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A NEW METHOD OF DETERMINING OVENBIRD AGE ON THE BASIS OF RECTRIX SHAPE

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Abstract.—Understanding age-specific differences in life history characteristics depends on accurate assessment of age. Use of rectrix shape for aging Ovenbirds (*Seiurus aurocapillus*) as HY/SY or AHY/ASY individuals was investigated using a macroscope, videocamera and image analysis software to analyze rectrix tip angles of 82 birds of known age. AHY/ASY birds had significantly larger tip angles than HY/SY birds and were correctly classified over 90% of the time. This method of quantifying rectrix shape was time efficient and accurate.

NUEVO MÉTODO PARA DETERMINAR LA EDAD DE *SEIURUS AUROCAPILLUS* UTILIZANDO LA FORMA DE LAS RECTRICES

Sinopsis.—Para poder entender diferencias específicas de edades en las características de la historia natural de un ave, es necesario poder determinar con exactitud la edad de los individuos. Se utilizó la forma de las rectrices para poder clasificar a individuos de *Seiurus aurocapillus* en individuos de primer año o más viejos. Para determinar diferencias en las edades se utilizó un macroscopio, una cámara de video y un programa de computadoras para analizar imágenes. Se utilizó como muestra, el ángulo de las rectrices de 82 individuos de edad conocida. Las aves mayores de un año presentaron ángulos mayores en la punta de las rectrices que las aves de primer año. Las edades pudieron clasificarse en el 90% de las ocasiones. Este método, que permite cuantificar la forma de las rectrices, es preciso y eficiente en relación al tiempo que requiere.

Many bird species exhibit age-related differences in fecundity, mortality, habitat use and social dominance. The Ovenbird (*Seiurus aurocapillus*) is a forest-nesting warbler whose breeding and biology has been relatively well studied (Van Horn and Donovan 1994). Their ground-nesting behavior in the summer and ground-feeding behavior during summer, winter and migration facilitate capture and observation for testing life history hypotheses. Despite these qualities, age-related differences in habitat use, breeding success and site fidelity have not been studied in Ovenbirds because many cannot be reliably aged beyond 5 mo after fledging (Pyle et al. 1987).

Here, we investigate the potential of using rectrix shape to age breeding Ovenbirds as first-year breeders (second-year [SY] birds) or older breeders (after-second-year, [ASY] birds) and wintering Ovenbirds as first-year birds (hatching year [HY]/SY) or older birds (after-hatching-year [AHY]/ASY). Immature (HY/SY) Ovenbirds undergo a partial first prebasic and prealternate molt; their tail feathers are retained throughout their first winter season and are not molted until after their first breeding attempt (Pyle et al. 1987). Barring accidental loss, a first-year breeder (SY) has the same rectrices it acquired immediately after hatching. These rectrices are often tapered in shape (Pyle et al. 1987). By contrast, older birds (AHY/ASY) undergo a complete, second pre-basic molt, in which all flight feathers and rectrices are replaced after the breeding season but prior to fall migration. The newly acquired rectrices are paddle-shaped (Pyle et al. 1987). The difference in rectrix shape between the two age-classes is purportedly due to differences in development and wear (Laaksonen and Lehikoinen 1976). During the breeding season, SY rectrices are 11–12 mo old and often appear worn (Pyle et al. 1987), whereas ASY rectrices are 1–3 mo younger than SY rectrices depending on the timing of the second pre-basic molt relative to the completion of nesting. An Ovenbird arriving on the breeding grounds or the wintering grounds for its second time or more has newer rectrices that are less worn and are not distinctly tapered as those on a younger bird. These differences in molt phenology and morphology produce measurable differences in rectrix shape between first-year (HY/SY) birds and older (AHY/ASY) birds, and have been used in aging many other bird species (e.g., Collier and Wallace 1989, Meigs et al. 1983, Svensson 1984). Measurable differences in rectrix shape can be perceived by visual examination by even inexperienced banders (70–80% accuracy) and classification of birds to their correct age-class can improve with experience (Weinberg and Roth 1994).

In this paper, we: (1) describe a new method for measuring rectrix shape, (2) determine if HY/SY and AHY/ASY Ovenbirds differ measurably in rectrix shape, (3) determine the reliability of aging Ovenbirds based on rectrix shape and (4) devise a function that can be used to age Ovenbirds in the field.

