BREEDING BIOLOGY, HABITAT USE, AND PRODUCTIVITY OF GEESE AT KOKECHIK BAY, ALASKA - 1982.

by
Margaret R. Petersen

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Migratory Bird Section,
National Fishery Research Center - Seattle
U.S. Fish and Wildlife Service
1011 E. Tudor Road
Anchorage, Alaska 99503

ABSTRACT

Here I present the results and their preliminary analysis from the first of a multi-year field study on emperor geese (*Anser canagicus*), cackling Canada geese (*Branta canadensis minima*), and black brant (*B. bernicila nigricans*) at Kokechik Bay, Alaska. The emphasis of this field season was to mark nesting female emperor geese, delineate study plots, and determine nesting chronology, clutch sizes, nesting success, and nesting habitats used by geese. A total of 41 female emperor geese were trapped on their nests and marked with laminated plastic neck collars. Capture success was highest and eggs lost to predators or abandoned by adults was least when eggs were vocal, pipped, or young were present. Nesting chronology for geese was earlier in 1982 than 1971 and 1972; both considered late years. Emperor geese initiated clutches (first egg) between 27 May-14 June, with peak initiation of clutches 27-29 May in upland habitat and 31 May-3 June in intermediate habitat. Cackling Canada geese initiated most clutches (first egg) on 29 May in upland habitat 31 May in intermediate habitat, and 2-4 June in lowland habitat. Emperor geese laid larger clutches (6.66 ± 0.33), and cackling Canada geese laid normal sized clutches (4.70 ± 0.24) in 1982, as compared to other years. Emperor geese that nested in upland habitat had larger clutches and initiated clutches earlier than geese that nested in intermediate habitat. Clutch sizes did not vary for cackling Canada geese nesting in different habitats. In contrast to other areas of the Yukon-Kuskokwim Delta in 1982, hatching success was good for emperor (90.5%) and cackling Canada geese (81.1%) at Kokechik Bay. Nesting success for black brant (48.6%) was similar to that reported elsewere in 1982. The higher nesting success for geese at Kokechik Bay may have been a result of low fox populations as compared to the rest of the delta. Emperor geese nested further from water than cackling Canada geese and black brant. All species of geese nested above the drift line left by the spring snow melt. Emperor geese nested at higher sites than cackling Canada geese in upland habitat, and all geese nested at the same height in intermediate and lowland habitats.

Work planned for future field seasons at Kokechik Bay is similar to studies conducted in 1982, and will include:

1. observations of behavior and movements of marked and unmarked families of emperor and cackling Canada geese, and an evaluation of their use of Kokechik Bay in spring;

2. observations of nest sites selected, chronology of egg laying, and hatching success, and identification of physical and biological factors influencing nesting success and nest sites selected by geese; and

3. observations of movements of broods, interactions of marked geese within and between families, and use of intertidal mudflats, lowlands, and tidal marshs by family groups of geese in late summer and fall.

INTRODUCTION

This summer was the first field season of a 5-year study to be conducted on emperor geese (*Anser canagicus*), cackling Canada geese (*Branta canadensis minima*), and black brant (*Branta bernicula nigricans*) at Kokechik Bay. The analysis of data presented in this report is preliminary, and will be subjected to a more detailed analysis at a later date. The primary objectives of this field season (7 June-10 August 1982) were to:

1. select specific sampling areas or study sites suitable for long-term studies;

2. mark nesting female emperor geese and family groups of emperor and cackling Canada geese with numbered neck collars to aid in individual recognition of birds and;

3. begin observations of habitats selected by nesting pairs, and initiate studies on nesting densities, clutch sizes, nesting chronology, and nesting success of emperor geese, cackling Canada geese, and black brant.

STUDY AREA

Kokechik Bay is seperated from the Bering Sea by a low, sandy spit and low, barrier island. The Askinuk Mountains rise abruptly along the northern shore, and form the northern and western boundries of the bay. A 23 km long, narrow, flat band of low tundra extends from less than 1 km to 5 km from the shore of the bay to a line of bluffs. This narrow band (and lowlands adjacent to the Kokechik and Kolomak rivers) contains important goose nesting and brood rearing habitat. The highest nesting densities of emperor geese in the world are found there, as well as large colonies of black brant, and high densities of cackling Canada geese. Detailed descriptions of habitats can be found in Eisenhauer and Kirkpatrick (1977).

Much of Kokechik Bay has been selected for ownership by the Paimute, Sea Lion, and Chevak corporations. Some portions of the bay have been transferred to private ownership, and others are in the process of being transferred. The area is part of the Yukon Delta National Wildlife Refuge, and is managed by the refuge staff until the lands are in private ownership.

METHODS

Trapping and Marking

A total of 41 female emperor geese were captured at their nests in traps designed by Weller (1957) and modified for emperor geese. Most traps were placed 10 to 15 m away from the nest, moved to within 5 m of the nest the next day, then moved on the nest the third day. Some traps remained near the nest for several days until the eggs pipped, then were placed on the nest. Nesting geese were trapped from the first week of incubation until the last egg hatched. An additional 188 geese of all ages and sexes that were in family groups were captured while flightless. Each bird was banded with a yellow laminated neck-collar with black digits.

Nest Searching

Three plots of 129 ha, 61 ha, and 454 ha (Figure 1) were searched for goose nests by walking along shorelines, to each island, to each pingo, and the areas between lakes and ponds. Two areas (I and II) were searched beginning the first week of incubation and each nest was checked frequently thereafter. The other (area III) was searched once during the peak of hatch. All nests were revisited to determine nesting success.

