Skull Pneumatization in Passerines: A Table of Last Dates Many Passerines in the Northeast Can be Aged Safely by Skulling

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ABSTRACT

A description of the skull pneumatization process is followed by a table of cutoff dates which show the latest date in the autumn that a passerine species in the northeast with a fully pneumatized skull may be identified as "After Hatching Year."

INTRODUCTION

Examination of the top of a bird's head to determine the degree of skull pneumatization (also inappropriately called ossification) has been a valuable tool for many years to determine a bird's age. The pneumatization process was described as early as Dwight (1900) in his classic publication on passerine molt. Miller (1946) described a method to examine skull pneumatization whereby feathers are plucked from an area at the top of the skull and an incision made in the skin to view the actual skull. This method was refined greatly by Norris (1961) whereby the skin on top of the skull was wet by saliva (or some other fluid) and the bone surface examined in good light with a hand lens.

Miller (1946:33) stated: "The skull of a passerine bird when it leaves the nest is made up of a single layer of bone overlaying the brain; at least, the covering appears single when viewed macroscopically. Later the brain case becomes double layered, the outer layer being separated from the inner layer by an air space across which extend numerous small columns of bone. It is not necessary to section the bone to determine the condition. Externally the skull of the immature bird appears uniform and pinkish in live or freshly killed specimens. The skull of the adult is whitish, due to the air space, and also it is finely speckled as a result of the dense white bony columns between the layers." Birds with partially pneumatized skulls will have areas that exhibit both conditions. It may be difficult, if not impossible, to determine the state of pneumatization on birds that are molting the feathers on top of the head or have injured the top of their skull. These birds are considered "age unknown." As reported by Baird (1964), if the bird's head is held between the thumb and the index finger, the loose skin can be moved back and forth, thus enabling one to see, with the use of a hand lens, the many white dots of the adult or the boundary between the whitish ossified and the clear pink unossified areas in the immature Verheyen (1953) stated that it is apparent that the progress of pneumatization is not a hindrance in any way to migration, that it can be temporarily arrested and can constitute an index of sexual immaturity. For a detailed technical description of the pneumatization process, which goes beyond the scope of this paper, the reader is referred to the excellent reference by Verheyen (1953). For a description of the process specific to the family Parulidae the reader is referred to Eaton (2001) Several investigators have reported on the rate of pneumatization and the timing of completion of the process: Leberman (1970), Mellencamp (1969), Nero (1951), Schneider (1981), Smith (1979), Stewart (1972), and Yunick (1977, 1979a, 1979b, 1980, 1981, 1984, 1987, 1992).

Determining the amount of skull pneumatization is especially useful for aging birds whose plumage characteristics (mouth part color, eye color, etc.) may have already taken on adult characteristics The purpose of this paper is to discuss some of the pneumatization characteristics for northeastern

North America passerines and to provide a table (Table 1) showing a cutoff date in the northeast after which it is usually no longer safe to classify a bird with a completely pneumatized skull as an after-hatching-year (AHY) adult.

METHODS

Viewing - Whereas many banders prefer to use some magnification (3X to10X) to assist with the examination, others feel that after considerable experience with "skulling" they are fully capable of determining the condition of the skull without additional magnification. In either case, good lighting conditions are required. It is the writer's experience that a lower magnification, such as 3X, allows for a greater depth of field making the examination easier. A larger lens, such as provided on an OptiVISOR (readily available from opticians or hobby shops) provides a wide field of view which also facilitates viewing the skull.

Scoring - A method of quantifying or scoring the amount of skull pneumatization in birds has been developed by the Institute of Field Ornithology for use in their MAPS (Monitoring Avian Populations and Survivorship) program (DeSante et al. 2003), whereby a rating of zero through six is assigned– where zero is for birds with no skull pneumatization and six is for birds with a completely pneumatized skull. They assign a rating of eight for birds that were not able to be "skulled." This rating system was used for the evaluation of the degree of pneumatization for this paper. Birds with a skull score of six were determined to be hatching-year by other aging parameters such as plumage, molt limits, mouth color, etc. or were aged "unknown."