STUDY AREAS AND METHODS

We collected rectrix number 3 from 82 Ovenbirds of known age in eight geographic locations in 1993 and 1994. Seventeen rectrices were collected during the 1993 breeding season in the St. Croix River Valley, Minnesota (45°10′N, 92°40′W) and in the Chequamegon National Forest, Wisconsin (46°10′N, 91°0′W). Sixty rectrices were collected during fall migration (1993) at five banding stations: Long Point Bird Observatory, Ontario (42°33′N, 80°10′W), Toronto Bird Observatory, Ontario (43°40′N, 79°23′W), Manomet Bird Observatory, Massachusetts (41°50′N, 70°30′W), Island Beach, New Jersey (39°50′N, 94°0′W), and Gulf Islands National Seashore, Alabama (29°50′N, 88°50′W). Five rectrices were collected during the winter (1994) in Guanica National Forest, Puerto Rico (17°50′N, 66°50′W). All rectrices were collected under permit.

Age determination of Ovenbirds.—All birds were captured in mist nets, banded and aged. During the breeding season before the pre-basic molt, we definitively aged Ovenbirds as HY or AHY (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1978). We banded Ovenbirds in the Chequamegon National Forest and the St. Croix River Valley during the summers from 1991–1992, however, and breeding adults that were banded and subsequently recaptured in 1993 were classified as ASY individuals. Rectrices from eight HY and nine ASY birds were obtained during the breeding season.

During fall migration, Ovenbirds can be aged as HY or AHY birds. HY Ovenbirds have incompletely pneumatized skulls and rusty-edged tertials, whereas AHY Ovenbirds have completely pneumatized skulls and lack rusty-edged tertials (Taylor 1972, 1973). All AHY birds, however, have undergone their second pre-basic molt and thus have new, paddle-shaped tail feathers. We classified all Ovenbirds captured during migration without rusty tertials and with completely pneumatized skulls as AHY birds. Rectrices from 36 HY and 24 AHY birds were obtained during fall migration.

On the wintering grounds, Ovenbirds often cannot be reliably aged because both young and old birds usually have completely pneumatized skulls and the rusty-edged tertials of HY/SY birds have often worn away. In the Guanica National Forest, Ovenbirds have been captured and banded during January since 1972 (Faaborg and Arendt 1992). Birds that were banded prior to 1994 and subsequently recaptured in 1994 were classified as ASY birds. Rectrices from five ASY wintering birds were obtained.

Quantifying differences in rectrix shape.—Although rectrices were obtained from birds of known age, we quantified differences in rectrix shape "blindly," that is, without immediate knowledge of age. We smoothed each feather to its natural contour, and placed it under a Bausch & Lomb macroscope. We acquired images of each rectrix with a Videoscope CCD 200E camera (Video Scope International, Washington, D.C.) attached to the macroscope. We illuminated the feathers from above using a dual-fiber light source. The camera was attached to a computer that was calibrated for the scope's magnification. We saved the images and analyzed them using Image-1 (Universal Imaging Corp., West Chester, PA) image-analysis software.

We used the Image-1 program to superimpose a 1.5-mm grid of calibrated distances over the image of the feather. The grid was aligned along the feather rachis and centered on the feather tip (Fig. 1). We obtained the rectrix tip angle following methodology described in Meigs et al. (1983) and Collier and Wallace (1989). Beginning at the rectrix tip and moving across the inner vane, we measured 1.5 mm perpendicular to the rachis and then down to the point where the feather intersected the 1.5 mm grid line that paralleled the rachis (Fig. 1). We used the "measure distance" function in Image-1 to obtain an angle for the line segment beginning at the rectrix tip and ending at the feather-grid-intersection. We repeated this procedure on the outer vane portion of the feather, obtaining angle measurements for two line segments per feather. The difference between these angles was computed and defined as the tip angle. We repeated the entire process four times for each feather. Randomly chosen feathers were also measured by both investigators to check for observer consistency.

We used the mean of the four measurements for each feather to compute the mean tip-angle for each age class. Differences among age classes in mean tip angle were tested using an analysis of variance (Sokal and Rohlf 1981). We determined discriminant equations to classify birds, and determined the accuracy of aging Ovenbirds based on rectrix shape by

