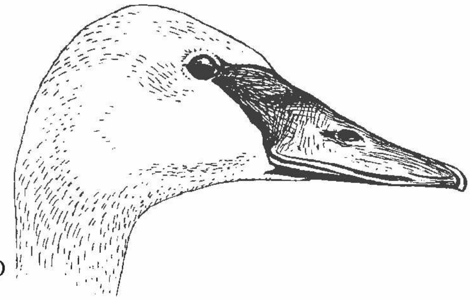
Winter body mass and measurements of Trumpeter Swans *Cygnus buccinator*



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Morphological measurements and body mass were recorded for Trumpeter Swans captured in Idaho and Montana in the United States during a range restoration programme. Although 887 Trumpeter Swans were captured during four winters (November to mid-January 1990-91 to 1993-94), sample sizes varied for different measurements due to limited time and personnel. Mean body mass varied among sex/age classes and among years. Mean body mass (kg) for adult and cygnet males was 11.9 and 9.9, and for females was 10.3 and 8.7. Annual variation in body mass was directly related to mean air temperature during the four trapping periods. An index of body condition followed the same pattern as body mass, being lower in colder winters. Structural measurements included three bill measurements, tarsus, and mid-toe. ANOVA of the first principal component scores (based on bill 2 and mid-toe length) indicated that structural size varied among sex/age classes, but not among years. A discriminate function based on mid-toe length correctly classified the sex of 67% of females and 79% of males. The rate of infestation with nasal leeches (x=12%) was highest in cold winters and was probably related to body condition; the lightest swans had the highest infestation rate. Interpopulation comparisons of Trumpeter Swans using morphological measurements could be improved by better definition of measurement techniques. Tip of bill to anterior edge of nares (bill 1) measurement ≥50 mm for adults and ≥48 mm for cygnets will separate most Trumpeter from Tundra Swans.

Keywords: Body Mass, Cygnus Buccinator, Cygnus Columbianus Columbianus, Morphology, Rocky Mountain Population, Structural Measurements, Trumpeter Swan, Tundra Swan, United States.

The Rocky Mountain Population (RMP) of Trumpeter Swans *Cygnus buccinator*, numbered over 2500 in February 1994 (Niethammer 1994), and consists of two flocks that mix during winter (Mitchell & Shandruk 1992) and are indistinguishable. The migratory Canadian flock nests in Alberta, British Columbia, Yukon and Northwest Territories and is increasing rapidly. The mainly non-migratory Tri-state flock nests in the Greater Yellowstone or Tri-state Area of Idaho, Montana, and Wyoming and is declining (Niethammer 1994, Shea *et al.* in press). Most RMP swans winter in the Tri-state Area, a region of harsh winter climate, where temperatures can drop to -50° C. Due to excessive concentrations of RMP swans on limited winter habitat, the US Fish and Wildlife Service and the Pacific Flyway Council initiated a winter range restoration experiment in winter 1990. All Trumpeter Swans captured were moved to warmer sites during four winters (1990-93) in an attempt to encourage future occupation of these areas.

There is little information on body mass and structural measurements of Trumpeter Swans, and none from the autumn-winter period. The relocation programme (Drewien *et al.* 1992, Drewien & Clegg 1994) presented an opportunity to obtain limited morphological measurements. This paper describes body mass and selected structural measurements of Trumpeter Swans during late autumn and early winter.

Methods

Capture

Trumpeter Swans were captured from November through mid-January during winters 1990-93 on the Henry's Fork River at Harriman State Park (HSP), Idaho (n=771), and during winter 1990 at Red Rock Lakes National Wildlife Refuge, Montana (n=116). Swans were captured by 'night-lighting' (n=765), bait trap (n=92), and snowmobile (n=30) (Drewien *et al.* 1992, Drewien & Clegg 1994). Each swan received a tarsal ring and an alpha-numerically coded green plastic neck-collar. The presence of nasal leeches *Theromyzon rude* was noted; leeches were removed by flushing with saline solution and counted. Swans were released at new wintering sites up to 1000 km distant.

