initiated on:										
		May				June						
		24-25	26-27	28-29	30-31	1-2	3-4	5-6	7-8	9-10	11-12	13+
Cackling												
Goose	61				4.9	11.5	36.1	16.4	18.0	3.3	4.9	4.9
Whitefronted												
Goose	26	7.7	0	11.5	15.4	23.1	19.2	11.5	11.5			
Emporor												
Goose	24					20.8	12.5	29.2	16.7	12.5	4.2	4.2

Table 2. Nest sites of geese at Old Chevak, Alaska in 1977.

Site	Species		
	Cackling	Emporor	White-fronted
	Goose	Goose	Goose
	N=143	N=36	N=29
Island	66.4%	16.7%	
Dried Island	24.5%	16.7%	
Island Subtotal	90.9%	33.4%	
Peninsula	7.7%	30.6%	6.9%
Shore	1.4%	5.6%	31.0%
Marsh-Pingo Edge			6.9%
Shore Subtotal	9.1%	36.2%	44.8%
Slough Bank		8.3%	51.7%
Head of Slough			
Near Pond		22.2%	3.4%
Slough Subtotal		30.5%	55.1%

Habitat, Density and Spacing of Nests

These subjects are yet to be analyzed. There were some obvious clumps and some features of uniform spacing in different areas which should be revealing in relation to habitat and nest site selection behavior and predation.

Clutch Size

The average clutch size and frequency of different clutches are presented in Table 3. These data represent clutch sizes of all nests found or re-examined after they were complete. Thus, they include nests found throughout the nesting season and the values are probably most comparable to others reported in the literature. Comparison to other data will be accomplished in the future. The value for Cackling Geese is about average and below that found in the early springs, as would be expected by the delay to nesting of 4-5 days beyond when the bulk were probably capable of laying (12 days after arrival, see Raveling 1978). The Emperor clutches were large and this suggests that they could compensate for the delay with food intake after arrival or nesting birds arrived later. The clutch size for White-fronts equals the smallest of which we are aware. As they arrived first, White-fronts experienced the longest delay to nesting and depressed clutch sizes would be expected. It is likely that one and two egg clutches represent continuation nests or clutches that had suffered partial predation.

Clutch size data are difficult to compare between years and studies because of different methods of nest searching and recording data. We were able to analyze these effects in 1977 because we intentionally searched a large portion of area A (Fig. 1) during and just after egg laying to document nest initiation and maximum clutch sizes before they were affected by partial predation. We revisited these nests late in the incubation period to provide data on predation and to provide a sample taken in the manner of many investigators who search for nests only after all nests are complete. We also searched the control area (D - Fig. 1) late in the incubation period on only one day and there had been no human activity in this area prior to our search. Results are presented in Table 4. The frequency of small clutches was higher for nests visited late in incubation and there was no essential difference between our original search sample revisited late in incubation and the control area. This suggests that our activity did not materially affect partial predation (but, it did affect total predation - see below) and that the sample taken early most closely estimates clutches actually laid by the geese.

Statistical analyses and more full discussion of these data will be presented in final reports. Here, we stress the importance of investigators describing their methods in detail and the use of caution in making clutch size comparisons. We suspect that the effects of partial predation are more pronounced in Cackling Geese than in Emperor Geese and White-fronts.

Clutch Size and Season Phenology

Within the peak period of nest initiation of 8 to 10 days, the average clutch size of all species declined, as expected (Fig. 2). Interestingly, the latest clutches initiated, while usually smaller than average, did not show further decline. Either these birds were able to replenish stored reserves that were depleted earlier in the season or they represent a segment of the population that migrated in late (possibly 2 year olds). This phenomenon deserves further investigation.

Table 3. Frequency of clutch sizes of goose nests in 1977.

Species	N	Ave. Clutch Size	Frequency (%) of clutches of:									
			1	2	3	4	5	6	7	8	9	
Cackling												
Goose	81	4.2	4.9	11.1	17.3	18.5	25.9	16.0	6.2			
Emporor												
Goose	27	5.3	3.7	0	11.1	14.8	25.9	22.2	14.8	3.7	3.7	
White-fronted												
Goose	26	3.7	3.8	11.5	30.8	26.9	23.1	3.8				

Table 4. Clutch sizes of Cackling Goose nests found at different times.

