

ON THE BODY TEMPERATURES OF NESTLING  
ALTRICIAL BIRDS.

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THE study of body temperatures of birds, with the exception of the comprehensive investigation of Wetmore,<sup>1</sup> has only been sparingly considered by ornithologists. Bergtold<sup>2</sup> has studied the influence of body temperature on the incubation periods of birds and finds that the length of incubation is determined by the temperature of the incubating parent. Simpson and Galbraith<sup>3</sup> secured records of the body temperatures of a limited number of birds at three hour intervals for a week which demonstrated the existence of a diurnal rhythm. Other references are found scattered in the literature, largely in journals and books of physiology. Records of temperatures of nestling birds, however, are conspicuous by their absence in most of these sources.

Many of the observations on birds have been secured from freshly killed specimens. The major portion of Wetmore's results were obtained in this manner. This gives reliable results but is only a cross section of the thermic life of the bird and gives only a limited conception of the fluctuations that take place in it as a living reacting organism. An excellent opportunity is presented, in the case of nestling birds, however, for securing a continuous series of observations. As a result a composite picture can be made of the alternations undergone by the body temperatures in young birds and of the factors that influence them.

The present paper is based on over 450 observations of body temperatures. These are scattered among twenty-four species of nestling altricial birds in all stages of development.

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<sup>1</sup> Wetmore, Alexander. *A Study of the Body Temperature of Birds.* Smithsonian Miscellaneous Collections, Vol. 72, No. 12, Washington, Dec. 1921, pp. 1-52.

<sup>2</sup> Bergtold, W. H. *A Study of the Incubation Periods of Birds.* Denver, 1917, pp. 1-109.

<sup>3</sup> Simpson, S., and Galbraith, J. J. *An Investigation into the Diurnal Variation of the Body Temperature of Nocturnal and Other Birds, and a few Mammals.* Journ. of Phys., Vol. XXXIII, 1905, pp. 225-238.

## METHOD OF OBTAINING TEMPERATURES.

All temperatures are rectal. A small bulb clinical thermometer, lubricated with petrolatum, was used and inserted gently well into the bowel and maintained there until the mercury ceased to rise. This can be done with little fear of injury even in recently hatched birds. The young bird frequently defecates at this time and relaxes the bowel for the necessary manipulation. Temperatures should be taken at once in the nest since removing the young for even short periods of time causes a marked fall of temperature. This is well illustrated in the case of two young Mourning Doves (*Zenaidura macroura carolinensis*) about eight and nine days old that were taken from the nest at 7:40 P.M. July 20, 1926 and temperature readings recorded every five minutes thereafter for thirty-five minutes. There was a gradual and continuous fall throughout this period. The larger bird gave an initial reading of 106.0 followed at five minute intervals by 104.7, 103.5, 103.2, 102.7, 101.2, and 101.0. The smaller registered, in the same length of time, 105.1, 104.2, 104.1, 103.7, 103.1, 102.4, and 102.9. The temperature of the surrounding air remained practically constant at 97 during this time.

All birds were banded at the first observation, or if too small, were marked for identification and banded when larger. In this manner the exact identity of each individual was known and the fluctuations in its temperature followed with accuracy.

## FACTORS THAT INFLUENCE BODY TEMPERATURES.

*Age.* In altricial young this is a very important factor which can readily be substantiated by abundant observations. Other things being equal the younger the bird the lower will be its temperature. With advancing age the temperature rises, becomes more constant and less subject to violent fluctuations in response to external influences. Part of this no doubt is due to the development of contour feathers but some at least must be attributed to a stabilization of the thermogenic mechanism.

A number of examples among the recorded cases are of interest and instructive in this regard. The temperatures of one hundred and five nestling Doves were studied. One hundred and one of these nestlings were banded. Since young Doves offer practically

no resistance to handling, temperature changes caused by struggling can be eliminated. The influence of age is thus more readily ascertained in this species. The general statement is true, practically without exception in this series, as reference to appended tables shows, that under uniform conditions younger birds show lower temperatures than do more fully developed fledglings.