Measurements

Nearly all measurements were made by RCD to minimize variation among observers, a precaution taken in other studies (Evans & Kear 1978, Limpert *et al.* 1987). Body mass was measured to the nearest 0.1 kg. Structural measurements were made with dial calipers to the nearest 0.1 mm. Three measurements of the bill were made, bill 1=tip of bill to anterior edge of nares, bill 2=tip of bill to posterior edge of the bony process inside the opening through the nares, and bill 3=tip of bill to posterior edge of nares. Mid-toe length was measured on the dorsal surface from the joint with the tarsometatarsus to the base of the nail (Dzubin & Cooch 1992:12). Tarsus was measured as the length of the tarsometatarsus bone (Dzubin & Cooch 1992:11). R2, a ratio of body mass to bill 2, was calculated as an index to body condition.

Time constraints of capturing, processing, and transporting swans within a 24-36 h period with few personnel limited opportunities to measure all birds, or to obtain additional morphological measurements. Only one series of measurements was taken from an individual swan; repeatability of measurements was not assessed. Body mass was measured in winters 1990-93. Bill 1 was measured only during winter 1991 for comparison with other studies. Bill 2 was measured during winters 1991-93. Bill 3 was measured in winters 1992-93 at the request of Wildlife Departments of Montana, Nevada, and Utah for comparison with specimens taken during Tundra Swan *Cygnus columbianus columbianus* hunts. Mid-toe was measured during winters 1991-93. Tarsus was measured in winters 1991 and 1993.

Swans were placed into four sex/age classes: adult males and females, and cygnet males and females. Sex was determined by cloacal examination. Yearlings (subadults) were included with adults because some were not separable from adults based on the presence of juvenal grey plumage on neck and wing coverts. Limpert *et al.* (1987) noted the same problem in Tundra Swans. They found that some measurements of cygnets exceeded those of yearlings. They thought that birds with grey feathers could be those in poorest condition, biasing mean measurements. Tobish (1991) stated that Trumpeter Swan yearlings moult their last grey feathers on the neck and wing coverts during their second fall. The presence of grey feathers is definitive for yearlings, but the opposite is not true.

Statistical Analysis

Factors affecting variability in structural measurements and body mass were analyzed with ANOVA. Data were tested for homogeneity of variance with SigmaStat for DOS (Kuo *et al.* 1992) and for normality with PC SAS 6.04 (SAS Institute Inc. 1987). PC SAS was also used for ANOVA, regression, principal component analysis (PCA), and discriminant function analysis. No heterogeneity of variance was detected. Non-normality in some groups was detected in the ratio, R2. These data were not transformed, instead a more conservative significance level (α=0.025) was used. With symmetric distributions and large samples Keppel (1991) recommended a more restrictive α level to offset the lower F value resulting from non-normality. Significance level of α=0.05 was used in other tests. PCA was used to summarize bill 2 and mid-toe length into PC1, a score for each swan based on the first principal component axis. The first principal component axis (PC1) is frequently used as a measure of overall body size (Rising & Somers 1989). Two-way ANOVA with interaction (year was one factor, and the sex/age class was the second factor) was performed on body mass, R2 and PC1 (the scores on principal component 1). If the overall ANOVA was significant and the interactions were not significant, pairwise comparisons were made on significant main effects using the Tukey/Kramer procedure for unequal sample sizes. Body mass was regressed against day of winter (from 1 November through mid-January) with a second order or quadratic function to describe body mass changes over the winter. A second order

Table 1. Measurements of Trumpeter Swan captured at Harriman State Park, Idaho and Red Rock Lakes National Wildlife Refuge, Montana during winters 1990-93.

