

NESTING EFFORT OF NORTHERN PINTAILS IN ALBERTA¹

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Abstract. We studied nesting effort and success of Northern Pintails (*Anas acuta*) in southern Alberta. Annual nesting success estimates ranged from 6–18%. Clutch size averaged 7.2, and declined in a simple curvilinear fashion with nest initiation date. We found no relationship between egg size and clutch size or evidence from one year to the next of a trade-off between current and future investment in eggs. Within-year renesting rate ranged from 55%, based on a sample of 20 decoy-trapped females that lost their first nests to predators, to 85% based on a sample of 13 nest-trapped females forced to renest when we removed their clutches. Greater investment in initial clutches led to longer delays in laying replacement clutches. Because delays in renesting are costly (late-nesting females produce fewer offspring), females must contend with a trade-off between maximizing reproductive output in initial clutches versus the risk of delayed renesting if the first clutch should fail. We suggest that pintail reproductive traits have evolved primarily in response to short nesting seasons and variable environments.

Key words: *Anas acuta*, clutch size, nest initiation date, nesting success, Northern Pintail, renesting, reproductive trade-offs.

INTRODUCTION

The amount of time and energy that individuals allocate to reproduction evolved in response to diverse selective pressures. Many species of northern temperate birds must breed, nest, and raise their young during a relatively short summer. In addition to season length constraints, environmental factors often vary temporally and can exert strong selective forces on reproductive effort and success. For example, initiation date and reproductive effort of waterfowl may be influenced by external forces such as seasonal temperature regimes and wetland conditions (Greenwood et al. 1995). Furthermore, early-nesting waterfowl produce larger clutches (Duncan 1987a, Blums et al. 1997), may have greater nesting success (Flint and Grand 1996a), larger and faster growing young (Lindholm et al. 1994), greater fledging success (Guyn and Clark 1999), and higher local recruitment (Dzus and Clark 1998). Here, we evaluate variation in nesting effort and success of female Northern Pin-

tails (*Anas acuta*; hereafter, pintail) breeding in a prairie habitat.

Nutritional requirements of egg laying are often hypothesized to constrain egg production (i.e., egg-production hypothesis), an argument that is frequently cited in clutch size theory of waterfowl (Ankney et al. 1991), but is strongly supported only for arctic nesting geese (Ankney and MacInnes 1978). Alternatively, factors related to timing of nesting may cause females to exercise restraint when forming eggs. Production of additional eggs can have costs in terms of delayed hatching, because later hatching reduces chances of local recruitment (Dzus and Clark 1998). Furthermore, the laying of additional eggs may reduce opportunities for renesting due to either energetic or seasonal constraints. Thus, we examine whether there is a trade-off between larger first clutches and the amount of time required to lay a replacement clutch.

One of the most pervasive reproductive patterns in waterfowl and other birds is a decline in clutch size with initiation date (Rohwer 1992), a pattern often presumed to result from either renesting or delayed nesting by younger females, which in turn lay smaller clutches.

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However, smaller clutch sizes later in the season may be due to seasonally declining nutrient availability (Ankney and MacInnes 1978), or may reflect an attempt to reduce current reproductive investment in an effort to enhance future breeding potential (Hussell 1972). Therefore, we also test for a seasonal decline in pintail clutch size and look for relationships between current and future reproductive effort.

Egg size is an important determinant of reproductive investment. In most species of waterfowl, individual females show a high repeatability for egg size, suggesting that they cannot alter egg size in response to environmental conditions (Flint and Sedinger 1992). Egg size is thought to be an important reproductive trait because of its positive correlation with offspring survival (Thomas and Peach Brown 1988, Dawson and Clark 1996). Egg composition has been shown to vary allometrically with egg size, and therefore total clutch volume is a better predictor of nutrient investment in a clutch than is clutch size (Flint and Grand 1996b), so we assess variation in clutch volume when examining current versus future investment in eggs.