Type of Search & Nests	N	Ave. Clutch Size	Frequency (%) of clutches of:						
			1	2	3	4	5	6	7
Early - before predation	51	4.5	2.0	3.9	19.6	21.6	29.4	17.6	5.9
Same nests - late in incubation	33	3.9	3.0	18.2	18.2	24.2	21.2	15.2	
Control area - late in incubation	30	3.8	10.0	23.3	13.3	13.3	20.0	13.2	6.7

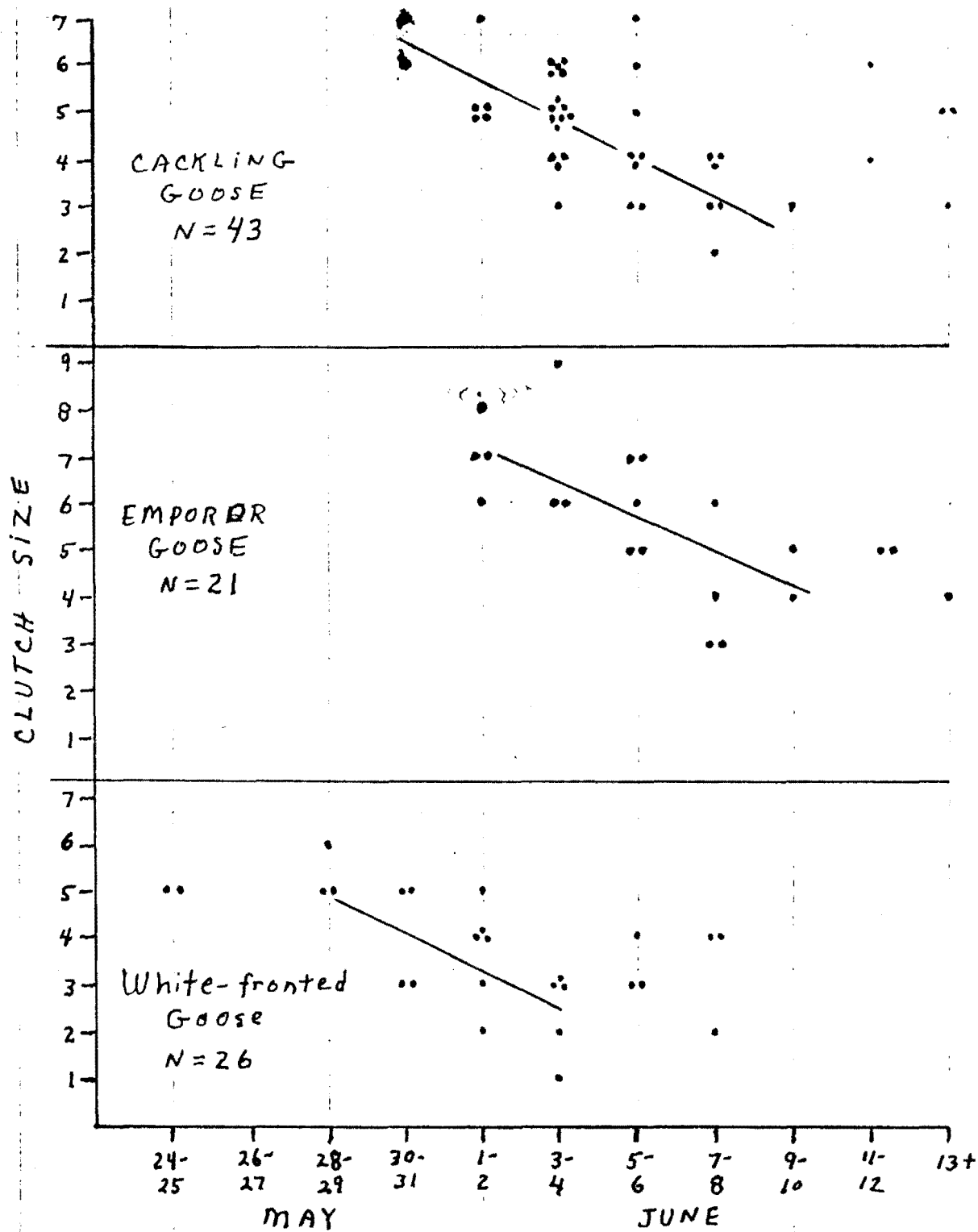


Figure 2. Clutch size in relation to date of nest initiation.

Clutch Size, Habitat, and Nest Site

These subjects have yet to be analyzed. In some cases, such analyses indicate optimum and marginal habitat as birds which lay smaller clutches are either younger or delayed in nesting until after the bulk of the population has established their territories.

Egg Sizes

These data have yet to be analyzed. In some instances, the last egg laid is the smallest and this may be related to energetics and clutch size. We also wish to analyze for possible differences between years.

Nesting Success

A successful nest is defined as one in which at least one egg hatched. Details on partial predation and hatchability await future analysis.

About 60% of Cackling goose nests were destroyed compared to 31% and 14% for Emperor and White-fronted Geese, respectively (Table 5). This high rate of loss of Cackler nests should not be compared directly to other studies because large portions of our search area (especially area B - Fig. 1) contained shallow ponds which dried up rapidly. Islands in these ponds became connected to shore. Regardless of habitat, Cackling Geese that had nests on the mainland lost them to predators (96%). In contrast, Emperor and White-fronted Geese were highly successful in nesting on the mainland.