Nesting Chronology

Data collected at nests of each species of goose included: number of eggs in and around the nest, float angle (Westerskov 1950) of one or more eggs, and the presence or absence of an adult female. Eggs in clutches found early in incubation were numbered sequentially from darkest to lightest stained. Hatching success was determined by the presence and condition of eggshell membranes, the number of eggs pipped, and/or the number of goslings in the nest. A nest was considered successful if one or more eggs hatched. The fate of individual eggs was recorded from nests checked after the eggs hatched or the goslings left the nest. Dates when emperor geese initiated clutches were estimated from hatching dates by assuming that geese incubated eggs 24 days, laid 1 egg per day, and skipped one day for clutches of 5 or more eggs (Eisenhauer and Kirkpatrick 1977). Cackling Canada geese were assumed to have a 26 day incubation period, and a daily egg laying rate of 1 egg per day with one day skipped for 5 or more eggs (Mickelson 1975). General notes on shapes of emperor goose eggs were noted, and 274 eggs from 41 nests were placed on a grid and photographed to evaluate variations in egg shape and sizes of eggs between and within clutches. These data will be evaluated at a later date.

Nesting Habitat

To characterize the habitat used by each species of goose nesting on the area, a series of measurements was taken at each goose nest in areas I and II. These data included the following: date, general habitat (upland, intermediate, and lowland; see Raveling et al. 1978), cover density (Jones board; Jones 1968), distance to water, distance to marsh (plants growing in standing water), distance to nearest goose nest of the same species, distance to nearest goose nest, distance to nearest gull nest, distance above or below spring melt water line (drift line), abundance of tall grass, abundance of short grass, abundance of dwarf shrubs, distance above pond, distance below pingo top, exposure, size of nearest pond, number of islands on each pond, nest site (island, shore, peninsula, slough bank, pingo, and field), and fate of the eggs. These data (when appropriate) were also taken within 10 m of each nest at a site chosen randomly along a north-south line. Detailed statistical analysis of the 54 emperor goose, 31 cackling Canada goose, and 37 brant nests, and 122 random sites will be completed at a later date.

Statistical Analysis

I performed Chi-square tests on data to: 1. evaluate the loss of nests due to trapping at different stages of incubation; 2. compare the nesting success of geese nesting in study areas I and II vs. those geese nesting in area III; and 3. compare the nesting success of cackling Canada geese, emperor geese, and black brant at various nesting sites. When the data did not meet the assumptions for analysis of variance tests, I performed nonparametric tests (Sokal and Rohlf 1969). These included Wilcoxon two-sample tests, Mann-Whitney U-tests, and Kruskal-Wallis tests on data to evaluate nesting chronology for all species, and clutch size distribution in some cases. Analysis of variance tests were performed on most clutch size data, the proportion of eggs hatching in different clutch sizes, and nesting habitat data. I performed paired-t tests on measurement data from each nest and its random site. Angular transformations were calculated on all percentage data before statistical tests were performed, and are presented as percentages in the tables and text of this report.

RESULTS AND DISCUSSION

Trapping

Emperor geese were most successfully captured when their eggs were vocal, pipped, or young were present. At that stage, geese were easily caught on their nests (15 of 15 attempted) and no birds abandoned eggs, and birds that could not be caught early in incubation were captured. Eggs were abandoned by females (or destroyed by jaegers or gulls before females returned) at significantly higher rates (X^2=7.86, df=1, p<0.01) before the eggs pipped. Sample sizes are too small to evaluate differences in losses of nests due to banding during early, mid-, and late incubation (Table 1). However, losses may be less during the latter 2 weeks of incubation.

Obviously, emperor geese are most effectively trapped when their eggs are hatching or are about to hatch. However, the syncrony of hatch (see Nest Chronology) precludes trapping a large number of geese when the eggs are hatching. Thus, when using a trap such as the Weller trap to capture geese during incubation, some destruction of eggs by avian predators or losses due to females abandoning nests should be expected. Some females may also change nest sites in subsequent nesting attempts as a result of trapping, so the interpretation of data on collared geese must be completed with care. Geese may abandon their nests less if other types of nest traps are used. Various trapping methods will be attempted throughout the course of this study.

Nest Chronology

Emperor geese laid eggs at Kokechik Bay beginning 27 May, and initiated the last nests on 14 June. Peak of nest initiation occurred on 27-29 May for emperor geese in upland habitat and 31 May-3 June in intermediate habitat. Cackling Canada geese initiated nests on 29 May in upland habitat, on 31 May in intermediate habitat, and 2-4 June in lowland habitat. However, the dates for both species are only estimates from hatching dates, and sample sizes are small. The apparent difference in initiation dates between the two species may only be an artifact of the 24 day incubation period I used to estimate egg laying dates. Eisenhauer and Kirkpatrick (1977) estimated incubation as 24.3±1.38 days, and Headley (1967) observed incubation to be 25.1±0.48 days. Thus, emperor geese may have initiated clutches earlier than my estimate, and before cackling Canada geese in all habitats used by both species.

As expected, emperor geese that had eggs hatch early in the season nested in upland habitat, and later nests were in intermediate habitat (Figure 2; t_s=-5.84, p<0.001), as did cackling Canada geese (Figure 2; t_s=54.39, p<0.005). Peak of hatch for emperor goose (30 June-2 July) in all habitats was similar to that of cackling Canada geese (30 June-4 July). This similarity may, in part, reflect the different incubation periods for the two species. A more detailed analysis based on known dates of egg laying, and a detailed evaluation of incubation behavior of both species of geese in needed.

Emperor geese may have initiated clutches earlier at Kokechik Bay then elsewhere on the Delta. Byrd et al. (1982) reports peak initiation dates for 84 emperor geese as 10-13 June, as compared to 27 May-3 June at Kokechik Bay. Factors causing this difference could include differences in the timing of melt and break-up among different areas on the Delta, differences in habitats surveyed, differences in age structures in the population at various locations throughout the Delta, and differences in the methods used to calculate initiation dates. Kokechik Bay had similar snow cover at Tutakoke River, and more snow cover than the Kumlunak Peninsula during egg laying (Byrd et al. 1982); thus, the timing of melt and break-up may not have been a significant factor causing the variation among study areas. Habitats were not described for areas other than Kokechik Bay, thus, can not be evaluated for differences in timing of clutch initiation. Perhaps some of the differences in timing could be attributed to a large proportion of younger birds nesting at possibly less desirable locations throughout the Delta.

