

TEMPERATURE AND GROWTH STUDIES ON THE
BARN SWALLOW.

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FOR THE past several years the writer has conducted a series of observations and banding studies on the Bank Swallow (*Riparia r. riparia*) in the Lake Okoboji region, northwestern Iowa and in the Albany and Oneida Lake regions, New York State. Although these investigations have not been terminated, they have reached a stage where similar inquiries may be profitably undertaken with some closely related species. In so doing interesting comparisons can be made and deductions based on newly discovered items of coincidence or antithesis can be drawn.

Since the Barn Swallow (*Hirundo erythrogaster*) is second only to the Bank Swallow in point of numbers in most parts of New York State, it was chosen as the first subject of our comparative investigations. As with the Bank Swallow these inquiries were concerned with the general activities and nesting habits of the bird. Attention also was given to certain detailed phenomena of its life history and biology with emphasis on matters relating to body temperature and rate of growth.

The present discussion is confined principally to a consideration of young Barn Swallows from the time they hatch until they are ready to leave the nest. The material which serves as the foundation of this account was obtained in the summer of 1934 from the Barn Swallows occupying an old and little used barn located on a small farm near Voorheesville, New York about 13 miles southwest of Albany. A small creek is nearby and a paved highway lies 30 feet from the structure.

Our studies began soon after the Swallows arrived at the barn, about May 1, and continued through July. During this period regular visits to the nesting site were made on Mondays, Wednesdays and Fridays at approximately the same time of day. Thus our records were obtained on alternate days except from Friday to Monday when two days intervened between visits. Mrs. Stoner assisted in collecting the data.

At the time of our first visit several formerly occupied mud domiciles were still attached to the joists 9 to 10 feet above the earth floor of the building. Several pairs of Swallows evidently had nested in this limited space of about 18 by 24 feet during previous seasons so that, within certain limits, this nesting could be termed "colonial." This feature also characterized the 1934 nesting here.

All domiciles constructed in former seasons were numbered and new nests, as rapidly as construction started, also were similarly designated. In this way reference to them could easily be made. The time of deposition

and hatching of the eggs was noted. Since we did not always visit a given nest on the day that the young hatched it was sometimes necessary to estimate the age of the birds in hours. Our previous experience with hundreds of young Bank Swallows was of value in this connection.

With the hatching of each brood, temperature, weight and growth records were begun and continued regularly as above noted. All the young were marked as soon as hatched or shortly thereafter. This was accomplished temporarily through the use of colored strings tied about the neck or tarsus of the nestling. When the birds were five to eight days old, the numbered metal bands furnished by the U. S. Biological Survey were substituted for the strings.

Each time, on arriving at the nesting colony, the domiciles were examined as speedily as possible and the temperatures of all the young birds taken within a few minutes. Numbered columns and designated space for the records and various kinds of data desired were prepared in advance so that no time was lost on the ground. The temperature readings were made with a very sensitive, specially designed, non-self-registering mercury thermometer graduated in two-tenth degree divisions in the Fahrenheit scale. This instrument has an over-all length of 153 mm.; the stem is roundly triangular in cross-section, its greatest diameter 4.5 mm. The bulb is 12 mm. long by 1.5 mm. in diameter. All readings were taken by the interthoracic method. Only a few seconds were required for the registration of each bird's temperature.

As rapidly as the temperatures were taken the nestlings were placed in a small box divided into numbered, cotton-lined compartments. The birds thus could be readily identified for the weighing, measuring and other observations that were to come later.

The weights were taken on a triple beam balance sensitive to one-tenth gram. This balance was installed in a specially designed case to prevent deflection of the beams by any slight breeze. A spirit level attached to the floor of the case aided in promptly adjusting the instrument for use.

Measurements were made with dividers on a steel rule graduated in the metric scale to one-half millimeter divisions.

At first the records for the young occupying each of seven nests were kept separate. All but one of the nest records were complete or nearly complete. Thirty-four different nestlings furnished the data here discussed. Practically complete records were obtained on 26 of these birds while partial records were had from eight others. Of this, latter group the records for two nestlings enter into the picture only once.

Upon completion of the season's work the birds reared in the seven nests were grouped according to age but without regard for family relationship and the information on their temperatures, weights and measurements

arranged in statistical form. In some instances 24 hours or a little more elapsed between the time of hatching of the first and last egg in a nest. As a result of this grouping it was possible to work out a composite arrangement of data based on the precise age of the 34 nestlings. This material serves as the basis for the following considerations.

Weight.—At the time of hatching or within two to four hours thereafter, the weights of young Barn Swallows varied from 1.5 grams to 1.9 grams. The average weight of 31 individuals varying in age from one to 24 hours was 2.39 grams with a minimum weight of 1.5 grams and a maximum of 3.5 grams.