Our search activities had some, but minor effect, on predation on Emperor nests. Five of the 11 predated nests had been destroyed before we found them for the first time and one was probably predated after it had been deserted after the nest flooded. Two others were destroyed late in the incubation period. We may have contributed to the loss of three nests. Seven of the 11 destroyed nests were apparently predated during the egg laying period. Once incubation began, nests of Emperors were highly successful.

Human activity may have contributed to the loss of two of the four destroyed White-front nests. The other two were destroyed before we found them. The high nesting success of the White-front may be an inflated value because it is difficult to find nests that have already been destroyed. Because of their choice of islands or peninsulas, nests of Cackling Geese and Emperor Geese that have already been destroyed are easy to locate if destruction occurred after down had been deposited in the nest.

Human activity affects predation rates on Cackling Geese because: they leave their nests at much greater distances from a human than do Emperor Geese or White-fronts; their island nests are readily visible and easily located by jaegers and gulls which have a tendency to follow humans; they nest in high density and a disturbed pair may in turn disturb other geese when their territories are intruded upon. We had an opportunity to measure the magnitude of this disturbance in 1977. The control area (D - Fig. 1) was visited on only one day late in the incubation period and there had been no human activity in this area prior to our search. As in our intensive search area, all or nearly all shore nests had been destroyed (Table 6), so human activity had little or no effect in leading foxes to nests. They find them anyway. However, only about one-half as many island nests were destroyed in the control area as in our other study plots. The effect is undoubtedly not that great, however, as one cannot identify nests which were destroyed early in the egg laying period (first one or two eggs) unless they are located at that time because there are no down or contour feathers in the nest bowl.

Table 5. Predation on nests of geese in 1977.

Nest Site	% Nests Destroyed		
	Cackling Goose	Emporor Goose	White-fronted Goose
Island	42.1 (N=95)	50 (N=6)	
Dried Island	97.1 (N=35)	50 (N=6)	
Peninsula	100 (N=11)	27.3 (N=11)	50 (N=2)
Shore	50 (N=2)	0 (N=2)	11.1 (N=9)
Marsh-Pingo Edge			50 (N=2)
Slough Bank		67 (N=3)	6.7 (N=15)
Head of Slough			
Near Pond		0 (N=8)	0 (N=1)
Mainland Subtotal			
(including dried island)	95.8 (N=48)	26.7 (N=30)	13.8 (N=29)
TOTALS	60.1 (N=143)	30.6 (N=36)	13.8 (N=29)

Table 6. Predation on Cackling Goose nests in different search areas.

Nest Site	% Nests destroyed in:	
	Control Area	Intensive Search Area
Island	26.5 (N=34)	50.8 (N=61)
Dried Island	100 (N=12)	95.7 (N=23)
Peninsula	100 (N=3)	100 (N=8)
Shore		50 (N=2)
Mainland Subtotal (including dried island)	100 (N=15)	93.9 (N=33)

As geese may prepare or investigate several old nest bowls, which are in great quantity on the study area, one depends on finding feathers in the nest before identifying it as having been active.

The problem represents a dilemma to field investigators. Finding nests during egg laying no doubt causes the destruction of some of them. But these provide the best data on nest initiation, nest spacing and density. Searches conducted later, while causing less destruction, result in conservative estimates of predation and underestimate density and clutch size. The effects would also vary depending upon predator density and their dependence on eggs in particular years. These subjects will be investigated further.

The details of the relative importance of foxes versus avian predators have yet to be analyzed.

Black Brant

Two small colonies of Brant were found. Five nests in the southern portion of area A (Fig. 1) were all predated. Twenty nests were established in area B. Seventeen of these had been destroyed before we found them; one was destroyed after we found it and two hatched. Because of this high rate of destruction on such a small sample, we are unable to analyze nest initiation, clutch size, etc. data as for the other species. Details on location and site will be presented later. Our area is on the very edge of Brant nesting range and this high rate of destruction is common. The importance of habitat, colony size, and predators in limiting Brant will be discussed in future reports.

Fake Nest Experiment

All 18 nests simulating slough bank White-front nests were destroyed, mostly by jaegers (Table 7). Four of the 18 simulated Cackler nests still contained eggs six days after the nest was built. Jaegers destroyed most of the remainder.

