

LIFE HISTORY OF THE BLUE-DIADEMED MOTMOT *MOMOTUS MOMOTA*

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The male of this beautiful, large motmot is about 16 inches in length, and the female is slightly smaller. In plumage, however, the sexes are indistinguishable. In both, the crown is black, bordered all around by a wide band of blue, which covers most of the forehead. Below this blue diadem, a broad patch of black extends from the lores around the eyes to the ear-coverts, and it is confluent with a narrow black band around the back of the head. Below the eyes and behind the ear-coverts, the black mask is narrowly margined by turquoise. The hindneck is olive-green to tawny. The back, rump, and upper tail-coverts vary in shade from olive-green to parrot-green. The wings are brighter green, with bluish green primaries. The two central feathers of the long tail, which are greenish basally and bluer toward the apex, extend far beyond the lateral rectrices, and near the end each has a short length of shaft from which the vanes have fallen, transforming it into a slender stalk that supports an isolated, blue, black-tipped, spatulate expanse of feather. The lower cheeks, chin, and throat are light bluish green. The foreneck and chest vary, on different individuals of this dichromatic species, from light olive-green to tawny, and the same colour becomes paler on the more posterior under parts. In the centre of the chest is a small but conspicuous, isolated patch of black. The black bill is broad and heavy, with coarse serrations along the edge of the upper mandible in its middle half. The large eyes are dull red, and the short legs and feet are grey. This description refers to *M. momota lessonii*, the race inhabiting Central America. In northeastern Mexico is a form *M. momota coeruliceps* with the crown wholly blue, which has long been known as the Blue-crowned Motmot. It is unfortunate that this designation has recently been extended to the species as a whole, for when applied to more southerly forms it is misleading.

The Blue-diademed Motmot ranges from northeastern Mexico to northwestern Peru, Trinidad, and northern Argentina. As is frequently true of species that extend over a vast area, this motmot has adapted itself to varied environments, and even in Central America it selects greatly different habitats in different regions. In Guatemala it ranges from both coasts up to about 4,500 feet above sea level, which altitude it also reaches in Mexico. In Costa Rica, it occurs throughout the Pacific lowlands, both in Guanacaste, where the dry season is long and severe, and in the more humid and heavily forested region south of the Gulf of Nicoya; but it is apparently absent from the Caribbean lowlands. In this country it is common in the Central Plateau and the surrounding mountains, up to at least 7,000 feet above sea level. In this deforested highland area the motmot inhabits coffee plantations with low shade trees, patches of light secondary woods, thickets, hedgerows, shady gardens, and wooded ravines. In the Terraba Valley of southern Costa Rica, where it is the only motmot, it is found in second-growth woods, shady pastures and plantations, and the marginal areas of heavy rain forest, but is rare in the depths of these forests. In the Lancetilla Valley of northern Honduras, however, it was, in 1930, primarily an inhabitant of the heavy rain forest, whence it extended its forays into adjacent areas of second-growth. In the cleared and bushy lands of the valley it was replaced by the abundant Turquoise-browed Motmot *Eumomota superciliosa*. Among the cacti and thorny scrub of dry interior valleys of northern Central America, where this species and the Russet-crowned Motmot *Momotus mexicanus* are abundant, the Blue-diademed Motmot is absent.



The Blue-diademed Motmot forages much from the ground, and it is often seen perching quietly in the shade at no great height. When in an excited or inquisitive mood, it swings its long, racquet-tipped tail with a slow, pendulum-like motion from side to side, or sometimes twitches it more rapidly sideward; and often the bird holds its tail tilted stiffly far to the right or the left. When more strongly excited, it may elevate its tail. To about-face while perching, it lifts this member over the branch with a graceful flourish and thereby avoids abrasion. The motmot's flights are sudden, swift, and direct, but rarely long continued; it passes between trees like a flash of blue and green.

