THE RELIABILITY OF AGING SOME FALL MIGRANTS BY SKULL PNEUMATIZATION[1]

By Robert M. Stewart

It is important to determine the reliability of using skull pneumatization as a criterion for aging passerines. One difficulty with the aging technique is that by September or October young birds that hatched early in the season might have completed pneumatization ("ossification") and thus appear to be adults in this characteristic. Knowledge of pneumatization rates in hatching-year birds is therefore required. Pneumatization rates have been determined for the House Sparrow (*Passer domesticus;* Nero, 1951), the Zebra Finch (*Taeniopygia castanotis;* Serventy, Nicholls, and Farner, 1967), and the Ruby-crowned Kinglet (*Regulus calendula;* Leberman, 1970). No rates have been determined for migrants in the western United States. However, evidence is presented in this paper to support the hypothesis that the skull pneumatization technique is reliable for some western passerines during fall migration. Since many of the common western migrants cannot be aged by plumage characters, it seems necessary to establish some reliability for this technique before discussing such topics as age composition at inland versus coastal stations and differential migration of young and adults.

Estimations of the degree of skull pneumatization were made from 15 August to 31 October 1969-1971 at Point Reyes Bird Observatory, Marin County, California, and at Mono Lake, Mono County, California from 27 August to 27 September 1970. Birds were captured in mist nets and aged by the skulling technique described by Miller (1946) and Norris (1961). Individuals were then banded and released.

A system for estimating pneumatization rates has been established at Point Reyes Bird Observatory (C. J. Ralph, unpublished data). Ralph's system used a "0" for no pneumatization of the skull; "1" for a skull that was 1/3 pneumatized, "2" for a skull 2/3 pneumatized, and "3" for a skull fully pneumatized. In 1969 I modified this classification to record the patterns of pneumatization noted in common western migrants (Figure 1). The "0" and "3" categories remained as in the old system. The "1" was used to represent a triangle of pneumatization at the base of the skull. Number "2" represented a skull that had *discrete* unpneumatized "windows" on either side of pneumatization adjacent to the median line. A "1+" (recorded by the number 4 on capture records) designated pneumatization between "1" and "2". At one extreme this category represented more than a triangle of pneumatization at the base of the skull, and at the other extreme it differed from a "2" skull by the *lack of separate* left and right "windows" (see "1+" diagram in Figure 1). In addition, I used the "1+" designation when there was a very thin median line that separated very large lateral

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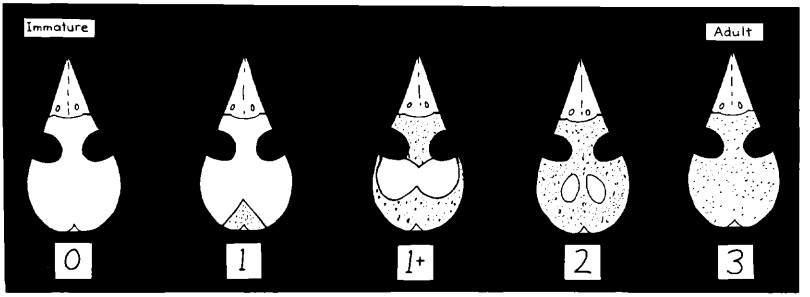

FIGURE 1. Scheme for estimation of skull pneumatization in western passerines.

"windows." To facilitate the analysis for this paper all "1+" skulls were lumped into the "1" skull category. The general method used was to estimate the degree of skull pneumatization in individual birds, combine these data for each species into successive 15-day periods, and compare the successive periods.

At least three interpretations of pneumatization data are possible, assuming a steady rate of pneumatization from "0" to "3." (1) If complete pneumatization occurs during fall migration in *a large proportion* of the young of a species, one would expect many more "2" than "0" and "1" skulls. In addition, a continuous increase in number of "3" and a continuous decrease in "1" and "2" skulls would be expected as the season progressed. (2) If, during fall migration, complete pneumatization occurs in *relatively few or none* of the young of a species, one would expect a high proportion of "0", "1", and "3" skulls and relatively few "2" skulls. Young birds would not have progressed to the "2" stage and individuals with a "3" skull would be adults. (3) If, during fall migration, the number of individuals with "2" skulls increases as the season progresses, but there is no continuous increase in proportion of individuals with "3" skulls, the species probably has a slow pneumatization rate. Thus there would be few individuals developing from stage "2" to "3" during the migration period.

Leberman (1970) reported that in the eastern race of the Ruby-crowned Kinglet full pneumatization occurs by October. I assume that the western races have similar rates because there is a high number of individuals with "3" skulls at PRBO in early October, increasing in late October (Table 1). There is a corresponding decrease in "0", "1", and "2" skulls. Given our present knowledge of the pneumatization rates in this species, and the high ratio of incompletely pneumatized individuals to completely pneumatized individuals in essentially all species captured at PRBO (Ralph, 1971; Stewart and Mewaldt, in preparation), the pneumatization data from Ruby-crowned Kinglets are best explained by interpretation number 1. I suggest that by October most young Ruby-crowned Kinglets have reached complete pneumatization. Thus this species cannot be reliably aged by using this technique during fall migration in central California.

