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Abstract: Various methods of determining age of passerine birds, using eye color, shape of flight feathers, plumage color patterns, etc. are presented in handbooks for bird banders, such as Pyle, *et al.*, Identification Guide to North American Passerines (1987). We compared several such methods with the standard, reliable (but time-consuming) method, "skulling", in 22 species of passerines captured and banded during Fall 1994, in a general netting operation at the University of Wisconsin-Milwaukee Field Station. In many species these methods were in agreement; however in 10 species there was substantial disagreement, especially involving buffy covert tips in thrushes and shape of rectrices or primary remiges in warblers. Since members of these groups are caught in large numbers, it is important to reevaluate these criteria and find more reliable methods.

Introduction

One of the main objectives of bird banding is the determination of survival rates and longevity of the various species of birds. These are basic facets of population dynamics, required for effective conservation and management. Also, it is important to know age (and sex) differences in the timing of migration, routes of migration, dispersal distances, and physiological and behavioral changes during the annual cycle. Thus, much effort has been devoted to finding methods of determining age and sex in captured birds.

Among methods of age determination, the most reliable for small passerines is "skulling", that is, checking the extent of development of skull ossification and pneumatization. This method was developed and refined over the last half-century by various investigators (Miller, 1946; Norris, 1961; Baird, 1964; Yunick, 1981; Pyle, *et al.*, 1987). Newly fledged birds possess a single thin layer of bone in the frontal and parietal regions of the skull which covers the dorsal surface of the brain. Gradually another layer of bone forms underneath the first layer, connected to it by columns of bone. The space between the layers is occupied by extensions of the bird's air sacs, thus

"pneumatized". The time required for this process varies with species, from a few months in most, to a year or so in a few. In the fall, by wetting the feathers of the crown and parting them to the sides, the skull can be viewed through the thin transparent skin; some magnification and a strong light source are required. Young birds show a pink coloration (the brain and its blood vessels), while adults' skulls appear white and speckled, due to the second layer and columns of bone, respectively.

Because skulling is very time-consuming, attempts have been made to find quicker alternative methods of aging birds. Various plumage and morphometric characters have been used, depending on species. These include the shape of certain flight feathers, eye color, plumage colors and patterns, dimensions of wing, tarsus, bill or other body parts, and patterns of molting. Some of these vary continuously over a wide range, thus requiring subjective judgement; others have not been rigorously tested for reliability. The main objective of this study was to test some of the methods described in Pyle, *et al.*, (1987) against the skulling method.

Methods

From mid-August to early November, 1994, 50 species of birds were mist-netted and banded at the UWM Field Station in Ozaukee County, Wisconsin, during the course of a one-day-per-week general netting program conducted by C.M. Weise. The banding crew attempted to assign each bird to one of two age classes: HY (hatching year), i.e., the bird was hatched in 1994, or AHY (after hatching year), i.e., the bird was hatched in some prior year. We generally applied one or more of the alternative criteria described in Pyle, after which W.P. Mueller checked the skull for degree of ossification using a dissecting microscope with a constant light source. It was not always possible to use both methods, especially when large numbers of birds were being trapped in a short time, or when birds were trapped just before nightfall. In addition, there were some species in which skulling was unnecessary because a time-tested unequivocal alternative method of ageing was available, e.g., eye color in the Junco, or rectrix shape in the Chickadee.

Results and Discussion

Table 1 shows the results of our efforts to determine the ages of passerine birds in 1994. Of the 709 birds caught, 574 were passerines of 44 species. Mueller checked the skulls of 203 individuals of 36 species, and of these, 160 birds of 22 species were also aged by an alternative method. Whether the alternative method agreed with the skulling was then noted.

In 12 species, the alternative method consistently agreed with the skulling method (Table 1). However, in 10 species there were cases of discrepancy, the proportions varying from 9 percent in the American Redstart, to 60 percent in the Nashville Warbler (100 percent in the Connecticut Warbler, but only one bird was examined) (Table 1).

In thrushes, the principal disagreement was due to the absence of buffy tips on the secondary coverts in some HY birds. In 1994, all birds that had buffy tips were HY, but some without were also HY. In subsequent years, Weise has found a few thrushes with buffy tips that had ossified skulls. Thus, the presence of buffy tips is a good, but not foolproof, indicator of HY, but the absence of buffy tips is inconclusive.

In warblers the most frequent discrepancy involved our assessment of the shapes of the rectrices and the outer three primary remiges, i.e., whether these feathers were tapered (=pointed or acute) toward the tip, or truncate (=rounded or obtuse). Pyle's diagrams apparently show extremes; most of the birds we examined were intermediate and our determinations were equivocal. In the Tennessee Warbler, not only did 35 percent of the flight feather determinations disagree with skulling, but in 27 percent of the birds there were discrepancies between rectrices and primaries. In other species of warbler only the rectrices were used or, in some species, color patterns such as shape and size of white spots in the tail, but again the determinations disagreed with those from skulling in a large proportion of the cases. Many of these species, e.g., Tennessee Warbler, Magnolia Warbler, Blackpoll Warbler, and Yellow-rumped Warbler, are caught in large numbers and therefore banders urgently need alternative ageing methods faster than skulling.