One hypothesis was that the concealed and dispersed mainland nests of White-fronts may confer some anti-predator advantage against jaegers and gulls which cause large losses on goose nests on islands. The corollary was that body size and attentiveness of White-fronts enabled them to defend their nests against foxes which readily destroy shoreline nests. Similarly, we expected foxes to take most of the simulated dried island or shore Cackler nests. The high destruction by jaegers at both types of nest sites demonstrates their rather remarkable abilities to identify nests, even those which are covered with sparse down and placed in relatively heavy Elymus vegetation. There are many biases and difficulties inherent in interpreting fake nest experiments. These experiments will be continued and full discussion will be postponed to the final reports.

Ptarmigan Abundance

Willow Ptarmigan are probably major food items of foxes. Therefore, an initial attempt was made to index their abundance to see if there is correlation between prey abundance and the impact of fox predation on goose nests. Three censuses of Ptarmigan were made in the vicinity of Old Chevak on 10, 11, and 13 May when most birds were visible as pairs (Table 8).

Sixty territorial males were plotted between 22-29 May from our tent camp to the junction of the Keoklevik and Kashunuk Rivers. Spacing was obviously uniform. Statistical analysis and determination of areas have yet to

Table 7. Fate of fake goose nests.

Nest Type	N	"Successful"	Fate	
			Avian Predated	Fox Predated
White-front (Slough bank)	18	0	16(88.9%)	2(11.1%)
Cackler (Dried island or shore)	18	4(22.2%)	13(72.2%)	1(5.6%)

Table 8. Indices of Willow Ptarmigan abundance in 1977.

Date	Miles Walked	Hours	No. Ptarmigan	No./ Mile	No./ hr.
10 May	3.5	3	37	10.6	12.3
11 May	3.0	4	47	15.6	11.8
13 May	2.7	1.5	26	9.6	17.3
Totals	9.2	8.5	110	12.0	12.9

be accomplished. Because "floating" males may quickly occupy territories made available by predation, the usefulness of censusing male Ptarmigan is questionable. However, we will continue this to test for a correlation of predator-prey buffer effects.

Microtine Abundance

An initial attempt was made to use voles seen per unit time spent walking in the tundra as a possible index to abundance. When records were kept, 14 voles were seen in approximately 125 man-hours of walking in May or 8.9 hours per vole or 0.11 vole per hour. Twelve voles were seen in approximately 219 man-hours recorded in June for indices of 18.3 hours per vole or 0.05 vole per hour. More detailed analysis can be made if future data suggest that these indices are useful. Regardless of their precision, it was obvious that voles were scarce compared to their peak years of abundance.

Snap trapping captured 15 voles in 1000 "trap-nights" between 23 May - 2 June or 1.5 per 100 trap-nights. Results from 1 to 23 July were 42 voles in 2100 trap-nights or 2 voles per 100 trap-nights. Details on age, sex, weight, habitat type and the effect of moving traps can be analyzed later if this proves to be a useful index. One Brown Lemming (Lemmus trimucronatus) and one shrew (Sorex sp.) were also captured.

Correlated with the low abundance of voles was the dearth of Snowy Owls seen early (one) and the few sightings of Short-eared Owls (15 between 10 May and 20 July - probably mostly of the same individual or pair).

Other Prey Items

No attempt was made to census small birds which may be important prey for Parasitic Jaegers. Nor was it within our capacity to measure invertebrates that are important for Long-tailed Jaegers.

Only two Arctic Hares (Lepus arcticus) were seen on two different occasions near the same location in late May.

Predator Abundance

We have little direct evidence of the density of predators. This would require full time studies in themselves.

Tracks and other signs of foxes were common. Only 3 Red fox were seen: at Old Chevak; near the north boundary of area A - Fig. 1; and near the junction of the Onumtuk Slough and Kashunuk River near the southeast boundary of area D (Fig. 1). Sign of Arctic fox was more common and they were seen on seven occasions. An active den was located in area A (Fig. 1), and they were also seen in area B (Fig. 1). Tracks were common on mud flats around ponds.

Parasitic and Long-tailed Jaegers were nearly always in evidence as we walked anywhere in the study areas. It was difficult to relate their density to predation on eggs as there were apparently migrants or groups of non-breeding jaegers present in late May and early June during some of the egg-laying period. Both species were seen destroying goose nests. Two nests of Long-tailed Jaegers and one nest of a Parasitic Jaeger were found. Another resident pair of Parasitic Jaegers probably had a nest as judged by their behavior at a specific location, but we were unable to locate it, but did see a chick after hatching. Details of the location of these nests and quantification of observations of Jaeger hunting behavior and food items observed to be taken have yet to be analyzed.

We do not have evidence that Glaucous Gulls, Mew Gulls (Larus canus) or Sabine's Gulls (Xema sabini) caused any nest destruction in our study areas. A mink (Mustela vison) may have destroyed one Cackling Goose nest.

