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## LIFE HISTORY OF THE BLUE-THROATED GREEN MOTMOT

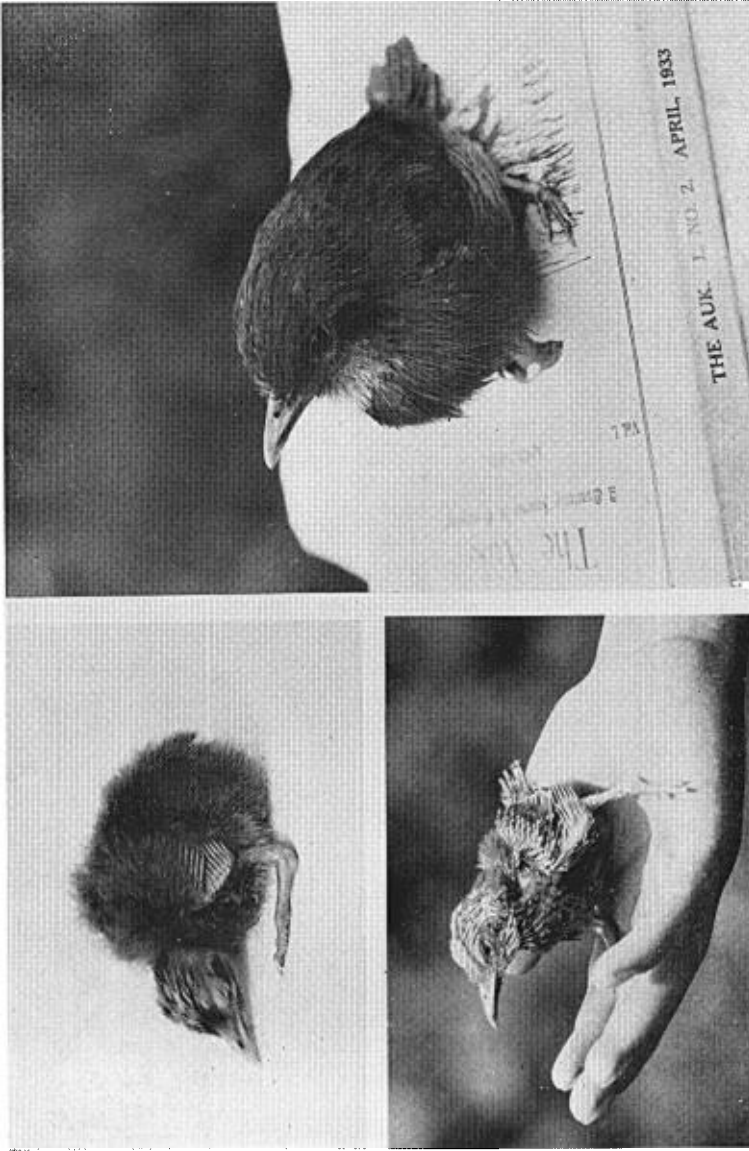
BY ALEXANDER F. SKUTCH

*Plate 22*

THE motmots are a small family of medium-sized, arboreal birds confined to tropical America. Their nearest relatives in this hemisphere are the kingfishers which they resemble, in external characters, most obviously in the form of the foot, which has the two outer toes joined for a good part of their length, and only a single toe directed backward—in sharp contrast to some of the other non-passerine arboreal birds of the tropical American forests, with two toes directed backward. In their mode of reproduction, motmots and kingfishers also show many resemblances. Motmots and trogons are, to my mind, the two most beautiful families of larger birds in the American Tropics; but their coloration is strikingly distinct. The plumage of the trogons is very brilliant, often with a metallic luster, while motmots are clad in softly blended pastel shades, chiefly of blue, green and chestnut. Their loveliness is enhanced by the peculiar grace of their tails. The rectrices are strongly graduated in length, and in most species the shaft of each feather of the long central pair is naked for an inch or two just before the tip, forming a slender stalk that supports an oval disk or racquet at the end. When these feathers first grow out, the vanes are intact along the entire length of the shaft, but often narrowest in the subterminal portion from which they will later be removed. The feather barbs appear also to be more loosely attached in this region, and break away as the bird preens its tail, leaving the shaft naked.<sup>1</sup> The Blue-throated Green Motmot (*Aspatha*

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<sup>1</sup> There is a weakened structure of the barbs close to their juncture with the shaft which facilitates the separation.—ED.



(Upper left) BLUE-THROATED GREEN MOTMOT, 11 DAYS OLD. (Lower left) TURQUOISE-BROWED MOTMOT, 12 OR 13 DAYS OLD (NOTE FAR GREATER DEVELOPMENT OF DOWN ON THE SLIGHTLY YOUNGER BLUE-THROATED GREEN MOTMOT). (Right) FLEDGLING BLUE-THROATED GREEN MOTMOT, ABOUT FIVE WEEKS OLD.

*gularis*) differs from nearly all other members of the family in its entire central rectrices.

Some members of the motmot family, as the Great Rufous Motmot (*Baryphthengus martii*), dwell among the tree-tops in heavy lowland forest. But the exquisite Turquoise-browed Motmot (*Eumomota superciliosa*) prefers the tangled thickets that cover abandoned clearings in the humid districts, or the cacti and thorny scrub of arid regions, where it lives side by side with another species, the Chestnut-headed Motmot (*Momotus castaneiceps*), restricted to a semi-desert valley. The subject of the present study is again quite exceptional in the family in its high-mountain habitat. Motmots appear to be most abundant in northern Central America and southern Mexico. Here, especially in the more arid and open regions, they are among the abundant and conspicuous birds; one can not walk far through the thorny scrub and cacti of such districts as the middle Motagua Valley of Guatemala, or the Pacific side of the Isthmus of Tehuantepec, without becoming aware of them. On the other hand, during nearly a year in northwestern South America, in which I travelled widely on both sides of the Andes in Perú, Ecuador and Colombia—most of the time not primarily engaged in studying birds, but always alert to see them—I did not meet a single motmot.

Little has been published on the life history of motmots. Among the most extended notes on their breeding habits that have come to my attention are those published long ago by Robert Owen (1861, quoted by Salvin and Godman, 1879–1904), and by Gaumer (1881–1882), who presents certain theories I find it difficult to accept. The present study is one of a series projected some fifteen years ago to illustrate with life histories of representative species the habits of the principal families of neotropical birds. The publication of results has proceeded even more slowly than the gathering of information in the field. My observations on the Blue-throated Green Motmot were made on the Sierra de Tecpán, above the town of the same name in the Department of Chimaltenango, west-central Guatemala, from February to December, 1933. In another paper (Skutch, 1942) I have described briefly the climate and vegetation of this region. Here I need repeat only that the woods on the mountain slopes between 7000 and 9000 feet—the zone in which most of the nests of this motmot were found—are composed largely of oaks, pines, alder, arbutus, and other broad-leafed trees; while from 9000 feet to the summit of the range at 10,000 feet, where our bird nests in small numbers, the dominant tree is the cypress (*Cupressus benthamii*), which forms magnificent forests of gigantic trees in an almost pure stand. The

climate is marked by strong seasonal variations, with an often very wet rainy season extending from about mid-May to mid-October, and a rather severe dry season covering the remainder of the year. From early November until the beginning of April, heavy frosts form almost every clear, still night on the open fields above 7000 feet. To one who knows the lowland motmots, nothing could be more surprising than to find a member of the family residing the year around in a climate such as this.

The Blue-throated Green Motmot is endemic in the highland area of Guatemala and Chiapas, where it ranges from about 4000 to at least 9600 feet above sea-level. By no means rare, it is yet so elusive that despite rather extensive travels through the highlands of the former country, I saw it only on the Sierra de Tecpán, where I spent so much time studying the birds. Although a not quite typical member of the family, and at all times excessively shy, its strong attachment to its burrows made it possible to follow all stages in its life history more completely than I succeeded in doing with the generally more confiding Turquoise-browed Motmot, to which I devoted much attention in the lowlands. In the concluding section of this paper, this highland motmot is briefly compared with its lowland relations.

