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PRODUCTIVITY OF NESTING SPECTACLED EIDERS ON THE LOWER KASHUNUK RIVER, ALASKA[1]

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Abstract. We studied the chronology and success of nesting Spectacled Eiders (*Somateria fischeri*) along the lower Kashunuk River on the Yukon-Kuskokwim Delta from 1991–1995. Nest initiation dates ranged from 16 May–22 June. Median nest initiation dates were correlated with the break-up of ice on the Kashunuk River. Clutch sizes declined seasonally, and mean clutch size varied among years ranging from 4.8–5.6 eggs. The frequency of nests containing inviable eggs (24% of successful nests, $\bar{x}$ = 0.6 unhatched eggs per successful nest) did not differ among years or nest initiation dates, and may be related to exposure to contaminants. The rate of partial depredation also did not vary among years or initiation dates (23% of nests, $\bar{x}$ = 0.5 eggs taken/successful nest). We detected no effect of marking or visitation on daily survival rate of nests. Nests initiated early in the year were more successful than late nests; thus, early nesting females laid larger clutches and were more likely to nest successfully than late nesters. Nest success varied among years and declined from 73% in 1991 to 18% in 1994. Nest success increased to 76% in 1995 when we reduced the Mew Gull (*Larus canus*) population on the study area. While inviability and partial depredation averaged over 1 egg per successful nest, the production lost in nests that were abandoned or completely destroyed by predators was much greater. Our data indicate that Spectacled Eiders nesting on our study area experience relatively high production; however, without information regarding annual survival and recruitment. it is not possible to draw conclusions about population growth rates.

Key words: Somateria fischeri, *Spectacled Eider, nest success, nesting chronology, duckling production, clutch size, Yukon-Kuskokwim Delta, Alaska.*

INTRODUCTION

Spectacled Eider (*Somateria fischeri*) populations in western Alaska probably have been declining since the 1970s (Stehn et al. 1993, Ely et al. 1994), and the species was declared threatened in 1993. Demographic studies of Spectacled Eiders are difficult to conduct because they nest in remote areas along the Chukchi, Bering, and Beaufort sea coasts and spend much of the year offshore in these northern seas (Petersen et al. 1995).

Dau (1974) studied the nesting biology of Spectacled Eiders on the Yukon-Kuskokwim (Y-K) Delta from 1969–1972 and provided estimates of clutch size, hatching success of eggs, and apparent nest success. Stehn et al. (1993) provided information on clutch sizes and an index to apparent nest success from random plots throughout the Y-K Delta from 1965–1992. They suggested that apparent declines in clutch size since the mid-1960s and early 1970s were due to either poor detection of small clutches or changes in the age structure of the population. Numerous demographic studies of congeneric colonial nesting Common Eiders (*Somateria molissima*) exist, however it is unlikely that those estimates apply to Spectacled Eiders which are smaller bodied and nest farther inland in relatively low densities (Stehn et al. 1993). We investigated the possibility that low production was impeding the recovery of Spectacled Eider populations. Our objectives were to describe nesting chronology and clutch size, estimate nest success, and examine factors influencing the productivity of Spectacled Eiders nesting along the lower Kashunuk drainage on the Y-K Delta, Alaska. We also examined the potential bias in our estimates of nest success.

METHODS

STUDY AREA

The Hock Slough study site on the lower Kashunuk River lies in the central portion of the coastal fringe of the Y-K Delta (61°20′N, 165°35′W). The area falls mainly on old estuarine deposits; therefore, elevations are extremely low, and high tides flood nearly the entire area. Grand et al. (in press) describe the study area in

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detail. We searched on foot and with the aid of dogs an area up to 27.4 km^2 each year for nests. In 1991, eider nests were discovered between mid-May and late June while we were searching slough banks and pond shores for Northern Pintail (*Anas acuta*) nests (Flint and Grand 1996). In 1992–1995, we searched specifically for Spectacled Eider nests from 1–10 June, systematically using 4–8 persons walking 20–50 m apart. Nests discovered opportunistically also were included in the analysis. We numbered and candled each egg to determine viability and stage of incubation (Weller 1956). Typically, nests were marked with a 1 m lathe placed 5 m north of the nest. During each visit to a nest, we recorded the presence of the female, condition and number of eggs, and stage of incubation.

