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# Article III.—THE NESTING HABITS OF WAGLER'S OROPENDOLA (*ZARHYNCHUS WAGLERI*) ON BARRO COLORADO ISLAND

By Frank M. Chapman

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## INTRODUCTION

The field studies on which this paper is based were made at the station of the Institute for Research in Tropical America, on Barro Colorado Island, Canal Zone, Panama. They cover the greater part of three nesting seasons, and the period immediately preceding them, as follows: (1) December 27, 1925 to February 20, 1926; (2) December 22, 1926, to April 2, 1927; (3) December 22, 1927 to April 1, 1928. During the first season only part of my time was given to this work; the second and third seasons it was my chief occupation.

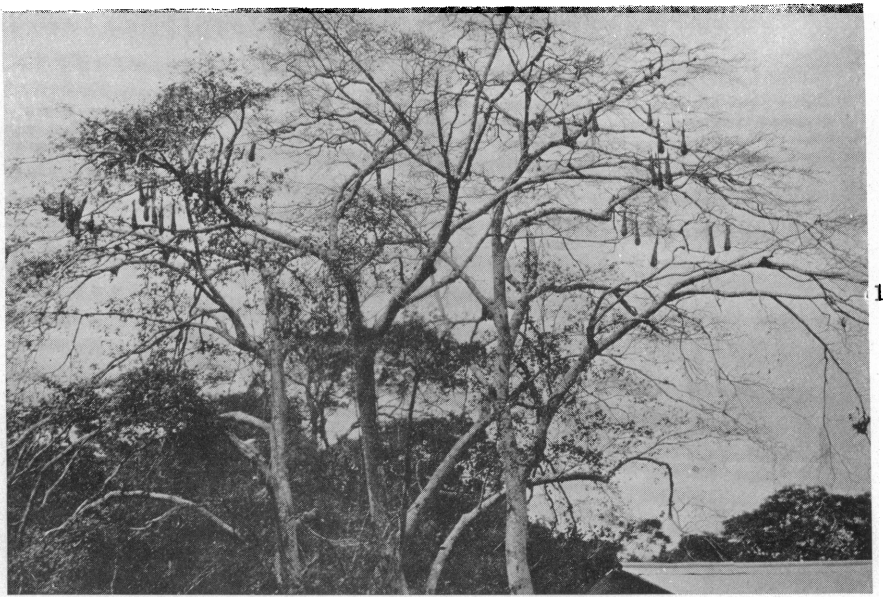
The colony of birds under investigation nested in a sand-box tree (*Hura crepitans*) growing about 100 feet from the northerly corner of the Institute's main building; a situation favorable for continuous observation of the birds from the time of their first appearance in the morning until they retired in the evening. On the other hand, the nature of the nesting-sites prohibited examination of the contents of the nests *in situ* and the

only specimens of nests, eggs, or young obtained were the few that fell through the accidental breaking of the limbs to which the nests were attached. These gave a limited amount of data with which to check conclusions based on observations made from a distance.

In 1924, when the Institute's station was established on Barro Colorado, a colony of oropendolas occupied a tree about 100 feet from the one now used. On June 26, 1925, possibly because it was deprived of the protection of the trees that had grown near it, this tree fell before the wind. It contained 57 nests. The following nesting season the birds selected the tree now used. The present tree, therefore, was apparently chosen because of its proximity to the one which fell, rather than for its special fitness in affording suitable nesting-sites. It is a sand-box tree 132 feet in height, growing from near the bottom of a steep slope about thirty feet below the level on which the laboratory stands. The lowest nests were about 100 feet above the base of the tree, the highest about twenty feet below its top. The nearest nests to our viewpoint at the laboratory level were distant about eighty feet. This statement is of interest chiefly from the standpoint of the photographer. With an elaborate equipment, including lenses up to twenty-three inches in focal length, the distance, a background of leaves, the comparatively small size and dark colors of the birds, prevented me from securing adequate photographs of them.

The conditions under which the birds were watched were far more satisfactory. My observation post was the open space beneath my house situated fifteen feet higher than the laboratory, and about 100 yards from the tree in which the oropendolas nested. Seated in a camp-chair with a desk-board across its arms, and using a 24-power binocular mounted on a tripod, the birds, wholly unaware of my presence, seemed to be within reach of my hand. Every detail of their movements, even to the motion of the tongue when calling, could be seen clearly and with such ease that I could observe and record their actions for hours at a sitting without fatigue. I did not acquire this high-power glass until the second season. Its lack in 1925–1926, when an 8-power glass was used from the laboratory level, greatly detracted from the value of that season's work.

Diagrams were made showing the relative position of the nests. Each one was numbered and its history, as far as possible, carefully recorded. When last observed, the colony of 1926 contained thirty-nine nests; that of 1927, twenty-nine nests. In 1928 sixteen nests were built but, for various reasons, as recounted beyond, all were deserted, apparently before eggs were laid, and the colony was abandoned.



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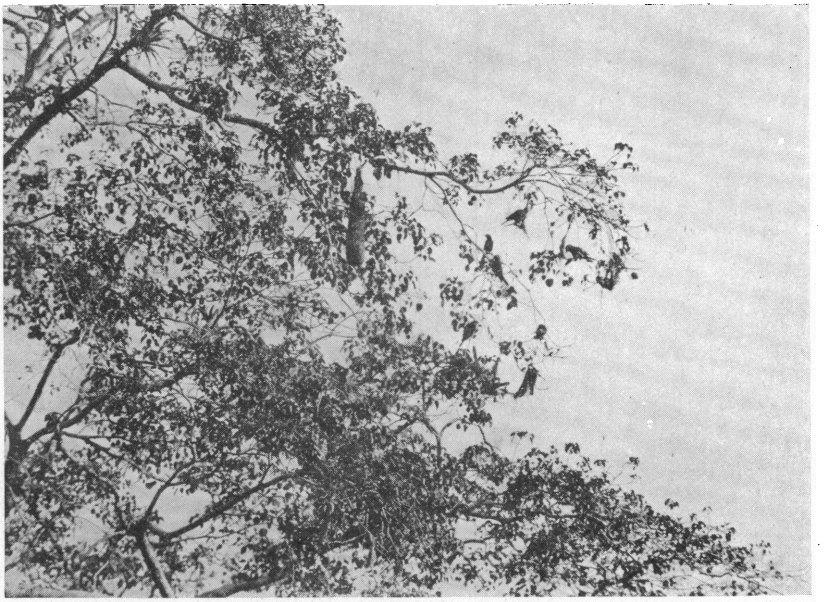

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PLATE II

Fig. 1. The *Zarhynchus* colony in the sand-box tree, from the point at which, with the aid of a 24-power binocular, most of the observations on which this paper is based were made. The roof of the main laboratory building appears in the right foreground. Photographed with a 14-inch lens.

Fig. 2. Eight females of *Zarhynchus* beginning to build their nests in the sand-box tree. Group 1 of the colony of 1927, January 8. An old nest hangs at the left of those under construction. (See page 144.) Photographed with a 14-inch lens, from the laboratory level.

It is a significant comment on our lack of knowledge of the habits of tropical American birds that, although by size, voice, and nests the oropendolas and caciques are among the best known birds of that region, their life histories are as yet unwritten. One finds short descriptions of their loud notes and the postures of the male when calling, of the appearance and, in some few cases, structure and contents of their nests. There are also several records of parasitism by *Cassidix oryzivora*, but all the statements made are based on casual or brief observations and no definite, continuous study of any member of the group has apparently been made.

The oropendolas offer, however, an exceptionally interesting subject for the field student. If the nature of the nesting-site prohibits close examination of the nest *in situ*, it at least gives an admirable view of the colony as a unit and hence of the group activities of its members. The movements of the individual may also be closely followed and the colonial habits of the species enable one to observe a number of birds at the same time and under similar conditions. Thus, one can more readily distinguish normal from exceptional habits. While I hope that my observations have covered a long enough period to reveal the more fundamental facts in the home-life of *Zarhynchus*, it must be remembered that they relate to but one colony of these birds. They should be regarded, therefore, merely as the starting point for a further study of this species and of other members of the oropendola-cacique group.

## RELATIONSHIPS

*Zarhynchus wagleri* is a member of the group[1] of icterine birds known as oropendolas.[2] With the caciques[3] they were placed by Sclater in a subfamily, Cassicinæ, of the family Icteridæ, a distinction not currently recognized.[4]

So far as the records and my own experience[5] go, all these birds nest in colonies, build pensile nests, and nest during the dry season. The great age of these groups is indicated by the marked structural differences existing between certain of the genera which compose them, and we may assume at least a corresponding age for those nesting habits which they possess in common.

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[1]Genera: *Zarhynchus*, *Ocyalus*, *Clypeicterus*, *Ostinops* and *Gymnostinops*.

[2]This is the Spanish name for the Old World oriole (*Oriolus oriolus*), which, like the English name "oriole," has been applied to a New World bird. It is based on the European bird's golden color and habit of building a pendulous nest, but, so far as the color of the plumage is concerned, is not strictly descriptive of any New World species to which it is applied.

[3]Genera: *Cacicus* and *Cassiculus*.

[4]Cf. Ridgway, 1902, Bull. U. S. N. M., 50, II, p. 172.

[5]*Cacicus cela* and *Ostinops decumanus* in Trinidad and Colombia; *Ostinops salmoni* in Colombia; *Gymnostinops montezumæ* in Mexico.

*Zarhynchus wagleri* inhabits the humid Tropical Zone from southern Mexico to western Ecuador. In Colombia it is known only in the Colombian-Pacific Fauna. Specimens from the northern part of this range (Guatemala and probably northern Honduras northward) average slightly smaller and are somewhat darker. They represent the race known as *Zarhynchus wagleri mexicanus*. Combining characters of the most unlike members of the group, it is difficult to say to which *Zarhynchus* is most closely related. As with *Clypeicterus* and *Ocyalus* the maxilla is expanded into a broad frontal shield covering the forehead; the wings are even more pointed, the outer primaries more incised than in the latter; it differs from both these genera and agrees with the remaining members of the group in possessing occipital plumes, which are as highly developed as in *Ostinops decumanus*. In general color it is also nearest to that species and this resemblance, in connection with the fact that the ranges of the two species meet only in northwestern Colombia and in Panama, may possess some significance.

In view of the fact that the subtropical and hence, presumably, more recently evolved oropendolas[1] have a yellow band or marks at the base of the maxilla, it is noteworthy that two young *Zarhynchus* taken from fallen nests on Barro Colorado, June 26, 1925 and April 1, 1927, respectively, and a young female with half-grown tail taken in eastern Panama, May 27, all have well-marked yellow, supraloral marks.

Chiefly for the purpose of affording a basis for comparison of the sexes I append a brief description of *Zarhynchus*.

MALE.—Head, neck all around, throat and upper breast seal-brown; upper back and wings glossy black; lower back and rump and upper tail-coverts chestnut; tail bright yellow, the two central feathers and outer webs of the outer pair black; sides seal-brown shading through the flanks and ventral region to chestnut lower tail-coverts. Feathers at the base of the frontal shield elongate, those in the center of the occiput reaching an average length of 50 mm. and with a basal width of about 2 mm.; two outer primaries incised or narrowed near their ends; bill large, heavy, and sharply pointed, the maxilla expanded over the entire forehead as a broad, rounded elevated shield. Length (skin), 350; wing, 215; tail, 130; culmen, 68; greatest width of frontal shield, 21 mm.

FEMALE.—Differs from the male chiefly in her smaller size. The black of the body is less extensive and less glossy but this difference is too slight to be noticeable in life. The bill is much smaller, its frontal development less pronounced, the frontal crest shorter and of fewer feathers; and the primaries are only slightly incised. In flight, the radiation of the ends of the primaries is less pronounced and this character, the absence of sound when flying, and smaller size are the characters which in life distinguish the female from the male. Length (skin), 268; wing, 153; tail, 102; culmen, 51; greatest width of frontal shield, 16 mm.

[1] *Ostinops alfredi, O. atrocastaneus, O. sincipitalis.*

## SEASONAL MOVEMENTS

In a broad sense *Zarhynchus wagleri* is a resident, non-migratory species. Studied locally and intensively and on Barro Colorado, at least, it is non-resident and migratory. It appears at its breeding station with remarkable regularity and at the conclusion of the nesting season leaves it. While breeding, all its wants are supplied in the forest near its home; at this time it probably rarely goes more than 400 yards from its nest-tree. The extent of its wanderings at other times of the year is unknown, but its appearance within the nesting territory during the non-breeding season is purely casual.

While *Zarhynchus* breeds during the dry season, the date when it begins to nest is not closely dependent on the cessation of rain. There has been much variation in the date on which the wet season may be said to have ended and the dry begun on Barro Colorado during the three years the oropendolas have been under observation, as the appended data from the laboratory rain-gauge show.

As for temperature, it varies so little during the year that it probably plays no part in determining the season when birds nest. Possibly this is one of the reasons, perhaps the chief reason, why birds in the tropics nest throughout the year. The mean temperature for July in Panama is 81.1°; for February, 80.8°; a difference of only three-tenths of a degree. Comparison of the mean temperatures on Barro Colorado for December and January of the three years covered by my studies of *Zarhynchus* shows a slight decrease in the second month the first year, a negligible increase in the remaining two. The data follow:

MEAN TEMPERATURE FOR DECEMBER AND JANUARY 1925–1928

| | | | |
|---|---|---|---|
| Dec. 1925 | 82 | Jan. 1926 | 80.5 |
| Dec. 1926 | 79.5 | Jan. 1927 | 80.2 |
| Dec. 1927 | 80.1 | Jan. 1928 | 80.6 |

TABLE OF RAINFALL ON BARRO COLORADO ISLAND DURING DECEMBER AND EARLY JANUARY, 1925–1928

| December | 1925 | 1926 | 1927 |
|---|---|---|---|
| 1 | .05 | .81 | .64 |
| 2 | .22 | .13 | .10 |
| 3 | 1.67 | .22 | 0 |
| 4 | 1.76 | .25 | .15 |
| 5 | .47 | .24 | .78 |
| 6 | .13 | 3.06 | 0 |
| 7 | 0 | 1.36 | 0 |
| 8 | 0 | T | .30 |

| December | 1925 | 1926 | 1927 |
|---|---|---|---|
| 9 | 0 | .04 | .36 |
| 10 | 0 | 1.02 | .07 |
| 11 | 0 | .34 | .02 |
| 12 | 0 | .89 | 0 |
| 13 | 0 | 1.05 | 0 |
| 14 | 0 | .55 | 0 |
| 15 | 0 | .13 | 0 |
| 16 | 0 | .11 | 0 |
| 17 | 0 | .33 | 0 |
| 18 | 0 | T | 0 |
| 19 | 0 | T | 0 |
| 20 | .02 | 0 | .10 |
| 21 | 0 | T | 1.40 |
| 22 | 0 | .45 | 1.50 |
| 23 | 0 | .62 | .40 |
| 24 | 0 | .18 | .03 |
| 25 | 0 | 0 | 0 |
| 26 | 0 | 0 | .08 |
| 27 | 0 | 0 | .83 |
| 28 | 0 | .32 | 0 |
| 29 | 0 | .04 | 0 |
| 30 | 0 | 0 | 0 |
| 31 | 0 | .08 | 0 |
| Total | 4.32 | 12.22 | 6.76 |

| January | 1926 | 1927 | 1928 |
|---|---|---|---|
| 1 | 0 | .41 | 0 |
| 2 | 0 | .02 | 0[1] |
| 3 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 |
| 5 | 0 | .19 | 0 |
| 6 | 0 | .12 | 0 |
| 7 | 0 | 0 | 0 |
| 8 | 0[1] | .25[1] | 0 |
| 9 | .16 | .12 | .07 |
| 10 | .40 | .96 | .17 |
| 11 | 0 | .08 | 0 |
| 12 | 0 | .48 | .10 |
| 13 | 0 | 0 | 0 |
| 14 | .20 | 0 | 0 |
| 15 | 0 | .18 | 0 |
| Total | .76 | 2.81 | .34 |

[1] *Zarhynchus* began to build nests.