	adult ♂	adult ♀	cygnet ♂	cygnet ♀
Body Mass (kg)				
n	152	120	167	147
x	11.9	10.3	9.9	8.7
SD	1.1	1.0	1.2	1.0
max	14.5	12.5	12.2	11.3
min	9.1	7.0	6.8	6.1
R2 (body mass / bill 2)				
n	132	100	151	133
x	0.455	0.394	0.373	0.338
SD	0.037	0.031	0.039	0.035
max	0.521	0.452	0.441	0.430
min	0.350	0.328	0.266	0.253
Bill 1 (mm)				
n	24	23	40	38
x	54.7	54.1	54.0	52.5
SD	2.2	2.3	2.4	2.6
max	59.4	57.7	57.8	57.7
min	50.9	49.3	47.3	47.7
Bill 2 (mm)				
n	133	103	154	137
x	59.9	58.9	59.0	57.4
SD	2.1	2.7	2.7	2.6
max	67.5	66.0	65.8	62.8
min	53.1	51.5	48.7	49.8
Bill 3 (mm)				
n	94	71	118	98
x	69.2	68.3	68.6	67.0
SD	2.5	2.9	2.8	2.6
max	76.3	74.2	75.6	72.9
min	62.5	60.9	60.0	57.8
Tarsus (mm)				
n	84	64	108	86
x	132.2	127.0	130.1	124.7
SD	4.4	4.9	4.4	4.7
max	145.2	138.0	141.2	136.2
min	121.4	115.1	119.5	115.3
Mid-toe (mm)				
n	124	97	146	115
x	147.3	140.7	145.8	139.3
SD	5.3	5.1	5.3	5.3
max	161.9	153.3	162.8	151.5
min	133.6	129.9	130.5	121.5

function was used because Evans & Kear (1978) and Limpert *et al.* (1987) found that body mass of Bewick's Swans *Cygnus columbianus bewickii* and Tundra Swans peaked in early winter. Discriminant function analysis was performed with mid-toe length to predict sex. Cross validation was used to evaluate the accuracy of the discriminant function. A sign test was used to compare relative body mass of swans (by year * sex/age classes) infested with nasal leeches with that of non-infested swans.

Results

Body mass

Body mass varied among sex/age classes (P=0.001) and among years (P=0.001); the interaction term was not significant (P=0.4416). All sex/age classes differed in body mass, adult males being the heaviest and cygnet females being the lightest (**Tables 1 & 2**). Body mass was similar in 1990 and 1991, and in 1992 and 1993; mean body masses were lower in 1990 and 91 than in 1992 and 93 (**Table 2**). The second

Table 2. Comparison of mean body mass, R2 (body mass/bill 2) and PC1 (principal component 1) of Trumpeter Swans captured in winters 1990-93 at Harriman State Park, Idaho and Red Rock Lakes National Wildlife Refuge, Montana. Results are from a two-factor ANOVA and multiple comparison tests (Tukey/Kramer test). Means followed by the same letter were not significantly different ($P > 0.05$). No interaction effects were significant.

Year	Sex/age	*n*	*x*		SD
Body mass (kg)					
1990	all	62	9.4	a	1.5
1991	all	179	9.6	a	1.5
1992	all	163	10.6	b	1.5
1993	all	182	10.8	b	1.4
Body mass (kg)					
all	adult ♂	152	11.9	a	1.1
all	adult ♀	120	10.3	b	1.0
all	cygnet ♂	167	9.9	c	1.2
all	cygnet ♀	147	8.7	d	1.0
R2 (body mass/bill 2)					
1991	all	171	0.362	a	0.052
1992	all	163	0.397	b	0.052
1993	all	182	0.401	b	0.047
R2 (body mass/bill 2)					
all	adult ♂	132	0.445	a	0.037
all	adult ♀	100	0.394	b	0.031
all	cygnet ♂	151	0.373	c	0.039
all	cygnet ♀	133	0.338	d	0.035
PC1 (Principal component 1)					
1991	all	133	-0.122	a	1.265
1992	all	163	-0.064	a	1.189
1993	all	182	0.147	a	1.221
PC1 (Principal component 1)					
all	adult ♂	124	0.698	a	1.046
all	adult ♀	97	-0.357	b	1.103
all	cygnet ♂	142	0.297	c	1.106
all	cygnet ♀	115	-0.819	d	1.070

order regression of body mass against date was significant (P=0.001), and all parameters were significant (P=0.0001), suggesting an early winter peak. However, regression coefficients were near 0, and the coefficient of determination was very small (adjusted R^2=0.0801). Thus, little of the variability in body mass was explained by date; essentially there was no change in body mass from November through mid-January.