In this connection it may be of interest to note that the 18 Barn Swallow eggs which were weighed averaged 1.9 grams with a maximum of 2.1 grams and a minimum of 1.4 grams. Incidentally, too, the lightest and smallest egg (second clutch) proved to be fertile.

Increase of weight of young was most rapid between the 4th and 10th days. For 18 birds 10 days old the average weight was about 19.5 grams. However, maximum weight (average about 21 grams) was not attained until the 12th day. Thereafter the weight gradually diminished until the time of leaving the nest when it averaged about 17.5 grams. The average weight of the three adult brooding and incubating females captured between June 13 and July 20 was 19.63 grams.

It thus appears that, as in the case of the Bank Swallow, the weight of young Barn Swallows at the time of first leaving the nest averages somewhat less than that of adult birds. However, young individuals attain their maximum weight about a week before attempting initial flight.

Temperature.—Many uncontrollable factors are associated with the mechanics of obtaining bird temperatures by the methods employed in our work. In addition, probably other unsuspected factors have a bearing upon our findings. Therefore, some difficulty is involved in properly evaluating the data. However, the results here reported are well in line with those obtained by other investigators working on other species of birds so that it is believed our records closely reflect the actual circumstances.

For 31 young Barn Swallows varying in age from 1 to 24 hours and all brooded by the adult immediately preceding the taking of the readings, the average temperature was 97.45° Fahr. The minimum reading was 92.0 degrees, the maximum 101.6 degrees. Increase in temperature was most rapid during the first ten days of nest life but the rate of increase was more rapid during the first five days of life than during the succeeding five-day period. The average for 10 five-day old birds was 103.71 degrees while for 18 10-day old individuals it was 105.58 degrees. Readings on 15 17-day old birds gave an average of 107.9 degrees which is about 0.5 degree higher than that of the average for the three adult females whose temperatures were recorded as 107.1, 108.4 and 106.8 degrees, respectively.

Tarsus.—For 16 nestlings varying in age from 1 to 12 hours the average tarsal length was 3.15 mm. For 15 birds varying in age from 13 to 24 hours the average tarsal length was 3.9 mm., while for the entire 31 nestlings falling in the 1- to 24-hour age group the tarsus averaged 3.51 mm. in length.

In 17 young, varying in age from 121 to 145 hours, the average tarsal length was 8.44 mm. with a maximum of 9.50 mm. and a minimum of 7.50 mm. Rate of tarsal growth was most rapid during the first six days of nest life; it diminished markedly between the 6th and 10th days. Maximum length was attained on the 11th to 12th days.

Ulna.—Measurements of the ulna were made as a part of the attempt to record the comparative rate of growth of the various skeletal structures. For seven nestlings varying in age from 1 to 4 hours the average ulnar length was 5.0 mm. with a maximum of 5.5 mm. and a minimum of 4.0 mm. The rate of increase in length was greatest during the first 10 days of nest life, averaging about 2.4 mm. a day. By the 12th day full growth had been acquired, the ulnar length then ranging from 24.0 to 26.0 mm. with an average of 25.35 mm.

Of the two adult females on which this measurement was taken one had an ulnar length of 24.0 mm., the other 24.5 mm.

It will be noted that in the young, ulnar growth is completed or nearly completed at about the same time as the tarsus attains full length. This synchronization of growth in bony structures apparently extends to other parts but our records on this point are not yet sufficiently complete to warrant a definite statement.

Outer Primary.—In some individuals the outer primary first appeared as early as the 4th day. For 10 nestlings five days old the average length of the follicle was 1.3 mm. During the succeeding five days the outer primary in 18 birds attained an average length of 21.66 mm.

The daily growth rate of the outer primary varied considerably. It showed only slight tendency toward uniformity at the same age period not only among the members of a given brood but also among non-related individuals of a specific age group. For example, of a family of five nestlings, individual A might have the longest outer primary one day but 2 or 4 days later individual C or D might rank first in this respect. The greatest difference recorded on any occasion among the several young of any one family was 17 mm. for birds 11 to 12 days old while the greatest difference among the individuals of a given age group but not of the same brood was 16 mm. at 12 and 15 days, respectively.

The actual rate of increase in length of outer primary averaged a little more than 4 mm. a day. For 18 nestlings 15 days old, the average length of the outer primary was 46.11 mm. while the average daily rate of feather

growth between the 10th and 15th days amounted to 4.89 mm. This was the highest growth rate of primary recorded.

Notwithstanding the limited number of records for young in the older age groups, the measurements indicate that the average rate of outer primary growth for birds from 15 to 20 days old also is maintained at more than 4 mm. per diem.