The end of the wet season, therefore, varied from December 6 in 1925 to at least January 12, in 1927. That this variation was not reflected in the dates when the oropendolas began to nest will be seen from the following data:

Dates at which *Zarhynchus wagleri* began to nest at Barro Colorado Laboratory, 1926–1928.[1]

| | | | |
|---|---|---|---|
| 1926 | Nesting | began | January 8 |
| 1927 | " | " | January 8 |
| 1928 | " | " | January 2 |

This remarkable periodicity indicates the regularity of the annual physiological cycle of the species. While in the main coincident with the dry season the bird's exact nesting period does not appear to be affected by the annual fluctuations in the date when the wet season ends, but rather is governed by those sexual changes which mark the approach of the season of reproduction. They prompt the birds to go, we may say, to migrate, to the nesting-tree. The extent of the migration we do not know. The birds may spend their lives within a radius of not more than a mile or two from the place of their birth. The significant fact is that the journey to their nesting range is begun in response to a periodically recurring physiological condition, that it is made regularly to a definite place, presumably before visited, and that as such it is fundamentally as true an example of migration as though it were made from the South Temperate to the North Temperate Zone.

The case is paralleled by the return of tropical sea-birds to their nesting-grounds situated within the limits of their winter wanderings, to which I long ago called attention in a paper[2] designed to show that primarily bird migration was, and is, induced by those developments in the sexual organs which precede the season of reproduction. Hence, it follows, that if because of sterility or immaturity this development does not occur, the bird in which it is lacking may remain in its winter quarters throughout the nesting season.[3]

The members of the laboratory colony do not all begin nesting at the same time. Just as with migrants to the Temperate Zone there are late arrivals. Thus in 1926, new nests were begun as late as February 11, in 1927 on February 13, and 1928 on February 7.

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[1]Compare also the nesting dates given beyond for the violet-throated hummingbird (*Anthracothorax violaceicollis*).

[2]1894, 'Remarks on the Origin of Bird Migration,' The Auk, XI, p. 12.

[3]In mid-July, 1922, I took specimens of both sexes of the following Arctic-breeding shore-birds in southern Ecuador: *Squatarola squatarola, Numenius hudsonicus, Limnodromus griseus scolopaceus*. None had the sexual organs enlarged. See 'Distribution of Bird-Life in Ecuador,' 1926, Bull. Amer. Mus. Nat. Hist., LV, pp. 192, 194.

Short visits are paid to the nest-tree some days before nest-building actually begins. In the season of 1926 I made no record of such visits. The following year I reached the island on December 22, 1926, and the appended observations were recorded before January 8, 1927, when nest-building began.

### Season of 1926–1927

December 23.—Two males call in the tree in the early morning and then soon depart.

December 24.—No birds seen in the tree; one heard in the distance.

December 29.—Three reported but sex not stated.

December 30.—A male calls at 7:15 A.M. and later one female visits the tree.

December 31.—A male calls in the early morning and several females come for a short time later.

January 1, 1927.—One male and one female came.

January 2.—One bird heard in the distance.

January 3–5.—Observer absent.

January 6.—*Zarhynchus* shows a group interest in the nest-tree. First came a male with four females, then two males with eight females. The first group left with the male, in the second, the two males went off together while, later, the eight females flew off in another direction. Nothing is decided and no actual construction has begun. The birds are site-hunting and follow each other closely. When one female goes to inspect a new limb all the others follow her. There was one combat between two of them; at 9A.M. all the birds had left the tree for the day.

January 7.—At 8 A.M. two males and three females came to the nest-tree for a short stay, the females following each other about. At 8:30 two males flew over alone; they lit in the forest and called. Three males in the tree call; no females come. A little later there were eight females and one male in the tree. The females examined remains of old nests and soon left together.

January 8.—Nest-building began.

### Season of 1927–1928

In the nesting season of 1927–1928, I reached the island on December 22, 1927, and my notes, until the birds began to build, are as follows:

December 22-25, 1927.—No oropendolas seen.

December 26.—At 8:30 A.M. a male calls a few times and leaves.

December 27.—No birds seen in nest-tree; one heard in the distance.

December 28.—Male visits tree and calls at 6:20 and 8:20 A.M. Heard later in the distance but not seen in the tree again.

December 29.—At 7:30 A.M. two males call in the tree. Later three females, acting as a unit, fly from place to place prospecting. Grapple and whirl while fighting, once. A male in the tree but, as usual, they ignore him.

December 30.—Two females prospect together. A male calls, definitely addressing them and thus beginning his prolonged courtship.

December 31.—Observer absent.

January 1, 1928.—Two females worked on an old foundation, and a male called vigorously.

January 2.—Nest-building began.

It will thus be seen that preliminary visits are paid the nest-tree some days before nesting actually begins.

## THE QUESTION OF A SECOND BROOD

The nesting season of *Zarhynchus* is so closely associated with the dry season that it is difficult to believe that they nest also in the wet season. Nevertheless, the facts indicate that at least some birds breed after the rains begin, though whether their activities represent an actual second breeding season or are individual I am unable to say. I, myself, have not been on Barro Colorado between April 2 and December 22 and for the following observations, made during this period, I am indebted chiefly to Dr. J. Van Tyne of the University of Michigan.

Dr. Van Tyne writes that only one of the 57 nests in the tree that fell on June 26, 1925, contained anything. This nest held two nestlings nearly ready to fly. A male collected on this date had testes measuring 17 mm. in length.

On July 8, 1925, 43 nests were counted in the oropendola colony situated about 400 yards from the laboratory. Eight or ten birds were present and at least three or four nests were in use. A male collected at this colony on July 9 had testes measuring 19 mm. in length.

In 1927, after my departure on April, 2, Dr. Van Tyne reports that on April 5 he saw young fed for the last time in nests that had been begun on January 8 and adds the following observations:

April 5.—Noticed two females fighting over what seems to be a prospective nest-site somewhat to the right of any of the present nests.

April 9.—Returning this afternoon from Panama City (Pearl Island trip) I find a whole group (I count a dozen) of new nests being started. The group is situated immediately to the right of and somewhat lower than the old right-hand group of nests. One nest is well along (⅓ length) and the rest merely started. I have seen no bird yet using any of the five marked [old] nests. I suppose they are empty by now. Are not the new nests being built for second broods?

April 11.—The nest-building is progressing rapidly. There are now nineteen nests under construction and more apparently being started. The males have been much more noisy since this new nest-building began. Also the false-alarm business (i.e., cackle and dive for safety) has been much more frequent. *Legatus* and *Cacicus* are much in evidence. *Legatus* looks into some of the old nests but does not enter. *Cacicus* merely sits around and sings.

April 12.—I can now count twenty-two new nests. Only about four of the old nests seem to be still occupied. The females that are building are continually stealing nesting material from each other and from old nests.

April 14.—There are ten of the nests which are now completed as far as the outside is concerned—they continue to work inside. All of these nests are strikingly shorter than the first brood nest. Most of them are barely a foot long.

April 19.—At 6 A.M. (eight minutes before sunrise) the oropendolas were nearly all at their nests about to begin work. 6:30 P.M. none of the females are roosting in the nests yet. But there are several of the old nests still in use.

April 21.—Only eighteen of the new group of nests appear to be under active construction. Others seem to have stopped entirely and are probably discarded. Today six new nests were started in a separate group about half-way between the two old groups of nests and some ten feet lower. All are close together on the same branch. Why do they do things by groups like this? What is this smaller group within a nesting colony?

On April 26 the wet season began—3.78 inches rain. Rain continued—averaging nearly an inch a day. This seems to have stopped the oropendolas. They continued to hang around for nearly a week but finally gave up and left entirely. *Legatus* is still hanging around (May 11) as ineffectual as ever. *Cacicus* makes rare visits to the abandoned colony but the oropendolas (*Zarhynchus*) almost never.

In July, 1928, Mr. Zetek reported to me the presence of 11 oropendola nests in a large outstanding tree near the observatory on the summit of the island. These nests had not been built when I left the island on April 2, nor were the birds known to nest in these trees at any previous time. Mr. Jay A. Weber, who was on Barro Colorado from July 22 to August 10, 1928, at my request, made repeated observations of these nests and he reports that no oropendolas were seen near them or indeed on the island during his stay.

Possibly these nests were built in April before the rainy season began, by the birds that had been prevented from nesting in the sand-box tree at the laboratory. On the other hand, taken in connection with Dr. Van Tyne's observations, recorded above, this late building may indicate a regular attempt at the production of a second brood.

## VOICE

The notes of *Zarhynchus* are loud, varied and frequently uttered. Those uttered by both sexes are (1) the characteristic blackbird "chuck" or "chut," which is apparently a location call or conversational note, and its varying tone doubtless conveys varying meanings; (2) a "cack-cack" development of the call-note which expresses suspicion and alarm. This is given by the male more frequently than by the female whose voice joins that of the male in the presence of actual or suspected danger, as described beyond. The call is then louder, uttered more rapidly and resembles the sound produced by a small watchman's rattle, or "matraca"; (3) a whining call which seems to be a note of combat, real or threatened. This is given by the males when two or more at close quarters are courting the same female, and by the females when in the contest for a nest-site they grapple and whirl downwards. The females also sometimes

whine just after entering the nest, but the significance of the note is then not apparent.

The notes peculiar to each sex are the female's gasping "wee-chuck-chuck-chuck," a low husky gurgle which one bird addresses to another in disputes over the nesting-site, and the male's announcement of presence and his song. I distinguish between these two calls of the male, but lack of experience with the species in the non-breeding season makes the distinction an arbitrary one.

I at once confess my inability to transcribe the male's calls either by notation or syllabification, and faith in my power to convey even an approximate idea of them is weakened by the fact that, for the greater part, descriptions written one year mean little or nothing the next! What I have termed the announcement of presence call is uttered before courtship begins, when, for example, the male is alone in the nest-tree. I write it as "agua" or "waco" or "chap-pa-qua"; "hope you choke."[1] The tone is loud, deep, liquid and gurgling and the call is usually interspersed with "chucks." The courtship, or "crash" call, which I consider the male's real song, begins with the one just described and adds a sputtering crackle ending in an explosive crash. In my notes I have also termed this remarkable production a sputtering, masticatory, ejaculation. The polysyllables help convey some idea of its character. This call, as described under courtship, is given with obvious muscular effort. It can, indeed, be seen coming as the bird's body begins to swell from below upward and, rising on tip-toe, he delivers his vocal appeal, then sinks back deflated. Of all these themes there are endless variations and combinations and as the season advances changes occur which, while evident to the ear, are too subtle to be put on paper.

### Wing "Notes"

The flight of the female is essentially noiseless, but the flight of the male is often accompanied by a sound, evidently produced by the passage of the widely radiating, emarginate outer primaries through the air. This sound varies in rhythm in response to the character of the bird's flight. It is apparently under the bird's control and may be withheld, when the flight of the male is as noiseless as that of the female. It probably has some sexual significance. As a rule it marks the time of the bird's wing-beat as with a loud "fluff, fluff, fluff," he flies steadily with even strokes or passes on deep, swinging loops. When the male pursues the female in

[1]The latter phrase is the only one that has held in my notes for two years and for this reason I give it.

courtship-flight it is a loud startling, rushing roar, such as might be produced by the sudden violent tearing of some textile. On several occasions it accompanied a peculiar flight as the bird pointed its bill toward the ground and, with short, jerky wing-beats, produced a staccato "plop, plop, plop." This may have been some form of sexual display.

## THE QUESTION OF TERRITORY

The question of territorial rights while nesting apparently does not enter into the location of an oropendola colony. On Barro Colorado three nesting colonies of these birds are known. One is 400 yards from the laboratory colony, the other nearly two miles from it in the opposite direction. Birds apparently en route to the nearer colony sometimes stop in the laboratory tree and mingle with the local birds without their presence being questioned.

Nor do groups within the colony appear to be concerned by the question of boundaries. The first bird to arrive selects its group location from the unoccupied field, the choice being made by the females. Each year of my observations the first group to arrive has selected a different location. Always, however, a situation was chosen that had been used before. Here the point of attachment, which is usually all that is left of the preceding year's nest, offered an attractive place for the beginning of a new nest.

The nests are always built on the southerly and westerly, which is the leeward, side of the tree during the period of tradewinds that prevail in the dry season. Here the nests receive some protection from the windward side of the tree, and it is probable that the birds can enter them more readily flying up, than they could when flying down wind.

The tree is large enough to afford sufficient space for subsequent groups without arousing the enmity of those already located, and I have seen no ill-feeling displayed between the members of different groups as such. Size is, indeed, to be desired in a colony, and the larger its population the more protection do its component individuals receive from their common enemies.

It was soon evident that the birds were not monogamous, but it was by no means clear whether they were polygamous or promiscuous. The relationships of the males to one another were also to be determined. No reference to these subjects has been found in the literature concerning oropendolas and caciques.