Body mass was directly related to mean temperatures during annual trapping periods (**Figure 1**). Annual mean daily temperatures during trapping periods were -11° C in 1990, -7.5° C in 1991, -6.8° C in 1992, and -6.0° C in 1993. Mean body masses of all sex/age classes were lowest in 1990 and 91, the coldest winters, and highest in 1992 and 93, the warmest winters (**Figure 1, Table 2**).

Structural Measurements

Structural measurements are summarized in **Table 1**. Bill measurements, being different measurements of the same structure, were highly correlated. Bill 2 was correlated with bill 1 (r=0.962), and with bill 3 (r=0.917).

R2, an index of body condition, varied among years (P=0.001) and among sex/age classes (P=0.001); the interaction term was not significant (P=0.4046). R2 followed the same pattern as body mass. R2 did not differ between 1992 and 1993; 1991 was lower than in 1992 and 1993 (**Table 2**). All sex/age classes differed. R2 was directly related to mean air temperature during the annual trapping periods, with lower ratios in colder years (**Figure 1, Table 2**).

PC1 did not vary among years (P=0.0589), but did vary among all sex/age classes (P=0.0001) (**Table 2**). The interaction term was not significant (P=0.5798). Mean PC1 scores were highest for adult males followed by cygnet males, adult females and cygnet females (**Table 2**).