Table 1 also shows the outcome of the age determinations that were made. As is to be expected in the fall, HY birds made up a high proportion of the birds sampled, but there was variation among species. For example, American Redstarts were 85 percent AHY. Few conclusions can be drawn from

Table 1. Age determinations in passerine birds in 1994.

Species[a]	Number Caught	Number Examined	Age determined by: Skull Only	Other Method Only	Both	No. that disagree (percent)	No. in each age class (percent)[b] AHY	HY	U	Other method used[c]
Yellow-bellied Flycatcher	5	2	2	0	0			2(100%)	3	
Least Flycatcher	2	1	1	0	0			1(100%)	1	
Blue Jay	10	10	0	10	0		4(40%)	6(60%)		D
Black-capped Chickadee	127	121	0	119	2	0	33(27%)	88(73%)	6	A
Brown Creeper	6	3	3	0	0		3(100%)		3	
Winter Wren	1	1	1	0	0			1(100%)		
Golden-crowned Kinglet	8	5	5	0	0		5(100%)		3	
Ruby-crowned Kinglet	15	4	4	0	0		3(75%)	1(25%)	11	
Gray-cheeked Thrush	8	7	0	0	7	2(29%)	2(29%)	5(71%)	1	C
Swainson's Thrush	20	20	0	4	16	5(31%)	5(29%)	12(71%)	3	C
Hermit Thrush	41	39	0	6	33	0	4(11%)	34(89%)	3	C
Wood Thrush	1	1	0	1	0			1(100%)		C
Gray Catbird	16	16	0	16	0		4(25%)	12(75%)		E
Solitary Vireo	1	1	1	0	0		1(100%)			
Philadelphia Vireo	6	6	6	0	0		2(33%)	4(67%)		
Red-eyed Vireo	15	15	0	14	1	0	3(20%)	12(80%)		E
Golden-winged Warbler	1	1	0	1	0			1(100%)		D

Table 1. Continued

Species[a]	Number Caught	Number Examined	Age determined by: Skull Only	Other Method Only	Both	No. that disagree (percent)	No. in each age class (percent)[b] AHY	HY	U	Other method used[c]
Tennessee Warbler	41	41	0	7	34	12(35%)	5(15%)	29(85%)		A,B
Nashville Warbler	5	5	0	0	5	3(60%)	1(20%)	4(80%)		A
Northern Parula	2	1	0	0	1			1(100%)		D
Magnolia Warbler	16	13	0	0	13	7(54%)	4(31%)	9(69%)	3	A,D
Cape May Warbler	1	1	0	0	1	0		1(100%)		A,D
Yellow-rumped Warbler	3	1	1	0	0			1(100%)	2	
Black-throated Green Warbler	2	2	0	1	1	0	1(50%)	1(50%)		D
Blackburnian Warbler	2	1	0	1	0			1(100%)	1	D
Palm Warbler	1	1	1	0	0		1(100%)			
Bay-breasted Warbler	1	0	0	0	0				1	
Blackpoll Warbler	5	5	0	1	4	2(50%)		5(100%)		D
Black-and-white Warbler	7	7	0	0	7	3(43%)	1(14%)	6(86%)		D
American Redstart	17	17	0	6	11	1(9%)	12(75%)	4(25%)		D
Ovenbird	13	12	3	1	8	1(13%)	6(46%)	7(54%)		D
Connecticut Warbler	1	1	0	0	1	1(100%)		1(100%)		D
Canada Warbler	1	1	0	1	0		1(100%)			D
Common Yellowthroat	21	21	0	18	3	0	7(33%)	14(67%)		D,F

Table 1. Continued

Species[a]	Number Caught	Number Examined	Age determined by: Skull Only	Other Method Only	Both	No. that disagree (percent)	No. in each age class (percent)[b] AHY	HY	U	Other method used[c]
Northern Cardinal	9	9	0	9	0		8(89%)	1(11%)		D,F
Rose-breasted Grosbeak	1	1	0	1	0			1(100%)		D
Rufous-sided Towhee	1	1	0	1	0			1(100%)		D
American Tree Sparrow	5	3	3	0	0		2(67%)	1(33%)	2	
Fox Sparrow	15	11	11	0	0		2(18%)	9(82%)	4	
Song Sparrow	10	7	0	5	2	0	3(43%)	4(57%)	3	D,F
Swamp Sparrow	21	19	0	17	2	0	8(42%)	11(58%)	2	D,F
White-throated Sparrow	13	12	0	6	6	0	3(25%)	9(75%)	1	D
Dark-eyed Junco	38	15	0	14	1	0	1(7%)	14(93%)	23	E
American Goldfinch	39	36	1	34	1	0	16(44%)	20(56%)	3	D

[a] Standard common names and order of listing from A.O. U. Checklist (1983)

[b] Percentages based only on birds assigned an age class

[c] Other methods used: A-shape of rectrices; B-shape of primaries; C-buffy tips on coverts; D-species-specific plumage color

this limited data set, but data collected over time and with adequate sample sizes may show year-to-year or long-term changes in productivity, or they may reveal differences in the routes or timing of migration among the age and sex classes.

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