MONITORING

In 1991, we did not revisit Spectacled Eider nests until after hatch when fate was determined from nest contents. In 1992 and 1993, nests were visited at 10- and 7-day intervals, respectively. In 1994, we subjected nests to one of two treatments to estimate the impact of repeated visitation: marked with lathe and visited at 7-day intervals, or not marked and not visited until hatch (control). In 1995, we added a third treatment, marked and not visited until hatch, so we could estimate the effects of marking and visitation independently. The destruction time of control nests in 1994 and nests in all three treatments in 1995 was determined by examining the recorded temperatures of dummy eggs (Flint and MacCluskie 1995) placed in the nest at the time of discovery.

Within 2 days after hatch, we visited nests and determined egg fates from nest contents. We subtracted depredated and unhatched eggs from the number of eggs laid into the nest to determine the number of ducklings produced. We calculated nest initiation dates by subtracting the estimated age of embryos, as determined by candling, plus the number of eggs laid into the nest from the date of discovery. Spring break-up on our study area begins when mixed snow pack and meltwater flood the entire area. Spring floods recede when the ice breaks on the large sloughs that drain into the Kashunuk River. Finally, ice on the Kashunuk River breaks up and flows out to sea. Therefore, we used the date of the initial movement of ice on the Kashunuk River near Old Chevak, 15 km upstream from our study site (61°23′N, 165°28′W), as an indicator of phenology (C. R. Ely, unpubl. data).

STATISTICAL ANALYSIS

All means are reported with standard errors. We only used nests containing eggs that showed signs of embryonic development in the analyses of nest initiation date and nest success. Only nests that survived to incubation were used to calculate clutch sizes. Because we trapped females on the nest 0–5 days prior to hatch for concurrent studies, we excluded observations after trapping from the analysis of nest success. We did not include nests observed in 1991 in the analysis of partial depredation, egg viability, or ducklings hatched, because those nests were not visited regularly during incubation. We adjusted for annual differences in nesting chronology by subtracting the median nest initiation date each year prior to comparisons of clutch size, partial depredation, and egg viability.

We used one-way analysis of variance for ranked data to compare median nest initiation dates among years (Conover 1980). We used linear regression to test the relationship between nest initiation dates and break-up of river ice. We used analysis of covariance with years as a main effect and adjusted initiation dates as a covariate to examine the effects of year and initiation date on clutch size. Orthogonal contrasts (Steel and Torrie 1980) were used to compare mean clutch sizes among years. We defined clutch size as the number of eggs laid into a nest, partial depredation as the number of eggs missing from nests that remained active, and successful nests as those in which at least one egg hatched. Egg viability was determined from the number of eggs that did not hatch in successful nests. We also used analysis of covariance to examine partial depredation on nests, egg viability, and ducklings hatched in relation to year and nest initiation date. We used contingency tables to examine annual variation in the proportion of nests where partial depredation and inviable eggs occurred.

We used daily survival rates (DSR) to examine nest success (Johnson 1979). Nests found destroyed, abandoned, or hatched, and those for which an accurate initiation date could not be determined, were not used in the analysis of nest success. We examined variation in DSR among years due to nest age and initiation date using the technique of Klett and Johnson (1982) as

TABLE 1. Date (Julian) of break-up of river ice, clutch size (least squares mean ± SE), chronology of nesting (Julian dates), and nest success (± SE) of Spectacled Eiders along the lower Kashunuk River, Alaska 1991–1995.

Year	n	Break-up	Clutch size	Nest initiation date: Earliest	25%	Median	75%	Latest	Nest success
1991	22	144	5.6 ± 0.2	136	141	143.5	148	157	0.73 ± 0.11
1992	25	156	5.2 ± 0.1	149	153	157.0	161	173	0.42 ± 0.11
1993	66	144	5.2 ± 0.2	142	145	148.0	151	161	0.29 ± 0.06
1994	69	142	4.8 ± 0.1	138	142	145.0	150	162	0.18 ± 0.05
1995	81	141	5.3 ± 0.1	138	144	145.0	149	170	0.76 ± 0.06
Overall	263	145	5.2 ± 0.1	136	144	147.0	151	173	0.48 ± 0.12

modified by Grand (1995). For nests monitored with temperature recorders, nest exposure days were inferred from nest temperature records. Nests were assumed to have been destroyed when nest temperature began declining and subsequently remained below 30°C. When the time of nest destruction was not known, we used maximum-likelihood estimates assuming constant DSR for each year (Johnson 1979) as an initial estimate of DSR and then calculated the conditional probability that a nest was destroyed on each day of an observation interval, given that it was destroyed by the end of the interval. Similarly, the exposure of failed nests was partitioned across observation intervals. To avoid DSR based on a small sample, we then summed the exposure and mortalities for all nests within 5-day nest age (AGE) and 10-day initiation date (INIT) groups (Grand 1995, Flint and Grand 1996). Using these partitioned estimates, a separate DSR was calculated for each AGE and INIT. Variation in DSR by year, AGE, INIT, and the interaction of AGE and INIT was examined using analysis of covariance with exposure days as a weighting factor (Klett and Johnson 1982). We used year as a main effect, and AGE and INIT were treated as continuous covariates.