The disparity in peak initiation dates of emperor geese between areas could also be an artifact of the difference in how peak initiation dates were calculated. Byrd et al. (1982) estimated peak initiation dates by backdating from float angles of eggs, whereas I estimated peak initiation dates by backdating from hatching dates. An analysis of float angles of eggs from nests at Kokechik Bay resulted in an estimated peak hatch of 3.00 days (N=32, SE=0.44, range 0-9 days) later than what actually occurred. For emperor geese, estimates of egg laying dates from float angles may result in dates that are later than when geese were initiating clutches. Thus, comparisons between studies should be limited to data obtained using identical methods.

Cackling Canada geese apparently initiated nests on similar dates throughout the Delta in 1982. Byrd et al. (1982) found that most nests were initiated 2-8 June, whereas at Kokechik Bay geese initiated nests 29 May-4 June. Possibly, nest sites used by cackling Canada geese become available on similar dates throughout the Delta.

Nest Sites

Emperor geese nested primarily on the shores of lakes and ponds, and on the sides of pingos, and cackling Canada geese nested on islands, shores of ponds, and peninsulas (Table 2). Although sample sizes are insufficient for statistical comparisons, there appears to be an overlap of nest sites by the two species with both species using shores of ponds. However, cackling Canada geese may prefer island nest sites (Mickelson 1975). At Kokechik Bay, island sites may be limited, thus cackling Canada geese may select areas generally not used in other parts of their breeding range. A detailed analysis on the availability of suitable islands, the characteristics of islands used by cackling Canada geese, and a study on the interactions of the two species while selecting nests is needed.

Black brant nested only on islands and shores of ponds (Table 2). However, black brant nested only in lowland habitat, thus little interaction between the three species is probable (see Nesting Habitat).

In 1982, emperor geese chose nest sites in apparently similar proportions to that observed by Eisenhauer and Kirkpatrick (1977). Since our study area, thus the availability of sites, was not identical to theirs, a statistical comparison between our sets of data are not meaningful at this time. A more detailed analysis on the availability of nest sites in our respective study areas would make comparisons more meaningful.

Clutch Size

Emperor geese laid an average of 6.66 eggs per nest (N=56, SE=0.33, range 2-12) in nests found during the first week of incubation. Of those 56 emperor goose nests, 33.9% (19) had 8 or more eggs laid in them. In addition, one emperor goose had one cackling Canada goose egg in it. Emperor geese laid larger clutches in 1982 at Kokechik Bay as compared to geese nesting there in 1971-73 (4.27 to 5.42 eggs/clutch; Eishehauer and Kirkpatrick 1977). One possible reason for the larger average clutch size in 1982 may include fewer young birds nesting (thus fewer small clutches). However, modal clutch sizes were generally similar between the two projects, and the primary difference seems to be the relatively large number of nests with 8 or more eggs present in 1982. The nesting season was later in 1982 than 1973 when 72.6% of the geese had begun laying eggs by 1 June (as compared to 46.2% of nests in 1982), thus the larger clutch sizes in 1982 does not reflect an early year. However, more geese were laying eggs by 1 June in 1982 than 1971 and 1972. Average clutch sizes of emperor geese nesting elsewhere on the Delta were smaller (3.33-5.08 eggs/nest) than at Kokechik Bay; however, detailed analysis of the various sets of data was not possible.

Cackling Canada geese laid an average of 4.70 eggs per nest (N=37, SE=0.24, range 2-7) at Kokechik Bay. This is within the range reported by Mickelson (1975) an Onumtuk Slough from 1969 to 1972, and similar to that found elsewhere on the Delta in 1982 (Byrd et al 1982). However, statisical analysis of all of the data may provide insight into similarities and differences between years and nesting areas.

Clutch sizes for both species generally decreased for clutches begun later in the season (Figure 3). Some later emperor goose nests may have included eggs laid by more than one female, although the total number of eggs in the nests were within the normal clutch range (5-7 eggs). However, a more detailed analysis of egg sizes and shapes in each nest is needed.

Emperor geese that laid eggs within the usual clutch sizes of 2-7 eggs in upland tundra habitats had significantly larger clutches than geese that laid eggs in intermediate habitats (U_s=281; n_1=20, n_2=13; p<0.001). However, when clutches of more that 7 eggs are included, clutch sizes were similar (Table 3). Larger clutches (7 or more eggs) were distributed equally between upland and intermediate habitats. Clutch sizes for cackling Canada geese did not vary between habitats. However, since the sample is only of nests that had eggs hatch (81.1% of cackling Canada goose nests), the similar clutch sizes may be an artifact of our sampling only earlier, more successful nests.

Clutch sizes of both species did not vary significantly between nest sites. Clutch sizes were similar for emperor geese nests along shores of ponds and on pingos (Table 4). Cackling Canada geese also had similar sized clutches on shores, peninsulas, and on islands, as did black brant (Table 4). Few nests were found in some catagories of nest sites, and perhaps larger sample sizes would show some differences. Small, normal, and large clutches of emperor geese were found throughout all nest sites in about equal proportions (Table 5).

Nesting Success

Of 84 emperor goose nests, 90.5% had one or more eggs hatch; of 53 cackling Canada goose nests, 81.1% had one or more eggs hatch; and of 37 black brant nests, 48.6% had one or more eggs hatch (Table 6). There was no significant difference in success between the areas intensively studied and the area surveyed only once, when the nests that were abandoned because of trapping are excluded from the sample. Nesting success in 1982 is similar to that found by Eisenhauer and Kirkpatrick (1977) at Kokechik Bay, and Mickelson (1975) at Onumtuk Slough. Sample sizes are too small to test for differences in the type of predation found for all species (Table 6). Nests of both species were destroyed by foxes, gulls, and jaegers.