Nesting success is a critical determinant of productivity. Nesting success of pintails varies annually and geographically (Flint and Grand 1996a), resulting in wide differences in productivity among populations. For females that lose a clutch, renesting is an important strategy that enables females to increase the probability of reproductive success within years (Cowardin and Johnson 1979). Renesting propensity often is dependent on stage of incubation and date at the time of nest loss (Grand and Flint 1996a). We determine nesting success for pintails, test for annual differences, estimate renesting rate, and examine variation in renesting propensity.

Life-history traits of pintails differ from most other upland nesting ducks. Pintails are among the earliest-nesting duck species (Bellrose 1980), and have one of the smallest clutch sizes (Austin and Miller 1995). Furthermore, the incubation period of pintails is relatively short (Bellrose 1980), and renesting persistence is reportedly low (Austin and Miller 1995). Detailed information on pintail reproductive characteristics is lacking, a deficiency identified in recent pintail population models (Carlson et al. 1993, Flint et al. 1998). During 1994–1997, we studied nesting and renesting ecology of pintails in southern Alberta, Canada. Our objectives were

to determine nest initiation dates, clutch sizes, egg volumes, nesting success, and renesting propensity. We compare our results to those from other studies of nesting pintail populations and discuss whether the pintail's unique reproductive traits are adaptations to the environments in which they breed.

METHODS

STUDY AREA

Field work was conducted on the Kitsim Ducks Unlimited Project land (hereafter Kitsim) located near Brooks, Alberta, Canada (50°30'N, 112°3'W) during 1994–1997. Kitsim was constructed during 1980–1983, encompasses approximately 40 km², and contains a main reservoir and 65 managed wetland basins. Basins range in size from 0.5 to 24 ha with some containing small nesting islands measuring 40 × 18 m (Giroux 1981). Water in most basins was less than 1 m deep, except for 1–2-m deep moats around islands. Basins are interconnected through a canal system that allows irrigation water to flow into them through the main reservoir. Depending on water availability, basins are usually reflooded in mid-spring and late-fall, and some become dry by mid-summer.

Upland habitat consisted of mixed-grass prairie, of the needlegrass (*Stipa*)-grama (*Bouteloua*) association (Coupland 1961), which was subject to seasonal grazing by cattle. Dispersed clumps of prickly pear (*Opuntia polyacantha*), ball cactus (*Mamillaria vivipara*), and silver sagebush (*Artemisia cana*) were obvious vegetation components. Emergent wetland vegetation was primarily cattail (*Typha latifolia*) and spikerush (*Eleocharis palustris*). Extensive oil development, consisting of existing well sites and active drilling, occurs throughout the eastern half of the project land.

NEST SEARCHING

During 1994–1996, all upland habitat on approximately 21 km² was systematically searched for nests beginning early May and ending early July. Complete searches were conducted twice each season with an inter-search interval of approximately 28 days. Searches were conducted between 07:30 and 13:00 (Gloutney et al. 1993). A nest was defined as a bowl with ≥ 1 egg tended by a female when found (Klett et al. 1986). Upland habitat was searched using procedures similar to those described by Higgins et al.

(1969) and Klett et al. (1986). Nesting islands in all wetlands were searched on foot at least once during late April or early May. Each time a nest was revisited on an island, the entire island was searched again. This ensured that most islands were searched every week until early July.

Nesting females were identified to species, and stage of incubation was determined by egg candling (Weller 1956). Nest initiation dates were calculated by subtracting the clutch size and number of days of incubation from the date of discovery (Sowls 1955). Nests were revisited every 6–10 days until ≥ 1 egg hatched or the nest was abandoned or destroyed. On each revisit, the number of eggs and stage of development of embryos were recorded. On the last visit, we assigned nest fate to one of five categories. A nest was considered successful if at least one egg hatched, as determined by presence of shell membranes (Klett et al. 1986) or ducklings in the nest bowl, and destroyed if no ducklings hatched and evidence of predation was present. Abandoned nests were non-depredated clutches no longer tended by a female (eggs cold and additional eggs not being deposited daily). For nests that appeared to be abandoned on the day of discovery, we attributed the abandonment to investigator activity. Nests were deemed nonviable if all eggs were infertile or embryos were dead. Nest fate was unknown if the nest could not be relocated. Cause of nest failure was assigned to predation, weather, nest parasitism, fire, livestock, investigator activity, machinery, human activity, or unknown.