Plans for 1978

We plan to use the same search areas as 1977 and the same general methods of searching and data recording. Interpretation of density, spacing of nests, clutch size, and hatching success can most properly be made only when several years of data from the same areas are available. Continuous data are necessary to evaluate these factors in relation to weather and season phenology and "cyclic" variations in predator-prey relationships. Thus, the need for our "long-term" cooperative agreement.

We have hopes that we can develop an automated monitoring system to record nest attentiveness and body weights of incubating geese. Nest attentiveness is related to the chances of losing a nest to predators and, in turn, attentiveness is probably related to the need to leave the nest to feed to replenish depleted energy reserves. There is variation among the species in their tendency to leave their nests in the presence of disturbance and, probably, predators. We would like to quantify these behaviors.

FORAGING ECOLOGY OF THE CACKLING

GOOSE DURING BROOD REARING

After hatching had occurred, the major thrust of our 1977 field work became the initiation of studies of foraging by Cackling Geese. There are two main components to this study. The need to understand the timing of nesting, hatching, growth and molting in relation to optimum food supplies was pointed out above. Secondly, the "simple" ecosystem and food habits of geese allow an opportunity to test current theories of food selectivity and optimization. What is needed, then are measures of feeding behavior, food availability, food quality, and amount and quality of food ingested. The main effort in 1977 was the initiation of pilot studies to assess the feasibility of different techniques required to accomplish measurements of these items.

METHODS

The study of foraging ecology of Cackling Geese was divided into five sections: 1. Vegetation sampling; 2. Insect sampling; 3. Observation of tame geese; 4. Observation of wild geese; 5. Collection of wild geese.

Vegetation Sampling

Samples of plant species were collected from areas that were both heavily grazed and not grazed by geese. These collections were for purposes of identifying species present and for proximate analyses of protein, lipid, fiber and water content.

Plant production was estimated from samples collected from exclosures set out on 20 and 22 June. Four 25 x 25 ft exclosures were made with 2 ft high netting. Two exclosures were in meadows with mixed vegetation; one exclosure was in a "pure" stand of Carex Ramenskii and one was in a "pure" stand of C. subspothacea on a mudflat. Three samples were collected from each exclosure at 7 to 11 day intervals through 12 August. The exclosures were subdivided into one square foot squares and random numbers were used to select the three squares to be sampled. All vegetation within a 100 cm² ring placed in each selected square was clipped to ground level. Clippings were weighed on a 5 or 10 g Pesola spring scale and then frozen for future analyses of species composition and for proximate analyses.

Insect Sampling

Five "sticky" boards were made from 6 x 24-inch pieces of presswood covered with a thin layer of Mapco Stikum Special. They were placed horizontally on the ground in meadows (4) and on mudflats (1) near our tent camp (Fig. 1) on 20 June and left in position until 20 July. Numbers of insects entrapped on the boards were counted daily between 21-28 June. Thereafter, counts were made approximately twice per week. Insects were identified only to family level.

Observation of Tame Geese

Twenty-five goslings were taken from nests during hatching and reared in captivity so that they would be imprinted on the investigator. Eighteen of these came from off the study area and seven came from two different nests on the study area so as to minimize potential impact on our future studies.

Beginning when goslings were 4 days old, groups of approximately 10 were taken to areas where wild geese had been observed feeding. Individual goslings were observed for up to one minute and their pecking at each species of food item was recorded on tape. Recording sessions lasted from one to two hours for 12 different samples between 5-30 July.

Most (8) sessions occurred in a brood rearing area regularly observed in area E (Fig. 1). Plant species density was estimated by arbitrarily placing seven, 30 ft transects within the 150 x 150 ft area used for recording feeding behavior of the tame geese. Sampling was accomplished by counting and identifying all plant individuals contained within a hexagon of 1.5 inches to a side centered over the transect line at six randomly selected points along each transect.

Observation of Wild Geese

Foraging of wild geese was observed from the tower and cabin in area E (Fig. 1). Every two hour interval of the day, except between 0200 and 0400 was sampled. Two different sampling methods were used: 1. The location of all broods within a 0.25 mile radius of the cabin was plotted on a map and the activity of the family as a unit was recorded. 2. A particular family was observed constantly for periods which ranged from 0.5 to 3 hours. The activity of the family was recorded at 5 minute intervals. Feeding bout lengths and peck rates of individuals (usually an adult) were also recorded.

Collection of Wild Geese

Wild geese were collected by shooting throughout the brood rearing period in order to quantify their food habits. Ideally, families were observed for 30 minutes before collection to insure that they had been feeding and to obtain esophageal samples. Later in the season, birds were too wary to make this pre-collection observation period practical. Contents of the esophagus and stomach (combined proventriculus and gizzard) were removed immediately from collected birds and placed into separate containers with 70% ethyl alcohol. Within 3 hours of the time of collection, food items were removed from the alcohol, washed with water, and frozen in vials.

