Nesting Ecology of Tundra Swans on the Coastal Yukon-Kuskokwim Delta, Alaska

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Abstract.—Nesting ecology of Tundra Swans (*Cygnus columbianus columbianus*) was studied along the Kashunuk River near Old Chevak (61°26'N, 165°27'W), on the Yukon-Kuskokwim Delta of western Alaska from 1988–2000. Annual variation in snow-melt chronology, nesting phenology, nesting density, clutch size and nest success was examined. The same area (approximately 23 km^2) was searched each year and nests were found as early as possible in the laying period. Laying initiation dates ranged from 1–27 May and hatch dates from 12 June–4 July among pairs and years of study. The peak arrival of Tundra Swans and the phenology of nest initiation and hatch were highly correlated with the progression of ice and snow melt in spring. Nest density averaged 0.71 km^{-2} and 89% of nesting pairs hatched at least one egg. Incubation period ranged from 26 to 33 days with a median of 30 days. Clutch size varied significantly among years, driven by a low mean value of 3.4 eggs in 1999. Clutch sizes were generally larger than found in previous investigations on the Yukon-Kuskokwim Delta, and nearly one egg larger than reported for clutches from Alaska's North Slope (≈70°N). There was no indication of reduced clutch size in years of late spring snow melt, although nesting density tended to be lower.

Key words.—Tundra Swan, *Cygnus columbianus*, nesting ecology, clutch size, annual variation, Alaska.

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Tundra Swans (*Cygnus columbianus columbianus*) reach their highest breeding densities on the coastal Yukon-Kuskokwim Delta of Alaska (Dau 1981). Previous work on Tundra Swan reproduction on the Yukon-Kuskokwim Delta has focused on the use of aerial survey techniques to examine demographic and breeding productivity parameters (Lensink 1973; Dau 1981), or on description of behavior (Scott 1977; Ely *et al.* 1987). Here data are presented from 13 consecutive years of ground-based breeding studies on the coastal Yukon-Kuskokwim Delta. Annual variation in timing of nesting and snow-melt chronology, clutch size, nesting density, and nesting success is reported. Many of these parameters have been shown in other northern breeding birds to be sensitive to changes in the timing of spring environmental conditions (Crick *et al.* 1997).

STUDY AREA AND METHODS

The study area is located near Old Chevak (61°26'N, 165°27'W) on the central Yukon-Kuskokwim Delta of Alaska (Fig. 1). The physiography and vegetation of the area have been described in detail elsewhere (Babcock and Ely 1994). Briefly, lowland areas are composed of mixed sedge/grass/forb meadows with many lakes and shallow ponds that have maximum depths of <1 m. Upland areas, dominated by dwarf shrub/moss/lichen tundra, are 0.5–1.5 m higher in elevation than lowland meadows, and have numerous larger and deeper lakes.

Date of peak arrival of Tundra Swans was recorded as the day on which daily estimates of numbers on the study area showed the greatest increase. River ice break-up was the date on which river ice first broke and began flowing past our campsite, and date on which uplands were 90% snow-free was determined from daily ocular estimates from 3 m observation towers. Nests were found as early as possible in initiation of laying, so that laying sequence of eggs could be followed. The same area of about 23 km^2 was searched each year using consistent methods and effort. In most years some nests were also monitored outside our plots to increase the sample of nesting data. Nests were visited at least weekly to check status, though somewhat more frequently around initiation and hatch. Nest initiation date was defined as the date that the first egg was observed, or was back-calculated when possible from incomplete clutches assuming a laying interval of 42 hours (Hawkins 1986). Likewise, hatch date was the date that a cygnet was first observed in a nest, or back-dated one day if all eggs were hatched and cygnets were still present in the nest. Incubation period was only calculated from nests for which both initiation and hatch dates were known. Incubation period is defined as the span from the day the last egg was laid to the day of hatching

