

## AGE, SEX, AND WING LENGTH OF TOWER CASUALTIES: FALL MIGRATION, 1962

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The following report summarizes observations on skull maturation, sex, and wing length of 316 avian casualties at two television towers in Nashville, Tennessee during September and October, 1962.

One hundred twelve birds, part of a "fall" at WSM-TV tower during the night of September 5-6, were made available for study in the laboratory by A. F. Ganier. This sample of an early migratory flight offered the possibility of comparing age and sex of this "fall" with possible later ones. Birds that fell at both WSIX and WSM towers on the nights of October 5-6, October 16-17, and on later dates in October became available for study through the courtesy of Amelia R. Laskey and Henry E. Parmer, as well as Mr. Ganier. Total lists of birds collected at the two towers and circumstances of the accidents are described by the above mentioned persons<sup>(1, 2)</sup>. Descriptions of the two towers have been previously reported<sup>(3)</sup>. The stations are about 7 air miles apart; both are south and slightly west of the city. On any one night, it is the usual pattern for more birds to fall at WSM than at WSIX, but for this report, 227 birds collected at WSM and 89 collected at WSIX have been treated together. Dates given below indicate the date the birds were collected.

### *Composition of the Samples*

The 316 birds examined represented 24 species. Seventeen species of warblers, viz., Black-and-white, Tennessee, Nashville, Yellow, Magnolia, Myrtle, Black-throated Green, Cerulean, Blackburnian, Chestnut-sided, Palm, Ovenbird, Kentucky, Yellowthroat, Yellow-breasted Chat, Canada, and American Redstart, accounted for 274 or 86.4 percent of the birds of this study; 33 Red-eyed Vireos represented 10.4 percent†. In addition, 2 Brown Creepers, 1 Golden-crowned Kinglet, 1 Solitary Vireo, 2 Philadelphia Vireos, 1 Rose-breasted Grosbeak, and 2 Indigo Buntings were examined, but not incorporated in any analysis.

### *Methods of Examination*

*Examination of the Skull.* The external surface of skulls was exposed by stripping the skin forward and each was examined for maturity of development under a dissecting microscope. Microscopic examination was not necessary, but it was easy and in cases of extensive hemorrhage, one could readily determine whether blood was between bony plates or beneath a single plate. A matured skull appeared chalky, somewhat opaque, and presented a stippled effect over the whole calvarial surface. An immature skull appeared

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†Scientific names will be appended.

smooth and translucent, showing the pinkish color of the brain beneath. Since maturation of the calvarium is a gradual process, varying patterns of stippling and translucence were encountered<sup>(4)</sup>. For purposes of this paper, however, differentiation is made only between completely and incompletely ossified calvaria.

*Length of Wing.* The chord of the left wing was measured in millimeters. About half the birds were kept in a refrigerator and examined without subjection to freezing. The remainder were frozen and examined within about a month. All wing joints were easily manipulatable at the time of measurement. All measurements were made by the same person.

*Sex Determination.* Sex was determined by opening the abdomen on the left side at the level of the last rib. The abdominal viscera were pushed aside so as to expose both adrenal glands and the left gonad at the anterior edge of the kidneys. Usually, the right testis was also easily observed. Identification of the gonads was made only by visualization under a binocular dissecting microscope using 20-60x magnification. Testes appeared as small convex discs. They were translucent with a detectable vermiform internal pattern. The ovaries, which develop as an unpaired organ on the left side, were variable in size, loosely constructed, and incorporated round follicles of varying diameters.

Determination of sex was attempted on only a few of the 112 birds collected on September 6, and failed on a few other individuals because of decomposition.

#### OBSERVATIONS

*Skull Ossification.* Table I presents the proportion of completely to incompletely ossified skulls of warblers and Red-eyed Vireos which fell on three dates in September and October, 1962.

TABLE I. PROPORTION OF MATURED TO IMMATURED SKULLS OF WARBLERS AND RED-EYED VIREOS COLLECTED ON 3 DATES IN SEPTEMBER AND OCTOBER, 1962.

