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AGING *CATHARUS* THRUSHES BY RECTRIX SHAPE

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Abstract.—Rectrix shape was examined as a method of aging the four species of migratory North American *Catharus* thrushes. The tip angle of pointed and rounded rectrices was found to differ significantly for each species. The observation that pointed rectrices indicate hatching/second-year birds whereas rounded rectrices indicate after-hatching/after-second-year birds corresponded to other accepted aging criteria. Rectrix shape allowed greater precision in aging than keys in current use.

UTILIZACIÓN DE LA FORMA DE LAS RECTRICES PARA DETERMINAR LA EDAD EN ZORZALES DEL GÉNERO *CATHARUS*

Resumen.—La forma de las rectrices fue utilizada como método para determinar la edad de cuatro especies de zorzales *Catharus* spp.) Norte Americanos. Se encontró que diferían significativamente en cada especie el ángulo apical de las rectrices puntiagudas y redondas. Rectrices puntiagudas correspondieron a nacidos del año/aves de segundo año mientras que rectrices redondeadas a aves en donde no había remanente del plumaje juvenil. La forma de las rectrices permite determinar con mayor precisión la edad de estas aves, que otros métodos en uso.

In Europe, rectrix shape is used widely as a character to distinguish immature passerines from adults in the hand (Svensson 1984). In North America, rectrix shape has proven useful for aging a variety of species (Fairfield and Shirkoff 1980, Meigs et al. 1983, Samson 1974, Yunick 1983) and aging passerines by rectrix shape and other plumage characteristics has been advocated recently in Pyle et al.'s "Identification Guide to North American Passerines" (1987). If plumage characteristics are to be useful, quantification of the methods is required to establish their reliability. Our aim is to quantify the rectrix shape method of aging North American *Catharus*.

Currently accepted methods of aging North American *Catharus* thrushes include noting the presence or absence of greater secondary coverts and/or tertials retained from juvenal plumage and the degree of skull pneumatization (USFWS and CWS 1978). Using these criteria, birds may be aged as hatching-year (HY) or second-year (SY) by the presence of retained juvenal coverts or an incompletely pneumatized skull. Alternatively, birds may be aged as after-hatching-year (AHY) when there are no remnants of juvenal plumage and the skull is completely pneumatized or (in fall only) has small pinhole "windows." Thus, SY in fall and ASY in spring are not considered acceptable age codes.

Personal observations, and those of Pyle et al. (1987), indicate that rectrix shape is useful in aging *Catharus* thrushes. Juvenal rectrices appear more pointed than those of subsequent plumages. The first prebasic molt

of *Catharus* thrushes is partial and all flight feathers are retained until the second prebasic molt (Dwight 1900). Hence, HY/SY birds should have pointed rectrices; AHY/ASY birds rounded ones. The following study quantifies variability in rectrix shape in Hermit Thrush (*Catharus guttatus*), Veery (*C. fuscescens*), Swainson's Thrush (*C. ustulatus*), and Gray-cheeked Thrush (*C. minimus*). We investigate the reliability and usefulness of rectrix shape as a field technique for aging these species by comparing rectrix shape to ages assigned by accepted plumage and skull criteria.

METHODS

The four species of *Catharus* thrushes were studied at Long Point Bird Observatory, Long Point, Ontario during spring and fall migrations from 29 Mar. 1986 to 23 May 1987. Thrushes were captured in mist nets at three field stations located along the 30 km point. All stations lie at approximately 42°35′N and between 80°03′ and 80°25′W. Results from the three stations were examined collectively.

We recorded the following information from a sample of each species: rectrix shape, by visual inspection, as "pointed" or "rounded"; the presence or absence of greater secondary coverts retained from juvenal plumage; and the degree of skull pneumatization using Baird's (1964) technique. Rectrix shape was determined by evaluating the angles at which the distal edges of the inner and outer webs met the rachis at the tip of the feather. On rounded rectrices the distal edges are more nearly perpendicular to the rachis, giving both webs, particularly the outer, a squared appearance. On pointed rectrices the distal edges meet the rachis at a much shallower angle, creating a tapered appearance (Fig. 1). In order not to bias observers' opinions of rectrix shape, shape was judged before skulling and before examination of the wing coverts. Reconsideration of rectrix shape was not permitted. On some birds, many juvenal coverts had been retained and it was difficult to ignore their presence. However, in these cases, every effort was made to judge rectrix shape objectively. In the course of the study, we encountered a small number of rectrices which defied classification as pointed or rounded. These were termed "intermediate."