Clutch size for nests that survived to incubation was defined as the number of eggs laid in a nest. Clutch sizes of nests that had been parasitized (characterized by presence of Redhead [*Aythya americana*] or Mallard [*Anas platyrhynchos*] eggs in the nest bowl) or exhibited signs of partial nest predation were not used in analyses of clutch size. Maximum lengths and breadths of all eggs in a full clutch were measured to the nearest 0.1 mm with dial calipers. Egg volume was calculated using the equation $\text{Volume} = -0.63392 + 0.53163(\text{length})(\text{breadth})^2$ (Flint and Grand 1996b).

TRAPPING

We used mist nets or walk-in traps to capture nesting pintails late in incubation (Weller 1957, Bacon and Evrard 1990, Dietz et al. 1994). Body

mass (nearest 10 g with a Pesola spring scale), wing chord length (nearest 1 mm with a ruler), and combined length of the head and bill (hereafter head-bill length; nearest 0.1 mm with dial calipers) were measured for all females. The fifth secondary covert was collected, and a visual inspection of the middle secondary coverts was used to classify females as second year (SY) or after second year (ASY), following Duncan (1985). We likely misclassified the age of some females (Esler and Grand 1994a). Given that misclassification was likely random, this error would reduce test power and not lead to false conclusions. Females also were fitted with a standard U.S. Fish and Wildlife Service leg band and nasal tags (Lokemoen and Sharp 1985).

RENESTING

In 1997 we focused our study on renesting by pintails. We reduced the area searched for nests to approximately 6.6 km², enabling us to search the area three times with an interval of 21 days between searches. To obtain renesting estimates, we simulated a predation event by removing clutches from nesting pintails. Before clutches were removed, females were trapped using methods outlined above, and were banded, nasal marked, weighed, and measured. These females also were equipped with an 8-g anchored backpack radio transmitter (Advanced Telemetry Systems, Isanti, Minnesota) attached with a subcutaneous stainless-steel wire (anchor), glue, and three subcutaneous sutures (Mauser and Jarvis 1991, Pietz et al. 1995). The procedure was performed under local anesthetic (Lidocaine), and was approved by the University of Saskatchewan Animal Care Committee (Protocol #940149) on behalf of the Canadian Council of Animal Care.

Females were caught and radio-tagged as early in the season as possible. We limited our sample to females with nests initiated prior to the average median initiation date of 16 May (Table 1). We assumed that these nests were most likely first nests. We attempted to capture females on or before 7 days of incubation, and were successful in capturing 90% of them before this day. Before females were released, all eggs were removed and the nest bowl destroyed.

To determine renesting effort, we used a truck-mounted null-peak antenna system (Kenward 1987) to locate radio-tagged pintails a minimum of twice daily, primarily during the morn-

TABLE 1. Number of nests, initiation dates, clutch size, and nesting success for Northern Pintails nesting near Brooks, Alberta, Canada, 1994–1996.

Parameter	1994	1995	1996
Number of nests	87	93	113
Median nest initiation	12 May	13 May	23 May
Range	7 April–18 June	18 April–17 June	13 April–21 June
Median nest init. upland	13 May	19 May	24 May
Clutch size	7.33 ± 0.16 ^a	7.17 ± 0.16	7.05 ± 0.14
<i>n</i>	65	68	84
Upland nest success (%)	18.0	6.3	11.4
<i>n</i>	54	47	56
95% CI	9.8–32.7	2.3–16.1	5.6–22.6
Island nest success (%)	67.5	53.3	60.0
<i>n</i>	20	30	23
95% CI	45.8–99.0	35.3–80.2	38.2–93.6
Partial clutch loss ^b	16.6	50.0	11.7

^a Mean ± SE; adjusted for initiation date.