#### APPEARANCE

The bird-lover's first meeting with a new kind of bird is always a memorable occasion, and particularly so when the species is so distinct as this. Often it stamps the bird's essential character far more vividly upon the memory than many subsequent meetings, which serve only to modify the first impression. It is pleasant to recall my first encounter with the Blue-throated Green Motmot on the Sierra de Tecpán. The morning had dawned dark and cheerless, and the wind drove a chilling cloud-mist across the mountain from the west. I fled before the wind and clouds and started down a long, steep slope that faced the south, passing rapidly through a close stand of young oak trees, a coppice-growth from stumps left at an earlier cutting, among which stood an occasional pine, alder or arbutus. The ground was thickly covered with fallen oak leaves and pine needles, which rustled beneath my tread and made the descent excitingly slippery. I passed quickly downward, for there was little variety in the vegetation to attract my attention on the way; and near the foot of the long slope I came into a region where the stand of trees was more open, with flowering herbs and shrubs between them, and the sun shone from a blue sky. Here and there among the bushes,

the pretty flower-heads of the shrubby ageratum sent back an answering reflection of blue from the earth. On this leeward slope, wind and cloud-mist seemed very remote.

A green bird darted across a clear space and disappeared among the close-set branches of an oak tree. I stalked it; and after several successive retreats it remained stationary on a low branch, in full view. I was delighted with my find. The bird was of medium size, nine or ten inches long, entirely clad in a beautiful, soft shade of green, except for the pale buffy feathers that surrounded the eyes and covered most of the cheeks, the black ear-coverts, the azure throat, and the blue that terminated the two long central tail feathers, gradually blending into their green basal portions. It sat quietly on the branch, turning its big head toward me and calmly inspecting me with large, brown eyes. The deliberate way it twitched its tail from side to side, with an occasional abrupt jerk up and down, betrayed its affinity to the motmots; but the vanes of the long middle tail feathers were perfectly entire, without the racquet-like tips of all the members of this family I had previously seen. When the bird suddenly made a graceful about-face on its perch, lifting its tail over the branch with a flourish, I had no longer any doubt of its family relationship, in spite of the untrimmed tail feathers. The broad, heavy bill, hooked at the tip, with stiff bristles springing from the base, were added proof that my new bird was a motmot. After a few minutes it suddenly darted away, without having voiced a single note. I have used the neuter pronoun because I afterwards learned that the sexes of the Blue-throated Green Motmot are not distinguishable in the field, and I shall never know whether the first of the species that I ever beheld was a male or a female.

#### THE BURROWS—THEIR USE BEFORE THE BREEDING SEASON

This, my first encounter with the Blue-throated Green Motmot, took place during my first visit to the Sierra de Tecpán, in November, 1930. When I returned in February of the third year following, I found a number of burrows in the earthen roadside banks. The absence of cobwebs in the tunnels, and the freshness and sharpness of the two parallel grooves or ruts that ran along the bottom, left no doubt in my mind that they were in use and that they belonged to birds; but because of the earliness of the season, I doubted very much whether there were eggs or young within. As to the makers of these burrows, I felt certain that they must be the motmots. Aside from the Cobán Swallows (*Notiochelidon pileata*), whose burrows would be marked on the bottom with a multitude of fine scratches instead of

deep furrows, I had found on the mountain no other birds belonging to families which customarily nest underground. But my conjecture that the burrows belonged to the motmots needed confirmation.

Using the expedient of setting a little green twig upright in the entrance of a burrow, in such a manner that any bird passing in or out would be obliged to push it over, and then revisiting the burrow at intervals, I learned that it was entered only at the close of the day. The following evening I arrived before sunset to watch in front of this burrow, from a place of concealment among the bushes on the opposite side of the road. I waited an hour, but no bird came to enter the tunnel; the Whip-poor-wills began to call and the earliest fireflies to glow, and I was beginning to fear that my vigil had been made in vain. Just as I was about to abandon the fruitless watch, a form dimly seen flew out of the dusk and darted into the burrow, uttering a sort of laughing call as it went. I had not seen the vapory figure clearly enough to recognize to what species the bird belonged. It was already too dark to write in my notebook, and most diurnal birds had become silent for the night. Only the Rufous-collared Thrushes (*Turdus rufitorques*) continued their twilight carolling from their roosts among the pine trees.

The next morning, long before dawn, I went out into the mist and cold drizzle to make another attempt to clear up the mystery of the burrows, and took a post in front of the one that I had watched on the previous evening. Dawn had scarcely begun to augment the wan gray light that filtered through the thin clouds from the waning moon, when an obscure form darted out of the burrow, uttering the same queer note I had heard as it entered, and in an instant was lost in the fog. Although this note was sharper, it bore just sufficient resemblance to one of the calls of the familiar Lesson's Motmot (*Momotus lessonii*) to strengthen my suspicion that its author was a member of the same family. Before leaving the burrow, I set up a little twig in the entrance, and when I returned half an hour later I found that it had been pushed outward. There had evidently been a second bird in the burrow.

The following morning, as the earliest glow of dawn brightened the eastern sky, I took my stand just beside the entrance of a different burrow, and waited quietly. Before the brighter stars and the waning moon had lost their brilliance in the growing daylight, I heard low, musical murmurs emerge from the depths of the bank by my side. A minute later, a long-tailed bird flew out, passed in front of me and crossed the road, uttering a low, throaty note which again faintly resembled the call of an excited Lesson's Motmot. After another

minute a second bird flew out, but alighted in the road directly in front of the burrow. By taking a single step forward and bending over I might have touched it, or at least the spot where it stood. It was still too dark to distinguish its colors, but its graceful form stood sharply outlined against the gray roadway. It must have lingered in this motionless attitude a full minute before it darted away. A moment later the clear, mellow, almost soprano call of one of these birds sounded from among the oak trees.

By this time I had no reasonable doubt that the burrows in the roadside banks belonged to the green motmots; but I wanted to have a really satisfactory view of the birds as they came out in the morning, and make quite certain that I was right. It was of no use to stand beside the burrows in the dawn—the occupants always emerged before there was enough light to distinguish colors—so I decided to delay their departure until a time more convenient to myself. Toward the end of the night, I stopped the mouths of some of the burrows with handkerchiefs. I waited until it was quite light before removing the obstruction, then stepped to one side to watch the birds emerge. At first I managed to frighten them, and they would not abandon their deep retreat while I waited. But my failures taught me what precautions must be taken, and finally one morning, a few minutes after I had stealthily pulled the handkerchief from the entrance of a burrow, two Blue-throated Green Motmots darted forth and were clearly seen. These, then, were the tenants of the baffling burrows.

On my rambles over the mountain I had discovered more than a dozen burrows of the type of these, chiefly in the roadside banks among the forests of oak, alder and pine between 8000 and 9000 feet above sea-level; but a few were in the sides of wash-outs on steep slopes. I determined to make a census, and learn how many occupants each contained. After a few unsatisfactory trials, I abandoned the attempt to count the motmots as they entered for the night. They never retired into their dormitories until the light had grown very dim, and it was difficult to follow their swift movements. For a variety of reasons, it was not practicable to watch the majority of these burrows from a blind. Although I experienced difficulty in seeing the birds in the dusk, their keener eyes invariably picked me out from my partial concealment among the bushes. They flew back and forth, hesitating to enter in my presence, and sometimes fluttered before the entrance without going in, thereby completely confusing my count, because I could not see clearly just what they did. At times they became alarmed and flew away to pass the night elsewhere.

