Aging And Sexing Gray Catbirds by External Characteristics

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ABSTRACT

Using a field sample of 1248 Gray Catbird *(Dumetella carolinensis)* encounters in New Jersey, we examined various characteristics, including those observed by earlier writers and those used in the Bird Banding Manual II, to determine which combination of characteristics may be useful in aging and sexing that apparently monomorphic species. Multivariate techniques were applied to a large field sample, followed by closer examination of iris, mouth, and tongue color changes during the hatching year, to determine the variables that discriminated older age groups from each other, and the sexes from each other.

Summary information is given on age-related changes and characteristics. Some catbirds evidently may undergo a complete post-juvenal molt. Browner plumage thought by earlier workers to be sex related, were found to be age related. Extent of chestnut in the crissum was individual, both age and sex related. Wing and tail increased in length with age, particularly at the complete post-breeding molt in the second year, and more slowly after. After-second-year and older birds were separable from second-year birds in a pool of after-hatching-year birds by evaluation of soft part color changes and feather measurements. Males obtained soft part color changes sooner than females.

Field tests on subsequent samples of catbirds resulted in age discrimination of second-year and after-second-year birds from a pool of after-hatching-year birds with 88.5% accuracy, and sex discrimination of known males and females with 78% accuracy. We present classification functions and encourage other field workers to use and test our results.

INTRODUCTION

One of our most common species, the Gray Catbird *(Dumetella carolinensis),* eludes detailed analysis of population age and sex composition, intraspecific and interspecific behavior, and differential age and sex wintering range ecology, because age and sex are difficult to determine outside of the breeding season. The birds appear completely monomorphic. Earlier investigators wrote that females are paler (Audubon 1834) and duller with brown pileum, wings, and tail (Dwight 1900), and that males have more extensive chestnut in the crissum (Ridgway 1907). Chapman (1916) noted that some females have a slightly browner crown and upper parts than the male, but that they vary too little to make the sexes certainly distinguishable. Dwight, writing about the first winter plumage acquired by the molt of body feathers and wing coverts, described the barring on the tail feathers of the hatching year bird and the retention of these rectrices and remiges with their coverts in the first fall molt whereupon young and old become practically indistinguishable.

At the onset of this study in 1972, methods available for aging catbirds were according to Wood (1969), separating hatching year (HY) birds from after-hatching year (AHY) birds from January through September. Birds captured from October through December were aged unknown (U). In 1977, when this study was well under way, the more detailed key in "North American Bird Banding Techniques" (Bird Banding Manual Vol. II) was published. The key facilitates discrimination of HY birds from AHY birds June through December and second calendar year (SY) birds from AHY birds January through April by iris and mouth color. The "Notes for Further Study on Catbirds" in the Bird Banding Manual Vol. II call for information on the rate of eye and mouth color change, suggested by Klimkiewicz, and on the frequency of retained juvenal coverts, suggested by Weske.

In the present study, drawing on a data base from a long-term field study by the first author, we examine the possible relationships observed by earlier writers; pursue the above recent questions; and use multivariate techniques to determine which set of relevant variables may be most useful in determining the age and sex of catbirds, multivariate techniques being potentially more predictive than univariate techniques (*cf.* Desrochers 1990).

Our results demonstrating that birds can be aged beyond the second year (ASY) were first reported at the 1979 EBBA-NEBBA Joint Annual Meeting, followed by more years of field work to build sample size for the multivariate analysis.

METHODS

Data Collection : Catbirds were mist netted in migration (end of April through May, and September through October) at a coastal barrier beach, Island Beach State Park, Ocean Co., N.J., from 1972 to 1981. The study continued inland during the migration (May, September, October) and breeding seasons (June through August) in abandoned, overgrown hayfields in Hopewell Township, Mercer Co., N.J., from 1978 through 1989. Birds were initially aged according to Wood (1969) and then by the Bird Banding Manual II when available in 1977 (see AGE, Appendix). Sex was determined by brood patch or cloacal protuberance during the breeding season.