The discriminant function based on mid-

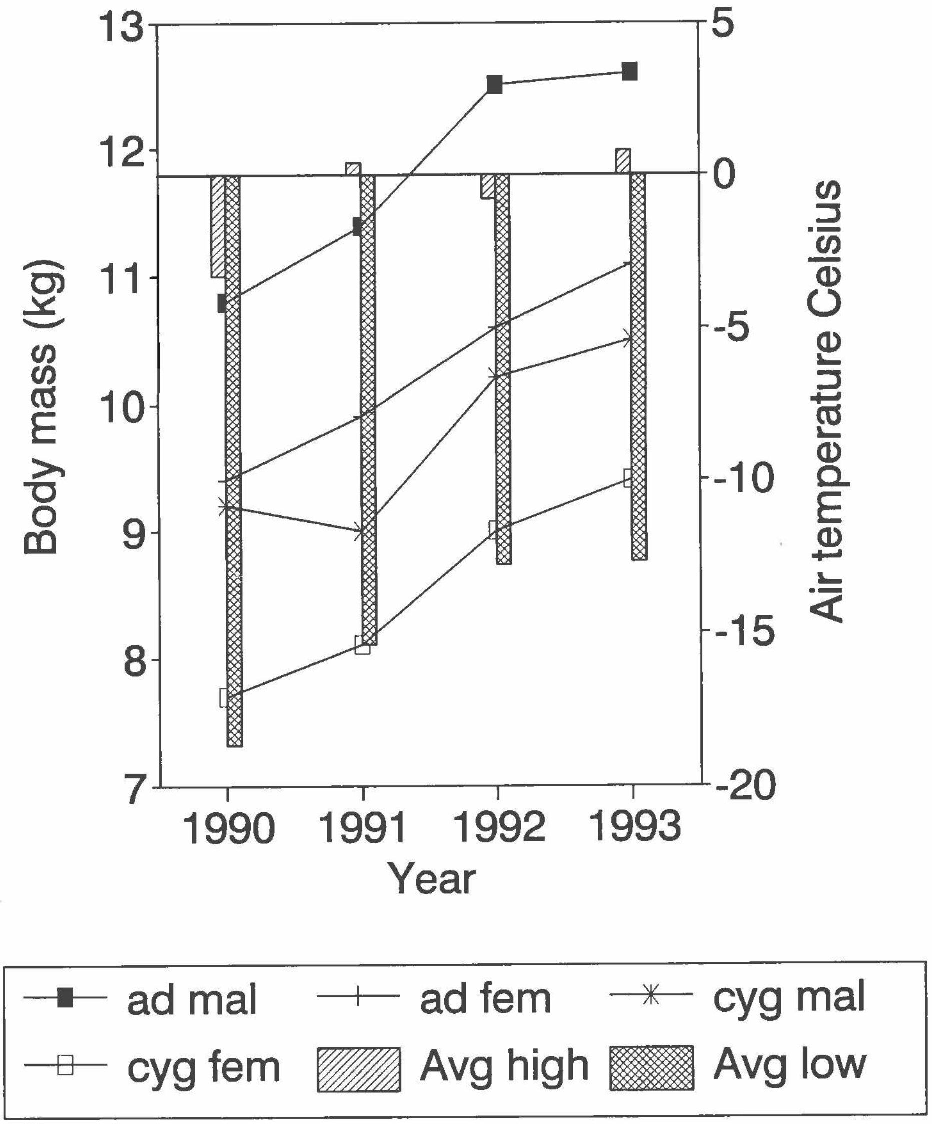

Figure 1. Mean body mass of sex/age classes of Trumpeter Swans captured at Harriman State Park, Idaho during winters 1990-93. Mean daily high and low air temperatures during annual trapping periods are shown by the bars. Body mass of all sex/age classes was related directly to mean air temperatures during the four winters.

toe length correctly identified the sex of 67% of the females and 79% of the males. Discriminant functions of other measurements or combinations of measurements did not improve the prediction rate.

Leeches

Mean body mass of swans infested with nasal leeches was lower in 14 of 16 swan sex/age * year classes than that of uninfected swans (P=0.0018). Infestation rate ranged from 5% in 1992 to 29% in 1990, and averaged 12% over four winters. Infestation was heaviest in 1990 and 1991 and was probably related to body condition (R2), which was lower in 1990 and 91 than in 1992 and 93. Infestation was lowest in adults and lowest in females (ad ♂=8%, ad ♀=4%, cyg ♂=16%, cyg ♀=13%). The maximum number of leeches found on a single swan was 18, and the mean number on infested swans was 4.6.

Discussion

Body Mass and Structural Measurements

Adult males were heavier than adult females, exhibiting the sexual dimorphism reported by Scott (1972) for Trumpeter and other swans. Cygnets showed similar sexual dimorphism, but generally were lighter than adults.

No meaningful trend in body mass was detected from November through mid-January, contrary to the findings of Evans & Kear (1978) and Limpert *et al.* (1987) who found early winter peaks in body mass of Bewick's and Tundra Swans. Although regression equations in this study were significant, little variability in body mass was explained, making the regression equation meaningless. Had trapping continued later in winter, an early winter peak may have been detected.

Differences in body mass among years were probably related to air temperature (**Figure 1**) and food availability. Body mass was related directly to mean temperatures. The coldest winter was 1990 with warmer mean temperatures in each successive year; body mass followed the same pattern. Similar relationships of body mass and temperatures were observed in Tundra Swans wintering in Maryland and North Carolina (Sladen *et al.* 1981, Limpert *et al.* 1987) and in Mute Swans *Cygnus olor* in The Netherlands (Beekman 1991). Lower body mass could affect survival and reproductive success the following spring. Andersen-Harild (1981) noted that lower body mass could reduce survival in Mute Swans. Lower winter temperatures were correlated with later nest initiation and lower clutch size in Mute Swans (Birkhead *et al.* 1983, Beekman 1991).

The combination of cold temperatures and limited food availability may have prevented Trumpeter Swans from increasing mass after arrival on the winter area. Winters in HSP are extremely cold; mean daily temperature for the last two weeks of December 1990 was -10.5° C. The lowest temperature recorded during the trapping project was -50° C on 22 December 1990.