^b Proportion of successful nests which lost one or more eggs during incubation.

ing (07:00–12:00) when laying females are likely to be found on their nests (Gloutney et al. 1993). If a female's position was triangulated to the same upland location for five consecutive mornings, the area was visited using a portable receiving system to determine whether the female was in nesting cover, rather than on a nearby wetland. If the female was in cover, she was flushed and the nest, if present, located.

After verifying that a radio-tagged bird was nesting, we monitored nest fate using telemetry. If the female was absent during the daily tracking session, another radio check was made later in the morning. If she again was not on her nest, the nest was visited to determine its status (hatched, destroyed, or abandoned).

DECOY TRAPPING

To gather additional nesting information, pre-laying pintails were trapped during April of each year from 1994–1996 using decoy traps (Sharp and Lokemoen 1987). Traps were set in wetlands where pintail pairs were frequently seen, but to avoid capturing migrants we did not place traps on wetlands with large flocks (> 50 birds). Once captured, females were marked, radio tagged, and measured using techniques described above. Radio-tagged females captured in decoy traps were located twice daily between 07:00 and 13:00, from the morning following marking until late July. Locations and daily monitoring were conducted using methods previously described.

STATISTICAL ANALYSES

Variation in initiation dates was examined using general linear modeling procedures (PROC GLM, SAS Institute 1990) to evaluate effects of year and female age. Multiple comparisons were performed using Tukey's studentized range test. Due to annual variation in nesting chronology, nest initiation dates were standardized for all further analyses by adjusting initiation dates each year to a mean initiation date of zero. Principal components analysis (PROC PRINCOMP) using standardized measures of female head-bill length and wing length was used to provide an index of body size (PC1). PC1 described positive covariation between the two original variables and accounted for 61% of the original variation. To assess whether the relationship between clutch size and initiation date was nonlinear, we used a lack-of-fit test to determine whether the second-order term was necessary. Because clutch size typically declines with nest initiation date, we used analysis of covariance (ANCOVA; PROC GLM) with year and female age as main effects and female size index and adjusted initiation date (and initiation date squared) as covariates. Total clutch volume was calculated as the sum of individual egg volumes within an incubated clutch. Variation in total clutch volume was examined using ANCOVA with year and female age as main effects and adjusted initiation date (and initiation date squared) and female size index as covariates. To examine the trade-off between egg size and

clutch size, we examined variation in date-corrected clutch size (residuals from the clutch size versus initiation date regression) using ANCOVA with mean egg size as a covariate while controlling for possible year and female age/size effects. Current versus future investment in eggs was examined using full clutch information from individual adult females from two sequential years; date-corrected clutch size in year $t+1$ was regressed against date-corrected clutch size in year t . Similarly, initiation date in year $t+1$ was examined using ANCOVA, with covariates initiation date and clutch size in year t .

We estimated daily survival rates (DSRs) of nests by the Mayfield method as modified by Johnson (1979), first excluding nests that contained eggs that were broken by the investigator or abandoned due to our activity. Some nests were fenced to reduce predation for other components of the study (Guyn and Clark 1999), so these nests also were excluded from nesting success estimates. We estimated nesting success separately for island and upland nests, because island nests typically experience higher survival (Duebbert et al. 1983). To evaluate whether DSRs varied seasonally, we partitioned the number of exposure days, successes, and failures into early and late periods based on the annual median initiation date. We tested for variation in DSR across years, within years, and between island and upland nest locations following Sauer and Williams (1989). For ease of interpretation, we converted DSR to nesting success (P), where $P = (\text{DSR})^I$ and $I = 32$, the sum of average duration of laying period plus incubation interval in days (Klett et al. 1986).

