

SURVIVAL OF COMMON EIDER *SOMATERIA MOLLISSIMA* ADULT FEMALES AND DUCKLINGS DURING BROOD REARING

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We studied survival of adult female and duckling Common Eiders during brood rearing at two sites on the Yukon-Kuskokwim Delta, Alaska, in 1997. Duckling survival to 30 days of age was $19\% \pm 10\%$ (95% CI). Seventy-three percent of radio-marked adult females had lost all their ducklings by 30 days after hatch. Duckling survival was not related to hatch date. We estimate an average of 0.84 ducklings fledged per adult female radio-marked at hatch. Most broods moved to salt water within 15 days of hatch. Adult female survival during the first 30 days of brood rearing was $96 \pm 6\%$ (95% CI). Mortality of adult females during brood rearing is probably higher than during other times of the year.

Keywords: brood rearing, survival, Common Eider, *Somateria mollissima*, Yukon-Kuskokwim Delta

Reproduction is a physiologically stressful period for breeding waterfowl. In general, breeding females tend to experience greater mortality during the reproductive season than at other times of the year (Milne 1963, Korschgen 1977, Ringelman & Longcore 1983, Cowardin *et al.* 1985, Kirby & Cowardin 1986). Specifically, Milne (1963) estimated that half of adult female annual mortality in Common Eiders occurred during the breeding season. Similarly, Grand *et al.* (1998) estimated that 22% of annual mortality in Spectacled Eiders *Somateria fischeri* occurred during the brood rearing period. These results suggest that brood rearing is a period of relatively high vulnerability in the annual cycle of breeding eiders. Given that adult female survival is a major determinant of population dynamics in waterfowl (Goudie *et al.* 1994, Schmutz *et al.* 1997, Flint *et al.* 1998), it follows that adult female survival during the breeding season has the potential to influence population dynamics.

Juvenile survival is a critical, yet highly variable, component of waterfowl productivity (Johnson *et al.* 1987, 1992). Coulson (1984)

concluded that recruitment had a strong influence on Common Eider population dynamics in Britain. Milne (1974) demonstrated considerable annual variation in the proportion of ducklings surviving to fledging and linked years of high duckling survival to subsequent increases in population size. Estimates of the proportion of Common Eider ducklings surviving to fledging vary from 10% in Scotland to 24% in Nova Scotia (Milne 1974, Mendenhall & Milne 1985). Estimates of the number of ducklings fledged per female varied from 0.47 in the Netherlands to 0.89 in Finland (Hilden 1964, Swennen 1983). Thus, brood rearing may be a bottleneck in annual productivity, and low duckling survival may be a major determinant of recruitment. Our goal in this study was to measure survival of adult female and duckling Common Eiders during brood rearing on the Yukon-Kuskokwim Delta (Y-K Delta), Alaska. We compare our results to those from other studies of Common Eiders and to sympatric nesting species on the Y-K Delta. We interpret these results in terms of their potential importance in population regulation.

Table 1. Estimates of Common Eider duckling survival through to 30 days post-hatch on the Yukon-Kuskokwim Delta, Alaska, 1997.

Variable	Site		
	Kigigak Island	Tutakoke River	Sites combined
No. Broods marked	21	27	48
No. Broods with 1 Duckling ^a	6	7	13
No. Broods Missing ^b	6	4	10
No. Ducklings	107	110	217
No. Mortalities ^c	91.5	85.2	176.7
Survival rate	0.1449	0.2255	0.1857
SE(Survival rate)	0.0554	0.0873	0.0521
Ducklings/brood	0.74	0.92	0.84

^a Indicates the number of radio marked females that were associated with ducklings at 30 days post-hatch.

^b Indicates the number of radio marked females that were missing at 30 days post hatching. All of these females were assumed to have lost their broods and departed the study area.

^c Fractions of mortalities occurred due to averaging of brood sizes within crèches.