A typical pattern of *Catharus* pneumatization and our rating system are shown in Figure 2. Small, horizontal, elliptical unpneumatized patches ("windows") within the occipital triangle were ignored, as these are present in all individuals regardless of age (pers. obs.). Windows in nearly pneumatized skulls (="3") were measured with calipers to the nearest 0.1 mm along their longest axes. We trained ten field biologists, in addition to ourselves, to collect the above data.

After recording the above information, either a left or right fifth rectrix was collected from a sample of individuals of each of the four species. On any individual, rectrices one through six differ among themselves in basic shape. Therefore, it was necessary to standardize the rectrix collected. Feathers were then measured using an adaptation of the method

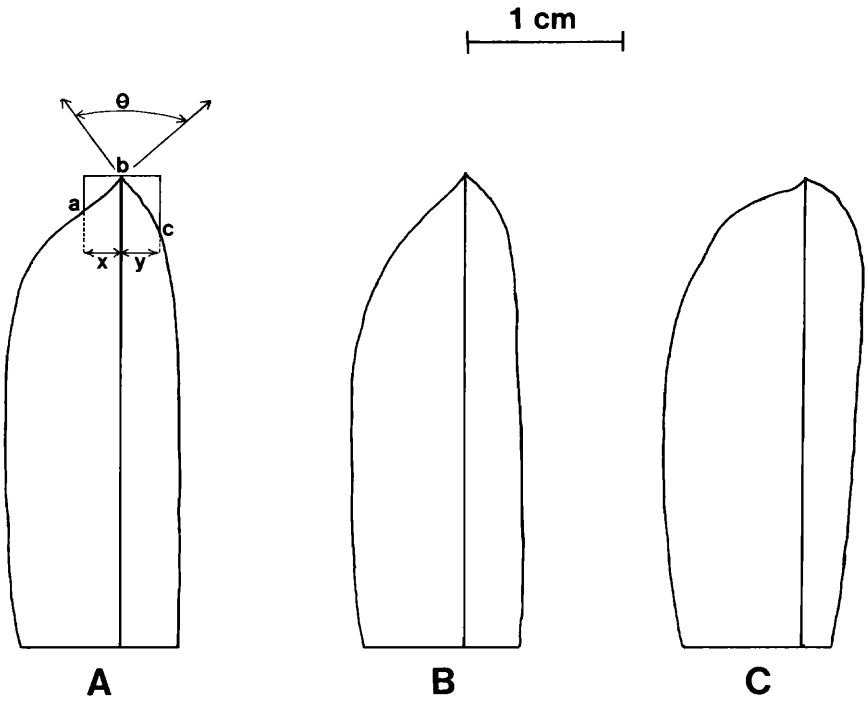

FIGURE 1. Rectrix tips of a *Catharus* thrush. A. The tip angle Θ was the angle between the lines ab and bc where x = y = 2 mm. B. A pointed fifth rectrix typical of an immature in first basic plumage. C. A rounded fifth rectrix typical of an adult in basic plumage.

employed by Meigs et al. (1983) (Fig. 1). Rectrices were placed flat on a 1 mm grid with the rachis oriented along one grid line. The locations where the outer and inner feather edges crossed a grid line 2 mm to each side of the tip and parallel to the rachis were plotted. The tip angle Θ was measured directly with a protractor to the nearest degree. Spring Gray-cheeked Thrush rectrix samples were augmented by examining specimens (n = 31) from the Royal Ontario Museum, Toronto. Rectrices were measured in the same manner, but were not removed from the birds.

Results were analyzed with standard statistical methods (Steel and Torrie 1980). Birds with intermediate rectrices were not included in analyses that involved rectrix shape as one of the variables.