Field work from 1972 to 1986 yielded a data base of 1248 encounters used for analysis. Of these, 1045 were first captures, 67 repeats, 2 foreign recoveries, and 134 return encounters involving 102 individuals of which 10 were SY birds returning to breed on their natal grounds, and 24 were multiple returns of two to five times. Determinate ages (see AGE, Appendix) were known for 762 encounters; 469 HY; 258 SY; 21 third year (TY); 11 fourth year (4Y); 2 fifth year (5Y); and 1 sixth year (6Y). Indeterminate age birds totalled 466: 407 AHY; 30 ASY; 10 ATY; 6 A4Y; 7 A5Y; 5 A6Y; and 1 A7Y. There were 390 birds of known sex: 219 males and 171 females. Repeats by early arriving adults provided sex information during the breeding season. Repeats of local fledglings provided information on soft part color changes.

Field work from 1987 through 1989 accumulated 316 further encounters, including 43 new SY birds, 32 older return encounters, and 76 males and 68 females. We used these birds to test the age and sex discriminant functions derived from the original data base.

Measurements were taken of variable physical characteristics which were reported or observed to show promise in determining age or sex. When it became evident during the preliminary stage of the study that the variables suggested by the earliest workers were inadequate alone to distinguish age or sex, more variables were added to be used in combination. In the final analyses of age, birds with missing variables were eliminated. The variables and methods of evaluating them are listed in the Appendix with the names used in our computer analysis for referential convenience. These names are in capital letters. All lengths are in the nearest millimeter. Some of the codes and Munsell color notations are also provided, as they are needed to use the classification functions.

Method of Analysis: Analyses using SPSS release 9.1 (Nie *et al.* 1975) included a t-test to verify that the coastal population did not differ from the inland population on WING and TAIL. Initially, descriptive statistics for the entire sample and all subsamples defined by age categories, sex categories, and their combinations were computed. Analyses concerned with the prediction of age used only those birds whose placement in an age group could be made with certainty (determinate age), using plumage, time of year, and previous capture (see AGE, Appendix). Birds which were aged SY using iris or mouth color alone, as recommended by the Bird Banding Manual Vol. II, were not used, as the relationship of those variables with age was being studied. The analysis concerned with the prediction of sex used only those birds whose sex was determined by presence of brood patch or cloacal protuberance.

The primary technique for the age and sex analyses was the Discriminant Function Analysis (DFA) provided by the DISCRIMINANT facility of SPSS (Nie *et al.* 1975). Pearsons correlations were computed between each of AGE and SEX and each of their potential predicting variables. Only those variables whose correlation with the relevant dependent variable met a criterion of $\alpha \leq 0.05$ were retained. Then Discriminant Function Analyses were applied to the surviving variables for AGE and for SEX. Each DFA used the "direct" method (simultaneous entry of variables) with listwise deletion of missing values. Univariate F Ratios were examined to interpret the relative contributions of each variable to the overall discrimination task.

We examined in detail two questions concerning age. One was the changes in color variables during the hatching year (*cf.* Wood 1973 on iris color). We gave each HY bird captured during the breeding seasons a "fledgling age" (FAGE), defined to be the number of days between the date of capture of the first local fledgling of the year and the subsequent date of capture of each HY bird being aged. Correlations were computed between fledgling age and the color variables of interest.

