RHYTHM IN THE BROODING AND FEEDING ROUTINE OF THE BLACK-CHINNED HUMMINGBIRD

WITH ONE ILLUSTRATION

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Investigations in the field of bird behavior have disclosed the seasonal rhythm of the reproductive processes, but the rhythmic nature of daily activities during the reproductive period has received relatively less attention. In this paper an attempt is made to inquire into the rhythm of the brooding and feeding routine as practiced by a Black-chinned Hummingbird (*Archilochus alexandri*) under my observation at Phoenix, Arizona, in the spring of 1939.

It is generally established that the component activities of the reproductive cycle—mating, nest-building, egg-laying, incubating—are governed by endocrine secretions and are associated, one setting off the next in sequence in cyclical order and according to season, so that the total of these processes forms a rhythmic whole. As seasonal changes and climate influence the rhythm of the reproductive cycle, so meteorological conditions affect the rhythm of the brooding routine. The overt behavior observed in the brooding routine is not called into action merely by glandular secretions or internal physiological stimuli. It is not these alone that send the adult bird to her nestlings when threatening clouds darken the sky. During the brooding routine, the female must respond to such situations and conditions as arise unpredictably in the external environment—heat, cold, rain, wind, and even preying animals. The brooding bird is subject not only to internal stimuli, which give rise to purely instinctive behavior, but to external stimuli as well. The former, because of its rhythmic excitation, imparts to brooding routine a rhythmic character, and the latter, because of its unpredictability, tends to disturb that rhythm.

Before proceeding further, the terms "brooding instinct" and "brooding routine" need clarification. We identify an instinct by the need it tends to satisfy, and that need is evident in the kind of response elicited or adjustment made, which in turn involves movements and acts. In other words, we recognize an instinct in the acts we see invoked. Thus, the instinct to brood is recognized in the posture assumed by the brooding bird, whether covering her nestlings with or without outstretched wings, or standing astride the nest to shield the young. When these postures are repetitive and follow a sequence,

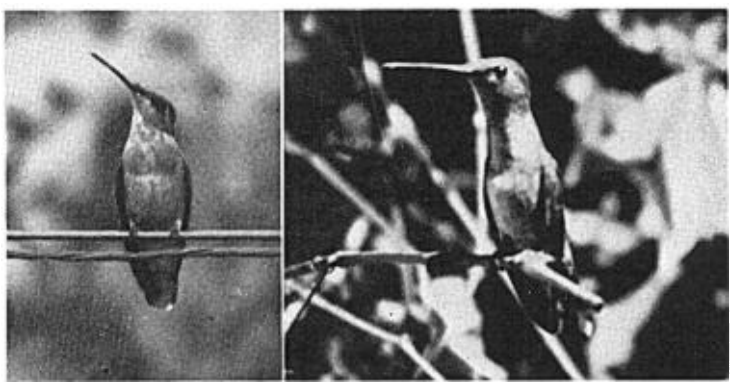

Fig. 58. Two views of female Black-chinned Hummingbird studied at Phoenix, Arizona.

the resulting behavior becomes a routine. The routine, like the posture, is subject to modification, as when cool winds compel the adult bird to brood her young longer than usual.

It is the thesis of this paper that (1) because the physiological stimuli are in ascendence during the early stages of nest life, the brooding-feeding routine tends to rhythm; (2) as the brooding instinct subsides, its rhythmic character disappears, and (3) responses to external stimuli tend to disturb the rhythm of the routine.