Aging nomenclature follows that used in the Bird Banding Manual (USFWS and CWS 1978). For the purposes of this study, we make the following definitions. A bird of known age is a bird aged as SY in spring or as HY in fall by the presence of an unpneumatized skull (except as noted below) and/or retained juvenal greater secondary coverts or a bird aged as AHY in fall by a completely pneumatized skull and an absence

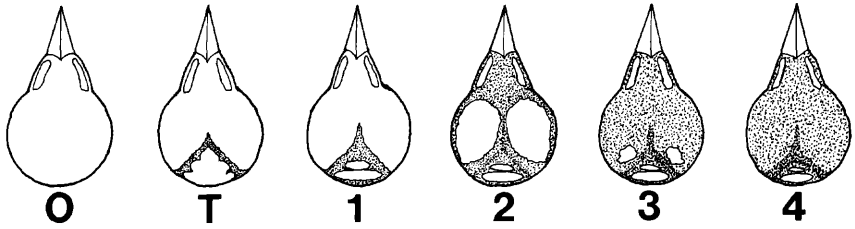

FIGURE 2. Typical pneumatization pattern of a *Catharus* thrush. Skulls were rated from unpneumatized ("0") to completely pneumatized ("4"). T = trace pneumatization. The elliptical "windows" in the occipital triangle are present into adulthood and, except to note their formation between "T" and "1," these windows were not used in the skull evaluation. Pneumatized areas are stippled.

of juvenal coverts. We stress that, by this definition, an AHY bird may be two, three or more years old, and thus scarcely of known age. However, we use the term throughout the paper, and readers should be aware of our usage. Alternatively, a bird of presumed age is a bird aged by rectrix shape alone as SY or ASY in spring when the skull is completely pneumatized and juvenal coverts are absent or a bird aged as SY in fall by a nearly pneumatized skull (="3," before 1 Oct.) or by pointed rectrices alone when the skull is completely pneumatized (before 1 Oct.). Spring migration covered the period 1 Mar.–30 Jun. and fall migration the period 1 Jul.–30 Nov.

RESULTS

Table 1 divides the number of birds examined of each species into categories based on the three variables used in this study: rectrix shape, skull pneumatization and juvenal covert retention. Within each season, the percentage of birds with intermediate rectrix shape never exceeded 4.5% in any species.

Mean rectrix tip angles are shown in Figure 3. Rounded and pointed formed two distinct classes of rectrix shape, as defined by their tip angles, in both spring and fall for each of the four species. Within each season and species, the mean tip angle of pointed and rounded rectrices differed significantly (Table 2). Differences in rectrix shape, which could be discerned subjectively in the field, were verified objectively in the lab. Thus, rectrices which observers judged to be pointed were measurably pointed and those judged to be rounded were measurably rounded. Relative differences in tip angle between pointed and rounded rectrices were consistent from fall to spring in each species, and indicated consistency in the measurement method. Worn feathers, in which the distal 1–2 mm had abraded away, always produced larger tip angles than comparable fresh feathers of the same basic shape (pointed or rounded), because of the way in which the tip angle Θ was measured. This was exemplified by the generally increased tip angle in spring rectrices compared to fall

TABLE 1. Plumage and skull characteristics of all *Catharus* thrushes examined, by season. Skull ratings are shown in Figure 2. "Pointed," "Rounded" and "Intermed" refer to rectrix shape (see text and Fig. 1). "P" = at least one juvenal greater secondary covert present and "A" = juvenal coverts absent.

		Fall							Spring				
	Skull	0–2		3		4			3		4		
Species	Coverts	P	A	P	A	P	A	Total	P	A	P	A	Total
Hermit Thrush	Pointed	63	3	1	—	—	—	67	6	—	141	25	172
	Rounded	—	2	—	—	—	13	15	—	1	10	173	184
	Intermed	1	—	—	—	—	1	2	1	—	1	7	9
Swainson's Thrush	Pointed	101	47	—	2	1	2	153	12	13	16	12	53
	Rounded	1	3	—	6	—	35	45	—	4	—	94	98
	Intermed	5	1	—	—	—	2	8	1	1	1	3	6
Veery	Pointed	24	1	—	1	—	—	26	14	—	6	3	23
	Rounded	—	—	—	3	—	6	9	—	2	2	40	44
	Intermed	—	—	—	—	—	—	0	1	—	—	1	2
Gray-cheeked Thrush	Pointed	52	6	—	2	—	1	61	3	—	2	1	6
	Rounded	1	1	—	1	—	17	20	1	—	1	14	16
	Intermed	1	—	—	—	—	1	2	—	—	—	1	1

