TIMING OF COMPLETION OF SKULL PNEUMATIZATION IN THE PINE SISKIN

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The unusually early and heavy 1975 fall flight of Pine Siskins (*Carduelis pinus*) at my home banding station in Schenectady, N.Y. presented an opportunity to measure the progress of completion of skull pneumatization in this species. This study was undertaken to determine the usefulness of skull examination as a means of determining age in this species in fall and winter.

At the time of capture and banding, the birds' skulls were moistened with water and examined through the skin by unaided eye to determine whether pneumatization was complete or incomplete. Six birds were designated "unknown" because they were in sufficiently heavy molt on the crown so that the exact condition of the skull could not be determined. These were exluded from the analysis. The data were grouped into time periods of monthly thirds and are given in Table 1.

The birds appeared on 8 November and increased in number thereafter. By late December they were declining and continued to do so as they either dispersed locally or abandoned the area to move farther south. In late January an even greater invasion of Common Redpolls (*Carduelis flammea*) began. During the peak of the redpoll activity, siskins declined sharply in number with only a very few new birds and some previously banded birds frequenting the feeders.

The data from Table 1 were plotted in Figure 1 to examine the agreement of three different treatments of the data as indicated in the figure headings. In all cases the percentage of birds with incomplete pneumatization was plotted against time (banding period). All three regression lines agree reasonably well in predicting that pneumatization will be complete by late February or early March. The 95-percent confidence limit (± 2 SD) extends the completion dates to early March in Figures 1B and 1C, and to late March in Figure 1A. From among the small sample of birds caught after early February, the latest capture date for a SIP (skull incompletely pneumatized) bird was 5 March, in agreement with the predicted time of completion.

Wood (1969) recommends using skull examination into September to distinguish adult from immature birds in this species. The data presented here suggest that the period of usefulness of skull examination extends into mid-November. Beyond November a sufficient number of immature birds complete pneumatization and cannot be distinguished from adults using this criterion.

Evidence to support this hypothesis relies on an examination of the November data per se, and on the collective agreement of some related factors. The following arguments were considered to determine whether November represents the onset of completion of pneumatization in immatures, or whether complete pneumatization might have occurred earlier.