Tabulating - Table 1 is provided for use with those passerine species where there is sufficient data to be confident of the cutoff date for the latitude range of southern New Jersey and Pennsylvania and areas north to middle New England and northern New York. Considerable banding data were also surveyed from points west to Long Point on the north shore of Lake Erie. This is the geographical range of this study. There are some species for which the writer had relatively few specimens to evaluate (Horned Lark, American Pipit, Lapland Longspur, and Bobolink) and these are labeled "insufficient data." Also not included in the table are species difficult to "skull" for which the writer feels accurately assessing the degree of pneumatization is not consistently possible.

Eaton also provided valuable suggestions for the preparation of the table of cutoff dates. He pointed out that bird skulls in museums are often prepared with a cleaning procedure involving dermestid beetle larvae to consume the flesh or with a maceration procedure using a flowing water procedure. It may be more difficult to assess accurately the degree of pneumatization from skulls prepared with the dermestid procedure (S. Eaton pers. comm.). Therefore, where pneumatization data were available from skulls prepared with the dermestid procedure and from live birds, emphasis was given to the data from live birds. Similarly, for specimens where the preparation procedure was unknown, emphasis was given to banding data from live birds.

RESULTS

Table 1 is based on the examination of preserved bird skulls in collections at several museums and universities in the state of New York and on the evaluation of actual banding data at a large banding station at Long Point, ON, on Lake Erie, and on the writer's personal banding in central and western New York, including Braddock Bay Bird Observatory near Rochester, NY, and on the New Jersey shore at Island Beach State Park. It is not intended for this paper to replace such excellent works as the Bird Banding Manual (1991) or Pyle's (1997) definitive work on aging birds. It could be used, along with those manuals, as a quick reference guide specifically for geographical areas in the northeast. Consider this as a work in progress and refinements are strongly encouraged. The writer would be very grateful to banders and other investigators interested in this subject to provide additional information and regional corrections to these data.

DISCUSSION

Timing - Some species, and at least some individuals of a species, are known to have delayed pneumatization; i.e., they do not complete the process in their first autumn but go into their first winter and spring (or later) with "windows" of

unpneumatized skull. Even in species with completely pneumatized skulls in the first autumn, some have a more prolonged pneumatization period than do others. That is, once the process has started, the timing for the process to complete is not the same for all species. Also, even with species with the same rate of pneumatization, the initiation of the process varies. Leberman (1970), commenting on the frequency of two different patterns of pneumatization in Ruby-crowned Kinglets (*Regulus calendula*), pointed out that perhaps birds passing through a banding area represent several discrete populations, each with a slightly different genetic makeup. These factors, plus the presence of young fledged at different times throughout the breeding season (Yunick 1977), contribute to birds with different timing of completion of the pneumatization process. In addition, Wiley and Piper (1992) suggested that the timing of pneumatization might provide an indication of a young bird's nutritional state. In fact, the process of pneumatization, in some birds, apparently can be arrested temporarily before it continues to completion or near completion later in the same season (Verheyen 1953).

Rate - As reported by Yunick (1977, 1979a, 1980), the rate of completion is not constant for all stages of the process, at least for some species. Two species that appear to have a very rapid rate of pneumatization are Ruby-crowned Kinglet and American Tree Sparrow (*Spizella arborea*). Schneider (1981) reported that Field Sparrows (*S. pusilla*) have a more rapid rate of pneumatization in the early stages of the process. To date, this observer has seen no definitive evidence indicating different pneumatization rates for males and females of the same species.

Hamel and Wagner (1990) reported that both Song Sparrows (*Melospiza melodia*) and Swamp Sparrows (*M. georgiana*) showed faster pneumatization in laboratory-held birds than in wild birds. Most individuals of some species such as *Empidonax* flycatchers and Yellow Warblers (*Dendroica petechia*) leave our area for the south before most of them have a fully pneumatized skull, so there is a certain level of doubt regarding the cutoff dates for those early departing species. Eaton (2001) reports some warblers with "windows" as late as January or February on their wintering grounds.