The best time to count the motmots was as they left their burrows

in the dawn. On many a frosty morning of February and March, I arose before the east began to brighten, dressed hurriedly and warmly, and walked briskly through the cold night air to keep a tryst at a distant burrow. At the earliest glow of dawn, I stationed myself in the roadway, a few feet to one side of the entrance, where the motmots could not see me until they were already outside of the burrow. I soon discovered that if I leaned against the bank, slight sounds or vibrations through the earth would warn the shy occupants that some animal was close at hand, and they hesitated to come forth.

Before the brightest stars had been quenched by the flood of day, while the Rufous-collared Thrushes and the Brown-backed Solitaires (*Myadestes obscurus*) welcomed the dawn from the dark woods, low, musical murmurs would emerge from within the bank at my side. Sometimes they would be repeated again and again; but usually, upon hearing them, I had not long to wait until a motmot, dim, shadowy and colorless in the uncertain light, darted from the burrow so close beside me that I could hear the rustle of its beating wings, crossed the road voicing low, rapidly repeated guttural notes, and vanished among the bushes on the opposite side. Sometimes a second unsubstantial being followed almost at once; sometimes it delayed a few minutes before joining the first in the thickets below the road. Then from amidst the dark foliage there would issue a deliciously mellow piping, full and round and clear, an undulatory call that carried far across the dim woods and frost-whitened meadows. At times the first to emerge raised its clear voice while the mate still delayed in the burrow, and the answer of the latter came as a liquid murmur from within the earth; but usually it waited for the mate, and the two sang in unison to greet the new-born day with a single fluid harmony. When the two motmots were so far apart that I could distinguish their individual voices, I noticed that the voice of one, probably the male, was deeper and fuller than that of his mate.

This dawn song, which is rarely repeated during the hours of full daylight, and then almost exclusively in the mating season, is so clear and melodious that the bird which utters it must be ranked with the tinamous as one of the most gifted vocalists among families which are not true song-birds. It is incomparably more musical than the call of any other motmot that I have heard. How different from the dull, wooden *cawaak cawaak* of the lovely Turquoise-browed Motmot, or the deep, lusterless *cwaa cwaa* of the Broad-billed Motmot (*Electron platyrhynchus*), or the frog-like *coot coot* of Lesson's Motmot; how different again from the whispered hoot with which the Great Rufous Motmot greets the day! In addition to the rapid, undulatory piping



just described, the Blue-throated Green Motmots sometimes deliver a series of single liquid notes, which follow rapidly with rising inflection—an utterance no less pleasing than the other.

#### POPULATION

The motmots' burrows were scattered along the roadside banks, always close to the woods, and usually well separated from each other by fifty yards or more of intervening roadway. The birds considered that a bank three feet high was sufficiently lofty for their home-site, provided that it was vertical. Rarely two occupied burrows were close together. At the top of a narrow wash-out on the slope of a deep ravine, covered with cypress forest, I found two burrows only seven feet apart; but this was exceptional. Of the thirteen burrows to which I made visits in the dawn during February and March, eleven were occupied by a pair each. One burrow, from which a single motmot had emerged, was found the next morning to be deserted, and remained so throughout the year. Three motmots slept together in one of the burrows in the wash-out, two in the other. At this season the burrows were rarely if ever entered during the day, as the little twigs that I set upright in the entrances always testified. The burrows were only dormitories in which the motmots sought shelter from the nocturnal chill of these high mountains. The motmots of the hot lands, so far as I have been able to discover, occupy their burrows only while they hatch their eggs and rear their offspring.

Among the oak forests below 9000 feet, it was easy to find the motmots' burrows, for the birds made no attempt to conceal their entrances in the bare earthen banks. Had I needed them, I believe that I could have located several dozen within a radius of a mile. It was indeed far easier to find the burrows than to see the motmots themselves while abroad in the woods; I rarely caught sight of them except when I stood beside their dormitories to watch them emerge at dawn. I was told of a collector of long experience who several years before my arrival had worked for a month on the same hacienda. Although the *pájaro verde* had been described to him and he was on the lookout for it, he did not see a single individual, and went away unconvinced of its presence in this region! Certainly the casual observer would have called the green motmot a rare bird; but I found seven pairs sleeping in the banks along a mile of winding mountain road, and am not sure whether a species present in such numbers should be designated as rare. Basing my estimate upon the number of nests of each species that I found, and making all allowance for the greater ease of discovering those of the motmots with their more limited choice of

sites, I believe that these birds were quite as abundant as the Mexican Trogons (*Trogon mexicanus*), which almost anyone would have called a common bird among the oak woods. Yet I saw a trogon a score of times for every occasion that I glimpsed a motmot. The trogon's bright red belly and foolish habit of taking flight with a noisy cackling whenever it thinks itself discovered, make it conspicuous; but the motmot's almost uniformly green plumage, and its habit of stealing discreetly and noiselessly away whenever it finds itself observed, make it extremely difficult to see.

Among the cypress forests near the summit of the mountain the motmots were far less abundant. Indeed, I never suspected their presence until I found a burrow, and I never chanced to see one of the birds except when I stood at the entrance of the burrow to watch its occupants emerge early in the morning. By searching the banks along many miles of logging roads, I found one more burrow. These burrows were at an altitude of about 9600 feet, and a single pair of motmots slept in each.

#### FORM AND CONTENTS OF THE BURROWS

As March advanced, I waited for the motmots to dig new burrows in which they would breed; but when they failed to do so, I thought it advisable to open the old ones, so that I could time the laying of the eggs. I had learned, by studies of kingfishers and motmots in the lowlands, that the safest method of opening a burrow is to dig from the surface a vertical shaft that will barely touch the back of the nest-chamber, into which an opening just large enough to admit the hand is made. With the burrows in the soft alluvial soils of the lowland valleys, this was not difficult of accomplishment. After measuring the length of the burrow by pushing in a pliant section of a vine, and noticing the direction of its curvature, I could usually judge with sufficient accuracy the point where I should begin to dig. But the tunnels of the green motmots were often so tortuous that I could not even guess where they ended. Some took one or even two sharp turns, which made it impossible to push in a vine and determine their length. One went straight into the bank for 22 inches, then made a turn of 90 degrees to the right, and continued in this direction for 18 inches more. Here it turned abruptly through somewhat more than 90 degrees to the left, then extended 24 inches more to the end. To locate the end, I found it necessary to uncover much of the tunnel at the first bend, whence, by feeling with a stick and groping with my hands into the more distant portions, I formed a rough idea of the position of the sleeping chamber. Here I dug a second shaft which

fortunately touched the side of the chamber. I bridged over the uncovered part of the tunnel with pieces of wood, then filled in the earth and covered over the excavation with leaves and litter. The aperture in the side of the sleeping chamber, through which I intended to look inside from time to time, was closed off with a stone, and the hole filled and concealed in the same manner.

These twists and turns in the tunnels were apparently made because the motmots encountered roots and stones which forced them to change the direction in which they dug. The end of another burrow, almost directly beneath a small oak tree, was even more troublesome to locate, and required several successive attempts on different days, including the sinking of two shafts, before I finally reached it. Later, while trying to reach a third nest, after the eggs had been laid, I erred in my calculations and dug directly into the top of the nest-chamber, where unfortunately I broke a perfectly fresh egg. It was necessary to roof this chamber with a plank of oak wood before I could refill the hole. The remarkable outcome of these excavations and remodellings of mine was that not a single one of the four burrows that I opened was deserted. This was undoubtedly because the owners had become very strongly attached to them through long months of use, and so were willing to overlook these alterations. In the lowlands, where kingfishers and motmots dig their burrows only a short while before they are ready to lay eggs in them, the birds will almost surely desert if the slightest alteration is made before incubation is well advanced. Yet none of the lowland members of these families that I have studied is quite so shy as the Blue-throated Green Motmot.

