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Age Determination of American Black Ducks in Winter and Spring

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Abstract

*Age-specific studies pertaining to survival and productivity of American black ducks (*Anas rubripes*) are constrained by the fact that no technique has been developed to reliably determine age as second year or after second year from late winter to late spring. We developed a qualitative age-class scoring technique that can be readily used in the field. When tested on 5 independent observers, known-aged birds (*n = *106) were correctly classified with 94–98*% *accuracy. To reduce subjectivity and provide an objective corroboration of age estimates, we also developed multivariate models from measurements of wing feather variables (weight and length of greater secondary covert 9, and width of tertial covert 5) that determined age with ≥90*% *accuracy (*n = *255). There was ≥94*% *agreement between qualitative and quantitative age assignments of wild birds caught in spring (*n = *172). The application of these age determination techniques should be useful in a host of life-history studies conducted on wintering, spring staging, and nesting grounds.* (WILDLIFE SOCIETY BULLETIN 34(5):1401–1410; 2006)

Key words

after second year, age determination, American black duck, Anas rubripes*, banding, coverts, Ontario, postseason, second year.*

The ability to discriminate waterfowl as second year (SY, a bird known to have hatched in the calendar year preceding the year of observation and in its second calendar year of life) or after second year (ASY, a bird known to have hatched earlier than the calendar year preceding the year of observation; year of hatch otherwise unknown) enables wildlife researchers to study many life-history characteristics such as age-specific survival, productivity, habitat use, movements, and geographic distribution. This is especially important for the American black duck (*Anas rubripes*, hereafter black duck), a species of special concern in the North American Waterfowl Management Plan because of population declines in both the Atlantic and Mississippi Flyways (Canadian Wildlife Service and United States Fish and Wildlife Service 1986). Notwithstanding concern over the black duck decline (e.g., Feierbend 1984, Boyd and Hyslop 1985, Nichols 1991, Conroy et al. 2002), no technique has been developed to separate age classes from late winter to late spring, as has been done with other species (e.g., blue-winged teal [*A. discors*], Dane 1968; redhead [*Aythya americana*], Dane and Johnson 1975; mallard [*Anas platyrhynchos*], Krapu et al. 1979, Gatti 1983; canvasback [*Aythya valisineria*], Serie et al. 1982; northern pintail [*Anas acuta*], Duncan 1985; and ring-necked duck [*Aythya collaris*], Hohman and Cypher 1986). Consequently, many key questions relating to how different black duck life-history characteristics vary by age have gone unanswered.

Age-specific life-history characteristics can be studied using band-return data and approximately 40% of all black duck bandings have occurred postseason, but because age determination techniques have not been developed, the value of these data has been limited. For instance, over 300,000 postseason (83% of all postseason bandings) banded black ducks have simply been assigned the default age of either after hatch year (AHY, a bird known to have hatched before the calendar year of observation; year of hatch otherwise unknown), or unknown (Canadian Wildlife Service Bird Branding Office files), instead of either SY or ASY.

Our objectives were to develop techniques to discriminate SY from ASY black ducks using qualitative field methods and multivariate models. We describe a field method using qualitative observations of wing feather characteristics that produces an age class score (ACS), and we tested this method by comparing assigned ages to those of known-age birds. To eliminate observer subjectivity and provide an easily repeatable and quantifiable technique, we also developed and tested multivariate models using discriminant functions. We performed multivariate analysis because there is much overlap in the range of feather measurements in SY and ASY waterfowl and no single measurement has been found to reliably determine age.

Study Area

We captured all ducks in spring and autumn at the Big Creek National Wildlife Area (BCNWA), Long Point, Ontario, Canada, during migration. The Long Point peninsula extends 35 km into the eastern basin of Lake Erie (42°35′N, 80°30′E to 42°33′N, 80°03′E) creating a 280,000-ha lacustrine embayment (Inner Bay) and 24,000 ha of coastal wetlands that are some of the most significant staging areas for waterfowl in eastern North America

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(Dennis et al. 1984). Long Point supports 50,000 black duck use-days in spring and 200,000 black duck use-days in autumn (Petrie 1998) and is at the northern edge of black duck wintering range, depending on ice conditions (Bellrose 1976, Ross 1987).

Methods

Age Terminology

Hatch year (HY, a bird capable of sustained flight and known to have hatched during the calendar year of observation) and SY birds, when grouped for statistical analyses, are referred to as "juvenile" birds. AHY and ASY birds, when grouped for statistical analysis, are referred to as "adult" birds.

Sources of Known-Age Birds and Wings

To study and develop criteria useful for reliably separating age classes, we examined wing feathers from 4 sources: 1) live birds caught in bait traps in autumn and held captive until the following April, 2) birds harvested in southern Ontario, 3) wings submitted to the Canadian Wildlife Service Species Composition Survey (SCS), and 4) live birds caught in bait traps in March and April.