Submerged aquatic vegetation in the Henry's Fork River was the only available food for wintering swans. Neither natural uplands nor agricultural fields were available in the area, and surrounding land was normally covered by > 1 m of snow. More of the river was ice-covered during colder winters, limiting access to food. The carrying capacity of the aquatic vegetation in the Henry's Fork has been reduced by severe over-grazing by Trumpeter Swans. In 1989 nearly all the vegetation was eliminated (Shea 1992, Shea *et al.* in press), but has been slowly recovering. Sladen *et al.* (1981) found that wintering Tundra Swans showed increases in body mass following a change from feeding on submerged aquatic vegetation to field feeding. Trumpeter Swans wintering in warmer climates such as coastal British Columbia (McKelvey 1981) may be heavier than swans in this study.

Indices of body condition, such as the ratio of body mass to bill 2 or to mid-toe, could be used to compare relative body condition among years or seasons. Comparison among studies can be done if care is taken to describe measurement techniques in detail, so that comparisons are of the same structures. Comparisons should probably be confined to the same sex/age classes, since there is no reason to expect all sex/age classes to have identical ratios of structural measurements to body size at the same body condition.

Adult structural measurements were not expected to vary among years due to cessation of skeletal growth. The low probability of the differences in the PC1 means among years suggests that considerable variability existed and may be due in part to different sample sizes of sex/age classes during different years. In Mute Swans, skeletal growth continues beyond the first year (Mathiasson 1981). We were not able to separate yearlings from adults reliably. The proportion of yearlings in our samples could have varied among years, increasing the variability. Less than 1% of the total variance in the PC1 scores was accounted for by year; the marginal significance in PC1 scores among years was probably not meaningful biologically. Therefore, differences in body mass among years were probably not a function of changes in structural size.

Piersma & Davidson (1991) stated that body mass alone, or in combination with other measurements, cannot be used as a measure of body size. Other factors such as food supply, disease, parasites, and physiological cycle affect body mass. Piersma & Davidson (1991) and Moser & Rusch (1988) suggested that skeletal volume was the best measure of body size, as it did not vary after maturity. Structural measurements can be used as indices of relative body size, but plumage measurements, such as wing chord, and tail length, which vary over time, should be avoided (Moser & Rusch 1988, Rising & Somers 1989). Mid-wing, tarsus length, and bill measurements are less variable over time. Moser & Rusch (1988) found mid-wing and tarsus measurements to be good predictors of skeletal volume in Canada Geese *Branta canadensis*. Single structure comparisons should also be avoided. Combining several skeletal measurements with principal components analysis, or multiple regression may provide better predictions of body size (Moser & Rusch 1988, Rising & Somers 1989). The combination of three measurements, one from the skull (bill 1), one from the legs (tarsus), and one from the wings (mid-wing) may provide a good combination to assess swan body size.

Leeches

We found infestation by nasal leeches was associated with lower body condition in Trumpeter Swans, suggesting that swans in poorer condition are more susceptible to leech infestation. Heavy, healthy swans were seldom parasitized by leeches. Bartonek & Trauger (1975) thought that nasal leeches could attach rather quickly, and that infestation of ducks increased when distraction or disturbance diverted attention from normal preening efforts. Disturbance was probably not a factor in this study as most swans were equally disturbed. The climate in the Tri-state Area is extremely harsh, requiring large time allocation to foraging. Time allocated to foraging cannot be used for preening to remove leeches. Birds in poorest condition probably expend more time foraging.

Leeches have caused mortality in Trumpeter Swan cygnets by occlusion of the trachea (Tuggle 1986). Heavy infestations could place additional stress on birds in poor condition, but is unlikely to cause direct mortality of adult and nearly grown cygnets. Adult *Theromyzon rude* take a mean of 275-305 mg of blood per meal (Davies 1984), and remain attached for about 2.5 h (Davies & Wilkialis 1981). Based on these findings a Trumpeter Swan parasitized with 4.6 leeches would lose about 13 g of blood per day. This loss may become significant if the infestation rate was maintained over the entire winter. Attachment beneath the nictitating membrane of the eye can cause temporary blindness, and impair feeding or the avoidance of predators (Bartonek & Trauger 1975). Eye infestation was rare in this study and was not identified as a mortality factor.