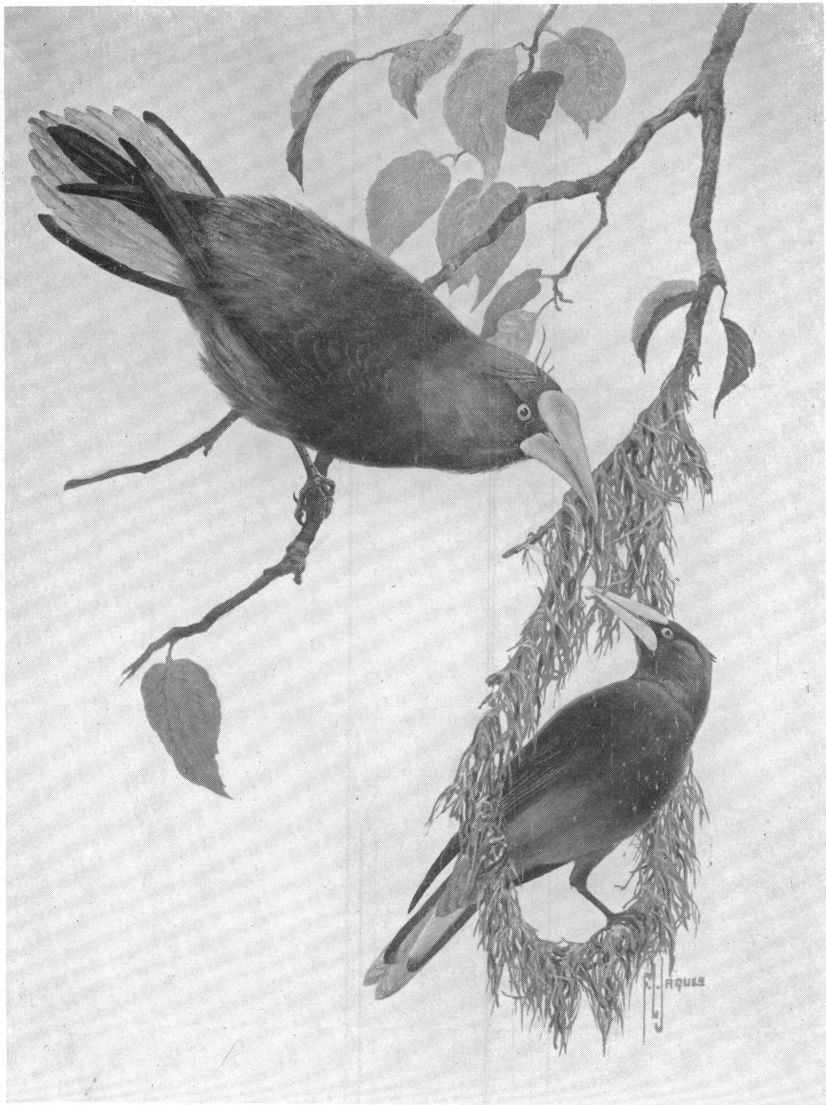

PLATE III

The Courtship of *Zarhynchus*.

The male (upper figure), with dorsal feathers displayed, tail partly opened, flank feathers slightly raised, and crown plumes spread laterally, is addressing the female. She ignores his presence and proceeds with the building of her nest which has reached the loop stage.

From a drawing by F. L. Jaques. (About one-fourth natural size.)

## COURTSHIP AND SEXUAL RELATIONS

To determine the sexual or marital relations of the members of an oropendola colony is one of the most interesting and at the same time most difficult problems connected with the study of these birds. At the time of my departure the colony of 1926 contained about six or seven males and thirty-nine females; that of 1927 five or six males and twenty-nine females; that of 1928 was never fully organized. In each case the number of females given was determined by the number of nests. Unattached females may have visited the nest-tree but they did not function as members of the colony.

The opening of the nesting-season is announced by the location call of the male, given from the nest-tree, on numbers of occasions, some days before nesting actually begins. Females may or may not be present at such times; however, should there be any in the tree the male pays no attention to them. It is not until they begin to build that his prolonged courtship actively begins. He then takes a post usually above the working females and addresses the group collectively; or he focuses his attention on a single bird (but not always the same bird). Generally he perches on the nest-branch above her and repeatedly utters the courtship or "crash" call. As the season advances and the period of egg deposition approaches he presses his suit with greater energy, and at its maximum his demonstration is thus described in my records of February 18, 1927:

"The usual position of the male when addressing the female is above her, often on the limb to which her nest is attached or, should she be inside, at its entrance. From this point of vantage he leans down toward her, his blue eyes glare as though they would pop from their orbits, his crest feathers are elevated and expanded laterally, his wing-tips are crossed above his tail, and the fluffy feathers of the lower back are spread out over the edges of the inner wing-quills. This attitude is invariably accompanied by the "crash" or courtship call—indeed is assumed for the purpose of uttering this call. In the delivery of it the bird rises on his toes, as it were, nervously flits, while slightly spreading the tail, raises the dorsal feathers and fluffs out the body feathers, chiefly of the flanks. The movement of the body feathers may be caused by the muscular exertion incident to the delivery of his notes, but the spreading of the back feathers seems a part of the display. When not specifically directed toward a female but addressed generally to a group, the bird's attitude is more erect, like the normal perching position, the tail is not flitted and the performance is less tense, less excited."

This muscular and vocal demonstration evokes no response from the female who, acting as though wholly unaware of the male's presence, continues without interruption her nest-building and her journeys to and from the forest. The male may accompany her on these journeys or he may turn his attention to another female.

It is not apparent that a male has any group relations or group rights. As many as six males have been seen courting in one group at the same time and they fly from group to group. At an unexpectedly early date the male pursues the female in what appears to be a mating flight, though I have never seen it lead to mating. In 1927 this act was first observed on January 12, four days after nest-building began. In 1928 it occurred within the first week of building. On these occasions the male with a rush and a roar of wings pursues the female at full speed while she twists and turns and apparently spares no effort to evade him. Usually the birds are lost to sight in the forest but in every case where the flight has been watched to its conclusion the female alights in a tree, the male perches near her and the incident is closed. Frequently the pursuing male is joined by a second and even by a third when the affair becomes a thrilling exhibition of flight power not without its dramatic appeal. As the nesting season advanced it was observed that each male concentrated his attention on a certain female which he accompanied to and from the nest and that his rights appeared to be recognized by other males none of which disputed his claims. The male at this time did not rush after the female but went with her quietly, as though he were her accepted mate. My entry of February 26, 1927, in regard to the owner of nest No. 5, Group 1, who is later referred to in connection with the loss of her nest, illustrates this habit; it reads:

"Male accompanies female with great regularity to and from the nest waiting immediately above while she is inside and leaving just after she does. She always leads both going and coming. Their flight is normal, there is no rush of pursuit, and no other male interferes."

While waiting for the female to come out of the nest the male may now be silent or he may call a rather automatic call without any of the action and vocal energy of the courtship period. On February 28 and March 1 a male with a black-tipped bill was recorded regularly accompanying the female of nest No. 17, Group 2, in the manner above described. This nest was begun February 7 and it is probable that the female was about to lay.

Further evidence indicative of an understanding between the sexes is supplied by observations in which the female not only acknowledged

the presence of the male, but apparently caressed him. Thus on January 27, 1926, and February 10, 11, and 22, 1927, a female perched by the side of a male, away from the nest but in the nest-tree, was seen to pick at or stroke the male's plumage. The record of February 11 reads: "A female picks at the head of a male gently (a caress?) several times. He apparently is conscious of the attention and welcomes it." Quoting again from the entry for February 11: "A female perched near the place where one was observed yesterday, runs her bill through the male's neck feathers, while he, with bowed head and half-open bill seems to enjoy the proceeding." Again, on February 22: "A female, in the body of the tree, caresses a male. Two other males come but the female pays no attention to them and continues picking at the feathers of the first male. She then flies off with him leaving the other males."

Since this attention on the part of the female was not restricted to the immediate vicinity of the nest, where it could be readily observed, it may have been indulged in far more frequently than my records show. Together with the regular association of a male and a female for a short time it leads to the conclusion that at least during the period when the ova require fertilization a male and a female associate as a pair.

After incubation begins the male shows no further interest in the female. In this connection my entry for February 22, 1927, reads: "No. 5, Group 1, is the only bird of the seven in the group that attracts a male, from which I conclude that the other six have laid." And on February 23, I find this: "No males in Group 1 today. Their attention is devoted to the builders in Group 2." February 28 I quote further: "No males have been seen in Group 1 since I can remember."

Although the males are such ardent and persistent wooers they exhibit no really pronounced sexual jealousy. Possibly its absence is due to the excess in the numbers of females over males. But in the small colony of 1928, when there were probably half as many males as females and the competition for a mate should have been keener than in the preceding years, no change was observed in the relations of the males to one another. When several males (I have seen four) court the same female simultaneously the situation is apparently threatening. The birds whine excitedly and an attack seems imminent but at the worst it results in a pursuit in which one bird retreats slowly before another, flying from limb to limb but not usually leaving the nest-tree. No notes are uttered—the whine seems to be the only battle cry—there is no resistance and hence no fighting, and the whole affair is quiet and dignified. On one occasion (January 26, 1927) one male drove a second from perch

to perch and finally out of the nest-tree, then out of three other trees and finally into the forest where they were lost to view; but it was done quietly and slowly. It is only the females that fight.

## THE SITE

In the tree now occupied by the laboratory colony, the nest-site is a single terminal, "dripping" or downward pointing branch or twig about the thickness of a lead pencil. Nests preserved from the tree that fell show that its terminal branches had an upward curve, creating, therefore, a short horizontal section at the turn which offered a more favorable place of attachment for the nest than is given by the branches of the tree now occupied. In any event, the site should permit the nest to swing free without danger of entanglement with nearby limbs even when, as sometimes happens, it is blown to an almost horizontal position.

If the birds of a group arrive and work together they usually build nests as near to one another as the available sites permit. The selection of a site may be made at once and peacefully, it may cause the display of some animosity accompanied by actual fighting, or it may be the occasion of a remarkable performance extending over several days. In the first instance, nest-building proceeds at once without friction and it is possible that these birds have been associated before. In the second instance the birds grapple claw to claw and, fighting with their bills, whirl downward like a single bird with set wings extended. When within ten to twenty feet of the earth they separate, fly to the nearest perch and sit there quietly for a few seconds side by side. Then they usually return to the nest-site. These conflicts may be repeated from time to time but cease when nest-building is under way and right to the possession of a site is acknowledged.

An extreme illustration of the desire for close companionship while nesting occurred in the season of 1928. On January 31 two females began to build nests Nos. 3 and 4 of Group 2. The birds were on friendly terms, selected sites not more than a foot apart, and proceeded quietly with their work. On February 3, when the nests were well started, they were joined by two more females who insisted on aiding them in the construction of their nests. I quote from my journal: "Nest No. 3 is the more advanced and the newcomer confines her efforts to the upper or attachment portion where she is permitted to work by the owner. No. 4 has room for only one worker and every attempt on the part of the volunteer to assist is at once resented by the owner. The birds then lock grips and whirl downward fighting and squealing as they fall. An occasional floating feather

shows that these aërial combats are not mere matters of form. For the greater part of the time the two birds sit motionless, with bills half open glaring fixedly into space; No. 4 on her nest, the would-be helper on a branch distant only a few inches. For at least ten minutes they hold this pose then spring at each other and, grappling, whirl downward." The first-named volunteer finally built a complete nest, using the attachment of No. 3 for her foundation, while the one who for some time persisted in her efforts to assist the builder of No. 4, finally built a nest of her own from an immediately adjoining branch.

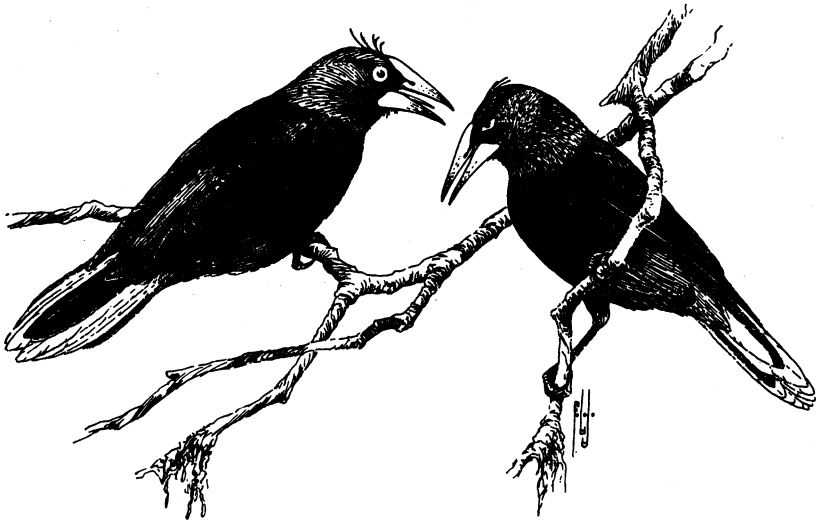

Fig. 1. Females in dispute over nest-sites.

In some cases, however, the matter of site-ownership is not so quickly settled, when the actions of the builder of nest No. 4 and her rejected assistant developed the singular performance to which I have before referred. The most pronounced and prolonged dispute of this nature was made by two females in Group 2, of the 1927 nesting season. These birds were first observed at 7:35 on the morning of January 19, facing one another on terminal site-twigs about one foot apart. One went through the motions of the male's "crash" call repeatedly. I could see its bill move but could hear no sound. The other, with head bowed, listened. Finally they grappled and fell fighting. The struggle thus begun lasted for five days before each bird was reconciled to the presence of the other, and at the end of this time each began building on its own

site. Sometimes one, sometimes the other, "held the floor," but they never both called together and the bird addressed, apparently oblivious of all else, gave her entire attention to the speaker. Seen at such times, one would assume that the calling bird was a courting male, the silent one a receptive female, but this illusion would be destroyed when the listening bird would claim the privileges of the floor and speak as vigorously as her protagonist, the argument often ending in a grapple and fight as they whirled downward. I quote from my journal records of illustrative observations:

January 20, 7:55 A. M.—Two females face each other, bills about three inches apart and call alternately; crests erect.

January 21, 9:44 A. M.—Nos. 1 and 2, Group 2, at same sites as yesterday. No. 2 assumes a downcast [listening] pose, No. 1 addresses her. Both now facing each other only eight inches apart; a laughable performance, crests arising as they speak. [This was continued until 10 A. M. when both picked at old nesting material.]

January 22.—No. 1, perched above No. 2, who is on her site, calls frequently, addressing No. 2 below, who, with her head bowed in the usual pose, eyes half-closed, bill sometimes partly open, apparently listens intently to the notes No. 1 is practically pouring into her ear. A male alights on the limb above, and shakes it so that Nos. 1 and 2 lose their balance. No. 1 falls on No. 2, they grapple and whirl downward, but return at once and assume their former poses and actions.

January 24, 7:20 A. M.—Nos. 1 and 2 still at it; the form of approach this morning being the statement and counter statement. They never call together but one follows the other and I can hear the husky gurgle of both.