Because DSR did not vary by AGE, we estimated annual nest success by summing exposure days and mortalities within INITs and calculating a separate DSR for each INIT. We corrected for INIT related variation in DSR by weighting each respective estimate of success by the proportion of nests initiated in each respective INIT block. We calculated the standard error of nest success each year using a bootstrap approximation with 1,000 repetitions (Effron and Tibshirani 1993). We compared estimates of nest success using χ^2-test for independent survival rates (Sauer and Williams 1989). Because we found no differences among years or INITs in the number of ducklings hatched from nests, we used the product of the proportion of successful nests and the proportion of nests initiated as an indicator of duckling production during each INIT. We used DSR^{29} to estimate nest success based on an average clutch size of 5 eggs and an average incubation period of 24 days.

RESULTS

CHRONOLOGY AND CLUTCH SIZE

Over 87% of nests were discovered prior to 12 June. Nests included in analyses were found during laying (33%) or incubation (67%). The timing of nest initiation varied among years ($F_{4,258} = 18.9$, $P < 0.01$). Median nest initiation date was correlated with the date of break-up on the lower Kashunuk River ($R^2 = 0.86$, $P = 0.01$) (Table 1). In all years, females initiated nests over a relatively short period. The mean period over which 90% of eiders initiated nests was 15.8 ± 1.1 days.

Clutch size ranged from 2–7 eggs, varied among years, and declined with nest initiation date ($F_{5,257} = 18.8$, $P < 0.01$). The rate of decline was similar each year (−0.10 ± 0.01 eggs day^{-1}). Clutch size was lower in 1994 versus all other years ($F_{1,257} = 12.4$, $P < 0.01$), but clutch sizes in 1992, the late year, were similar to 1991, 1993, and 1995 ($F_{1,257} < 0.01$, $P = 1.0$). We estimated an average of 4.3 ± 0.2 ducklings hatched in each successful nest (n = 15, 15, 22, and 33 in 1992–1995, respectively). Number of ducklings hatched per nest did not vary among years or nest initiation dates ($F_{7,77} = 1.4$, $P = 0.21$).

We found inviable eggs in 24% of all nests we monitored, and there was no variation in the proportion of nests containing at least 1 inviable egg each year ($n = 85$, $\chi^2_3 = 4.7$, $P = 0.19$). The occurrence of nests containing inviable eggs was not related to clutch size ($\chi^2_4 = 4.9$, $P = 0.29$). The mean number of inviable eggs in nests containing at least one dead egg was 2.0 ± 1.4 and did not vary by year or nest initiation date ($F_{7,50} = 0.6$, $P = 0.77$). We found an average of 0.6 ± 0.1 inviable eggs in successful nests across all years.

The proportion of successful nests from which predators took eggs was correlated with nest success (see below) ($R^2 = 0.93$, $F_{1,2} = 25.9$, $P = 0.04$). Partial depredation was lowest in 1995, the year we reduced the Mew Gull population on the study area. Eggs were taken from 37% of successful nests in 1992-1994 and 12% of successful nests in 1995 ($\chi^2_1 = 4.5$, $P = 0.03$). Predators took an average 0.5 ± 0.1 eggs from successful nests, and the number of eggs taken did not vary among years or nest initiation dates ($F_{7,15} = 1.2$, $P = 0.37$).

NEST SUCCESS

The DSR of nests marked and visited in 1994 (0.9378 ± 0.0155, $n = 14$) was not different ($\chi^2_1 = 1.4$, $P = 0.24$) from that of control nests monitored with temperature loggers (DSR = 0.9588 ± 0.0152, $n = 61$). In 1995, we found no differences ($\chi^2_2 < 0.01$, $P = 1.00$) in the DSR of nests subjected to marking and 7-day visitation (0.9931 ± 0.0478, $n = 27$), nests marked and not visited until hatching (0.9941± 0.0540 $n = 20$), and those not marked or visited until hatching (0.9901± 0.0496 $n = 23$).