Nesting success for emperor geese and black brant at Kokechik Bay was within the range found for other locations on the Delta in 1982 (emperor geese, 30-94% success; black brant, 34-56% success; Byrd et al. 1982). In contrast, however, cackling Canada geese at Kokechik Bay were much more successful (81.1%) than elsewhere on the delta (0-28%; Byrd et al. 1982).

Emperor goose nests with clutches within the modal range (5-7 eggs) hatched a similar proportion of eggs within each clutch size. Similarly, smaller clutches (2-4 eggs) had a similar proportion of eggs hatch, as did large (8-11 eggs) clutches. However the percent of eggs hatching between small, normal, and large sized clutches varied significantly (F=14.69; df=2, 37; p<0.001), with the smaller clutch sizes having proportionally more eggs hatching (Table 7). The large clutches were the least successful of the three groups.

Although the proportion of eggs hatching was greatest in the smaller clutches, their relative productivity was the least (Figure 4). Normal and larger clutches had similar numbers of eggs hatching, although large clutches had a lower percentage of eggs hatching. Larger clutches apparently produced the same number of young per nest as normal sized clutches.

No clutch size was more successful than any other clutch size for cackling Canada geese. However, clutches of 4-7 eggs produced more young per nest than did smaller clutches (Table 8). The similarity in hatching success for cackling Canada geese may in part reflect the pattern of predation for that species. Usually, if eggs were lost all eggs in the nest were destroyed. Few cackling Canada geese lost only one or two eggs during incubation, with most losses including all of the eggs in the nest. If one egg hatched, all of the eggs usually hatched. In contrast, Emperor geese rarely lost any eggs during incubation, and few pairs lost all of their eggs. The proportion of eggs hatched reflects a proportion of eggs remaining in the nest after the rest of the eggs hatched. Indeed, for emperor geese, it was common to find 1 or 2 eggs not hatched in the normal sized clutches (5-7 eggs), and 3 or 4 eggs in larger clutches (8-11 eggs). Preliminary observations suggest that many of the emperor goose eggs that did not hatch were fertile, viable eggs with live goslings within 2-6 days of hatching. Further analysis of eggs will be completed at a later date.

Too few emperor geese pairs had no eggs hatch to test for the effect of nest sites on hatching success (Table 9). Cackling Canada geese, however, were more successful when they nested on islands than on peninsulas and shores (Table 9; X^2=6.23, df=1, $p<0.05$). Nests of both species were destroyed by foxes, and gulls and jaegers (Table 6). Nesting on islands by cackling Canada geese is believed to provide protection from foxes (Mickelson 1975); however, too few nests were destroyed to test for differences between types of predator and nest location. In contrast, black brant were most successful when they nested on shorelines (X^2=6.27, df=1, $p<0.05$). Other factors such as distance to nesting gulls, distance to nearest goose, etc. may be important factors in the nesting success of black brant.

Too few emperor geese had no eggs hatch to compare the nesting success of geese nesting in upland and intermediate habitats (Table 10). Cackling Canada geese nesting in upland habitats may have been more successful at hatching eggs than geese nesting in intermediate or lowland areas (Table 10); however, small samples preclude meaningful statistical comparisons. Black brant only nested in lowland habitats on our study area.

Nesting Habitat

Preliminary examination of the data suggests that geese choose nest sites with similar as well as dissimilar characteristics. As expected, all species nested at sites above the normal height of water in nearby ponds (Table 11). These sites were also significantly higher than random sites chosen within 10 m of the nest (emperor geese, t=4.97, df=53, p<0.001; cackling Canada goose, t=5.09, df=30, p<0.001; black brant, t=4.69, df=36, p<0.001). Emperor geese generally nested further from water than cackling Canada geese and black brant (F=12.27; df=2, 119; p<0.001).

The height of the nest in relation to the drift line varied among emperor geese nests, and between emperor geese and cackling Canada geese nests. Emperor goose nests in upland habitat were situated higher above the drift line than nests in intermediate and lowland habitats (F=3.66; df=2, 51; p<0.05; Table 11). Cackling Canada geese nested at the same height above the drift line in all habitats. Black brant nested only in lowland habitat on the study area. Of the two species that nested in upland habitat, emperor geese nested at higher locations than cackling Canada geese (F=5.54; df=1, 31; p<0.001). However, at all other types of habitat, geese generally nested at the same height above the drift line. All geese nested at locations that were above the drift line and significantly higher that locations chosen randomly near each nest (emperor goose, t=4.84, df=53, p<0.001; cackling Canada goose, t=5.49, df=30, p<0.001; black brant, t=3.96, df=36, p<0.001).

These observations of the charcteristics of nest sites correspond well with the timing of nest initiation. Emperor geese nested at the higher (possibly drier) sites in upland habitats that may have been available earlier, and cackling Canada geese nested at the lower sites. Thus, in upland habitat, emperor geese initiated nests before cackling Canada geese. Whereas in habitats with less relief (intermediate and lowland), nest initiation dates were essentially identical for both species. Perhaps, since emperor geese will nest farther from water and on pingos, they can begin laying eggs earlier than cackling Canada geese who apparently wait for sites on the islands and shorelines close to ponds to become free of snow and melt water. There is overlap in the general types of nest sites chosen by all species, and perhaps a more detailed analysis of the data will allow a better description of the characteristics of the preferred nest sites for each species.