On this date the discussion closed, and although there had been some attempt at nest-building, it was not until January 25 that work was definitely begun. It then appeared, as will be shown later, that both these birds were inexperienced builders. Possibly they were building their first nest and hence had been selecting their first site. Several other couples in Group 2, 1927, acted as did Nos. 1 and 2, but in no other instance was the dispute so prolonged. This group was not definitely organized and seemed to be composed largely of individuals who had not before been associated.

## NEST-BUILDING

When the nest-building instincts are fully developed the birds work regularly and persistently giving the greater part of each day to their task. During the building season there is a variation of only about five minutes in the time of the sunrise (6:35 –6:40) and correspondingly little variation in the birds' working hours. In January, with clock-like regularity, one or more males call from the nest-tree at from 6:30 to 6:35 A. M. and twenty to thirty minutes later the females arrive and begin

their day's labors. For the succeeding four hours they are steadily employed in gathering material and using it. They receive no aid whatever from the male either in securing material or building. He, however, is almost constantly with them, both while they collect building material and while in the nest-tree, and his unremitting attentions and frequently uttered calls may prove a source of encouragement.

Toward mid-day the birds usually retire to the forest and the nest-tree is deserted. In the early afternoon work is resumed and continued until about half-past five o'clock when the birds in a body go to the forest, generally taking the same direction, perhaps to a regularly frequented roost. From this schedule there is, of course, more or less variation, and as the season advances the birds retire later.

Comparatively few nests survive the rainy season and those that do remain are frayed and ragged. A new nest, therefore, is built each year. On one occasion, after a rain, a bird was seen to use some wet, and hence weavable, material from an old nest in the construction of its home, but, as a rule, only the attachment of the preceding year's nest enters into the building of the new one.

Strong but pliable material is required by the weaver. A green tendril eight to ten inches long is much used, particularly in the early stages of the work. This, like twine, can be wrapped about a limb many times, forming, in effect, the foundation of the nest-bag. Air-rootlets, fine strips of bark, filamentous blossoms, plant-fibres, string-like strips from the stem of *Monstera* torn off by the strong, serviceable bill of the bird, what resemble weed-stalks (but no twigs) form the greater part of the nest-bags examined. I use the term "nest-bag," for the pensile structures seen hanging from the nest-tree are merely the receptacles for the nest proper. This is composed of nearly a hatful of fragments of soft leaves and bark and short pieces of fibre loosely placed, not packed or woven, at the bulbous bottom of the woven bag. In the old, as well as freshly fallen, nests that I have examined this material is not definitely shaped into a circular nest with a depressed center and surrounding walls, but is a formless bed probably designed to prevent the eggs from rolling about and breaking when the nest-bag is violently blown about by the strong trade-winds of the dry season.

All the nesting material, except that which may be stolen from a neighboring nest, is secured in the immediately adjoining forest, usually within sight of the nest-tree.

In well-organized colonies in which the community spirit is developed, the females, when building, usually leave the nest-tree to collect material,

in a body, and they may be seen gathering it together in the same tree. Material dropped when building is not abandoned, but by a graceful swoop is caught in the air, the retriever returning with it to the nest.

Building birds often take material from another bird's nest either in their own or an adjoining group. Some birds, indeed, are chronic robbers and steal a large part of their material. Slovenly builders are more apt to be robbed than those that leave no loose and tempting ends about their structure. A poor builder is often, therefore, heavily handicapped, for a day's work may be undone in a short time by her thieving neighbors. Birds that do not work continuously and which consequently have their nests unprotected are frequently robbed. There is a limit, however, beyond which it does not pay to try to secure material from another bird's nest. Only the looser, partly woven ends may be easily taken. After that the robber may tug and pull, adding her weight to her strength but she gets little or nothing for her labor.

On one occasion a long fibre streaming from the bill of a returning female was grasped by three other females and, becoming entangled in a limb, it was lost to all of them. Thoroughly to understand the method by which a nest is constructed would require closer inspection, and from every side, than I have been able to give, even with the aid of a high-power glass. The foundation of the nest is laid by wrapping long rootlets, tendrils or fibre about the supporting limb until it is well covered. To this is woven additional material forming a flat piece or apron, ten or twelve inches in length, its extent depending in part on the nature of the attachment. Where the supporting limb is more or less horizontal the apron takes shape more readily than when it is perpendicular. Four nests preserved from the tree that was occupied when the laboratory was established, and that subsequently fell, are attached to horizontal limbs and have broad bases or aprons. But the nest-tree now occupied, as I have before remarked, offers, as a rule, perpendicular limbs from which an apron is less easily woven. Apparently, therefore, the present tree is less adapted to the needs of *Zarhynchus* than the one that fell, its proximity to the former site having induced the birds to occupy it in spite of its unsuitability. Possibly for this reason the colony does not grow and in time the tree may be abandoned.

Under the normal method of procedure when the apron or base of the nest is finished an opening or hole three or four inches in diameter is made in its lower part and the base of the ring or loop thus formed becomes the lip of the entrance to the nest. This is on one side and usually extends from the lip or rim of the opening to the top, or place of the

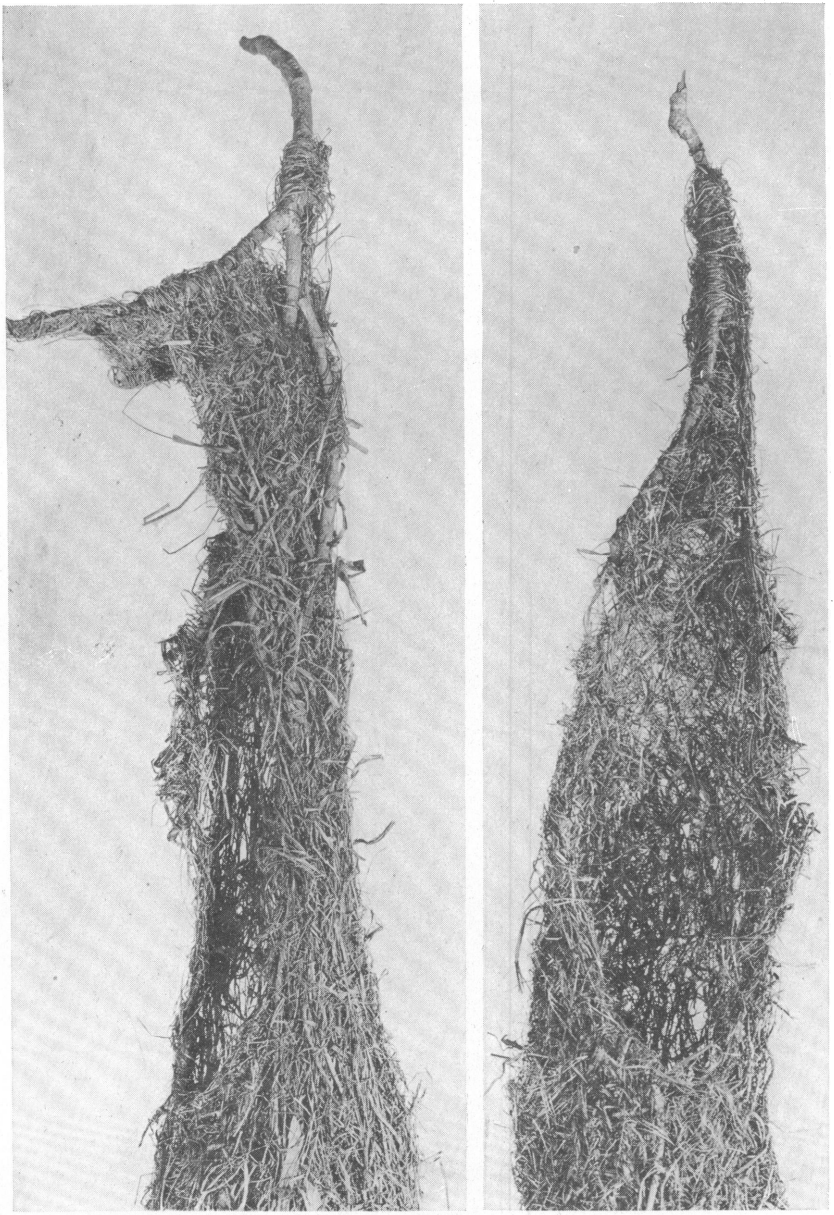

PLATE IV

Nests of *Zarhynchus* showing openings and method of attachment to site. The nest at the left is from the tree that fell shortly after the laboratory clearing was made; the one at the right is from the sand-box tree. The former is believed to have been better adapted to the builders' needs.

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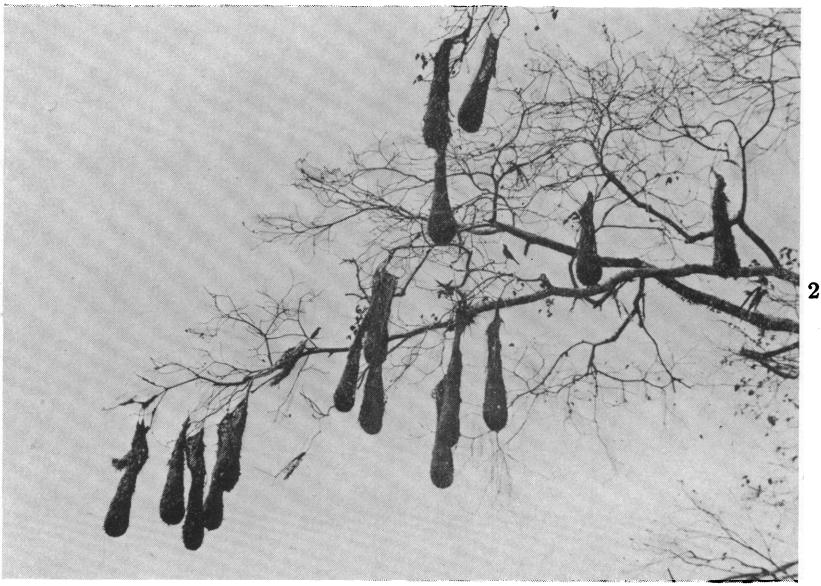

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PLATE V

Fig. 1. *Zarhynchus* nest in the early stage of construction at which the loop is made. (See also Plate III.)

Fig. 2. A portion of the *Zarhynchus* colony of 1927 in the sand-box tree. Note the pair of *Legatus albicollis* at each side of the central group of nests. These birds appeared and harried the nest-owners persistently during the remainder of the nesting season. (See Plate VIII.) Photographed with a 23-inch lens from the laboratory level.

nest's attachment. The formation of this opening is evidently the most difficult part of nest-construction. Its base is usually strengthened by the use of additional material and closer weaving.

In this loop or ring the bird stands working first above and then below. From this stage downward she works inside the lengthening bag which is evidently formed about her body as a mold, until the lower part of the nest is reached when the outline bulges in response to the increased diameter needed for the reception of the true nest. The weaving here is a little closer and the walls of the nest thicker.

Even when the long sack is nearly completed, but is still open below, the builder leaves and enters the nest by way of the door. Entrance is made on the wing with, as the nest is approached, a slight downward dip followed by an abrupt upward turn which serves to check the speed of the bird's flight. The bird thus flies into its nest without pausing on the threshold. The regularity with which this procedure is followed is an indication of its importance. With its back exposed and head concealed a bird, perched at the nest-opening and looking in, would evidently be at the mercy of a foe from without, and this point of exposure is, therefore, passed as quickly as possible. When leaving the nest, however, the position and the conditions are reversed and the bird often perches in its doorway and leisurely surveys the surroundings.

The use of the nest-opening from the day it is available trains the bird's sense of location. I have never knowingly seen a bird make the mistake of entering the wrong nest, even when, as is often the case, several are near together. Under normal conditions it is, indeed, rare for a bird to exhibit the slightest hesitation in finding her own doorway. Changes, however, may occur which for a moment tend to confuse it. For example, when the nests swing widely in a high wind not only are they in motion but the actual position of the opening is altered and both factors cause the returning bird to hover for a second or two before slipping into the nest.

A more pronounced case of this nature occurred through the breaking of one of the limbs to which nest No. 5, Group 1, 1927, was attached. The nest now half turned around and then spun back, the entrance, therefore, being first on one side then on the other. The owner was at first confused but soon adapted herself to the new situation though she was usually forced to discover the exact position of the nest-opening on each return.

Once the bird begins to work inside, little can be seen of her while building until she begins to close the nest at the bottom. Then her bill

may be observed actively thrusting and pulling as she hangs head downward within.

There is wide variation in the nest-building ability of different birds. This is probably in part individual but it is doubtless also a measure of the extent to which their instinct has been developed by experience. Some birds evidently know exactly what they want to do and work rapidly and effectively; others show but little interest in their work and seem at a loss to know how to use the material they have collected.

The members of Groups 1 and 2, of the season of 1927, illustrated, respectively, these extremes. The first, as has before been stated, were apparently an organized group of birds that had been associated before, and hence, presumably, were more or less experienced. The second group was composed of birds that had not established communal relations and some of which, at least, seemed to be building their first nest.

Group 1 began building on January 8, and for that day my record reads: "Seven females came back from the forest together bringing green tendrils. Some work at old, some at new sites. The first tendril is attached to the limb skilfully and rapidly. It is put over and under, pulled here and poked there. They work feverishly but definitely. Their heads go over a limb with a tendril and then reach under it to get the end and pull it through. No needle-worker could proceed with less hesitation." These birds further showed their energy and earnestness by working in the rain.

On January 9, my journal reads: "A thoroughly rainy morning, with showers and thunder; the whole sky overcast. I see twelve females and one male in the field of my 24-power glass. The females are using some fibre and all work furiously, about one half on old sites the rest on new. There is very little confusion and each bird 'sticks to its own knitting.' . . . They thrust over and pull under without apparent study and without waiting. Everyone seems to know exactly what she wants to do and goes at it like a master workman absorbed in her task."

The same concentration and effectiveness was shown by this group throughout the period of construction. On January 22, the entry reads: "These birds work whole-heartedly with strict attention to business, rarely coming into contact with one another. Sometimes a head appears through a nest-bottom pulling vigorously at a fibre here or poking in a loose end there. Position is a matter of indifference. They work upside down or right side up; nor do feathers of wings or tail impede their movements. The tail may be bent any way, the wings closed or half-

spread. They are intent on only one thing and are not concerned with appearances."

Compare with these extracts the following, describing the nest-building efforts of birds Nos. 1 and 2 of Group 2. We have already seen that these birds devoted five days to discussion of the nest location before work actually began. I quote from my notes:

January 24, 7:53 A.M.—No. 1 returns with short brown fibre but doesn't seem to know what to do with it. After a half-dazed moment she weaves it into foundation. . . . 9:05, No. 2 returns with a bill full of green tendrils but loses three-fourths of them. No. 1 comes with a bill full of the same kind of material; they fight and she loses all of it.