The four burrows ranged from 56 to 70 inches in total length, and were exceedingly diverse in shape. Each at its end widened into an oval chamber with a low vaulted roof in which the motmots slept and afterwards reared their young. The chambers ranged from 10 to 14 inches in length, from  $7\frac{1}{2}$  to  $8\frac{1}{2}$  inches in width, and were from 4 to 5 inches high in the center. No bedding of any sort had been brought in, but the floor of each chamber was covered with a great mass of fragments of the indigestible hard parts of insects, especially of beetles, mixed with the loose earth. These fragments had been regurgitated by the birds during the course of many nights, and indicated clearly what they had been eating. There were very few seeds, showing that berries formed an altogether subordinate part of their diet. The volume of regurgitated shards and exoskeletons revealed that the burrows had been in use for a long period, for below the loose debris they had become consolidated to form a hard floor of considerable depth. Aside from these, the dormitories were perfectly clean, with no traces of excrement and very little odor.

## THE EGGS—INCUBATION

I had now prepared four burrows into which I could peep whenever I desired. After each visit to the chamber, I was careful to close with wood or stone the aperture I had made, then to fill in and tamp the earth above it, and finally to conceal the whole with leaves and litter. Largely as a result of these precautions, I did not lose a single egg or nestling (except the one egg broken while preparing the burrow for study).

All four of the female motmots laid their three pure white eggs at very nearly the same time, during the first ten days of April, just after the last of the nocturnal frosts at this altitude. They were deposited on alternate days—that is, at intervals of approximately forty-eight hours. The appearance of eggs in the burrow did not change the sleeping habits of the tenants, which continued to enter in the late dusk and pass the night in their customary chambers. Whether the eggs were actually incubated during the night before the set was completed, I had no means of telling, but during the day I frequently found them warm, and sometimes, even in the late afternoon, a motmot flew out when I opened the chamber to look in.

One afternoon both motmots flew out of a burrow, but only after I had been digging many minutes above their heads. When finally I uncovered the opening I had made in the side of the chamber, I could feel two warm eggs within. The following afternoon there were still only two eggs; and the bird that attended them bravely remained and allowed me to touch it (because I do not know the sex), with my finger tips. I felt a great desire to lift it out in order to make a better acquaintance with one of these retiring birds, but prudence suggested that I desist. A better opportunity would come later. This motmot was unusually brave; all of the others left their eggs before I could uncover the side-entrance to the chamber.

The measurements of the eleven eggs in the four burrows average  $28.8 \times 22.8$  millimeters. The eggs showing the four extremes measured  $30.6 \times 22.6$ ,  $28.6 \times 23.8$ ,  $27.8 \times 22.6$ , and  $28.2 \times 21.8$  millimeters. In form the eggs were almost equally blunt at the two ends, and scarcely ovate. The pure white shells had little or no gloss.

During the entire period of incubation, both sexes continued to sleep in the burrow at night; but even if the sexes had been distinguishable, I still should have been unable to tell which was actually responsible for keeping the eggs warm. They continued their old habit of emerging at the first light, about half-past five at this season of the year. Now I failed to hear the soft murmurings which had

preluded their departure during the colder months; they were either silent or uttered only one or two low notes. The exits of the two birds were sometimes separated by only a minute or so, sometimes by as much as ten minutes. After emerging, they continued to sing in their soft, melodious voices, but no more than, and often not so much as, on the frosty mornings of February and March. Although not more inclined to sing, they called much more, especially before sunrise, when each of the pair sounded its flute-like monosyllable over and over at intervals of a few seconds, as they answered each other from various parts of the woods. While they breakfasted, the eggs were left unincubated; but the walls of their sleeping chamber, fairly dry at this season, had been well warmed by the animal heat of the two birds during the night, and the eggs in their snug niche remained moderately warm for half an hour or more. I took advantage of this period, when both parents were away, to open the burrow and see whether the eggs were hatching.

This much I was able to learn merely by standing beside the burrows in the dawn, as I had done for the past two months; but to discover how the motmots arranged their time on the eggs during the remainder of the day, it was necessary to use the tent, and to set signals in the form of soft green twigs in the entrance of the burrow. Even with these aids the task was not easy, for the motmots were so shy that the presence of the brown cloth wigwam, twenty-five or thirty feet from the burrows, would keep them away, and it was necessary to conceal the blind itself, at least partially, among the raijón bushes. By spending the better part of three days sitting motionless in my tent, and by using green-twig signals at other burrows as subsidiary evidence, this is what I learned:

After both birds flew from the burrow at dawn, the eggs were left unattended for three-quarters of an hour to an hour, a situation rather unusual among species of which both sexes aid in incubation. Then, at 6:15 or 6:30, one of the pair (which, to my regret, I can merely designate as A, since I do not know the sex), re-entered the burrow. Here it remained warming the eggs until about 10:00 or 10:30, roughly four hours. Then the other (B) returned, relieved A, and sat for about four hours longer—until, between two and three o'clock in the afternoon, A returned for another spell of sitting. At about six in the evening, the latter suddenly darted from the burrow, leaving the eggs again unattended while it went for supper. In about half an hour, one of the pair (now impossible to tell whether A or B), re-entered the nest, and when the evening twilight had become very dim, the mate rejoined it for the night.

These were the approximate times I found at one nest; but there was considerable variation in the hours of relief among different pairs, although I believe that the general scheme of dividing the day between the two was the same for all. On the first day that I watched before a burrow from a blind, when I did not know that the presence of the brown wigwam would be so objectionable to the birds, one motmot remained on the eggs, faithfully awaiting the long-delayed relief, for more than seven hours and probably a full nine—that is, from some time before nine o'clock in the morning (when I began to watch) until after four in the afternoon (when I removed the offending blind). This, however, was a session exceptionally long, caused by exceptional circumstances. On another day, this same motmot sat for six hours, as I learned by setting up a twig in the entrance, without disturbing the relief by my presence. Sometimes, especially when incubation had just begun, I found the eggs cold as early as half-past four or five o'clock in the afternoon, indicating that the bird which had been in charge of the nest had gone early for supper.

At times, the bird arriving to relieve its mate flew directly into the burrow, without giving any warning save the whirr of approaching wings, and the other partner, that had been sitting, darted out a minute later. At other times, the relief, upon arriving, perched near the burrow and called forth the mate with the peculiar low sound I had been accustomed to hear earlier in the season, as the motmots prepared to enter their burrows in the evening twilight. The call was so low that it was barely audible to me as I sat in the tent, but it did not fail to make its impression on the keen ears of the mate in the burrow, which came out at once and made way for the new arrival.

In the lowlands, I had many times tried to determine how many days the eggs of kingfishers and motmots required to hatch; but because of the readiness with which these birds abandon their burrows if they are tampered with before incubation has begun, I usually failed, with a single exception. The exception occurred when an Amazon Kingfisher (*Chloroceryle amazona*) did the unusual thing of laying a fresh set of eggs in an old burrow, from which the newly hatched nestlings of the first brood had mysteriously vanished. Since I had opened the burrow before the first set of eggs hatched, I was able to record the dates on which the eggs of the new set were laid, and to learn that they hatched after 22 days of incubation. In view of the close relationship between kingfishers and motmots, it was interesting to find that the Blue-throated Green Motmots' eggs in my four burrows hatched in 21 or 22 days after the last in each set had been laid. Strangely enough, in two of the burrows all of the eggs hatched within

24 hours; while in each of the other burrows the first two nestlings were born on the same day, the third on the following day. Yet in each nest the first egg had been laid five days before the last, and during the interval the parent birds not only passed every night in the burrow but were sometimes found within during the day as well. This leads me to believe that during the period of laying they did not actually incubate the eggs by night, but rather slept to one side of them.

#### THE NESTLINGS

The little motmots hammered for three or four days at the hard, white shells which held them in thrall, before at last they had made a gap which extended most of the way around the egg, and they were able to push off the large end and squirm forth upon the hard earthen floor of their dark nursery. The new-born birdlings were pink-skinned and absolutely featherless. Their eyes were represented only by two prominent black lumps on the sides of the head. Decidedly they were not beautiful creatures; but before they were a day old, they could already stand erect upon the full feet, with the swollen belly as the third point of the tripod, and even walk a trifle in a halting and tottering fashion. The empty shells from which they had escaped were promptly removed by their parents.