TABLE 1. Estimation of skull pneumatization in Ruby-crowned Kinglet in October of 1969 and 1970 at PRBO

degree of pneumatization	per cent of total	
	1-15 Oct. N = 60	16-31 Oct. n = 43
0	1.5	0.0
1	4.5	0.0
2	17.0	7.0
3	77.0	93.0

At PRBO and Mono Lake a large proportion of "0" and "1" skulls were observed in the Swainson's Thrush (*Hylocichla ustulata*), Warbling Vireo (*Vireo gilvus*), and Wilson's Warbler (*Wilsonia pusilla*) (Table 2). At both stations the paucity of individuals with "2" skulls is significant. Similarly, in the Yellow Warbler (*Dendroica petechia*) at Mono Lake essentially no birds were observed with "2" skulls. The paucity of "2" skulls suggests that the number of young birds attaining "3" skulls through 30 September is very small or negligible. These data fit interpretation 2. The Yellow Warbler at PRBO shows an increase of "2" and "3" skulls with time, suggesting that some young birds might complete pneumatization before 30 September. However, the number of "2" skulls is low compared to the combined number in the "0" and "1" categories. Thus most young birds probably are still in early pneumatization development during September. I suggest that by estimating pneumatization, individuals of Swainson's Thrush, Warbling Vireo, Yellow Warbler, and Wilson's Warbler can be reliably aged during fall migration at least through 30 September.

In the Hermit Thrush (*Hylocichla guttata*), Golden-crowned Sparrow (*Zonotrichia atricapilla*), and Fox Sparrow (*Passerella iliaca*) there is a slight increase in "2" skulls but no continuous increase in "3" skulls with time (Table 3). In all three species there was an increase of "3" skulls from the period 16-30 September to the period 1-15 October. That the per cent of "3" skulls *decreased* for the following period, 16-31 October, suggests that there is no large number of young birds developing "3" skulls as was suggested in Ruby-crowned Kinglet. Therefore, I suggest that these species appear to fit interpretation 3 and thus probably have slow rates of pneumatization. In one species of *Zonotrichia*, the White-throated Sparrow (*Zonotrichia albicollis*), a slow rate of pneumatization has been reported (Mellencamp, 1969).

TABLE 2. Estimation of skull pneumatization for some common migrants.

species	degree of pneumatization	per cent of total PRBO 1969-1971 16-31 Aug.	1-15 Sept.	16-30 Sept.	Mono Lake 1970 1-15 Sept.	16-30 Sept.
		n = 61	n = 123	n = 54		
	0	47.5	52.8	27.8		
Swainson's	1	50.8	41.5	57.4		
Thrush	2	0.0	2.4	3.7		
	3	1.7	3.3	11.1		
		n = 38	n = 165	n = 43		
	0	44.7	3.6	11.6		
Warbling	1	50.0	89.7	81.5		
Vireo	2	0.0	2.4	6.9		
	3	5.3	4.3	0.0		
		n = 16	n = 62	n = 26	n = 52	n = 12
	0	12.5	0.0	7.6	9.6	0.0
Yellow	1	81.3	77.4	46.2	53.8	91.6
Warbler	2	0.0	9.7	19.2	1.9	0.0
	3	6.2	12.9	27.0	34.7	8.4
		n = 64	n = 55	n = 13	n = 26	n = 7
	0	31.3	23.6	15.4	7.6	0.0
Wilson's	1	59.4	71.0	84.6	57.7	42.8
Warbler	2	1.6	1.8	0.0	3.9	0.0
	3	7.8	3.6	0.0	30.8	57.2

TABLE 3. Estimation of skull pneumatization for three wintering species at PRBO, 1969-1971.

species	degree of pneumatization	per cent of total 16-30 Sept.	1-15 Oct.	16-31 Oct.
		n = 38	n = 287	n = 163
	0	52.6	18.4	14.7
Hermit Thrush	1	36.8	56.9	54.6
	2	8.0	12.2	18.4
	3	2.6	12.5	12.3
		n = 69	n = 130	n = 66
	0	7.2	1.5	0.0
Golden-crowned Sparrow	1	58.0	36.9	56.0
	2	23.2	28.5	36.4
	3	11.6	33.1	7.6
		n = 50	n = 54	n = 52
	0	2.0	1.8	0.0
Fox Sparrow	1	50.0	38.9	34.6
	2	26.0	27.8	45.2
	3	22.0	31.5	19.2

My interpretations for all species reported here are of course tentative and documentation of the rates of pneumatization in individual birds of these species is desirable.

CONCLUSIONS

Criteria for comparing the degree of skull pneumatization in passerines were developed at Point Reyes Bird Observatory. These criteria are reliable for determining the age of several but not all species of western passerines during fall migration. The criteria can be used at least through September to age Swainson's Thrush, Warbling Vireo, Yellow Warbler, and Wilson's Warbler. Most individuals of the Hermit Thrush, Golden-crowned Sparrow, and Fox Sparrow can be aged through October. Data on western Ruby-crowned Kinglets support Leberman's observations on age and

degree of pneumatization for eastern individuals. In this species, pneumatization proceeds so rapidly that age cannot be reliably determined for most individuals by this method by October.

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