Study Areas

This study was conducted at two sites on the outer coastal fringe of the Yukon Delta National Wildlife Refuge, Alaska in 1997. The first study site was along the drainages of the lower Kashunuk and Tutakoke Rivers (61°20'N, 165°35'W). The second study site was on Kigigak Island, at the mouth of the Ninglick River (60°50'N, 165°00'W). Common Eiders at both sites nest in sedge-graminoid meadows as defined by Kincheloe & Stehn (1991). Both study areas were searched on foot by several observers during egg laying and early incubation with 98 nests located at the Tutakoke River site and 126 nests located on Kigigak Island. Common Eiders at Tutakoke River are nesting in association with a large colony (>5,000 pairs; Sedinger *et al.* 1998) of Black Brant *Branta bernicla nigricans*. Common Eiders nesting at Kigigak Island occur within localised

concentrations (totaling <2,000 pairs) of Black Brant and dispersed nests of Cackling Canada *Branta canadensis minima* and Emperor *Anser canagicus* Geese. At both sites, most Common Eider nests are within 2 km of the Bering Sea coast.

Methods

Marking

We used radio-telemetry to monitor mortality of duckling and adult female Common Eiders. We trapped females on their nests 0 to five days before hatch using a mist net or a string-activated bow-net (Sayler 1962). Eggs were candled throughout the incubation period to determine approximate date of hatching (Weller 1956, Gorman 1974). A total of 60 females were fitted with a 15 g subcutaneously anchored radio transmitter (Pietz *et al.* 1995).

Initial brood size was assumed to be equal to the number of eggs present in the nest on the last visit prior to hatch.

Using aircraft, we determined the location of radio-marked females remaining on each study area approximately bi-weekly. When unable to locate females on the study area, we searched a minimum 40 km radius from nest locations. To estimate duckling survival rates, we counted ducklings in eider broods with radio-marked females from aircraft at approximately 30 days post-hatching.

Duckling survival analysis

We used the method of Flint *et al.* (1995) to estimate the Kaplan-Meier survival rate of ducklings; this technique allows for mixing of young among broods and does not require the assumption that the survival probability of ducklings within broods was independent. We calculated the survival rate for each site separately and compared survival rates among sites using a randomisation procedure as described by Flint *et al.* (1995). For this randomisation, we compared the squared difference in survival rates between sites to the squared difference in survival rates from 1000 random populations. We calculated an average size for broods observed in crèches and we assumed random variation in any error associated with our brood counts. We examined the influence of hatch date on duckling survival using analysis of covariance with location as a factor, hatch date as a covariate and initial brood size as a weighting factor (Grand & Flint 1996). We included the interaction between location and hatch date in the initial model, but removed this term if the type III result was non-significant (ie $P > 0.05$).

Adult female survival analysis

We calculated adult female survival using a standard Mayfield approach (Johnson 1979). We censored females if they could not be located within 40 km of their nest sites (Bunck *et al.* 1995). That is, females were only included in the analyses until the last location of the individual (either dead or alive). We assumed

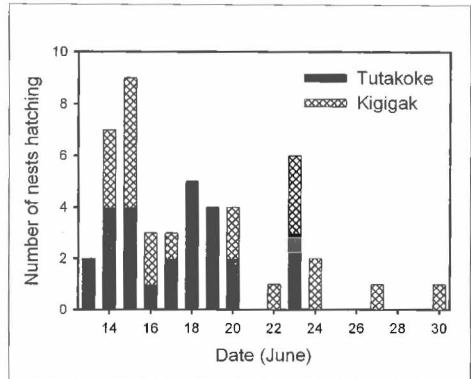


Figure 1. Hatch dates of radio-marked females by study site on the Yukon-Kuskowim Delta in June 1997.

that all mortalities occurred at the midpoint of the observation interval in which a mortality signal from a radio-transmitter was first recorded. Due to logistical constraints, carcasses of dead females were recovered several weeks later. We compared daily survival rates among study sites using the Z-test described by Johnson (1979).