To have a source of known-age black ducks in spring from which to develop discriminant functions, we captured wild, free-flying birds from late November to early December in 2001, 2002, and 2003 (53 AHY M, 24 AHY F, 56 HY M, 30 HY F), using baited funnel traps, and held them in captivity until the following spring. Wishart (1981) and Gatti (1983) suggested that captive birds may not provide a reliable source from which to develop quantitative models because of potential differences in mean measurements of feather variables. To address this concern and limit the effects of captivity on moult, we caught these birds in late autumn (similar to Duncan 1985). We determined age and sex through definitive cloacal characteristics (Gower 1939), which are accurate until midwinter and then become unreliable due to maturation. We held birds in an outdoor pen during winter and fed ad libitum. We took feather measurements in spring.

The second group of known-age birds consisted of individuals harvested in autumn 2003 (17 AHY M, 17 AHY F, 36 HY M, 38 HY F) by hunters in southern Ontario. We determined age and sex of these birds by definitive cloacal characteristics (Gower 1939) and used these birds and captive birds (above) to develop discriminant functions.

The third group of specimens consisted of wings from black ducks harvested in Ontario and obtained at the Canadian Wildlife Service 2002 SCS (50 AHY M, 52 AHY F, 74 HY M, 79 HY F). We determined sex by wing length and age (AHY or HY) using criteria developed by Carney (1992) which is regarded as a valid method of separating age classes through to early winter. We discarded those that could not be positively identified as being either AHY or HY (about 5%). We considered the remaining subsample "assigned-age" wings and used it as the independent sample from which to test quantitative models. Several studies (Dane and Johnson 1975, Wishart 1981, Gatti 1983, Duncan 1985) have used assigned-age wings from SCS to develop discrimination techniques. We tested discriminant functions developed using groups 1 and 2 above on this sample of black ducks to determine classification rates on an independent sample.

The fourth group of birds were black ducks caught in baited funnel traps at Long Point in March and April 2003 and 2004 (86 ASY M, 27 ASY F, 37 SY M, 16 SY F). We transported the birds 1 km to a field station where they were held in pens containing straw and an ample supply of fresh water. We typically held them for several hours to allow time to preen feathers before analysis. We assigned age classes as either SY or ASY based on the qualitative techniques developed from birds caught in 2001 and 2002 and verified sex by examination of the cloaca (Hochbaum 1942). We tested the percentage of agreement of our qualitative and quantitative techniques on this group of unknown-age birds.

Feather Selection

We considered all wing feather groups retained until the prebasic moult for inclusion as potential indicators of age. This was determined by a study of the 3 cohorts of wild HY black ducks caught in autumn and held captive until the following April (group 1 above). Within each feather group, we selected individual feathers based on their apparent usefulness for separating age classes during the initial year of the project (2001) and also their known ability to discriminate age classes in other species (Dane and Johnson 1975, Gatti 1983). We examined primary 5 (P 5), primary coverts 4–7 (PC 4–7), greater secondary coverts 5 and 9 (GSC 5 and GSC 9), and tertial covert 5 (TC 5; feather type and position no. from Palmer 1976).

We selected P 5 because the 5 proximal primaries are the first to grow in and P 5 is the largest. Any differences in feather size between HY and AHY birds because of body size at the time of feather growth should be accentuated in P 5 (Dane and Johnson 1975). We selected the middle primary coverts (PC 4–7) as a useful group for assessing both characteristics of edging and shape because PC 4–7 are the most likely PCs to exhibit squared terminal ends (Reed 1973) and because juvenile black ducks typically exhibit edging on the wider (inner) vane of several of the innermost primary coverts (Carney 1992). We selected GSC 5 and GSC 9 because of their usefulness in separating age classes of mallards (Gatti 1983). We used TC 5 because it is retained (Ashley 2005). Some studies (e.g., Krapu et al. 1979, Wishart 1981, Duncan 1985) have used feather color and markings to discriminate age classes, but this technique appears less useful with black ducks.

Qualitative Analysis: ACS Method

The qualitative technique was limited to the fewest possible characteristics of feathers that could be easily and consistently recognized in the field, yet achieve a high level of correct classification. For this part of the study, we used known-age captive birds in spring (group 1 above; $n = 33$