These motmots never flock, but live in pairs at all seasons. During the day the members of a pair often forage separately and it is not always obvious that they are mated; but in the evening, as they go to roost, they associate more closely. In the Central Plateau of Costa Rica in late October of 1935, I repeatedly saw a pair of motmots resting about six inches apart in a low tree near the edge of a small coffee plantation, into which they soon flew to pass the night; and one evening I found a second pair perching equally close together. I have often heard two motmots calling softly to each other, in the thickets where they roost, in the evening or the morning twilight. The fact that in September and October the motmots dig the burrows in which they will nest in the following March or April, is additional evidence that they are mated through most, if not all, of the year.

I have investigated the possibility that Blue-diademed Motmots sleep in these burrows which they excavate long before the nesting season, as do the Blue-throated Green Motmots *Aspatha gularis* of the highlands (Skutch 1945), but always with negative results. Although they are so elusive, and retire into such dense vegetation that I have never succeeded in glimpsing them on their roosts, all the evidence points to the conclusion that they sleep amid the foliage. In El General, I have heard their calls issuing at night-fall, and again at daybreak, from dense thickets at the forest's edge. While I resided in the Central Plateau, I often heard, at the first sign of day, the voices of a pair coming from the coffee plantation outside my window. I searched carefully for a hole in which they might have slept, but could find none. Motmots are active in the twilight, and go to rest later than most birds. Once, in the dusk of evening, I watched a motmot try to take a dust bath on a bare spot in a field beside the thicket where it roosted, but the ground was too hard.

### FOOD

Blue-diademed Motmots are largely insectivorous, but they vary their diet with fruits. Beetles appear to be their principal fare, and among other kinds they capture many dung-beetles. In a shady pasture where these scavengers are active, one often sees a motmot perching on a lower limb of a tree, intently watching the ground, to which it suddenly descends to capture a dung-beetle. Other insects that I have seen in motmots' bills are large cicadas, phasmids or stick-insects nearly as long as the motmot without the tail, large green orthopterans, and larvae of various kinds. Spiders and small lizards are occasionally captured, but I have not seen them catch large, conspicuous butterflies such as the Turquoise-browed Motmot often eats. The prey is beaten against the bird's perch until it becomes quiescent, often until it is badly mangled, before it is swallowed or carried to the motmot's young. Sometimes the food is prepared on the ground. Once I watched a motmot struggling with a large winged insect in the shade of the forest. The bird picked up its victim, beat it against the ground, dropped and picked it up again, repeating this until finally the green wings fell off. Then the insect was carried away, probably for a nestling. On another occasion, I watched a motmot spend about a minute standing on the ground and pushing aside fallen leaves with regular sweeps of its bill, alternately to the right and left. It seemed to be searching for something that it had dropped while perching above this spot.



Occasionally a motmot accompanies a swarm of army ants, along with a variety of smaller birds, to catch the insects, spiders, lizards and other creatures which the ants drive from concealment in the ground litter and make readily available to the birds. I have most often seen motmots with army ants in the marginal parts of the forest.

Of fruits, I have seen Blue-diademed Motmots eat the orange pulp of the Central American rubber tree *Castilla elastica*; the green drupes, like small olives, of the olivo or aceituno *Simaruba glauca*; the fragrant white rose-apple *Eugenia jambos*; and the globose fruits of the wild ginger *Renealmia exaltata*, filled with small arillate seeds. I have seen them fly up to bunches of fruit of the spiny pejibaye palm *Guilielma utilis*, apparently to pluck off pieces of the hard flesh, of which many tanagers, woodpeckers, and other birds eat freely; and I have found the regurgitated seeds of other kinds of palms in their burrows. The motmots swallow whole the large seeds of trees of the nutmeg family, including *Compsonura sprucei*, to digest the thin, bright red aril that embraces the seed and cast up the latter intact (see also under Nestlings). Occasionally I have found these motmots resting in pairs on a bare roadway in the twilight, apparently to pick up food, although possibly it was gravel that they sought. Blue-throated Green Motmots have a similar habit.