Species	Date	Total	Skull Ossification		
			Complete	Incomplete	% Complete
Warblers	Sept. 6	97	16	81	16.5
	Oct. 6	96	54	42	56.2
	Oct. 17	81	42	37	51.9
Red-eyed Vireos	Sept. 6	15	5	10	33.3
	Oct. 6	18	2	16	11.1

The proportion of completely ossified warbler skulls increased more than three fold between the first week in September and the first week in October and remained essentially the same during the next ten days. The proportion of matured skulls of Red-eyed Vireos dropped from 33 percent on September 6 to 11 percent on October 6.

Table II presents observations on skulls of the four species of warblers represented by the largest samples.

TABLE II. CHANGES IN PROPORTION OF COMPLETELY OSSIFIED SKULLS OF 4 WARBLERS.

Species	Date	Total	Skull Ossification		
			Complete	Incomplete	% Complete
Black-and-white	Sept. 6	21	0	21	0.0
	Oct. 6	5	2	3	40.0
Magnolia	Sept. 6	21	0	21	0.0
	Oct. 17	18	16	2	88.9
Tennessee	Sept. 6	4	3	1	75.0
	Oct. 6	93	37	56	39.8
	Oct. 17	15	3	12	20.0
Palm	Oct. 6	5	4	1	80.0
	Oct. 17	20	12	8	60.0

The Magnolia Warbler was the only species among these four that showed a definite change in age composition as indicated by a drop from 100 percent to 11 percent incompletely ossified skulls during 6 weeks. It is of interest that the sample of 21 Black-and-white Warblers collected on September 6 had also 100 percent incompletely ossified skulls. Unfortunately, the later sample was too small to indicate significant change.

*Skull Maturity Related to Plumage.* Birds of a single species collected on a single day were first ranked according to some plumage character. Following examination of the skulls, it was observed that matured or immature skulls often fell strongly at one end of the graded plumage pattern. For example: eighty-five Tennessee Warblers collected October 6 were ranked from the brightest green heads and backs to gray or "colorless" heads, dull backs and dull upper tail coverts. Though the dividing lines were arbitrary, the birds fell naturally into four groups as indicated in Table III. After an orderly examination for ossification of the skulls, it was interesting to find matured and immature skulls strongly grouped on the basis of a plumage gradation. Group IV proved to be 100 percent matured and with one exception Group III was also matured.

TABLE III. TENNESSEE WARBLERS

Group	Plumage	Total	Skull Ossification		
			Complete	Incomplete	% Complete
I	greenest	27	3	24	11.1
II	less green	23	11	12	47.8
III	brownish green	16	15	1	93.7
IV	gray or "colorless"	19	19	0	100.0

This same pattern held for Blackburnian and Kentucky Warblers, but their numbers were so few that significance could not be attached to the observations.

As will be shown later, no correlation could be seen between ossification of the skulls and wing lengths.

*Wing Length and Sex.* The most interesting material deriving from these examinations has to do with the relation of wing length to sex. Observations on five species, Tennessee, Palm, Magnolia, and Kentucky Warblers, and Red-eyed Vireos seem to warrant presentation in some detail.

Tennessee Warbler: Wing measurements of 113 Tennessee Warblers ranged from 57.5 mm. to 68.0 mm. For Table IV, fractional measurements of 0.5 or more were graded up to the next higher digit and those of 0.4 mm. and less were graded down to the next whole digit. Only those individuals for which sex was determined have been included in the following analysis.

When data from Table IV are projected into Fig. 1, Chart I, plotting length of wing against incidence, two peaks appear: one at 61.0 mm. and another at 64.0 to 65.0 mm.

If a curve for the incidence of females and another for the incidence of males are plotted against wing length, one sees that the peak at 61.0 mm. (Fig. 1, Chart II) represents females and the other, 64.0 to 65.0 mm., represents males. All wing lengths 61.0 mm. and below were of females; all 64.0 mm. and above were of males. In the range of 62.0 to 63.0 mm., there was an overlap of only 2 males with a literal count of 1 male and 10 females with a measurement of 62.0 mm.; 1 male and 3 females measuring 63.0 mm.

Further analysis of Table IV shows that when the incidence of female Tennessee Warblers with matured skulls and females with immatured skulls are plotted against wing length, the two curves practically parallel each other (Fig. 1, Chart III). The same can be said for male Tennessee Warblers.

The Tennessee Warbler with the longest wing, 68.0 mm., was not included in the above table because determination of its sex failed, but its skull was completely ossified. The shortest wing, 57.7 mm., was that of a female with a skull about 1/3 ossified.

