

TEMPERATURE AND GROWTH STUDIES OF THE
NORTHERN CLIFF SWALLOW

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THIS study of the Northern Cliff Swallow, *Petrochelidon pyrrhonota albifrons* (Rafinesque), is one of a series of investigations which the writer has conducted on the Barn Swallow (The Auk, 52: 400-407, 1935), the Bank Swallow (Roosevelt Wildlife Annals, 4: 122-233, 1936) and the Eastern Phoebe (New York State Museum Circular, 22: 1-42, 1939) in an attempt to compare certain features of the life history, body temperature and growth rate of the young. It is believed that such a comparison will furnish some interesting and worthwhile contributions to our knowledge of the biology of these birds as well as provide a better understanding of the taxonomic relationships and differences exhibited by them. For comparative purposes, temperature and measurement data on a few adult individuals also are introduced. The method of presentation of results is similar to that employed for the Barn Swallow in a past number of this journal (*loc. cit.*).

Preliminary observations on the weight and temperature of Northern Cliff Swallows were initiated in the Oneida Lake (New York) region in 1931. However, the major part of the studies here reported upon have been confined chiefly to three Cliff Swallow colonies all within a radius of twenty miles of Albany, beginning about June 1 and continuing through July and early August of the seasons 1934 to 1938, inclusive. The largest colony comprised 66 domiciles. Regular visits were paid to these nesting colonies thrice weekly. Thus our records were obtained on alternate days save for one two-day interval each week. Mrs. Stoner assisted in collecting the data.

On the occasion of our first seasonal visit to each colony, the domiciles were counted and numbered and the number of eggs in each nest was recorded. At subsequent visits, newly constructed domiciles, if any, were marked and the condition of affairs in those previously examined was ascertained. Owing to the fact that the eggs in some nests hatched between visits it was necessary to *estimate* the age of these small birds in hours. Previous experience with hundreds of young Bank and Barn Swallows provided satisfactory criteria on this point.

With the hatching of a brood, temperature, weight and growth records for each nestling were begun and continued to the time it left the parental domicile. Included in these were seven different measurements of body structures and ten of feathers. The young were first marked with colored threads tied about the tarsus. Later,

the numbered metal bands furnished by the U. S. Fish and Wildlife Service were substituted for the threads.

Within a few minutes after our arrival at a nesting colony the domiciles and their contents had been examined while the temperatures of the young birds were taken immediately upon their removal from the nest. Previously prepared equipment and record blanks facilitated this procedure and permitted procurement of the data with a minimum of disturbance to the activities of the colony, some of which might be reflected in our findings. As rapidly as the birds' temperatures were obtained, the nestlings were transferred to a box divided into small, numbered, cotton-lined compartments there to await further observations.

Temperature readings were taken with an extremely sensitive, specially designed, non-self-registering mercury thermometer graduated to two-tenth-degree divisions in the Fahrenheit scale. The instrument was quickly inserted down the throat, well into the gullet of the subject, whereupon the reading was almost immediately indicated.

Weight readings were obtained with a triple-beam balance sensitive to one-tenth gram. After the birds had attained some size, a small metal box was used to confine them on the scale platform. Measurements were made with dividers on a steel rule graduated in one-half-millimeter divisions.

In all measurements involving feathers, the "length" here means the distance between the tip of the feather and the point at which the shaft emerges from the skin. The "distance beyond sheath" is the distance between the feather tip and the distal end of the enveloping sheath. In the humeral, ulnar and certain other bony measurements, the skin and at least a small amount of other tissue of course intervened between the parts and the divider points. On this account the measurements cited are slightly in excess of the actual measurements of the bones themselves.

Incorporated in this report are the records from 83 young Northern Cliff Swallows, the inhabitants of 35 different nests. In the field, the records were kept separate for the individuals occupying each nest. Later on these birds were grouped according to age in days and without regard for family relationship. On this basis the information relating to temperatures, weights and measurements was tabulated. In some cases the hatching time of a clutch of eggs extended over a period of more than 24 hours. This necessitated the placing of the nestlings into two age groups, one or more falling in the 1- to 24-hour group, the others falling in the 24- to 48-hour group. Indeed, in a few

instances, more than 48 hours were required in which to complete the hatching of a single egg-clutch. From this grouping resulted a composite series of data based on the age—either estimated or known to within a few hours or less—of the 83 nestlings.

Complete or nearly complete records were obtained on about 60 per cent of the young on which we began taking records; approximately 20 per cent provided but a single series of records while a similar proportion provided from two to seven. A series of eight or nine sets of readings on a single family of young was the maximum number that we could expect to obtain in relation to the intervals elapsing between observations.