Although the actual *daily* growth rate of the outer primary was not measured on any individual nestling, the growth rate of this structure for a large number of *two-day* periods is available. These records show that the minimum increase in primary length for that time interval was 1.0 mm. for one individual between the 4th and 6th days of its nest life while the maximum two-day increase of 21.5 mm. occurred in another individual of a different family between the 10th and 12th days of its nest life. Other minimum two-day increases in length of outer primary ranged from 1.5 mm. to 3.0 mm. while maximum increases ranged from 12 to 18 mm.

At the time of first flight—17 to 18 days—the outer primary averages about 56 mm. in length; our records show a minimum length at this age of 50.0 mm. and a maximum of 62.0 mm. In the few 20-day old birds that we measured the outer primary averaged 67.6 mm.

The length of the outer primary on the single adult female from which such a measurement is available was 114.5 mm.

In one nestling the vanes of the outer primary emerged from the sheath on the 8th day; in all other individuals the vanes first appeared on the 9th day. While the length of the vane extending beyond the tip of the sheath was subject to considerable variation among birds of a given age group, in general, it increased progressively with the growth of the feather. For example, the average length of the vane beyond the sheath in 10-day old birds was 5.11 mm., in 15-day birds 29.94 mm., and in 17-day individuals 41.86 mm.

Outer Tail-feather.—In a few individuals the outer tail-feathers became evident as early as the 3rd day but in only three nestlings were they as much as 1 mm. in length at four days. However, for 10 5-day old birds the average length was 1.2 mm. During the succeeding five days the outer tail-feather in 18 birds attained an average length of 13.69 mm. And for 18 nestlings 15 days old the average length of the outer tail-feather was 31.41 mm.

In two adult females which were captured the outer tail-feather measured 75.0 mm. and 85.0 mm., respectively.

It will be observed that the outer tail-feather increases in length at a somewhat slower rate than the outer primary averaging only 2.40 mm. per diem for nestlings from the 5th to 10th day after hatching and 3.54 mm. for birds 10 to 15 days old.

Middle Tail-feather.—Only one nestling out of the 21 3-day old birds that were examined showed any trace of the outer tail-feather. However, all 5-day old birds showed development of this feather but its average length in individuals of this age was only 0.95 mm. At six days the average length was 2.11 mm., at 10 days 11.69 mm. and at 15 days 27.52 mm.

Although the outer and middle tail-feathers appeared at about the same time, from the beginning, the rate of growth of the latter lagged a little. This lag was accentuated as the birds grew older with the result that in 17-day young the average difference in length of these two feathers was 5 mm.; at 20 days it had increased to almost 9 mm.

As in the case of the primaries the webs of the rectrices emerged on the 9th day but the rate of emergence thereafter was slower and more irregular than for the webs of the primaries.

In the two adult females available for this measurement the length of the middle tail-feather was 43.0 mm. and 46.5 mm., respectively.

On each of the 19 visits to the barn where these Swallows were reared the air temperature in the building at the level of the domiciles was taken. The lowest temperature recorded here was 70.0° Fahr., the highest 85.5 degrees; average 76.9 degrees.

It was a matter of some speculation and interest as to what influence, if any, a consistently higher air temperature might have on the rate of growth of the young. A limited amount of information on this point was supplied by a family of young occupying a domicile—"Nest 13"—attached to a rafter just beneath a tin roof in a building adjacent to the barn. The lowest air temperature recorded at this nest on any of our eight visits while it contained young was 73.5° Fahr., the highest 97.0 degrees; average 91.5 degrees.

The records of the young reared in Nest 13 are not included in the growth and temperature statistics considered above.