TABLE IV. WING-LENGTH OF TENNESSEE WARBLERS  
RELATED TO INCIDENCE, SEX, AND AGE.

Wing-length in mm.	58	59	60	61	62	63	64	65	66	67	Total
Incidence Total	3	10	7	20	11	4	11	11	8	4	89
Male	0	0	0	0	1	1	11	11	8	4	36
Female	3	10	7	20	10	3	0	0	0	0	53
I ♀	3	6	5	8	3	1					27
A ♀	0	4	2	12	7	2					26
I ♂					1	1	6	4	3	1	20
A ♂							5	7	5	3	16

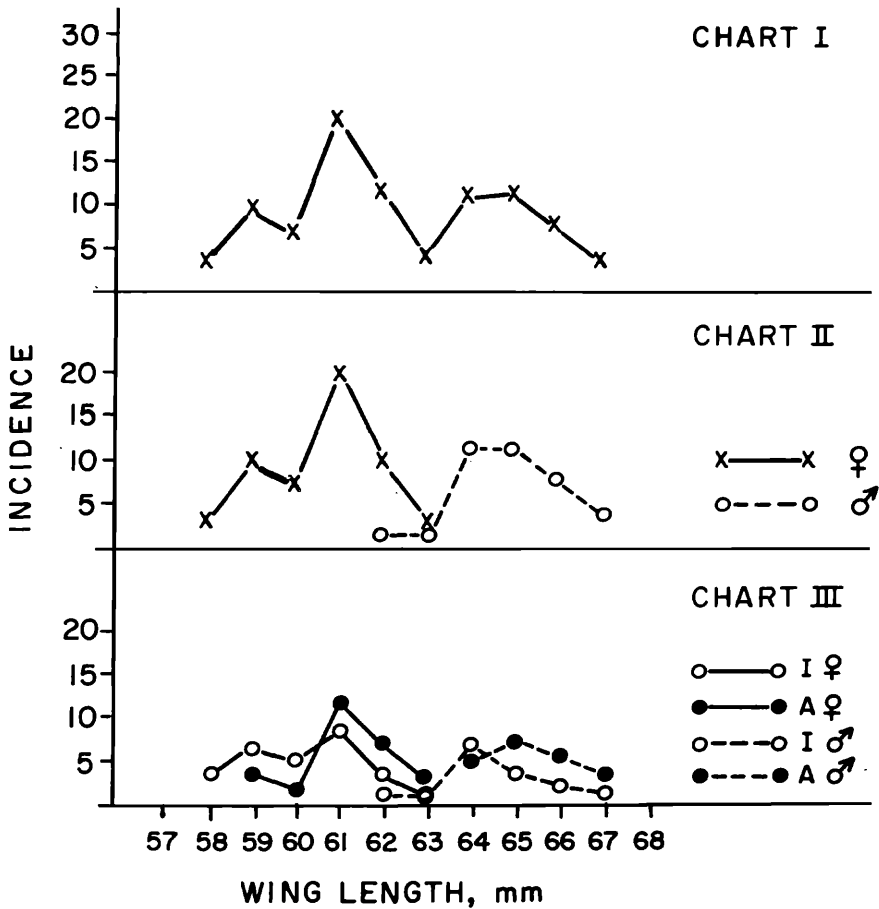


Fig. 1. Tennessee Warblers. Chart I: Total incidence plotted against wing length. Chart II: Incidence of males and females plotted against wing length. Chart III: Incidence of adult females, immature females, adult males, and immature males plotted against wing length.

Palm Warbler: Of 25 Palm Warblers judged to be of the western race, *palmarum*, 16 had completely ossified skulls; 9 were immature. Fourteen female wing measurements ranged from 59.2 to 65.0 mm. Eight male wings ranged from 64.0 to 66.2 mm. A single immature male fell far out of line with a measurement of 61.0 mm.

One Palm Warbler with completely yellow underparts of strong color stood out from the others and was judged to be of the larger eastern race, *hypochrysea*. Measurement of its wing was 66.2 mm.; it was female with an incompletely ossified skull.

Magnolia Warbler: Two groups of Magnolia Warblers have already been compared as to skull ossification in Table II. The early group of 21 (September 6) had 100 percent immature crania. Wing

TABLE V. KENTUCKY WARBLERS — RELATION OF PLUMAGE VARIATION TO OSSIFICATION OF SKULL, WING LENGTH, AND SEX.