July 5 at 5:30 P.M. a two day old Dove (*Zenaidura macroura carolinensis* No. 437960) registered 103.2 while its three day old nest mate (No. 437961) was 103.9. On July 10 at 4:00 P.M. the first bird had increased to 104.9 and the latter 106.1. This accession in temperature occurred in spite of the fact that this day and hour was twelve degrees cooler than the earlier date. On July 14 at 5:30 P.M. the temperature of the first bird had again increased and was now 107.4 although this day was twenty two degrees cooler than July 5.

A nestling Dove (No. 437972) four days old on July 16 at 8:00 P.M. registered 102.1 (85°). Temperatures in brackets indicate the state of the surrounding air. July 20 at 7:40 P.M. it was 105.1 (98°). July 22 when about ten days old it was 106.8 (82°) at 8:00 P.M. On July 24 at 7:30 P.M. after it had left the nest it registered 107.9 (92°).

A five day old Dove (No. 437973) on July 16 at 8:00 P.M. registered 103.2 (85°). July 20 at 8:00 P.M. it had increased to 105.9 (97°), July 22 at 8:00 P.M. it was 106.1 (82°) and on July 24, 7:30 P.M. when able to fly it was 107.8 (92°).

Two Doves (Nos. 441928 and 441929) when about five and four days old respectively on July 20 at 7:30 P.M. (98°) registered 104.6, 104.5. July 22 at 7:30 P.M. (83°) they were 105.3 and 104.8. July 24 at 1:30 P.M. (89°) they had increased to 106.7 and 106.4 although in the evening of that date the younger one had made an unexpected recession to 103.7. July 26 at 8:00 P.M. a still further increase was recorded at 107.2 and 106.9 while the outside air was 87°. On July 27 at 7:30 P.M. (91°) the highest reading of all was attained at 107.6 and 109.1. The latter bird struggled a little which no doubt accounts for the unusually high temperature.

A Dove five days old (352399) and its nest mate four days old (No. 352400) registered 103.0 and 100.7 respectively on August 4 at 6:30 A.M. (66°). The next day at 6:30 A.M. (71°) they were

104.4 and 103.5. The day following this at 7:00 A.M. (77°) there was an unaccountable drop in the temperatures which were 103.6 and 103.3 respectively. On August 8 at 7:00 A.M. (66°) they registered 105.4 and 105.2. On August 10 at 6:30 A.M. (83°) the temperatures had risen still further and were 105.5 and 106.5 respectively. Note that these are all morning records.

A Dove three days old (No. 352403) registered 98.6 and its nest mate two days old (No. 352404) 93.9 on August 4 at 6:30 A.M. (66°). At 8:00 P.M. the same date (95°) they were 103.3 and 101.7. August 5 at 8:00 P.M. (100°) they were 103.4 and 104.5. August 7 at 8:00 P.M. they were 103.6 and 102.5 while the surrounding air was 84. August 8 at 8:00 P.M. (101°) they were 104.4 and 105.8. August 9 at 3:00 P.M. (100°+) they were 107.2 and 107.1. On the afternoon of the next day a sudden cool shower soaked the young and this was reflected by a sudden drop in the body temperatures to 103.0 and 100.7. Records on these two nestlings were made three times a day for a week and an interesting and instructive chart of the alternations undergone in the body temperatures was obtained.

A young Turkey Buzzard (*Cathartes aura septentrionalis*) early in its development attained the temperature normal to the species; the range covered was not great being a rise of only slightly over two degrees. Thus when five days old it registered 101.2. At one week of age it was 102.5 and at two weeks of age it had risen to and above the normal for the species. Thereafter there was a remarkable constancy of temperature at about 103.6 except when influenced by other factors shortly to be mentioned. The Buzzard therefore apparently stabilizes its temperature long before the appearance of feathers and while the general development of the body is still very immature.