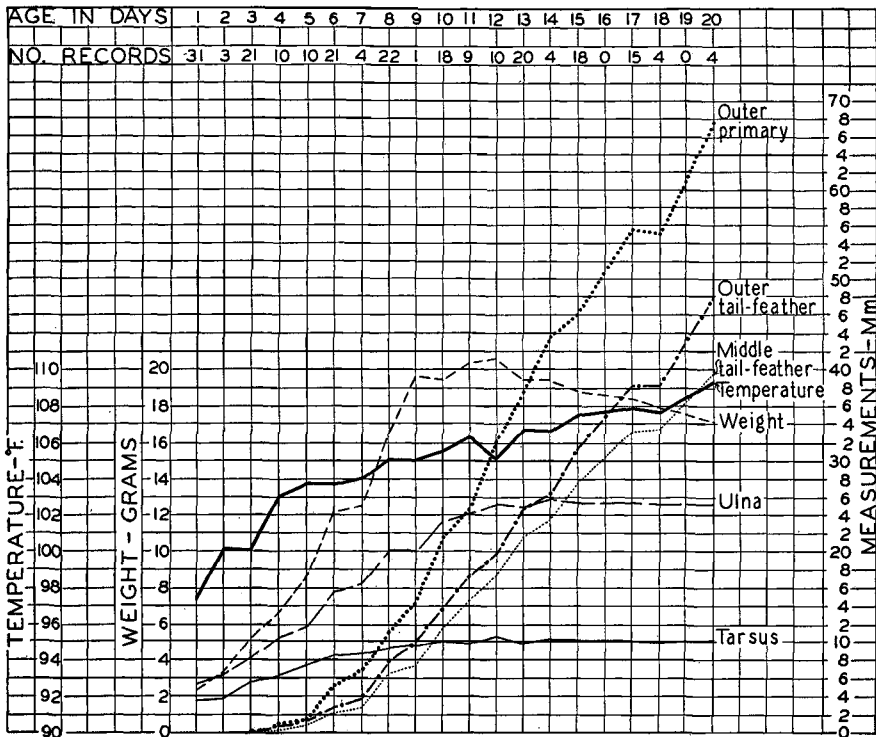
As might be expected, in poikilothermic animals, the average body temperature of nestling Barn Swallows of a given age, up to about 17 days, that were subjected to these higher air temperatures was consistently higher than for nestlings of the same age in domiciles surrounded by lower air temperatures. For example, the average temperature for the young in Nest 13 when they were two days old was 102.15 degrees, at six days 107.42 degrees, at 16 days 109.53 and at 18 days 106.93 degrees.

In the matter of weight the nestlings living under higher temperature conditions consistently averaged lighter than nestlings of the same age in the other nests. This discrepancy varied from 0.4 gram at two days to 4.3 grams at nine days and 4.27 grams at 11 days. Although the young in Nest 13 never attained an average weight of more than 17.76 grams, as the time for leaving the nest approached, their weights declined just as in the birds reared in the other nests.

The rate of growth of the bony structures of the young in Nest 13 was a trifle slower than the average for nestlings reared in the barn. However, maximum size was attained in all birds at the same age period.

Rate of feather growth, as indicated by primaries and rectrices, averaged just a little less among the individuals of Nest 13 than among the young reared in the nests subjected to uniformly lower air temperatures.

The conclusion is reached, therefore, that consistently high air temperature of the surroundings in which young Barn Swallows are reared is reflected in the higher body temperature of the nestlings subjected to it. However, this higher air temperature in no way appears to affect the metabolic activities of the birds by accelerating or stimulating increase in body weight or rate of growth of bony or feather structures. On the contrary, air temperatures that appear to be excessively high affect young Barn Swallows unfavorably, retarding slightly the rate of increase in weight as well as bone and feather growth.



Mean daily rate of increase in temperature, weight and growth of young Barn Swallows occupying seven nests from hatching to time that flight ability was attained. Albany, N. Y., June-July, 1934.

SUMMARY.

In young Barn Swallows increase in temperature is most rapid during the first five days of nestling life; the rate of increase subsides markedly thereafter while the bulk—weight and size—continues at its former or even at a somewhat accelerated rate during the succeeding 5 or 6 days.

The temperature control mechanism apparently becomes established at about the 9th to 10th day when the body temperature of the nestling ceases to respond markedly to fluctuations in air temperature.

Temperature control becomes fairly well established and body weight and measurements approach the maximum before the primary flight feathers acquire their maximum rate of growth. This slowing down of the general growth rate suggests that the bodily metabolism has become fairly well adjusted by the time the rapidly developing feathers begin to call upon the vitality of the young bird. From an evolutionary standpoint this also may indicate the relatively recent acquisition of feathers by the avian class.

Bony growth, as indicated by measurements of ulna and tarsus, is most rapid during the first 9 to 10 days of nestling life. By this time adult or near-adult size of these structures has been attained.

Growth of primaries and rectrices is most marked after the fourth day of nestling life and subsequent to the initial rapid ascent in the temperature curve. While the latter begins to flatten out at about nine days, development of these feathers proceeds as before or even at a somewhat accelerated rate.

The outer primary increases in length more rapidly than the outer tail-feather while the latter in turn grows faster than the inner tail-feather. At the time the bird first leaves the nest the outer rectrix averages about 5 mm. longer than the inner; in birds 20 days after hatching this difference has increased to about 9 mm.

Such rapid growth of these and other contour feathers demands a great amount of energy and vitality. When the situation is analyzed there is little wonder that the weight, temperature and growth curves for other body structures than feathers tend to flatten out while the feather-growth curves rise rapidly (Fig. 1). After the other body structures have developed the metabolism of the bird is, for a time, almost wholly directed toward the production of feathers.

Body and feather growth in young Barn Swallows appear to be affected adversely when the birds are reared in domiciles subjected to excessive heat.

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