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The Condor 95:222–225
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SURVIVAL AND PRE-FLEDGING BODY MASS IN JUVENILE EMPEROR GEESE¹

JOEL A. SCHMUTZ

*Alaska Fish and Wildlife Research Center, U.S. Fish and Wildlife Service,
1011 East Tudor Road, Anchorage, AK 99503*

Key words: Body mass; *Chen canagicus*; Emperor Goose; migration; physiological condition; survival.

A positive relationship exists between fledgling body mass and juvenile survival for some altricial (Krementz et al. 1989, Magrath 1991, Linden et al. 1992) and precocial (Owen and Black 1989, Longcore et al. 1991, Francis et al. 1992) species. Because the energetic demands of migration are high, physiologic condition may be a proximate determinant of juvenile survival in geese. Owen and Black (1989) found that pre-fledging body mass of Barnacle Geese (*Branta leucopsis*) was positively related to juvenile survival to winter. First-year survival in Lesser Snow Geese (*Chen caerulescens caerulescens*) was also affected by pre-fledging

body mass (Francis et al. 1992). It is not clear, however, when such mass-related mortality occurs. Both species migrate >3,000 km to wintering areas, but make use of fall staging areas while en route (Owen 1980, Francis and Cooke 1992). Survival of geese between fledging and staging areas has not been addressed. Measurement of survival during this interval could provide insight to the timing of juvenile mortality in arctic geese.

In contrast to Snow Geese and Barnacle Geese, Emperor Geese (*Chen canagicus*) have relatively short migrations (Owen 1980). Emperor Geese breed principally on the Yukon-Kuskokwim Delta (YKD) in Alaska (Eisenhauer and Kirkpatrick 1977). Virtually all Emperor Geese stage on the Alaska Peninsula during spring and fall migrations. They then disperse in winter throughout the Aleutian Islands, on the south coast of the Alaska Peninsula, and on Kodiak Island. Emperor Geese thus migrate 600–750 km between breeding and

¹ Received 23 June 1992. Accepted 12 October 1992.

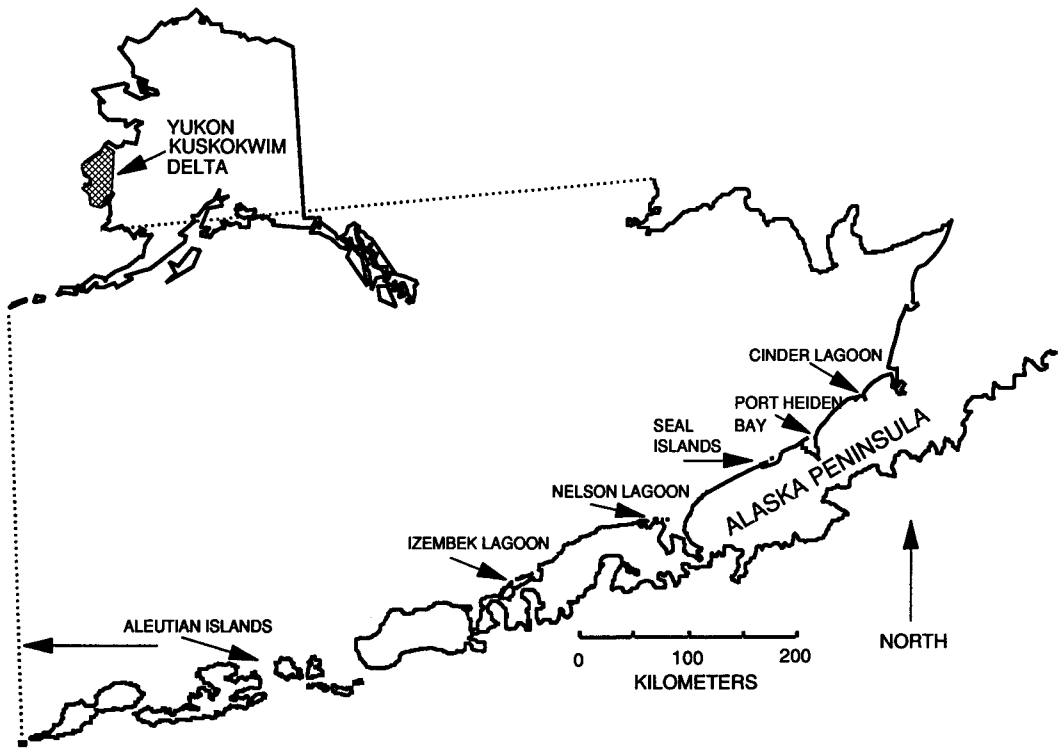


FIGURE 1. Distribution of Emperor Geese during breeding on the Yukon-Kuskokwim Delta and fall staging on the Alaska Peninsula.

staging areas. Distances between staging and wintering areas are probably highly variable (0–2,200 km) based on their comparatively dispersed distribution at this time of year.

