Weights and measurements of wintering Tundra Swans

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Introduction

The weight of a bird is one of the easiest body parameters to measure in the field. Weights have been used as a measure of condition for a variety of waterfowl species, primarily geese (Hanson 1962; Raveling 1968; Ankney 1979; Owen and Ogilvie 1979) and diving ducks (Erskine 1971; Ryan 1972; Nichols and Haramis 1980). An extensive analysis of the weights and measurements of the second largest North American species of waterfowl, the Tundra Swan *Cygnus columbianus columbianus* has not been conducted. Banko (1960) gave results from 23 adult Tundra Swans, Sladen *et al.* (1981) reported some preliminary data on weights using a portion of the data set analysed in this paper, and Bortner (1985) presented structural measurements and weights of 196 wintering swans collected in North Carolina. The weights of the European subspecies, the Bewick's Swan *C. c. bewickii* wintering at Slimbridge, Gloucestershire, England have been analysed for seasonal and individual variations (Evans and Kear 1978).

The opportunity to analyse a large series of weights and measurements of Tundra Swan has resulted from the long term ecological and behavioural study of these birds begun in 1966 by the Swan Research Program at the Johns Hopkins University. This study involves marking the swans with individually coded plastic neck and tarsus bands in addition to the standard U.S. Fish and Wildlife Service aluminium band (Sladen 1973). Birds captured on their breeding and wintering grounds have been routinely weighed as part of the banding process. Since 1982 a series of morphological measurements have also been taken. This paper reports on the analysis of weights and measurements of wintering Tundra Swans captured during November–April.

Methods

Rocket nets, funnel traps, and drugs were used to capture 1,280 swans on their eastern wintering grounds in Maryland (1967–84) and 2,303 in North Carolina (1972–84). Swans were caught in the Chesapeake Bay area of Maryland from November through April. Sample sizes for November and December were small because the waterfowl hunting season and accompanying restrictions on baiting reduced the number of potential trapping sites. In eastern North Carolina, swans were captured by rocket net at Mattamuskeet and Pungo National Wildlife Refuges between 17th January and 24th February. The median date of capture was 9th February (n=28 catches).

After being banded, aged, and sexed, each swan was placed in a restraining jacket, weighed to the nearest 0.1 kg using a Chatillon spring balance. Measurements were taken of the culmen length, anterior end of the nares to tip of bill, gape length, tarsus length, and middle toe length (not including the claw). The culmen length is an imprecise measurement in juveniles because of individual variation in the amount of feathering remaining on the culmen. Almost all of the measurements (>96%) were taken by HAA. The bird as then released. Only the weight and measurements at first capture or weight at first recapture in subsequent years were used in the analyses. Swans were aged as adults, subadults (second winter) and juvenile (first winter) based on plumage characteristics. Individuals were classified as subadults if there was evidence of unmoulted gray juvenile plumage, found chiefly on the head, neck, and wing coverts, on an otherwise

Table 1. Average weights (kg) of Tundra Swans captured on their Maryland and North Carolina wintering grounds (November–April) 1966–67 to 1983–84.

	N	Mean ± SE	Range
Adults			
Male	1447	7.2±0.02	3.8–10.5
Female	1290	6.3±0.02	4.1– 9.0
Subadults			
Male	87	6.6±0.08	5.1– 8.6
Female	57	5.8±0.09	4.1– 7.0
Juveniles			
Male	299	6.1±0.05	3.4– 8.9
Female	403	5.6±0.04	3.2– 8.0

Wildfowl 38 (1987): 108–113

white (adult) plumaged bird. A similar criterion was used by Evans and Kear (1978) to identify subadult Bewick's Swans. Sex was determined by cloacal examination.

Differences among means were tested with one-way analysis of variance (ANOVA) with multiple comparisons. Significance was determined at the $P \geq 0.05$ level unless otherwise stated. Statistical tests followed procedures from Sokal and Rohlf (1981).

Results

Weights

Mean weights and ranges for each age and sex class, a total of 3,583, obtained from 1967 to 1984, are shown in Table 1. The distribution of weights of adults and juveniles approximated a normal distribution and tests for skew and kurtosis were not significant.

Significant differences were found in the weights of each age class within a sex for birds captured on the wintering grounds (Table 1). Adult males were 9% and 15% heavier than subadults and juveniles respectively, while adult females were 8% and 13% heavier than subadult and juvenile females. Males were also significantly heavier than females in all age groups with wintering males being 14% heavier in adults, 12% in subadults, and 9% in juveniles.