Pattern - For many passerines, there are two or more different patterns of pneumatization in an incompletely pneumatized skull. Leberman (1970), Nero (1951), Yunick (1979a) and others have addressed the patterns of pneumatization in several species. It is important for the bander to be aware of these different patterns when assessing the completion of pneumatization of a bird in the hand. Yunick (1987) suggested that whether a bird has peripheral or median line pneumatization is related to the bird's skull size and configuration. Usually the pneumatization pattern is fairly symmetrical with respect to the left and right side of the skull. However, Parkes (1998) showed an example of a Song Sparrow with a very asymmetrical pneumatization pattern. Examination of living birds and of preserved bird skulls in several museums and universities revealed a significant number of birds that pneumatized at the fore part of the skull last. This area is often the most difficult part of the skull to examine because the skin often does not move as freely in this area. It is important to evaluate carefully this part of the skull.

Cutoff - It is my experience that banders will encounter some individuals of any given species with unpneumatized skulls after the listed cutoff date in Table 1. The cutoff date is the date after which at least some individuals of that species will have a fully pneumatized skull and, therefore, cannot be aged AHY. There will be some individuals of that species that will not develop a pneumatized skull until later, perhaps not even until the following year or, as in some cases, perhaps never. The writer has intended that the table be conservative so a HY bird is not reported as an AHY.

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Table 1. A table of cut off dates after which birds in the northeast with pneumatized skulls should not be aged AHY.

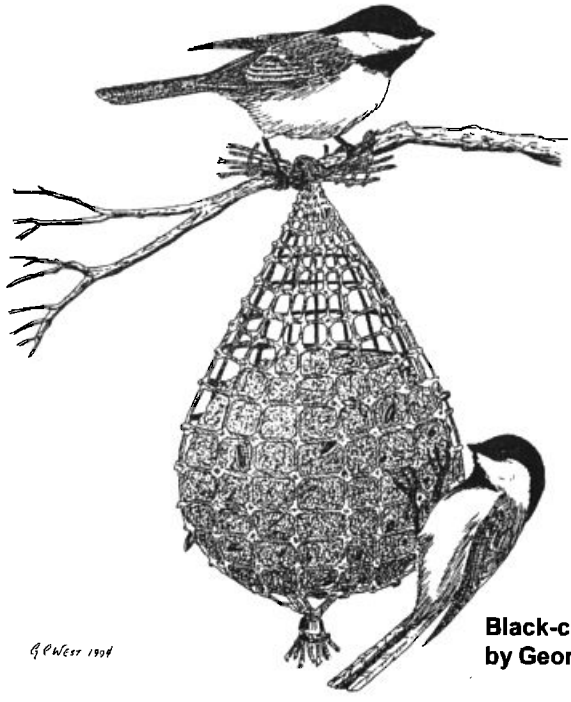
Name		Code	Cutoff Date
Olive-sided Flycatcher	*Contopus cooperi*	OSFL	Insufficient Data
Eastern Wood-Pewee	*Contopus virens*	EAWP	October 1
Yellow-bellied Flycatcher	*Empidonax flaviventris*	YBFL	October 1
Acadian Flycatcher	*Empidonax virescens*	ACFL	October 1
Traill's Flycatcher	*Empidonax alnorum/trailii*	TRFL	October 1
Least Flycatcher	*Empidonax minimus*	LEFL	October 1
Eastern Phoebe	*Sayornis phoebe*	EAPH	Mid September
Great Crested Flycatcher	*Myiarchus crinitus*	GCFL	October 1
Eastern Kingbird	*Tyrannus tyrannus*	EAKI	October 1
Loggerhead Shrike	*Lanius ludovicianus*	LOSH	Insufficient Data
Northern Shrike	*Lanius excubitor*	NOSH	Insufficient Data
White-eyed Vireo	*Vireo griseus*	WEVI	Mid October
Yellow-throated Vireo	*Vireo flavifrons*	YTVI	Mid October
Blue-headed Vireo	*Vireo solitarius*	BHVI	November 1
Warbling Vireo	*Vireo gilvus*	WAVI	Mid October
Philadelphia Vireo	*Vireo philadelphicus*	PHVI	Mid October
Red-eyed Vireo	*Vireo olivaceus*	REVI	Mid October
Horned Lark	*Eremophila alpestris*	HOLA	Insufficient Data
Purple Martin	*Progne subis*	PUMA	Insufficient Data
Tree Swallow	*Tachycineta bicolor*	TRSW	Insufficient Data
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	NRWS	Insufficient Data
Bank Swallow	*Riparia riparia*	BANS	Insufficient Data
Cliff Swallow	*Petrochelidon pyrrhonota*	CLSW	Insufficient Data
Barn Swallow	*Hirundo rustica*	BARS	Insufficient Data
Carolina Chickadee	*Poecile carolinensis*	CACH	October 1
Black-capped Chickadee	*Poecile atricapillus*	BCCH	October 1
Tufted Titmouse	*Baeolophus bicolor*	ETTI	November 1
Red-breasted Nuthatch	*Sitta canadensis*	RBNU	October 1
White-breasted Nuthatch	*Sitta carolinensis*	WBNU	October 1
Brown Creeper	*Certhia americana*	BRCR	Mid October
Carolina Wren	*Thryothorus ludovicianus*	CAWR	Mid October
House Wren	*Troglodytes aedon*	HOWR	Mid October
Winter Wren	*Troglodytes troglodytes*	WIWR	Mid October
Sedge Wren	*Cistothorus platensis*	SEWR	Insufficient Data
Marsh Wren	*Cistothorus palustris*	MAWR	Mid October
Golden-crowned Kinglet	*Regulus satrapa*	GCKI	October 1
Ruby-crowned Kinglet	*Regulus calendula*	RCKI	October 1
Blue-gray Gnatcatcher	*Polioptila caerulea*	BGGN	Mid October
Eastern Bluebird	*Sialia sialis*	EABL	Mid October
Veery	*Catharus fuscescens*	VEER	October 1
Gray-cheeked Thrush	*Catharus minimus*	GCTH	October 1
Bicknell's Thrush	*Catharus bicknelli*	BITH	October 1
Swainson's Thrush	*Catharus ustulatus*	SWTH	October 1
Hermit Thrush	*Catharus guttatus*	HETH	October 1
Wood Thrush	*Hylocichla mustelina*	WOTH	Mid October
American Robin	*Turdus migratorius*	AMRO	Mid October
Gray Catbird	*Dumetella carolinensis*	GRCA	Mid October
Northern Mockingbird	*Mimus polyglottos*	NOMO	Mid October
Brown Thrasher	*Toxostoma rufum*	BRTH	Mid October