The other question was how to best discriminate SY from ASY catbirds in a pool of AHY catbirds. The age scale, AGE, was defined to consist of three groups: HY birds, SY birds, and a third group, ASY, consisting of all birds known with certainty to be at least in their third calendar year. The preliminary DFA was biased by the presence of a large sample of HY birds and included more variables than practical. Some variables were redundant and some difficult to measure reliably in the field. A second DFA analysis was required. All older birds were pooled into ASY, now totaling 98 cases, necessary to obtain an adequate bird to variable ratio for multivariate analysis (Tabachnick & Fidell 1983) in the older age group. Correlations were recomputed between candidate variables and the subscale of AGE containing only SY and ASY, with the cutoff set at a stringent $\alpha \leq 0.01$ to aid in selection of the variables most relevant to this disrimination task. Listwise deletion of birds with missing data on these variables resulted in 122 SY and 78 ASY remaining cases. We undertook a second DFA using the "stepwise" method (sequential entry of variables, Wilks' lambda being the measure of discriminatory power used to determine which variable to enter next) to derive a more concise function (Tabachnick & Fidell 1983). The classification functions were based on equal prior probabilities for all groups, as the information needed for a Bayesian adjustment was not available. These functions were tested against the sample of recent captures and recaptures of known age (n=61) which were not included in the sample from which the functions were derived.

RESULTS AND DISCUSSION

Birds captured at Island Beach State Park and at Hopewell did not differ on a t-test for WING and TAIL (p wing = 0.60, p tail = 0.44). These populations were pooled for analysis. Overall wing and tail measurements of the New Jersey birds were comparable to those of Gray Catbirds on Long Island summarized by Raynor (1979). Averages of a sample of birds banded at Raccoon Ridge Nature Observatory in northwestern New Jersey, of 20 Florida skins from the University of Miami, and of 21 New Jersey skins from Princeton University were also comparable with the central New Jersey sample, so it is assumed that clinal differences are not involved in this study. A χ^2 was used to test the distribution of sex across age. There was no significant dependency ($\chi^2 = 4.89$, $p = 0.30$), so we may assume that differences across age groups are not attributable to varying proportions of sexual makeup of those groups, or vice-versa.

Descriptive Results for Age -- Table 1 gives a profile of the average Gray Catbird within a given age category. In general, migratory HY birds in the first winter plumage were smaller, with lower iris, mouth, and tongue scores, with more light gray tips on the pairs of tail feathers. Many birds (150 of 236) in the first winter plumage had detectable retained feathers after molt: browner primaries and primary coverts; and/or some or all retained greater secondary coverts with browner edges as described by Dwight; and/or brown-edged tertiaries. The later broods did not have as much time to molt the secondary coverts before day length and energy budgets would demand a switch to preparation for migration (Payne 1972). Of the 236 HY birds scored for both brood age and retained feathers, retained feathers were detected on 55% of the early brood (n=144) and 77% of the late brood (n=92), significantly different by χ^2 ($p>0.005$).

The remaining birds (86 of 236) in the first winter plumage had gray remiges and coverts practically indistinguishable from adults and fresh greater secondary coverts with lighter gray outer edges, making age detection the following spring possible only by iris and mouth as described in the Bird Banding Manual Vol. II. HY birds may have a higher incidence of complete molt than previously realized, as suggested above by this 36% of the birds recognized as HY by only iris and mouth color and short wing and tail. A HY net casualty of 3 September 1984 with unpneumatized skull, gray-brown irides, pink and yellow mouth, and gray and pink tongue (now skin #16609 at Princeton University) showed active, symmetrical molt in two primary and three secondary flight feathers.

The irides of HY birds changed from gray to medium brown and mouth and tongue color changed progressively from yellow to mixtures of yellow, pink, gray, and black (see IRIS, MOUTH and TONGUE in Appendix) from the time that local fledglings first appeared in the mist nets in early July until the last migrants departed in late October (Figure 1). The correlations between fledgling age and the color variables (Fig. 1) were significant at 0.50 for IRIS, 0.53 for MOUTH, and 0.52 for TONGUE (n=163). Only 1 of 163 known local fledglings had adult-like dark brown irides (code 6), 7 had black with pink mouths (code 6), and 6 had gray tongues (code 3). Each of these exceptions had HY characteristics on the other color variables. Thus, extreme values on all of the color variables enable one to rule out an age of HY.

