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SURVIVAL OF NORTHERN PINTAIL DUCKLINGS ON THE YUKON-KUSKOKWIM DELTA, ALASKA

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Abstract. We studied survival rates of Northern Pintail (*Anas acuta*; hereafter pintail) broods and ducklings along the lower Kashunuk River on the Yukon-Kuskokwim Delta, Alaska. Survival rates were determined for 770 ducklings in 111 broods. Brood sizes at hatch were smaller in 1993 versus 1991 and 1992. Duckling survival rates were lower than those reported in previous studies and differed among years. Survival rates of ducklings declined with hatching date at a rate of 0.6% per day. Most mortality occurred during the first 10 days after hatch. Duckling survival rates were correlated with reported annual and seasonal variation in nesting success. This covariation probably results in large geographic and annual fluctuations in pintail production on the Yukon-Kuskokwim Delta. Early nesting pintails had better nesting success and duckling survival, which may offset higher nutritional costs of early nesting through higher recruitment.

Key words: Alaska; brood survival; duckling survival; hatching date; Northern Pintail; Anas acuta; *recruitment; productivity.*

INTRODUCTION

During 1991–1993, approximately half of the Northern Pintails (*Anas acuta*; hereafter pintails) counted on surveyed areas in North America were found in Alaska (U.S. Fish and Wildl. Serv., Laurel, MD, unpubl. data). Hestbeck (1995) suggested that productivity was relatively constant in northern areas, but diminished in prairie-parkland areas in recent years. With this shift in distribution and indications of decreased productivity at lower latitudes, there is increased interest in the productivity of populations breeding in northern areas. Clutch size (Flint and Grand 1995) and renesting ability (Esler and Grand 1994) do not appear to limit pintail populations in Alaska. Although nesting success may be low in interior Alaska (Grand 1995), success of nesting pintails (i.e., the proportion of hens hatching at least one egg) in some areas in western Alaska is potentially higher than in the Prairie Potholes Region of Canada (Flint and Grand 1996).

Cowardin and Johnson (1979) demonstrated the relative importance of hen success and duckling survival to recruitment by Mallard (*Anas platyrhynchos*) populations. Johnson et al. (1987) pointed out the importance of duckling survival estimates in the study of duck population dynamics. However, it is difficult and expensive to obtain estimates of duckling survival and mortality, and waterfowl managers typically use brood counts to index productivity. Ball et al. (1975) were among the first to point out that studies using marked individuals were needed because duckling mortality is underestimated in brood counts since total brood loss is ignored. Subsequent research indicates that total brood loss accounts for most duckling mortality (Talent et al. 1983, Duncan 1986, Orthmeyer and Ball 1990, Rotella and Ratti 1992, Mauser et al. 1994). Our objectives were to determine rates of total brood loss and duckling mortality for pintails on the Yukon-Kuskokwim Delta (YKD) by observing radio-marked females during brood rearing. We also examined the effects of hatching date and year on brood loss and duckling survival.

METHODS

We conducted this study along the lower Kashunuk River (61°10′ N, 165°30′ W) in the central portion of the coastal fringe of the YKD. Flint and Grand (1995) provide a physical description of the habitat. Tande and Jennings (1986) and Kincheloe and Stehn (1991) described elevation and floral characteristics of the area.

We searched approximately 27 km^2 for nests, and tracked broods over an area of approximately 90 km^2. Nest searches and monitoring

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were conducted from mid-May through early July as described in Flint and Grand (1996). We trapped females on nests 1–5 days before hatch using bow-nets (Salyer 1962). Females were marked with USFWS aluminum leg bands and 20 g back-mounted transmitters (Dwyer 1972). After handling, we anesthetized females using methoxyflurane to reduce nest abandonment (Rotella and Ratti 1990). We monitored the presence of each radio-marked female on the study area daily using simultaneous triangulation from a network of four to five fixed stations. Monitoring the location of females daily reduced the number of missed observations. Also, we were able to detect malfunctioning transmitters before they failed completely, therefore we were certain those females did not leave the study area after losing broods between counts.

Initial brood size was determined by subtracting the number of eggs that did not hatch from clutch size recorded during the last nest visit. We counted the number of surviving ducklings in broods of radio-marked females at ages 7, 14, 21 (1991 only), and 30 days after hatching. We located brood-rearing females and attempted to count ducklings with a minimum of disturbance. However, in open tundra habitat we found it impossible to approach females undetected, and sometimes broods moved overland between adjacent wetlands in response to our presence. We restricted our analysis to ducklings less than 30 days of age because older ducklings were capable of limited flight and some females were suspected of abandoning older broods.

