ON THE HOUR OF LAYING AND HATCHING OF BIRDS' EGGS.

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I. INTRODUCTION

Do birds have a particular hour of the day for laying their eggs ? Is this time constant for the individual ? For the species ? Does it vary with the order of the eggs in a set ? To what degree does it vary within a genus or larger group ? Do eggs tend to hatch in some particular part of the day, or is hatching spread over the 24 hours ? The answers to these questions are of interest in themselves. They throw light on the daily rhythm of the bird's activities and perhaps provide a clue to the affinities of genera or higher groups. Knowledge of the hour of the day when eggs are laid and when they hatch aids in the accurate determination of incubation periods, and is in other ways helpful in life-history studies. My interest was first directed to this question twenty years ago, when I tried to determine, by watching the laying of the eggs, which of a pair of birds was female and which male. In many species of cuckoos, American flycatchers, and other birds, the sexes are so similar in appearance and voice that it is scarcely possible to make certain which is the female except by seeing her lay. I should have spared myself a great many hours of fruitless watching if I had known beforehand at what hour to expect the deposition of the eggs. With one pair of Groove-billed Anis *Crotophaga sulcirostris*, the members of which I could distinguish by daubs of white paint I had placed upon their black plumage, I learned by this method that the individual which for some months I had been calling the male was actually the female.

The records reported in this paper were made chiefly on my farm in the valley of El General on the Pacific slope of southern Costa Rica, at about 2500 feet above sea-level, between 1942 and 1949. When no locality is given in the text, it will be understood that the observation was made in this vicinity. Here, at 9° north latitude, during the period from March to July inclusive, when the great majority of the birds are laying, the days are only slightly longer than the nights, and the sun rises at six o'clock or a little earlier. The birds, however, become active in the half-light, the time varying with the species and the season, but rarely more than 30 or 40 minutes before the sun's earliest rays fall upon the hilltop behind our house.

With wild birds it is not feasible to determine to the minute the time of laying. Usually I inspected the nest somewhat before the expected time of laying, to make sure that the egg had not yet been deposited, and again after the expected time, to view and mark the egg. Often the bird would be sitting

in the nest as I approached; then I would watch from a distance until she spontaneously flew away, or more often I would go off and return later. Since too frequent visits to the nest may upset a bird's routine or cause her to drop her egg elsewhere, inspections at intervals of less than half an hour are inadvisable. Often the bird may occupy the nest for the better part of an hour, or even more, laying her egg some time during this period. Even with continuous watching it may be impossible to tell just when the egg is dropped; for many small bird do not, like the domestic hen, stand conspicuously while extruding the egg. The best that one can do is to bracket the actual moment of laying between two observations whose closeness will depend upon how frequently the observer can visit the nest. Thus a certain irregularity in the data is inevitable. This will explain divergences in the method of presentation of the following records.

Although a few published reports on the hour of laying are quoted in the present paper, no effort has been made to collect all of those scattered through ornithological publications. To Mr. and Mrs. Darwin E. Norby I am indebted for a few of the records included herein, notably some of those on Salvin's Manakin.

2. TIME OF LAYING.

Fringillidae—Finches.

Arremonops conirostris Black-striped Sparrow.—The set in this locality generally consists of 2 eggs, laid with an interval of 25 to 26 hours. The first is deposited at or soon after sunrise, the second on the following day, usually between 7.00 and 8.00. Actual records follow :

	Egg 1	Egg 2
Nest 41	—	before 7.30
Nest 42	before 6.20	7.00–4.45
Nest 43	before 6.25	7.25–8.30
Nest 44	5.30–6.40	6.30–7.50
Nest 46	before 6.40	7.00–7.55
Nest 49	—	7.00–8.25
Nest 50	5.50–6.35	6.50–8.15

Atlapetes torquatus Striped Atlapetes.—The set regularly contains 2 eggs, laid on consecutive days. I have records of 3 second eggs, all of which were laid after 9.00, as follows: nest 14, 9.15–14.20 ; nest 18, 10.00–12 00 ; nest 23, 9.10–16.20.

Cyanocompsa cyanoides Blue-black Grosbeak.—Two eggs form the set. At nest 6 the first egg was laid before 9.30, the second before 10.15.