Two young Great Horned Owls (*Bubo virginianus virginianus*) were studied during their stay in the nest. There was a gradual rise in the body temperatures during this entire time. This was true regardless of the time of day at which the observations were made or the state of the surrounding atmosphere, as reference to appended tables demonstrate. On April 19 when sixteen days old the smaller Owl had a temperature of 102.2. When twenty-three days old it was 103.8. This rose to 104.0 at the age of thirty-two

days; 104.2 at thirty-six days of age and two days after leaving the nest was 105.0 when the young Owl was about forty-four days old. On April 20 the larger Owl when twenty-one days of age registered 102.6. This was 103.8 at twenty-seven days of age and 104.8 when thirty-six days old. Thereafter, although it was ten days longer in the nest, no records could be obtained on this youngster as it invariably gravely and sedately vacated the nest on my approach and walked far out of reach on the smaller limbs. These temperatures are somewhat higher than the mean given by Wetmore for this species. They, however, represent resting temperatures in every instance except in the case of the smaller Owl when out of the nest (105.0) when a slight degree of resistance was made to the examination.

Flickers (*Colaptes auratus luteus*) seem to form a rather curious exception among the birds that I have studied. A number of naked young were followed for nearly two weeks as feathers developed. There was no indication of a rise in temperature during this time. The first temperatures recorded were as high as any subsequently found and the final observation at the time of leaving the nest showed a body temperature in these birds far below that normal to the species as reported by Wetmore.<sup>1</sup> It is not known when the final temperature is attained. Very small Flickers were not found but an observation on a young Red-bellied Woodpecker seems to show that the temperature is very low at first and is then rather quickly stabilized at a higher level but one which is, nevertheless, considerably below the mean for the species. When a few days old, naked and quite small, the Red-bellied Woodpecker (*Centurus carolinus*) registered 98.4. Five days later when it had developed in size it had increased to 102.8. The significance of these findings in the case of Woodpeckers is not known. It is an interesting speculation as to whether or not there is any correlation between these observations and the rearing of the young in protected nests such as in hollow trees.

Kingbirds furnish another example of increasing body temperatures coincident with advancing development. On June 30 at 6:30 A.M. four young Kingbirds (*Tyrannus tyrannus*) were found. They were about five days old and were almost naked save for a few tufts of white down. They registered 102.9, 103.6, 102.5, and

the smallest was 101.5. On July 5 at 8:30 A.M. when contour feathers had begun to develop they showed an increase to 106.6, 107.5, 106.7, and the smallest 104.5. The temperature of the two days was practically identical at these hours. On July 10 all had left the nest except the smallest which registered 105.5.

Phoebes (*Sayornis phoebe*) also show an increasing body temperature with advancing age. On June 23 at 3:00 P.M. five fledglings, four to six days old were examined. Their temperatures were 102.2, 100.1, 101.4, 96.8, and 102.7. The lowest reading was found in the smallest bird of the lot which appeared considerably younger than the others of the family and which was visibly chilled when removed from the nest. Two days later, noon June 25, these youngsters registered 105.4, 105.5, 104.4, 103.1, and 106.4 respectively. Contour feathers were just beginning to develop on this date. The temperature of the day was practically the same as on the former date.

The temperature of very young birds is apparently remarkably low. Thus two freshly hatched Blue Jays (*Cyanocitta cristata*) gave readings of only 95.8 and 96.0 on June 29 at 8:00 P.M. in spite of the fact that the surrounding air registered slightly over 100 at this hour. On the appearance of feathers much higher temperatures are found. As an instance a nestful of young Blue Jays that were out in contour feathers and nearly ready to leave the nest June 19 at 4:30 P.M. (67°) registered 105.0, 106.0, 105.8, and 106.0. These readings while high are still two to three degrees lower than the temperature of adult Jays.

A young Catbird (*Dumetella carolinensis*) when six days old, June 16 1:00 P.M. had a temperature of 101.8. This was before the development of contour feathers. A week later, June 23 3:30 P.M. it had left the nest and was found hiding in adjacent lilac bushes. An observation made at this time showed an increase of temperature to 105.0. This was not due to atmospheric conditions as this day was one degree cooler than the former day and hour.

A number of Brown Thrashers (*Toxostoma rufum*) were observed at various stages of development. Those that were naked and small gave low readings while those nearly ready to leave the nest had high temperatures, as high as 108.8 which is probably very nearly the normal for the species. Subsequent readings were made

on four young Thrashers that demonstrated a definite rise in the individual case. Thus on July 8 at 5:30 P.M. four Thrashers about six days old and in pin feathers registered 104.5, 104.2, 104.1, and the smallest 103.1. Four days later (July 12 7:30 P.M.) when contour feathers had begun to develop there was an increase in the temperature to 105.2, 105.4, 105.5, and 103.5 respectively. This rise took place in spite of the fact that the surrounding air was nine degrees cooler on this date than on the former.