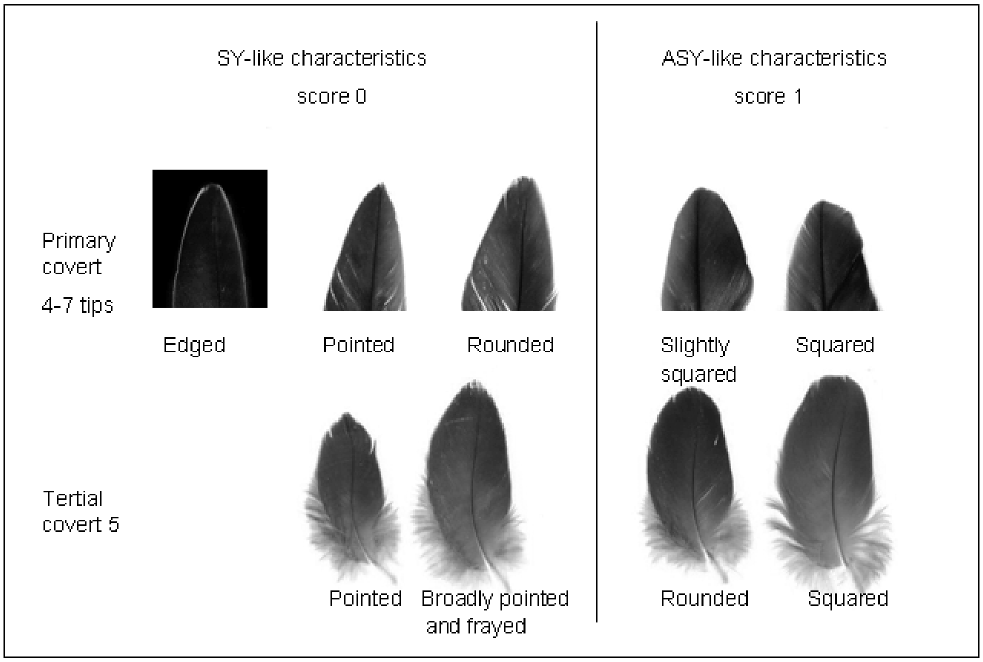

Figure 1. Edging, shape, and condition categories of primary covert 4–7 tips and tertial covert 5 of second year (SY) and after second year (ASY) American black ducks from southern Ontario, Canada, 2001–2003.

ASY M, 18 ASY F, 33 SY M, and 22 SY F) for which all feathers were present and not damaged beyond normal wear. We computed ACS by summing values assigned to various characteristics of PC 4–7 and TC 5. Juvenile-like characteristics were scored as 0 and adult-like characteristics as 1. We assessed 4 characteristics on each bird for a cumulative score of 0–4 tallied for each bird.

First, we analyzed PC 4–7 for the presence or absence of juvenile-like light, buffy cream color pigmentation (edging) along the feather margins. Edging, if detected on any primary covert (but typically found terminally on the broader vane of several of the outermost primary coverts [Palmer 1976]), was given a value of 0 and no edging a value of 1 (Fig. 1).

Second, the shape of primary covert (4–7) was assessed as 1) pointed, 2) rounded, or 3) squared (Fig. 1). Squaring of the broad vane produces an asymmetrical terminal profile that varies from slight to obvious. If none of the primary coverts were square (i.e., pointed or rounded) a value of 0 was tallied; if $\geq$1 primary coverts (4–7) exhibited squaring a score of 1 was assigned.

Third, TC 5 shape was assessed as either: 1) pointed, 2) broadly pointed, 3) rounded, or 4) squared (Fig. 1). Pointed and broadly pointed TC 5 received a value of 0 and rounded to square TC 5 received a value of 1.

Fourth, because immature feathers are structurally weaker than adult feathers and often show more wear, the condition of TC 5 was assessed as 1) obviously frayed, faded, or translucent, 2) faded with structural damage to feather, 3) slight fraying or wear and dark or opaque, and 4) no wear and dark or opaque. Thus, classifications 1 and 2 received a value of 0 and classifications 3 and 4 were given a value of 1.

Five independent observers with varying degrees of familiarity with the technique evaluated the qualitative method. We trained inexperienced observers for one-half hour by examining a subset of known-age specimens. For the test we taped TC 5 and the tips of primary coverts from captive birds in spring to cue cards. To determine the presence of pigmented margins, black paper was available to slide underneath the tips of the primary coverts to provide greater contrast. Investigators were given the sex of each bird because this would be obvious in the field. We determined percentage of correct classification post hoc by comparing assigned to actual ages.

Quantitative Analysis: Discriminant Function Analysis Method

We examined the following feather characteristics as potential criteria for quantitative age separation: mass, length (L), and maximum vane width (VW) of P 5, GSC 5, GSC 9, and TC 5; top width (TW) of PC 4, GSC 5, GSC 9; and calamus diameter (CD) of P 5, and we developed equations from feather variables obtained from captive (group 1) and hunter-harvested (group 2) birds.

We plucked feathers to be measured except PC 4–7 where the tip (3 cm) was clipped. We did this because we assessed only the tip, allowing us to leave most of the feather on the bird. Two examiners measured feathers in the laboratory. They took measurements after feathers were oven-dried for 24 hours at 60°C. They measured feather mass (to 0.1 mg) with a Sartorius Basic scale (Data Weighing Systems, Elk Grove, Illinois) and lengths of straightened feathers measured from the tip of the calamus to the tip of the rachis to the nearest 0.5 mm. We measured other feather and skeletal measurements (to 0.01 mm) with digital

Table 1. Percentage of captive and wild known-age second year (SY) and after second year (ASY) male and female American black ducks from southern Ontario, Canada, 2001–2003, with age-related feather characteristics in spring.