Results

Sample size for estimation of duckling survival was reduced because 12 females failed to hatch any eggs; thus we measured duckling survival on 21 broods at Kigigak Island and 27 broods at Tutakoke River. Average age of ducklings at the final count was 28.7 ± 3.4 days (SD). Duckling survival rates were not different among study areas ($P = 0.932$, **Table 1**). Assuming missing females had lost all young and departed the study area, 73% of radio-marked females lost their entire brood by 30 days post-hatching. Duckling survival was not related to hatch date ($F = 0.02$, $df = 1, 45$, $P = 0.879$), and there was no interaction between location and hatch date ($F = 0.43$, $df = 1, 44$, $P = 0.513$) (**Figure 1**). Crèche sizes at the final observation were small with only one crèche containing more than two females. The associations of successful females by site were (No. females / No. ducklings): Tutakoke 1/2, 2/11, 2/5, 2/15, 4/9, 1/2, 1/3 and Kigigak 2/5, 2/3, 2/5, 1/3, 1/3, 1/3.

Sample size for estimation of adult female

Table 2. Estimates of adult female survival during brood rearing for Common Eiders on the Yukon-Kuskokwim Delta, Alaska, in 1997.

Variable	Site		
	Kigigak Island	Tutakoke River	Sites combined
No. Females	25	26	51
Exposure days	689.5	746.5	1436
No. Missing ^a	5	4	9
Mortalities	1	1	2
Daily survival rate (DSR)	0.9986	0.9987	0.9986
SE(DSR)	0.0015	0.0013	0.0009
30 day survival (DSR ³⁰)	0.9588	0.9617	0.9588
CI around (DSR ³⁰)	0.8787–1.00	0.8872–1.00	0.9037–1.00

^a Indicates the number of radio marked females that were never located after departure from the nest. These females were not assigned exposure days and therefore were excluded from the analysis of adult female survival.

survival rate was reduced because nine females were never detected on the study area after nest departure; thus estimates of adult female survival are based on 25 females at Kigigak Island and 26 females at Tutakoke River. Adult female survival rate did not differ between sites ($Z = 0.51$, $P = 0.610$; **Table 2**). Because the carcasses of the two females that died were recovered many days after mortality, the cause of death could not be determined.

Discussion

Duckling survival

Our duckling survival estimates assumed that missing females lost all their young (either to mortality or adoption) and dispersed from the breeding area. Radio-marked females without ducklings were regularly observed on the study area; however, these females were usually in flocks of >10 birds and further out to sea than broods. Additionally, these flocks frequently flushed when approached by aircraft. Based on

this observed segregation between brood rearing and non-brood rearing females, it seems likely that other non-brood rearing females moved beyond the range of our detection. Therefore, we assumed that all missing females had lost all their young. Alternatively, if our failure to locate a female was actually caused by radio-transmitter loss or failure, our estimates of duckling survival are biased low; we have no data to test this assumption.

The behaviour of Common Eiders to form crèches (Munro & Bédard 1977) complicates the estimation of duckling survival. The method of Flint *et al.* (1995) allows for mixing of young among broods and does not require the assumption that the survival probability of ducklings within broods was independent. However, this technique requires the assumption that we were equally likely to observe increases and decreases in brood size as a result of brood mixing (Flint *et al.* 1995). Gorman & Milne (1972) suggested that crèche attendance by females was not random but was related to relative hatch date such that later

hatching females were more likely to attend crèches. Whereas, Bustnes & Erikstad (1991) demonstrate that females in better body condition were more likely to attend crèches. Therefore, in our specific application, we made two basic assumptions: (1) we assumed we marked a random, representative sample of females with regard to crèche attendance; (2) we calculated an average brood size for radio-marked females observed in crèches and therefore, our estimates assumed that we were equally likely to over- and under-estimate true brood size of females associated with crèches. If we marked females that were more likely to attend crèches regardless of the presence of their ducklings, we will over-estimate duckling survival, and vice versa. To account for this potential bias we attempted to distribute the sample of radio transmitters among hatch dates (Figure 1). Further, we found no relationship between duckling survival probability and hatch date suggesting that bias in sampling females associated with hatch date did not influence our estimates. Capture of females for application of radio transmitters was done without regard to clutch size (ie initial brood size), thus we have no reason to suspect a bias resulting from averaging of brood sizes within a crèche. Further, most crèche sizes were small (eg two females) reducing the potential magnitude of this bias. Overall, we assumed that we radio-marked a random, representative sample of females; this assumption is common to radio telemetry studies and we have no reason to suspect it was violated.