Young naked Robins (*Planesticus migratorius*) have relatively low body temperatures. A rapid rise occurs during the period in the nest and at the time of the initial flight temperatures approximating the normal for the species are found. In several instances very high temperatures were found in well developed fledglings, in one case being over 110 which is somewhat above the mean for the adults. A follow up reading in one young Robin readily demonstrated this rise. When two days old, July 5 at 5:30 P.M. (96°), it registered 104.3 which is, however, a relatively high temperature for so young a bird. When eleven days old, July 14 at 5:30 P.M. (89°) the temperature had increased to 106.1.

One family of Bluebirds (*Sialia sialis*) was studied. The evidence in this case is definite but the results are influenced by other factors that complicate the findings. Three young Bluebirds when about five days old and still without feathers registered 98.3, 95.8, and 94.6, June 25 at 6:30 A.M. (61°). On June 29 at 5:30 P.M. (100°) when feathers were developing they were 106.9, 106.2, and 107.1. July 2 7:00 A.M. (78°) they registered 103.6, 103.8, and 103.2. They were now well feathered and nearly ready to fly. It is to be noted in this case that high temperatures of the nestlings are coincident with high atmospheric readings which makes the evidence less satisfactory in the demonstration of the influence of age alone on body temperatures. The only incubating parent among all of the nests studied was caught and observed in this instance, The nest was in a hollow pipe and on discovery of the site the female was taken out of the pipe and her temperature taken to which examination she submitted without fear or protest. A reading of 109.2 was obtained. It is of interest to note that this temperature is one degree higher than the maximum for the species reported by Wetmore.<sup>1</sup>

It is obvious from the instances cited that body temperature increases with increasing development of nestling birds. A comparison with the mean temperature normal to the species, however, shows that the temperature at the time of leaving the nest, in most cases, is considerably below that of adult birds. It is a question when the normal adult temperature is attained.

*Temperature of surrounding air.*<sup>1</sup> Thermotaxis or the thermoregulatory function in young birds is apparently poorly developed. Profound alterations in body temperature are caused by changes in the temperature of the surrounding air. It is this factor that makes it necessary for the parent to continue incubation of the young on cool days and to stand as a shield from the sun, especially in the case of exposed nests, on very hot days. External heat, it is well known,<sup>2</sup> may be a cause of fever in human infants also, but to a much milder degree. Rapid changes in body temperature that would be fatal to man are experienced daily by young birds with perfect equanimity. In any study of body heat of young altricial birds the state of atmospheric temperature must be considered. The factor of age is manifested by a rising mean temperature but superimposed on this is the profound influence of external heat or cold so that violent undulations are brought about.

There is a diurnal rhythm manifest in young birds the peak of which is roughly coincident with the hours of greatest intensity of sunlight. This tends to subside somewhat more rapidly than the atmospheric air cools. Evening temperatures are usually lower than those of early afternoon although in many instances the thermographic reading shows little or no decline in the temperature of the surrounding air. As a corollary of this it is probably true that there is a mild seasonal variation so that the body temperatures of nestlings hatched in the hotter months of midsummer average higher than do those of earlier or later hatchings.

A few cases are rather instructive in this regard. Three Mourning Doves (*Zenaidura macroura carolinensis*) were rather intensively studied in the nest, temperatures being recorded three times a

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<sup>1</sup> Acknowledgements are due Professor E. C. Converse, Kansas State Agricultural College, Manhattan, Kansas, for use of thermographic records of hourly temperatures throughout the period of this investigation.