Saltator maximus Buff-throated Saltator.—The set regularly contains 2 eggs, laid with an interval of somewhat more than 24 hours, apparently sometimes as much as 26 hours. First eggs are generally deposited in the hour following sunrise, the second between 7.00 and 8.00 but sometimes later. Records follow :

	Egg 1	Egg 2
Nest 22	before 11.00	7.00–8.20
Nest 23	—	6.45–7.45
Nest 24	—	7.00–8.25
Nest 28	6.20–7.30	—
Nest 31	—	7.20–9.05
Nest 34	before 6.45	after 7.10
Nest 38	6.00–6.35	6.45–8.20
Nest 39	—	8·20–9.20
Nest 43	after 7.00	7.10–8.35
Nest 44	before 7.20	8.00–10.15
Nest 45	—	8.15–9.20
Nest 48	5.50–6.35	—
Nest 51	—	7.20–10.15

Saltator albicollis Streaked Saltator.—The set regularly consists of 2 eggs, laid on consecutive days. One second egg was laid between 5.30 and 6.55.

Sporophila a. aurita Variable Seedeater.—This tiny finch lays sets of 2, rarely 3, the eggs being deposited early in the morning on consecutive days. Seven second eggs were laid between 5.30 and 8.30, nearly all before 7.00. The actual records are 5.30–6.25, 5.30–6.30, 6.10–6.50, 6.10–7.30, 6.15–6.50, 5.50–6.40, 6.45–8.30. At a single nest I made records of the laying of both eggs, the first 5.40–6.40, the second 6.10–6.50. With this species the interval between eggs seems to be very nearly 24 hours.

Tiaris olivacea Yellow-faced Grassquit.—Sets contain 2 or 3, very rarely 4, eggs, laid early in the morning on consecutive days. The interval separating the deposition of the eggs appears to be very nearly 24 hours, and third eggs tend to be laid as early as second and first eggs. Seventeen eggs of all orders were laid between 5.10 and 6.40. Three of these eggs are known to have been laid before 6.00, 9 before 6.20. Only 1 is definitely known to have been laid after 6.00, and this was deposited 6.10–6.40.

Although early laying prevails among the local finches, a few, including the Striped Atlapetes, lay late in the morning. The interval between eggs is about 24 hours in the Variable Seedeater and Yellow-faced Grassquit, but 25 to 26 hours in the bigger Black-striped Sparrow and Buff-throated Saltator.

Thraupidae—Tanagers.

Eucometis penicillata Gray-headed Tanager.—Sets of 2 eggs, rarely 3, laid on consecutive days. At nest 16 egg 1 was laid before 6.45, egg 2 6.00–6.45. Another first egg was laid 6.00–7.00, and a second egg in a different nest was laid before 7.05.

Ramphocelus passerinii costaricensis Song Tanager.—Sets of 2 eggs, very rarely 3, laid before or soon after sunrise on consecutive days. The interval between laying is very nearly 24 hours, and second eggs are laid at about the same hour as first eggs. Thirty-five eggs, both firsts and seconds, were laid between 5.15 and 6.50, and none is known to have been deposited outside

this period. Eight eggs are known to have been laid before 6.00, 3 after 6.00. At least 22 of the layings fell within the interval 5.20–6.30. A few typical records follow :

	Egg 1	Egg 2
Nest 65	5.55–6.42	5.25–6.14
Nest 89	5.20–6.08	5.47–6.22
Nest 90	5.20–5.50	5.25–6.10
Nest 118	5.40–6.15	6.05–6.25
Nest 151	5.30–6.15	5.40–6.20
Nest 167	5.30–6.00	5.20–6.00
Nest 169	5.30–6.00	5.50–6.40

Tanagra luteicapilla Yellow-crowned Euphonia.—Two to 4 eggs in a set, laid early in the morning on consecutive days. At nest 2 egg 3 was laid before 6.35. At nest 17 egg 2 was laid 5.30–6.45, egg 3 was laid 5.35–6.35.

Tangara chrysophrys Yellow-browed Tanager.—Two eggs in a set, laid early in the morning on consecutive days. One second egg was laid 5.45–6.25.

Tangara gyrola Blue-rumped Green Tanager.—Two eggs in a set, laid early on consecutive days. One second egg was laid before 7.05.