CONCLUSIONS

Importance of Kokechik Bay

Kokechik Bay was an island of good productivity for cackling Canada geese nesting on the Yukon-Kuskokwim Delta in 1982. The success rate for emperor geese was high and for cackling Canada geese the highest of any reported on the Delta in 1982 (Byrd et al. 1982). The reasons for these differences are not yet clear. A combination of events may have contributed to very low success elsewhere, and they may include: 1. heavy predation by foxes, and gulls and jaegers because of low microtine abundance; 2. a dry spring and low water levels, resulting in greater availability of normally more secure nest sites to predators; and 3. a late spring breakup and high snow pack, resulting in fewer geese nesting and smaller clutch sizes. No foxes were observed on the study area at Kokechik Bay, and old fox dens (believed to be red fox, *Vulpes fulva*) on the area were not active. Perhaps more foxes are trapped and shot at Kokechik Bay than elsewhere because of the proximity of Kokechik Bay to the villages of Hooper Bay and Chevak, and the relatively high price of red fox pelts.

The resulting lower fox population could allow a higher hatching success as has been found for ducks in the mid-west (Duebbert and Lokemoen 1980). At other locations on the Delta in 1982, arctic foxes (Alopex lagopus) were predominant, and destroyed many cackling Canada goose and black brant nests, suggesting that emperor geese may be able to defend their nests from arctic foxes better than the other species of geese.

Geese nesting at Kokechik Bay used nest sites and nested in habitats that seem to be similar to other areas. Thus, Kokechik Bay may provide nesting areas representative of those preferred by geese throughout the Delta. A more detailed analysis of the data collected in 1982 on characteristics of nest sites, a comparison between different study areas, and an evaluation of nest sites chosen over a longer period of time and early, normal, and late nesting seasons is needed before the characteristics of preferred habitats of geese can be described.

Plans for Future Studies

1. Spring Migration. I will initiate a study of use of coastal habitats by geese during spring. This study will focus primarily on movements of marked individuals within the Kokechik Bay study area, timing of arrival of marked geese, and the process and timing of family break-up of emperor and cackling Canada geese. The objectives of this aspect of the project are to: 1. develope a better understanding of movements and social status of geese in spring and to facilitate more accurate analysis of the standard spring surveys; and 2. document spring arrival dates of individuals to develope a more detailed evaluation of nesting chronology.

2. Nest Site Selection and Egg Laying. I will continue and expand a study to evaluate nest site selection of emperor and cackling Canada geese, and black brant, and chronology of egg laying by emperor and cackling Canada geese at Kokechik Bay. I will collect data on a wide array of habitat parameters at each nest site, on snow melt and water drainage in each habitat type, and observe nest site selection and intra- and inter-specific interactions of marked geese. The primary objective of this aspect of the project is to accurately characterize the nesting habitat used by each species of goose, and evaluate factors limiting and influencing their nesting distribution and timing of egg laying.

3. Incubation Behavior. I will initiate a coopertive study with Steven C. Thompson, student, University of California, Davis on the incubation behavior of the three species of geese nesting at Kokechik Bay. This study will involve detailed measurements of nest attendence, microenvironment of nests, and behavior of incubating birds. This study is an intergal part of the project, and the information will be useful in evaluating nesting success and factors influencing that success.

4. Nest Success. I will continue and expand the study of nesting success and factors influencing that success for emperor and cackling Canada geese. I will focus on collecting data on the variability in egg survival rates (procedures described in Klatt and Johnson 1982) between species and within species in various habitats, on making detailed observations of pairs of marked geese during the egg laying period, and on characteristics of eggs. The primary objectives of this aspect of the

project are to: 1. develope a basic understanding of the factors influencing nesting success for prediction or manipulation of the conditions necessary for the optimum number of eggs to hatch; and 2. develope insight into theoretical questions of clutch size and kin selection.

5. Movements of Family Groups. I will initiate a study on the movements of broods, and use of general habitats by emperor and cackling Canada geese at Kokechik Bay. Movements of marked family groups will be observed from observation towers, and their use of various habitats for roosting and feeding evaluated. The primary objective of this aspect of the project is to determine the types of habitats used, and the amount of area used by family groups of geese at Kokechik Bay. Thus, the approximate carrying capacity of the area for brood rearing can be determined.

6. Feeding Ecology of Flightless Emperor Geese. I will initiate a study to evaluate the relative importance of various food items eaten by geese, and the abundance, distribution, and nutrient value of major food items. Briefly, this will involve detailed observations of movements and feeding behavior of geese; sampling invertebrates in the intertidal zone, and grasses and sedges in lowland areas; and sampling feeding geese. The purpose of this aspect of the project will be: 1. to determine why geese use certain areas to raise goslings and molt, 2. to accurately define parameters of the habitat necessary for molting geese, and 3. to more accurately define the carrying capacity of brood rearing areas.

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Table 1. Fate of nests of emperor geese trapped on their nests.

Stage of incubation	Number of successful[1] nests (%)	Number of unsuccessful nests (%)
1 to 8 days	3 (50.0%)	3 (50.0%)
9 to 16 days	9 (69.2%)	4 (30.8%)
17 to 24 days	7 (63.6%)	4 (36.4%)
Eggs pipped or vocal	15 (100.0%)	0 (0.0%)

[1]A successful nest had one or more eggs hatch.

Table 2. Nest sites used by geese at Kokechik Bay.

Nest site	Number (%)		
	Emperor goose	Cackling Canada goose	Black brant
Island	0	14 (45.2%)	11 (28.9%)
Peninsula	4 (7.4%)	7 (22.6%)	0
Shore	31 (57.4%)	10 (32.3%)	27 (71.1%)
Field	5 (9.3%)	0	0
Pingo	13 (24.1%)	0	0
Slough	1 (1.9%)	0	0

Table 3. Clutch sizes of geese in different habitats at Kokechik Bay.

	Clutch size, $\bar{X} \pm SE$, (N)		
Species	Upland	Intermediate	Lowland
Emperor goose			
1-7 eggs	5.62±0.43 (13)	4.87±0.28 (20)	5.00±0.00 (2)
1-12 eggs	7.25±0.56 (20)	6.25±0.48 (28)	—
Cackling Canada goose	4.67±0.55 (9)	4.53±0.41 (15)	4.83±0.48 (6)
Black brant	—	—	2.66±0.17 (32)

Table 4. Clutch sizes of geese at different nest sites.