January 25, 8:14 A.M.—No. 1 sits with a straw in her bill, motionless until 8:23 when she uses it.

January 29, 8:05 A.M.—No. 2 is still trying to form an opening—the doorway—but it will not take shape. She pokes and pulls and weaves but apparently lacks sufficient experience to succeed. She can weave but she doesn't seem to know what to weave.

January 30, 8:30.—No nest in Group 2 has a completed opening, and only No. 2 has attempted to make one. All the facts observed suggest that these are young birds making their first attempt at nest-building, in which case their instinct must develop slowly with experience.

February 7.—No. 1 has broken the bottom of her ring and works with wide-spread feet grasping each end of it. No. 2 has deepened her saucer but has not yet a doorway.

February 10.—No. 1 still struggling with her entrance. No. 2 has completed hers and can now get inside the beginnings of a bag.

February 14.—No. 1 has brought the loose ends of her doorway together and is almost concealed when at work.

In view of these facts it is obvious that the time required to build a nest depends, at least in a measure, on the skill, energy and persistence of the builder. This statement would call for no qualification if all nests were made to the same model. They vary, however, in length and in amount of lining. It is not impossible that when an undue amount of time has been spent on the earlier stages of a nest it may be brought hastily to completion because of the approaching needs of the female for a receptacle for the eggs. When this need does not force a completion of the task, and consequent closing of the nest-bottom, the bag may be continued to the maximum length.

In the absence of examination it is impossible to say exactly how many days are required to finish a nest. One may note the time when the weaving of the bag is finished and its lining begun, but it is not improbable that while the female is laying, or even after she has begun to incubate, she may add to the nest-lining.

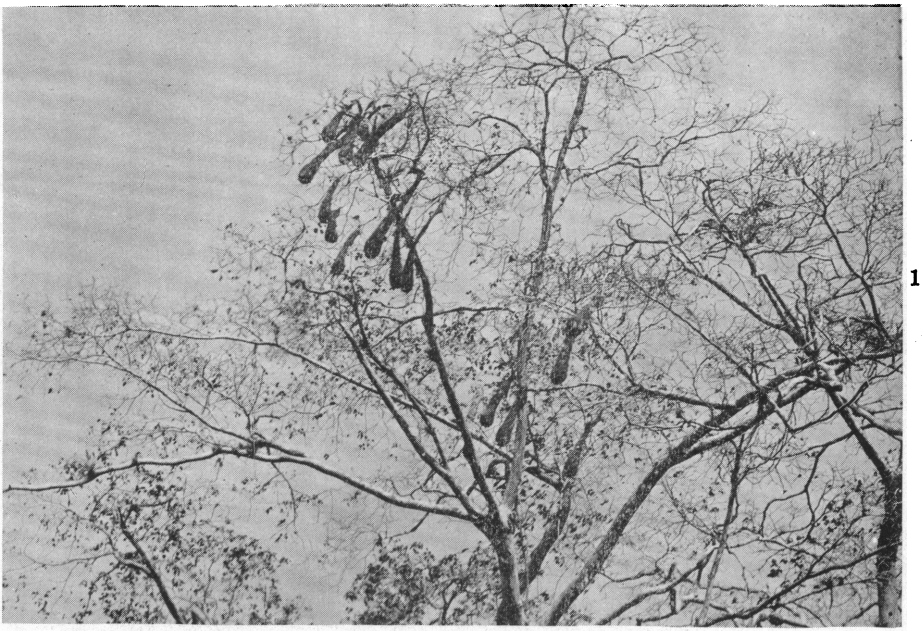
I have, therefore, accepted as evidence indicating the completion of the nest its occupation at night. This is a definite, observable act and obviously marks an important change in the attitude of the female toward her home. Doubtless at or near this time the eggs are laid.

Throughout the period of building the females, as before stated, at the end of a day's work accompany the males to the forest. They usually go in a body, the males leading. But there comes a day when the growing attachment of the female for her nest is stronger than the impulse that induces her to follow the male to the roosting-place. The conquest of the old habit by the new one is recorded in my entry for February 13, 1927: "Tonight for the first time this year the females were seen to enter the nests for the night. There was an unusual number of birds in the colony at 6:10. At about 6:15 they all flew off but returned at 6:18. Again they took flight leaving, however, three females who, after preening, entered nests Nos. 1, 2, and 8 of Group 1, respectively."

After this event is inaugurated the gathering in the nest-tree of the members of the colony becomes a nightly habit. Even the birds whose nests are not ready for occupation stay in the tree until those whose homes are apparently completed enter them. All sit about industriously preening their plumage in preparation for the night. At about 6:15 the first female enters her nest. She is soon followed by others and by 6:30 all who are to stay have gone to bed and the remainder of the group fly to the forest.

In 1926 this habit was first observed on February 7; in 1927, on February 13. The 1928 colony was too much disturbed to develop it observably. Recalling that nest-building was begun in both the first-named years on January 8, it follows that in these groups of early builders not less than thirty-one days were required to build the nest-bag and line it. I have suggested, however, that with the advance of the season the increased development of the ovaries may induce the builder to finish her work in a shorter time. For example, nest No. 17, of Group 2, 1927, begun February 7, was believed to have been completed in twenty-three days, and nest No. 13 of Group 1, 1927, begun February 5, in twenty-five days.

Completed nests vary from one foot and ten inches to three feet and four inches in length, but the greatest diameter of all (always in the bulbous base) is eight inches. Length, as we have seen, may depend on the proximity of the egg-laying period and hence is variable, but the diameter of that part of the bag containing the true nest is fixed by the size of the sitting bird and, therefore, is always essentially the same.



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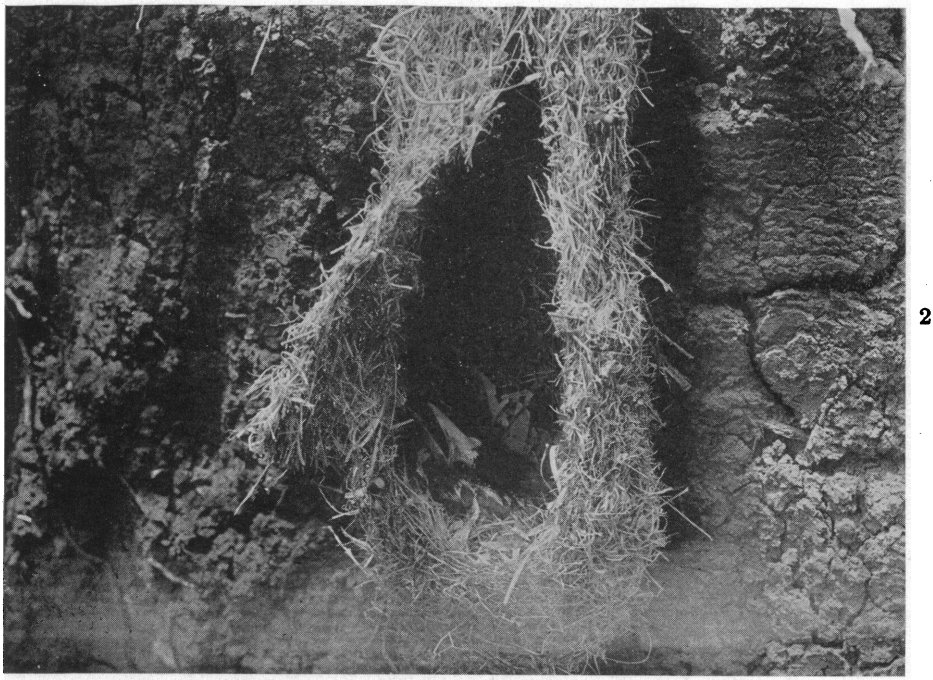

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## Plate VI

Fig. 1. *Zarhynchus* nest-bags in the sand-box tree swaying in a fresh breeze. Their motion illustrates the necessity for the soft nesting material at the bottom of the bag forming the true nest. Photographed from the laboratory level, with a 14-inch lens.

Fig. 2. Fallen nest of *Zarhynchus* cut open at the bottom to show the single nestling it contained, nearly ready to fly. Note the light (yellow) marks on the forehead at each side of the base of the bill. April 1, 1927.

## THE EGGS

The terminal branch to which nest No. 5, of Group 1, 1927, was attached was broken, presumably by a strong wind, on the morning of March 7, and the nest fell. It contained two eggs which apparently constitute a full set for the species. One of the eggs was broken, the other measured 33 by 22 mm. In color it is pale blue with numerous irregularly shaped brownish-black marks varying in size from a pin-point to a currant and clustering most thickly about the larger end. Both eggs contained embryos which I estimated to be about twelve or thirteen days old. My records give the following history for this nest: It was begun January 8 and was first slept in February 13. On February 21 the female entered and left the nest fourteen times between 8:33 and 9:25 A. M. February 22 she entered and left six times between 8:17 and 9:04. On both days she was accompanied by a male on every journey to and from the nest. The record for the 22d reads: "No. 5 is the only bird of the seven in Group 1 who attracts a male, from which I conclude that the other six have laid." February 23 she left the nest only once between 8:17 and 9:04 A. M. and was not accompanied by a male. This evidence suggests that she began to incubate February 23, or twelve days before the nest fell. I shall have something to say about the subsequent activities of No. 5, the owner of this fallen nest.

Incubation in Group 1, 1927, was believed to begin on February 18, when the owner of nest No. 2 left her nest at 9:54 and returned at 9:59; these being her only movements during an hour's observation. On March 7, she carried food to the nest. On the basis of these observations the period of incubation in this instance was seventeen days. On March 11, this bird was seen removing excreta from the nest.

## THE YOUNG

Long before the eggs hatch the male loses interest in the female and when the young appear they are cared for only by the female. In 1927 young were first noted on March 2 in nest No. 2 of Group 1. On March 22 the young in this nest were first heard to call as they were being fed. On the 31st the female fed them by reaching down from the opening without entering the nest, and on April 1 they were seen at the doorway. My observations ended April 2, but it is not probable that the young of this nest took flight before April 5–8.[1] On this assumption the dates of the more important events in the history of this nest are as

[1]The observations of Dr. Van Tyne indicate that the earlier date is the correct one.

follows: Nest begun January 8. Female first sleeps in nest February 13 (assumed date of the completion of the nest). Young first noted, March 2. Probable date of flight of young, April 5–8 or 87–90 days from the beginning of the nest.

The period of nearly three months between the beginning of the nest and flight of the young is of course shortened when less time is given to the construction of the nest. For example, nest No. 13, Group 1, 1927, which, as stated above, is believed to have been built in twenty-five days, fell on April 1. It contained one well-grown young which would doubtless have flown in not more than a week or sixty-three days after the nest was begun.

## NOTES ON THE ACTIONS OF A BIRD THAT LOST HER NEST

As stated above, nest No. 5, Group 1, 1927, containing two eggs about twelve days advanced, fell on the morning of March 7. The subsequent behavior of the owner of this nest seems worthy of record. The branch to which the nest was attached broke between 7:30 and 8:30 A. M. when I was in the forest. My observations began at 8:45 when, to quote from my record: "the female was seen fluttering about the vacancy left by the fall of her home and alighting on the neighboring nests Nos. 4 and 7. Two males and a female joined her and after a few minutes she flew west. At 9:30 she was again looking for her nest but soon departed and did not return for at least an hour, after which I was absent until evening. Between 6:10 and 6:30 P. M. she made four attempts to find her nest, perching on the branch to which it had been attached and examining the entrances to nearby nests; then she flew east to the forest with three other oropendolas."

March 8.—A female, after looking about the former position of nest No. 5, flew to a perch about twenty feet below. Later a female brought new green tendrils to this perch and began to weave. Still later a female perched on the remaining attachment of the fallen No. 5, then at various places above and below and on each side, then flew down and weaved a little where the nest had just been started twenty feet below. This action was interpreted as indicating that the new nest had been started by the bird that had lost her nest and eggs the day before.

March 9.—The female believed to be the owner of nest No. 5 worked a little at the nest started yesterday then started a second one on the right fork of the same branch; net result about two square inches on No. 1.

March 11 (absent March 10).—No. 5 works casually and ineffectively but at three places, all within a few feet of one another.

March 12.—No. 5 was not seen.

March 13.—No. 5 not seen by me but reported by Mr. W. E. Hastings to have done some work.

March 14.—No. 5 not observed.

I find no further reference to this bird in my journal until March 17 when there is the following entry: "No. 5 works at position No. 3 for a few minutes, then disappears. She had made practically no progress since the first day or two." The next and last entry is March 28 when Mr. Hastings reported that a female attended by two males came to the limb on which the new nests had been started and did a few strokes of work.

If I am correct in identifying the bird that began these nests with the one that had lost her nest twenty feet above the new position, and the record of March 8 seems to justify this belief, it appears that after devoting thirty-six days to nest-building and approximately twelve to incubation she could, after one day's manifestation of interest in the lost nest, return to that part of her annual cycle, which in the normal process of development had been reached when she first began to nest, fifty-eight days prior to her loss. Its promptings, however, were not sufficiently strong and definite to enable her to complete a new nest.

## ENEMIES

Aside from the parasitic blackbird, *Cassidix*, and flycatcher, *Legatus*, two other birds were found to attack the oropendola colony on Barro Colorado. Only one of these is diurnal, nevertheless the males are constantly on guard. It is, indeed, their duty to act as watchmen of the colony. While building, the females' attention is of necessity concentrated on their work and until they begin to weave inside the structure they are exposed to attack from birds of prey. The males, however, in spite of their almost constant wooing, are ever on guard and when a hawk is seen they are the first to utter the rapid, cacking alarm note, the females joining them in calling on certain occasions. This is a signal for the whole colony to dive precipitately into the lower growth of the adjoining forest.

Turkey buzzards do not, as a rule, evoke this call and generally the white snake-eating hawk (*Leucopternis ghiesbrechti*), a pair of which lived near the laboratory, was permitted to pass unchallenged. But at times even the appearance of these birds, more particularly the latter, was the occasion for an outcry and the accompanying downward rush to cover. Rarely a low-flying airplane created alarm. Often the warning cry is given without apparent reason but its cause may have been clear to the birds if unseen by me. Possibly also it may have shades of meaning to which human ears are deaf.

The response of the oropendolas to this note is variable. At times

they act as one bird and plunge from their nests or perches into the forest. I have even seen a bird when flying toward her nest dodge abruptly downward in the air when hearing the alarm. On the other hand, while it evidently puts the birds on their guard, they may not move when hearing it.

The significance of this call is understood not only by oropendolas but obviously by other species. On February 8, 1926, five toucans (three *Pteroglossus*, two *Rhamphastos piscivorus*) and two caciques (*Cacicus vitellinus*) that were in the nest-tree dived with the oropendolas when the alarm was given. On the following day it induced even a trespassing *Cassidix* to seek safety with her intended victims from a supposed common enemy.