On the day when the nestlings hatched, the devotion of their parents was at its highest, most ardent point, and they remained covering their infants through all the noise of opening the burrows. I reached into the dark chamber and took hold of the guardian bird—mother or father, I could not tell which—which struggled ever so gently to escape. Slowly and carefully I drew it forth to the light, and beheld a creature whose feathers were as fair to the eye as I had already found them soft to the touch—and I have never placed hands upon a bird with softer, finer, looser plumage than these motmots. It looked silently and resignedly up at me with large, deep brown eyes, as soft in cast as the plumage was soft in texture. When I held it on its back for a few seconds, it seemed to fall into a waking sleep, and lay perfectly passive in my hand, as many other kinds of birds do under the same conditions. After I had replaced the nestlings, I lowered the parent carefully over them; and there it remained quietly while I closed over the hole, tamped down the earth upon it, and went away.

From only one of my four burrows did the parent motmot flee away while I was opening the chamber on the day the eggs hatched. But after the nestlings were two days old, the parents invariably retreated into an inaccessible portion of the tunnel, or else darted out and away before I could uncover the aperture in the side of the cham-

ber and reach in. Only once during the period of incubation had I been permitted to touch a bird on the nest.

It is characteristic of young kingfishers and motmots that their feather-sheaths or 'pin-feathers' grow very long and conspicuous before the horny sheaths begin to ravel off and release the enclosed feathers. But the course of events with the young green motmots was quite different. At the age of ten days, when Turquoise-browed Motmots are beginning to bristle with the long, horny pins and bear no trace of down feathers, the blue-throats were nearly covered with very long, soft, ample down. Their backs were almost concealed beneath an abundance of dark gray down, while the down on the sides and flanks was more or less tawny. Upon examining the nestlings closely, it was easy to see that these down feathers sprang from certain very limited regions of the body; but the long, soft filaments billowed over and concealed the bare skin of the extensive featherless regions, and at this early age the little birds appeared decently and warmly clad. I can hardly doubt that this difference between the mode of feathering of the Blue-throated Green Motmots and their turquoise-browed relations has resulted from the different needs of each. The former, resident in the cold highlands, require early protection so that their parents may cease to brood them by day and devote more time to finding their food; the latter, in their burrows in the warm lowland soil, stand in no great immediate need of feathers. The earlier appearance of down feathers on the Blue-throated Green Motmots is not an indication of a generally more rapid development; on the contrary, they mature more slowly than the Turquoise-browed Motmots, and remain in the burrow several days longer.

Aside from their relatively rapid feathering, these young motmots developed slowly, as is the way in their family. They were twelve days old before their eyelids began to separate. Considering that sight must be of little use to them in their dark burrows, and that moreover they would run the risk of getting particles of their earthen ceiling into their eyes, this lengthened period of sightlessness is a wise provision of Nature. The flight feathers did not begin to cast off their long sheaths until the nestlings were sixteen days old. At this age they could hardly perch, but walked clumsily about, supporting themselves upon the whole foot, the heel of which was protected by a prominent, thick callosity, which was entirely smooth like that of jacamars, rather than roughened with small tubercles as with kingfishers, toucans, trogons and woodpeckers. Whenever I opened the burrow to take a look at the little birds, they were at first silent; but if I waited quietly for a minute or so, they began to call and to utter a sort of trill in a pleasant, soft voice.



Both parents joined in bringing food to the nestlings, whose fare consisted chiefly of big caterpillars of hairless sorts and other insect larvae, with an admixture of winged insects. On the morning when the three nestlings in Burrow 2 were fifteen days old, I spent four hours watching from the tent and saw the parents take food in to them nineteen times during this period. The old birds were exceedingly cautious in their approach to the nest and alighted low in the *raijón* bushes across the road, whence they carefully surveyed their surroundings from comparative concealment. While they waited there, peering cautiously around, I enjoyed a better opportunity to study their appearance than ever before—for one does not see a bird in true perspective while it is held in the hand. Despite their soft green plumage and clear blue throat, they seemed to me just to escape being beautiful. The pallid tawny feathers on their faces gave them a wan and even slightly sickly appearance which prevented their being completely satisfying to my eye. Assured that the coast was clear, they darted rapidly across the road into the mouth of the burrow, silently or uttering a queer little throaty noise. The food delivered, they shot forth head first from the burrow, one to five minutes later.

In common with other motmots and the generality of birds that nest underground, the parents never made any demonstration or feint of attack when I took their nestlings from the burrow, and never tried to lure me away as birds which nest on the surface of the ground so often do. Rather they remained at a safe distance while I was near the nest, and were either silent or made their little throaty noise.

By night, both parents continued to sleep in the burrow with their children, even after the latter had become well clothed with feathers and seemed too big to be brooded. A habit of such long duration is not easily broken. Both emerged at the break of day, as they always did. During the nestlings' final ten days in the burrow, however, some of the adults began to make different arrangements. In one instance the parents, which had only two nestlings, both continued to sleep with them so long as they remained underground. But at another burrow, only a single parent stayed with the youngsters during their last few nights in their nursery. A third pair arranged matters in still a different manner. First one, then the second parent gave up the habit of sleeping in the burrow; and during the last four nights before they took flight, the nestlings were alone. Those parents which elected to sleep in the open must have found the change from their snug underground quarters most uncomfortable, for by this time the rains had set in and nights were cold and wet. But the grown motmots that continued to sleep in their nests also had their troubles.

In the morning before they flew out, the nestlings made a terrible din, importuning to be fed with many loud trillings and mellow-voiced calls, which would have been pleasant enough to hear if they had not all been uttered at once, without any attempt at unison, in so confined a space. After continuing for many minutes, this clamorous chorus would end abruptly when the besieged parents retreated into the open. They lost no time in bringing breakfast to their hungry offspring, and sometimes returned with an insect in their bill before the light was strong enough to reveal their colors.

Meanwhile the nestlings which, when we last glimpsed them, were little clumsy balls of gray down, scarcely able to see or to perch, have been slowly acquiring their plumage and their strength. It was interesting to watch their transformation from gray to green. A bird may change its color by several methods. The most usual is by means of a molt, when the old feathers are bodily shed, a few at a time, and replaced by entirely new ones of a different color. Another mode of transformation which is not uncommon is known as 'plumage wear'; the dull tips that terminate the newly sprouted feathers gradually drop off, revealing far brighter hues that were overlaid and concealed by them. But the young motmots followed neither of these schemes. They could ill afford to shed their warm gray down—they needed every bit of it to get through the ordeal that lay just ahead—so they retained it all, but covered it over and concealed it by green feathers of subsequent growth.

While the development of certain feather rudiments was hastened to give the naked little birds a protective covering of fluffy down, other feathers continued to grow more slowly. This was particularly true of those along the very center of the back, which showed only their green tips at a time when the outer feathers of the same tract had become fluffy tufts of down. But these green feathers continued slowly to grow out from their sheaths and, spreading sideways, pushed down and concealed their loose gray neighbors which a short while before had been so prominent. Spreading still more broadly, the green feathers of the central row finally overlaid the gray down on the shoulders. Meanwhile the wings, which were gradually clothing themselves in green, began to conceal the loose gray and tawny feathers of the sides and flanks. Blue feathers appeared on the throat, tawny ones of the cheeks, and black ones over the ears. When this process of overlaying and concealing the infantine down was completed, the young motmots, now about four weeks old, quite closely resembled their parents except for their shorter wings and tails. They had gained a coat of green, and lost nothing. They had lost

even less than young passerine birds must lose, for the natal down of the latter, which is pushed out on the tips of the body feathers, must drop off before the fledglings appear grown-up.

A color transformation closely resembling that of the motmots is found in the nestlings of the Quetzal (Skutch, 1944).