RESULTS AND DISCUSSION

Vegetation Sampling

The net weight of vegetation clippings from exclosures showed wide variation (Table 9). Data from the meadows containing a variety of species do not show consistent trends. Collections from "pure" stands of different types of sedges, on the other hand, show peaks of standing crop occurring in the first two weeks of July, which coincided with the peak of hatching. Carex subspothacea again showed high levels in August. Mixed meadow samples would be expected to exhibit a more variable pattern than "pure" stands because the different species have different growth patterns and vegetation composition and density was less uniform than in "pure" stands.

Two other problems in our plant collections need evaluation and modification. Collections should begin earlier as, in some locations, much new growth had already occurred by 20 June. The three 100 cm² samples on a date within an exclosure appear to be too few in number and cover too small an area to properly estimate the standing crop.

Finally, wet weights are probably not a useful index to evaluate with

Table 9. Wet weights (g) of 300 cm² vegetation samples.^a

	Exclosure No.			
	<u>1.</u>	<u>2.</u>	<u>3.</u>	<u>4.</u>
	Mixed Meadow	Mixed Meadow	"Pure" <u>Carex</u> <u>subspothacea</u> on mudflat	"Pure" <u>Carex</u> <u>Ramenskii</u>
Date				
20-22 June	13.2	2.5	10.1	14.0
30 June	8.2	6.7	11.8	14.4
7 July	11.8	5.7	19.1	20.7
16 July	8.0	7.0	19.4	16.7
23 July	8.5	7.1	15.8	17.3
1 August	11.3	8.1	24	10.0
12 August	5.7	6.1	23.9	11.3

^aSum of three 100 cm² samples.

25.
respect to our objectives. Water and protein content will fluctuate widely as the plants mature and turn from vegetative to reproductive status. Chemical analyses of components of the samples, yet to be done, should provide a better estimate of the relationship of the plants to the need for nutritional quality of food by growing young and molting adults.

Insect Sampling

The total numbers of insects captured on the five "sticky" boards indicate two peaks of abundance during the sampling period from 21-28 June and 16-20 July -(Fig. 3). Values given where samples were not counted daily represent an "average" figure obtained by dividing the total number counted by the number of days since the last counting. This procedure, thus, makes the assumption that the number of insects landing on the boards was evenly distributed between counting days. This is clearly not true, but may not interfere with estimating gross differences in peaks of insect abundance.

There are several other problems attendant to sampling insects and interpreting these data. Almost nothing is known about the relative vulnerability of different species to being captured by this (or any other) technique and how weather (precipitation, winds, temperature) may affect results. Members of the families Tupulidae, Culicidae, and Chironomidae were identified. All others were placed in an "other" category and almost always contained the most individuals. Analyses of data with respect to weather, variation among boards and families have yet to be accomplished pending a decision as to whether or not this technique may be useful. For example, Culicids (mosquitoes) were not adequately sampled as they commonly alighted or hovered near the boards but did not become trapped even on days when they were extremely abundant. Mosquitoes may be important food items for young goslings in certain circumstances. However, we do not yet have data to indicate that insects captured by this technique may be important for geese (if, indeed, any are at any time). Sampling should probably be daily instead of spread out.

Because of the above constraints, it is undesirable to place much importance on the insect data. A low level of abundance was present during the hatch and for the first 2 weeks after hatching. Insects were not evident in the food samples obtained from collected geese (see below). Perhaps the lack of synchrony in the goose hatch with the indicated insect abundance accounted for low use of insects by goslings. Only future results can resolve this. Nesting and hatching were about 1 week later than in early or "normal" seasons and it is possible that insects may be more important in other years.

Observations of Tame Geese

These data have yet to be analyzed. Their choice of food items will be compared to that observed to be taken by wild geese. If they are similar to wild geese, then the close range observations of the tame birds will be useful for evaluating the selectivity of geese in choice of size, location, and species of food items.

Observation of Wild Geese

Both methods of recording activity (mapping and recording of all families in the vicinity and continuous observation of one family) yielded similar results (Table 10). These data represent the activity of entire families as a unit. As expected, feeding occupied most of the time budget of the geese