The need for a lookout and for prompt obedience to this danger signal was tragically illustrated on February 12, 1927. At noon on that day Mr. Maunsell S. Crosby, who was standing near the nest-tree watching the oropendolas at work, saw an eagle hawk (*Spizastur melanoleucus*) drop from the sky, strike an oropendola that was working on her nest and bear her to a neighboring branch. The hawk, which was identified by Mr. Ludlow Griscom, was still standing on its victim when a few moments later, attracted by the unusual outcry, I reached the tree. It soon flew off with its prey to the forest. This event caused tremendous excitement among the oropendolas, their united cries of alarm producing the effect of a loud chorus. They all left the tree and for the remainder of the day the colony was completely disorganized.

The following day the effects of this catastrophe were still evident in the nervousness of the birds and the frequency with which the alarm call was uttered. Normally this call may be heard three or four times during a morning, but during two hours on the morning of February 13 it was given at 8:50, 8:51, 8:55, 9:04; 9:07; 9:10; 9:12; 9:22; 9:40; 10:12, 10:15, 10:26, 10:44 and 10:50, a total of 14 times in two hours. Beyond two buzzards that flew over at 9:10 and 10:44, respectively, no cause for alarm was seen by me during this period. The first seven times the alarm was sounded all the birds responded promptly, diving to the protection of the lower growth. Later their reaction was not so keen and on three out of seven signals they did not respond.

The incident illustrates the exposure to attack by a predatory bird of an oropendola working outside her nest, the need for a guard, the importance of prompt obedience to his warning, of the quickening of reactions through experience, and of their decline after frequent call has been made upon them.

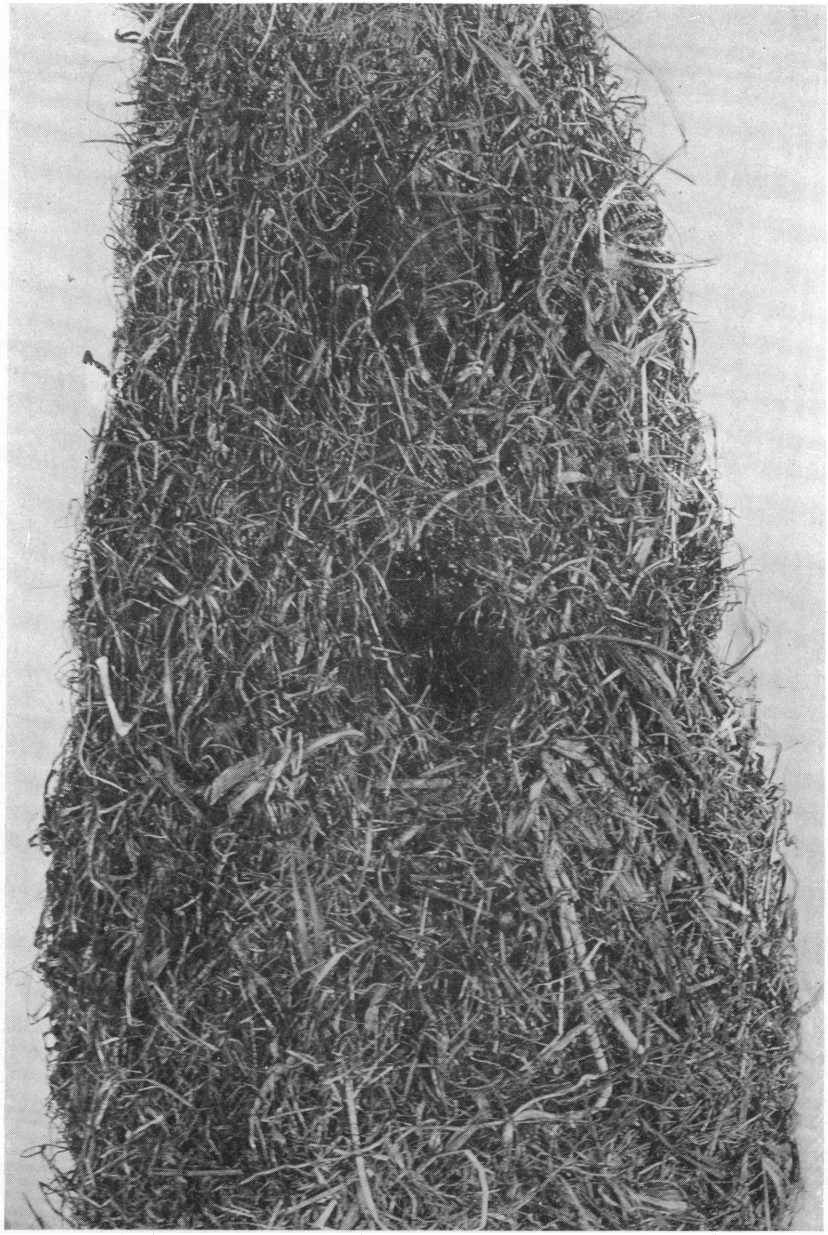

PLATE VII

Nest-bag of *Zarhynchus* to show opening at the nest level, made, apparently, by the owl, *Pulsatrix perspicillata*, to secure the contents of the nest.

It might be imagined that the birds in their long nest-bags swinging from the tips of slender branches were immune from attack. They can doubtless be reached by tree-snakes, though I have no evidence of their being preyed on by these, or by other reptiles. Possibly marmosets may be able to approach them, but we have never known them to do so. Furthermore, any diurnal enemy would doubtless be subjected to attack from the sharp, strong bill of the female, and perhaps also of the male *Zarhynchus*. It is, however, a nocturnal winged foe that proves to be one of the most serious enemies of the oropendola. This statement is based on observations made on Group 1, 1928, and recorded in my journal for January 25, as follows: "7:30 A. M. Some mishap has befallen Group 1 [containing 8 nests] during the night. Nest No. 3 is hanging upwind across the lower part of No. 4, and has a large, round hole in its bottom evidently made from without. No. 5 has a similar opening. Nos. 2 and 4 each have a small round hole in the side near the bottom. I showed these nests to Donato who at once said: "El buho" (local name for *Pulsatrix perspicillata*) and added that early one morning in the preceding year he had seen an owl fly from its perch in the dead tree adjoining the sand-box tree and pick at the oropendola nests. Certainly whatever did this work had wings."

The owl named is seen or heard about the clearing nightly. Donato, our resident factotum, is a careful observer, and it is probable that his identification of the marauder is correct. All the nests mentioned were begun on January 2 and it is possible may have contained eggs though I had no record of the birds' sleeping in their homes. The owners of Nos. 2 and 5 returned to their homes and were evidently incubating as late as February 3.

Apparently the attack of the owl or owls created a condition which made the remaining birds in the group more susceptible to persecution by *Legatus* and eventually the whole group-site was abandoned. On former occasions I had seen holes an inch and a half in diameter at the side of the nest-bag about on a level with the nest and supposed that they were made by the owner; but if they are made by the foot of an owl reaching in while clinging to the nest it is evident that the home of *Zarhynchus* is far from impregnable.

## PARASITIC BIRDS

*Zarhynchus*, while nesting, is parasitized by two other birds, one of which, in effect a large cowbird (*Cassidix*), visits the colony from time to time to deposit its eggs, while the other, a flycatcher (*Legatus*), is a permanent resident who in seeking to gain possesson of an oropendola

nest for its own uses becomes a community affliction of the first magnitude.

*Cassidix oryzivora.*—It has long been known that *Cassidix oryzivora* is parasitic on certain members of the oropendola-cassique group.[1] Possibly, since their ranges are conterminous, it may prove to be parasitic upon all of them. Whether it also parasitizes other species does not appear to be known.

To our scanty knowledge of the relations between this species and its hosts I append a summary of my observations on Barro Colorado.

In 1926, *Cassidix* was first observed on January 28; in 1927, on January 19, and in 1928 on January 11, or respectively 20, 11, and 9 days after the beginning of nest-building. In 1926 earlier visits to the oropendola colony may have been overlooked for my attention was not then focused on these birds. From the dates mentioned until that time in each year when my observations ended, *Cassidix* was frequently seen in the *Zarhynchus* nest-tree. For some periods my records show daily visits and at times several visits each day.

A female is first recorded as entering a nest in 1926 on February 4; in 1927, in spite of frequent attempts, one was not seen to succeed until February 25; and in 1928, on January 18. Since on the last-named date the nest entered was not completed, the bird was evidently making a reconnaissance. As most of my observations were made in the morning the greater number of my records of the presence of *Cassidix* in the oropendola tree were made before noon. The earliest is at 7:40 A. M. but the species was seen in the colony as late as 6:30 P. M.

The birds seemed to come from a distance and usually alighted at or near the top of the sand-box tree. Here they would remain for several minutes and then pass from limb to limb and along the limbs toward the *Zarhynchus* nests selecting, as a rule, those finished or most nearly completed. The earlier visits of *Cassidix* appeared to be for inspection and when attacked by *Zarhynchus* they quickly retreated and soon took flight. Later, when their needs were doubtless more pressing, they persisted in their attempts to enter the oropendola nests sometimes succeeding in spite of the combined efforts of several oropendolas and the resident pair of *Legatus* to prevent them. On leaving the tree they usually started

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[1]The recorded species and localities are as follows:
*Ostinops decumanus.*—Southern Brazil, GOELDI, 1894, 'Aves do Brazil,' p. 284; 1897, Ibis, p. 364. British Guiana, 1896, LLOYD, Timehri, N. S., X, p. 37.
*Gymnostinops montezumæ.*—Costa Rica, CRANDALL, 1914, Zoologica, I, pp. 339, 341.
*Zarhynchus wagleri wagleri.*—Costa Rica, CRANDALL, 1914, Zoologica, pp. 338, 342.
*Cacicus cela.*—Para, Brazil, KUSHEL, 1896, Ibis, p. 585; 1897, J. F. O., p. 168. GOELDI, 1897, Ibis, p. 364. British Guiana, LLOYD, 1897, Timehri, N. S., XI, p. 5.
*Cacicus hæmorrhous.*—British Guiana, LLOYD, 1897, Timehri, N. S., XI, p. 5.

on an extended flight, sometimes over the lake, that soon carried them out of sight.

Visits from single birds or twos was the rule, more rarely three were observed together and on February 8, 1927, five females, the greatest number seen together, perched in the tree-top. Several attempts were made by single birds of this group to enter nests but they were prevented by *Zarhynchus*. Finally all left together in the usual long flight.

The male *Cassidix* was recorded on only three occasions, January 19, 1927, February 10 and 19, 1928. On the first-named date a male was accompanied by three females before which he slightly expanded his ruff. On February 10 there were also three females with a single male. On February 19 there was only one female with a single male. The actions of these birds seemed to indicate that more than a passing relation existed between them and I quote my description of it: "7:30 A. M. A male and female *Cassidix* in the top of the sand-box tree. The male's plumage glistens brightly and he is conspicuously the larger of the two. Some minutes after I discovered them the female started alone, circled the tree twice in a rising spiral flight, then headed east. The male continued preening. In about three-quarters of a minute a female alighted near the male and half a minute later started due east. He followed. Assuming that there was only one female, did she circle on her first flight while awaiting for the male to follow? Did she return because he did not?"

*Cassidix* is obviously recognized as a common enemy not only when she seeks to enter a nest, but when, early in the nesting-season, she enters the nest-tree. Not alone the bird whose nest is threatened but other birds in the same group, and also from other groups, join in attacking her; while *Legatus* assails at times with more zeal than *Zarhynchus*. An incident illustrating these facts is recorded in my journal for February 7, 1926: "At 4 P. M. a female *Cassidix* tried to enter several nests but so clumsily that before she discovered the combination she was driven off by a combined attack of several female oropendolas. Evidently, they recognized her as an enemy and united in communal defence without regard to the nest threatened. I saw a female from Group 1 fly to the protection of a nest in Group 3. *Cassidix* retreated to another part of the tree where she was not molested. Within ten minutes she made another attempt but was again defeated. Even two *Legatus* seemed to recognize this visitor as undesirable and with fluttering wings flew excitedly about her. At last she left the tree, a solitary outcast, followed by half-a-dozen oropendolas to the boundary of their territory."

Several entries describe the aggressiveness of *Cassidix*. Thus, February 15, 1926, at 10:37 A. M.: "*Cassidix* tries to enter a nest in Group 2 but is mobbed and driven off; she fights back" and at 10:50 the entry reads: "*Cassidix* tries to enter Group 3, is driven off by *Zarhynchus*; fights them in the air; *Legatus* joins in the attack as *Cassidix* is routed." And on February 25, 1927, at noon: "*Cassidix* enters two nests, staying fifteen to thirty seconds in each. Two *Zarhynchus*, and both *Legatus* drive her off repeatedly, but she fights them as though she were defending her own nest."

A curious performance is recorded at 8:34 A. M. on February 13, 1927, when my notes read: "A female *Cassidix* displays before or addresses a female *Zarhynchus* on a new nest at the left of No. 5, Group 2. She draws herself up to full height, slightly expands her ruffs, with bill down then curls head downward until bill touches lower breast. *Zarhynchus* meanwhile concerned and whines slightly. The performance is repeated." Less marked was the action of two females who, on February 18, 1928, posed on a limb in the sand-box tree with their bills pointed upward, like boat-tail grackles.

The probability that *Cassidix* is aware of the conditions existing in a *Zarhynchus* colony is indicated by the fact that after the nesting colony of 1928 was abandoned *Cassidix* was not seen in it. On February 26 my journal reads: "Apparently not an oropendola left in the tree." On the following date this entry appears: "*Cassidix* in Group 2 examines and enters nearly every nest, its longest stay being three seconds. It was opposed only by male and female *Legatus*. No *Zarhynchus* in the tree." This is my last record of *Cassidix* for the season, though observations were continued until April 1.

In these observations the long flights, the visits of inspection and the forced entrance into nests are of interest. If *Cassidix* is parasitic only on species of the oropendola-cacique group it must cover comparatively great distances in its search for a host. In my experience the nesting places of colonial birds of the same species are not close together. On Barro Colorado, for example, as we have seen, only three colonies of *Zarhynchus* are known. *Cassidix*, therefore, must not only cover much territory but presumably she must be aware of the stage of the nesting-season which has been reached by her prospective hosts. It would be useless to deposit eggs in the nests of birds not prepared to incubate them. Unless, therefore, *Cassidix* can control the development of her ovaries she must either waste eggs or know where to place them to advantage.

