ATTENTIVENESS AND INATTENTIVENESS IN THE NESTING BEHAVIOR OF THE HOUSE WREN.[1]

(*Plates X–XIII*)

BY S. PRENTISS BALDWIN AND S. CHARLES KENDEIGH.

DURING the last two summers at the Baldwin Bird Research Laboratory, Gates Mills, near Cleveland, Ohio, work has been carried on rather intensively to discover the relation between the time that the adult House Wrens (*Troglodytes aedon aedon*) spend at their nesting activities and the time that they spend in seeking food and rest for themselves. This relation is a very important one for the birds, for in the first instance, they are concerned with the duty of reproducing their kind, and in the second, with maintaining their own life processes.

Two methods were used in making this study. The first of these methods was that of observation. Usually several hours a day were spent in recording the movements of particular birds under very favorable circumstances. While the birds were inside the box, their activities were watched through observational tubes. These tubes were arranged with but little trouble and caused the normal actions of the birds to be disturbed not at all. In making these, the back of the wooden bird-box was taken out, and a transparent glass plate was put in its place. The box was then tacked up on the side of a building over a hole cut through the wall. This hole was of the same diameter as the inside of the box. Thus a person inside the building could look through the hole and the glass and observe everything that the bird did within. But to do away with all possible source of fright to the birds, a section of an old stove pipe was tacked against the opening in the wall, inside the building, and a piece of cardboard with a small peep-hole punctured in the middle was placed in the end of the pipe. This made the back of the box appear black from inside the nest box, yet allowed one to take detailed observations from inside the building. Several boxes were arranged in this way. The activities of the birds while away from the box were more difficult to follow. This could be done only with the use of binoculars.

[1] Contribution No. 10 from the Baldwin Bird Research Laboratory.

Although observation is probably the most accurate and unquestionable way to study bird activities, its limitations are such that its value as a method is greatly impaired. The second method that we used overcame many of these limitations, yet did not sacrifice anything materially in the way of accuracy. This method was based upon the use of thermoelectricity in registering the visits of the adult bird to the nest and much of her activity there. The main purpose of this paper is to describe this method.

According to Kimball,[1] knowledge of the principle of thermoelectricity dates back to 1821, when Seebeck, of Berlin, discovered

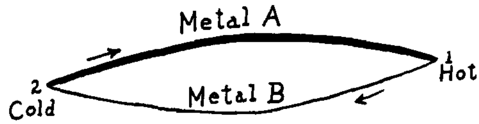


Fig. 1.

that "in a circuit made of two different metals if one junction is hotter than the other there is an electromotive force which causes an electric current." Thus if two different metals, designated A and B above (fig. 1), be joined together at points 1 and 2, and point 1 heated to a temperature higher than point 2, a current will flow around the circuit. The direction of the current depends on the character of the metals used. If the thermo-electric circuit be broken at any point, as at point 3 in the diagram (fig. 2), the current, of course, will cease flowing, and a difference of potential or electromotive force will appear.

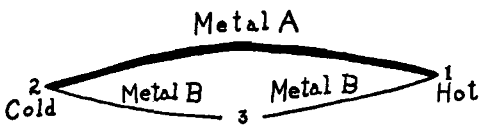


Fig. 2.

The magnitude of this electromotive force depends on the temperature difference between points 1 and 2 and furnishes a means of measuring this temperature difference. If one of the junctions, for example, the cold junction at point 2 be maintained at a con-