Other Trumpeter Swan Studies

A study comparing allele frequencies of genetic loci of Alaskan, Canadian, and Tri-state Trumpeter Swans found no evidence that the populations differed (Vyse & Barrett 1981, Barrett & Vyse 1982). Barrett & Vyse (1982) found no difference between Alaskan and Tri-state adult Trumpeter Swans in body mass and bill 1. Our body mass and bill 1 measurements were similar to those of Barrett & Vyse (1982), except that we found longer bill 1 lengths in adult females (**Table 3**). Hansen (1973) stated that Alaskan Trumpeter Swans were larger than Tri-state swans. Mid-toe measurements from Alaska are significantly longer than RMP swans (**Table 3**), suggesting that Alaskan swans either have larger feet, or that they were measured differently. Hansen et al. (1971) did not report methods for making morphological measurements, other than for bill 1. As noted by Dzubin & Cooch (1992), this makes interpretation and comparison of reported values difficult. Significant differences between morphological measurements from our study and others (**Table 3**) could, in part, be due to differences in methodology. Additional morphological and genetic data are needed to address the question of differences between Alaskan and RMP Trumpeter Swans.

Trumpeter and Tundra Swans

Tundra Swans are hunted in a number of locations in the United States and there is concern that Trumpeter Swans may be shot accidently in some locations due to their similarity of appearance (Gillette 1992). Banko (1960:68) stated that a swan > 1 year old of either sex which measured ≥ 50 mm from tip of bill to the front edge of

Table 3. Comparison of body mass and structural measurements from adult Trumpeter Swans captured at Harriman State Park, Idaho, during winter 1990-93 with those from other published studies. Means from this study and from Hansen *et al.* (1971) include both adults and yearlings. Means were compared with t-tests.

Source	Swan source[a]	*n*	Mean	SD	Sig[b]
Body mass (kg)					
adult ♂					
Hansen *et al.* 1971	AK	17	11.2	1.20	NS
Barrett & Vyse 1982	AK	7	11.8	0.63	NS
Barrett & Vyse 1982	RRL	27	11.4	0.72	NS
This Study	HSP	152	11.9	1.08	
adult ♀					
Hansen *et al.* 1971	AK	19	9.5	2.09	SIG
Barrett & Vyse 1982	AK	15	10.2	0.66	NS
Barrett & Vyse 1982	RRL	47	10.3	1.23	NS
This Study	HSP	120	10.3	1.01	
Tarsus length (mm)					
adult ♂					
Banko 1960	[c]	5	122.9		SIG
Hansen *et al.* 1971	AK	19	115.7	5.32	SIG
This Study	HSP	84	132.2	4.45	
adult ♀					
Banko 1960	[d]	3	121.7		SIG
Hansen *et al.* 1971	AK	18	111.3	11.29	SIG
This Study	HSP	64	127.0	4.93	
Mid-toe length (mm)					
adult ♂					
Banko 1960	[c]	5	141.1		SIG
Hansen *et al.* 1971	AK	19	160.0	4.71	SIG
This Study	HSP	124	147.3	5.31	
adult ♀					
Banko 1960	[d]	3	143.3		SIG
Hansen *et al.* 1971	AK	18	151.8	8.99	SIG
This Study	HSP	97	140.7	5.14	
Bill 1 (mm)					
adult ♂					
Hansen *et al.* 1971	AK	20	55.2	2.59	NS
Barrett & Vyse 1982	AK	7	54.0	2.57	NS
Barrett & Vyse 1982	RRL	27	54.0	1.97	NS
This Study	HSP	24	54.7	2.15	
adult ♀					
Hansen *et al.* 1971	AK	19	52.9	2.27	NS
Barrett & Vyse 1982	AK	8	51.0	3.71	SIG
Barrett & Vyse 1982	RRL	47	50.0	3.63	SIG
This Study	HSP	23	54.1	2.31	

a. AK = Alaska; RRL = Red Rock Lakes National Wildlife Refuge, Montana; HSP = Harriman State Park, Idaho.
b. Significance difference ($\alpha \leq 0.05$) between means when compared against this study.
c. Five specimens from Idaho, Wyoming, Wisconsin, and Michigan.
d. Three specimens; one from Montana.

the nostril (bill 1) was probably a Trumpeter Swan. Those measuring < 50 mm were probably Tundra Swans. Our data for adults support Banko's findings; one of 47 (2%) was < 50 mm (**Table 4**). Limpert *et al.* (1987) supported using the 50 mm criteria to separate adults of the two species. They found bill 1 measurements of 1.2% of adult male and 2.6% adult female Tundra Swans (n=469) ≥ 50 mm (**Table 4**).