Tangara icterocephala Silver-throated Tanager.—Two eggs in a set, laid before or soon after sunrise on consecutive days, rarely on alternate days. At nest 10 the second egg was laid before 6.00. At nest 12 egg 1 was laid before 5.50, egg 2 was laid 5.25–6.10. At nest 13, egg 2 was laid 6.10–7.00 on a dark and drizzly morning.

Tangara nigro-cincta Golden-masked Tanager.—The 2 eggs are laid early on consecutive days. Although at some nests the interval between eggs seems to be little over 24 hours, at others it is definitely in excess of 25 hours, as indicated by the following records :

	Egg 1	Egg 2
Nest 41	before 6.10	6.00–6.30
Nest 43	5.35–6.00	7.25–11.25
Nest 55b	5.40–6.30	7.20–8.55

Four other second eggs, not included in the above, were laid before 6.55.

Thraupis episcopus Blue Tanager.—Sets in this region contain 2 eggs, laid early on consecutive days, at an interval of about 24 hours.

	Egg 1	Egg 2
Nest 35	before 5.45	5.40–6.30
Nest 43	5.40–6.10	5.30–6.10
Nest 44	before 6.15	6.00–6.40

Seven other second eggs, not included in the above, were laid at some time before 7.40, 5 of these before 7.00, and 2 before 6.30.

Parulidae—Wood Warblers.

Basileuterus fulvicauda Buff-rumped Warbler.—The set regularly contains 2 eggs, laid with an interval of 24 hours, both early in the morning, before

or soon after sunrise. Six eggs were laid before 6.55, and at least 3 of these before 6.10. Only 1 of the 7 eggs for which I have records is known to have been laid after 6.30, this in the interval 6.30–7.50. At nest 15, egg 1 was laid before 6.10, egg 2 between 5.35 and 6.10 next day.

Myioborus miniatus aurantiacus Yellow-bellied Slate-throated Redstart.—The set contains 3 or sometimes only 2 eggs, laid on consecutive days. At Vara Blanca in the Costa Rican highlands I made records of 5 eggs which were laid before 7.40; but they may well have been deposited an hour or two earlier.

Coerebidae—Honeycreepers.

Coereba flaveola Bananaquit.—Sets of 2 eggs. A second egg was laid before 6.25.

Cyanerpes cyaneus Blue Honeycreeper.—Sets of 2 eggs, laid on consecutive days. Two second eggs were laid before 6.30.

Turdidae—Thrushes.

Catharus aurantiirostris Orange-billed Nightingale-thrush.—Sets of 2 eggs, laid with an interval of 1 or 2 days. One second egg was laid before 6.35.

Catharus occidentalis Russet-capped Nightingale-thrush.—Sets of 2 eggs. At Tecpam, Guatemala, a second egg was laid after 10.30.

Turdus grayi Gray's Thrush.—Sets of 2, 3, or rarely 4, laid on consecutive days, in the morning but at irregular hours, sometimes early but often toward noon. The single first egg for which I have a record was laid before 6.35. Of 5 second eggs, the earliest were laid 6.55–8.00 and 7.10–8.40, the latest 8.50–10.25 and 10.35–12.00. Of 4 third eggs, the earliest were laid 7.00–9.00 and 9.00–10.15, the latest 10.15–11.20 and 10.20–11.15.

Apparently the Turdidae are irregular in their hour of laying, sometimes depositing their eggs early in the morning, but often late. In the United States, Eastern Bluebirds *Sialia sialis* " lay rather late in the morning, usually around 8.30, which is about two hours after sunrise in the first week of March ", in Arkansas (Thomas 1946). A Mountain Bluebird *Sialia currucoides* laid her second to fifth eggs very early in the morning on successive days, but her sixth and last egg between noon and 16.45 (Haecker 1948). A Wood Thrush *Hylocichla mustelina* laid about 10.30 o'clock on 2 consecutive mornings (Weaver in Bent 1949). A Bicknell's Thrush *Hylocichla minima bicknelli* in one instance laid at noon (Wallace in Bent 1949).

Troglodytidae—Wrens.