Feather variable[a]			ASY M $n = 42$	Total ACS[b]	SY M $n = 32$	Total ACS	ASY F $n = 21$	Total ACS	SY F $n = 32$	Total ACS
Primary covert 4–7 edging	SY-like	Yes	0	0	75	75	10	10	82	82
	ASY-like	No	100	100	25	25	90	90	18	18
Primary covert 4–7 shape	SY-like	Pointed	0	7	55	86	5	5	68	100
		Rounded	7		31		0		32	
	ASY-like	Squared	93	93	13	13	95	95	0	0
Tertial covert 5 shape	SY-like	Pointed	0	5	6	78	5	29	18	86
		Bluntly pointed	5		72		24		68	
	ASY-like	Rounded	76	95	19	22	66	71	14	14
		Broadly rounded	19		3		5		0	
Tertial covert 5 condition	SY-like	Fraying or faded	2	4	56	75	14	28	36	72
		Faded and damaged	2		19		14		36	
	ASY-like	No wear	33	95	3	25	19	72	5	28
		Slight fraying	62		22		52		23	

[a] If primary coverts 4–7 exhibited a combination of pointed and rounded tips they were classified as pointed; a combination of rounded and squared tips was classified as square; and if all primary coverts 4–7 were rounded they were classified as rounded.
[b] ACS = age class score.

calipers. We flattened feathers to measure VW at the widest point on the rachis and TW was measured 3 mm proximal of the rachis tip. We measured CD of P 5 at the superior umbilicus in the plane of the feather vane.

We also measured wing chord (WC), tarsus length (TL), culmen length (CL), and culmen width (CW) as potential indicators of age. We measured wing chord (to 1.0 mm) from the notch of the radiale to the longest primary using a standard wing board (Carney 1992). We measured the diagonal length of the tarsometatarsus bone from the most medial condyle of the tarsus where it articulates with the midtoe to the rounded exterior portion of the distal condyles of the tibia (where this bone is nearly at right angles to the tarsus). We measured CL along the center line of the dorsal surface of the bill from the distal tip to the intersection of the skin and premaxilla and CW at the maximum width of the premaxilla.

To determine if feather variables collected from autumn-shot birds and captive birds in spring were similar, we performed 2-sample t-tests on each of the 18 feather variables within each age and sex class. We pooled group variables without differences ($P \geq 0.05$) between means into one known-age group. For variables with different means ($n = 8$), we used only measurements from captive birds in spring because they were considered to be the more representative sample. We then performed quadratic linear discriminant analysis (StatSoft 2000, module Discriminant Analysis) on the remaining variables to assess the relative importance of variables in classifying ages and to identify combinations of subsets of variables that produced the simplest model with the greatest predictive success.

Since large discriminant functions can become impractical and unwieldy and increase the probability of individuals missing variables, we tested only models using $\leq$4 variables. We gave preference to variables that had relatively little variation within each sex and age class and were less subject to measurement error. We evaluated the predictive ability of these models using global cross-validation (jack-knifing) and independent test samples (group 3, SCS wings) using the module Classification Tree (StatSoft 2000) and estimated probability of a priori classification from sample size. We set the significance level at $\alpha = 0.05$.

Results

Qualitative Analysis

We assessed qualitative characteristics of primary and tertial coverts on 127 known-age black ducks in spring (Table 1). Due to feather damage, we tested a subset ($n = 106$) of feather specimens in good condition. Individual characteristics were variable in accuracy of age determination (72–100%) but the composite ACS were much more accurate. The qualitative method was 94–99% accurate at determining the age of captive birds using these feather samples. One inexperienced observer scored 94%, whereas the other observers scored 98–99%. The most accurate observer classified 97% ASY males to ACS 3–4 ($n = 33$), 100% SY males to ACS 0–2 ($n = 33$), 100% ASY females to ACS 2–4 ($n = 18$), and 100% ($n = 22$) SY females to ACS 0–1. We caught 11 previously banded birds of known age in spring. Nine (100%) ASY males scored 3–4 and 2 (100%) ASY females scored 2–3. By assigning ACS of 0–2 for SY males, 3–4 for ASY males, 0–1 for SY females, and 2–4 for ASY females, the qualitative model was a very accurate method of determining ages of known-age black ducks in the spring.

Table 2. Measurements of selected morphological variables from juvenile and adult male American black ducks of known age from southern Ontario, Canada, 2001–2003.