#### DEPARTURE OF THE FLEDGLINGS

The young motmots remained long in their burrows, for they were nearly four weeks old before their slowly developing wing plumes would support them in the air. They finally departed from the nest from 29 to 31 days of age. This long period of helplessness surprised me, since the young Turquoise-browed Motmots left their natal burrows in the lowlands at the age of 26 to 28 days, yet they are about the same size. Both sets of nestlings had been removed for occasional examinations and photography. Perhaps the less favorable climate of the high mountains was responsible for the slightly slower development of the Blue-throated Green Motmots.

On the morning of June 3, I arose early, for I had a number of visits to make before daybreak. I climbed down a bushy slope to see whether a Pink-headed Warbler slept with her nestlings, then entered the heavy forest to peep into the nest of a Kaup's Redstart, and finally ended my journey beside a motmots' burrow in the roadside bank a mile from the house. As the cloud-mist that shrouded the mountain turned from black to gray, soft, musical murmurings issued from the earth. Soon one of the parent motmots flew out, and in five minutes was followed by its mate. In the pine trees across the road the pair sang briefly, in spite of the unpromising dawn. The sounds from within the burrow continued after their departure, for the last of the nestlings had not yet left home. Its calls soon became louder and quite different in quality from any that I had heard from a young motmot which had not yet flown. They continued intermittently for many minutes, sounding as though they came from a point near the entrance, and then the fledgling launched forth on its initial flight. Its course was somewhat wavering, but it knew instinctively how to make good use of its hitherto untried wings and rose steadily, mounting to a high branch of a pine tree growing on the slope below the road. As it departed from the burrow, one of the parents greeted it with loud, excited calls. Its graduation from the nest marked also a turning point in my own activities, for it was the last to leave the burrow of the eleven young motmots over whose infancy and childhood I had watched.

## DIGGING THE NEW BURROWS

Now I confidently looked forward to seeing the whole family, parents and young, reunited in their burrow in the evening, because the wet season was firmly established and a cold rain fell almost every night. But it is never quite safe to hazard a prediction of the behavior of men or of birds. At the close of the following night, I again stood beside this burrow, and as the day broke a single motmot silently flew out, in place of the four—adults and young—I had expected would emerge. Two mornings later, both of the parents flew out of this burrow in the gray dawn; and they continued to occupy it nightly until the end of the year. Meanwhile, their children were left to weather out the rainy and misty nights among the foliage.

Other pairs arranged things differently. The parents who had left their nestlings entirely alone during their last nights in the burrow never returned to it, but elected to share their offsprings' fortune in the open. Then there was the burrow in which a single parent had kept the nestlings company during their final nights there. After the young birds' departure, the other parent resumed sleeping there, and the united pair continued to occupy it until the new burrow was completed. Another pair of motmots, which also continued to sleep in the burrow after the fledglings left, abandoned it when a few days later, a pair of Cobán Swallows claimed it and began to carry in leaves and pine needles for their nest.

Like kingfishers and jacamars, the motmots made no provision for the sanitation of their burrows, which were considerably befouled during the long tenancy of the nestlings. Those which continued to sleep in the old burrows after the young birds departed merely awaited a favorable opportunity to dig new ones for themselves. At first, they were too busy satisfying the hunger of their fledglings to engage in this difficult task, and the weather was so continuously wet that the excavation of a burrow would have been a most unpleasant undertaking. But during the last week in June there was a temporary lull in the rains, and the motmots quite generally took advantage of it to dig their new burrows. The soil was now in good condition for working, neither so wet as to be muddy nor so dry as to be powdery, as toward the end of the long dry season when they began to nest. Most of the young birds had now been a-wing nearly a month, and were doubtless able to find at least a good share of their food for themselves, relieving the parents of this burden and freeing their time for the new undertaking. No young motmot appeared upon the scene while I watched a pair, parents of three, dig their burrow. Yet the excava-

tion of new sleeping quarters seemed to be a seasonal phenomenon, not directly controlled by the circumstance that the young could now feed themselves. I recall one particular pair whose offspring were still in the nest more than two weeks after the majority of the nestlings had flown from their burrows. Yet this pair dug their new home at the same time as all their neighbors.

The site chosen for the new burrow was usually in the same bank, close by the old. One pair began their new tunnel only 20 inches distant from the one they had occupied during the previous year; another pair chose to go 28 feet away to dig their new home. These were the extreme distances among the five pairs I kept under observation at this period. One other pair, to which we have already had occasion to refer, continued to occupy the old burrow, in which two nestlings had been reared, at least until the end of the year. The chamber at the end of this burrow was the one to which I had been obliged to give a wooden ceiling, which at least could not have been distasteful to the occupants.

At the beginning of July, I spent many hours in the tent, watching a pair of motmots at work. Their plumage was worn and faded; apparently they had not yet molted and renovated the feathers worn by their arduous labors of the past three months. They had two periods of work daily, one in the morning, from about seven o'clock to nine or ten; the other in the afternoon, between three and six. So far as my observations went, they worked longer and more steadily in the afternoon. Male and female divided the task, laboring in alternate shifts of three to twelve minutes. They always came to the burrow together, and one remained perching not far off while the mate dug inside. As with jacamars, puff-birds, kingfishers, trogons and other motmots, I do not believe that either of the pair would have entered the excavation to work unless the other were close by. On entering the tunnel, the bird kicked vigorously backward, throwing out two parallel, intermittent jets of loose earth. These jets moved inward as the bird passed onward, until they fell short of the entrance and at last disappeared in the darkness of the burrow. Without much doubt, the diggers continued to kick backward until they reached the end of the shaft, and thus on each inward trip the earth loosened by the bill at the head of excavation on previous visits was gradually moved outward. On leaving, the motmots never pushed or kicked the loose earth before them. I have never seen jacamar, kingfisher, or motmot come to the mouth of the burrow it was digging for the purpose of ejecting loosened material, as woodpeckers do when carving out their holes in trees.

While one of the pair of motmots worked inside, the mate, resting in the bushes close by, repeated almost incessantly a single low, soft monosyllable, and at intervals flagged its tail slowly from side to side. Usually the partner which had been waiting entered the burrow quite promptly after its mate emerged, most often alighting in the road before rising to the mouth of the tunnel. Rarely it became impatient and entered while the mate was still inside, but then one or the other always came out very promptly.

#### BEHAVIOR DURING THE SECOND HALF OF THE YEAR

Once completed, the new burrows were promptly occupied. No eggs were laid in them that year, for the motmots raised a single brood; they were used as sleeping quarters only, and all were still occupied when my sojourn on the mountain came to an end the following January. The events in the motmots' lives from now onward were not so exciting as those I had witnessed during the breeding season; but I continued to make occasional visits to each burrow in the dawn, and so, in the dim light of the fog-drenched mornings of the wet season, or the frosty dawns of November and December, I received vague intimations of the vicissitudes in the lives of their tenants. During the latter half of the year, they were far more silent than they had been in February and March. Now, standing beside the burrow in the dawn, I seldom heard the low, confidential murmurs which then had precluded their departure. Sometimes they sang a little after emerging, but seldom as much as during the early months of the year; and on many a blustery morning of November they were perfectly silent.

In August, one burrow was suddenly abandoned. Illuminating the interior with the beam of a flashlight, I could barely glimpse the dead body of one of its tenants, seeming to gaze with dull, lusterless eyes upon the outer daylight to which it could never return. The cause of its death must ever remain unexplained, and after this occurrence I lost all interest in the burrow, supposing that it would remain forever deserted. At this period the survivor spent much time calling in the vicinity of the abandoned dormitory. But one day at the beginning of November, while passing before this burrow, I happened to notice the skull of the dead motmot lying in the roadway below the entrance. On looking into the tunnel, I found that the two parallel ruts, made by the feet of the birds while passing in and out, were again sharp and fresh, indicating that it was once more in use. The following morning, waiting beside the entrance, I saw two birds fly forth into the cold, dark, windy dawn. The persistent calls of the widowed one had been at length answered, and he (or she?) had found a new mate. Then

the pair, possibly after a period passed in another dormitory, had cleaned the burrow, and made it fit for continued occupation. But in the middle of December, when I paid my last visit to this burrow, it had only one occupant. Again I can only conjecture what befell the other.