Troglodytes musculus Neotropic House Wren. In Costa Rica sets contain usually 4 eggs, often 3, rarely 5, laid early in the morning on consecutive days, with an interval of 24 hours. I have records of 19 eggs of all orders, all laid before 7.00, and with one possible exception all before 6.40. Seven

of these eggs are known to have been laid before 6.15; the latest record is 6.25–7.00. Some selected records follow :

	Egg 1	Egg 2	Egg 3	Egg 4
Nest 27	before 6.35	5.50–6.20	6.25–7.00	—
Nest 29c	before 5.50	5.30–6.05	5.35–6.15	5.40–6.15
Nest 29d	—	before 6.10	before 6.20	before 6.30
Nest 34	—	5.30–6.35	5.30–6.40	5.55–6.25

In Arkansas, U.S.A., in April, when the sun rose at 5.21–5.26, a Carolina Wren *Thryothorus ludovicianus* laid her 5 eggs within an hour, or possibly a little more, after sunrise—the earliest 5.43–6.24, the latest 5.54–6.58 (Nice and Thomas 1948).

Tyrannidae—American Flycatchers.

Elaenia chiriquensis Bellicose Elaenia.—Sets of 2, laid toward the middle of the morning on alternate days, or more rarely on consecutive days, apparently usually between 7.00 and 9.00.

	Egg 1	Egg 2
Nest 20	before 9.50	before 8.10
Nest 47	8.00–11.00	—
Nest 49	7.00–9.00	—
Nest 50	—	7.20–9.00
Nest 51	7.50–10.00	before 10.35

Elaenia flavogaster Yellow-bellied Elaenia.—In Central America, sets regularly contain 2 eggs, laid in the middle or late morning on alternate days. The following records indicate an interval between eggs of about 48 hours. The first was made in Guatemala in 1932, the others in Costa Rica in later years.

	Egg 1	Egg 2
Nest 3	10.10–10.30	10.35–11.10
Nest 42	—	8.30– 9.10
Nest 43	—	9.00–10.05
Nest 44	9.05–17.00	8.30– 8.15
Nest 48	8.30– 9.55	—
Nest 50	—	10.35–17.20
Nest 54	9.45–13.05	before 8.30

Megarhynchus pitangua Boat-billed Flycatcher.—Sets of 2 or 3, laid usually on alternate days. A second egg was laid 10.00–12.05, another second egg 11.30–13.10.

Myiodynastes maculatus Streaked Flycatcher.—Sets of 2 or 3, laid (in 1 nest) on alternate days. A second egg was laid 9.50–10.10, on Barro Colorado Island, Panamá Canal Zone.

Myiozetetes cayanensis Cayenne Flycatcher.—Sets of 2, 3, or rarely 4, eggs, laid (in 1 nest) on alternate days. A second egg was laid 7.30–10.15, in the Canal Zone.

Myiozetetes granadensis Gray-capped Flycatcher.—Sets of 2, 3, or rarely 4, eggs, laid with an interval of usually 2 days, but at times 1 day and rarely 3 days. The eggs may be deposited at almost any time from an hour after sunrise until near noon. Of 21 recorded layings, the earliest was some time before 7.35, the latest 11.15–12.10. Two eggs were laid before 8.00, 4 before 9.00. Ten eggs were laid after 9.00 and 3 after 10.00. Mid-morning laying is indicated by 3 records, 8.00–10.00. No regular differences in time of laying in relation to the order of the egg are indicated by the records. A few selected records follow :

	Egg 1	Egg 2	Egg 3
Nest 24	10.00–12.30	—	7.40– 9.40
Nest 30	7.30– 9.25	7.30– 8.35	before 7.35
Nest 33	9.20–12.20	9.00–10.25	—
Nest 44	—	7.15– 9.30	8.00– 9.00
Nest 45	9.45–10.50	8.50–10.30	9.00–11.15

Myiozetetes similis Chipsacheery Flycatcher.—Sets of 2, 3, or 4 eggs, laid usually on alternate days but sometimes on consecutive days. One egg was laid in the middle of the morning, 8.25–9.50, but 3 were laid before 8.30, one of these before 7.45.

Tyranniscus vilissimus Northern Tyranniscus.—Sets of 2 eggs, laid during the first half of the forenoon, with an interval of 2 or 3 days between layings. One first egg was laid before 8.00, a second egg 7.40–9.00, another second egg 8.05–8.55.