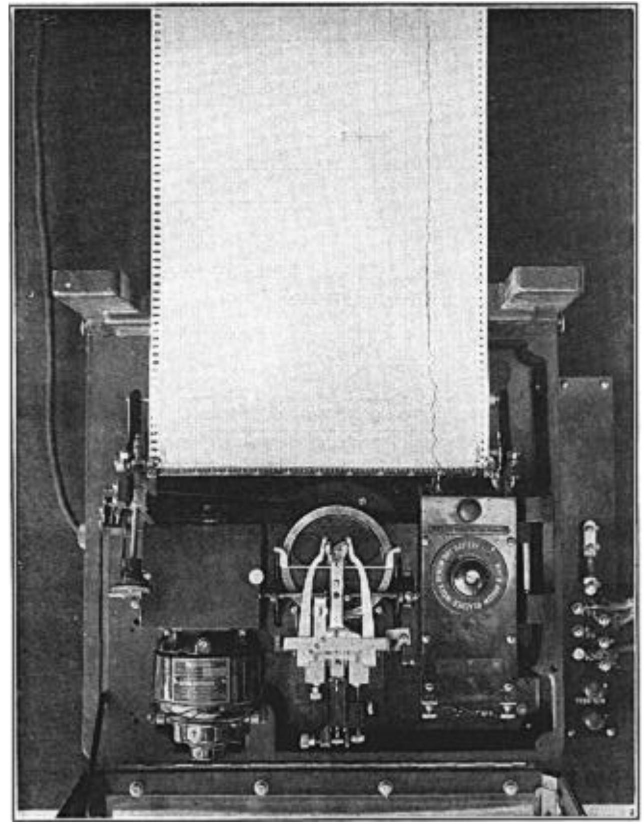
[1] College Physics, 1917, p. 442.

stant temperature, the temperature at point 1 is determined when the electromotive force is known.

Owing to the small magnitude of the electromotive forces involved (generally less than .002 volt in the work to be described) only the most delicate and sensitive instruments can be employed for their measurement. When, as in the present case, a record of temperature variations is to be made, the instrument must be designed not only for great sensitiveness, but also for strength enough to make the record. The Leeds and Northrup Company have developed such a recorder (Pl. X, fig. 1). Their instrument is operated in conjunction with a thermocouple composed of the two metals copper and constantan, the latter an alloy of nickel and copper. The two thermocouple wires are run directly to the recorder which is therefore at the same temperature as the cold junction. An electrically compensating device embodied in the instrument, automatically corrects for external temperature variations at the recorder and gives as true an indication of temperature at the warm junction, as if the cold junction were maintained constant at zero.

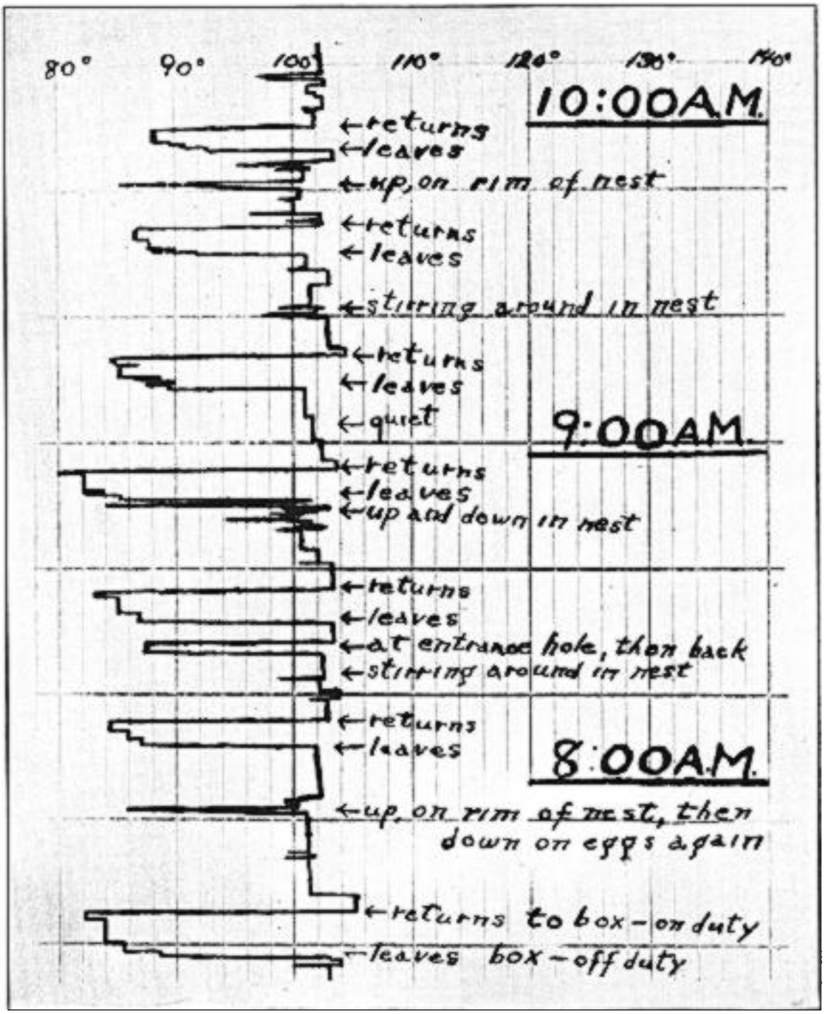
The recorder operates on the potentiometer system by which a small sensitive galvanometer needle is caused to swing to the right or left whenever the warm junction is at a temperature higher or lower than that indicated on the recorder. At once, through the agency of levers, cams, etc., a small electric motor causes a wheel attached to the recording pen to rotate one way or the other until the temperature indicated by the recorder is again the same as that at the warm junction. At this point the galvanometer needle is again in its neutral position and the recording pen is at rest.