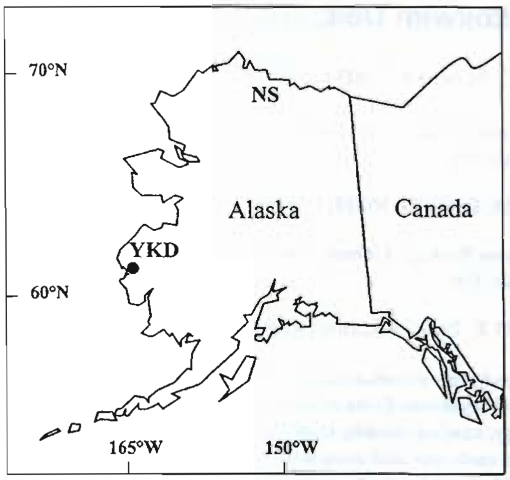

Figure 1. Location of the study area (●) on the Yukon-Kuskokwim Delta (YKD) of Alaska, and location of Alaska's North Slope (NS).

the first egg. Nests were considered successful if we saw at least one pipped egg or a cygnet in the nest, or if visited after hatch, by the presence of at least one characteristic hatched eggshell membrane (Girard 1939).

RESULTS

Tundra Swans were usually present on the study area upon our arrival in late April or early May of each year, when most of the nesting habitat was still snow covered. Measures of spring ice break-up phenology had an interannual range of 15–20 days; peak arrival of swans varied by 17 days among years, and both median nest initiation and hatch date had similar interannual ranges (Table 1). During 1988–1995, with the exception of 1992, median initiation date followed peak arrival by an average of 12 days (range 9–14 days), and in no year did the earliest laid egg precede the date on which uplands were estimated 90% snow-free. Initiation and hatch dates were most highly correlated (Pearson product-moment, here and below) with the date of 90% snow-free uplands ($r_{10} = 0.96$, $P < 0.0003$, and $r_{10} = 0.95$, $P < 0.0004$, respectively), and peak arrival with the date of Kashunuk River ice break-up ($r_6 = 0.89$, $P < 0.003$). Incubation period lengths ranged from 26 to 33 days, with a mean of 29.51 ± 0.17 days (N = 63). Variation among individuals in incubation period was correlated with date of 90% snow free uplands ($r_{61} = 0.29$, $P < 0.02$) and river ice break-up date ($r_{61} = 0.32$, $P < 0.01$), but was not correlated with variation in clutch size ($r_{61} = -0.22$, n.s.). Clutch size varied among years (ANOVA $F_{12, 259} = 2.86$, $P < 0.001$), due mostly to the low value for 1999. There was no significant correlation between average clutch size and river ice break-up date ($r_{11} = -0.48$, n.s.), date of peak arrival ($r_6 = -0.10$, n.s.), or mean nest initiation date ($r_{11} = -0.07$, n.s.). Nest density ranged from 0.48–0.96 km^{-2} and correlated negatively with river ice break-up date ($r_{11} = -0.59$, $P < 0.04$). The proportion of nests that successfully hatched at least one cygnet had a 13-year mean of 0.89 (range 0.73–1.0).

DISCUSSION

Timing of nest initiation and hatch were highly correlated with snow-melt phenology. Median initiation date followed peak arrival by an average of 12 days, suggesting that the estimated 12 day rapid follicle development for Tundra Swans (Alisauskas and Ankney 1992) may begin around the time of arrival on the breeding grounds. Median initiation date from this study (17 May, Table 1) was considerably earlier than the 8-year median of 24 May for the coastal Yukon-Kuskokwim Delta reported by Dau (1981) for the period 1972–1979. This result is consistent with observed trends in northern regional climate inferred from atmospheric CO_2 records (Keeling *et al.* 1996) and satellite imagery (Myneni *et al.* 1997) showing earlier spring plant green-up. Changes in Tundra Swan nesting phenology parallel the advances in laying dates reported for several species of birds in the United Kingdom (Crick *et al.* 1997).

Although incubation period ranged from 26–33 days, the median of 30 days was somewhat shorter than the commonly reported 32 days (Kear 1972; Hawkins 1986). This difference may be due to geographic differences or small sample sizes in the earlier studies. In the present study, incubation periods were shorter and nest initiation earlier in years of earlier snow melt, thus it is possible that better body condition in early years allowed higher incubation constancy

Table 1. Annual variation in spring snow-melt chronology and Tundra Swan nesting variables, 1988–2000, near Old Chevak on the Yukon-Kuskokwim Delta, Alaska. Sample sizes given in parentheses.