There are scattered references to motmots preying on smaller birds, but it is not always clear whether this behaviour was observed in free or in captive motmots. I have never seen a motmot of any kind take eggs or nestlings, but the anxiety of parent birds of a variety of small species when a Blue-diademed Motmot comes in view makes me suspect that it is a nest robber. Gray's Thrushes *Turdus grayi* repeat their plaintive cries incessantly whenever one of these motmots approaches their nest. Although for many years I have lived surrounded by motmots, I have only once seen one of them with an avian victim (see under Nestlings). Evidently these motmots only exceptionally prey on other birds.

### VOICE AND COURTSHIP

In Honduras, many years ago, I transcribed as "kut kut" the deep, resonant, far-carrying call of the Blue-diademed Motmot. The corresponding note of the motmots here in southern Costa Rica seems to me softer, and I have generally written it as "coot coot". This call, which mated birds use to answer each other, is frequently repeated in the dim light of dawn and again as the day fades, and it is heard far less often while the light is strong. Sometimes, especially near their nests, the motmots produce a low, hollow sound, "whoo'whoo-hoot", whispering and ghostly, such as may be crudely imitated by blowing across the mouth of a large empty bottle or, better, an aluminium canteen. When approaching their burrows the motmots may voice an even lower "whoo-whoo-o-o-o-o-o", uttering these notes with a distinctly undulatory or rippling effect, and apparently expressing caution or slight anxiety. When alarmed, or concerned for the safety of its offspring, the motmot gives voice to a dry, nasal "wac wac" or to a clacking sound such as may be at least suggested by tapping sharply with a pencil upon a thin board of hardwood. Sometimes these wooden notes follow the ghostly "whoo whoo-hoot". A motmot who perched several yards above a large mica, a snake that preys insatiably upon the eggs and young of birds, protested with surprisingly loud, sharp, staccato barks or cackles—notes which seemed indicative of the highest pitch of alarm.

Early on 12 February 1951, the soft "coot coot" of Blue-diademed Motmots, repeated over and over, drew my attention to three of these birds perching close together in the top of a guava tree behind our house. One held in its bill a green guava leaf over an inch in length. For several minutes, the trio rested motionless, except for abrupt sideward or up-and-down movements of their long tails. Presently they shifted positions, until two, including the holder of the leaf, sat close side by side, while the third perched a yard or so away from them. This bird now plucked a small dead twig, hardly larger



than a match stick, held it in its bill for a moment, then dropped it. The other motmots remained side by side for a number of minutes, the one with the leaf repeating a soft "coot" over and over. Meanwhile, the lone bird called "coot coot" again and again. Then the motmot who thus far had taken nothing in its bill moved to a neighbouring twig and plucked a fragment of bark or dead leaf, which it promptly dropped. Soon after this, the three flew off through the trees, and the motmot with the green leaf carried it up to a high bough. One now vanished, but the other two followed each other from tree to tree, in each of which they rested for a while to call "coot" and "coot coot". One seemed always to use the single and the other the double note; but I could not tell the sex of either.

From time to time in the following years, I again noticed a motmot holding a leaf or other inedible object. Before sunrise on 5 September 1959, I watched two motmots high in an *Inga* tree. One had in its bill a small piece of green leaf which it held for a good while. The other held a smaller object which I did not recognize. On the evening of 3 September 1962, I was watching two motmots resting in a tree, when a third approached with some rather large dead leaves hanging limply from its bill. Soon all flew into the neighbouring thicket, where I could not follow. These motmots carrying inedible objects seemed to be courting or pairing, in some instances to be trying to win a mate by disrupting an established pair. Nest material is sometimes held by courting birds of other families, but it is most surprising to find motmots doing so, for they make no use of such material but breed in burrows quite devoid of lining. Can we infer from this behaviour that their remote ancestors built nests or lined their burrows?

Neither when competing for a mate, nor on any other occasion, have I ever seen motmots of any species fight.