Seasonal Weight Variation

Data for all banding locations and all years were pooled to provide a sufficiently large sample size in each wintering month to analyse seasonal variation (Table 2). Adult swans exhibited a peak weight in December of 8.3 kg for males and 7.5 kg for females. However, the small sample size in November precludes attaching any statistical significance to the increase to December. The adult males and females then lost approximately 1.2 and 1.3 kg respectively between December and January. Weights for adults remained fairly stable through the remainder of the winter, although decreasing slightly in March to 7.1 kg for males and 6.1 kg for females.

Juveniles by contrast were apparently at their peak weight, 7.0 kg for males and 6.7 kg for females, in November, though in very small samples. Juvenile males lost weight throughout the winter to 5.9 kg in March. Although juvenile females showed an apparent decline in weight from November to December, they were slightly heavier in January and February but declined by 0.4 kg in March to a seasonal low of 5.3 kg.

The subadults were only captured in adequate numbers in January and February. The weights of both subadult males and females were stable in these two months, at 6.6 kg and 6.1 kg.

Annual Weight Variation

The consistent sampling time, location, and method of capture in North Carolina pro-

Table 2. Seasonal variation in the weights (kg) of 3,583 wintering Tundra Swans, 1966–67 to 1983–84.

	NOV	DEC	JAN	FEB	MAR	APR
Adult Males	7.3 (1)	8.3±0.17 (28)	7.1±0.06 (212)	7.2±0.03 (1061)	7.1±0.07 (144)	7.0 (1)
Adults Females	6.6±0.52 (6)	7.5±0.13 (29)	6.2±0.06 (176)	6.3±0.02 (928)	6.1±0.05 (149)	5.9±0.75 (2)
Subadult Males			6.6±0.15 (18)	6.6±0.10 (64)	7.1±0.35 (5)	
Subadult Females			6.1±0.20 (10)	6.1±0.10 (42)	5.3±0.24 (4)	4.8 (1)
Juvenile Males	7.0±0.49 (5)	6.8±0.24 (22)	6.4±0.24 (25)	6.4±0.06 (186)	5.9±0.12 (54)	5.3±0.14 (7)
Juvenile Females	6.5±0.55 (3)	5.6±0.19 (22)	5.7±0.15 (33)	5.7±0.05 (261)	5.3±0.10 (78)	5.3±0.36 (6)

Values are mean ± SE and number of individuals (n).

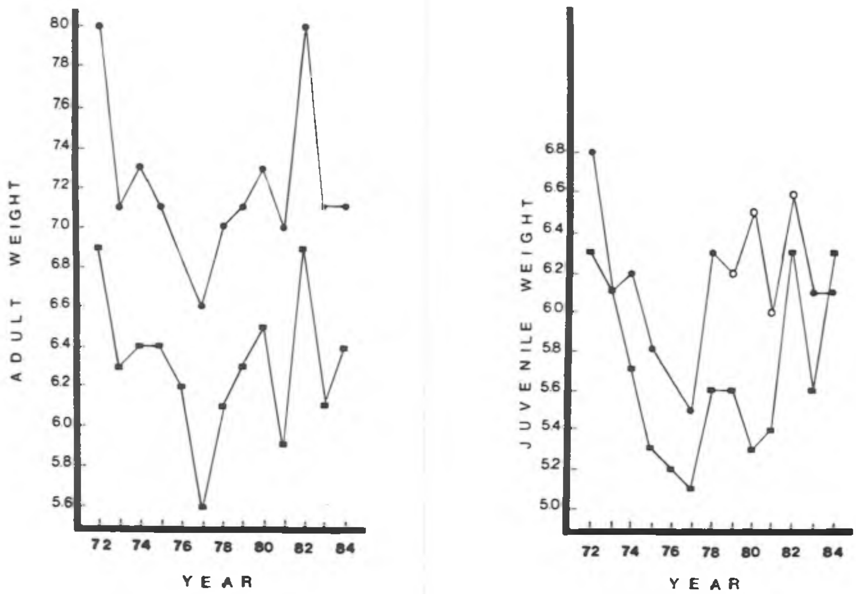

Figure 1. Annual average weights (kg) of wintering Tundra Swans captured between 17th January and 24th February (median = 9th Feb) at Mattamuskeet and Pungo NWRs, North Carolina. (●) = Male (■) = Female. Open symbols indicate sample sizes < 5.