In this paper, I examine the relationship between pre-fledging body mass of Emperor Geese and their survival to fall staging areas. By examining survival of Emperor Geese over a relatively short time period, I hope to provide a useful comparison to other species as well as new insight into the timing of mass-related mortality.

METHODS

Emperor Goose goslings were captured and marked with individually coded neck collars at nine sites on the YKD during 31 July–4 August 1990. Goslings were captured by driving flocks of flightless adults and their young into corrals. Numbers of geese captured per occasion was intentionally small ($\bar{x} = 120$) to minimize effects of banding. Goslings were sexed by cloacal examination and weighed with spring scales. Most goslings were weighed to ± 25 g, although some were weighed to ± 2.5 g. Goslings too small to retain neck collars were not collared (4.3% of captures), thus the smallest geese in the population were not included in these analyses. Goslings that became separated from the main body of the flock after release from banding and goslings showing other evidence of possible injury

were excluded from survival analyses (2.9% of collared goslings).

Geese were resighted with high-power spotting scopes during early September to early November at five staging areas on the Alaska Peninsula (Fig. 1). Aerial surveys from 1985–1991 indicate that >88% of the fall staging population is located in these five areas on the north coast of the Alaska Peninsula: Izembek Lagoon, Nelson Lagoon, Seal Islands, Port Heiden Bay, and Cinder Lagoon (R. King, unpubl. data). At each staging area, goose flocks were opportunistically observed to maximize the total number of unique individuals seen. Specific sampling on a given day within staging areas was dictated by tide and weather considerations, but all accessible areas of goose concentration were visited multiple times per season.

The probability of observing a given marked bird in the fall, θ , was a function of two parameters: ϕ , the probability of survival from banding to fall, and ρ , the probability of resighting an individual given that it has lived. I used binary regression analysis (Cox 1970) to determine whether the continuous independent variable of body mass at capture was related to the binomial response variable, θ . Assuming there was no relationship between ρ and body mass, then the significance of the binary regression is a direct test of the relationship between body mass and survival. The slope of the binary regression is indicative of the strength

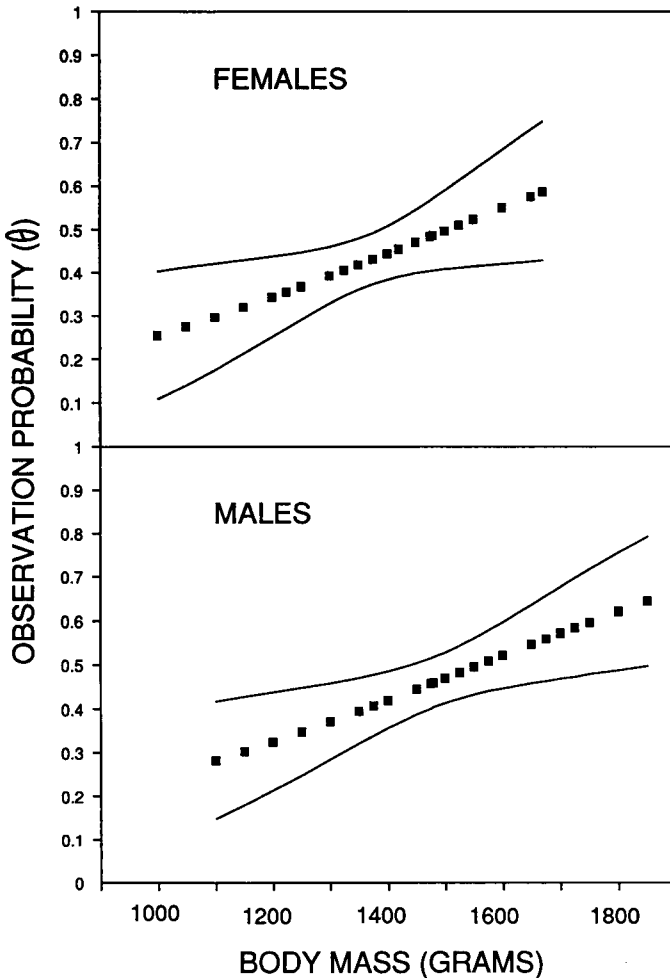


FIGURE 2. Predicted observation probabilities (binary regression predicted values with 95% confidence limits) for juvenile Emperor Geese based on their body mass at banding. Because ϕ and ρ are confounded and with their product being the observation probability, θ , interpretations about survival should concern the slope of the line but not the values on the y-axis.

of the relationship. Note, however, that specific survival probabilities for given body masses cannot be given because ϕ and ρ are confounded.