Since the same number of individuals was not always available for all the measurements indicated in the accompanying graph, the number of individuals concerned in the compilation of the various structures represented by the curves is omitted. In most cases of key measurements for certain age groups, the number of individuals concerned is indicated in the text.

Weight.—At the time of hatching or within two to six hours thereafter, the weights of young Northern Cliff Swallows varied from 1.6 to 2.2 grams. For 18 individuals varying in age from one to 24 hours, the average weight was 2.6 grams with a minimum of 1.6 grams and a maximum of 3.6 grams.

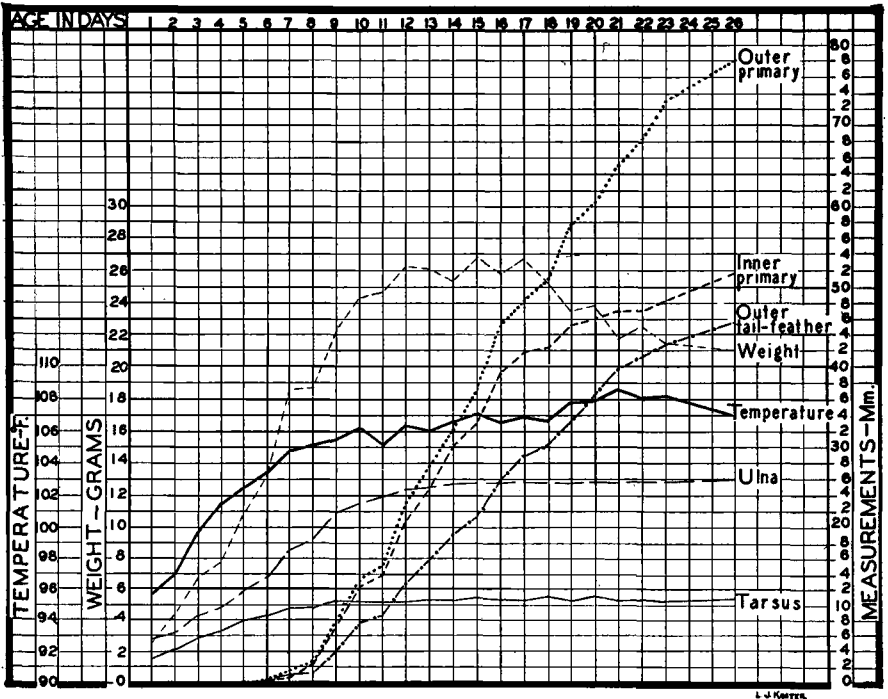
By way of comparison, it may be noted that the average weight of 52 eggs from 15 clutches was 1.97 grams with a minimum of 1.4 grams and a maximum of 2.4 grams, one egg for each extreme. Thirty-two of the eggs fell in the 2.0- to 2.4-gram group, 18 in the 1.6- to 1.9-gram group.

Weight increase in the young was most rapid between the 4th and 10th days; the average rate of increase, 2.36 grams a day, was greater than for any other like period of time. For seven birds ten days old, the average weight was 24.3 grams; maximum weight, average about 26.3 grams, was attained on the 12th day. This average held until the 17th day, then gradually diminished until, at the time of leaving the nest—23 to 26 days—the birds averaged about 21.5 grams.

Among the nestlings studied, only five individuals attained a weight of as much as 30 grams. The heaviest bird weighed 2.2 grams at age 6 to 8 hours, 30.2 grams at age 12 days, 32.8 grams at 14 days and 33.2 grams at 17 days. However, at age 21 days the weight of this individual had dropped to 21.0 grams, truly a remarkable decrease for a nestling that appeared to be in a normal and healthy condition.

The average weight of three incubating or brooding adults was 23.83 grams; maximum 25.6, minimum 21.1 grams.

Temperature.—The difficulty of obtaining accurate temperature records of birds by means of even a very sensitive mercury thermometer and of properly appraising the findings are well apparent to the writer. However, the results obtained in this investigation closely approximate those reported upon by the writer for allied species of this family and compare favorably with the results of



TEXT-FIGURE 1.—Mean daily rate of increase in temperature, weight and growth of 83 young Northern Cliff Swallows from hatching to the time that flight ability was attained. Albany, N. Y., seasons of 1934–1938, inclusive.

workers who have used more refined methods with other species of birds. So, it is believed that our records represent with reasonable fidelity the actual conditions.