Nest site	Clutch size, $\overline{X} \pm SE$, (N)		
	Emperor goose	Cackling Canada goose	Black brant
Island	---	4.50±0.40 (14)	2.56±0.29 (9)
Peninsula	5.00±1.22 (4)	4.14±0.70 (7)	---
Shore	6.60±0.47 (30)	5.22±0.36 (9)	2.73±0.21 (23)
Field	5.75±1.03 (4)	---	---
Pingo	7.69±0.70 (13)	---	---
Slough	5.00±0.00 (1)	---	---

Table 5. Distribution of clutch sizes at different nest sites used by emperor geese.

Nest site	Size of clutch Small 1-4 eggs	 Normal 5-7 eggs	 Large 8-12 eggs
Peninsula	1	2	1
Shore	6	10	9
Field	1	2	1
Pingo	1	6	6
Slough	0	1	0

Table 6. Nesting success of geese at Kokechik Bay.

	Plots I & II	Plot III	Total
Emperor geese			
No. successful nests	40	36	76
	(93.0%)	(87.8%)	(90.5%)
No. unsuccessful nests	—	1	1
(reason unknown)		(2.4%)	(1.2%)
No. nests destroyed by jaegers	2	3	5
or gulls	(4.6%)	(7.3%)	(6.0%)
No. nests destroyed by foxes	1	1	2
	(2.3%)	(2.4%)	(2.4%)
Cackling Canada goose			
No. successful nests	23	20	43
	(74.2%)	(87.0%)	(81.1%)
No. nests destroyed by jaegers	4	1	5
or gulls	(12.9%)	(4.4%)	(9.4%)
No. nests destroyed by foxes	3	2	5
	(9.7%)	(8.7%)	(9.4%)
Black brant			
No. successful nests	18		18
	(48.6%)		(48.6%)
No. nests destroyed by jaegers	11		11
or gulls	(29.7%)		(29.7%)
No. nests destroyed by foxes	8		8
	(21.6%)		(21.6%)

Table 7. Percent of eggs hatching from different clutch sizes of emperor geese.

Clutch size	No. nests		Percent of eggs hatching $\bar{X} \pm SE$	
Small				
2 eggs	1		100.0 ± 0.00	
3 eggs	5		98.5 ± 3.33	
4 eggs	2		100.0 ± 0.00	
Total		8		99.4 ± 4.71
Normal				
5 eggs	6		91.3 ± 7.98	
6 eggs	9		84.7 ± 4.34	
7 eggs	4		75.9 ± 4.52	
Total		19		85.7 ± 3.51
Large				
8 eggs	2		75.0 ± 0.00	
9 eggs	4		61.8 ± 5.80	
10 eggs	4		33.2 ± 12.04	
11 eggs	4		51.1 ± 10.04	
Total		14		52.5 ± 4.89

Table 8. Percent of eggs hatching and numbers of young produced from different clutch sizes of cackling Canada geese.

Clutch size	No. nests	% eggs hatching $\bar{X}\pm SE$	No. young produced
2 eggs	4	30.9±21.54	0.75±0.48
3 eggs	4	27.0±21.26	1.00±0.71
4 eggs	3	82.1±13.23	3.00±0.58
5 eggs	8	93.7±11.26	4.25±0.62
6 eggs	9	76.3±12.50	3.89±0.81
7 eggs	1	100.0	7.00

Table 9. Nesting success of geese at different nesting locations.

Nest site	Emperor goose		Cackling Canada goose		Black brant	
	Succ.	Unsucc.	Succ.	Unsucc.	Succ.	Unsucc.
Island	---	---	13 (92.9%)	1 (7.1%)	2 (18.2%)	9 (81.8%)
Peninsula	3 (100%)	0	3 (42.9%)	4 (57.1%)	---	---
Shore	20 (90.9%)	2 (9.1%)	7 (70.0%)	3 (30.0%)	17 (63.0%)	10 (37.0%)
Field	3 (75.0%)	1 (25.0%)	---	---	---	---
Pingo	13 (100%)	0	---	---	---	---
Slough	1 (100%)	0	---	---	---	---

Table 10. Nesting success of geese in different habitats.

Habitat	Emperor goose		Cackling Canada goose		Black brant	
	Succ.	Unsucc.	Succ.	Unsucc.	Succ.	Unsucc.
Upland	19 (100%)	0	9 (90.0%)	1 (10.0%)	---	---
Intermediate	20 (90.9%)	2 (9.1%)	10 (66.7%)	4 (33.3%)	---	---
Lowland	1 (50.0%)	1 (50.0%)	4 (66.7%)	2 (33.3%)	18 (48.6%)	19 (51.4%)

Table 11. Selected characteristics of nest sites used by geese.

Characteristic of nest site	Emperor goose	Cackling Canada goose	Black brant
Height of nest above pond. cm, $\overline{X}$=$\pm$SE, (N)	40.4$\pm$3.18 (54)	26.1$\pm$3.25 (31)	18.3$\pm$1.30 (37)
Height of random site above pond. cm, $\overline{X}\pm$SE, (N)	25.1$\pm$3.54 (54)	11.8$\pm$2.16 (31)	12.7$\pm$0.97 (37)
Distance of nest to water. m, $\overline{X}\pm$SE, (N)	5.0$\pm$0.72 (54)	1.8$\pm$0.41 (31)	1.5$\pm$0.21 (37)
Height of nest above drift. cm, $\overline{X}\pm$SE, (N)		4.3$\pm$2.26 (31)	1.5$\pm$1.31 (37)
Upland habitat	19.8$\pm$3.85 (23)	3.0$\pm$6.28 (10)	---
Intermediate habitat	7.3$\pm$2.95 (28)	6.0$\pm$2.00 (15)	---
Lowland habitat	8.7$\pm$4.98 (3)	2.6$\pm$3.71 (5)	1.5$\pm$1.31 (37)
Height of random site above drift. cm, $\overline{X}\pm$SE, (N)	-2.9$\pm$3.36 (54)	-10.0$\pm$2.09 (31)	-3.4$\pm$1.13 (37)

Figure 1. Location of study plots at Kokechik Bay, Alaska - 1982.