Immediately after the eggs are hatched, the brooding instinct is so strong that it is not easily influenced by external conditions, weather particularly. On April 20 (the chicks were hatched on April 18 and 19) brooding was heavy, although the day was clear, the temperature range from sixty to ninety-nine degrees, and the nestlings adequately shielded from direct sunlight. When the older chick was six days old (April 23), a cool wind blew with a velocity of sixteen miles per hour, so that the female, as far as I could ascertain from recorded data, brooded slightly more than she did on April 20. Although 42.3 per cent of the trips to the nest on this date were made for the purpose of brooding only, as against 45.7 per cent on April 20 (see table 1), the average number

TABLE 1

Frequency of observed trips to nest in brooding-feeding routine during first fourteen days of nest life

Date	Age of young (days)	No. and per cent of trips to feed and brood		No. and per cent of trips to brood only		No. and per cent of trips to feed only	
April 20	2, 3	19	54.3	16	45.7	....	....
April 23	5, 6	26	57.7	19	42.3	....	....
April 27	8, 9	4	44.4	....	....	5	55.6
April 29	11, 12	1	10.0	....	....	9	90.0
May 1	13, 14	....	....	....	....	16	100.0

of minutes spent in the nest each time the female visited it was 6.8 for April 20 and 8.1 for April 23 (table 2). These periods represent time spent both in feeding and brooding. If the figures are reduced to time spent in brooding only, we find that on April 23 more time was spent in brooding only than on April 20, an average of 7.5 minutes per trip on April 23 as compared to 6.3 minutes on April 20.

TABLE 2

Duration of brooding and feeding during first nine days of nest life

Date	Age of young (days)	Average time spent in brooding and feeding (minutes per trip)	Average time spent in brooding only (minutes per trip)
April 20	2, 3	6.8	6.3
April 23	5, 6	8.1	7.5
April 27	9, 10	1.8	0.8

The effect of cool winds on brooding behavior is shown in individual sittings (see tables 5 and 6). The longest time spent in one sitting on April 20 was 17 minutes (1:25 p.m. to 1:42 p.m.), whereas on April 23 the longest sitting was 23 minutes (1:43 p.m. to 2:06 p.m.). Eight sittings on April 20 exceeded 10 minutes while fifteen sittings on April 23 exceeded 10 minutes.

Rain had no appreciable effect on the frequency and duration of brooding on April 28, although no detailed data are available for that day. However, at this stage of nest life (ten days after the hatching of the older chick) the nestlings were not in as great need of such care as they were earlier. Frequent showers occurred in the afternoon,

making it impossible to observe what effect the rain would have on the brooding routine. Despite the steady downfall of rain that made food-getting difficult and that jeopardized the use of her delicate wings, the female diligently probed flowers and gleaned shrubs in search of food for herself and her young. From casual observations made indoors, I found no evidence of prolonged stays at the side of her young. In table 1, we note that by April 27, the day preceding the rain, the old bird had discontinued trips to the nest to brood only; and in table 2 we find that only an average of 1.8 minutes per trip was spent in the nest to brood and feed.

TABLE 3

Trend of brooding and feeding routines during first fourteen days of nest life

Date	Total time of observation	Number of trips to nest			Average number of trips per hour to feed	Average number of trips per hour to brood
		Brood and Feed	Brood only	Feed only		
April 20	8 hr. 22 min.	19	16	....	2.3	4.7
April 23	10 hr. 43 min.	26	20	....	2.4	4.2
April 27	3 hr. 32 min.	4	....	5	2.5	1.1
April 29	3 hr. 21 min.	1	....	9	3.0	0.3
May 1	4 hr. 50½ min.	....	....	16	3.1	0.0

The instinct to feed the young arises from the same physiological source as does the instinct to brood, but whereas they differ in kind, both operate in rhythmical fashion. The feeding instinct endures longer in the nest life of the young than does brooding and is less subject to those environmental conditions that influence the latter. Upon examining table 3 we find that the brooding instinct follows a definite but not uniform trend as it wanes. The wide variation in the time spent in observation probably accounts for some irregularity in the trend shown by the figures, as does the fact that during the first nine days of nest life both feeding and brooding together were the object of some of the trips to the nest. Hence, allowance might be made for these factors.

The trend of the feeding routine, unlike that of the brooding routine, is remarkably uniform, despite the intruding factors just cited. As a matter of fact the average number of trips per hour in which feeding was partly or wholly the object of the trips varies only .8 from April 20 to May 1.