Variable[a]	Juvenile[b] Mean	SE	Range	*n*	Adult[c] Mean	SE	Range	*n*	*P*[d]	Standardized canonical coefficients
Variables in model										
W GSC 9 (mg)	22.5	0.26	18.5–27.3	68	27.4	0.36	20.7–35.6	51	<0.001	1.044
L GSC 9 (mm)	60.1	0.32	54.5–68.5	68	61.4	0.42	53.5–71.5	51	0.013	−0.658
VW TC 5 (mm)	17.98	0.18	13.79–22.43	68	20.62	0.18	18.42–24.97	51	<0.001	0.476
Variables not in model										
W P 5 (mg)	292.9	4.57	256.7–387.9	32	316.0	4.16	226.0–382.4	51	<0.001	
W GSC 5 (mg)	25.1	0.26	21.0–30.2	68	30.1	0.39	23.4–36.9	51	<0.001	
W TC 5 (mg)	13.2	0.28	8.2–21.4	68	16.4	0.41	11.9–27.2	51	<0.001	
CD P 5 (mm)	3.45	0.02	3.06–3.63	32	3.69	0.03	3.30–3.97	34	<0.001	
L P 5 (mm)	179.7	1.37	168.5–206.5	32	183.1	0.94	169.5–194.5	51	<0.001	
L GSC 5 (mm)	67.6	0.34	59.5–72.5	68	69.6	0.42	61.5–75.5	51	<0.001	
L TC 5 (mm)	49.2	0.45	39.5–62.5	68	51.7	0.61	43.5–64.5	51	0.001	
VW P 5 (mm)	30.92	0.20	26.00–35.33	68	32.87	0.22	29.48–36.06	51	<0.001	
VW GSC 9 (mm)	17.72	0.16	14.92–20.98	68	19.96	0.15	16.62–22.18	51	<0.001	
VW GSC 5 (mm)	16.47	0.14	14.03–18.71	68	18.39	0.24	10.82–23.63	51	<0.001	
TW PC 4 (mm)	6.29	0.08	4.85–7.86	68	7.41	0.09	6.30–8.91	51	<0.001	
TW GSC 5 (mm)	9.64	0.17	7.52–19.23	68	10.17	0.15	7.54–12.50	51	0.029	
TW GSC 9 (mm)	9.90	0.16	7.69–18.16	68	10.40	0.14	8.85–13.24	51	0.028	
TW TC 5 (mm)	8.36	0.13	5.66–10.68	68	9.59	0.17	6.35–11.09	34	<0.001	
WC (mm)	283.2	1.00	264–293	32	290.1	0.77	277–305	34	<0.001	
CL (mm)	54.04	0.26	50.44–59.27	55	53.55	0.28	48.39–58.24	53	0.931	
CW (mm)	23.61	0.10	21.90–25.08	55	23.72	0.10	21.93–25.10	53	0.435	
TL (mm)	47.18	0.17	44.06–49.69	55	47.06	0.20	42.18–51.01	53	0.650	

[a] W = weight, GSC = greater secondary covert, L = length, VW = maximum vane width, TC = tertial covert, P = primary, CD = calamus diameter, TW = top width, PC = primary coverts, WC = wing chord, CL = culmen length, CW = culmen width, TL = tarsus length.

[b] Includes autumn-shot hatch year birds and captive second year birds measured in spring, except W P 5, CD P 5, L P 5, WC, and VW GSC 5, which use only captive data.

[c] Includes autumn-shot after hatch year birds and captive after second year birds measured in spring except CD P 5, TW TC 5, and WC, which use only captive data.

[d] Significance of differences between group means based on *t*-tests.

Quantitative Analysis

Feathers of autumn-shot birds were similar in size to feathers of captive birds in spring in 64 of 72 feather variable categories (4 age or sex classes $\times$ 18 variables), and we pooled similar data sets for males (Table 2) and females (Table 3). Eight variables, mostly those involving primary feathers, showed differences between group means, with autumn measurements smaller than spring measurements (Table 4). Therefore, we used only data from spring captive birds for these variables in further analysis. Although there was much overlap in feather measurements between juvenile and adult black ducks, all variable means from adult males and females were correspondingly larger than juveniles. There was no difference in mean skeletal measurements between juvenile and adult males (Table 2) and females (Table 3).

A single variable, W GSC 9 with a cut-off value of 24.8 mg (juvenile $<$ 24.8 mg $<$ adult), was capable of correctly classifying the age of 89% of known-age males (90% adult and 85% juvenile, $n = 119$) and 95% of known-age females (83% adult and 98% juvenile, $n = 97$). A 3-variable discriminant model for both males and females achieved a slightly higher and more consistent ($\sim$90%) classification accuracy. Some gains in accuracy were achieved with optimal discriminant models, but these models contained many variables and unique sets of variables for each sex and did not improve the overall classification by more than 2% when compared to a reduced model using only 2 feathers and 3 variables (Table 5). We present here equations developed using the reduced models.

Female:

$$D = -8.486003 + (0.45566 \text{ W GSC } 9) + (-0.153406 \text{ L GSC } 9) + (0.38997 \text{ VW TC } 5),$$

and Male:

$$D = -3.25079 + (0.44439 \text{ W GSC } 9) + (-0.23446 \text{ L GSC } 9) + (0.342625 \text{ VW TC } 5)$$

with a calculated value of SY $< 0 >$ ASY.

Means of frequency distributions of unstandardized canonical scores for adult and juvenile females were $\bar{x} = 1.77$ and $\bar{x} = -1.00$, respectively, and for adult and juvenile males $\bar{x} = 1.59$, and $\bar{x} = -1.19$, respectively (Fig. 2).

Comparison of both qualitative and quantitative techniques on wild birds in spring of unknown age ($n = 172$; group 4) resulted in $\geq$94% agreement.