If we saw ducklings with a female, or the female performed a distraction display, we assumed at least one duckling in the brood was alive. We assumed all ducklings were dead if we saw no ducklings and the female did not attempt to hide from or distract the observer on two consecutive visits one to three days apart. When unable to locate radio-marked females on the study area, we used aircraft to search a minimum 40-km radius from the center of the study area. We assumed that all ducklings were dead when a female with a functioning transmitter was relocated further than 20 km from the study area. We observed some failed and failing transmitters during the study. Those broods were not included in overall estimates of duckling survival and were right-censored in the analysis of survival by age. Ambient temperatures (±0.2°C) were recorded hourly using a single channel data logger.

ANALYSES

We defined brood survival as the proportion of broods containing at least one duckling 30 days after hatching. Variance was determined from a binomial distribution (Steel and Torrie 1980). We assumed errors counting ducklings were random, and censored duckling exposure days to avoid dependency among observations. Therefore, we did not use exposure days for ducklings missed on a prior count.

We calculated duckling survival rates through 30 days posthatching using the Kaplan-Meier method (Pollock et al. 1989), and estimated the variance of the duckling survival rate as a proportion in a cluster sample with individual broods as clusters (Flint et al. 1995a). However, many of our observations at ages <30 days were not complete, as ducklings were not counted. Thus, the number of duckling counts in some age classes was small, and we could not use Kaplan-Meier methods to describe the age of mortality. We compared survival among years using a chi-squared test for independent survival rates (Sauer and Williams 1989). We examined the effect of hatching date on duckling survival using analysis of covariance. The proportion of ducklings surviving within a brood was the response variable. Year was the main effect, and hatch date was the covariate. Initial brood size was used as a weighting factor to remove bias from the estimates of duckling survival (Flint et al. 1995a). Hatching dates were adjusted using the differences among mean nest initiation dates each year prior to analysis (Flint and Grand 1996).

We calculated daily survival rates (DSR) for ducklings from Kaplan-Meier survival rates by the formula: $DSR = (S)^{1/i}$, where i is 30, the length of the observation interval in days and S is the proportion of ducklings surviving the interval (Flint et al. 1995a). We examined variation in DSR with duckling age using conditional probabilities of mortality and exposure (Klett and Johnson 1982). We allowed for counting errors by adding ducklings to the brood using the same procedure (Flint et al. 1995b). We calculated the conditional probability of an observed change in brood size occurring on each day of an observation interval, given that it had occurred by the end of the interval. This method partitioned exposure days and changes in brood size among each day of the interval in which a change in brood size was observed. We summed the mor-

TABLE 1. Average brood size (± SE) at hatch and earliest, latest, and median hatch dates of Northern Pintails along the lower Kashunuk River, Alaska.

			Hatch dates		
Year	n	Brood size[a]	First	Last	Median
1991	44	7.07 ± 0.217^A	16 June	13 July	28 June
1992	50	7.16 ± 0.256^A	23 June	16 July	30 June
1993	17	5.94 ± 0.633^B	18 June	7 July	26 June
TOTAL	111	6.94 ± 0.176	16 June	16 July	30 June

[a] Means followed by the same letter do not differ $P < 0.05$.

talities and exposure days over all broods and calculated the survival probability for each day. This method allowed us to estimate survival rates of ducklings for each day through 30 days of age. The product of individual DSRs provided an estimate of the survival function and cumulative estimates of duckling survival (Klett and Johnson 1982, Flint et al. 1995b). Klett and Johnson (1982) did not suggest a means of estimating confidence intervals on survival curves. The proportion of mortalities occurring by 10 days of age was estimated by $(1 - S_{10})/(1 - S_{30})$ where S_{10} is the product of DSRs through age 10 and S_{30} is the product of DSRs through age 30. Standard errors follow estimates of means, survival rates and regression parameters.

RESULTS

We used 111 females that successfully hatched at least one egg in our analysis (Table 1). Those 111 broods contained 770 ducklings. We did not include 24 females on nests that failed to hatch due to predation or flooding; 3 females that lost transmitters; and 3 (1991 only) that were censored due to suspected transmitter failure prior to 30 days posthatching. Average initial brood size differed among years ($F = 3.00$, df = 2, 109, $P = 0.005$). Initial brood sizes were larger in 1991 and 1992 than in 1993 ($P < 0.05$). Duckling survival through 30 days of age also varied among years ($\chi^2 = 9.46$, df = 2, $P = 0.009$). Survival rates were higher in 1991 and 1992 versus 1993 (0.1447 ± 0.0345, 0.1315 ± 0.0336, and 0.0396 ± 0.0213, respectively; $\chi^2 = 9.42$, df = 1, $P = 0.002$). Brood survival also varied among years ($\chi^2 = 5.51$, df = 2, $P = 0.0637$) at 0.4545 (± 0.0751), 0.3654 (±0.0445), and 0.1765 (±0.0925) in 1991–1993, respectively.