	PLUMAGE			SKULL OSSIFICATION	WING mm.	SEX
	Face	Top of head	Forehead			
1	very black	black, gray veil	very black	complete (A)	66.0	♂
2	very black	black, gray veil	very black	complete (A)	68.5	♂
3	slightly less black	slightly less black, gray veil	less black	complete (A)	67.0	♂
4	less black	less black, very brown veil	less black	incomplete (I)	70.5	♂
5	less black	less black, less brown veil	no black	complete (A)	65.0	♀
6	very little black	no black	no black	incomplete (I)	54.0	♀
7	practically no black	brown, no black	no black	incomplete (I)	53.0	♀

measurements of this group ranged from 60.0 mm. downward to 54.0 mm. A curve plotting incidence against wing length gave a single peak at 55.0 mm. Unfortunately, no sex determinations were made. The later sample (October 17) of 18 individuals was 89 percent matured. Wings of 5 males ranged from 60.0 to 63.7 mm.; wings of 8 females ranged from 57.0 to 59.0 mm.

Kentucky Warbler: A group of 7 Kentucky Warblers was too small for a test of grading plumage, but the observations proved to be of interest. Before any dissection was done, careful notes on plumage were recorded and the birds were numbered 1-7, ranging from very black face and very black head veiled with gray to practically no black and a brownish head. Skulls were examined, wings measured, and sex determined as usual. Table V reproduces the notes from the laboratory work sheet.

Here a primary grading of plumage served to group the sexes at the poles of the gradient and the mature and immature skulls fell in an orderly fashion in relation to both sex and wing length on the plumage gradient.

Other warblers were in too few numbers to warrant analysis.

Red-eyed Vireo: Skull readings on two groups of Red-eyed Vireos presented in Table I show that in the samples studied the proportion of matured skulls decreased from 33 percent on September 6 to 12 percent on October 6. Wing measurements on the September

group ranged from 73.2 to 82.0 mm. The highest incidence was at 79.0 mm., but there was no definite single or double peak of incidence as compared with the Magnolia and Tennessee Warblers. Wing measurements of 18 Red-eyed Vireos collected a month later ranged from 74.0 to 80.0 mm. Curves with male and female incidence plotted against wing length show a tendency toward double peaking, but it would take many more birds to establish a basis for any conclusion. The longest winged females both had incompletely ossified skulls.

#### DISCUSSION

Numerous accounts of avian casualties at ceilometers and television towers have been published in recent years. The meteorological circumstances of such episodes, and the magnitude and species composition of flights represented by the dead birds have received chief attention in most reports. In their monograph, "Studies of Birds Killed in Nocturnal Migration," Tordoff and Mengel<sup>(5)</sup> reported determinations of age, sex, weights, and some measurements of over 1,000 birds killed during fall migration, 1954, near Topeka, Kansas. These authors reviewed the related literature and discussed the possible significance of information that might derive from accumulated studies of such casualties. The present paper presents a small amount of data that may add to such an accrual.

The observations of Miller<sup>(6)</sup> and of Nero<sup>(4)</sup> on ossification of avian skulls establish the basis for interpreting a completely ossified skull as that of an adult bird and as Tordoff and Mengel indicate, the differentiation between complete and incomplete ossification is so nearly unequivocal that one may interpret by this method the age of birds in the fall as adult or immature with a degree of surety.

Likewise, direct visualization of gonads establishes the sex of an individual without question. On the other hand, in many species, secondary sexual characters are at the present time difficult to recognize, especially in the fall, and external signs of immaturity are in many instances subtle and elusive. An attempt has been made to interpret certain plumage characters and wing measurements in relation to established age and sex of individual birds.

Gradations of plumage variations of species currently considered have been relative and subjective. In three species, Tennessee, Kentucky, and Blackburnian Warblers, relative ranking of a plumage character weighted the extremes with mature or immature individuals as established by direct examination of skulls. By such an experience, an observer may learn to recognize with some confidence the age of the extremes of a plumage gradient. Table III of Tennessee Warblers illustrates this point.

In a small group of Kentucky Warblers, the sexes were segregated on a plumage gradient. In Tennessee, Palm, and Magnolia Warblers and in Red-eyed Vireos, there was no tendency for the sexes to be segregated by the method of plumage ranking used.