For nine young Cliff Swallows varying in age from one to 24 hours and brooded by the adult immediately before the readings were taken, the average temperature was 95.55° F.; minimum reading 88.4 degrees, maximum 100.0 degrees. As in the case of the Barn Swallow, increase in temperature was most rapid during the first ten days of nest life, with the greatest rise occurring in the first five-day period.

The average for eleven five-day-old birds was 102.45 degrees; for the same number of 10-day-old nestlings it was 106.14 degrees. At age 20 days, the average for 19 nestlings was 107.87 degrees. Average temperatures for nestlings increased slightly to age 23 days, but for two young 26 days old the average was only 107.10 degrees while for two adults it was 109.5 degrees. Undoubtedly this discrepancy in results was due in part to circumstances incident to the capture of these temperamental birds as well as, in part, to the instability of the temperature-control mechanism and the consequent extraordinary rapidity with which this condition is registered with the instrument and technique employed.

Attempt was made to obtain the comparative growth rate of the bony endoskeleton through measurements of the tarsus, ulna and humerus.

Tarsus.—At the time of hatching, the average tarsal length is 3.0 mm. For 18 nestlings varying in age from six to 24 hours, the average tarsal length was 3.19 mm. Average tarsal length for twelve 5-day-old birds was 7.91 mm. with a minimum of 7.0 mm. and a maximum of 9.0 mm. Near-maximum length, 11.0 mm., was attained at age 12 to 13 days with highest growth rate occurring during the first six days of nest life. Our figures indicate that tarsal growth rate in the Cliff Swallow slightly exceeds that in the Barn Swallow.

Average tarsal length for three adults was 11.0 mm. with a minimum of 10.0 mm. and a maximum of 12.5 mm.

Ulna.—For four nestlings varying in age from six to eight hours, the average ulnar length was 5.1 mm. Rate of increase in length was greatest during the first ten days of nest life, averaging about 1.76 mm. a day. However, a small but steady amount of growth continued for the succeeding seven or eight days. Average ulnar length for 14 nestlings in the 18-day-old age group was 25.78 mm. Some fluctuations in the average length also occurred after the 18th day with an exhibited tendency toward further slight increase in length.

The average ulnar length for three adult individuals was 26.16 mm.

Humerus.—For the four 6- to 8-hour nestlings mentioned above in the discussion on ulnar growth, the average humeral length was 4.5 mm. During the first five days these two bones grew at approximately the same rate although, even at this early stage, the ulnar growth rate slightly exceeded the rate for the humerus. However, during the 6th to 12th days the growth rate of the ulna increased to slightly more than double that of the humerus. As in the case of the ulna, increase in humeral length was greatest during the first ten days of post-natal life averaging about 1.03 mm. a day. At age 18 days, the average

humeral length for 14 nestlings was 16.85 mm. Thereafter, the composite age-groups exhibited a little fluctuation for humeral length with a slight tendency to increase in length of the member.

Average humeral length for three adults was 17.50 mm.

Outer primary.—One of the chief differences between the Barn Swallow and the Northern Cliff Swallow is the comparatively retarded growth rate of the principal flight feathers in the latter species. Undoubtedly this is correlated in part with its protracted period of nestling life which averages two to five days longer than that of the Barn Swallow.

In most nestling Cliff Swallows, the outer primary becomes evident as a minute rounded point on the fourth day and in a few instances even as early as the third day. For 12 nestlings five days old, the average length of this feather was only 0.13 mm., more than 1.25 mm. less than for young Barn Swallows of this age. And, for seven 10-day-old Cliff Swallows the average length of the outer primary was only 9.08 mm. as compared with 21.66 for the Barn Swallow. For 17 Cliff Swallows at age 15 days, average outer primary length was 37.29 mm. (46.11 mm. for the Barn Swallow); at age 18 days, 14 Cliff Swallows exhibited an average length of 51.07 mm. for the outer primary (56.0 mm. in the Barn Swallow) and at age 20 days, the average length of the outer primary in 19 Cliff Swallows was 60.63 mm. (67.6 mm. in the Barn Swallow). At the time of first flight—20 to 21 days—the outer primary averages 60 to 65 mm. in length. For seven 23-day-old Cliff Swallows the outer primary averaged 73.06 mm. in length while at 26 days the average length of this feather for three individuals was 78.16 mm.

For three adult Cliff Swallows, the average length of the outer primary was 86.0 mm., maximum 93.0 mm., minimum 81.0 mm. (Barn Swallow 114.5 mm.).