Year	Uplands 90% snow-free	Kashunuk River ice break-up	Peak arrival	Median date initiation, range	Median date hatch, range	Mean ±SE clutch size	Nests km^{-2}	Proportion of nests hatching ≥1 egg
1988	12 May	24 May	4 May	17 May (11) 12–25 May	22 June 17–29 June	4.6 ± 0.3 (17)	0.61 (14)	0.92 (12)
1989	22 May	3 June	12 May	25 May (10) 23–27 May	1 July 29 June–3 July	4.6 ± 0.2 (20)	0.61 (14)	0.85 (13)
1990	12 May	26 May	6 May	18 May (20) 11–26 May	23 June 17–30 June	4.7 ± 0.1 (27)	0.91 (21)	0.96 (25)
1991	6 May	24 May	2 May	16 May (19) 12–23 May	21 June 18–28 June	4.8 ± 0.2 (24)	0.96 (22)	0.83 (23)
1992	20 May	5 June	19 May	23 May (12) 20–27 May	28 June 23 June–2 July	4.7 ± 0.1 (23)	0.74 (17)	0.96 (23)
1993	13 May	24 May	7 May	18 May (24) 13–22 May	23 June 19–27 June	4.6 ± 0.2 (28)	0.83 (19)	0.82 (22)
1994	3 May	22 May	4 May	13 May (21) 7–20 May	18 June 13–25 June	4.8 ± 0.1 (23)	0.78 (18)	1.00 (25)
1995	6 May	21 May	6 May	17 May (8) 15–20 May	22 June 18–26 June	4.4 ± 0.2 (17)	0.65 (15)	0.73 (15)
1996	30 April	18 May	—	12 May (13) 6–27 May	20 June 15 June–4 July	4.8 ± 0.2 (21)	0.83 (19)	0.89 (19)
1997	25 April	19 May	—	7 May (8) 1–11 May	15 June 12–19 June	4.2 ± 0.1 (21)	0.78 (18)	0.88 (16)
1998	20 May	31 May	—	20 May (3) 18–22 May	28 June 27–29 June	3.9 ± 0.2 (18)	0.57 (13)	1.00 (7)
1999	14 May	5 June	—	20 May (1)	28 June	3.4 ± 0.1 (10)	0.48 (11)	0.86 (7)
2000	—	4 June	—	16 May (5) 12–19 May	23 June 19–26 June	3.8 ± 0.1 (14)	0.52 (12)	0.89 (9)
Median or mean	10 May	27 May	7 May	17 May	23 June	4.5	0.71	0.89

and therefore shorter incubation length. Nesting density appeared to be stable or even decrease somewhat during our study, and was lower in late break-up years. Apparent nesting success was generally high with a mean of 89%, compared with a range of 25%–85% for Cackling Canada Geese (*Branta canadensis minima*) and Greater White-fronted Geese (*Anser albifrons frontalis*) nesting on the area over the same years (C. R. Ely, unpub.), and there was little apparent variation between years. The large body size of Tundra Swans compared with other waterfowl breeding in the area likely affords them greater protection from the typically small-bodied local egg predators such as Arctic Fox (*Alopex lagopus*), Mink (*Mustela vison*), Glaucous Gull (*Larus hyperboreus*), and Parasitic Jaeger (*Stercorarius parasiticus*).

Clutch size varied little during this study and was slightly greater than earlier estimates for the coastal Yukon-Kuskokwim Delta (4.42 this study; 4.26 in Lensink 1973; and 4.26 in Dau 1981). Our mean clutch size was almost one egg larger than the 3.62 average clutch size recorded for a sample of Tundra Swans nesting on Alaska's North Slope (Monda *et al.* 1994). The geographic difference in reproductive investment could be related to the earlier springs and longer snow-free period of the Yukon-Kuskokwim Delta. Also, Tundra Swans breeding on the Yukon-Kuskokwim Delta are of the Western Flyway population and have a shorter spring migration route (3,500–4,000 km) than do Eastern Flyway swans nesting on the North Slope (5,000–5,500 km), and this may lead to differences in the amount of reserves available for reproduction (Bart *et al.* 1991). Assuming a body mass of 6.3 kg and individual egg mass of 280 g (Alisauskas and Ankney 1992), North Slope swans invest only 16% of their mass in eggs versus 20% for Yukon-Kuskokwim Delta females. We saw no evidence of late spring thaws leading to reduced clutch sizes as found by Lensink (1973) and Dau (1981) for Tundra Swans, and for geese by Barry (1962) and MacInnes and Dunn (1988). Bruggink *et al.* (1994) found no effect of spring conditions on reproductive performance of Canada Geese (*B. canadensis*), while Lindberg *et al.* (1997) found that clutch size actually increased in late spring years for Brant (*B. bernicla*) breeding on the Yukon-Kuskokwim Delta. Our inability to detect effects of spring phenology on Tundra Swan clutch size is possibly due to the lack of very late spring thaws during the years of our study.