Second year birds characteristically had medium brown irides or darker brown irides with a lighter ring. Their mouths were mostly black with pink, the residual pink being at the corners and in the roof of the mouth. All catbirds have pink under the tongue and in the respiratory aperture in the roof of the mouth. Second year tongues were pink or some combination of pink, gray, and black. SY birds, carrying their shorter juvenal flight feathers until their first complete molt in the fall, were also smaller than older birds, including the 10 SY returns (SY birds in Table 1). These feathers and retained coverts on both male and female appeared duller or browner, noticeably faded in contrast to the newer secondary flight feathers. Feather tips sometimes wore ragged, especially in the tail where some of the light gray spots were eliminated.

Third year (TY) catbirds had longer, grayer wing and tail feathers by 1-3 mm, having gone through their first complete molt in the fall of their second year (Table 1). They still had the barring or watermarking on the tail, but had fewer light gray tips on the tail. Their irides were dark brown or blackberry, the black mouths showed little if any pink at the corners, and tongues were gray or gray and black. By the fourth year, their mouths and tongues were in most cases black. New primary and tail feathers increased on an individual basis to our longest recorded length of 96 mm wing and 106 mm tail, and the chestnut in the crissum increased to our longest recorded length of 30 mm deep, 34 mm long, and 33 mm short. This trend continued in 14 returns of 4Y to 6Y birds and in 32 returns of ATY to A7Y birds through spring of 1989. The trend of wing and tail increase was also seen in the multiple returns of 24 individuals (Wilcoxon Signed Ranks test, p = 0.01). Francis and Wood (1989) also report wing length increases in four species of wood warblers from the second to third summer, and continued increase in subsequent molts in the Yellow-breasted Chat *(Ictera virens)*.

DFA Results for AGE -- The first Discriminant Function Analysis resulted in two significant ($p \leq 0.0001$) functions that correctly classified 90.2% of the sample they were computed from. Function 1 discriminates HY from SY and older birds. The primary contributions to this discrimination are made by IRIS, MOUTH, and CORTIP, the TONGUE being redundant. When other means of aging were not available, such as juvenal plumage or retained feathers after molt, the soft part color variables were sufficient in distinguishing HY and SY from AHY birds, as described in the Bird Banding Manual Vol. II. Our first Discriminant Function Analysis verified this. Function 2 discriminates SY from ASY. The strongest contributors are MOUTH, WING, CULMEN, WINGDIFF, TAIL, WINGTIP, and TONGUE.

The second DFA separated SY from ASY. The variables which met the criteria for this analysis were CORTIP, IRIS, NINETEN, TAIL, TONGUE, WING, WINGDIFF, and WINGTIP. This analysis resulted in a significant discriminant function ($p \leq 0.0001$) which correctly classified 89.0% of the cases it was computed on (90.2% of the SY and 87.2% of the ASY cases). WINGTIP, WING, WINGDIFF, and TAIL had strong roles reflecting the increased length of the new flight feathers after that first complete fall molt and subsequent fall molts.

The derived classification functions follow below. One uses these classification functions by replacing the variable names in each expression with the field data for those measures (coded as defined in the Appendix), summing the products of each variable times its classification function coefficient, subtracting the constant (698.542 or 777.455) from this sum, and assigning the bird to the age class having the highest resulting classification score. The chore of computation is greatly reduced by making a table of the products of a coefficient times each observed measurement of its respective variable, or by using a programmable calculator.