Discussion

Black duck age may be determined from late winter to late spring using characteristics of wing feathers with $>$90% accuracy. The qualitative ACS method was the most reliable and accuracy of classification did not vary significantly between observers. Experienced observers tended to score slightly higher than inexperienced observers, suggesting that

Table 3. Measurements of selected morphological variables from juvenile and adult female American black ducks of known age from southern Ontario, Canada, 2001–2003.

Variable[a]	Juvenile[b] Mean	SE	Range	n	Adult[c] Mean	SE	Range	n	P[d]	Standardized canonical coefficients
Variables in model										
W GSC 9 (mg)	21.5	0.22	17.7–26.0	62	26.1	0.39	19.8–31.3	35	<0.001	0.891
L GSC 9 (mm)	59.9	0.30	55.5–68.5	62	61.8	0.46	56.5–70.5	35	<0.001	−0.388
VW TC 5 (mm)	17.63	0.16	15.32–20.24	62	20.11	0.24	17.31–23.77	35	<0.001	0.522
Variables not in model										
W P 5 (mg)	257.4	2.57	206.8–308.9	62	283.4	3.52	244.4–325.0	35	<0.001	
W GSC 5 (mg)	24.2	0.29	19.1–29.2	62	28.4	0.53	22.5–36.8	35	<0.001	
W TC 5 (mg)	13.1	0.33	8.6–21.4	62	15.4	0.46	11.2–22.8	35	<0.001	
CD P 5 (mm)	3.28	0.02	2.84–3.62	62	3.43	0.02	3.17–3.73	35	<0.001	
L P 5 (mm)	170.0	0.69	157.0–184.5	62	175.5	0.89	166.3–185.0	35	<0.001	
L GSC 5 (mm)	67.0	0.36	58.5–75.5	62	68.6	0.55	59.5–74.5	35	0.012	
L TC 5 (mm)	48.6	0.54	38.5–61.5	62	52.0	1.12	44.5–81.5	35	0.002	
VW P 5 (mm)	29.99	0.24	19.2–33.0	62	32.40	0.27	29.47–35.49	35	<0.001	
VW GSC 9 (mm)	17.62	0.16	15.25–20.37	62	19.76	0.25	16.99–23.50	35	<0.001	
VW GSC 5 (mm)	16.16	0.14	13.59–19.21	62	17.57	0.20	15.78–21.53	35	<0.001	
TW PC 4 (mm)	6.51	0.08	4.49–7.95	62	7.69	0.16	5.25–9.32	18	<0.001	
TW GSC 5 (mm)	9.35	0.10	7.38–11.04	62	9.90	0.16	8.00–12.50	35	<0.001	
TW GSC 9 (mm)	9.79	0.12	7.98–11.83	62	10.11	0.15	8.25–12.32	35	<0.001	
TW TC 5 (mm)	8.14	0.13	4.39–10.03	62	9.46	0.13	7.50–11.44	35	<0.001	
WC (mm)	265.7	0.74	244–276	69	272.5	0.92	256–288	41	<0.001	
CL (mm)	50.48	0.28	46.11–53.04	31	50.32	0.46	45.20–56.56	25	0.858	
CW (mm)	22.42	0.11	21.11–23.52	31	22.50	0.13	21.33–24.09	25	0.634	
TL (mm)	44.32	0.16	42.71–47.62	31	44.53	0.29	42.09–47.34	25	0.377	

[a] W = weight, GSC = greater secondary covert, L = length, VW = maximum vane width, TC = tertial covert, P = primary, CD = calamus diameter, TW = top width, PC = primary coverts, WC = wing chord, CL = culmen length, CW = culmen width, TL = tarsus length.
[b] Includes autumn-shot hatch year birds and captive second year birds measured in spring.
[c] Includes autumn-shot after hatch year birds and captive after second year birds measured in spring except TW PC 4 which use only captive data.
[d] Significance of differences between group means based on *t*-tests.

some gains in accuracy may be achieved with practice. Determining the shape category of primary coverts and tertial coverts was straightforward with little discrepancy between investigators. Feather shape was very indicative of age since 93% of adult males and 95% of adult females had squared tips of primary coverts. In contrast, Reed (1973) found only 67% of adult wings ($n = 202$) he examined had squared primary covert tips. However, from Reed's figure 1, it is suspected that squaring of the tips needed to be more obvious than the shapes included as squared in this study, which classified primary coverts with any amount of squaring of terminal ends as squared. Using this method age can be determined accurately for a high percentage of individuals, but classification dependent upon a singular shape characteristic can be misleading because a small proportion of most age and sex cohorts exhibit some traits of the other age cohort.

Assessing pigmentation of primary coverts required careful observation. Traces of light edging as a result of wear and not pigmentation may lead one to score this characteristic as juvenile and not as adult. Abrasion also could cause the buffy-colored tips to break off, requiring one to examine side margins for pigmentation.

Feather wear also was an important component of scoring

Table 4. Feather variables of American black ducks shot in autumn and captive American black ducks in spring with differences between group means. Samples from southern Ontario, Canada, 2001–2003.