When at rest, the electromotive force of the thermocouple is exactly balanced with a potential produced by two dry cells. This relation is made clear on next page (fig. 3). The potential of the dry cell current is greater at A than at B and grades gradually from the first extreme to the second because of the increasing resistance in the slide wire. Thus by varying the location of point C through the revolving of the wheel mentioned in the paragraph above, any thermocouple potential may be balanced against an equal potential in the dry cell circuit. The two potentials are of opposite polarity, and so oppose each other.



1. TEMPERATURE RECORDER.

2. POSITION OF THERMOCOUPLE IN NESTS LIKE A THREAD ACROSS THE EGGS.



SECTION OF TEMPERATURE RECORD WITH INTERPRETATION WITH RESPECT TO MOVEMENTS OF THE BIRD. (FAHRENHEIT SCALE.)

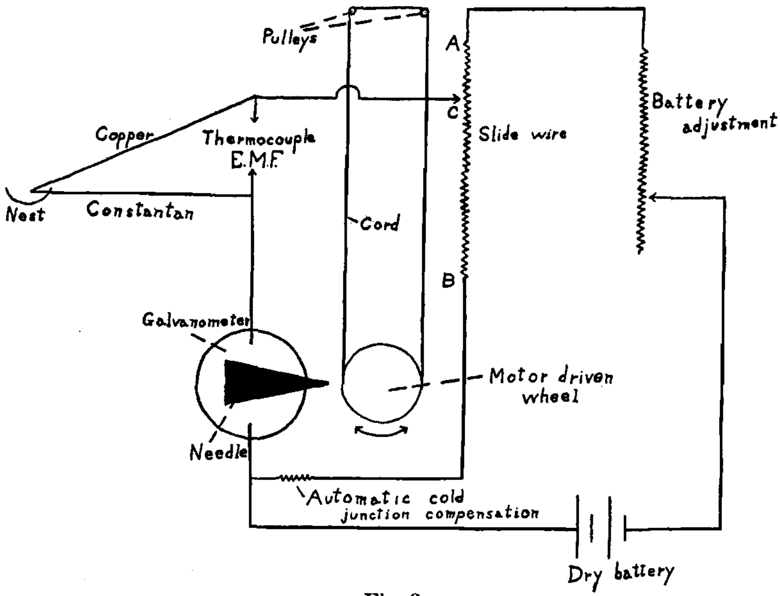


Fig. 3.

Hence, when the two potentials are equal, no current flows around the thermocouple and a uniform temperature record is produced. When the thermocouple potential becomes greater or less than the potential of the dry cell circuit at point C, a current flows around the thermocouple until C is shifted to a point between A and B which will again make the two potentials equal.