Table 1. Continued

Name		Code	Cutoff Date
American Pipit	*Anthus rubescens*	AMPI	Insufficient Data
Bohemian Waxwing	*Bombycilla garrulus*	BOWA	Insufficient Data
Cedar Waxwing	*Bombycilla cedrorum*	CEDW	November 1
Blue-winged Warbler	*Vermivora pinus*	BWWA	Mid October
Golden-winged Warbler	*Vermivora chrysoptera*	GWWA	Mid October
Tennessee Warbler	*Vermivora peregrina*	TEWA	Mid October
Orange-crowned Warbler	*Vermivora celata*	OCWA	Mid October
Nashville Warbler	*Vermivora ruficapilla*	NAWA	Mid October
Northern Parula	*Parula americana*	NOPA	Mid October
Yellow Warbler	*Dendroica petechia*	YWAR	Mid October
Chestnut-sided Warbler	*Dendroica pensylvanica*	CSWA	Mid October
Magnolia Warbler	*Dendroica magnolia*	MAWA	October 1
Cape May Warbler	*Dendroica tigrina*	CMWA	Mid October
Black-throated Blue Warbler	*Dendroica caerulescens*	BTBW	Mid October
Myrtle Warbler	*Dendroica coronata coronata*	MYWA	Mid October
Black-throated Green Warbler	*Dendroica virens*	BTNW	Mid October
Blackburnian Warbler	*Dendroica fusca*	BLBW	Mid October
Pine Warbler	*Dendroica pinus*	PIWA	Mid October
Prairie Warbler	*Dendroica discolor*	PRWA	Insufficient Data
Western Palm Warbler	*Dendroica palmarum palmarum*	WPWA	Mid October
Yellow Palm Warbler	*Dendroica palmarum hypochrysea*	YPWA	Mid October
Bay-breasted Warbler	*Dendroica castanea*	BBWA	Mid October
Blackpoll Warbler	*Dendroica striata*	BLPW	Mid October
Cerulean Warbler	*Dendroica cerulea*	CERW	Mid October
Black-and-White Warbler	*Mniotilta varia*	BAWW	October 1
American Redstart	*Setophaga ruticilla*	AMRE	October 1
Prothonotary Warbler	*Protonotaria citrea*	PROW	Insufficient Data
Worm-eating Warbler	*Helmitheros vermivorum*	WEWA	Insufficient Data
Ovenbird	*Seiurus aurocapilla*	OVEN	Mid October
Northern Waterthrush	*Seiurus noveboracensis*	NOWA	October 1
Louisiana Waterthrush	*Seiurus motacilla*	LOWA	Insufficient Data
Connecticut Warbler	*Oporonis agilis*	CONW	Mid October
Mourning Warbler	*Oporonis philadelphia*	MOWA	Mid October
Common Yellowthroat	*Geothlypis trichas*	COYE	October 1
Hooded Warbler	*Wilsonia citrina*	HOWA	Mid October
Wilson's Warbler	*Wilsonia pusilla*	WIWA	Mid October
Canada Warbler	*Wilsonia canadensis*	CAWA	Mid October
Yellow-breasted Chat	*Icteria virens*	YBCH	Mid October
Scarlet Tanager	*Piranga olivacea*	SCTA	Mid October
Eastern Towhee	*Pipilio erythrophthalmus*	EATO	Mid October
American Tree Sparrow	*Spizella arborea*	ATSP	November 1
Chipping Sparrow	*Spizella passerina*	CHSP	Mid October
Clay-colored Sparrow	*Spizella pallida*	CCSP	Mid October
Field Sparrow	*Spizella pusilla*	FISP	Mid October
Vesper Sparrow	*Pooecetes gramineus*	VESP	November 1
Savannah Sparrow	*Passerculus sandwichensis*	SASP	Mid October
Grasshopper Sparrow	*Ammodramus savannarum*	GRSP	Insufficient Data
Henslow's Sparrow	*Ammodramus henslowii*	HESP	Insufficient Data
Nelson's Sharp-tailed Sparrow	*Ammodramus nelsoni*	NSTS	Insufficient Data
Saltmarsh Sharp-tailed Sparrow	*Ammodramus caudacutus*	SSTS	Insufficient Data

