

PATTERN AND RATE OF CRANIAL 'OSSIFICATION' IN THE HOUSE SPARROW

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Determination of skull condition has been long accepted as a method of distinguishing immature from adult passerine birds. Chapin (1946: 35-37), for example, described this method, suggesting that various groups of birds should be studied in order to test its reliability. Davis (1947) attempted to correlate bursa and gonadal development with the ossification of the skull. Miller (1946) described a method of aging live birds, based on skull changes. Although commonly referred to as "ossification," the changes which occur involve the formation of a double layer of bone separated by small bony columns. In his description of this process of cranial development, Miller stated (*loc. cit.*, p. 33): "The skull of a passerine bird when it leaves the nest is made up of a single layer of bone in the area overlying 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." Miller and others suggest that this condition is attained progressively, from posterior to anterior. Harrison and Harrison (1949), who have dealt with this subject in close detail, refer to the developmental process as "pneumatisation." The reader should consult their important paper for further aspects of this problem. The present paper describes the pattern and rate of cranial development in one species—the House Sparrow, *Passer domesticus*.

METHODS AND RESULTS

Specimens of known age were obtained through the recovery of banded young. A total of 346 nestling sparrows, aged according to wing and bill characters as described by Weaver (1942: 183-187), were banded at Madison, Dane County, Wisconsin, between May and August, 1949. Of these, 51, or nearly 15 percent, were recovered as fledged immatures of various ages during the period May,

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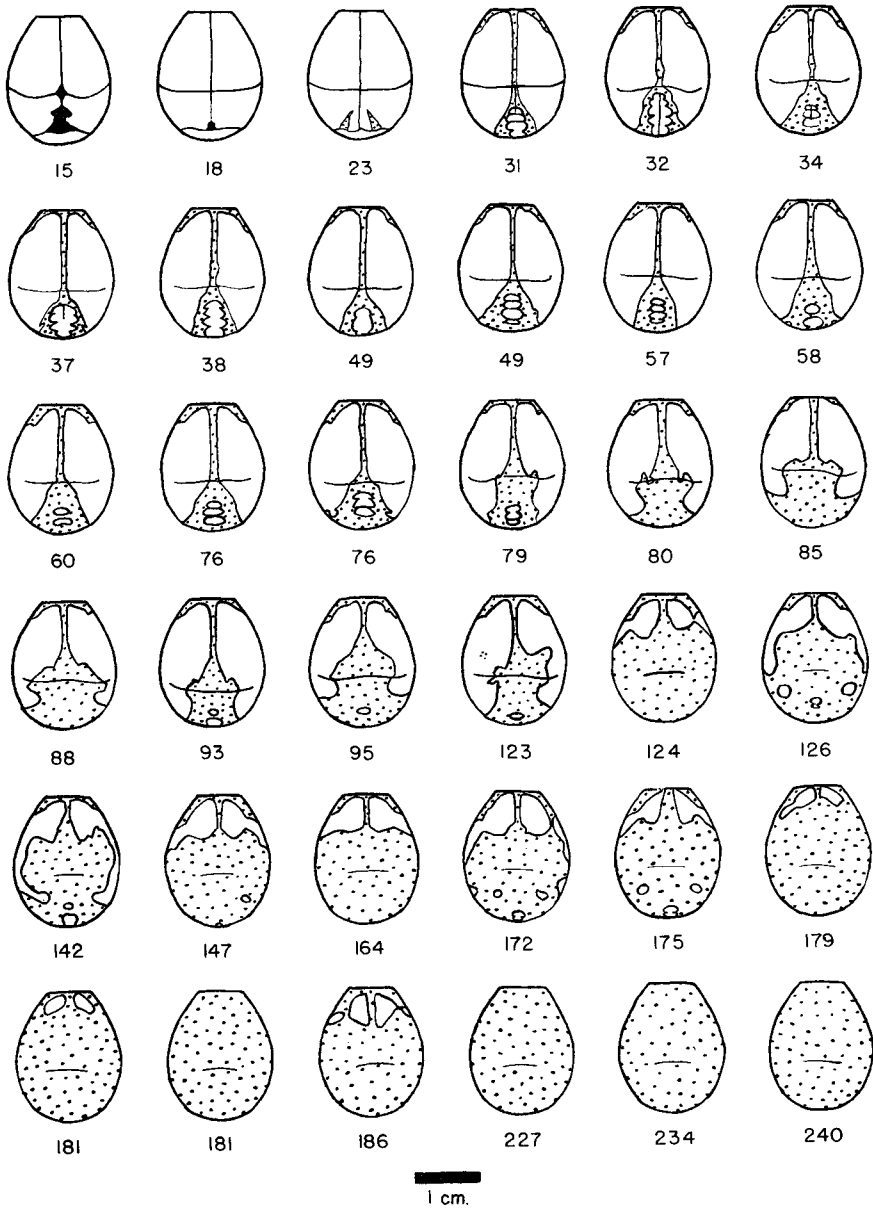


FIG. 1. Dorsal view, crania of 36 wild House Sparrows showing ossification pattern. Numbers under drawings indicate age in days.

1949, to March, 1950. Over 1600 sparrows were killed in recovering these banded birds. The methods of collecting included trapping, shooting into daytime flocks and night tree roosts, and capturing by hand and shooting in night barn roosts. The majority of recoveries were taken from night barn roosts at, or near, the point at which they had been banded. One bird, however, was recovered at a distance of four miles.