The recording pen bears on a paper rolled past at a constant speed by means of the same small motor above mentioned. Thus there is furnished a paper and ink record of temperature variations with time. This paper is marked in degrees of temperature and the instrument can be adjusted to use either the Centigrade or Fahrenheit scale. We have given some thought to this question of which scale should be used for this and other temperature studies in our laboratory, and finally decided to use Fahrenheit, because it is in more general use, is better understood by most people, and its unit of measurement is smaller. A straight line along the paper indicates a constant temperature while a more or less sloping line indicates a more or less rapidly changing temperature.

The operation of the recorder requires a small amount of power from the electric light circuit and also the daily standardization of the current from the dry cells.

The potentiometer system of thermocouple temperature measurements has one point making it especially suitable for use in life history studies. The accuracy of the readings obtained is practically independent of the length of leads employed and of external temperature variations.

This, in brief, is the principle and manner in which the recorder works. The recorder is placed in the laboratory, and wires are run out to any nearby nest. The warm junction end of the thermocouple is placed in the nest (Pl. X, fig. 2). The thermocouple wire at this point is thin and flexible and is run from one side of the box through the nest just above the eggs (if it is eggs that happen to be in the nest) and then out the other side. The junction of the two metals, copper and constantan, comes at the middle of the nest.

When the adult bird enters the box and settles down on the eggs, she, of course, applies heat to them and warms up the nest cavity. The increase in temperature causes an increase of electric potential at the recorder, and this is registered on the paper evolving from the recorder in the laboratory by a variation in the line drawn by the pen. Every time that the bird settles down in the nest there will be one kind of variation in the line, and every time that she leaves the nest there will be another kind of variation—because of the difference in the temperature of the nest. In fact, every time that she stirs around in the nest to any extent, shifts her feet, gets up on the rim of the nest, or goes to the entrance of the box for an instant, all such movements will be registered by characteristic marks in the record (Pl. XI). Since the recorder is in action day and night we have thus a fairly complete record of the activities of the adult bird at the nest. It is possible to get such records of the female from the beginning of the nest-building activities until the end of the brooding period. We have not been successful as yet in using this method for recording the number of times that the adult birds feed the young, since they do not brood everytime they enter the box, but possibly it may be so used.

The possible use of this form of instrument in our problem of obtaining nest temperatures was first suggested to us by Dr. C. Baldwin Sawyer,[1] and it was largely under his direction and with the coöperation of the Leeds and Northrup Company that the recorder was installed and fitted to our needs.

The advantages of this method are obvious. Perhaps its greatest merit lies in the continuous record, day and night, which it gives us of the bird's activity over the greater part of the nesting period. Observation, alone, could never give us such a record except with preposterous effort. The use of the instrument also gives valuable temperature data. When the bird is sitting, we get a record of the approximate temperature being applied to the eggs, which temperature approaches that of the belly of the bird. When the bird is gone, we get a record of the nest temperature to which the eggs are subjected. This record is accurate to within one degree Fahrenheit, plus or minus. Another instrument based upon the same principle but which is not self recording is giving us nest and egg temperature records accurate to within at least one-tenth of a degree.

One criticism may be offered to this method in that it introduces a foreign object into the nest cavity. It may be thought that this would make the actions of the bird abnormal, but this is not so. Of course, different birds respond to the wire in different ways, but in the nests with which we have experimented, the adult bird after the first day or two paid little or no attention to it. We obtained a check on the amount of uneasiness which the wire might have caused the sitting bird by observations at other nests where there were no wires.

Another possible objection is that the record merely gives us circumstantial evidence, and that our interpretation of the variations in the temperature line must be largely arbitrary. Frequent checking of the record by direct observation of the bird in the box, however, makes us believe that our interpretations are never far from the truth. Several times during the summer, two people

[1] It is our good fortune that Dr. Baldwin Sawyer, who is a nephew of Mr. Baldwin, spends many a week end on Hillcrest Farm, and has given freely of his time and thought in working out the temperature experiments. Dr. Sawyer is an officer of the Brush Laboratories Co., of Cleveland, therefore an expert in electro-chemical and physical problems. We must also add that he has helped us considerably in the preparation of this paper, and the first three text-figures are of his designing.