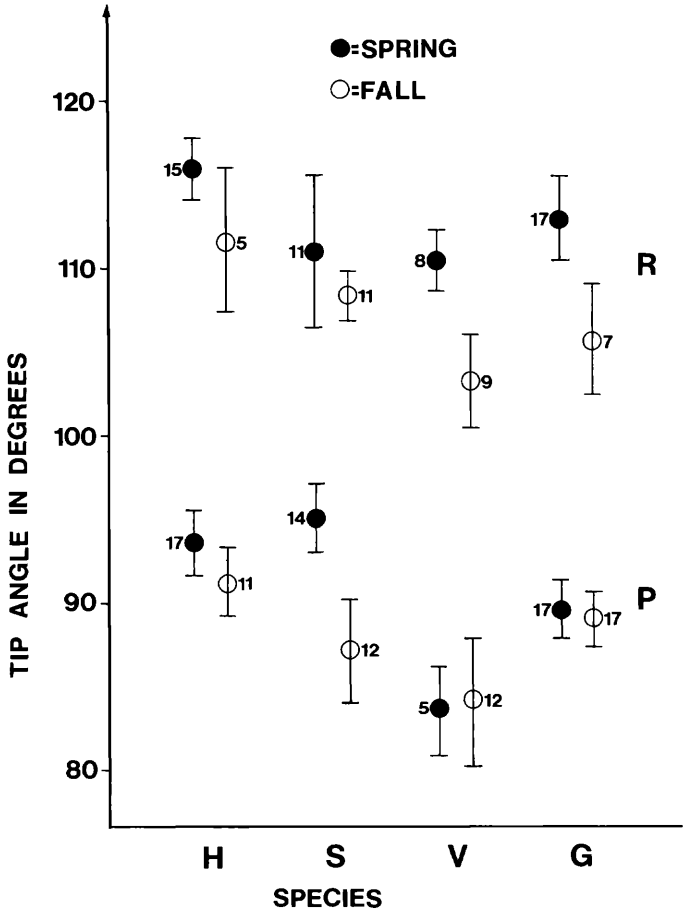

FIGURE 3. A comparison of the mean rectrix tip angles of rounded (R) and pointed (P) rectrices for Hermit Thrush (H), Swainson's Thrush (S), Veery (V) and Gray-cheeked Thrush (G). Bars represent ± one standard error. Sample sizes are given beside each mean.

ones. Feather wear was presumably responsible for the only significant increase ($t = 2.29$, df = 24, $P < 0.05$) in mean tip angle from fall to spring (Swainson's Thrush pointed rectrices).

In fall, pointed rectrices were correlated with the presence of an incompletely pneumatized ("0"–"2") skull (χ^2 values: Hermit Thrush = 62.61; Swainson's Thrush = 145.42; Veery = 24.03; Gray-cheeked Thrush = 57.29, df = 1 for all, $P < 0.005$ for all) and retained juvenal coverts (χ^2 values: Hermit Thrush = 59.87; Swainson's Thrush = 28.46; Veery = 19.30; Gray-cheeked Thrush = 45.23, df = 1 for all, $P < 0.005$ for all, Table 1). Similarly, rounded rectrices were correlated with the pres-

TABLE 2. Comparison of mean tip angles between the two classes of rectrix shape in Hermit Thrush, Swainson's Thrush, Veery, and Gray-cheeked Thrush. Spring (S) and fall (F) results are treated separately. See Figure 3 for mean values and sample sizes.

Species	Season	df	t
Hermit Thrush	S	30	7.97**
	F	14	5.20**
Swainson's Thrush	S	23	3.61*
	F	21	6.01**
Veery	S	11	6.85**
	F	19	4.86**
Gray-cheeked Thrush	S	32	7.45**
	F	22	4.47**

* = $P < 0.01$, ** = $P < 0.001$.

ence of a completely pneumatized skull and an absence of juvenal coverts. Depending on the species, 96.7% (n = 60)–100% (n = 25) of all birds with skull ratings "0"–"2," and 97.7% (n = 43)–100% (n = 64) of all birds with juvenal coverts had pointed rectrices. Thus, the reliability of rectrix shape as an aging criterion was strongly supported by other accepted aging criteria.