Hatch dates ranged over 27, 23, and 19 days during 1991, 1992, and 1993, respectively. Kaplan-Meier estimates of duckling survival within broods declined with hatching date by 0.00680 (±0.00357) per day ($F = 3.78$, df = 1, 110, $P = 0.054$, $R^2 = 0.0333$; Fig. 1). We detected no difference in the rate of decline in survival among years ($F = 0.90$, df = 2, 106, $P = 0.4095$). Within years, duckling mortality was highest during the first 10 days posthatching (Fig. 2). During 1991, 1992, and 1993, 80, 72, and 89% of duckling losses occurred during the first 10 days after hatching.

DISCUSSION

Cowardin et al. (1985) suggested that recruitment rate was the most important factor affecting population size for Mallards in North Dakota. Our data indicate that nesting success and brood survival, which determine recruitment rates, also limit pintail populations in subarctic environ-

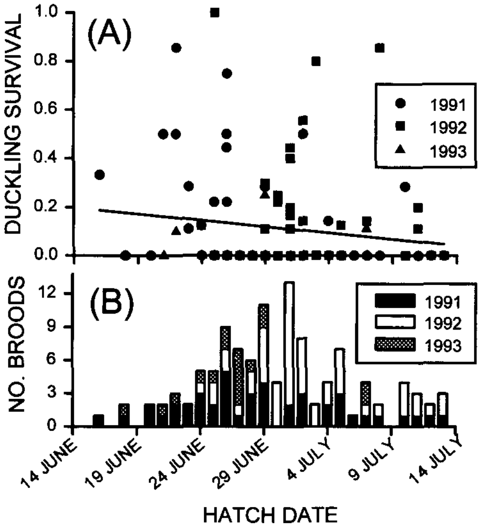

FIGURE 1. Pintail duckling survival (a; y = 0.3052 − 0.0069x) and number of broods observed (b) each year by hatching date on the Yukon-Kuskokwim Delta, Alaska, 1991–1993.

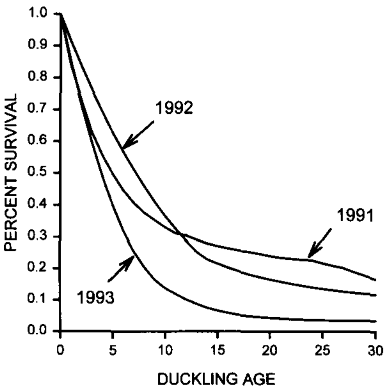

FIGURE 2. Proportion of pintail ducklings surviving by age on the Yukon-Kuskokwim Delta, Alaska, 1991–1993.

ments. Flint and Grand (1996) found that nesting success was variable and, at least in some areas, higher than nesting success in Prairie areas. However, our estimates of duckling survival are the lowest published for ducks (Table 2). Brood survival in 1991 and 1992 was similar to that observed in most studies of duckling survival, but brood survival in 1993 is also the lowest reported for a study of marked duck broods. Disturbance during observation could have lowered duckling mortality; however, we observed the highest survival rate in 1991, when we visited broods most frequently.

We underestimated duckling survival if partial nest predation occurred between the last nest visit and hatching, thereby inflating our estimates of initial brood size. This type of error would have influenced our estimates most in 1993, when partial predation of successful nests was highest (Flint and Grand 1996). The magnitude of this potential bias is not known. However, visitation intervals at hatch usually were short (≤2 days), reducing the likelihood of an undetected predation event.

We used the approach of Flint et al. (1995b) to examine the timing of duckling mortality (Fig. 2). The resulting pattern of higher survival rates among older ducklings is similar to that observed in other studies of duckling survival and in waterfowl populations in general (Ball et al. 1975, Zicus 1981, Ringelman and Longcore 1982, Hill and Ellis 1984, Mendenhall and Milne 1985, Clark et al. 1987, Savard et al. 1991). When we estimated duckling survival by age, we assumed that duckling counts were unbiased. We were more likely to underestimate the number of ducklings in broods because some ducklings were not seen. Thus we likely underestimated duckling survival, especially when ducklings were ≤10 days old, and the initial decline in survival (Fig. 2) may be too steep (Flint et al. 1995b).