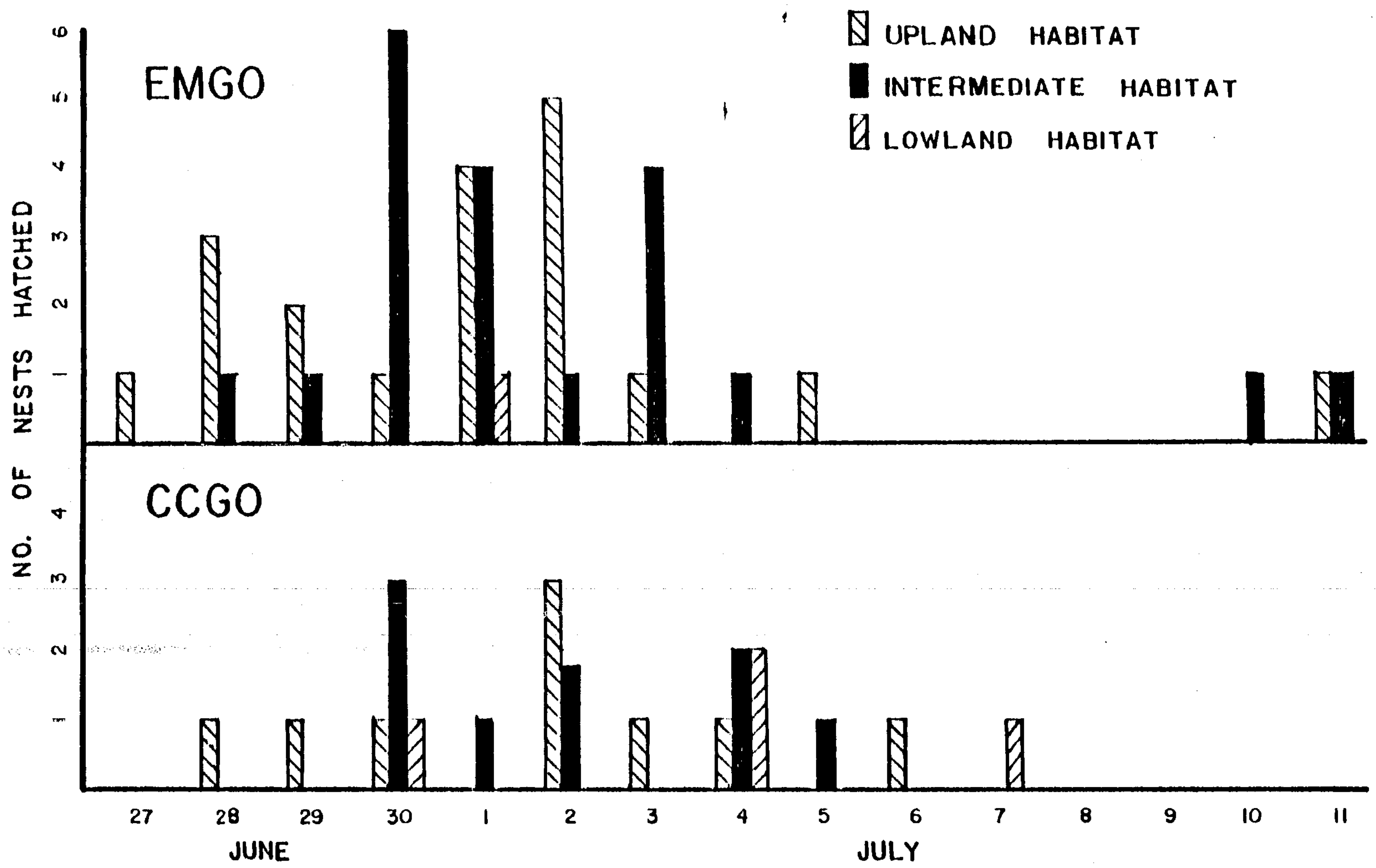

Figure 2. Hatching dates of emperor geese (EMGO) and cackling Canada geese (CCGO) nests in each habitat on study areas I and II.