As in the Barn Swallow, the daily growth rate of the outer primary in the Cliff Swallow varied somewhat among nestlings; but neither among the members of a given brood nor in our age groupings, irrespective of family relationships, did the discrepancy in length of the feather often exceed 10 mm. From the time of first measurable appearance of this flight feather—in most individuals on the 4th day of nest life, to age 21 days, the average age at first flight—the daily growth rate of this feather averaged 3.6 mm., approximately 0.4 millimeter less per diem than in the Barn Swallow. During the 10th to 15th days, the average daily growth rate of this feather amounted to 4.81 mm., a rate almost as high as in the Barn Swallow. For the nestlings falling in the 15- to 20-day age group the growth rate decelerated somewhat, averaging for the period 4.26 mm. per diem.

It will be noted, therefore, that at the time of initial flight, the outer primaries of both the Barn and Cliff Swallows are about the same length but that in the latter species three more days have been required to permit the ability of protracted flight. Furthermore, in the Barn Swallow, at first flight, the outer primary has attained only about one-half its adult length while in young Cliff Swallows with this ability it has acquired approximately three-fourths of its adult length. This may be associated with the heavier body, actually shorter primary feathers, more rounded wing and consequent less buoyant flight of the latter.

As in the Barn Swallow, the vane of the outer primary in the Cliff Swallow seldom breaks through the sheath before the 9th day. And, as in that swallow, the length of the feather beyond the sheath varied considerably among the members of a given age group as well as among the members of a family; indeed, a difference of several millimeters often prevails in the exposed portion of like feathers of opposite wings of some nestlings. A similar circumstance frequently prevailed in the other flight feathers measured. Undoubtedly, the rate at which the vane is released from the sheath is dependent to a considerable degree upon the extent of nest activities and exercises. The average length of vane beyond the sheath was 2.71 mm., in 10-day birds (5.11 mm. in Barn Swallow); 18.47 mm. in 15-day birds (29.94 mm. in Barn Swallow), 30.60 mm. in 17-day nestlings (41.86 mm. in Barn Swallow) and 45.13 mm. in 20-day Cliff Swallows (54.0 mm. in Barn Swallow).

Inner primary.—Although this feather appeared externally as early as the outer primary, it did not attain the length of that feather nor grow as rapidly. Until the 15th day of nest life, the growth rates of these two feathers were practically the same. But from the 15th day, deceleration in growth of the inner primary occurred and the disparity in length between the two feathers gradually became more obvious. For the 15- to 20-day age period, the average growth rate of this feather was 2.6 mm. per diem (4.26 mm. for outer primary).

As in the Barn Swallow, both inner and outer primaries in most nestlings began to emerge from the feather sheaths on the 9th day. And, although the rate of emergence of the vanes of these feathers varied considerably in different individuals, in the Cliff Swallow it was consistently lower than in the Barn Swallow.

Other wing feathers.—It is interesting to note that the coverts of both outer and inner primaries appear externally at about the same time—the 8th day. However, between the 8th and 28th days, the inner primary covert increased at an average daily rate of 1.60 mm.

(length 24.08 mm.) while average daily growth rate of the outer primary covert for this period was only 1.02 mm. (length 15.33 mm.). In other words, the covert of the more rapidly growing outer primary increased in length at a considerably slower rate than did the covert of the much shorter and less rapidly growing inner primary.

Outer tail feathers.—In a few nestlings the outer tail feathers appeared as early as the second or third day, but in only one bird were they as much as 1 mm. in length at six days. Indeed, the average length of this feather for 16 7-day-old birds was only 1.05 mm. For seven 10-day birds the outer tail feather averaged 7.57 mm. (Barn Swallow 13.69); for 17 nestlings 15 days old, the average length of the outer tail feather was 21.20 mm. (Barn Swallow 31.41) while for 18 birds at 20 days it averaged 36.30 mm., 12 mm. less than in Barn Swallows of the same age group. During the following six days the average growth rate of this feather declined to about 1.5 mm. per diem, the length at age 26 days being 45.66 mm.

For three adult individuals captured in their domiciles the average length of the outer tail feather was 50.83 mm.