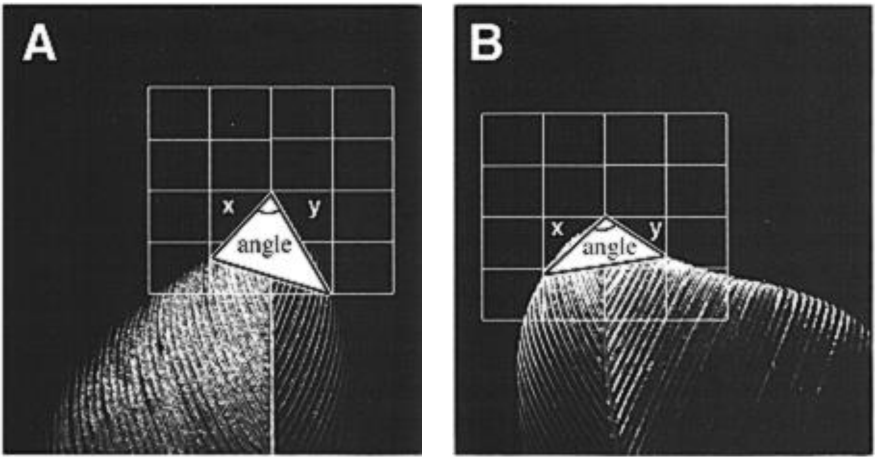

FIGURE 1. Image-1 image of a representative HY/SY (A) and AHY/ASY (B) Ovenbird overlaid with a 1.5 mm grid. The angle of segment x is 140° and 118° in (A) and (B) respectively. The angle of segment y is 215° and 218° in (a) and (b) respectively. Tip-angle measurements (°) obtained by subtracting the two line segment angles (215° − 140° = 75° tip angle for HY/SY; 218° − 118° = 100° tip angle for AHY/ASY).

using a discriminant function cross-validation analysis (Proc Discrim, SAS Institute Inc. 1990).

Tolerance intervals.—As there is some probability of misclassification using the discriminant function approach, we constructed tolerance limits using the mean feather tip angles, sample sizes and mean within-group variance from the analysis of variance (Wald and Wolfowitz 1946). The tolerance intervals allow nearly 100% accuracy in classification by eliminating any rectrices that could potentially be misclassified, and thus are a more conservative approach to classifying Ovenbirds based on rectrix shape. The term, $\bar{x} \pm \phi$ (SE) defines the tolerance intervals by which Ovenbirds can be classified as HY/SY or AHY/ASY birds, where $\bar{x}$ is the mean tip angle for each age class, SE is the standard error for each age class and "ϕ" is the tolerance value. We used 99 and 99.9 tolerance values, which means we are 99% "confident" that the tolerance limit includes 99.9% of the angles of each age group.

RESULTS

Age-related differences in rectrix shape.—AHY/ASY Ovenbirds had larger tip angles ($\bar{x}$ = 96.08 ± 8.08° (SD), n = 38) than HY/SY Ovenbirds ($\bar{x}$ = 72.20 ± 8.63° (SD), n = 44; F = 165.53; P = 0.0001; R^2 = 0.67). Two discriminant equations were derived to classify Ovenbirds based on tip angle:

$$\text{If age} = \text{ASY, then } \phi = -65.73970 + x(1.36845) \text{ and}$$

$$\text{If age} = \text{HY, then } \phi = -37.12789 + x(1.02841),$$

where x is the angle of a bird of unknown age and ϕ the discriminant score. Substituting for x in both equations, a bird was classified into the age class of the equation that yielded the highest score (ϕ). Using these equations, 92.11% of the ASY birds were correctly classified as ASY, and 90.91% of the SY birds were correctly classified as SY. Four HYs and three ASYs were misclassified as the other age.

Tolerance intervals.—Ovenbirds also can be classified as HY/SY or AHY/ASY by the following tolerance limits:

tip angles $\geq$ 90.05 indicate AHY/ASY;
tip angles $\leq$ 77.92 indicate HY/SY;
tip angles $\leq$ 90.05 and $\geq$ 77.92 indicate AHY/U.

DISCUSSION

Using the two discriminant functions given above, breeding and wintering SY and ASY Ovenbirds can be reliably aged from tip angles with over 90% certainty. Using tolerance limits described, Ovenbirds can be classified as HY/SY or AHY/ASY with over 99% certainty if tip angles are greater than 90° or less than 78°. If field workers can visually perceive tip angle as $\geq$90° or $\leq$78° (e.g., Weinberg and Roth 1994), then Ovenbirds potentially can be accurately aged without direct measurement of the rectrix. We believe that, with practice, most workers can perceive these differences in the field without removing a rectrix. Errors in classification, however, may be greater in the field; we encourage field-testing the tolerance limits described to determine the error rate of classification by visual inspection. In field situations, workers should examine tip angles of the third and other rectrices to determine whether HY/SYs replaced a lost feather with an AHY-shaped one. If both third rectrices are missing, adult birds with completely pneumatized skulls should be classified as AHY.

The combination of a simple macroscope, computer and image analysis program allowed us to obtain rapid, reliable, and extremely accurate tip-angle data. Once the system was in place, each feather could be measured four times in approximately 1 min. Other investigators used paper grids for measurements (e.g., Collier and Wallace 1989). We believe, however, that working with a feather image, rather than the feather itself, helped reduce measurement error. The image could be moved on screen so that we could align the 1.5-mm grid precisely. Measurements made in this manner are very precise; our four measurements taken on a single feather usually did not differ by more than 1–3°.

The Image-1 software package can perform a variety of tasks applicable to ornithological studies. Other software packages, such as NIH Image, are available via Shareware to most institutions in the U.S. and can perform similar tasks at low cost.

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