Tyrannus melancholicus Neotropic Kingbird.—Sets of 2, 3, or rarely 4, eggs, laid on consecutive or alternate days. A first egg was laid before 9.00; 2 second eggs 9.35–11.00 and 11.30–13.00.

The flycatchers for which records are avilable lay during the forenoon, but later than most of the tanagers and finches. None has been known to lay before sunrise, but some lay close to midday. Even in the same species there may be great variation in the hour of laying, within the interval 7.00–12.00.

Pipridae—Manakins

Manacus aurantiacus Salvin's Manakin.—Sets of 2, laid around midday on alternate days. There are available 15 records of layings, 4 of which were made by Mr. Darwin Norby. No egg is known to have been laid before 11.00 and none after 14.00. Nine records fall definitely within this interval, but the others are indeterminate on one side or the other. Two eggs are known to have been laid before noon, the earliest before 11.45; 6 after midday, the latest 13.15–14.25. At nest 44 egg 1 was laid 10.30–15.30, egg 2 11.00–12.15.

Schiffornis turdinus Thrush-like Manakin.—Sets of 2. A second egg was laid 10.00–15.40.

Colibridae—Hummingbirds.

Amazilia tzacatl Rieffer's Hummingbird.—Sets of 2, laid on alternate days. A second egg laid before 7.15.

Phaeochroa cuvierii Cuvier's Hummingbird.—Sets of 2, laid on alternate days. Three second eggs laid 5.45–6.30.

Phaethornis longuemareus Longuemare's Hermit.—Sets of 2, laid on alternate days. Three second eggs laid 5.30–6.35.

Caprimulgidae—Goatsuckers.

Nyctidromus albicollis Pauraque.—This crepuscular and nocturnal bird lays 2 eggs; in one instance the interval between layings was 2 days. In Guatemala a second egg was laid 15.40–18.15; in Costa Rica a second egg 14.05–17.40. This is the only species included in this study which lays in the late afternoon, after 14.00.

Cuculidae—Cuckoos.

Crotophaga ani Smooth-billed Ani.—Several females lay in a communal nest, each depositing 4 to 7 eggs, about the middle of the day. The interval between layings for each female is generally 2 days. At a nest in the Panamá Canal Zone an egg was laid 11.45–16.45 and another 11.40–13.40. At a different nest belonging to the same flock of anis 2 females laid 2 eggs between 12.30 and 13.55, and on another day 2 eggs were laid before 12.55. Davis (1940) stated that in Cuba eggs may be laid at any time from before 7.00 to after 17.30, but are usually deposited in the early hours of the afternoon.

Crotophaga sulcirostris Groove-billed Ani.—My observations on this species were made chiefly in the Caribbean lowlands of Honduras and Guatemala in 1930 and 1932. The nest is built by a single pair, or more commonly by 2 or 3 pairs together. Each female lays 4 or sometimes only 3 eggs, with an interval of 2 to 4 days between layings. A first egg was laid 12.45–18.00, 2 second eggs 11.10–12.30 and 12.00–12.18.

3. TIME OF HATCHING.

With some species of birds eggs may hatch during the morning, afternoon, or night, with no strongly marked preference for a certain part of the day. With others there is a tendency for the eggs to hatch in a particular quarter of the 24-hour day. When this occurs, two possibilities may be considered: (1) there is a daily rhythm in the efforts of the birdling to break through the shell and escape; (2) the time of hatching is determined solely by the hour of laying and the incubation period, but is uninfluenced by a daily rhythm in development or in the activities which result in the birdling's emergence from the shell. Thus if the eggs are regularly laid at about 6 o'clock in the morning and the incubation period ranges from 288 to 294 hours, the eggs would hatch during the forenoon of the twelfth day after the set is completed.

Because the hour at which the event occurs is with many species less regular, the determination of the time of hatching is more difficult and time-consuming than in the case of laying; and only for a few species have I accumulated a somewhat significant volume of data. As a matter of convenience in recording these observations, the day was divided into 3 unequal periods: (1) the forenoon from dawn to noon; (2) the afternoon from noon to nightfall; and (3) the night of nearly 12 hours. One cannot visit nests of diurnal birds during the night without the risk of causing a disastrous disturbance. If the distribution of the hour of hatching is random, one would expect that nearly half of the total number of eggs would hatch during the night, a quarter during the forenoon, and a quarter during the afternoon. Marked deviations from this distribution would invite investigation.