We defined renesting interval as the number of days between the date of egg removal and the date the first egg was laid in a subsequent nest. For decoy-trapped females, we used logistic regression (PROC LOGISTIC) to investigate the probability of renesting in relation to female age, past investment (number of days a nest was active), and date which the first nest was destroyed. Furthermore, we used multiple regression to examine the relationship between renesting interval, and the variables past investment and date of first-nest destruction. For nest trapped females, we examined the relationship between female body mass at capture (corrected for size) and incubation stage with linear regression (PROC REG). Likewise, regression analysis was used to examine the relationship

between initiation day of the first nest and female body mass. We used ANCOVA to investigate the relationship between renesting interval, and weight at capture, initiation day of first nest, female size index and age, and total clutch volume of the first clutch.

Values reported are means \pm SE. Unless indicated otherwise, all 2-way interactions were tested and we used a significance level of $P < 0.05$.

RESULTS

NESTING ECOLOGY

Pintail nests ($n = 292$ during 1994–1996) were typically initiated over a 9-week period, with first nests appearing in mid-April (Table 1). Seasonal patterns of nest initiations were similar in 1994 and 1995, but were delayed in 1996 by approximately 10 days ($F_{2,292} = 6.4$, $P = 0.002$; Tukey's test, $P < 0.05$). When we included only nests where females were trapped, initiation dates did not differ by year ($F_{2,153} = 1.2$, $P = 0.3$) or female age ($F_{1,153} = 1.3$, $P = 0.3$).

Using all nests where full clutch size was determined, a quadratic term best described the relationship between clutch size and initiation date (lack-of-fit test, $F_{1,215} = 18.5$, $P < 0.001$; Fig. 1); clutch size did not vary with year ($F_{2,214} = 1.3$, $P = 0.3$) when initiation date was controlled. When we reduced the sample to include only those nests where we caught the female, full clutch size did not vary with female age, year, or size of female (all $P > 0.1$) when initiation date was controlled.

We measured a total of 1,564 eggs with a mean egg volume of 39.85 ± 0.22 cm³. Total clutch volume, adjusted for initiation date, did not vary with year, female age, or size index (all $P > 0.1$). We found no relationship between egg size and clutch size ($F_{1,106} = 0.04$, $P > 0.9$). Likewise, we found no evidence between years for a trade-off between current and future investment in eggs when we regressed date-corrected clutch size in year $t+1$ against date-corrected clutch size in year t ($F_{1,15} = 0.2$, $P > 0.6$). There also was no relationship between initiation date and clutch size in one year and initiation date in the next year ($F_{2,15} = 0.1$, $P > 0.8$).

NESTING SUCCESS

We detected no yearly difference ($\chi^2_2 = 1.9$, $P > 0.3$) in DSRs. Combined estimates (upland and island nests) of nesting success by year were

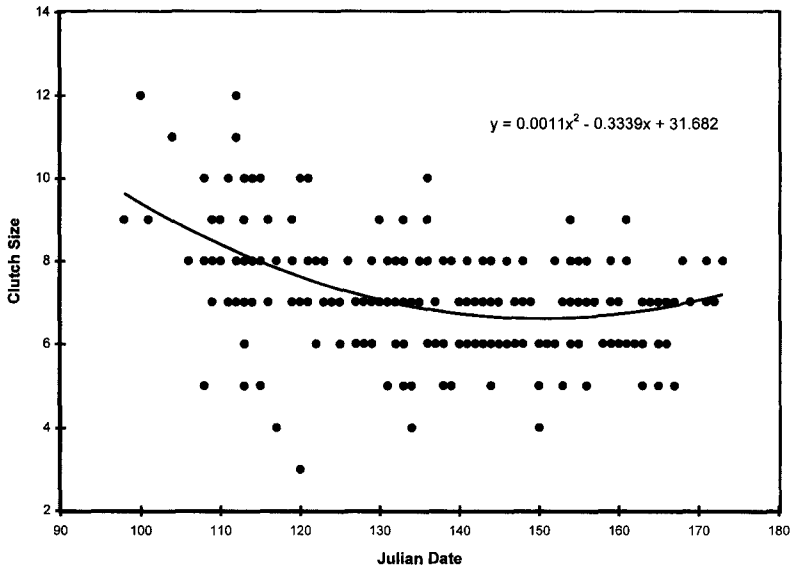


FIGURE 1. Regression of clutch size across nest initiation dates for Northern Pintails nesting at Kitsim, Alberta, Canada. Julian date 90 = 31 March.