The skull-ossification patterns of 36 representative birds from this series are graphically represented in Figure 1. These drawings show a series of dorsal views of the cranium, the frontal border of each skull being toward the top of the figure. Frontal sections were obtained by cutting along a line extending from just dorsal to the foramen magnum to a point dorsal to the orbits. The drawings were projected from accurate linear measurements, giving a relative picture with some distortion towards the borders. The number beneath each drawing indicates the age in days of the particular specimen. The solid areas in the first two drawings in the top row indicate connective tissue; the clear areas, a single layer of bone; and the speckled areas, the double-layered bone. The fine lines indicate sutures.

These sections show that formation of the double layer of bone begins in the posterior parietal and exoccipital regions about 23 days after hatching, and appears in the median suture between the frontals shortly thereafter. Up to about 80 days it is confined largely to lateral extension of the area posterior to the frontoparietal suture. After this age, growth proceeds in a somewhat arm-like fashion from the posterior third of each frontal bone towards the antero-lateral corners, resulting in near-division of the frontals into four, and finally two, clear areas. These latter anterior areas are the last to become double-layered. When the cranial roof is completely double-layered, the bird is considered an adult, at least so far as cranial criteria are concerned. These clear areas may disappear as early as 181 days after hatching or may persist to 221 days, the latter figure being derived from a skull which is not illustrated here. Note that the pattern of ossification is generally symmetrical. In some cases where it is not, as in the skull of 123 days, there is a peculiar hardening (indicated as stippling outside of the circumscribed stippled area) of the single layer of bone, suggesting an injury, which seems to have interfered with the normal progress of development in the area. According to Harrison and Harrison (*loc. cit.*, p. 64) "the whole process is considerably slowed down and even stopped by any serious disease that the particular bird may be suffering from."

The area of double-layering of each of these skull sections has been measured from the drawings by means of a planimeter. The percentage of ossification as calculated on this basis yielded the data shown in Figure 2. In this graph the percentage of the opaque area (stippled) is computed against the age in days, each dot on the curve representing one of the drawings in Figure 1. This curve shows that the thickening of the cranium of the House Sparrow progresses at

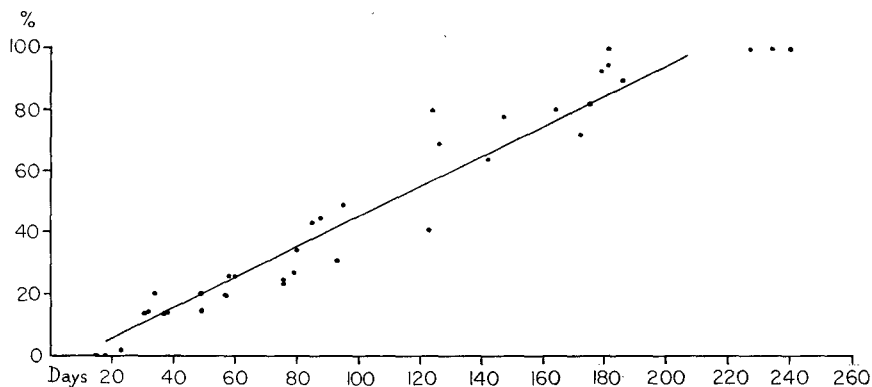


FIG. 2. Curve showing relationship of percentage of cranial ossification to age in days in the House Sparrow.

a fairly constant rate.

In the early stages of this study it was decided to raise young sparrows in cages, killing them at such times as to obtain a series of birds of known age, the supposition being that it would be difficult to recover sufficient banded nestlings. Figure 3 shows the skulls of 12 of these birds. These show consider-

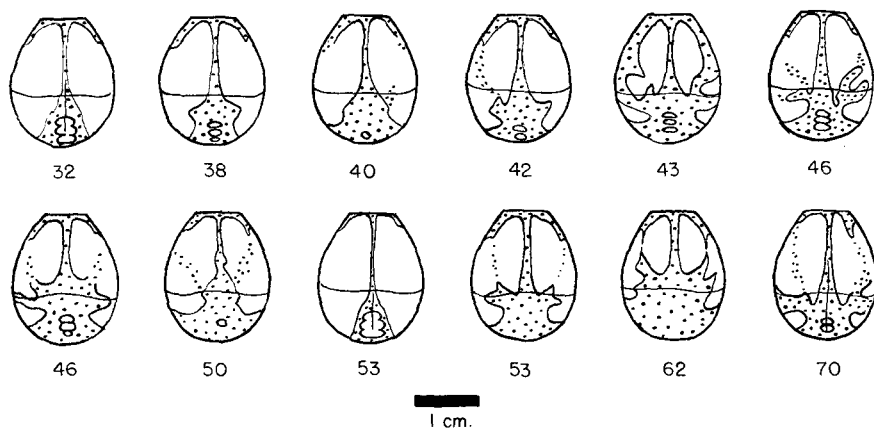


FIG. 3. Dorsal view, crania of 12 hand-reared House Sparrows showing ossification pattern. Numbers under drawings indicate age in days.

ably more variation in pattern and rate of development than those taken from the field. These irregularities may possibly be attributed to an abnormal diet, to an excess of head injuries as a result of caging, or to both. Irregular hardening of the single bone layer, as described above in the 123-day-old bird, is evident in seven specimens.

SUMMARY

1. Fifty-one House Sparrows of known age were obtained through the recovery of banded nestlings. The ages of these birds ranged from 15 to 240 days.
2. The crania of these specimens showed a progressive and symmetrical growth pattern.
3. Complete ossification had been attained in one specimen 181 days old, but another specimen 221 days old still showed small clear areas.
4. Skull sections from 12 birds reared in captivity show more variability and a less symmetrical pattern than do those of wild birds. There is also more abnormal bone formation, due, perhaps, to injury from caging and to artificial diet.

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