Because we found no differences in mean DSR due to observer impact, we combined all nests in the analysis of nest success ($n = 270$). The analysis of covariance model, DSR = YEAR AGE INIT AGExINIT, explained much of the variation in DSR ($F_{7,91} = 4.9$, $P < 0.01$). However, AGE ($F_{1,91} = 1.9$, $P = 0.17$) and the interaction between AGE and INIT ($F_{1,91} = 2.1$, $P = 0.16$) explained little of the variation. Most of the variation was explained by differences among years ($F_{1,91} = 4.6$, $P < 0.01$) and INIT blocks ($F_{1,91} = 8.9$, $P < 0.01$). Nest success declined later in the nesting season, however it was the pattern of nest initiations that had the greatest impact on the timing of duckling production (Fig. 1). Estimates of nest success each year varied from 18 to 76% (Table 1). Based on our estimates of nest success, partial depredation, and hatchability, most eggs (52%) were lost in nests that were abandoned or destroyed completely by predators. Only 5% of all eggs did not hatch because of inviability and 6% were taken from successful nests.

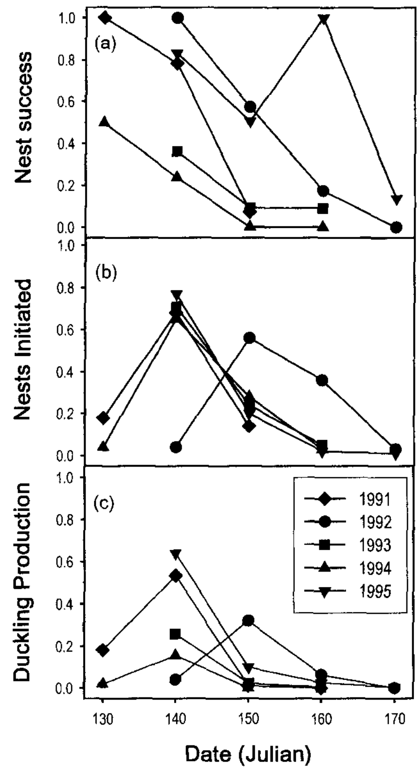

FIGURE 1. (a) Nest success (DSR^{29}), (b) proportion of nests initiated, and (c) duckling production (proportion of successful nests x proportion of nests initiated) of Spectacled Eiders during 10-day nest initiation periods along the lower Kashunuk River, Alaska 1991–1995.

DISCUSSION

Spring break-up on our study area proceeded with mixed snow pack and meltwater flooding the entire study site until ice in slough channels opened up and drained the area. The break-up of ice on the Kashunuk River occurred soon after the slough channels were open. The chronology of nesting by Spectacled Eiders varied among years in response to the timing of spring break-up (Mickelson 1975, Dau 1976). When cool temperatures delayed snow melt, break-up, and subsequent drainage, eiders initiated nests later. In relation to other waterfowl nesting at the same site, Spectacled Eiders initiated nests on approximately the same dates as Cackling Canada Geese (*Branta candensis mimima*; C. R. Ely, pers. comm., Mickelson 1975), but later than first nesting Northern Pintails (Flint and Grand 1996) and Black Brant (*Branta bernicla bernicla*; Lindberg et al. 1997), and well before Greater Scaup (*Aythya marila*; J. B. Grand, unpubl. data). Although Spectacled Eiders are known to renest infrequently, and some proportion of late nests may be renests (J. B. Grand, unpubl. data), 90% of females initiated laying over a relatively short period of approximately two weeks each year.

Dau (1976) also found reduced clutch sizes for Spectacled Eiders in years with late nest initiation, and attributed the differences to nutritional stress on nesting females. We observed no change in clutch size in 1992 when nest initiation began at least one week later than in other years. We assume that Spectacled Eiders, like Common Eiders, rely heavily on stored energy reserves for egg production (Parker and Holm 1990). Thus, we suggest that in 1992, Spectacled Eider females were able to maintain reserves for egg laying by feeding in spring staging areas or in flooded nesting habitats as Lindberg et al. (1997) suggested for Black Brant. Furthermore, in 1994 when partial predation was highest and nest success on our study area was lowest, we found a lower mean clutch size, similar to that reported by Ely et al. (1994) and Stehn et al. (1993) for the years 1965–1996, and Dau (1976) in years of late initiation. Therefore, we propose that the lower clutch sizes observed by others, like the annual changes in mean clutch size we observed, were due to undetected partial predation that occurred prior to onset of incubation.