29.5% (1994), 22.0% (1995), and 19.5% (1996). Success was higher for nests located on islands than those located in upland habitats ($\chi^2_1 = 45.2$, $P < 0.001$; Table 1). Nesting success did not differ among years for upland nests ($\chi^2_2 = 4.2$, $P > 0.1$) or island nests ($\chi^2_2 = 0.5$, $P > 0.8$). Based on annual median initiation dates, nesting success of upland nests did not vary between early and late nests ($\chi^2_1 = 0.8$, $P > 0.3$). The proportion of successful nests that lost one or more eggs during incubation varied from 12–50% during 1994–1996 (Table 1). The number of eggs lost did not vary with year or initiation date ($P > 0.3$). We estimate that predators destroyed 37–45% of all pintail nests (Table 2).

RENESTING

DECOY-TRAPPED FEMALES

We captured 73 females in decoy traps during 1994–1996. Of these females, 55 were consis-

tently tracked during the breeding season and 42 (76.3%) nested at least once. Fifteen nests subsequently hatched, leaving 27 females that could potentially renest. Of these, 20 were consistently tracked and 11 (55%) renested. Only one female renested twice. Analysis of renesting propensity was hampered due to quasicomplete separation of sample points, which prevented the determination of a maximum likelihood estimator in logistic regression. Further descriptive investigation revealed that probability of renesting was greater for those females that lost their nests early in the year. This analysis was based on a relatively small sample ($n = 20$), so results should be interpreted with caution. Renesting rate during the three years ranged from 36–67%, but these estimates did not differ ($\chi^2_2 = 2.2$, $P > 0.3$). For females which renested, nest initiation dates of first nests varied from 20 April to 21 May. Nest stage at time of destruction varied

TABLE 2. Fates (%) of Northern Pintail nests near Brooks, Alberta, Canada, 1994–1996.

Year	Successful	Destroyed	Abandoned	Investigator abandonment ^a	Other ^b
1994	42.5 (34) ^c	37.5 (30)	12.5 (10)	3.8 (3)	3.8 (3)
1995	32.9 (28)	45.9 (39)	15.3 (13)	4.7 (4)	1.3 (1)
1996	41.1 (37)	41.1 (37)	13.2 (12)	3.3 (3)	1.1 (1)

^a Hen flushed during laying (< 5 eggs), nest abandoned by next visit.

^b Final nest fate unknown.

^c Sample size.