SY = (2.082 x CORTIP) + (3.849 x IRIS)
+ (0.156 x NINETEN) + (0.677 x TAIL)
+ (4.142 x TONGUE) + (14.290 x WING)
+ (1.380 x WINGDIFF) + (1.010 x WINGTIP)
- 698.542

ASY = (1.261 x CORTIP) + (5.004 x IRIS)
+ (0.028 x NINETEN) + (0.808 x TAIL)
+ (5.603 x TONGUE) + (14.811 x WING)
+ (1.687 x WINGDIFF) + (1.360 x WINGTIP)
- 777.455

These classification functions tested on 61 birds of known age captured subsequently in 1987-1989 classified 54 birds, 88.5%, correctly. The errors were a 4Y bird with an unusually high CORTIP for its age classified as SY; three TY birds with short wings classified as SY; and three SY birds with low CORTIP score, long WINGTIP, and black TONGUE, respectively, classified as ASY. Retained feathers would have annulled the error in the SY birds.

DFA Results for Sex - The discriminant functions ($p \leq 0.0001$) which resulted from the sex analysis correctly classified 78.9% of the 242 birds used to derive the function (81.8% of 132 males, 75.5% of 110 females).

M = (1.640 x CHRISHORT)
+ (25.682 x CULMEN) + (7.292 x MOUTH)
+ (.892 x TONGUE) - 257.693

F = (1.489 x CHRISHORT)
+ (24.995 x CULMEN) + (6.544 x MOUTH)
+ (.432 x TONGUE) - 237.50

The samples were heavily weighted by SY birds (71% of the determinately aged males and 82% of the females) and AHY birds (75% of the indeterminately aged males and 80% of the females). Older birds of known sex, even after 12 years of data gathering, were sparse (24 males and 30 females), making it impracticable to treat them separately by age. However, wing, tail and primary feather differences between sexes of a given age were similar as described earlier. The emargination of primaries was monomorphic.

The shorter culmen of females has strong discrimination power, seen also in other avian sex determination models (*cf.* Brennan *et al.* 1984), useful in the catbird when combined with other functions. The discriminant functions reflect the tendency for more males than females to obtain black mouths and tongues and to obtain them sooner, but the sample of known HY males and females (sexed in subsequent capture) is too small to separate them out in Figure 1. We need a closer look at the variations in mouth and tongue color changes in fledglings; i.e., why some mouths in score 2 are yellow and gray instead of yellow and pink, and in score 3 are pink and gray instead of pink with some yellow. These may be sex differences.

The classification functions for sex tested on 144 adult birds of known sex captured subsequently in 1987-1989 classified 78% correctly (74% of 76 males; 82% of 68 females).

Practical Implications -- Using these functions we can separate groups of AHY birds containing both SY and older birds into SY and ASY even when there are no retained greater secondary coverts in the SY birds. In October through December (after the fall molt), HY birds will still be distinguishable. The SY birds will have longer flight feathers now resembling ASY birds and may become otherwise indistinguishable from other members of the ASY cohort. Therefore, all doubtful non-HY birds will have to be called AHY until January when they become ASY, when HY birds progress to SY and the distinction can be made between these new SY birds and the new ASY birds. A posterior probability of correct classification of age or sex can be computed by workers needing high confidence of age/sex assignment from their field samples. Birds below 95% probability of correct classification can then be rejected from a study. See Brennan *et al.* 1984 for the posterior probability computation.

The power to distinguish SY and ASY birds in a pool of AHY birds gives a handle on questions in catbird breeding biology and wintering ecology. Light colors of the soft parts and the abundant light gray tail tips on the HY birds may be signals of recognition that have some meaning in the interactions of young and adult on natal territories. The discriminant functions used on 22 birds of unknown age banded in January on winter grounds in Mexico, Guatemala and Costa Rica, resulted in 9 SY birds and 8 ASY birds. None of the SY birds had detectable retained feathers, suggesting a possible differential migration between broods. A local fledgling banded at Island Beach State Park, NJ, by K. G. Price was recovered in Guatemala (personal communication) suggesting the extent of winter range of New Jersey birds. In spring, SY birds' soft parts colors and faded, retained juvenal feathers may be a sign of immaturity that affects territorial defense and mate selection (*cf.* Lyon and Montgomerie 1986). There may be an advantage, therefore, to an early-brooded bird to acquire the indistinguishable adult plumage color as soon as possible, during the post juvenal molt. Finally, there may be an advantage of being apparently sexually monomorphic on winter grounds, where catbirds were observed defending food resources (H.B. Suthers, unpublished).