All samples of spring birds were made up of just two skull classes, "3" and "4." In spring, pointed rectrices were correlated with the presence of retained juvenal coverts (χ^2 values: Hermit Thrush = 227.81; Swainson's Thrush = 48.45; Veery = 42.87; Gray-cheeked Thrush = 7.08, df = 1 for all, $P < 0.005$ for all except Gray-cheeked Thrush, $P < 0.01$). Depending on the species, 71% (n = 7)–100% (n = 28) of all birds with juvenal coverts had pointed rectrices. The lowest confidence rate was associated with Gray-cheeked Thrush, probably because of the small sample size involved. Without this species, confidence rates ranged from 90.9% (n = 22)–100%. In Swainson's Thrush and Veery, 86.2% (n = 29) and 87.5% (n = 16), respectively, of all birds with "3" skulls had pointed rectrices. In these two species, pointed rectrices were correlated with the presence of an incompletely pneumatized skull (χ^2 values: Swainson's Thrush = 38.42; Veery = 23.37, df = 1 for both, $P < 0.005$ for both). The sample size of Hermit Thrushes with "3" skulls (n = 7) and the overall sample size of Gray-cheeked Thrush were both too small to demonstrate a relationship between rectrix shape and degree of skull pneumatization. Nonetheless, the use of rectrix shape as an aging method was again strongly supported by currently accepted criteria.

Incidence of complete juvenal covert replacement and adventitious rectrix loss are shown in Table 3. Values in the spring rectrix loss and spring covert replacement columns were underestimated by an unknown amount because SY birds that had completely pneumatized skulls, no juvenal coverts and rounded rectrices, as a result of adventitious loss, would have been excluded from both columns. Rates of adventitious rectrix

TABLE 3. Comparison of complete juvenal greater secondary covert replacement and adventitious rectrix loss between fall (known HY) and spring (known and presumed SY) Hermit Thrush, Swainson's Thrush, Veery and Gray-cheeked Thrush. Values given are percentages of birds with no retained juvenal coverts (covert replacement) or with rounded rectrices (rectrix loss). Sample sizes are given in parentheses.

Species	Covert replacement			Rectrix loss		
	Fall	Spring	z	Fall	Spring	z
Hermit Thrush	7.1 (70)	14.1 (185)	1.51*	2.9 (69)	7.0 (158)	0.11
Swainson's Thrush	32.3 (158)	50.0 (60)	2.42**	2.6 (152)	8.8 (45)	1.60*
Veery	4.2 (25)	17.9 (28)	1.57*	0.0 (25)	16.7 (24)	2.13**
Gray-cheeked Thrush	14.3 (63)	12.5 (8)	0.14	3.2 (62)	28.7 (7)	3.07**

Binomial test, * = $P < 0.06$, ** = $P < 0.05$.

loss in fall among all four species were comparable, and indicated a rate of rectrix loss common to all species. Since no one species would be expected to have a greater incidence of rectrix loss, these results supported our banders' abilities to detect rounded rectrices on birds displaying accepted HY characteristics. Thus, in spring, the larger variation in rates of rectrix loss among the four species was probably a result of small sample sizes, especially in Gray-cheeked Thrush, rather than inaccurate determination of rectrix shape. The increase in extent of covert replacement from fall to spring in Veery, Hermit Thrush, and, particularly, Swainson's Thrush may indicate that some birds of these species complete their covert molt in the period between fall and spring migrations. This would increase the number of birds in spring that did not display known SY characteristics.

In spring, the percentage of known (excluding birds aged by skull alone) and presumed SY birds with completely pneumatized skulls were: Hermit Thrush—96.2% ($n = 184$); Swainson's Thrush—49.1% ($n = 55$); Veery—42.3% ($n = 26$); and Gray-cheeked Thrush—50% ($n = 8$) (see Table 1). Among known and presumed SY birds with pointed rectrices, degree of skull pneumatization (ratings "3" or "4") was not correlated with the presence or absence of juvenal coverts for each of Hermit Thrush ($\chi^2 = 0.16$, df = 1, $P > 0.50$), Swainson's Thrush ($\chi^2 = 1.07$, df = 1, $P > 0.25$) and Veery ($\chi^2 = 0.53$, df = 1, $P > 0.25$). The sample size of Gray-cheeked Thrush was too small to permit statistical analysis. Lack of correlation between these two characters means that in any sample of SY birds there will always be a percentage of birds that have both "4" skulls and no juvenal coverts. These birds could be accurately aged as SY only by rectrix shape. Thus, if spring covert replacement (from Table 2) and the above skull pneumatization percentages among known and presumed SY birds are combined (i.e., multiplied as probabilities) within each species, the percentage of SY birds which would, on average, display no aging criteria except pointed rectrices are as follows: Hermit Thrush—

13.6%; Swainson's Thrush—24.6%; Veery—7.6%; and Gray-cheeked Thrush—6.3% (assuming no correlation for that species). Rates of pneumatization and extent of covert replacement in SY birds may vary among subspecies or populations of these four species. However, the non-correlative relationship between pneumatization and covert replacement would probably hold for each species. Thus, for any group of SY birds, some percentage of birds would be aged less precisely as AHY if rectrix shape was not used as an aging method.