When the brooding and feeding behavior occur conjointly in a routine manner, an interesting and significant phenomenon results (see tables 4, 5, and 6). The brooding and feeding routines alternate; that is, each trip made to the nest by the old bird is intended either for the purpose of brooding and feeding, or brooding alone, as is the case early in the nestlings' lives. Later, of course, there is a modification of this pattern; the female then may visit the nest to brood and feed conjointly or simply to feed the chicks. Whenever the old bird assumes the dual task of brooding and feeding, always the brooding act follows feeding, as though the young required as much of the former as the latter.

Note that on April 20 (table 4), the first thirteen trips to the nest follow the order: broods, feeds and broods, broods, feeds and broods. After this the sequence is interrupted on the fourteenth trip, to be resumed beginning with the twenty-third trip. This renewed sequence is maintained until the twenty-ninth trip from which point the alternating pattern is discontinued.

On April 23 (table 5), the rhythmic pattern changes. Now the routine runs: feeds and broods, feeds and broods, broods, feeds and broods, feeds and broods, broods. But the regularity of this sequence is disrupted, for after the tenth trip there is introduced

TABLE 4

Brooding-feeding routine on April 20

Order of trips to nest	Time entered nest	Time left nest	Minutes spent in nest	Minutes spent away from nest	Behavior in nest
1	9:38	9:39	1	....	broods
2	9:42	9:43	1	3	feeds, broods
3	9:44	9:53	9	1	broods
4	10:03	10:08	5	10	feeds, broods
5	10:12	10:22	10	4	broods
6	10:38	10:49	11	16	feeds, broods
7	10:51	10:56	5	2	broods
8	11:00	11:13	13	4	feeds, broods
9	11:17	11:26	9	4	broods
10	11:30	11:31	1	4	feeds, broods
11	11:32	11:36	4	1	broods
12	11:37	11:40	3	1	feeds, broods
13	11:43	11:50	7	3	broods
	(Time out from observation)				
14	12:48	1:01	13	....	broods
15	1:03	1:15	12	2	broods
16	1:17	1:19	2	2	feeds, broods
17	1:25	1:42	17	6	broods
18	1:43	1:47	4	1	feeds, broods
19	2:07	2:17	10	20	feeds, broods
20	2:19	2:30	11	2	broods
21	2:33	2:42	9	3	feeds, broods
22	2:44	2:53	9	2	broods
23	2:55	2:57	4	2	broods
24	3:04	3:08	4	5	feeds, broods
25	3:30	3:45	15	22	broods
26	3:46	3:51	5	1	feeds, broods
27	4:08	4:14	6	17	broods
28	4:19	4:25	6	5	feeds, broods
29	4:35	4:36	1	10	feeds, broods
30	4:45	4:52	7	9	feeds, broods
31	5:00	5:05	5	8	broods
32	5:06	5:11	5	1	feeds, broods
33	5:15	5:17	2	4	feeds, broods
34	5:41	5:52	11	24	feeds, broods
35	5:56	5:58	2	4	feeds, broods

Average time spent in nest, 6.8 minutes.
Average time away from nest, 6.0 minutes.

TABLE 5

Brooding-feeding routine on April 23

1	6:47	6:59	12	....	feeds, broods
2	7:09	7:19	10	9	feeds, broods
3	7:30	7:44	14	11	broods
4	7:44½	7:50	5½	½	feeds, broods
5	7:54	7:59	5	4	feeds, broods
6	8:02	8:11	9	3	broods
7	8:20	8:31	11	9	feeds, broods
8	8:41	8:51	10	10	feeds, broods
9	8:53	9:02	9	2	broods
10	9:15	9:21½	6½	13	broods
11	9:22	9:37	15	½	feeds, broods
12	9:38	9:39	1	1	feeds, broods
13	9:44	9:50	6	5	broods