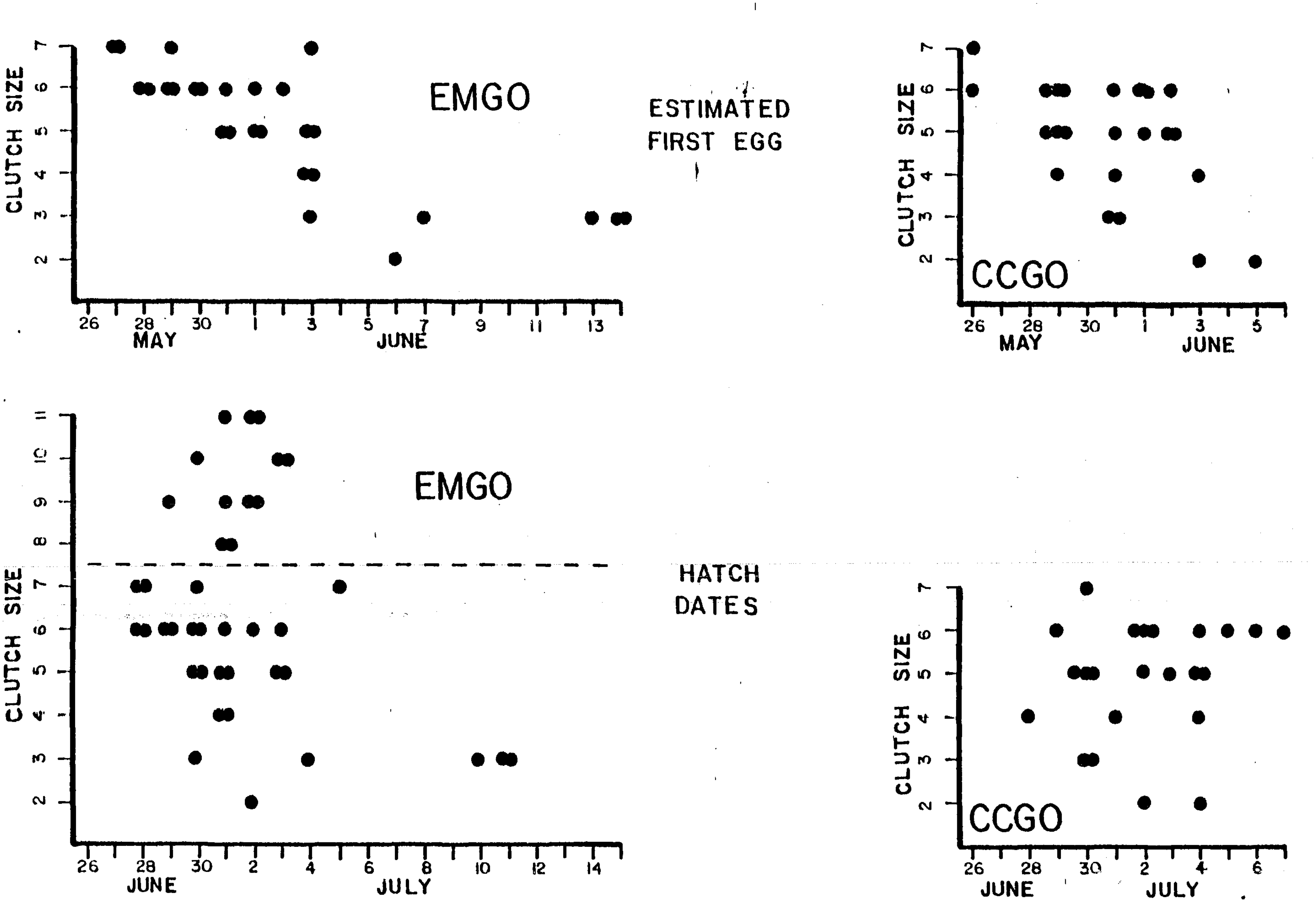

Figure 3. Clutch size distribution of emperor geese (EMGO) and cackling Canada geese (CCGO) by dates geese were estimated to lay the first egg and by dates when eggs hatched.

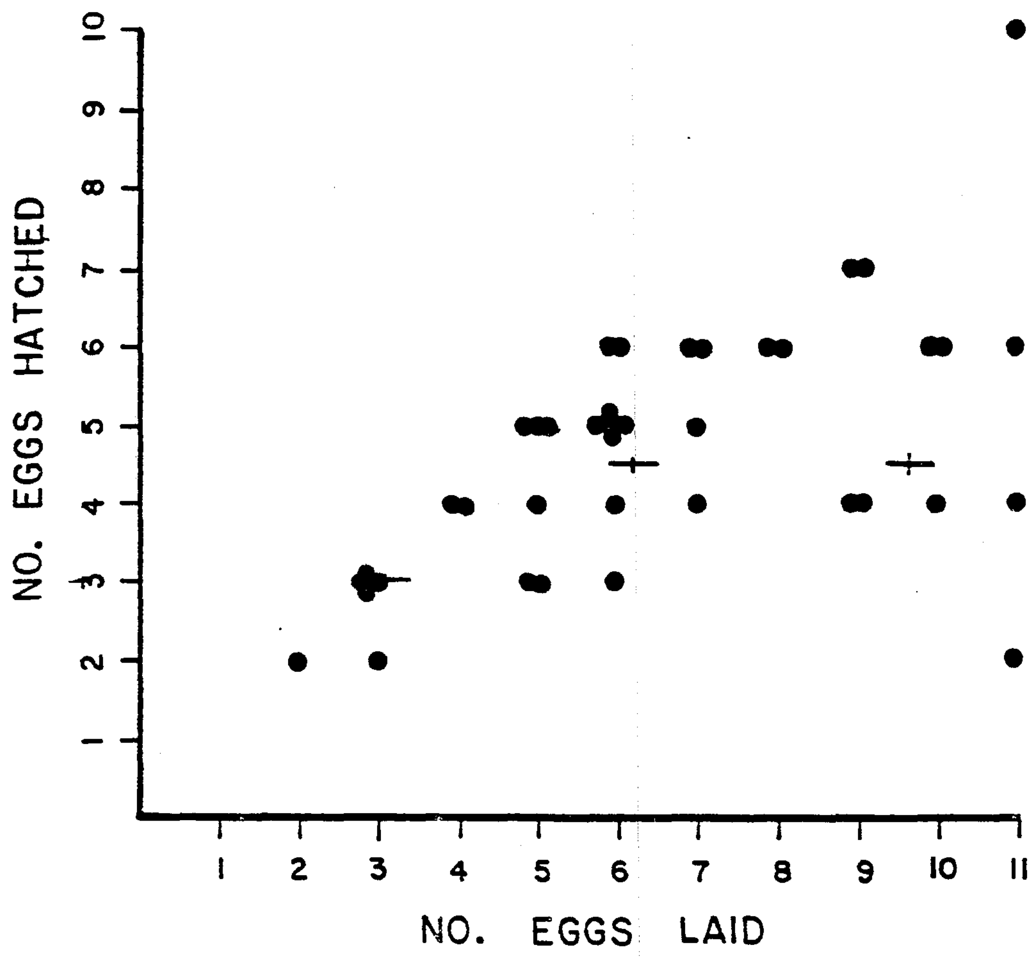

Figure 4. Number of eggs hatching in each emperor goose nest. Mean±SE for small (2-4 eggs), normal (5-7 eggs), and large (8-11 eggs) clutches.