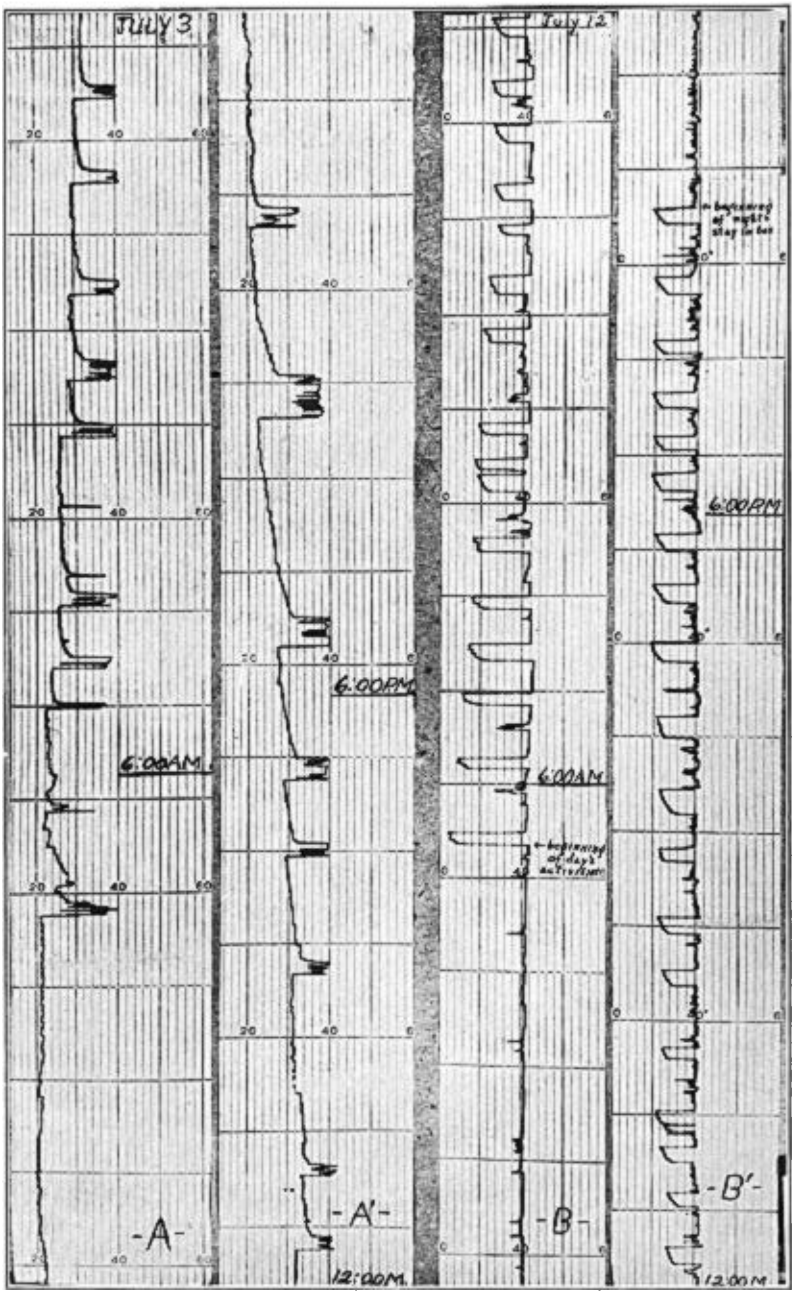
were used to check the record. One remained outside where he could observe nearly all the actions of the bird while the other stood inside the laboratory entirely out of sight of the nest and as that record unfolded called out what the bird was doing perhaps one hundred fifty feet away. The correlation was very satisfactory in its exactness.