For the Song Tanager I know the division of the day in which 27 eggs hatched. Eighteen of these hatched in the forenoon—10 in the early half and 5 in the late half, and 3 at an hour not more closely determined. Only 6 hatched during the afternoon and 3 during the night. If the distribution had been random during the 24-hour period, we should expect 13 to have hatched during the night, 7 in the morning and 7 in the afternoon. I believe that the observed distribution is adequately explained by the second of the alternatives given above: the eggs are laid with great regularity within half an hour of sunrise and the incubation period is normally a few hours in excess of 12 days, bringing the hatching into the forenoon of the twelfth day following the completion of the set. If incubation is delayed, the eggs hatch during the afternoon of the same day and, if severely delayed, during the following night, or even the next morning.

For the Gray-capped Flycatcher I timed the hatching of 19 eggs. Eleven hatched during the forenoon, of which 7 hatched before mid-morning and 3 between 9.00 and noon. Seven hatched during the night, but only 1 in the afternoon. Of 7 eggs of the related Chipsacheery, 3 hatched during the first half of the forenoon and 4 during the night, none during the late morning or afternoon. Taking the 2 species of *Myiozetetes* together, there are records of 26 hatchings, of which 14 occurred during the forenoon, 11 during the night, only 1 in the afternoon. With a random distribution, we should expect only 6·5 in the forenoon and an equal number in the afternoon.

With these flycatchers the hour of laying is far more variable than with the Song Tanager. The Gray-cap may deposit her eggs at any time from about an hour after sunrise until nearly noon. The completion of the set may require 5 or even 6 days, during which the eggs earlier laid receive a certain amount of warming. The period of incubation is also somewhat variable, in recorded instances ranging from 16 to 18 days. Moreover, the interval between the first fracture of the shell, which may be detected as a slight roughness when the egg is felt with the lips or a finger tip, and the final emergence of the nestling is both long and variable. In numerous instances

the birdling required more than 24 hours to break its way out of the shell; once it took at least 41 hours to escape. With the Chipsacheery, the incubation period is 15 or 16 days; and a roughening of the surface of the shell may be detected from 24 to 36 hours before the egg hatches. Taking all these facts together, I hold it unlikely that the hour of emergence of the birdling is determined by constancy in the hour of laying the eggs and in the length of the incubation period. Apparently the first of our alternatives holds here. It seems likely that the birdlings begin active efforts to break their way out of the shell at some time during the night, probably towards daybreak, and continue through the following morning. If they have not succeeded in effecting their release by midday, they rest through the afternoon and perhaps the greater part of the night, resuming their hammering at the shell toward morning and escaping before the following noon. This explanation does not rest upon actual observation of the behaviour of the birdling within the egg, but it fits the recorded facts. Whitman found that eggs of captive Mourning Doves *Zenaidura macroura* usually hatched in the early morning or between 10 o'clock and noon. If the egg does not hatch by 15 o'clock, one may be fairly certain that it will not do so until the next morning (quoted by Nice 1922). This suggests a diurnal rhythm in the activities which lead to emergence from the shell similar to that of *Myiozetetes*.

TABLE 1. *Time of Hatching of some Finches, Tanagers and Wood Warblers.*

Species	No. of eggs hatched during			Total eggs
	night	forenoon	afternoon	
Arremonops conirostris	2	2	0	4
Atlapetes torquatus	0	2	0	2
Saltator maximus	2	5	3	10
Sporophila aurita	5	8	2	15
Tiaris olivacea	1	5	0	6
Ramphocelus passerinii	3	18	6	27
Tangara chrysophrys	2	0	0	2
Tangara icterocephala	2	0	0	2
Tangara nigro-cincta	3	3	2	8
Thraupis episcopus	2	3	1	6
Basileuterus fulvicauda	5	5	1	11
Totals	27	51	15	93