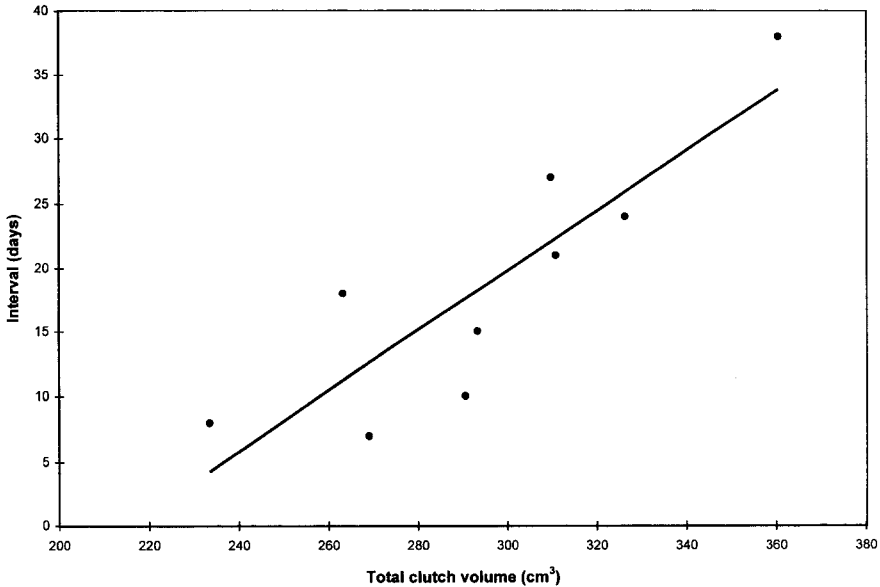


FIGURE 2. Renest interval length relative to total clutch volume of the first nest from Northern Pintails at Kitsim, Alberta, Canada.

from laying to 11 days of incubation. The interval between first and second nest attempts varied from 2 to 29 days ($\bar{x} = 8.6 \pm 2.7$). Few clutches in this sample were measured, therefore detailed analyses could not be performed; however, interval length was not related to past investment (number of days nest was active) or date the first nest was destroyed ($F_{2,9} = 0.8, P > 0.4$).

NEST-TRAPPED FEMALES

Twenty females were nest trapped and radio marked from 1 to 21 May 1997. Incubation stage at capture ranged from 3 to 8 days ($\bar{x} = 5.5 \pm 0.3$). Of these, three left the study area and four were killed (collisions with power lines) prior to renesting. Of the 13 birds remaining in the study sample, 11 (84.6%) initiated new nests, of which 3 were successful. Only two birds attempted a third nest; these two females were the only two that had abandoned their second nests. Although we could not conduct analysis of renesting propensity due to sample size limitations, the two females which did not renest "lost" their nest relatively late compared to others in the sample.

Female body mass at capture varied from 610–760 g, with a mean of 684.6 ± 9.2 g; body mass did not decline with increasing incubation stage ($F_{1,19} = 1.4, P = 0.2$), but incubation stage

only ranged over 5 days. There was no relationship between female body mass during early incubation and initiation day of the first nest ($F_{1,19} = 0.1, P > 0.7$). The interval between first and second nest attempts varied from 7 to 38 days ($\bar{x} = 18.7 \pm 2.7$ days). Interval length rose markedly with increasing total clutch volume of the first nest ($F_{1,9} = 20.7, P < 0.01$; Fig. 2), but was not related to female body mass, size index, age, or initiation day (all $P > 0.1$).

DISCUSSION

NESTING ECOLOGY

Clutch size did not vary among years and was similar to that reported for pintails nesting on the prairies (6.9; Duncan 1987a), but less than for pintails nesting in Alaska (7.63) and Manitoba (8) (Sowls 1955, Flint and Grand 1996a). Duncan (1987a) suggested that pintails in Alberta laid fewer eggs than pintails in Manitoba due to environmental constraints; but data to support his hypothesis were lacking. Nonetheless, the small average clutch size of pintails in this study (7.2), once again demonstrates that pintails lay small clutches compared to other prairie-nesting dabbling ducks.

The mean egg volume in this study (39.8 cm^3) was slightly larger than that found for pintails in

Alaska (38.9 cm³; Flint and Grand 1996b) and for pintails nesting in Alberta (Duncan 1987b; predicted mean egg volume using equation from Flint and Grand 1996b = 38.6 cm³). However, similar to Duncan (1987b) and Flint and Grand (1996b), we found no relationship between mean egg volume and clutch size. At the population level, it is interesting that pintails in Alberta tended to have larger eggs than pintails in Alaska, but produced smaller clutches. This suggests that there may be an intraspecific clutch-size vs. egg-size trade-off at the population level.

The rate of seasonal decline in clutch size was similar to that reported for other prairie nesting pintails but much less than for arctic breeders (Duncan 1987a, Flint and Grand 1996a). Flint and Grand (1996a) speculated that the seasonal decline rate in Alaska was steep due to a short breeding period. The breeding season in Alaska is roughly 20 days shorter (46 vs. 67 days) than in Alberta, a finding that is consistent with this idea. All work on pintails in Alberta (including this study) has been done on areas with managed wetlands. It is unclear whether the rate of decline in clutch size would differ in non-managed areas, where, in most years, wetlands would be dry by mid to late summer.