Order of trips to nest	Time entered nest	Time left nest	Minutes spent in nest	Minutes spent away from nest	Behavior in nest
14	9:52	9:59	7	2	broods
15	10:03	10:08	5	4	feeds, broods
16	10:15	10:25	10	7	broods
17	10:29	10:34	5	4	feeds, broods
18	10:38	10:45	7	4	broods
19	10:49	10:55	6	5	broods
20	10:56	11:03	7	1	feeds, broods
21	11:22	11:33	10	19	feeds, broods
22	11:35	11:53	18	2	broods
23	11:56	12:09	13	3	feeds, broods
24	12:20	12:32	12	11	broods
25	12:34	12:35	1	2	feeds, broods
26	12:35½	12:44	11½	½	broods
27	12:50	1:05	15	6	feeds, broods
28	1:16	1:19	3	11	broods
29	1:21	1:32	11	2	feeds, broods
30	1:43	2:06	23	11	feeds, broods
31	2:09	2:13	4	3	feeds, broods
32	2:27	2:37	10	14	feeds, broods
33	2:40	2:45	5	3	broods
34	2:50	2:53	3	5	broods
35	2:55	3:03	8	2	feeds, broods
36	3:06	3:08	2	3	broods
37	3:09	3:11	2	1	feeds, broods
38	3:19	3:24	5	8	broods
39	3:29	3:33	4	5	broods
40	3:53	4:02	9	20	feeds, broods
41	4:03	4:10	7	1	broods
42	4:26	4:38	12	16	feeds, broods
43	4:42	4:45	3	4	feeds, broods
44	5:02	5:13	11	17	feeds, broods
45	5:18	5:22	4	5	broods
46	5:26	5:30	4	4	feeds, broods

Average time in nest, 8.1 minutes.
Average time away from nest, 6.2 minutes.

an innovation which is a combination of the pattern followed on April 20 and the one inaugurated on the morning of April 23. What is a well-regulated routine during the early hours of each new day, becomes chaotic a few hours later, to be restored somewhat still later in the day.

By April 27 (table 6), the brooding-feeding routine has lost much of its rhythm; by April 29 it just about disappears (not shown by data here); and by May 1 only the feeding routine continues.

TABLE 6

Brooding-feeding routine on April 27

Order of trips to nest	Time entered nest	Time left nest	Minutes spent in nest	Minutes spent away from nest	Behavior in nest
1	8:44	8:45	1	....	feeds
2	9:05	9:10	5	20	feeds, broods
3	9:32	9:34	2	22	feeds, broods
	(Time out from observation)				
4	10:43	10:45	2	....	feeds, broods
	(Time out from observation)				
5	3:01	3:02	1	....	feeds

Order of trips to nest	Time entered nest	Time left nest	Minutes spent in nest	Minutes spent away from nest	Behavior in nest
6	3:45	3:46	1	43	feeds
7	4:02	4:03	1	16	feeds
8	4:21	4:23	2	18	feeds, broods
9	4:50	4:51	1	27	feeds

Average time in nest, 1.8 minutes.
Average time away from nest, 24.3 minutes.

Of the three days recorded in the tables, rhythm is most marked in the pattern of April 20. Had no time been taken out from observation, I might have seen the rhythmical pattern on this day continue for at least four or five more trips beyond the thirteenth, the average number of trips per hour on this day being 4. Nevertheless, the rhythmical pattern is better than that of April 23, on which day an unbroken rhythmical sequence was maintained during only the first nine consecutive trips. The pattern of April 27 is too erratic for comparison, but is significant as a point of reference in demonstrating the decreasing intensity of the brooding instinct. We are reminded that on April 20, when rhythm was most marked, the weather was favorable; while on April 23 a cool wind blew, which probably disturbed the rhythm.

Time spent away from nest indicates relaxation from the parental burden, for it is then that the adult bird attempts to re-create her energies. The proportion of time she devotes to her young and herself varies not only from trip to trip but also from day to day (see tables 4, 5, and 6). If the figures shown at the bottom of the tables are expressed in per cent, we find that the proportion of time spent away from the nest is as follows: 47 per cent for April 20, 43 per cent for April 23, and 94 per cent for April 27. Thus, as the brooding instinct wanes, the bird finds more time for herself.

Phoenix, Arizona, October 9, 1939.