RESULTS

Two hundred and seventy-two female and 302 male goslings were collared and included in analyses. Mean body mass did not change significantly during the five-day banding period ($R^2 < 0.01$, $P > 0.40$ for both sexes) and therefore was not a confounding factor.

Female and male goslings that were resighted during fall 1990 were, respectively, 2.3 and 2.8% heavier at banding than those not seen (Table 1). Body mass was positively related to subsequent survival ($P = 0.038$ for females, $P = 0.014$ for males). Predicted observation probabilities for individual birds based on their body masses at banding are shown in Figure 2.

DISCUSSION

I believe it valid to assume no relationship between body mass and ρ . This validity exists because all important staging areas were sampled and observations within staging areas were intensive. Observers were in all areas containing $> 2\%$ of the fall staging population (R. King, unpubl. data), including the most northeastern and southwestern sites. Furthermore, habitat and distances to unsampled areas were similar to sampled areas. Within staging areas, observers repeatedly visited most concentrations of geese, and goose flocks within staging areas seemed largely panmictic (unpubl. data).

A second important assumption is that there was no interaction between body mass and potential negative impacts of handling or wearing a neck collar. This assumption was not tested but careful banding proce-

TABLE 1. Pre-fledging body mass (grams) of Emperor Geese subsequently seen or not seen during fall migration.

	Body mass			
	n	\bar{x}	SD	Range
Females				
Seen	116	1,379	113	1,050–1,670
Not seen	156	1,348	128	1,000–1,650
Males				
Seen	139	1,499	133	1,150–1,850
Not seen	163	1,458	149	1,100–1,750

dures minimized any such bias. Given the small differences in mass between seen and not seen groups, it is imperative that future investigators of survival employ careful banding procedures. Perhaps future captures should include test flocks where mass is measured on subsets of geese at the beginning and end of the handling process to see if a change in mass occurs.

I conclude that, for my sample of collared geese, heavy goslings had significantly higher survival than lighter weight goslings between late pre-fledging and arrival on fall staging areas. Since geese were resighted at their primary staging grounds, these results suggest that body mass affected the ability of juvenile geese to depart breeding areas and/or affected survival during the first phase of migration. These results are particularly striking given the relatively short distances traveled by Emperor Geese to staging areas and suggest the pre-fledging body condition may be an important factor in survival of geese. Although Francis (1990) did not relate body mass to survival, he inferred that much of the first year mortality of Snow Geese banded just prior to fledging occurs either on the breeding grounds or during their initial migration.

There is both genotypic and phenotypic variation in pre-fledging body mass. Contributing factors to pre-fledging body mass include egg mass, hatch date, and gosling growth rate. Although a proportion of the variation in these factors is heritable (Boag and van Noordwijk 1987), environmental influences are also important (Cooch et al. 1991, Larsson and Forslund 1991, Sedinger and Flint 1991). Individual variation in hatch dates results from annual differences in timing of snow melt and resultant availability of nesting habitat (Petersen 1990). Growth rates are affected by the availability and quality of brood forage (Sedinger and Raveling 1986). Therefore, habitat conditions on the breeding grounds may affect survival of juvenile Emperor Geese during and/or just prior to migration.

I thank the Migratory Bird Management Office, Region 7, USFWS, for financial and logistic support, especially pilots W. Butler and R. King. The Yukon Delta National Wildlife Refuge was instrumental in banding operations and the following people are thanked for their tireless resighting effort: N. L. Barten, K. S. Bollinger, F. Bossuyt, A. C. Fowler, J. D. Mason, T. H.

Pogson, J. A. Pratt, and A. L. Seidl. R. Bromley, D. V. Derksen, J. W. Hupp, M. R. Petersen, and an anonymous reviewer are thanked for comments on the manuscript.

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