Then there was the burrow which I had watched the motmots dig at the beginning of July. The pair continued to seek its shelter together every night (as far as observations went), until mid-November, when I learned that one of them was no longer there. For two weeks the single bird slept alone, but at the end of that period it found another mate—or could it be that the same mate had returned after an absence? The imperfect glimpses into the lives of the motmots that I received make it impossible to give definite answers to these important questions. Not long afterward, at another burrow, I found three full-grown motmots sleeping together, for the second time in the course of a year. But this arrangement was only temporary, for a week later I learned that the third bird had gone elsewhere. These fluctuations in the number of occupants of each burrow suggest that during the period of the year when the nights are longest in the Northern Hemisphere, the motmots may at times pay visits to the burrows of other pairs, leaving their mates to sleep alone for a while.

Despite these temporary departures, if such they were, the motmots as a rule remained in pairs through the long season during which they did not breed. Because most of the burrows were so crooked, it was impossible to look in from the front and see how the occupants disposed themselves for the night. But one evening in November, darkness overtook me as I passed along a road through the forest still far from my abode: and as I approached a burrow that I had seen many times by day, it occurred to me that I had never tried to look into it during the night. I threw in the beam of my electric torch, and to my great surprise and delight, found that this exceptional tunnel was perfectly straight and I could look right into the dormitory at the end. The ray revealed a rather formless mass of light green in the center of the chamber. It was hopeless to try to distinguish head or tail of a bird, or to decide whether there was one motmot or several. The only distinct objects I could discern amongst the mass of soft, fluffy feathers were some wing plumes, and these but poorly. The sleepers were not awakened by the unaccustomed glare, but when I clucked softly with my mouth at the entrance, one unburied its head from among the green, downy feathers. More clucking, and some whistling were required to rouse the second bird, which faced directly into the light and started to preen its feathers. The two were pressed together so

closely that until they raised their heads it had been impossible to distinguish them. I turned out the light, waited a minute, then peeped in once more, and found that the motmots had already resumed their slumbers with their heads lost among their feathers. They must have felt very secure in their deep retreat not to have been greatly alarmed by the sudden and altogether unprecedented intrusion.

#### BEHAVIOR OF A YOUNG BIRD

And now that we have followed the adult motmots through the cycle of a year, one additional question remains to be settled. When do the young birds mate and dig their burrows? To this question I can unfortunately give no direct answer. I waited for the appearance of new burrows along the mile or more of roadway that I kept under constant surveillance. Six families of motmots had been reared in the banks along this stretch of roadway—probably about seventeen young birds in all—yet by the end of the year not a single new burrow had been dug there, except of course those which the parents had excavated close beside their old ones. This was not because the banks were overcrowded; there were long unoccupied stretches, including a considerable length of bank which had sheltered a seventh pair earlier in the year, but had been abandoned during March.

All this is not very helpful in answering our question, but I have just one bit of suggestive evidence. At the end of June, Pedro, the little Indian boy who waited table for us, brought me two young motmots which had been hatched very late and could not yet fly. He picked them up beside a stream; but when I returned with him to look at the spot, we could find no burrow from which they might have come, and their origin remained a thorough mystery. I decided to attempt to rear the two foundlings, and to liberate them when they could take care of themselves.

The first evening, it was necessary forcibly to open their bills and drop in the food; but already the next day they began to take particles offered to them with a forceps. One showed considerably greater skill at this than the other. We gave them chiefly hard-boiled egg, elderberries and blackberries. When hungry they called loudly, repeating a note which sounded like *cry cry cry*, and snapped avidly for food. They did not actually reach out and take the food, but merely groped in its general direction, and it was necessary deftly to drop the morsel into their open mouths. They would try to swallow anything with which their gaping bills came in contact, including each other, which was of course impossible. I inferred from this behavior that in the burrow feeding must present a very disorderly scene, were



anyone able to witness it. Probably the light is insufficient for the parents to see their nestlings, and the latter must grope wildly about with open bills, until one of them encounters the food and swallows it; this is all very different from the well-mannered conduct of nestlings reared in the open, which merely stretch up their gaping mouths and wait for the parent to drop in the offering.

When not interested in food, the two foundlings rested, standing in contact with each other. At first, they kept their eyes closed even during the day, as they must do in the burrow. By night, they slept pressed close together, each with its head turned back and buried among the fluffed-out feathers of its back and shoulders. One of the little motmots took its nourishment poorly from the first, and soon succumbed; but the other lived several weeks until it, too, died of some pulmonary infection which it apparently contracted from the domestic chickens.

Before the second motmot died, it learned to perch and fly across the room, and pick up food for itself. When it had acquired these accomplishments, and was probably somewhat over a month old, I surprised it one afternoon behaving very oddly. It descended to the bottom of its box, pecked at the paper covering or at the wall in front, then kicked back rapidly with both feet, sounding a tattoo against the board. At the same time it half-spread its wings and uttered low little murmurs. Now pecking and kicking backward are the chief activities in digging the burrow; can it be that at this early age the instinct to dig a burrow for sleeping was manifesting itself in the little motmot? If this be so, it is not unlikely that the young birds mate and dig their own burrows at the same time as the parents, at the end of June or in early July, when they are between two and three months old and scarcely to be distinguished from the adults. This is the only period in the whole year when I found any burrows being excavated, except once in March, when somebody maliciously plugged the entrance of a sleeping burrow and its evicted tenants were obliged to dig themselves a new one.

This, at least, is my present belief, but it will need to be confirmed by additional facts. I am glad that there still remain some unsettled points in the lives of these retiring birds which will be added incentives to renew my acquaintance with them, should fortune ever lead me back to their mountain haunts.

#### COMPARISON WITH OTHER MOTMOTS

Although at the first glimpse it might appear that the Blue-throated Green Motmot's lack of racquet-shaped central tail feathers is adap-

tive, in the sense that it represents a toning down of the bird's plumage in response to the more severe climatic conditions of the highlands, further consideration makes this appear unlikely. We may recall that the Quetzal, a highland member of a family most abundant in the lowlands, is by far the most ornate of the trogons. But the differences that have been noticed between the habits of the Blue-throated Green Motmot and its lowland relatives do seem to adapt it to the colder climate in which it dwells.

In the lowlands of Guatemala and Honduras, I found the Turquoise-browed Motmot digging its burrows in April and May; and soon after they were completed, eggs were laid in them. These burrows were in the low, sandy banks of rivers, where it was likely that they would be either flooded or washed away during the heavy rains of the winter months; and they would hardly make safe dormitories during this period. In 1930 and 1932, when I studied these lowland motmots, I was not so interested in the ways of sleeping of birds as I afterwards became, but a nocturnal visit to one nest of the Turquoise-browed Motmot revealed only a single parent sleeping with the eggs. The available evidence points to the conclusion that the burrows of the Turquoise-browed Motmot are in use only during the breeding season, and do not serve as dormitories. Except in their nesting season, I have spent little time in the range of these motmots, and am not sure whether they remain mated through the year.

For Lesson's Motmot I have abundant evidence that, like the Blue-throated Green Motmot, the birds remain paired at all seasons. Once, in southern Costa Rica, I found a pair beginning to dig a tunnel as early as October, in the side of a pit left by treasure-seekers who had uncovered an old Indian grave. So far as I could learn, neither member of the pair slept in this burrow until they began to nest in it in March of the following year. During an earlier October, a pair of these motmots retired every evening to sleep in a coffee plantation beside a house in which I was lodging in the Costa Rican highlands. A careful search through the little plantation failed to reveal a burrow; and although I did not succeed in finding the birds after dark, I concluded that they slept among the bushes. In Costa Rica, Lesson's Motmot ranges from sea-level up to about 5000 feet. In beginning to dig its burrows so many months before the nesting season, this motmot of lower elevations manifests a habit which, by further development, might lead to the Blue-throated Green Motmot's peculiar custom of excavating at the very end of the breeding season the tunnels in which it will nest the following year, and meanwhile using them as shelters against the nocturnal cold of high altitudes.