In fall, skull ratings were almost exclusively divided into just two classes: "4" and "0"–"2" (Table 1). Among all species, only 16 birds had "3" skulls. Careful consideration of rectrix shape and date of capture allowed us to age 14 of these 16 birds with reasonable certainty. Rounded rectrices indicated birds at least one year old which had already undergone a prebasic molt. Pointed rectrices, depending on the capture date, indicated either rapidly pneumatizing HY birds or SY birds which had not yet completed their second prebasic molt. In two birds we could not differentiate between these last two categories and aged the birds as unknown. Thus, rectrix shape allowed fall birds to be aged with greater precision than current Bird Banding Manual keys (USFWS and CWS 1978) or Pyle et al. (1987), which do not permit aging of SY birds beyond June/July. In addition, the presence of pointed rectrices after the prebasic molt, combined with a "3" skull, indicated an HY bird, even in the absence of retained juvenal coverts (Leberman and Clench, as cited in the Bird Banding Manual [USFWS and CWS 1978]). The average "window" size of a "3" skull in fall was 2.0 mm (n = 10) and no window was less than 1.0 mm.

DISCUSSION

We have demonstrated a measurable difference between the rectrix shape of different age classes in the four species of migratory North American *Catharus* thrushes. Furthermore, rectrix shape as an aging method was useful in the field. With experience, correct determination of rectrix shape could be made by visual inspection alone; precise measurement of the feather was not necessary.

As with any plumage technique, experience is required in order to gain accuracy in the method. Rectrix shape may be a difficult method to learn because the tip angle of a pointed (or rounded) rectrix varies somewhat from species to species. However, our banders were able to distinguish between pointed and rounded rectrices on all species after seeing approximately twelve rectrices of each shape from any of the four species. As well, the presence of additional aging characteristics in HY and many SY birds will help inexperienced banders. The bander can age *Catharus* with greater precision using rectrix shape than by using presently accepted keys. This method will be most helpful in spring and summer when a significant proportion of SY birds can be aged as SY that would otherwise be aged less precisely (i.e., as AHY). In fall, this method provides a criterion for aging most birds with "3" skulls more precisely.

In summary, all spring birds with pointed rectrices may be reliably aged as SY. The low rate of adventitious rectrix loss which occurs in all species will result in a few known SY birds with rounded rectrices. Therefore, all spring birds with rounded rectrices should be checked for other SY characteristics before they are aged as ASY. Since, at most, about 25% of SY birds must be aged by rectrix shape alone, and the overall rate of spring rectrix loss is about 10%, only a very small percentage of SY birds would be aged incorrectly as ASY if rectrix shape is used as an aging method. In fall, birds with pointed rectrices may be reliably aged as SY before the prebasic molt or HY after the prebasic molt. Birds with rounded rectrices may be reliably aged as AHY. Early fall (i.e., before 1 Oct.) birds with rounded rectrices and "3" skulls are almost certainly SY birds which have completed their second prebasic molt. However, since skull pneumatization may take one or more years to complete, these birds may be older than one year (USFWS and CWS 1978). Additional data on the rate of skull pneumatization in *Catharus* is needed to assess the reliability this age designation. Caveats with regard to adventitious rectrix loss also apply in fall. Generally, we advocate the use of multiple characters—skull pneumatization, presence or absence of juvenal coverts, and rectrix shape—to arrive at an accurate age assessment.

Some birds have intermediate rectrices which cannot reliably be assigned to any specific age class. However, in our study, approximately 95% of all rectrices could be classified as either rounded or pointed. This level of discrimination should apply to all four *Catharus* species, regardless of subspecific status (Pyle et al. 1987). With experience banders can discriminate accurately between rectrix shape classes without measurement; i.e., rectrix shape is a practical in-hand criterion for aging *Catharus* thrushes.

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