The recorder was in continual operation for ninety-one days and nights during this last summer, from May 23 to Aug. 22, 1926. This gave us some two hundred fifty feet of record. The instrument was attached at different times for varying intervals to four different Wrens' nests and to one Robin's. This, together with over seventy hours of observational notes, gave us a vast amount of data and some very interesting probabilities in the way of results. However, in this paper we are confining ourselves to one aspect of the subject, that of the general relation between the attentive and inattentive periods.

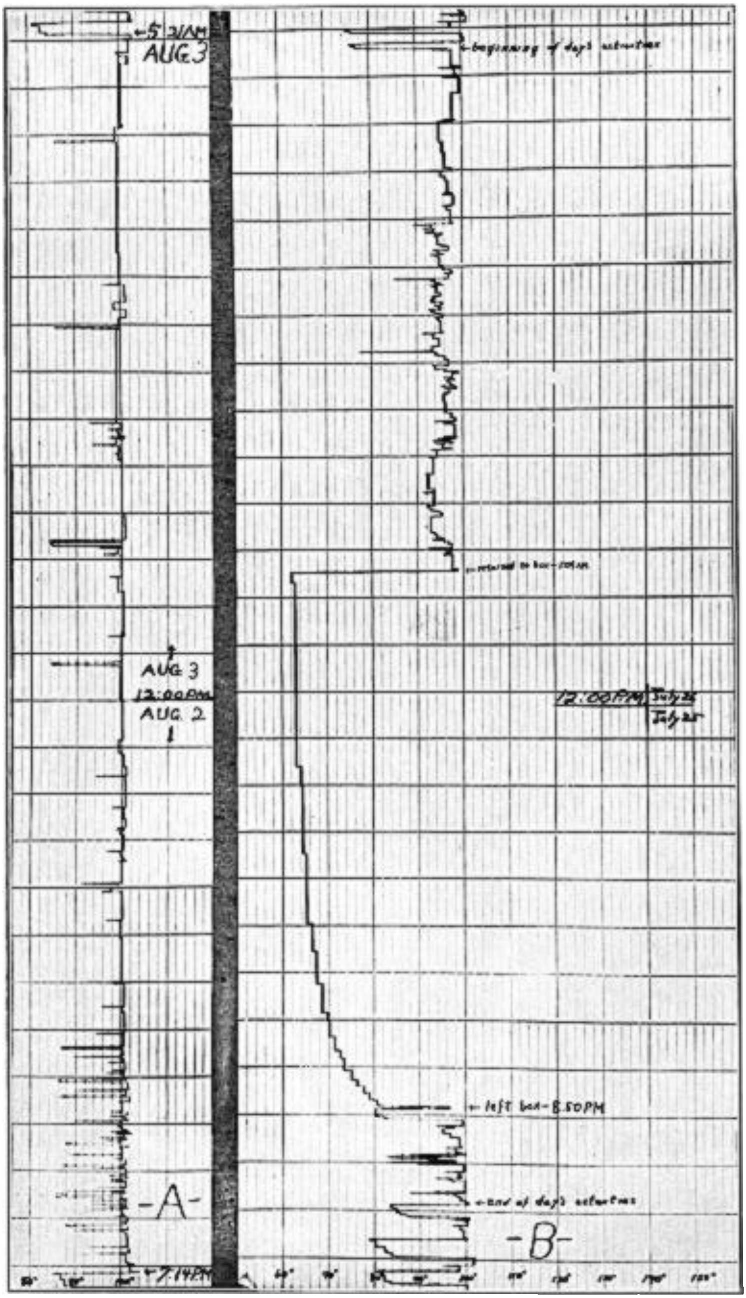
The differentiation between the periods of attentiveness when the bird is actually engaged in nesting activities and the periods of inattentiveness when it is feeding or resting is best developed with the female for it is she who is most active in the reproduction of the species. However, the same relation holds for the male as we shall see later.