Table 1. Continued

Name		Code	Cutoff Date
Seaside Sparrow	*Ammodramus maritimus*	SESP	Insufficient Data
Fox Sparrow	*Passerella iliaca*	FOSP	November 1
Song Sparrow	*Melospiza melodia*	SOSP	Mid October
Lincoln's Sparrow	*Melospiza lincolnii*	LISP	November 1
Swamp Sparrow	*Melospiza georgiana*	SWSP	November 1
White-throated Sparrow	*Zonotrichia albicollis*	WTSP	November 1
Eastern White-cr. Sparrow	*Zonotrichia leucophrys leucophrys*	EWCS	Mid October
Slate-colored Junco	*Junco hyemalis hyemalis*	SCJU	Mid October
Lapland Longspur	*Calcarius lapponicus*	LALO	Insufficient Data
Snow Bunting	*Plectrophenax nivalis*	SNBU	November 1
Northern Cardinal	*Cardinalis cardinalis*	NOCA	Mid October
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	RBGR	Mid October
Indigo Bunting	*Passerina cyanea*	INBU	Mid October
Bobolink	*Dolichonyx oryzivorus*	BOBO	Insufficient Data
Orchard Oriole	*Icterus spurius*	OROR	Insufficient Data
Baltimore Oriole	*Icterus galbula*	BAOR	November 1
Pine Grosbeak	*Pinicola enucleator*	PIGR	November 1
Purple Finch	*Carpodacus purpureus*	PUFI	November 1
House Finch	*Carpodacus mexicanus*	HOFI	Mid October
Red Crossbill	*Loxia curvirostra*	RECR	Insufficient Data
White-winged Crossbill	*Loxia leucoptera*	WWCR	Insufficient Data
Common Redpoll	*Carduelis flammea*	CORE	November 1
Hoary Redpoll	*Carduelis homemanni*	HORE	Insufficient Data
Pine Siskin	*Carduelis pinus*	PISI	November 1
American Goldfinch	*Carduelis tristis*	AMGO	Mid October
Evening Grosbeak	*Coccothraustes vespertinus*	EVGR	November 1
House Sparrow	*Passer domesticus*	HOSP	October 1



Black-capped Chickadees on Suet
by George West