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LITERATURE CITED

Alisauskas, R. T. and C. D. Ankney. 1992. The cost of egg laying and its relationship to nutrient reserves in waterfowl. Pages 30–61 *in* Ecology and management of breeding waterfowl (B. D. J. Batt, A. D. Afton, M. G. Anderson, C. D. Ankney, D. H. Johnson, J. A. Kadlec and G. L. Krapu, Eds.). University of Minnesota Press, Minneapolis.

Babcock, C. A. and C. R. Ely. 1994. Classification of vegetation communities in which geese rear broods on the Yukon-Kuskokwim Delta, Alaska. Canadian Journal of Botany 74:1294–1301.

Barry, T. W. 1962. Effects of late seasons on Atlantic Brant reproduction. Journal of Wildlife Management 26:19–26.

Bart, J., R. Limpert, S. Earnst, W. Sladen, J. Hines and T. Rothe. 1991. Demography of Eastern Population Tundra Swans *Cygnus columbianus columbianus*. Pages 178–184 *in* Proceedings of the Third IWRB International Swan Symposium, Oxford, 1989 (J. Sears and P. J. Bacon, Eds.). Wildfowl Supplement Number 1.

Bruggink, J. G., T. C. Tacha, J. C. Davies and K. F. Abraham. 1994. Nesting and brood-rearing ecology of Mississippi Valley Population Canada Geese. Wildlife Monograph 126.

Crick, H. P. Q., C. Dudley, D. E. Glue and D. L. Thomson. 1997. UK birds are laying eggs earlier. Nature 388:526.

Dau, C. P. 1981. Population structure and productivity of *Cygnus columbianus columbianus* on the Yukon Delta, Alaska. Pages 161–169 *in* Proceedings of the Second International Swan Symposium, Sapporo (G. V. T. Matthews and M. Smart, Eds.). International Waterfowl and Wetlands Research Bureau, Slimbridge.

Ely, C. R., D. A. Budeau and U. G. Swain. 1987. Aggressive encounters between Tundra Swans and Greater White-fronted Geese during brood rearing. Condor 89: 420–422.

Girard, G. L. 1939. Notes on life history of the Shoveler. Pages 364–371 *in* Transactions of the Fourth North American Wildlife Conference. American Wildlife Institute, Washington, D.C.

Hawkins, L. L. 1986. Nesting behaviour of male and female Whistling Swans and implications of male incubation. Wildfowl 37:5–27.

Kear, J. 1972. Reproduction and family life. Pages 79–124 *in* The swans (P. Scott and The Wildfowl Trust, Eds.). Houghton Mifflin Co., Boston.

Keeling, C. D., J. F. S. Chin and T. P. Whorf. 1996. Increased activity of northern vegetation inferred from atmospheric CO_2 measurements. Nature 382:146–149.

Lensink, C. J. 1973. Population structure and productivity of Whistling Swans on the Yukon Delta, Alaska. Wildfowl 24:21–25.

Lindberg, M. S., J. S. Sedinger and P. L. Flint. 1997. Effects of spring environment on nesting phenology and clutch size of Black Brant. Condor 99:381–388.

MacInnes, C. D. and E. H. Dunn. 1988. Components of clutch size variation in Arctic-nesting Canada Geese. Condor 90:83–89.

Monda, M. J., J. T. Ratti and T. R. McCabe. 1994. Reproductive ecology of Tundra Swans on the Arctic National Wildlife Refuge, Alaska. Journal of Wildlife Management 58:757–773.

Myneni, R. B., C. D. Keeling, C. J. Tucker, G. Asrar and R. R. Nemani. 1997. Increased plant growth in the northern high latitudes from 1981 to 1991. Nature 386:698–702.

Scott, D. 1977. Breeding behaviour of wild whistling swans. Wildfowl 28:101–106.