Variable[a]	Autumn Mean	SD	n	Spring Mean	SD	n	P[b]
HY M L P 5 (mm)	174.6	3.44	36	179.73	7.73	32	<0.001
HY M W P 5 (mg)	279.1	13.7	36	292.9	25.9	32	0.007
HY M CD P 5 (mm)	3.35	0.14	36	3.45	0.12	32	0.003
HY M WC P 5 (mm)	278.6	5.99	36	283.2	5.65	32	0.001
AHY M CD P 5 (mm)	3.55	0.16	17	3.69	0.17	34	0.008
AHY M WC (mm)	287.1	8.37	17	290.1	6.07	34	0.041
AHY M TW TC 5 (mm)	8.88	1.22	17	9.60	0.98	34	<0.001
AHY F TW PC 4 (mm)	6.69	0.76	17	7.69	0.86	18	<0.001

[a] HY = hatch year, L = length, P = primary, W = weight, CD = calamus diameter, WC = wing chord, AHY = after hatch year, TW = top width, TC = tertial covert, PC = primary covert.
[b] Significance of difference between group means based on *t*-tests.

Table 5. Percentage of correct classification, agreement between quantitative and qualitative methods for separating second year (SY) from after second year (ASY) American black ducks in Ontario, Canada, 2001–2003.

	% correct classification						% agreement between methods[c]		
	Cross-validation[a]			Independent sample[b]			Wild birds in spring		
	Overall	SY	ASY	Overall	SY	ASY	Overall	SY	ASY
F	$n = 97$	$n = 62$	$n = 35$	$n = 131$	$n = 79$	$n = 52$	$n = 46$	$n = 19$	$n = 27$
	91	92	91	91	90	92	96	89	100
M	$n = 119$	$n = 68$	$n = 51$	$n = 124$	$n = 74$	$n = 50$	$n = 126$	$n = 37$	$n = 89$
	90	90	90	90	85	96	94	95	94

[a] Percentage of cases estimated correctly using global cross-validation procedures.
[b] Percentage of ages correctly determined with qualitative age of species composition survey wings used as a relative benchmark.
[c] Percentage of agreement between qualitative and quantitative methods.

TC 5. Most SY birds showed obvious fading or fraying or were damaged by excessive wear, but some SY birds exhibited only slight wear, more typical of adult feathers. It also was important to assess feather condition because juvenile feathers may have little wear, but still appear lighter and more translucent than the more opaque and darker adult feathers. Despite these variations this technique was robust enough that cumulative effects of irregularities in wear, shape, and pigmentation in individuals usually did not result in incorrect age-class assignments. The use of an ACS system is advantageous compared to other qualitative methods because it limits the subjectivity of assigning age.

Determining black duck ages by the ACS method is not difficult if investigators are trained and feathers are clean and dry. Holding birds for a few hours in pens with straw gave them time to preen their feathers, which facilitated age determination. Good trap design can reduce the chance of feathers becoming wet and soiled. With feathers in good condition, summing scores and arriving at an age in the field takes little time.

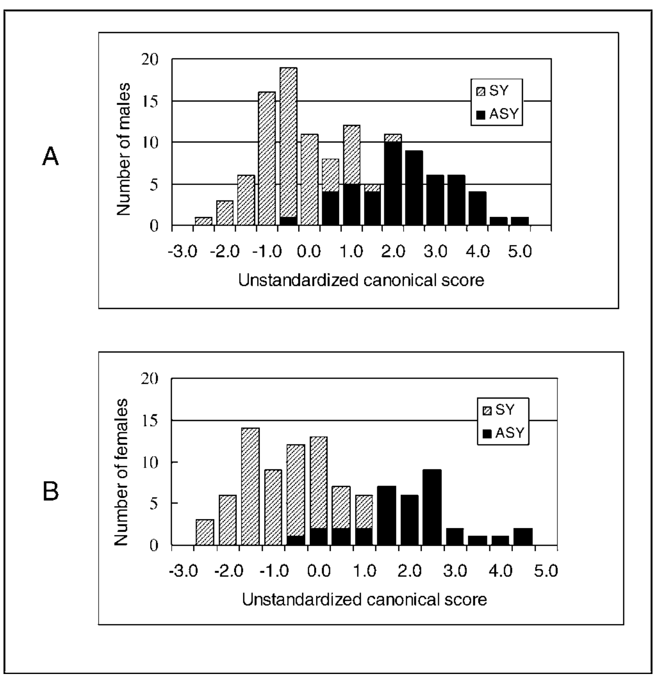

Figure 2. Frequency distribution of unstandardized canonical scores for second year (SY) and after second year (ASY) American black ducks, male $n = 119$ (A), female $n = 97$ (B) from southern Ontario, Canada, 2001–2003.