*Legatus albicollis*.—An unexpected result of my studies of *Za-*

*rhynchus* is the discovery that it is parasitized by *Legatus albicollis*. In each of the three nesting-seasons devoted to the oropendolas a pair of these flycatchers made their home in the nest-tree and constantly harried the oropendolas for the purpose of gaining possession of one or more of their nests. *Legatus* was also found in the two other known nesting colonies of *Zarhynchus* on Barro Colorado, and its association with *Zarhynchus*, at least on this island, appears therefore to be habitual. It will be interesting to learn whether it parasitizes other oropendolas. It arrives at about the time or even before the oropendola nests are completed and remains throughout their nesting-season. In the morning it appears in the nest-tree within a minute or two after the first *Zarhynchus* call is heard and it remains there until evening. It was never seen to feed from or near the nest-tree but at intervals of an hour or more it darted to the adjoining forest evidently for food, but was rarely absent more than three minutes.

Not less than ninety per cent of its time during the day was devoted to calling. No bird I have ever heard approaches *Legatus* in the continuity with which its notes are uttered. Morning, noon, or afternoon it was the exception, when consciously listening, not to hear the voice of *Legatus*. Both sexes call, but the male seems to be the more vociferous and, when incubating, the female is apparently silent.

Their usual note is "pee-ee" with a suggestion of the phœbe's (*Sayornis phœbe*) tone. To this is often added "teedle-dee-dee." There is also a "twee-twee-twee-twee," etc., uttered continuously, with closed bill, for as much as a minute. The female frequently uttered this note while the male called "pee-ee, teedle-dee-dee." During attacks on *Zarhynchus* both sexes utter an excited, reedy twittering and chattering.

*Legatus* evidently considers itself a member of the *Zarhynchus* colony and, although its motives are unworthy, it often attacks *Cassidix* more zealously than does the owner of the nest which that bird seeks to enter.

Since it is evident that *Legatus* plays an important part in the nest-life of *Zarhynchus* I give the more significant of my observations concerning it as a contribution to our knowledge of their relationships, which, as will be seen, are as yet by no means clearly understood. In 1926 *Legatus* was first noted in the nest-tree on January 29, twenty-one days after nest-building began, but it was not until February 9 that I realized the object of its presence. I quote from my records of that date: "It is evident that *Legatus* is interested in the *Zarhynchus* nests. Two of these birds have attached a claim to two detached nests at the left side of the

tree and fiercely attack their owners, often driving them from their own doorstep. The poor oropendola sits humbly in the protection of the leaves waiting for a chance to enter her own home and in spite of the swinging onslaughts of *Legatus* finally succeeds by a dash. I have not seen *Legatus* enter either nest but they examine the opening and perch at the point to which the nest is woven with an unmistakable air of proprietorship. What is their object?"

These birds were under observation until February 20 when I left the island for the season. They eventually focused their attention on one of the two nests, called in my notes "No. 1." On February 17 for the first time one entered this nest remaining three seconds, to which *Zarhynchus* still asserted ownership by also entering for the night, both *Legatus* then going to the forest. On the 19th at 12:05, after *Zarhynchus* left the nest, one *Legatus* entered and remained for five or six seconds. Both the flycatchers were about the nest the greater part of the day; at 3:25 *Zarhynchus* tried to enter it but was driven off and at 5:20 *Legatus* came from the forest and with almost no hesitation flew directly into the nest, remaining for ten or twelve seconds. At 4:40 the flycatcher was in the nest for fifteen seconds and *Zarhynchus* had not appeared. On February 20 at 7:35 A. M. *Legatus* entered the nest and remained for twenty-five seconds. Three minutes later *Zarhynchus* entered the second nest without protest, but at 7:45 when a *Zarhynchus* came to No. 1 it was driven away by *Legatus*. Thereafter, during the day, *Legatus* entered nest No. 1 frequently and my notes say, "It seems apparent that they now have possession of No. 1." Here, as above stated, my observations ended but I left a note asking Dr. J. Van Tyne, who reached the island February 28, to continue them. He reports that the activities of *Legatus* did not, apparently, lead to definite results.

In 1927 *Legatus* was first noted January 31 (twenty-three days after nest-building began). For the first few days the bird perched in the top of the tree frequently uttering its "pee-ee" note. I was now absent for three days, returning February 6 when there were two birds present. One of them dove at nests 1 and 3 of Group 1, and attacked one of their owners. From that date until the end of my observations on April 1, there were few moments during the day when these birds were not present in the nest-tree. Their notes were heard almost constantly and the greater part of their time was devoted to attacks on *Zarhynchus* and to examining its nests. These attentions were distributed throughout the colony, and were not concentrated on any one nest or bird. At the end of the period of observation the birds seemed to be no further advanced

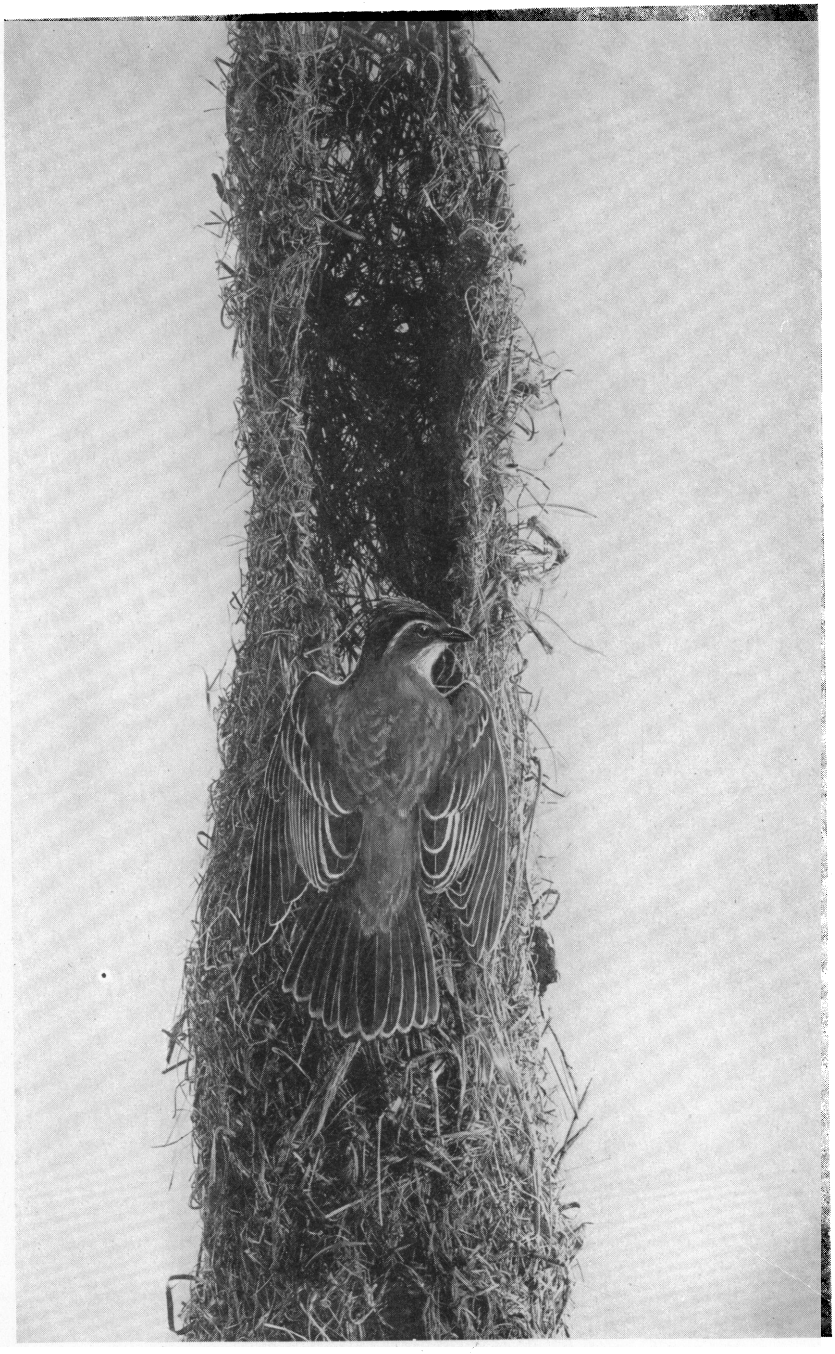

PLATE VIII

*Legatus albicollis* inspecting a nest of *Zarhynchus wagleri*, with a view to occupancy.

The figure of *Legatus* was drawn by F. L. Jaques on a photograph of the nest of *Zarhynchus*.

(Slightly less than one-half natural size.)

toward acquiring a home than they were at the opening of the season. Dr. J. Van Tyne, who reached the island February 24 and remained until August 21, was good enough to keep these birds under observation. His notes in full are given on p. 131. They show that *Legatus* was present until April 26 (when apparently because of heavy rains the oropendolas abandoned the colony) but that it was as "ineffectual as ever."

Several entries in my journal for 1927 may be quoted:

February 26.—*Legatus* attacks any bird entering Group 1, but seems still to prefer No. 1. Both go to the entrance drop and partly spread their wings, lower their heads and turn half right then half left with a queer little bow; a singular, self-conscious kind of performance.

March 11.—*Legatus* shows no decrease in energy or interest. It is now chiefly in the west end of Group 2, calling and fluttering excitedly at nest entrances.

March 24.—*Legatus* seems to be more aggressive and active. They attack almost any *Zarhynchus* and swing from Group 1 to Group 2 and back. No. 12 receives most of their attention but no choice has been made. There are two deserted nests in Group 1 but they probably contain eggs. But doubtless those in Group 2 do also.

As a rule *Zarhynchus* avoids *Legatus*, as already described, but when the small bird's attacks exasperate it beyond the limit of endurance it assumes the aggressive. The record for March 6, 1927, reads: "A female *Zarhynchus* pursues *Legatus* around and around the tree and is herself pursued by the other *Legatus*." On March 12 and 15 similar incidents were noticed, and from the record of March 22 I quote: "While *Legatus* was perched at the entrance to a *Zarhynchus* nest the owner popped out and pursued her persistently, following her at least ten times around through the tree and on two wide circles over the forest. Meanwhile the other *Legatus* pursued the attacker."

In 1928 a single *Legatus*, presumably a male, was heard calling from the nest-tree at 6:30 on the morning of January 16 (fourteen days after the nest-building began). After calling for about two hours from the upper part of the tree (not near the nests) he disappeared. At 5 P. M. he called again for a few times and departed. Probably the same bird was present on the 17th and 19th. On the latter date my entry reads: "Only one *Legatus* seen. He sits in the top of the oropendola tree calling, perhaps for a mate; but already shows a sense of proprietorship by chasing *Cassidix*."

On January 20 a second bird, probably a female, appeared. Three days later I wrote: "*Legatus* is now in full swing in Group 1. Both birds attack every *Zarhynchus*, indiscriminately, males as well as females. The males are not even permitted to court but are driven from their perches by the wasp-like attack of these two relentless little birds, who

one after the other dart at them and swing upward to dart again. The females are similarly annoyed both when they enter and leave the nest and also in the air, as they approach it. Often they are prevented from entering and take refuge among nearby leaves to await an opportunity to slip in unnoticed. The life of the whole group is being disorganized by the persistent and constant annoyance of these two irritating flycatchers. They have apparently chosen No. 6 for their especial victim but they by no means restrict their attention to her."

On January 28 one *Legatus* was seen sitting at the entrance to nest No. 5, which, although it had been attacked by an owl on the night of January 25, as before described, was still occupied by its owner. On February 1 No. 5 was entered by *Cassidix*. The bird remained for four seconds, *Legatus* alone protesting.

Between February 1 and 7 the record for *Legatus* is summed up in the entry for the 4th which reads: "*Legatus* continues its endless "peedle-deedeeing" but seems to get nowhere. Occasionally it chased a *Zarhynchus*. On the last-named date I record: "*Legatus* now worries the owners of Nos. 1 and 2, Group 1. The latter chased one of the flycatchers out of the tree this morning. If they want a nest why do they not take either No. 3 or No. 4 which are deserted but look in good condition. This afternoon the *Legatus*, which I believe to be the female entered No. 1 and remained for eighteen seconds."

There were no further developments until February 11. My record for that day is as follows: "It looks as though the *Legatus* puzzle had finally solved itself. At 12:45 I chanced to see *Legatus* enter No. 5, Group 1. On emerging, after four or five seconds, she left the tree and at the end of about two minutes returned and entered No. 5 again. Having my glass now turned on the nest I saw that she carried something in her bill. Moving with my 24-power glass to the end of the laboratory I saw, when some two minutes later she reëntered the nest, that she carried what appeared to be a small bit of a brown leaf. She entered the nest so quickly, however, that I could not be sure of the exact nature of her burden, but two visits later she brought an entire leaf perhaps three-fourths of an inch long. It seemed evident, therefore that she was building a nest. I say "she" for the one that remained outside, perching within a few inches of the nest-opening, called constantly and greeted the builder with vociferous, excited twitterings on her return. During the succeeding twenty minutes ten visits were made by the female, each time with building material. Only twice during the succeeding four hours did *Zarhynchus* appear. Once a female swept down as the female *Legatus*

was about to enter, and at 3:55, while the female *Legatus* was in the nest and the male at its door, a *Zarhynchus* came with the apparent intention of entering but she retreated quickly before the fury of the *Legatus* attack. Half a minute later the female flycatcher continued her work." Thereafter *Legatus* was left in undisturbed possession of this nest. It may be noted that my records now showed this nest to have been visited by *Cassidix*, attacked by owls and claimed by *Legatus*.

For the succeeding seven days *Legatus* continued peacefully to occupy, or at least frequent, this nest No. 5 of Group 1, but February 19, to my surprise, both birds were seen fiercely attacking nests Nos. 1 and 2 in Group 2, fully forty feet above No. 5 of Group 1. They perched at the entrance to the nest, fluttered excitedly and peered within just as though they were prospecting for a home. At 6 P. M. one was seen sitting with within No. 5, its head only showing at the entrance.

The combined attacks of *Legatus*, and what I believe to be *Pulsatrix*, finally resulted in the complete disorganization and abandonment of the *Zarhynchus* colony, and on February 26 I write "apparently not an oropendola left in the tree. *Legatus* having no fresh fields to conquer may now devote herself to her own affairs."

From February 19 to March 4 *Legatus* was heard calling with undiminished energy, but I saw only what I believe to be the male bird and assumed that his mate was sitting and would at any day produce a brood in nest No. 5. On March 4 the female was seen preening near the male but I did not succeed in tracing her to a nest, and on March 5 it appeared that they were interested in nest No. 2 of Group 2, and apparently had deserted No. 5 of Group 1, in which they had built a nest. No evidences of building in No. 2 were observed but the evidence indicated that on March 12 she was incubating in that nest. My record follows: "8 A. M. Female *Legatus* perches near the entrance to No. 2, Group 2, the male nearby. She preens her plumage disclosing a wide parting from sternum to vent, which bespeaks the sitting bird, then enters the nest."