Table 4. Comparison of Trumpeter Swan measurements (this study) and Tundra Swan measurements (Limpert *et al.* 1987). Percent overlap is the percentage of Trumpeter Swans ≤ the maximum value recorded for Tundra Swans by Limpert *et al.* (1987)

	Bill 1		Mid-toe		Tarsus	
	Trumpeter	Tundra	Trumpeter	Tundra	Trumpeter	Tundra
adult ♂						
n	24	305	124	305	84	290
$\bar{x}$ ± SD	54.7 ± 2.15	44.6 ± 0.16	147.3 ± 5.31	125.3 ± 0.44	132.2 ± 4.45	115.7 ± 0.39
range	50.9–59.4	37–54	133.6–161.9	105–136	121.4–145.2	94–146
% overlap	41		1		100	
adult ♀						
n	23	164	97	164	64	160
$\bar{x}$ ± SD	54.1 ± 2.31	43.4 ± 0.21	140.7 ± 5.14	119.3 ± 0.51	127.0 ± 4.93	110.3 ± 0.47
range	49.3–57.7	37–54	129.9–153.3	105–136	115.1–138.0	92–134
% overlap	17		20		92	
cygnet ♂						
n	40	34	146	34	103	33
$\bar{x}$ ± SD	54.0 ± 2.40	43.3 ± 0.43	145.8 ± 5.32	124.2 ± 1.17	130.1 ± 4.45	113.7 ± 0.70
range	47.6–57.8	39–48	130.5–162.8	102–138	119.5–141.2	100–122
% overlap	3		7		6	
cygnet ♀						
n	38	38	115	38	86	37
$\bar{x}$ ± SD	52.5 ± 2.59	43.0 ± 0.38	139.3 ± 5.30	119.3 ± 1.30	124.7 ± 4.67	111.3 ± 1.06
range	47.7–57.7	39–49	121.8–151.5	100–137	115.3–136.2	98–126
% overlap	8		37		65	

Banko (1960) had no information on bill 1 measurements for Trumpeter Swan cygnets during autumn or winter. Our data for bill 1 in cygnets showed that 5% of males and 18% of females had bill tip to nares measurements < 50 mm (**Table 4**). Limpert *et al.* (1987) found that mean and maximum bill 1 measurements for Tundra Swan cygnet males were 43.3 and 48 mm and for females were 43.0 and 49 mm (**Table 4**). These findings indicate that 48 mm is a better discriminating measurement for cygnets. We found that 3% of male and 3% of female Trumpeter Swan cygnets were < 48 mm; all were > 47 mm (**Table 4**).

In 1992, the Wildlife Departments of Montana, Nevada, and Utah requested Tundra Swan hunters to return post cards on which they marked the length from bill tip to the posterior edge of the nares (bill 3) of swans harvested. The data were used to detect Trumpeter Swans that were shot accidentally. We collected bill 3 measurements to assist in this survey. We found bill 3 measurements of 95% of adult Trumpeter Swans ≥ 64 mm (*n*=165) and 95% of the cygnets ≥ 63 mm (*n*=216). Using these criteria, preliminary data from 1992-93 Tundra Swan hunts in Montana suggested that 11 of 295 swans measured could have been Trumpeters (J. Herbert, pers. comm.). Additional bill 3 measurements from Tundra Swans are necessary to confirm these separation points between the two species.

If data on plumage coloration (white or grey) and mid-toe length were also collected, the sex and age of Trumpeter Swans killed accidentally could be determined in most cases. Species would be determined by bill 1 or bill 3 length, age by plumage, and sex from mid-toe length.

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