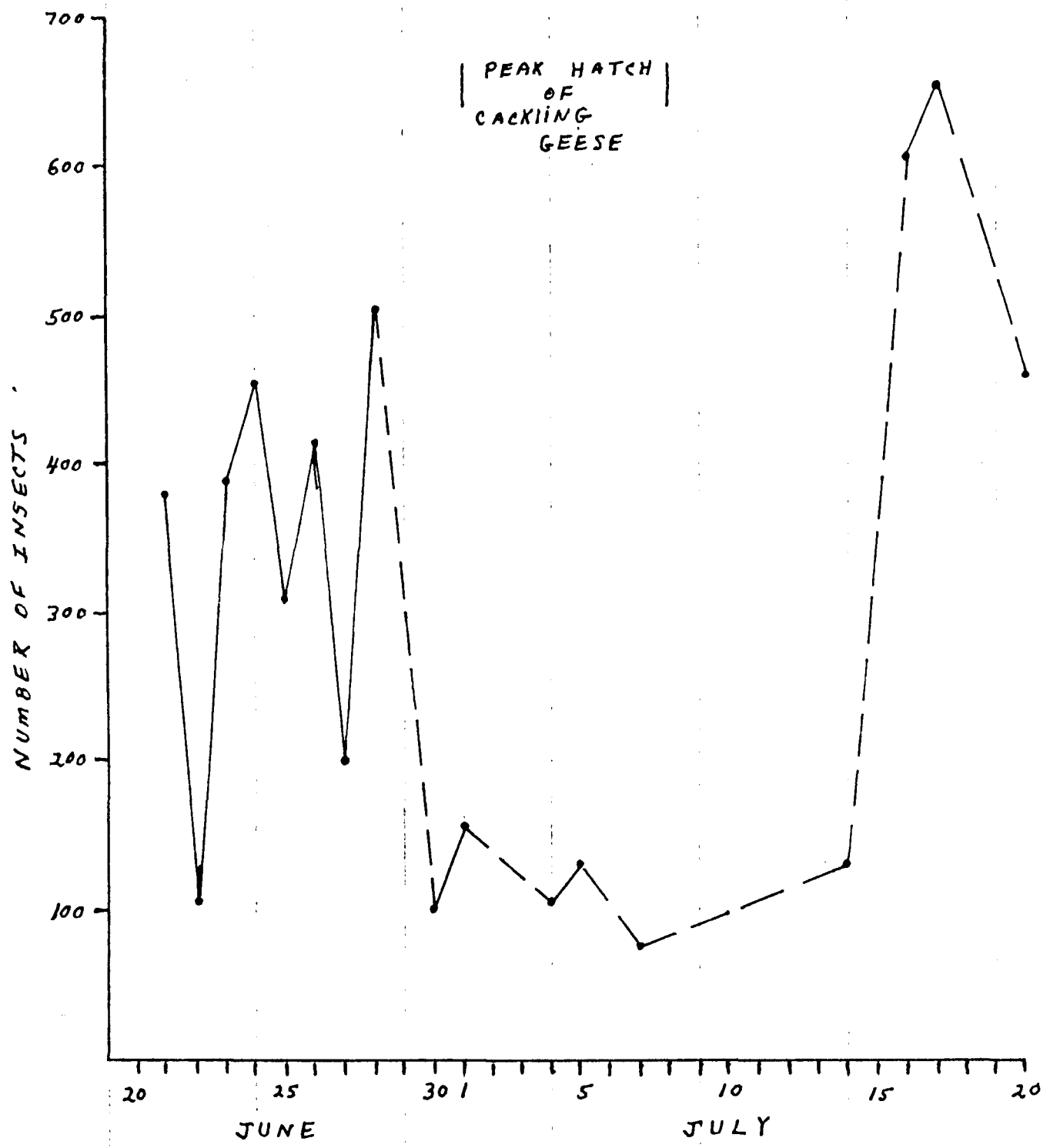


Figure 3. Numbers of insects captured on 5 "sticky" boards.

Table 10. Activity budget of families of Cackling Geese observed between
9 July and 11 August.

Observation Method ^a	N	% of time spent in:					
		Feeding	Preening- Resting- Sleeping	Bathing- Swimming- Drinking	Moving	Alert ^b	Aggression ^b
Map	371	70.3	24.8	1.8	2.4	0.5	
Continuous	554	65.3	26.4	4.5	1.8	0.2	1.8

^aSee methods.

^bOnly adults were observed engaging in these activities.

during brood rearing and molting, and aggression was at a low level. These data represent the total activities observed between 9 July and 11 August. Analyses by age of gosling, stage of molt, and time of day have yet to be accomplished. Most activities of families occurred as a unit, but more attention will be paid to differences between the adults and goslings and between sexes of adults in the future.

Feeding periods indicated in the activity budget in Table 10 were not spent entirely in feeding as actual foraging was frequently and continuously interrupted by pauses. The lengths of actual feeding bouts and between bout pauses are detailed in Table 11. These data can be used to refine the estimates of actual time spent feeding. Consistent trends were not evident in these data and variation was wide. Appropriate statistical treatments have yet to be undertaken. More precision is needed in the activities of the adults versus goslings and between sexes in the adult class.