TABLE 1

Completion of skull pneumatization in the Pine Siskin

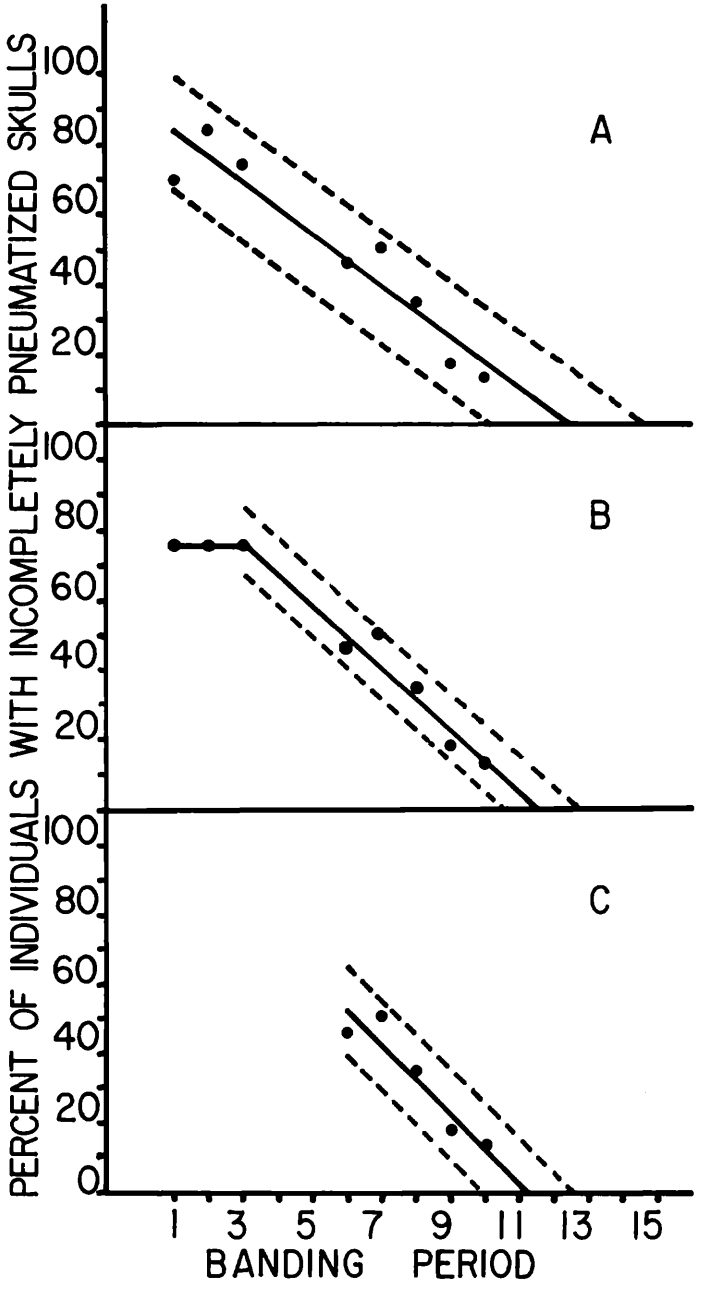
Banding period	Period designation[1]	Number banded SCP[2]	SIP[3]	Unknown	Total SCP and SIP	Percent SIP
1-10 Nov.	1	8	18	0	26	69.2
11-20 Nov.	2	11	57	0	68	83.8
21-30 Nov.	3	72	213	5	285	74.7
21-31 Dec.	6[4]	68	60	1	128	46.9
1-10 Jan.	7	43	44	0	87	50.5
11-20 Jan.	8	67	36	0	103	35.0
21-31 Jan.	9	36	8	0	44	18.2
1-10 Feb.	10	47	7	0	54	13.0
11-20 Feb.	11	0	0	0	0	—
21-28 Feb.	12	6	0	0	6	—
1-10 Mar.	13	4	1	0	5	—
11-20 Mar.	14	3	0	0	3	—
21-31 Mar.	15	7	0	0	7	—

[1]See text and use in Figures 1A-C.
[2]SCP = Skull completely pneumatized.
[3]SIP = Skull incompletely pneumatized.
[4]No banding was done during Periods 4 and 5 due to my absence from the station.

(A) Figures 1B and 1C were compared to determine the extent of agreement of the observed November age ratio with that predicted by other-than-November data. In Figure 1C, the regression line is based only on data gathered in the period December through February. When the regression line in that figure is extrapolated back to Period 3 (21-30 November), it predicts a value of 82.5 percent SIP birds. This percentage of birds with incomplete pneumatization is in agreement with the observed November average from Figure 1B of 76.0 $\pm$ 9.4 percent.

(B) The apparent age ratio based on the observed November average (76.0 percent immature) of 3.2 immatures per adult is in agreement with what one would expect shortly after the breeding season. Although no data are available on actual Pine Siskin breeding success with which to compare it, it was compared to the age ratios of two related northern fringillids and was found to

FIGURE 1. Timing of completion of skull pneumatization in Pine Siskins. The solid line is the regression line and the dotted lines are $\pm$2SD. A. All data points were used to give Immature Percentage(IP) = 90.9 - 7.30 (Banding Period, BP), SD = $\pm$8.59. IP = 0 at Period 12.5. B. All November data combined to give a weighted average which with the other data points gave IP = 105.1 $-$ 9.10 (BP), SD = $\pm$4.68. IP = 0 at Period 11.6. C. November data excluded to give IP = 112.8 $-$ 10.1(BP), SD = $\pm$6.63. IP = 0 at Period 11.3.


PERCENT OF INDIVIDUALS WITH INCOMPLETELY PNEUMATIZED SKULLS
100
80
60
40
20
0
A
B
C
1 3 5 7 9 11 13 15
BANDING PERIOD

compare favorably. From a sample of 382 migrant Dark-eyed Juncos (*Junco hyemalis*) captured at this same station during the period of September through November for the years 1964 through 1976, 75.4 percent were immature. From a similar sample of 787 White-throated Sparrows (*Zonotrichia albicollis*) caught between 1964 and 1974, 76.4 percent were immature. Neither of these species is known to undergo early pneumatization, thereby making skull examination an accurate indication of their age during the period mentioned.