Only two other studies estimated the proportion of ducklings surviving to fledging and our estimate of duckling survival falls within the range of their estimates (ie 10% and 25%) (Milne 1974, Mendenhall & Milne 1985). For Common Eiders, researchers more frequently report the number of young fledged per breeding female. In this comparison our estimate falls at the upper range of estimates based on long term averages (Hilden 1964, Swennen 1983). Additionally, our method also allowed us to estimate the proportion of females that lost all their young (either to adoption or mortality), and we found that a relatively small proportion of the successfully

hatching females fledge young in a given year. Our estimates, however, may have been negatively influenced by unusual weather patterns during summer 1997. Leonard *et al.* (1996) concluded that survival rates of Canvasback *Aythya valisineria* ducklings were lower in years with extremely low water levels, and Flint & Grand (1997) thought that low Spectacled Eider duckling survival in one year was associated with low water levels. Very dry conditions on our study sites during summer of 1997 resulted in extremely low water levels in ponds on our study areas. These low water levels may have reduced duckling survival directly by decreasing ducklings ability to avoid predators or by influencing food availability (Swennen 1991). Alternatively, low water levels may have reduced duckling survival by forcing broods to move to salt water earlier than usual. Swennen (1983) suggested that Common Eider ducklings experienced considerable mortality within a week after introduction to salt water. Within 15 days of hatch 80% of Common Eider broods we monitored had moved into salt water. At 15 days old, Common Eider ducklings are quite small (class IIb) and completely unfeathered (Mendenhall & Milne 1985). Consequently, the survival rate we measured may be lower than usual as a result of duckling inability to cope with early introduction into a salt water environment (ie high salinity, cold water temperatures). However, the timing of brood movements from fresh to salt water on the Y-K Delta in years with normal precipitation are unknown.

Given that half of fledged ducklings are females (Swennen 1991), we estimate that each adult female successfully hatching a clutch fledged 0.42 female ducklings. The overall reproductive success, in terms of female ducklings fledged per breeding female, will be even lower when total nest loss is considered. For species with high survival rates, the contribution of a single reproductive attempt to lifetime reproductive success is small (Coulson 1984). Thus, to interpret this value of ducklings produced per female in the context of population dynamics, we need information on annual variation in duckling survival, survival from fledging to breeding and adult survival.

Such additional information are unavailable for our population but compared to other populations of Common Eiders, we found no evidence that duckling survival on the Y-K Delta was unusual.

Adult female survival

We were unable to locate nine females at various intervals of the sampling period, thus these females were excluded from analyses (ie right-censored) after their last detection. Therefore, we assumed that the probability of censoring a female was independent of survival probability. If our failure to locate censored birds was related to their death, then our survival rate is biased high. Conversely, if censoring was strictly related to radio transmitter failure or loss, then our survival estimate may be biased low. As with most radio telemetry studies, we have no data to distinguish between these potential biases.

Adult female survival during the breeding season is likely lower than during the remainder of the year (Milne 1963). Our estimates of adult female survival during brood rearing fall within the range of those reported for Spectacled Eiders and other dabbling ducks (92-100%) (Ringelman & Longcore 1983, Cowardin *et al.* 1985, Kirby & Cowardin 1986, Flint & Grand 1997). When we compare our 30-day survival rate to reported annual survival rates from other studies of Common Eiders (Reed 1975, Wakeley & Mendall 1976, Coulson 1984, Kremetz *et al.* 1996), we estimate that 19-50% of mortality for successfully nesting female Common Eiders occurred during the brood rearing period. This supports Milne's (1963) estimate of 50% of annual mortality occurring during the breeding season and is consistent with the estimate that 22% of annual mortality in Spectacled Eiders occurred during the brood rearing period Grand *et al.* (1998). The combination of these results suggests that brood rearing is a period of relatively high mortality for eiders.

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