After the female becomes mated with a male, she soon begins to carry in lining for the nest, the rough part of which had been begun or finished by the male some time previous. The female, however, does not carry nesting material into the box continuously for long at a time, getting her food at odd moments when she is looking for material. On the contrary, she works assiduously at building the nest for a period of a few to several minutes, and then goes off and hunts actively for food for herself, only to come back when this period is ended to carry in more material for another stretch of time, and so on. While building her nest she is not concerned with looking for food. Likewise, when she is away looking for food she does not concern herself with nesting duties. She usually spends a good deal longer time away from the box than at the box during this phase of her nesting activities.

The same holds true for the days during which she is laying her set of eggs. Her inattentive periods are usually much longer than



A.A'—TYPICAL DAY RECORD FOR THE PERIOD OF EGG-LAYING. EGG NO. 3 WAS LAID AT FIRST VISIT TO BOX, PROBABLY AT TIME OF HIGH TEMPERATURE MARK.
B.B'—SAME FOR INCUBATION PERIOD. SIXTH DAY AFTER LAST EGG WAS LAID. (CENTIGRADE SCALE.)



A.—TYPICAL NIGHT RECORD FOR INCUBATION PERIOD. NOTE RESTLESSNESS DURING FIRST TWO HOURS OF EVENING, AS CONTRASTED WITH REMAINDER OF NIGHT.
B.—AN UNUSUAL NIGHT RECORD. (FAHRENHEIT SCALE.)

her attentive periods, although she comes to the box at regular intervals throughout the day (Pl. XII, AA′). As her set nears completion and the duties of incubation approach, the inattentive periods gradually shorten, and the attentive periods not only lengthen but become more numerous.

While incubating, the periods of attentiveness for female number 71653 (U. S. Biological Survey band number) averaged fourteen and three-tenths minutes long and the periods of inattentiveness six minutes, that is, she incubated the eggs during the day only for short periods at a time, and between these incubating periods she was away feeding (Pl. XII, BB′). The way these periods alternated with each other was very definite and regular although there was often quite a little variation in the actual length of the periods. The length of the inattentive periods was more uniform than the length of the attentive periods. This bird spent every night in the box during the incubation period (Pl. XIII, A), although once "she went out for the evening" at 8:50 o'clock and did not return until 1:04 the next morning (Pl. XIII, B). During the last three days of incubation, the duration of the periods of attentiveness greatly lengthened, but the length of the periods of inattentiveness remained practically the same. Although the above record is for only the one female, all the females of which we have data showed the same tendencies in their actions.

The day on which the eggs hatched was a very busy one for this female (number 71653). The activities during the early morning started at the normal rate. She left the box after the night's stay at 5:22 o'clock, and for over an hour and a half her trips to and from the box were much as they had been during the incubation period. However, beginning at 7:11 her record indicates considerable uneasiness. The reason for this became apparent when at 7:35 the first young bird was found to have just broken out of the shell. All of her eggs hatched during the rest of the day. The number of her attentive and inattentive periods during the day was eighty-two, although the average number per day during the incubation period had been only forty-three and a half. This unusual restlessness, however, was exceptional, since our records for other females are much steadier.

This female during the next few days gradually resumed her normal rate of activity. During the next six days when she spent considerable time brooding the young, her periods of attentiveness averaged about thirteen and eight-tenths minutes and her periods of inattentiveness about four and six-tenths.

When both adult birds were busy from morning till night with the feeding of the young, periods of attentiveness and inattentiveness still were the rule. The adults would feed the young several times in succession and then take a short period off when they would get some food and rest for themselves. Sometimes they would feed the young repeatedly and rapidly nine, ten, or more times before they would stop. Then again the number of feedings per period would be only three or four, or in many cases, but one. Usually the number of feedings per period averaged higher in the morning than in the heat of the day.

The following short extract from the observational notes of August 14 illustrates the relation between the two periods during this phase of the nesting activities. The female's record is here separated from the male's, but the behaviour is very similar in both sexes.