#### SITE AND FORM OF THE BURROW

The nests of birds which breed in burrows are often easy to find, for the tunnels are dug in bare vertical banks where the opening is visible at a glance, as is true of some kinds of kingfishers and motmots. But, at least in Central America, the secretive Blue-diademed Motmots usually choose far less obvious sites, so that their burrows are difficult to discover even when, by watching the birds, one learns their approximate location. Instead of beginning its tunnel in an exposed soil surface, this motmot prefers to start from the side of some pit or hollow in the ground, such as the den of a burrowing animal, or a hole dug by man. The mouth of the burrow may then be invisible until the searcher sticks his head into the larger excavation, which may be so dark that artificial illumination is necessary before the entrance can be seen. Five of the ten nests which I have discovered in 30 years were so situated; I passed by some of them repeatedly without ever suspecting their presence until I saw the parents in the vicinity with food in their bills.

The first of these nests was discovered many years ago in Guatemala, at the very foot of the Sierra de Merendon, beside the level valley of the Rio Motagua. It was close by a burrow of the Rufous-tailed Jacamar *Galbula ruficauda* which I had been watching. I had often seen the motmots in the vicinity, and had walked over their burrow many times, before one of them revealed its presence by flying out of the earth. They were already bringing food, and I decided to open the chamber to see their nestlings.

The motmots had started their tunnel six inches below the surface of the ground, in the side of what appeared to be the old den of some burrowing animal, now nearly filled with loose earth and vegetable debris. When I stuck a vine into the motmots' shaft, it entered for a distance of three feet. Measuring this distance back from the edge of the pit in the ground, I began to excavate, expecting to make contact with the rear of the nest chamber. After much digging in hard, stony soil penetrated by many roots, I finally broke into the burrow, but to my surprise I had struck the entrance shaft rather



than the nest chamber. At this point the tunnel turned sharply about 45 degrees to the left, and this bend had stopped the probe which I had used to measure the burrow's length. After uncovering the tunnel for two feet more, I finally reached the chamber, whence, by stretching my arm to its utmost limit, I managed to extract three nestlings, whose plumage was just expanding. The roof of their nursery was 29 inches below the surface of the hillside. The whole burrow, from its mouth to the back of the chamber, was 65 inches long. Although not the longest bird's burrow that I have opened, this one was probably the most laborious for the birds to dig, because of the hardness of the soil and the many stones and roots that it contained.

After admiring the three nestlings, I replaced them in their deep chamber. Then I split a log to form a ceiling over the portion of the tunnel which I had uncovered, and above the slabs of wood I filled in the earth to the level of the ground. While I was engaged in these laborious operations, the parents made not the slightest protest, although they saw me at work. After my withdrawal, they continued to attend their young in their altered burrow, although they now had to creep beneath two feet of wooden plank each time they carried food to the young. Without much doubt, they would have abandoned their nest if such a great change had been made before the eggs hatched.

I have not again attempted to prepare a Blue-diademed Motmot's burrow so that I could learn the incubation and nestling periods and follow the development of the young, for the risk of causing desertion appeared too great; but some years ago I dug out a burrow after the fledglings left. This was situated in level, stony ground, in an open spot amid light second-growth woods, beside a cattle path. Like my first burrow, it led out from the side of a hole or den which had apparently been dug by a mammal but was no longer used by it. The entrance of the motmots' tunnel was beneath an overhanging sod, so that I could not see it until I stuck my head down into the larger hole. This burrow was seven feet and two inches in total length, and it was nearly straight except for a gentle bend to the left near the inner end. Apparently the motmots would have made their burrow even longer if they had not run into rocks, as I inferred from the presence of a short spur leading up between these rocks. The top of the chamber was 12 inches beneath the surface of the ground; I could not learn its dimensions because its walls were destroyed by my digging. In the top of the entrance tunnel were two holes which communicated with the surface and admitted daylight, apparently made when horses or cattle walked over the burrow and their hoofs broke through.