TABLE 2. Summary of published duckling and brood survival estimates.

Species	Broods	Ducklings[1]	Ducklings[2]	Source
Northern Pintail				
(*Anas acuta*)	29%	—	—	Duncan (1986)
(*Anas acuta*)	18–45%		4–14%	This study
Gadwall				
(*Anas strepera*)	0%	—	—	Duncan (1986)
Mallard				
(*A. platyrhynchos*)	48%	63%	35%	Talent et al. (1983)
(*A. platyrhynchos*)	44%	45%	—	Ball et al. (1975)
(*A. platyrhynchos*)	34–70%	48%	22%	Rotell and Ratti (1992)
(*A. platyrhynchos*)	63%	—	40%	Orthmeyer and Ball (1990)
(*A. platyrhynchos*)	19–32%	—	34–36%	Mauser et al. (1994)
(*A. platyrhynchos*)	—	—	68%	Lokemoen et al. (1990)
American Black Duck				
(*A. rubripes*)	55%	—	34%	Reed (1975)
(*A. rubripes*)	81%	—	42%	Ringelman and Longcore (1982)
Wood Duck				
(*Aix sponsa*)	41%	57%	—	Ball et al. (1975)

[1] Does not include total brood loss (i.e., all ducklings in a brood died).
[2] Includes total brood loss.

CAUSES OF MORTALITY

Potential predators of ducklings included Glaucous Gulls (*Larus hyperboreus*), Mew Gulls (*L. canus*), Long-tailed (*Stercorarius longicaudus*) and Parasitic Jaegars (*S. parasiticus*), arctic foxes (*Alopex lagopus*), and mink (*Mustela vision*). Pintail broods often crossed the Kashunuk River (50–300 m) to reach rearing sites, and Glaucous Gulls were observed depredating entire duck and goose broods, including broods of marked pintails, as they crossed the river.

Some ducklings probably died each year from exposure to cool ambient temperatures, low water temperatures, and occasional flooding due to high tides amplified by weather conditions (Flint and Grand 1996). Ambient temperatures 15–30 June 1993 averaged 9.3°C (±2.7) and ambient temperatures during the month of July 1993 averaged 12.5°C (±4.2). Water temperatures during high tide events in 1993 were approximately 13°C (C.A. Babcock, pers. comm.). Low air and water temperatures probably necessitated brooding of young ducklings. During flood tides, brood-rearing females may not have had access to dry land for brooding ducklings. Effects of weather, fluctuations in predation rates, and obstacles to movement, such as large rivers, were not assessed, because it was not possible to determine the causes of mortality.

VARIATION IN SURVIVAL RATES

Pintails are the first ducks to initiate nests in the coastal fringe of the YKD (J. B. Grand, unpubl. data). One cost of early nesting is dependence upon nutritional reserves attained prior to or during spring migration. This dependency is greatest for the earliest nesting females (Esler and Grand 1994). Greater nesting success (Flint and Grand 1996), more time to renest, and greater duckling survival (this study) are perhaps the most significant benefits of attaining and transporting nutritional reserves necessary to nest early at high latitudes.

Flint and Grand (1996) found that nesting success of pintails declined throughout the nesting season. Like Orthmeyer and Ball (1990), Ringleman and Longcore (1982), and Rotella and Ratti (1992), we found that duckling survival declined in late hatching broods. As a result of this within year correlation between nesting success and duckling survival, early nesters produced a large portion of annual recruitment.

The decline in nesting success and duckling survival within years probably was caused by predation patterns. Flint and Grand (1996) suggested that gulls were important predators of duck nests, and that nesting success was higher earlier in the season because many nests of other species were available. The survival rate of pintail ducklings hatched in mid-July probably declined due to a similar lack of other prey for avian predators. Mickelson (1975) observed that most goose and eider nests in the area hatched during late June and early July. We frequently observed Glaucous Gulls feeding on ducklings and goslings during late June and July. Because the relative timing of prey availability is consistent among years, we would expect the pattern of declining duckling survival within years to be consistent each year.

Duckling survival and brood size at hatch also declined across years. Mendenhall and Milne (1985) observed unusually high survival rates among common eider ducklings in years when alternative food sources for gulls were abundant. We also would expect pintail duckling survival rates to reflect spatial and temporal changes in gull numbers and predation rates on nests. The correlation between nesting success and duckling survival within and among years would further amplify annual and geographic variation in pintail recruitment rates from the YKD.

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