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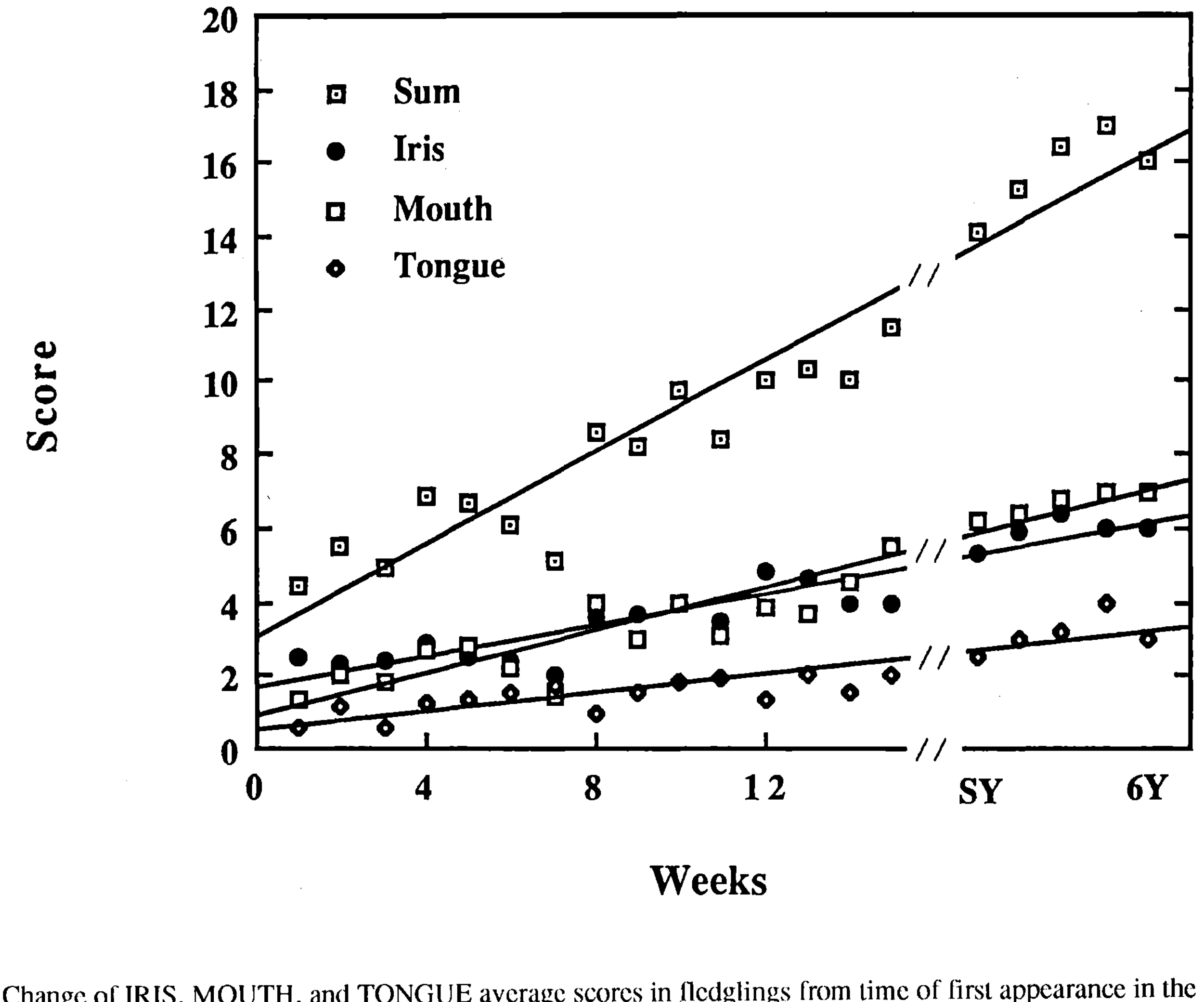
Figure 1. Change of Color Variables in Fledglings