Schrantz (1943) found that of 119 eggs of the Yellow Warbler *Dendroica aestiva* only 9 hatched during the afternoon, the other 110 during the night or early morning. With other passerine birds, also, hatching occurs with reduced frequency during the afternoon. Table 1 gives such pertinent data as I have on the time of hatching in three families, the finches, tanagers and wood warblers. The table includes records for 93 eggs of 11 species. Of these, 27 hatched during the night and 51 during the forenoon; but during the afternoon only 15 instead of the 23 which would be expected if the distribution were random. In the forenoon, however, more than twice the expected number of eggs hatched. In these groups there appears to be a tendency for the birdlings to be most active in pushing out of the shell during the (late ?) night and forenoon, although the restriction to certain times of day is not so marked as in *Myiozetetes*. How widespread among birds this trait may be only further studies can tell us. Of 8 eggs of Gray's Thrush, 4 hatched in the afternoon; and of 7 eggs of the Neotropic House Wren, 3 hatched in the afternoon. The numbers are too small to permit the drawing of conclusions, but suggest that in these species a different periodicity prevails.

4. CONCLUSIONS.

The foregoing observations make it evident that in a single locality there are wide variations in the hour of laying of the several species of birds. Each species has its own time for laying, which it follows with more or less constancy. The 8 species of tanagers for which records are available are all early layers, depositing their eggs from before to soon after sunrise. Of the 6 finches, 5 are early layers, but one, *Atlapetes torquatus*, lays after the middle of the forenoon. The two wood warblers both lay early, as do the two honeycreepers. But Gray's Thrush may lay at almost any hour of the morning; and the information available for other thrushes shows that in this family the hour of laying tends to be variable. The Neotropic House Wren is a consistently early layer.

Turning now to the sub-order Tyranni or Clamatores (non-oscinine Passeriformes) we find that the 9 species of American flycatchers lay well after sunrise and sometimes close to midday. Even in the same species there may be great range in the hour of laying, especially in the Gray-capped Flycatcher; but no instance of laying after midday has been recorded. In the related family Pipridae, Salvin's Manakin regularly lays in the middle of the day, from 11 to 14 o'clock. A single record of the Thrush-like Manakin, whose nest is seldom found, also indicates laying during the middle hours of the day.

Records of 3 species of hummingbirds show early laying. The only bird included in this study whose habits are not strictly diurnal is a goatsucker, the Pauraque; and it is significant that this species, active in the twilight and moonlight, is the only one for which laying in the late afternoon was recorded. Among the cuckoos, 2 species of anis lay in the middle of the day. These black birds, which hunt insects in grassy and weedy fields, often perch quietly in the early morning and become more active after the sun has dried the dew from the herbage, in this respect contrasting with the tanagers, finches, and other small passerines, which fly and hunt busily before sunrise.

Of birds whose set of 2 eggs is laid on consecutive days, some deposit the first and second eggs at about the same hour. Among these are the

Song Tanager, several species of *Tangara*, the Blue Tanager, the Variable Seedeater, and the Buff-rumped Warbler. Other two-egg passerine birds lay the second egg an hour or two later in the day than the first, so that the interval between layings is 25 or 26 instead of being about 24 hours. Examples of this are 2 finches, the Black-striped Sparrow and the Buff-throated Saltator. Of the oscinine birds whose sets contain 3 or 4 eggs, both the Yellow-faced Grassquit and the Neotropic House Wren deposit all their eggs at about the same hour, the interval between layings being very nearly 24 hours.

Birds which lay early in the morning, at about sunrise, are far more constant in their hour of laying than those which deposit their eggs later in the day. This contrast is brought out by a comparison between such early layers as the tanagers, finches, wrens and wood warblers and late layers like Gray's Thrush and the flycatchers.

The hour of hatching of a single species, or at a single nest, is usually far more variable than the hour of laying. If the hour of hatching were wholly random, we should expect nearly half the eggs to hatch during the nearly 12 hours of darkness in regions near the Equator, a quarter of the total number in the forenoon and a quarter in the afternoon. Some species show a significant deviation from this distribution. With flycatchers of the genus *Myiozetetes*, practically all of the eggs hatch during the night and the forenoon, only very rarely does one hatch in the afternoon. The birdlings, as mentioned, may take well over 24 hours to break their way out of the shell. It seems probable that the observed distribution of the hours of hatching results from a diurnal rhythm in their activity. Flycatchers are not particularly close sitters by day, but there is no reason to suppose that these highly diurnal birds emerge from their nests during the hours of darkness. Probably the constant warming during the night stimulates those activities of the birdling which result in its breaking out of the shell. Apparently it rests during the afternoon and probably the early part of the night, and endeavours most actively to escape during the latter part of the night and early morning. Further observations would be required to prove this hypothesis.