We also observed a seasonal decline in clutch size that did not differ among years. Dau (1976) found a nearly identical trend and attributed it to early nesting by more experienced females. Milne (1974), Gorman (1970), and Lewis (1939) also reported smaller clutches in Common Eider nests initiated later in the nesting season. Furthermore, Baillie and Milne (1982) found that, in Common Eiders, younger females nested later, laid smaller clutches, and were lighter at the end of laying in comparison to older females. Therefore, it is entirely possible that the seasonal decline in clutch size of Spectacled Eiders is due to age-related differences in reproduction. Alternatively, others have suggested that among waterfowl, condition is related to clutch size and females in poorer condition may delay nest initiation (Esler and Grand 1994).

When we examined the influence of declining nest success in light of the timing of nest initiation, we found that most ducklings were produced by females initiating nests during a relatively short period each year, and this occurred even when nesting chronology was delayed. Although productivity was greatly influenced by the fact that most Spectacled Eider nests were initiated over a two-week period each year, there was a detectable decline in DSR, and thus success, of nests started in later periods of initiation. Flint and Grand (1996) found that nest success of Northern Pintails on the same area declined in a similar fashion. Like Flint and Grand (1996), we believe that DSR of Spectacled Eider nests declines because there are fewer nests available for avian predators later in the nesting season. However, if young females or females in poor condition nest later (Baillie and Milne 1982, Esler and Grand 1994), they also may be less likely to complete incubation. Furthermore, Erikstad et al. (1993) suggest that body condition influences nest attendance, and Swennen et al. (1983) demonstrate that most egg loss occurs when female Common Eiders are off of their nests. Thus, the seasonal declines in clutch size and nest success may be related to age and or condition of late nesting females.

Although complete nest destruction or abandonment results in a much larger loss of production, 5% of the eggs in all Spectacled Eider nests did not hatch because they were inviable. Thus, approximately 10% of eggs in successful nests did not hatch due to either embryonic mortality or infertility. Whereas the proportion of inviable eggs was relatively low, the proportion of successful nests containing eggs that were inviable (24%) was higher than we expected. Swennen (1983) found that only 0.6–4.3% of successful Common Eider nests in the Netherlands contained eggs that did not hatch. Embryonic mortality in waterfowl has been correlated with exposure to heavy metals such as selenium (Heinz et al. 1989). Furthermore, poor hatching success has been attributed to lead poisoning in breeding waterfowl (Elder 1954), and extensive evidence of lead poisoning exists for Spectacled Eiders on our study area (Franson et al. 1995, Flint et al. 1997). The cause of embryonic mortality in our population is unknown, yet we suspect that it may be related to exposure to contaminants.

We found relatively wide variation (18–78%) in nest success among years that was likely due to changes in Mew Gull (*Larus canus*) populations. Although we did not conduct a controlled study of their influence on nest success, nest success declined from 1991–1994 and then increased sharply in 1995 following removal of Mew Gulls. Flint and Grand (1996) found that nest success of Northern Pintails on the same area also declined from 1991–1993. They attributed the decline to increased avian depredation as evidenced by increasing rates of partial depredation of nests. Our results support this conclusion because we found that nest success was highest and the rate of partial depredation was lowest when we controlled Mew Gulls.

Our estimates of nest success assumed that there was no observer bias. Esler and Grand (1994) found no effect of infrequent visitation on the depredation rate of dummy nests. Additionally, Greenwood and Sargeant (1995) found that nest success was uninfluenced by the type of nest markers we used, but Hein and Hein (1996) found that nest markers tended to increase predation rates of artificial nests. We also attempted to examine the effect of nest markers and weekly visitation on nest success by monitoring Spectacled Eider nests using temperature recorders. Although we found no significant differences in DSR between treatments in 1994, the estimates of DSR suggest that success of nests that we visited was 14% lower than that of unvisited nests. Thus, we caution that our presumption of no observer impact in 1994 may be related to small sample size. Removing gulls in 1995 affected the outcome of the nest experiment and we saw no apparent trend in the DSR among treatments in 1995. Because observer impacts were minimal when Mew Gull populations were reduced, we conclude that if observer impacts exist, they are likely caused by increased detection by avian predators. We also recommend that researchers incorporate similar tests of assumptions to quantify the biases associated with field studies.

In combination, nest success and duckling survival are good measures of productivity, and our data along with those of Flint and Grand (1997) suggest that productivity is relatively high. It is not surprising that our range of estimates for nest success is similar to, but somewhat lower than, the range of estimates of apparent success for Common and Spectacled Eiders (33–86%, Sargeant and Raveling 1992). Estimates of apparent nest success typically are biased high (Johnson 1979). Additionally, Flint and Grand (1997) found Spectacled Eider duckling survival higher than that for Common Eiders. However, without estimates of annual survival and recruitment it is not possible to interpret the significance of productivity estimates to population growth rates.

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