vided an opportunity to analyse between year fluctuations in swan weights (Figure 1). Maximum and minimum average weights occurred in the same years for adult males and females. The highest average weight was found in 1972 and 1982, while the lowest average weight was recorded in 1977. Adult Tundra Swans in 1977 were 8.4% for males and 11.1% for females below their average weights for that time of year. The peak weights were 11.1% and 9.5% above the average for adult males and females. The maximum average weight of 6.8 kg for juvenile males occurred in 1972, while the lowest average weight of 5.5 kg was found in 1977. The 1977 weight was 14.1% below the average weight for juvenile males for that time of year. The maximum average weight was 6.3% above the average for February. Juvenile females had their highest average weight of 6.5 kg in 1972, 1982, and 1984 and this was 10.5% above the overall average. Their minimum average weight of 5.1 kg (11.5% below average), occurred in 1977. Sample sizes for juvenile swans were much smaller than those for adult. Juvenile males were especially difficult to obtain. Less than five juvenile males were captured for banding in 4 (31%) of 13 years.

Measurements

The measurements of 581 swans taken since 1982 are shown in Table 3. Analysis of variance with multiple comparisons was used to test for significant differences in the mean values for each morphometric variable for all age and sex groups.

Culmen length was significantly different between all ages of the same sex, but only adults were significantly different between sexes, ($P<0.001$). The length from the anterior end of the nares to the tip of the bill was significantly different between all ages ($P<0.01$) except subadult and juvenile male and adult and juvenile females, and between all sex classes except juveniles. The gape length was significantly different among the age groups only between adult and subadult males, but was significantly different ($P<0.01$) between the sexes except in the subadults. The length of the middle toe excluding the claw was not significantly different in any of the age groups, significantly different ($P<0.01$) between the sexes. The tarsus length was significantly different among all ages except subadult and juvenile males and adult and juvenile females. Tarsus length was significantly different ($P<0.01$) for all sex classes.

Table 3. Structural measurements (mm) of 581 Tundra Swans wintering in Maryland and North Carolina during 1981–84.

	Culmen	Nares to Bill Tip	Gape	Middle Toe	Tarsus
Adult Males	103.7±0.31* (305) 90–118	44.6±0.16 (305) 37–54	93.5±0.23 (305) 81–106	125.3±0.44 (305) 105–136	115.7±0.39 (290) 94–146
Adult Females	101.1±0.40 (164) 89–117	43.4±0.21 (164) 37–52	90.6±0.27 (164) 84–100	119.3±0.51 (164) 105-136	110.3±0.47 (160) 92–134
Subadult Males	97.6±1.18 (27) 87–107	43.1±0.47 (27) 39–47	91.8±0.73 (27) 84–100	123.4±1.39 (27) 109–137	113.2±1.06 (27) 104–127
Subadult Females	94.7±1.43 (13) 87–105	41.1±0.50 (13) 38–45	89.2±1.14 (13) 84–97	117.8±1.76 (13) 104–127	105.2±1.74 (10) 96–113
Juvenile Males	88.4±1.24 (34) 79–104	43.3±0.43 (34) 39–48	92.6±0.59 (34) 85–100	124.2±1.17 (34) 102–138	113.7±0.70 (33) 100–122
Juvenile Females	89.1±1.22 (38) 73–104	43.0±0.38 (38) 39–49	90.9±0.48 (38) 84–98	119.3±1.30 (38) 100–137	111.3±1.06 (37) 98–126

*Values are mean ± SE, number of individuals (n) and range.

Discussion

The significant weight difference between Tundra Swans aged as juveniles, subadults, and adults and between males and females was similar to findings reported by Evans and Kear (1978) for Bewick's Swans. However, the Tundra Swans ranged from 0.4 to 0.8 kg heavier than the Bewick's Swans in mean weight.

The weight loss in wintering Tundra Swans which was found is similar to findings for other wintering waterfowl including Tundra Swans in North Carolina (Bortner 1985), Mute Swan *Cygnus olor* (Andersen-Harild 1981), Canada Geese *Branta canadensis* (Elder 1946; Hanson 1962; Raveling 1968; McLandress and Raveling 1981), Mallard *Anas platyrhynchos* (Owen and Cook 1977), and Black Duck *Anas rubripes* (Reinecke *et al.* 1982). The winter weight reduction observed in free-living waterfowl in these studies and in the present investigation is probably the result of an endogenous weight loss cycle to reduce energy costs from carrying extra weight.