Change of IRIS, MOUTH, and TONGUE average scores in fledglings from time of first appearance in the mist nets to the last capture during fall migration, compared with scores of adult birds up to six years. The dip in values at week 6 reflects the appearance of late broods. Maximum possible Sum is IRIS 7 + MOUTH 7 + TONGUE 4 = 18. Linear regression slopes are: Sum, y = 3.018 + 0.627x, R^2 = 0.927; Iris, y = 1.686 = 0.211x, R^2 = 0.871; Mouth, y = 0.864 + 0.289x, R^2 = 0.896; Tongue, y = 0.467 + 0.128x, R^ = 0.797. Sample sizes are 163 HY, 181 SY, 21 TY, 11 4Y, 2 5Y and 1 6Y.

Table 1. Age Characteristics of the Gray Catbird.
(Measurements in mm ± Standard Error of the Mean)
(See Appendix for measurements and soft part color scores.)

	AGE						
	HY[a]	SY	TY	4Y	5Y	6Y	A7Y
WING	86.6 ± 0.16	85.9 ± 0.18	89.2 ± 0.39	89.5 ± 0.62	89.5	92.0	95.0
WINGDIFF	37.2 ± 0.16	36.4 ± 0.20	39.6 ± 0.41	38.8 ± 0.98	39.0	38.0	42.5
NINETEN	25.2 ± 0.14	25.0 ± 0.18	26.2 ± 0.35	25.7 ± 0.45	26.0	26.0	27.0
WINGTIP	13.6 ± 0.15	13.0 ± 0.16	14.2 ± 0.48	14.3 ± 0.67	15.0	14.0	16.0
TAIL	89.8 ± 0.24	89.6 ± 0.25	94.2 ± 0.91	93.7 ± 1.25	92.0	94.0	98.0
CORTIP	5.1 ± 0.07	4.2 ± 0.11	3.2 ± 0.28	3.7 ± 0.50	5.0	6.0	4.5
CRISSHORT	18.0 ± 0.36	17.7 ± 0.31	17.6 ± 1.47	21.7 ± 1.26	21.5	22.0	14.5
CULMEN	15.2 ± 0.06	16.4 ± 0.06	16.4 ± 0.22	16.6 ± 0.20	18.0	16.0	17.0
IRIS	3.6 ± 0.07	5.3 ± 0.07	5.9 ± 0.33	6.4 ± 0.20	6.0	6.0	6.0
MOUTH	2.8 ± 0.08	6.2 ± 0.06	6.4 ± 0.16	6.8 ± 0.18	7.0	7.0	6.5
TONGUE	1.6 ± 0.06	2.5 ± 0.07	3.0 ± 0.17	3.2 ± 0.28	4.0	3.0	3.0
N	229	181	21	11	2	1	2
M	7	62	10	6	2	1	0
F	2	75	11	5	0	0	2

[a]after molt

APPENDIX: DESCRIPTION OF VARIABLES

AGE: Birds with juvenal characteristics through fall migration were aged hatching year (HY). Spring birds with retained, faded juvenal primaries and coverts and/or with retained juvenal greater secondary coverts that were brown edged and shorter in contrast to the new coverts were aged second year (SY). Gray plumaged spring birds with iris and mouth scores of 5 or less, comparable to the BBL Manual Vol. II key, were aged SY. Adult-looking birds with dark or blackberry irides, black mouth, and gray plumage were aged after hatching year (AHY). Returns were aged according to age at banding. In the DFA analyses, the ASY category consisted of all returned birds known to be at least in their third year, whether originally aged "determinately" as HY or SY, or "indeterminately" as AHY.