An unexpected site of a motmot's burrow was in the vertical side of a pit about five feet deep, left by treasure hunters who had opened an old Indian grave. Vegetation draping over the pit's rim concealed the mouth of the burrow until I jumped down into the grave. Another burrow was begun in the great mass of clay that clung to the roots of a tall campana tree *Laplacea semiserrata* which had been laid flat by a violent wind. What had been the lower side of this mass now formed a vertical wall about eight feet high, and in the centre of this uneven expanse of bare red clay the tunnel was begun, but it was never used for breeding.

Occasionally, perhaps only when a less obvious site is not available, the Blue-diademed Motmot digs or acquires a tunnel in an exposed bank, such as other kinds of motmots and certain kingfishers habitually select for their burrows. Once I found a pair of Blue-diademed Motmots feeding nestlings in a bank only two feet high, situated at the top of a steep slope at the forest's edge. This burrow went in so far that I could not see its contents.

Finally, in 1961, I discovered a burrow so short and straight that I could look in at the front and see what it held. This most exceptional burrow was in a sloping bank, three feet high, above the road behind our house in El General. Above the bank was a pasture with scattered trees; below the little-used roadway was tall second-growth woods such as these motmots frequent. The burrow, which was only 40 inches long, faced



these woods. Its flaring mouth was 6 inches wide by about 4 inches high, but the shaft narrowed inward until it was  $3\frac{3}{4}$  inches high by 3 inches wide. Although the tunnel was without a lateral curve, it was higher in the middle than at either end. This rise in the floor permitted me to see only the head of the incubating parent when I looked in with an electric torch. To see the eggs and newly hatched nestlings, it was necessary to insert a mirror on the end of a stick and a small bulb attached by a cord to the electric torch.

This burrow had been dug, or at least enlarged, by a pair of Buff-throated Automoluses *Automolus ochrolaemus* in 1956, when they reared a brood in it, as they did again in the following year. Then for three years no bird nested in it. When occupied by the automoluses, the burrow was only 29 inches long, and the entrance tube was considerably narrower than when I found the motmots using it. Whether the motmots themselves, or some other creature, had added 11 inches to the burrow's length and widened the tunnel, I do not know. The motmots took possession of it with the utmost secrecy. When, in March of 1961, I noticed that the old burrow had been cleared of cobwebs and was being entered by a bird, I looked into it periodically, expecting that the automoluses had returned and would build a nest. The days passed, and no nest material was carried in; then, when I threw in the beam of my torch one morning, I noticed at the far end of the burrow a motmot, already incubating three eggs.

#### TIME AND RATE OF EXCAVATION

As already mentioned, motmots begin to dig their burrows long before they will nest in them. In mid-October 1936, I found a pair digging the burrow in the side of the pillaged grave. The tunnel was already so long that, since it was not quite straight, I could not see the end when I threw in a beam of light. For several days, no more soil fell on the leaves which I spread over the pile of freshly excavated, loose soil below its mouth; but on 23 October a pair of motmots flew from the grave when I approached, and one of them had its bill well covered with clay, evidence that it had been digging. In the following April, I found the motmots feeding nestlings in this burrow, which had been enlarged little, if any, since the end of the preceding October, as I inferred from the absence of fresh earth on the large, leathery leaves which I had at that time pegged down beneath its entrance and inspected at intervals.

The burrow in the mass of clay adhering to the roots of the fallen campana tree was already seven inches long when I first noticed it on 11 November 1944. No earth was removed during four very wet days in the middle of the month; but on 22 November, after two drier days, I found that it had been lengthened to  $9\frac{1}{2}$  inches. The motmots now worked somewhat more actively, and by 5 December their burrow had become 24 inches long. Although more earth was removed in the following ten days, the burrow did not appear to lengthen, possibly because it made a sharp turn that stopped the vine which I pushed in to measure it. Thereafter, the motmots lost interest in their tunnel. They were always so shy that I did not succeed in watching them at work.

Here in El General, motmots seem not to use the same burrow in successive years, but after a successful nesting they may prepare a new tunnel not far from the old one, if a site is available. After raising a brood from the unusually short burrow in 1961, the motmots dug a new burrow, about 50 feet away in the same roadside bank, in which they again reared a brood in 1962. The burrow prepared for 1963 was only nine feet from the preceding one. Since I was absent during the breeding season of 1963, I do not know whether the pair reared a brood; but later in the same year they dug another burrow for use in 1964. This fourth burrow in the series was 22 feet from the third and about 80 feet from the first.