(C) The first case of complete pneumatization in an immature siskin was detected on 16 November, and then twice on 29 November, after which completion became common. This initial occurrence was determined by examining molt data on the birds captured in November (Yunick, 1976). On these dates, siskins had completely pneumatized skulls and the last traces of what logically appeared to be the first prebasic (postjuvenal) molt. Since these birds represented only one percent of the 288 recognizable immatures (SIP) caught for the entire month, they indicated a very low level of completion at this time. All other siskins in molt in November were recognized as immatures by the condition of their skulls, except for the two birds that were adults as indicated by flight feather molt and complete pneumatization.

(D) Based on my experience with the handling of thousands of Ruby-crowned (*Regulus calendula*) and Golden-crowned kinglets (*R. satrapa*) in September and October, and on the report that the former undergoes early pneumatization (Leberman, 1970), it has been possible to become familiar with the condition of the skulls of many birds that are finalizing the pneumatization process. One becomes familiar with the various stages of progress, and with the nearly final condition where only small windows, representing only five to 10 percent of the exposed area of the top of the skull remains unpneumatized. One also becomes familiar, in the handling of 100 to 400 of these birds on a flight day, with the presence of birds of all degrees of pneumatization completion. By casual observation one develops a "feel" for the onset, the peaking, and the completion of this process.

Applying this experience to these siskins, I found that none of the conditions associated with completion of pneumatization began to appear until very late November. Much variation existed in the extent of pneumatization among the captures of early and mid-November. A few birds had completed only about 25 percent pneumatization of the exposed top of the skull, whereas most others had completed more. However, no birds showed the nearly final stages in which only five to 10 percent remained unpneumatized. These birds did not begin to appear in noticeable numbers until late in November, and then they became noticeably more frequent in December. In these birds that did begin to approach completion of pneumatization, the last small "windows" were behind the eye and slightly toward the median line.

(E) The wide variation in extent of pneumatization in individual siskins in November is ascribed to the species' variable breeding

schedule (Yunick, 1976). Birds from early broods would be expected to show advanced pneumatization whereas later broods would have birds with delayed pneumatization. The period of time between the beginning and completion of the pneumatization process agrees closely with the span of extreme egg dates reported in the literature. Using the 95% limits in Figure 1B, complete pneumatization is projected to occur between 11 November and 10 March (125 days). Forbush (1929) and Bull (1974) give egg dates for New York of 18 March to 20 July (124 days). The earliest evidence of an immature with a fully pneumatized skull on 16 November, and the last occurrence of an immature with an incompletely pneumatized skull on 5 March are consistent with the dates in Figure 1B.

The collective concurrence of all of these factors supports the belief that no significant number of Pine Siskins completed skull pneumatization before mid-November, and that Figure 1B depicts the timing of the onset and completion of the skull pneumatization process. Thus, it is recommended that banders use skull examination as a means of distinguishing adult from immature Pine Siskins from August to mid-November. From mid-November to mid-March the method may be used to identify immatures only. Beyond mid-March this examination would be useless in this species. From the time of fledging to prior to the first prebasic molt (typically May through July), the immatures are readily distinguishable by their juvenal plumage. During molt in August through November, the adults are recognized by the presence of flight feather molt. Once the prebasic molt is complete in adults and immatures beginning in August or September, one could then resort to skull examination again.

LITERATURE CITED

BULL, J. 1974. Birds of New York State. Garden City, Doubleday/Natural History Press.

FORBUSH, E. H. 1929. Birds of Massachusetts and Other New England States. Norwood, Mass., Norwood Press.

LEBERMAN, R. C. 1970. Pattern and timing of skull pneumatization in the Ruby-crowned Kinglet. *Bird-Banding*, **41**: 121-4.

WOOD, M. 1969. A Bird-Bander's Guide to Determination of Age and Sex of Selected Species. University Park, Pa., State Univ.

YUNICK, R. P. 1976. Delayed molt in the Pine Siskin. *Bird-Banding*, **47**: 306-9.

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