<sup>2</sup> Talbot, F. B. Body Temperature and Its Regulations, in *Abt's Pediatrics* 6: 8, 1925.



day. One of these was freshly hatched when found on August 4. Unfortunately the mother failed to return after six visits and death resulted. A pair, two and three days old respectively, were located in a neighboring nest at the same time. These were followed for eight days or until August 11 at which time the writer left for a protracted absence. Interesting results were obtained which may be briefly summarized as follows. In every instance the early morning temperature was low. The peak occurred in midafternoon and the evening temperature was intermediate. On August 10 a cool shower fell about four in the afternoon and this was reflected by a marked fall in the temperatures of the young. The mean temperature gradually rose with increasing age and development. Throughout this investigation it was feared that the mother would weary of the repeated intrusions and leave the young to perish. But with a heroic devotion that could not but inspire profound admiration she returned doggedly to her duty.

Two Doves about three and two days old on September 19 at 2:00 P.M. registered 103.0 and 102.3 respectively. By evening there was a cooling of the body heat and at 6:30 P.M. their temperatures were only 99.6 and 100.9 respectively.

Flickers (*Colaptes auratus luteus*) give another example of this diurnal rhythm. On June 29 at 3:00 P.M. three naked young about nine days old registered 106.8, 106.8, and 105.9. In the evening at 8:00 P.M. although the air had not as yet cooled off they recorded 102.9 (smallest), 104.5, and 104.1 respectively.

The effect of external temperature is evidenced in another manner by a young naked Arkansas Kingbird (*Tyrannus verticalis*) about one week old. This bird and its mates had to be taken to the ground from a nest far out on a precariously slender limb. It became chilled in so doing as it was a rather cool morning (56 degrees, June 26 7:00 A.M.) and the thermometer which could not register lower than 94.0 was unable to record any reading. When this nestling was warmed by simply holding in the hand it reacted promptly to 97.1.

On June 11 at 1:00 P.M. a nest of young Lark Sparrows (*Chondestes grammacus*) was found on a bare exposed hillside. The mother stood over the nest with outstretched wings. The nestlings were in pin feathers and registered 105.6, 105.2, and 106.8.

Two days later when the sun had set at 7:30 P.M. the first bird registered 103.4 and the last was 103.2. No reading was made on the other as the young were becoming frightened and trying to leave the nest.

Young Brown Thrashers (*Toxostoma rufum*) furnish another instance in which the body temperature is highest during the hours of maximum intensity of sun light. Four young Thrashers (Nos. 437015-18 inclusive) were observed for several days. At 1:00 P.M. June 29, a very hot day, when about nine days old, they had the unusually high readings of 108.3, 107.5, 108.6, and the smallest 106.5. At 7:30 P.M. the same date, after the intensity of sunlight had diminished, they were 105.0, 104.8, 103.5 and the smallest 102.0 respectively. There was thus a drop of from three to five degrees in the short space of an afternoon.

Another nest of young Thrashers (Nos. 437956-59 inclusive) was observed at a later date. On July 10 at 3:00 P.M. when about eight days old and of nearly the same degree of development as the set reported above they registered 105.3, 105.2, 105.2, and the smallest 104.9. At 8:00 P.M. the same date they were 104.1, 103.7, 104.6, and the smallest 104.1 respectively. This was a cooler day than in the former case. There was, therefore, not as high a mid-day reading as in that instance and as a consequence the fluctuation is less. The evening temperatures in the two sets correspond fairly well.

A diurnal rhythm is manifested in young birds, therefore, the peak of which is roughly coincident with the hours of maximum intensity of sunlight and heat. This may cause a rise in body temperature from very low degrees in the early morning to unusually high points on very hot days and causes violent fluctuations in the thermal state of the body that is borne with surprising equanimity.

*Exertion.* Another factor that influences body temperatures in young birds is that of exertion. Violent struggling on the part of some (if not all) nestlings and young birds causes a marked and abrupt rise in temperature. Whether normal efforts put out in flight will do the same is not known nor is it possible to state at this time what influence fear plays in the findings given herein.

A young Turkey Vulture (*Cathartes aura septentrionalis*), already cited, was investigated from the time of hatching to the day of its

abandonment of the home cave. A reading was obtained in each instance in the cave after which it was taken out and photographed in the sunlight. It invariably struggled at these times which inevitably caused a rise in temperature of at least three degrees. This rise could be induced at will by causing the young Buzzard to fight or struggle. It was very pugnacious and teasing with a stick provoked it to a vicious attack at which times it clung to the stick with singular tenacity. After such an affray an investigation of its temperature showed that a prompt rise had occurred. Evidences of distress were manifested by quick panting respiration with the beak open, the glottis dilated widely and brought well forward to the front of the mouth the more readily to obtain cool air. This bird, it will be recalled attained its adult temperature at the age of two weeks and while still very immature in its development. It also underwent a mild diurnal rhythm as was evidenced by a night temperature when it was asleep in the cave. At this time there was a drop of one degree below the normal.