Sharpest correlation of sexual differentiation of birds of this study was with wing measurement in Tennessee Warblers. I cannot judge the degree of accuracy with which chord measurements

expressed in millimeters can be made. There is certainly a range of error and one may assume that the accuracy of any such measurement can be refined. I have not tested the variation of measurement of the wing of a live bird against measurement of the same wing following death, refrigeration, and freezing and thawing.

In the group of 89 Tennessee Warblers, there was an overlap in wing measurements of males and females of only 2.0 mm.; all wings 64.0 mm. and more were of males, all 61.0 mm. and less were of females. Fifteen birds (17 percent) were in the overlapping range. These data on this group of Tennessee Warblers coupled with those relating age and plumage character allow one to summarize that a decidedly bright-green headed, very green-backed Tennessee with wing measurements of 61.0 mm. or less could reasonably be called an immature female. A bird of the same color with wing length of 64.0 mm. or more could be called an immature male with a reasonable degree of accuracy. A bird with a definitely brown cast to its head or a definitely gray or "colorless" head with wing measurement of 61.0 mm. or less would likely be an adult female, or with a wing 64.0 mm. or longer, an adult male.

Observations on Magnolia and Palm Warblers and Red-eyed Vireos present a less clear relation of age, sex, and wing length but they offer a skeleton of data that can be added to when larger samples may admit of some conclusion.

A study like this presents an accurate account of the age and sex of samples of particular migrating flights and thereby goes a step farther than an analysis of the magnitude and species composition of such a flight. In addition, an analysis of the relation of accurately determined age and sex to the external characters of wing length and plumage variations may give banders a gauge for classifying species whose age and sex cannot at the present time be recognized in living birds, and thereby, these fragments of data gleaned from victims of ill wind become useful to our attempts at reading the intricate pattern of migration.

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#### Scientific Names of Birds mentioned in the Text

Brown Creeper, *Certhia familiaris*  
 Golden-crowned Kinglet, *Regulus satrapa*  
 Solitary Vireo, *Vireo solitarius*  
 Red-eyed Vireo, *V. olivaceus*  
 Philadelphia Vireo, *V. philadelphicus*



Rose-breasted Grosbeak, *Pheucticus ludovicianus*  
Indigo Bunting, *Passerina cyanea*  
Black-and-white Warbler, *Mniotilta varia*  
Tennessee Warbler, *Vermivora perigrina*  
Nashville Warbler, *Vermivora ruficapilla*  
Yellow Warbler, *Dendroica petechia*  
Magnolia Warbler, *D. magnolia*  
Myrtle Warbler, *D. coronata*  
Black-throated Green Warbler, *D. virens*  
Cerulean Warbler, *D. cerulea*  
Blackburnian Warbler, *D. fusca*  
Chestnut-sided Warbler, *D. pensylvanica*  
Palm Warbler, *D. palmarum*  
Ovenbird, *Seiurus aurocapillus*  
Kentucky Warbler, *Oporornis formosus*  
Yellowthroat, *Geothlypis trichas*  
Yellow-breasted Chat, *Icteria virens*  
Canada Warbler, *Wilsonia canadensis*  
American Redstart, *Setophaga ruticilla*

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### ABNORMALITIES AMONG BROWN-HEADED COWBIRDS TRAPPED IN ALABAMA

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The incidence of externally visible abnormalities in a population of Brown-headed Cowbirds (*Molothrus ater*) wintering at Montgomery, Alabama, was recorded during the winter of 1960-61. During this winter, 8,275 cowbirds taken by bait trapping were examined, banded, and released. Ten additional birds were killed for laboratory examination.

Of the 8,285 birds handled, 7,537 were males and 748 were females. Abnormalities were observed on 292 of the males and 29 of the females, an incidence of 3.9 percent in birds of each sex.

*Bird Pox.*—Seventy-seven birds (0.9 percent) had nodular proliferations on the legs, feet, or head resembling the nodules that are characteristic of bird pox. Except for one nodule at the base of a bird's bill, all nodules were on feet or legs. Thirteen females (1.7 percent) and 64 males (0.8 percent) had these pox-like nodules.

*Scaly Leg-Mite.*—Forty-four male birds (0.6 percent) and no females had infestations of scaly leg mites. The mites from one bird were identified as *Knemidocoptes mutans*, the same species that infests domestic chickens.