March 15, I record: "7:30 A. M. A male *Zarhynchus* alights on nest next to that of *Legatus*. They both attack with frenzy and finally drive him off. Then the male *Legatus* looks in the nest fluttering and calling excitedly and after he repeats this performance she enters. 5:15 P. M. Both *Legatus* sit near nest preening. She flies in and remains. He continues to call. Have not heard her call since she began to nest." From this date until March 24 the life of the two flycatchers centered about this nest which the female was seen to enter almost daily.

On the night of the 23d the twig to which nest No. 1 of Group 2 was

attached broke and the nest fell. It was found to have the round hole in the side at the inner nest level that I associate with nocturnal attack and, since there was not sufficient wind to account for the fall of the nest, I attribute the mishap to the weight and movements of the marauding visitor. There was nothing in the nest when, early on the morning of the 24th, I picked it up beneath the tree.

This nest hung with, and almost touched, No. 2 occupied by *Legatus*. The latter nest was also seen to be penetrated by a hole similar to that in No. 1. My records for the day read in part: "7:30–8 A. M. *Legatus*, male, sits above nest calling as vigorously as in January. The female appears, and preens showing the abdominal parting. The male flutters excitedly at the mouth of the nest but does not enter. He returns to a calling perch and the female enters the nest. All perfectly regular but where are the young?"

Later in the forenoon I wrote: "Male and female *Legatus* perched near nest. Both call 'tweet-tweet,' etc. This is the first time I had seen her call since she began incubating. . . . Female *Legatus* again near nest preening. She is off the nest more today than at any previous time during incubation. Twice the male has attacked her standing over her with fluttering wings while she with belly up hangs below him. I saw no blow struck but the attitudes were those of offense and defense. After a few seconds both flew off." At 11 A. M. the female entered the nest. March 25 *Legatus* called as usual. At 4 P. M. a male *Zarhynchus* alighted on their nest. *Legatus* attacked vigorously but for the first time under this threat no female appeared.

*Legatus* continued to call loudly and persistently on the 25th and 26th but no female was seen. On the 28th, however, one appeared. My record reads: "*Legatus* has not called in vain. A female of his species was present this morning and the evidence indicates that she was not the bird that occupied and was apparently nesting in No. 2. He chases her and is, I think, trying to show her one of the group of four nests in Group 2. She seems to be in fresher, less worn plumage than the supposedly missing female, and when preening, which she does only occasionally, the feathers do not part widely in the center of the abdomen. She perched for a moment on No. 2 but she did not enter."

March 29, 30, 31, *Legatus* called with all the vigor of the early season but no female appeared. At this point my record for the season ends.

I can present only a theoretical interpretation of the actions of this pair of birds. To me they indicate that the contents of their nest (No. 2,

Group 2) having been destroyed by night attack, the female deserted. The male then attracted the attention of another female but did not succeed in winning her as a mate.

## ASSOCIATED SPECIES

The sand-box tree in which the oropendolas nest forms an attractive and advantageous perch, particularly for birds that cross the clearing. During the period covered by these observations I have seen slightly over 50 species of birds in it. Four of these species, in addition to *Zarhynchus* and *Legatus*, nest in the tree; they are the violet-throated hummingbird (*Anthracothorax violaceicollis*), the Colombian flycatcher (*Myiozetetes texensis columbianus*), Natterer's cotinga (*Cotinga nattereri*), and the blue tanager (*Thraupis cana*). Of all the birds seen in the tree, only six appear to have direct association with *Zarhynchus*. They are a cowbird (*Cassidix oryzivora*), a flycatcher (*Legatus albicollis*), a hawk (*Spizastur melanoleucus*), an owl (*Pulsatrix perspicillata*), a cacique (*Cacicus vitellinus*) and a hummingbird (*Anthracothorax violaceicollis*).

The first two are parasitic, the second two, predaceous. Their observed relations to *Zarhynchus* have already been described under the section devoted to the enemies of *Zarhynchus*. The relations of the remaining two I will speak of here.

*Cacicus vitellinus.*—From the beginning to the end of the nesting season, as I have observed it, usually one cacique is present in the nest-tree acting as though it were a member of the colony. Rarely two males were seen, and on February 16 two males and two females were in the tree at the same time. One male, however, is the normal *Cacicus* representative. This bird often arrives as soon as the first *Zarhynchus*, and it, or another, may be in the tree the greater part of the day. It makes no attempt to associate closely with *Zarhynchus* and does not perch very near the nests, its chief activity being the delivery of its calls. While bearing a general resemblance to those of *Zarhynchus* the notes of *Cacicus* are more varied, more musical and louder, and they are uttered more continuously and more insistently, at times for an hour or more without ceasing. In view of the fact that no other individual of its own species is in the tree or apparently near, and that the bird addresses only a general and unresponsive audience, its energy and persistence are inexplicable. At its maximum the delivery of its notes is accompanied by an interesting display in which the wing-tips are crossed beneath the tail and behind the feet, the yellow rump feathers fluffed and expanded, while the wings and tail are violently trembled. This continues for several minutes as the bird

calls loudly. Occasionally a male *Zarhynchus* drives the too willing performer from his perch but beyond this no attention is paid to him. According to Jewell, as reported by Stone,[1] *Cacicus* nests in the Canal Zone in March. One might imagine, therefore, that the male or males that devote themselves so earnestly to the *Zarhynchus* colony might find more appreciative listeners in the females of their own species.

*Anthracothorax violaceicollis.*—Nesting in the sand-box tree evidently gives the black-throated hummer a sense of proprietorship which leads it to attack nearly every trespassing species including *Zarhynchus* and its enemy *Cassidix*. The bird, therefore, plays some part in the nest-life of the oropendola while the regularity of its return to the nest-tree affords additional evidence of marked periodicity and localization in tropical birds.

On January 16, 1926, a violet-throated hummingbird was discovered on the eastern side of the sand-box tree building its nest near the tip of an absolutely bare limb at least twenty-five feet from the nearest leaf. There was not a more exposed site in the tree. From this point it attacked birds trespassing within its territory with a dash and courage which promptly put them to flight. Oropendolas were frequently followed to their nesting quarters and sometimes driven from the tree. So effective and persistent were the bird's assaults it seemed not improbable that if they had been made before the oropendolas had begun to build they might have prevented them from settling in the tree.

On only one occasion did the bird retreat before a trespassing species, this was a white snake-hawk (*Leucopternis ghiesbrechti*) which in one instance perched within a few feet of the hummer which promptly took flight. On the other hand a bucco (*Bucco subtectus*) was permitted to sit for some time near the hummer's nest without molestation. The nest was apparently completed about January 20, and the bird began to sit sometime between January 21 and 25. It was believed to contain young on February 9, and on the 11th the parent was definitely seen to feed the young. On February 19 the bills of both young could be seen above the rim of the nest. On this date observation ceased.

In 1927 a hummingbird of the same species built a nest on the nearest available site to the one occupied in 1927, the limb on which that nest was placed having meanwhile fallen. When discovered on January 19 the bird appeared to be incubating. On the morning of January 30 this nest and bird were missing.

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[1] 1918, Proc. Acad. Nat. Sci., Phila., p. 280.

On January 11, 1928, a female violet-throated hummingbird was discovered building a nest at or very near the site occupied by this species in 1927. She apparently began to sit about January 15. The date of hatching was not ascertained but on February 3, during the process of feeding, the bills of the young could be seen above the rim of the nest. One of these young left the nest on February 20, the other on February 22. On March 12 a female, presumably the mother of the first brood, was seen on the nest, which had been renovated, apparently laying. On March 14 she began to sit and she was still incubating when last I saw her on March 24.

*Cotinga nattereri.*[1]—On March 24, 1927, I discovered a nest of Natterer's cotinga in the sand-box tree. So far as I am aware it is not only the first recorded nest of the species but of any member of the group of blue cotingas. It was about 90 feet above the ground, halfway between the trunk and the terminal twigs in the angle formed by an orchid growing from the side of a nearly horizontal limb about five inches in diameter. It was occupied by a female brooding two young that were covered, apparently, with snowy white down.

On March 31 the young were missing and on April 2 the nest was partly pulled to pieces by the female. During this period no male cotinga was seen.

On February 8, 1928, a female cotinga was seen building a nest in exactly the same place occupied by this species the preceding year. February 16 the female was on the nest, evidently laying, and from this date she was seen sitting on the nest until March 12. On March 13 she was missing and no cotinga was seen until March 20 when a female was observed perched in the top of the sand-box tree for about 30 minutes. She was not seen to visit the deserted nest. Four days later a female was seen in the sand-box tree with a rootlet in her bill and on March 28 a female began to build a nest on the north side of the tree, slightly above and about 50 feet from the abandoned nest.

It seems not improbable that the owner of the first nest, having been robbed of her eggs, had started a new nest. However that may be, I give these facts for the additional proof they afford that tropical birds may return to the same nest site and nest at approximately the same date in successive years. If the nest of 1928 had not been disturbed, the dates given indicate that the young would have hatched shortly, when on March 24, the nest would have contained young of approximately the same age as those discovered in the same nest-site the preceding year.

[1] I include certain of my notes on this species for the bearing they have on localization, periodicity and sexual relations in *Zarhynchus*.

On two occasions a female *Cotinga nattereri* was observed on the sand-box tree in 1926, but, as I have before remarked, the tree was not then under close observation and no nest was discovered though it is by no means unlikely that one existed.

On only three occasions during the three seasons I have passed on Barro Colorado have I seen a male *Cotinga nattereri* near the laboratory. None of these was in the sand-box tree. Two perched for a few moments at the top of a dead tree about 100 feet from the sand-box tree. They were alone. The third was at the border of the forest 120 yards from the sand-box tree. A few minutes after he flew back into the forest a female cotinga left the forest from nearly the same place and flew to the nest in the sand-box tree. This was on February 14, 1928, when my observations indicate that the female was laying. It is not improbable, therefore, that the sexes were associated on this occasion.

*Thraupis cana.*—A pair of blue tanagers nested in the oropendola tree in the season of 1927 and 1928. They selected for their site a large mass of parasitic plants (the lower side of which was occupied by a colony of stingless bees) where it was not possible to watch them closely and I have no notes on the progress of their nesting.

An iguana (*Iguana iguana*), between four and five feet in length, was usually present in the sand-box tree and on occasions two smaller ones were observed. They would lie motionless for hours stretched out on the larger, upper limbs, apparently sunning themselves. Rarely they ate the leaves of the tree. None of the birds that frequented the tree were seen to notice them, nor were the iguanas concerned with the birds.

## SUMMARY OF OBSERVATIONS ON A NESTING COLONY OF OROPENDOLAS (*ZARHYNCHUS WAGLERI*) ON BARRO COLORADO ISLAND, C. Z.

The tree occupied by the oropendolas, when, in 1924, the laboratory was established, having fallen in June of that year, the present site was selected the following year. The new tree, which is believed to have been chosen chiefly because of its proximity to the former home, does not apparently offer the advantages of the fallen one and the colony appears to be decreasing in numbers.

The birds exhibit much regularity in the date at which they begin to nest. In 1926 and 1927 nest-building began on January 8, in 1928, on January 2. A hummingbird (*Anthracothorax violaceicollis*) and a cotinga (*Cotinga nattereri*) that nested in the oropendola tree showed a similar regularity in site and date. While the nesting season coincides roughly

with the dry season, the exact time of its inauguration does not appear to be closely dependent on the rainfall. Temperature apparently presents too little variation to be a controlling factor. The return of these birds to the same place year after year illustrates the homing instinct, while the seasonal regularity of their visit is in evident response to those annual promptings of the reproductive system which are believed to have been the fundamental motivating factors in the origin of bird migration.

Data on a second or supplementary nesting-season are not conclusive.

The females outnumber the males about six to one. If this disparity of the sexes is an actual characteristic of the species it may be the cause of the colonial association that permits one male to mate with several females. The males show no marked sexual jealousy. Courtship begins with nest-building. A male may woo several females but he apparently has but one mate at a time; the length of this association covering only the period when the ova are ready for fertilization. A similar type of sexual relation appears to exist in the hummingbird and cotinga that nest in the oropendola tree.

The males take no part in the selection of the site, gathering of building material, construction of the nest, incubation of the eggs or care of the young. They are, however, in constant attendance on the females either as wooers or accepted mates until the eggs are laid. As watchmen of the colony they play an important part in the protection of the females, particularly in the early stages of nest construction.

Only two other colonies of *Zarhynchus* being known on the island there is no question of colonial territorial rights; but there is often pronounced competition among the females for possession of a nest-site.

A new nest is built each year, about one month being required for the completion of the bag and its contained nest. The females then begin to sleep in the nest, leaving the males, who never enter the nest, to return unaccompanied to their roost in the forest.

Two eggs are laid. The period of incubation is approximately 17 days. The young leave the nest about one month after hatching.

The terminal twigs of the nest-tree are brittle and in a strong wind sometimes break. Nests that fell from this cause contained both eggs and young but were not found to be infested by parasites. The only ascertained enemies of the oropendolas were other birds. They are parasitized by a cowbird (*Cassidix*), and a flycatcher (*Legatus*), no larger than a phœbe (*Sayornis phœbe*), constantly harries them with the evident purpose of securing possession of one of their nests for its own uses

The building female is at times susceptible to attack by hawks, from which it appears to be the duty of the male to guard her. In response to his alarm call the entire colony dives hastily into the lower forest growth. An owl (*Pulastrix*) makes an opening in the lower part of the nest-bag and the oropendolas appear to be at the mercy of this foe. The inaccessibility of the nest-site, and impregnability of the pendant, strongly woven nest-bag are, therefore, more apparent than real. Furthermore, the conspicuousness of their homes offsets the advantages of colonial nesting with its implied absence of marked sexual and territorial jealousy and increased protection through the community interests that make the enemy of one the enemy of all.

*Zarhynchus* cannot lay the slightest claim to the possession of a protectively hued plumage. In color, size, and habit, during the most critical period of its annual cycle, it is highly self-advertising. Its safety depends on that constant vigilance which keeps it ever on the alert and on the instant, unquestioned obedience to the alarm note that prompts it to dive headlong into the dense vegetation from which it is never far distant.

### Postcript

The day that this paper was completed I received word from Mr. James Zetek, resident custodian of Barro Colorado, that the sand-box tree in which the oropendolas nested was blown down by a severe wind storm on August 28, 1928. Evidently, like its predecessor, this tree, as a member of a forest community, had not developed sufficient hold upon the ground to stand alone.

I had hoped that this contribution to our knowledge of the nesting habits of *Zarhynchus* would form the opening chapters of a history that would increase in interest as added data enabled us to view the present in the light of the past. But so far as the sand-box colony is concerned I can now write only *finis*.