An exception to the trend for free-living waterfowl to lose weight over winter would seem to be Evans and Kear's (1978) data for Bewick's Swans wintering at Slimbridge. These birds increased in weight after their arrival in late October or early November until the end of December and then maintained or only slightly decreased their weight during January. The Bewick's Swans population wintering at Slimbridge averaged about 450 birds (Evans 1979) and was given supplemental feeds of up to 407 kg/day of grain (wheat or barley), but part of this was consumed by "thousands of ducks" and thus the amount taken by the swans was not known (Rees 1982). The daily supplemental feeds might have been sufficient to allow the swans to maintain a higher body weight at a lower energy cost by spending large proportions of their time at the provisioned site (Evans 1980). Unfortunately no weights and seasonal weight changes of Bewick's Swans not being supplementally fed, were available for comparison.

There were large and significant fluctuations in the weights of adult swans wintering in North Carolina in different years, with the sexes following similar patterns within their respective age groups. The minimum mean weights for all swans occurred in 1977. The 1976–77 winter had daily maximum termperatures, in the month preceding banding, averaging 8° C below normal and was the coldest winter during the study period. Andersen-Harild (1981) found that Mute Swans wintering in

Denmark began to die when their body weight fell to two-thirds of the normal average for that time of year. The Tundra Swans in the present study were not approaching that magnitude of weight loss and were probably not in danger of starving even during the severe winter of 1976–77.

With exception of the highly variable culmen length, juvenile females had by the winter achieved adult proportions in all the structural variables measured. Juvenile males were significantly different from adults in measurements of the nares to bill tip length and tarsus length, in addition to the culmen length. Although the differences were statistically significant, the values for juvenile males were 97.1 and 98.3% of the adult values for these measurements.

Swans classified as subadults in the present sample rather suprisingly had smaller measurements than juveniles for all morphological variables except the culmen length, where they were intermediate between juveniles and adults. Otherwise the differences failed to reach significance except in the nares – bill tip and tarsus measurements for females only. It is possible that the remnant gray juvenile plumage used to assign birds to the subadult age class had resulted in selecting birds which as juveniles the previous year had been in "poor" condition. Such juveniles might not have undergone as complete a body moult as juveniles in better condition. The latter could have undergone a complete body moult into all white plumage and so be classed as adults. Observations on captive raised Tundra Swans by WJLS and RJL do indicate that remnant juvenile plumage may not be present on a subadult. The "poorer" condition could also have been reflected in reduced body growth. Sedinger and Raveling (1984) speculated that the selection of high protein vegetation by young Cackling Geese *Branta canadensis minima* would result in a "maximised growth rate, final adult size, and ability to store fat and protein."

The mean measurements for adult culmen length and middle toe length were similar to averages reported by Banko (1960) although the range in values was much larger than his because of the larger sample size. The adult and juvenile culmen and tarsus measurements presented by Bortner (1985) were also similar to the present findings. The tarsus measurement was much larger than that reported by Banko and probably reflects a difference in technique. Banko also stated that the measurement of the distance from the anterior end of the nares to the tip of the bill could be used to differentiate Trumpeter Swans *Cygnus cygnus buccinator* from Tundra Swans. He concluded that an adult of either sex having a value of 50 mm or more for this measurement was a Trumpeter Swan. The nares to bill tip measurement in the present study ranged up to 54 mm for adult males and 52 mm for adult females (Table 3). However, as a proportion of the swans measured, adult males with 50 mm or more represented only 2.6% and adult females 1.2% of their respective samples. Thus, while there is some overlap between Trumpeter and Tundra Swans in all the morphometric variables examined (Banko 1960), the smallness of the overlap found for the nares to tip of the bill measurement would indeed provide a good basis for discriminating between Trumpeter and Tundra Swans.

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Summary

Tundra Swans *Cygnus columbianus columbianus* were captured on their eastern USA wintering grounds in Maryland and North Carolina during 1966–84. Weights were taken on 3,583 of these swans and 581 were also measured for culmen, gape, nares-to-bill-tip, middle toe, and tarsus length. Each swan was sexed and aged as an adult, subadult, or juvenile.

Significant differences in weights were found between age and sex groups, and within seasons. Variations in weights between years were examined for swans captured in late January and February. Significant differences were found in some structural measurements between sex and age groups.

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