Middle tail feathers.—This pair of feathers appears at the same time as the outer tail feathers—2nd to 3rd day of nest life—but, from the beginning the growth rate is *slightly* though consistently less than for the outer tail feathers. At age seven days, the average length of the middle tail feather was 0.58 mm. During subsequent nestling life the maximum discrepancy in length between outer and middle tail feathers averaged just a little more than 1 mm. in the several age groups. Of course this discrepancy gradually became more pronounced in the Barn Swallow. In 10-day Cliff Swallows the average length of the middle tail feather was 6.14 mm. (Barn Swallow 11.69); in 15-day birds 20.97 mm. (Barn Swallow 27.52), and for 18 20-day individuals 35.27 mm. (Barn Swallow 39.30). At age 26 days, the average length of the middle tail feather for three birds was 44.16 mm.

The average length of the middle tail feather for three adult Cliff Swallows was 44.33 mm.

SUMMARY AND CONCLUSIONS

This report considers weight, temperature and growth data obtained near Albany, New York, from 83 nestling and three adult Northern Cliff Swallows. The results of the study are compared with those obtained in a similar investigation on the Barn Swallow which were published in this journal (52: 399–406, 1935).

The Northern Cliff Swallow is characterized by a more nervous and unstable temperament than its phlegmatic relative, the Barn Swallow.

This instability of temperament is illustrated in the irregular occurrence and disappearance of the species in a given locality and probably accounts for the frequent reports of its local reduction in numbers or its absence from certain sections. It is further indicated by the Cliff Swallow's ready response to immediately disturbing factors which interrupt the ordinary routine associated with incubation of the eggs as well as brooding and care of the young. Hasty and irregular feedings frequently result in considerable disparity in size and irregularity in the growth of the nestlings of a family. Such irregularities are particularly evident among nestlings in the lower age groups. However, these discrepancies in size and feather growth among the members of a family early in life tend to disappear later on as the rapidly growing feathers conserve bodily heat and render metabolic activities more uniform.

In general, the average increase in temperature, weight and growth of most structures indicated on any given day for most of the age groups is "normal" and about what the experienced investigator might expect to find. However, it sometimes happens that one or more of the average measurements for such an age group may be a little *below* or *above* the normal while most of the measurements are in line with those for both the immediately preceding and immediately succeeding days. Usually this discrepancy levels out in the immediately succeeding age group.

For example, in the records presented for 12-day-old birds, the average measurements for humerus and hind toe with claw as well as width of bill at gape are apparently a little less than they should be while tarsal length and width of bill at nostril are fractionally greater than one might expect. On the other hand, the average length for all the feathers measured is somewhat in excess of expectations.

I believe that while this situation may be due in part to the human failure in obtaining refined accuracy of the measurements and to lack of adequate records, it also is a reflection of the unstable temperament of the Cliff Swallow.

In young Cliff Swallows the most rapid increase in body temperature extends over the first seven to eight days of nest life (five to six days in the Barn Swallow). During the succeeding five to six days, bulk—as indicated by weight and size—continues at or near its earlier rate of increase. Near-adult measurements and weight are acquired at the 12th to 13th days of nestling life (9th to 10th days in the Barn Swallow).

This study serves to illustrate the fact that feathers of a lower order of specialization and position attain full growth earlier than those

feathers which are more highly specialized from the standpoint of position and adaptability with relation to flight. However, the growth rate of these specialized feathers is considerably accelerated as compared with the general body feathers; that is, they attain a proportionately greater length in a relatively shorter space of time than do the body feathers.

Growth of the principal flight feathers is most marked in the Cliff Swallow after the sixth day (fourth day in the Barn Swallow) of nest life. This accelerated rate of feather growth continues well through the 21st day.

From about the 21st day until near-maximum primary growth is attained, five or six days later, the feather sheath breaks away at approximately the same rate as the feather grows; during this latter period, however, an evident deceleration occurs in the growth rate of these feathers.

Bony growth as indicated by measurements of ulna, humerus and tarsus is most rapid during the first ten to eleven days of nestling life when near-adult size of these structures has been attained. Thus 24 to 48 hours more are required by the Cliff Swallow to reach this condition than were recorded for the Barn Swallow.

The most notable imbalance between feather growth and bony growth and among feathers themselves occurs between the 11th and 14th days (see feather growth 11th day *vs.* 12th day). These instabilities appear to be concomitant with the establishment of temperature control.

The nesting sites of the Northern Cliff Swallows mentioned in this report were visited by us thrice weekly during a large part of the summer. During each visit the temperature, weight and 17 different measurements of each of several nestlings was obtained. Despite these disturbances of the birds' activities, little permanent interruption of routine procedures was apparent. Occasionally, in removing the young birds from the domiciles, the openings thereto were broken. But upon our departure from the scene the adults usually began immediately to repair the damage so that long before the time of our next visit the necessary reconstruction had been effected.

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