Activity budget data can be applied to data in the literature on the length of time required to fill the gut and the length of time required to digest food (through-put time is about 1 hour) and the data from collected birds. These comparisons should allow estimation of the quantity of food ingested and, thus, can provide the basis for a calorie-based energy budget. These data, in turn, can then be used to assess the size, quality, and species composition of range requirements for the geese.

Time spent by families in various habitat types was recorded along with activity in the mapping method of activity recording. Five habitat types were defined: 1. Meadow - characterized by Carex rariflora, C. MacKenziei, C. Ramenskii, and grasses; 2. Mudflats - near pond edges characterized by large patches of bare mud with some C. glareosa and containing small patches of meadow vegetation surrounded by C. subspothacea; 3. Hippurus - patches of H. tetraphylla on mud or in shallow water; 4. Water; 5. Upland tundra - elevated above meadows and characterized by Sphagnum, Empetrum, Betula, Salix, Rubus, and grasses

Only the mapping technique of recording activity can be used to assess habitat use because the continuous observation technique was biased toward meadow use. This was because families close to the observation point were selected for continuous observation because of ease of recording their behavior and meadows predominated around the observation post.

Mudflats were the most used habitat type early in the brood-rearing season, followed by use of adjacent meadows (Table 12). Use of meadows and upland tundra increased when goslings were older. Mudflats were used a greater proportion of time than would be expected from their prevalence (areas have yet to be calculated). The trends in habitat use are likely related to several factors: changing nutritional state of vegetation in different habitats; reduced availability on mudflats due to early grazing pressure; later availability of important food species in meadows and upland; increasing ability of goslings to obtain more coarse vegetation as they grow older; increasing mobility and strength of older goslings allowing them to move farther from water. Results of nutritional quality, enclosure, and behavior observations of tame goslings studies should allow us to more thoroughly assess the relative importance of these factors. For example, the increasing use of upland tundra was correlated with an increasing abundance of ripening crowberries (Empetrum nigrum)

Collection of Geese

Identification of the species of plants ingested by collected geese awaits microscopic examination of cell structure. When this is accomplished, some

Table 11. Time spent (seconds) in active feeding bouts and pauses between bouts by families of Cackling Geese.

Time period	Event	Habitat		
		Meadow	Mudflat	Upland Tundra
Before 30	Feeding	10.2	9.0	
July	Bout	(N=67)	(N=27)	
	Between	4.9	6.0	
	Bouts	(N=18)	(N=6)	
After 30	Feeding	11.4	12.2	7.2
July	Bout	(N=109)	(N=35)	(N=7)
	Between	8.1	3.3	2.3
	Bouts	(N=15)	(N=14)	(N=2)

Table 12. Habitat use by families of Cackling Geese during the brood-rearing period.

Time period	N	% of time spent in:				
		Meadow	Mudflat	<u>Hippurus</u>	Water	Upland Tundra
Before 29						
July	98	40.8	55.1	3.0	1.0	0
After 29						
July	146	58.2	32.8	0.6	0	8.2
Totals	244	51.2	41.8	1.6	0.4	4.9

esophageal samples may be sufficiently large to subject them to proximate analyses of protein, lipid, and fiber content. These data can then be compared to collected vegetation to test whether or not the geese are selecting higher quality food items.

The following is a qualitative description of food items found in the collected geese.

8 July - one adult female and 5 goslings. All had full esophagi and proventriculi. Contents were mainly Carex leaf blade tips and some Potentilla leaves. The size of the blades in the adult were larger in cross section than those in the goslings. One gosling contained two insects.

10 July - two tame goslings were sacrificed at the same site at which wild geese were collected on 8 July. Both esophagi were partially full of small Carex leaf blades.

14 July - one adult male and two goslings. The adult esophagus was 1/4 full of Carex leaf blades; one gosling had a full esophagus (Carex) and one was empty.

17 July - one adult female and four goslings. No esophageal contents. The proventriculus of the adult female was full of green Empetrum nigrum berries and the proventriculus of one gosling also contained some of these berries. The proventriculi of all the goslings were full of Carex leaf blades.

23 July - five goslings. Little food material.

10 August - three goslings. Esophagi contained some ripe berries of Empetrum nigrum and some Carex seeds.

Plans for 1978

Continued analysis of the data are needed before specific plans for the field season are finalized. In particular, the location and size of vegetation samples collected for plant growth and content data needs more evaluation as do the insect collections. We hope to also use exclosures in areas heavily grazed by geese to measure the effects of grazing on nutritional quality, productivity, and standing crop of vegetation.

Collection of food and non-food plants (same and different species) will be continued in order to evaluate selectivity by the geese. Coupled with this will be continued observation of tame goslings and collection of the tame and wild goslings to provide quantitative estimates of feeding rate and selectivity. Observation of foraging behavior of wild geese will continue as in 1977.

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Appendix

Manuscript in press:

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