Qualitative models using discriminant functions also are useful for determining ages of waterfowl (e.g., Duncan 1985, Harvey et al. 1989) but variables must be chosen cautiously (see Hohman et al. 1995, Sayler 1995) because model performance may be hampered by the confounding effects of developing functions from populations with different means and variation than those to which the discriminant functions are applied. It generally is assumed, however, that waterfowl age determination models are applicable across flyways because of the mixing of populations during migration and on the wintering grounds (Hohman et al. 1995). Of all the potential variables selected for our multivariate analysis, only skeletal measurements were similar between juvenile and adult birds. Some variables, especially those associated with primary feathers of captive birds (measured in spring), were found to be larger and more variable than remigial measurements of autumn-shot birds. Accordingly, primary feather measurements may be less useful for discriminant function modeling.

With these provisos, objective and accurate assignment of ages of male and female black ducks can be determined postseason using multivariate analysis of appropriate feather variables. Many combinations of variables used in discriminant analysis provided good discrimination based on the apparent error rate but performed poorly when tested on independent samples, or they performed well overall but possessed unacceptably skewed classification rates. We selected models that had high correct classification rates when developed and when tested by global cross-validation (jack-knifing) and conventional procedures.

The variable W GSC 9 was most important for separating age classes of both males and females and the first variable entered into all models. The single-variable model (with a cut-off value of 24.8 mg) provided nearly 90% correct classification for both males and females. Although this variable produced high overall classification rates, the classification of adults and juveniles was more disproportionately skewed than rates determined by discriminant analysis. The discriminant model is preferred because it decreases skewness in classification rates.

Reduced models (that excluded the potentially unreliable primary feather variables) performed nearly as well as full models. The most parsimonious model possessing a high degree of classification (>90%) for both males and females used only 3 variables and 2 feathers. We achieved slightly more accurate ($\leq$2%) classifications with 4-variable models. Discriminant functions used to separate age classes of waterfowl in other species produced classification rates in the range we obtained (c.f. Gatti 1983, Duncan 1985).

One disadvantage of using SCS wings as the independent sample from which to test the quantitative models is that errors in the original assignment of age classes using qualitative techniques will decrease the apparent accuracy of the model. Still, >90% accuracy was achieved when tested on SCS wings and the models should be expected to perform as well on other samples. Model development relied on birds collected in southern Ontario over 3 years and was tested on birds harvested in the province over 2 years. Also, banding-recovery data show that birds banded and harvested in southern Ontario disperse throughout the Mississippi and Atlantic Flyways as well as all provinces east of Ontario (c.f. Petrie 1998). The temporal distribution of samples used, combined with the dispersal of birds from Ontario to most of black duck range, suggests that prediction coefficients were developed from a heterogeneous sample of the population. Todd (1963) found no variation in body size by region, although Palmer (1976) suggested that there may be some clinal variation in size, although this assumption was not based on measurements (Longcore et al. 2000). Ankney et al. (1986) found no genetic differences between populations of the Atlantic and Mississippi Flyways. Consequently, age assignments based on discriminant functions developed herein should have general applicability across black duck range and prediction coefficients robust enough to account for temporal and spatial influences on feather size.

Age determination using quantitative techniques requires limited prior experience (Serie et al. 1982, Gatti 1983, Harvey at al. 1989) and is highly effective because it allows an objective corroboration of age estimates (e.g., Reynolds et al. 1995). Reliable age estimates may be ascertained by plucking and measuring only 2 readily identifiable feathers, the removal of which should not affect flight.

There was a high degree of agreement between the qualitative and quantitative methods when determining ages of black ducks in spring. This indicates that black duck ages can be accurately determined postseason under field conditions. Use of techniques developed herein can be applied to a broad range of research and management programs for which the determination of age as SY or ASY is necessary or beneficial, such as in postseason banding projects and for other management programs.

Management Implications

The development of accurate postseason techniques for age determination is a Black Duck Joint Venture research priority (B. Collins, Canadian Wildlife Service, personal communication) partly in response to fewer birds being banded annually during the preseason banding period. Some band recovery models assume that annual survival and recovery rates are age-specific (Brownie et al. 1985). The ability to determine ages of black ducks as SY and ASY instead of just AHY may increase the precision of model estimates. It is known that black ducks, like most species of ducks, have lower annual survival and recovery rates and higher harvest rates in their first year of life than in subsequent years (Krementz et al. 1987). Specific studies to determine differences in annual survival and recovery rates of SY and ASY black ducks banded in winter have not been conducted because the age of birds could not be reliably determined (Nichols et al. 1987). Whether these rates for SY birds banded postseason are more similar to HY birds banded preseason or ASY birds banded postseason, or somewhere in between, is unknown. Although it has been shown that SY mallards have similar vital rates to ASY birds (Hopper et al. 1978, Rakestraw 1981, Nichols et al. 1987) demographic parameters may differ between these species (Nichols et al. 1987) and warrant investigation in black ducks.

There also may be differences in age-specific productivity rates of black ducks. Pairings within and between age classes may produce significantly different reproductive outcomes because of such factors as courtship, breeding and nesting experience, and hormonal regulators in both the male and female. With the ability to determine age of each sex, studies of black duck productivity can include an age component.

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