With the Song Tanager, well over half the eggs hatched during the forenoon and very few during the night. Although here, too, there may be a diurnal periodicity in the birdling's efforts to escape, this hypothesis is unnecessary to explain the observed facts. The Song Tanager lays regularly at about sunrise, and its usual incubation period is between 12 and 12¼ days, which would bring the time of hatching to the forenoon of the twelfth day after the completion of the set. Constancy in the time of hatching may be caused merely by constancy in the time of laying and in the rate of development of the embryo. However, information is presented which suggests that among tanagers, finches and wood warblers there is also a daily rhythm in the activities which lead to the birdlings' escape from the shell. They seem to be least active in the afternoon, although their quiescence is not so marked as in *Myiozetetes*. An apparent advantage of hatching early in the day is that the nestling can be promptly fed; whereas if it hatched late in the afternoon or after nightfall it might have to wait many hours for its first meal.

SUMMARY.

1. Observations on the hour of the day when the eggs are laid are presented for about 40 species of Central American birds; observations on the hour of hatching for about 14 species.

2. In a single locality each species has its own time for laying. There are also well marked family trends, to which, however, exceptions are found. Tanagers, finches (with one decided exception), wood warblers, honeycreepers, wrens, and hummingbirds usually lay early, from before to soon after sunrise. *Turdus grayi* lays considerably later. American flycatchers lay consistently later than the tanagers, finches, etc., often waiting until the second half of the forenoon. *Manacus aurantiacus* and two species of *Crotophaga* lay around midday; the goatsucker *Nyctidromus albicollis* rather late in the afternoon.

3. Birds which lay about sunrise show less variation in the hour of laying than those which lay later in the day.

4. Among birds which lay sets of two, some deposit both at about the same hour, so that the interval between layings is about 24 hours (*e.g.* tanagers and very small finches). Others lay the second egg later in the morning than the first, so that the interval is 25 or 26 hours (*e.g.* the larger finches *Arremonops* and *Saltator*). *Tiaris olivacea* which has sets of two or three, and *Troglodytes musculus* whose set is three or four, both lay their eggs at intervals of approximately 24 hours.

5. The hour of hatching, for a given species or in a single nest, is more variable than the hour of laying.

6. With flycatchers of the genus *Myiozetetes*, eggs hatch during the (late ?) night and forenoon, scarcely ever in the afternoon. Apparently there is a diurnal rhythm in the birdling's efforts to break through and escape from the shell.

7. With the tanager *Ramphocelus passerinii*, eggs hatch predominantly in the forenoon, not infrequently in the afternoon, rarely during the night. Here the predominance of hatching in the forenoon may be caused by constancy in the hour of laying and in the length of the incubation period when this is not retarded.

8. Among passerine birds, there seems to be a well marked tendency for eggs to hatch in the afternoon far less frequently than would be expected if the distribution of this event were random through the 24 hours of the day. But apparent exceptions are noted.

LITERATURE CITED.

BENT, A. C. 1949. Life histories of North American thrushes, kinglets, and their allies. Smithsonian Inst. Washington.

DAVIS, D. E. 1940. Social nesting habits of the Smooth-billed Ani. Auk 57 : 179–218.

HAECKER, F. W. 1948. A nesting study of the Mountain Bluebird in Wyoming. Condor 50 : 216–219.

NICE, M. M. 1922–23. A study of the nesting of Mourning Doves. Auk 39 : 457–474, 40 : 37–58.

NICE, M. M. and THOMAS, R. H. 1948. A nesting study of the Carolina Wren. Wilson Bull. 60 : 139–158.

SCHRANTZ, F. G. 1943. Nest life of the Eastern Yellow Warbler. Auk 60: 367–387.

THOMAS, R. H. 1946. A study of Eastern Bluebirds in Arkansas. Wilson Bull. 58 : 143–183.