Among the lowland species, I have watched the excavation of the burrow only by the Turquoise-browed Motmot. Male and female alternate at the task, exactly as with the Blue-throated Green Motmot. At this time one member of the pair, doubtless the male, gives an occasional morsel to his mate. The shape of the motmot's tunnel appears to be determined largely by the character of the soil in which it digs and the number of obstructions it meets. While those of the Turquoise-browed Motmot that I have examined were only slightly curved, once in the Guatemalan lowlands I opened a burrow of Lesson's Motmot that was almost as crooked as those made by the Blue-throated Green Motmot. Hence the irregular form of the latter's burrow appears to be related to the nature of the ground rather than to the climate. (We have referred to an exceptional example that was quite straight.)

The nests of motmots, highland and lowland, are typically unlined, with the eggs resting upon the bare floor or the litter of regurgitated exuviae that has accumulated there, as with kingfishers and jacamars. Gaumer (1881-1882) mentions nests of the Turquoise-browed Motmot, situated in limestone caves and wells in Yucatán, that were composed of "sticks and mud, or grass and mud"; but this statement is so greatly at variance with the experiences of Owen (1861) and myself with another race of the same species that I think it best to withhold judgment upon this point until we have additional information.

In Guatemala and Honduras, the Turquoise-browed Motmot lays four or, less commonly, three eggs which are pure white. In this the observations of Owen in Baja Vera Paz agree with mine made in more humid regions farther east, some seventy years later. Gaumer records from four to six eggs in Yucatán, but in nests whose ascription to motmots has already been questioned. I have opened only a single burrow of Lesson's Motmot—it was a major job of excavation!—and found in it three nestlings.

Both sexes of the Turquoise-browed Motmot take turns at incubation and both join in attending the nestlings. We have already compared the rate of feathering and the length of the nestling period of this bird and the Blue-throated Green Motmot. This species also appears, like kingfishers, to raise only a single brood each year.

Although motmots are often said to be 'stupid' birds, my own studies lead me to quite a different evaluation of their mentality. In lowland districts where they have been little persecuted by man, motmots may be more or less indifferent to his presence; but even here my own experience has been that they incline to be wary. But those species that dwell in higher regions with a dense, bird-destroying

human population—as the Central Plateau of Costa Rica and the Guatemalan highlands—are among the wariest of all birds, and the ornithologist who wishes to learn how they live will more than once be brought to the conclusion that his wits are hardly a match for theirs.

#### SUMMARY

1. The Blue-throated Green Motmot (*Aspatha gularis*) was studied on the Sierra de Tecpán in the Guatemalan highlands, between 7000 and 10,000 feet above sea-level, from February through December, 1933. The activities of four pairs were followed in some detail, while subsidiary observations were made upon about a dozen others.

2. These motmots remained paired through the year, and at all seasons slept two by two in long, usually very crooked burrows they excavated in steep earthen banks. They entered and left these burrows in the twilight.

3. Although the number of burrows indicated a fairly high population, the motmots were at all times so exceedingly shy and elusive that they would be counted as very rare by any method of taking census not based upon the burrows.

4. The eggs were laid during the first ten days of April, in burrows which had already been in use for months as dormitories. The full set consisted of three eggs, laid at intervals of two days.

5. Incubation was carried on by both sexes, sitting alternately for periods of about three to six hours. Before sunrise, and again at the close of the day, the eggs were left unattended while both parents sought food.

6. The incubation period varied from 21 to 22 days.

7. The newly hatched nestlings were blind and quite devoid of feathers or down. At the age of ten days, they were nearly covered with long, soft, gray down. This was, during the latter half of nest-life, gradually covered over by green feathers of subsequent development, with the result that at the time they left the nest, the young motmots closely resembled their parents in plumage.

8. The downy feathers of these motmots expanded at a considerably earlier age than the plumage of nestling Turquoise-browed Motmots (*Eumomota superciliosa*) in the lowlands. This is regarded as an adaptation to the cooler climate of the highlands.

9. Both parents fed the nestlings, bringing them large hairless caterpillars and other larvae, as well as winged insects. They did not clean the nest.

10. Both parents continued to sleep in the burrow through the whole period of egg-laying and incubation, and with the nestlings

until they were about three weeks old. After this, one or both parents might abandon the burrow as a sleeping place; but one or both parents of other pairs slept with the nestlings until their departure.

11. The young motmots left the burrows at about the end of May, at the age of 29 to 31 days, when they could fly well. The one whose departure was witnessed flew out spontaneously before sunrise.

12. The fledglings were not led back to sleep in the burrows but remained out in the cold rains of this season. The parents usually but not always continued to sleep in the burrows after the fledglings' departure, in some instances resuming this habit when they had interrupted it during the young birds' final nights in the nest.

13. At the end of June, during a lull in the rains, the parents quite generally began to dig new burrows, in the same bank as the old and, in five instances, from 20 inches to 28 feet distant from it. Both sexes alternated in this labor. One pair had a period of working in the morning and another in the afternoon. The young birds did not appear while their parents were at work. The date of digging these new burrows appeared to be determined by the weather, rather than upon the interval which had elapsed since the departure of the nestlings.

14. Upon completion, the new burrows were used as dormitories by the parent motmots, and the old ones remained deserted, or were occupied by Cobán Swallows (*Notiochelidon pileatus*). In no instance was a second brood discovered.

15. During the second half of the year, the motmots continued to sleep in pairs in the burrows. Rarely three birds, or a single one, slept in a burrow; but this condition was temporary and sleeping in pairs was the rule.

16. The behavior of a hand-fed young bird is described. The available evidence suggests that the young motmots mate and dig burrows for sleeping at the same time as their parents dig them—that is, when they are about two months old. This still requires confirmation.

17. The Blue-throated Green Motmot is briefly compared with the Turquoise-browed Motmot and other lowland species. There is no evidence that the lowland motmots use burrows as dormitories; but Lesson's Motmot (*Momotus lessonii*) may begin to dig its burrow about half a year before it lays eggs in it.

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## THE UNDER-WATER ACTIONS OF DIVING DUCKS

BY ALLAN BROOKS

CONSIDERABLE attention has been paid in the past to the actions of various diving ducks when submerged. The earliest records that I can find are those of that painstaking naturalist, William Macgillivray, during the first half of the last century. On this side of the Atlantic, E. H. Forbush has probably written more on this subject than any other author and in his work on the Birds of Massachusetts he has compiled his own records with those of other observers.

For many years past I have endeavored to collect all the information possible from my own observations and to check them with those already recorded. In spite of the fact that diving ducks are especially plentiful on the Pacific Coast and that they are comparatively unmolested there, it has been difficult to get accurate records of healthy, un wounded birds. Crippled birds or those injured in any way must be ruled out, as also must sick birds, especially when these are emaciated.

The chief difficulty is to get well above the birds unobserved by them when they are feeding over a light-colored bottom of sand or gravel. Near my winter home at Comox, Vancouver Island, there are several fairly good vantage points—one where a long pier extends some 300 feet into the sea; another where a near-by vertical cliff overlooks a feeding ground with a bottom largely composed of light-colored sand. But it was not until the past winter, 1944-1945, that I encountered nearly ideal conditions for such observations. This was at Yellow Point on the sheltered inner waters of Chemainus Bay on the east coast of Vancouver Island. Here the house in which I resided was built into the rocky shoreline in such a way that from the front windows numbers of ducks of 12 different species could be seen diving for food directly below and not more than 25 feet away for most of the species