Well developed fledglings that have left the nest and are capable of caring for themselves are still subject to this influence. Two young but fully grown Red-tailed Hawks (*Buteo borealis*) were kept in an aviary and observed for a month. Their diurnal temperatures ranged from 106.6 to 108.0. These were resting temperatures and it is to be noted are not in accord with the findings of Wetmore<sup>1</sup> as the mean for the species. At 10:00 P.M. June 29 a night reading was made. The bird with 108.0 was now 104.8 and submitted sleepily to the examination. The other which had recorded 106.6 was much alarmed by the light and unaccustomed disturbance. It fought viciously, flopping onto its back and striking painful blows with the talons. It was subdued with difficulty after the temperature was found to be at the unprecedented figure of 109.2. Later, on July 1, both of these birds were released in the canyon of their home. In transportation they struggled violently and at the time of their release showed every evidence of extreme distress to judge from the state of their body temperature. They registered 109.2 and 109.3.

A young Great Horned Owl (*Bubo v. virginianus*) was kept in captivity for one month. The average daily temperature was found to be 104.8. When about twelve weeks old it was taken to

the site of capture and there released. It struggled violently during transportation and arrived in a state of distress from the exertion and heat of the body. The beak was partially open, the glottis dilated and far forward in the mouth, the respirations were labored and fast while saliva dripped from the mouth. The body temperature was found to be 108.2.

*Handling* alone may cause a drop in body temperature. This has already been illustrated in the case of the two young Mourning Doves (*Zenaidura macroura carolinensis*) referred to in the introduction. Other instances may be cited. Two Doves about five days old June 29 registered 104.5 and 103.6. Five minutes later they had dropped to 101.8 and 101.1. On June 30 a five day old Dove registered 104.2. In five minutes this had dropped to 101.8.

Two Yellow-billed Cuckoos (*Coccyzus a. americanus*) six and five days old were removed from the nest July 16 and observations made at once gave 105.4 and 104.3. After five minutes rest in the warm grass exposed to the sun they registered 103.8 and 104.5 respectively. In two minutes more the first had risen slightly to 104.6. In another minute the first was down again to 103.9 and the second was holding approximately at a level at 104.1. There was no struggling on the part of these two. Outside the gentle handling and removal from the nest no disturbing factors existed. This furnishes an instructive example of the fluctuations in body temperature undergone by nestlings. It is manifest also in the face of such volatile changes that too much reliance can not be placed on single observations unless uniform conditions prevail.

A final instance is found in the case of a young Brown Thrasher (*Toxostoma rufum*) which on June 28 when eight days old registered 105.1. Ten minutes later it was removed from the nest and again examined at which time there was a drop of exactly two degrees.

*Feeding* or the introduction of cold food may cause a transitory drop in body heat, as is evidenced by the following cases. Readings were made on three young Blue Jays (*Cyanocitta c. cristata*) June 23 at 9:00 A.M. They registered 103.6, 104.3 and 102.4. They were then fed chopped cold beef and another reading made. There was an abrupt and immediate drop in all as follows: 100.1, 103.0, and 100.2. After exposure to the warm sun they were up to 104.0, 105.9, and 102.9 respectively.

*Absence of the incubating parent* if prolonged must cause a drop in body temperature of the young. For short times they no doubt maintain practically normal conditions by nestling close together under the protection of the nest. How long the adult may stay away without danger to the young and what influence this factor has on the movements of the adult is not known. There is opportunity here for interesting investigation.

*Fatigue, hunger and illness* cause a considerable lowering of body temperature. From time to time well feathered young were picked up from the ground that were drowsy and apathetic and obviously ill. These always gave readings far below the normal for that stage of development. These birds were not banded nor included in the tables since they did not throw any light on the normal findings.

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