9:26 A.M.—Female feeds miller to one young.
9:31—Female feeds fly to one young.
9:32—Female feeds cricket to one young.
9:33—Female feeds one young.
9:34—Female feeds cricket to one young.
9:35—Female feeds insect to one young.
9:36—Female feeds insect larva to one young.
9:40—Female feeds spider to one young.
9:41—Female feeds insect to one young.
9:43—Female feeds larva to one young.
9:43—Female feeds insect to one young.
9:44—Female feeds insect to one young.
9:49—Female feeds insect to one young.
9:56—Female feeds one young.
9:57—Female feeds one young.
9:58—Female feeds insect to one young.
10:00—Female feeds insect to one young.
10:00—Female feeds insect to one young.

The periods of inattentiveness are the longer intervals between the feedings. These are from 9:26 to 9:31; 9:36 to 9:40; 9:44 to 9:49; and 9:49 to 9:56. The periods of attentiveness are represented by the series of feedings between these periods away. The length of time actually spent in the box delivering the food to the young was usually only twenty to thirty seconds in each case. Occasionally, the adult birds may swallow an odd bit of food during the period in which they are primarily engaged in feeding the young, but such an odd bit appears to be largely incidental and may possibly be a piece unsuitable for the young.

After the young birds leave the nest, the adults remain with them for some twelve or thirteen days more. For the first part of this period the adults feed the young practically everything that they get. The attentive and inattentive periods are as well differentiated as during the time the young were in the nest. However, during the last few days when the young become largely able to hunt food and take care of themselves, the inattentive periods gradually lengthen and the attentive periods shorten, so that the birds spend a longer and longer time away from the young and a shorter and shorter time with them. Finally, when the young are well able to look after themselves, the adult bird's duty to them largely ceases. What further relation they may have together is probably more that of individual with individual than parent with offspring.

During his courtship, the male's main duty is to sing, although he almost always begins the construction of the nest during this period also. His singing is not continuous, however. He sings only for periods at a time, and between these periods he does his feeding. He thus manifests the same relation between feeding and reproductive activities that the female does.

The following extract from the observational notes of May 8 1926, illustrates this relation for male number 57759.

8:52—Male Wren approaches vicinity of box, sings, carries several sticks into box.

9:05—Leaves, sings occasionally in distance at first but soon becomes entirely silent.

9:24—Returns, sings, then becomes silent and carries sticks into box. He usually gives short churring notes after depositing a stick, but he does not sing while actually working.

9:34—Begins to sing a little again, leaves, becomes silent.

9:45—Returns to vicinity of box, sings courtship song repeatedly.

9:56—Leaves, becomes silent.

The periods of attentiveness here are approximately from 8:52 to 9:05, 9:24 to 9:34; 9:45 to 9:56, and the periods of inattentiveness are from 9:05 to 9:24 and 9:34 to 9:45.

This relation is maintained after he has captured a female, and she is busily engaged at her incubation duties. His activities now are apparently not very important since about all that he does is to sing rather mechanically while being attentive. Occasionally he seeks to wile away his periods of attentiveness by carrying sticks into some nearby box and by beginning the construction of a new nest there. While doing so he sings his courtship song, and thus he often acquires a second mate while his first is still busy with her incubation duties. If his periods of attentiveness were filled with nesting activities, such as helping the female to incubate the eggs, he probably would never have time to engage in polygamous relationships with other females.

Thus we see that with the House Wrens of both sexes, there is a rather definite relation between the time they spend feeding and the time they spend in actual nesting operations, and that this relation takes the form of short alternating periods when they are primarily engaged in either the one or the other activity.

Life-history literature has frequently pointed out this relation for the female during the incubation and brooding periods and also for the male when he shared in these duties, but that such a relation held for both sexes during all phases of their nesting life has not been so generally recognized.

How this relation holds for other species of birds than the House Wren, we are not prepared to say. A certain amount of work with other species carried on during this last summer seems to indicate that the relation may possibly be much the same for all Passerine birds with only a difference in the length of the periods. With species below the Passeriformes this relation may or may not be considerably modified.

817 Williamson Bldg., Cleveland, Ohio.
136 Woodland Ave., Oberlin, Ohio.