NESTING SUCCESS

Duncan (1987a) reported that pintail nesting success was high (64%) on unbroken, grazed prairie; however, we studied pintails on large tracts of unbroken prairie and did not find higher nesting success than that found on areas of intensively farmed prairie (7%) (Greenwood et al. 1995). Although we believe that our estimates are unbiased, they may not be representative of mixed-grass prairie as a whole. Managed wetlands and oil and gas infrastructures (roads, powerlines, and well heads) were present on our study area and close proximity to large reservoirs may have had some impact on nesting success.

We found no seasonal difference in nesting success. In Alaska, pintail nesting success decreased seasonally, which was attributed to greater availability of alternative prey (i.e., other waterfowl nests) early in the season (Flint and Grand 1996a). Conversely, prairie nesting pintails are one of the earliest nesting ducks; therefore, there are few other waterfowl nests to function as alternative prey.

RENESTING

Renesting is a strategy which enables ducks to increase within-year reproductive success (Cowardin and Johnson 1979). For ducks, which typically have reduced reserves available for renesting (Krapu 1981, Rohwer 1992), food quality and abundance on the breeding grounds may regulate a female's renesting ability (Krapu 1981).

Our renesting estimate for pintails in 1997 is the highest ever recorded for pintails, but was based on a limited sample of radio-tagged females ($n = 13$) and may therefore not differ from previously published estimates. Duncan (1987a) reported that only 5 of 127 (4%) color-marked and 0 of 17 radio-tagged females renested. However, in that study the detection rate of color-marked females was unknown and nests of radio-tagged females were destroyed at various stages of incubation. Grand and Flint (1996) removed clutches from radio-marked females at 4 ± 1 days of incubation and reported that 56% (22 of 39) renested. Grand and Flint suggested their estimate was probably low because some nests were likely destroyed before being detected, and they were unable to monitor females that left the study area or those with failed transmitters. Our renesting rate estimate from decoy-trapped females was lower than our estimate obtained from nest-trapped individuals. Unlike nest-trapped birds, decoy-trapped females tended to disperse off the study site making tracking more difficult. Therefore, it is possible that we may have missed some short renesting attempts, resulting in a lower renesting rate estimate. Although pintails have previously been thought of as infrequent renesters, our data and Grand and Flint's (1996) suggest that they will often attempt a second nest. Even though our sample size is limited, it appears that pintails rarely attempt more than two nests, unlike mallards which have been reported to nest up to six times (Rotella et al. 1993).

Interval length between first and second nests was positively correlated with total clutch volume of the first nest in 1997. Flint and Grand (1996b) found that total clutch volumes overlapped for clutches of different size and therefore suggested that total clutch volume was a better predictor of nutrient investment. Because egg composition varies with egg size, females with larger clutch volumes in their first nests

committed more nutrients to egg formation. Although renesting pintail females do not use endogenous nutrient reserves for clutch production (Esler and Grand 1994b), females may need to reach some threshold level of stored reserves, perhaps to complete incubation, before initiating a second nest. If this is true, one would then predict that those females which commit the most to their first clutch would take the longest to renest. Furthermore, given that clutch size/volume decreased seasonally, females may be attempting to decrease the interval between nest attempts later in the year. Longer renest intervals may have important implications for reproductive success, given that 10 and 30-day delays could result in 7% and 21% reductions in duckling survival, respectively (Guyn and Clark 1999).

Pintails nest in the prairies, boreal forest, and tundra, environments in which they are challenged by wide fluctuations in timing and duration of resource availability during the nesting and brood rearing periods. We suggest that pintail traits of early nesting, small clutch size, and low renesting persistence are adaptations that enable them to cope with relatively short nesting seasons and variable environments.

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