BARRING: presence or absence of barring or watermarking on the rectrices (Dwight 1900), not to be confused with stress bars.

CORTIP: the number of pairs of tail feathers with pale gray corners and tips.

CRISDEEP: the length of the chestnut coloring on a center feather of the crissum as measured along the midrib of the feather.

CRISLONG: the length of the chestnut coloring on a center feather of the crissum as measured along the longer chestnut edge.

CRISHORT: the length of the chestnut coloring measured along the shorter chestnut edge.

CULMEN: the length of the exposed culmen.

EMARG: emargination of the primaries.

IRIS: iris color, scored from 1 to 7 as it progressed from fledgling's gray through brown to reddish black in steps of Munsell neighbors of (1) gray (10YR 5/1, 4/1), (2) brownish gray (7.5YR 5/2, 4/2), (3) grayish brown (5YR 5/4, 4/4), (4) reddish brown (2.5YR 4/4, 3/4), (5) reddish brown with lighter ring (10R 3/2 with 10R 5/4), (6) dark brown (7.5R 3/2), (7) reddish black (5R 1/1). This is an elaboration of Wood's (1973) method of separating AHY from HY by iris color, using the Munsell (1969) color ratings. We used the preferred system of letter-number notations (ASTM 1969), and we renumbered the 2.5-unit hue steps with a more manageable scale from 1 to 7, where 1 unit = 2.5 Munsell units.

MOUTH: mouth color, scored 1 to 7 as it progressed from fledgling's yellow through pink and gray to black in steps of Munsell neighbors of (1) yellow (10YR 8/8), (2) mostly yellow with some pink (7.5YR 9/2, 8/4) and/or gray (5YR 5/1), (3) mostly pink (5YR 9/2, 8/4), with some yellow, often at the folds of the mouth, and/or gray, (4) pink (2.5YR 8/4, 7/4), (5) mostly gray (10R 5/1) with pink (10R 8/4, 7/4), and/or black, (6) mostly black with some gray (7.5R 5/1) and/or pink (7.5R 8/4, 7/4), (7) black. We renumbered the 2.5-unit hue steps with a more manageable scale from 1 to 7, where 1 unit = 2.5 Munsell units.

NINETEN: the distance between the tips of primary #10 and primary #9, wing partially unfolded, underside.

PILLONG: the pileum length from the base of the exposed culmen to the back edge of the pileum.

PILWIDE: the width of the pileum measured behind the eyes.

PLUMAGE: scored from 1 to 5 as it progressed from (1) juvenal, (2) hatching year molting, (3) HY with retained greater secondary coverts, (4) HY or SY with retained primaries and primary coverts to (5) all new feathers; and the additional category (6) for AHY in molt.

SEX: by brood patch or cloacal protuberance scored 0 to 4 for none, small, medium, maximum, or receding, respectively.

TAIL: tail length, taken by a ruler slipped between the center pair of feathers until it touched the body.

TAILDIFF: the difference in length between the longest, innermost tail feather #1 and the shortest, outermost #6.

TONGUE: tongue color, scored 0 to 4 as it progressed from fledgling's yellow through pink and gray to black in steps of Munsell neighbors of (0) yellow (10YR 8/8, 9/2), (1) pink (5YR 8/4, 7/6) with faded yellow remaining at the tip, (2) pink (10R 7/4) or a mix of pink, gray (10R 6/1) and/or black, (3) gray (5R5/1) and black, or dark gray (5R 3/1), (4) black. We renumbered the 5-unit hue steps to a more manageable scale of 0 to 4, where 1 unit = 5 Munsell units.

WING: wing chord, with the wing folded naturally, unflattened.

WINGDIFF: the difference in length from the underside, betwen the shortest, outermost primary #10 and the longest primary #6.

WINGTIP: the difference between the longest primary and the longest secondary, with the wing slightly unfolded.