I first noticed the burrow in which the motmots nested in 1962 on 30 September 1961, when it was already  $20\frac{1}{2}$  inches long. It lengthened slowly, reaching its final length of 80



inches by 5 November. A little more earth appeared to have been removed as late as 21 November, but after that the burrow was neglected for months.

The burrow for the 1963 nesting season was first noticed by me on 1 September 1962, when it was four inches long. After the motmots had been working at this tunnel for at least three weeks, I set, in the roadway 50 feet from its mouth, the same hide from which I had watched them incubate and attend their young in the preceding year. Then, although obviously suspicious of the unobtrusive little brown tent, they had gone about their parental duties in front of it; now, doubtless because their motivation was much weaker, it upset them more. In the five days that I left the hide in view of the nest, they lengthened their tunnel only  $1\frac{3}{4}$  inches—less than they sometimes did in a single day. Attempts to watch the birds at work always failed, doubtless because their sharp eyes detected mine through the narrow slit that I left open for observation. Indeed, they were so easily disturbed that even the twig, no larger than a match-stick, which I set in the burrow's mouth to tell me if they had entered, deterred them from working, though never from attending eggs or young. However, by frequently measuring the tunnel's length and by catching the earth that was removed, I learned that they worked chiefly in the late morning and early afternoon, between 9.00 and 13.00 hours, rather than the early morning, when many birds prefer to build their nests. Now, at the height of the wet season, heavy rain fell on most afternoons, and often into the night. Mornings, although often cloudy, were seldom rainy, and frequently they were sunny. By delaying their work until late in the morning, the motmots gave yesterday afternoon's rain a few more hours to drain from the ground and dug in soil as dry as they could find it at this season.

In a few hours of work in the middle of the day, the motmots sometimes lengthened their shaft by 2 or even  $2\frac{1}{2}$  inches. On most days, however, they accomplished far less than this, and the tunnel lengthened very slowly. In the whole month of September, its length increased from 4 to 38 inches, or at the rate of slightly over one inch per day. It continued to be extended at about the same average rate through the following month, and on 29 October it was  $70\frac{1}{2}$  inches long. By 9 November it was 80 inches long, and after this it ceased to lengthen, although a little more earth was removed, doubtless in expanding the terminal chamber, during the next four days, after which work stopped. These motmots had devoted about  $2\frac{1}{2}$  months to digging their burrow. In the preceding year, when evidently they started to dig somewhat later, they worked harder and reached the final length of 80 inches by 5 November. This pair of motmots showed great regularity in their time for digging. In 1963, I first noticed their new burrow on 30 August, when it was  $5\frac{1}{2}$  inches long. When completed about 30 October, it was 75 inches long.

By preparing their burrow in the rainy season, far in advance of its use, the motmots gain two advantages. They find the soil soft and easily worked, although it is often muddy enough to cake on their bills; whereas if they excavated just before they lay their eggs in March or April they would, in many parts of their range, be obliged to dig in earth which had become dry and hard during the more or less severe dry season that prevails in the early part of the year. Secondly, in the long interval between the excavation of their burrow and its occupancy, the loose soil, which at first lies conspicuously beneath the tunnel's mouth and draws attention to it, is compacted by rain and more or less covered by fallen leaves. When laying begins, the burrow already looks old, and is perhaps less likely to arouse the interest of predators.

After the completion of their burrows in November, the motmots neglected them for months. Between November and March, a twig set upright in the tunnel's mouth remained upright for days together. From time to time it would be knocked over, but whether by a motmot, a Rough-winged Swallow *Stelgidopteryx ruficollis* prospecting for a nest site, or some other creature, I could not tell. As has already been said, the motmots



did not sleep in their burrows when not breeding. Finally, at the beginning of March, the twig was more frequently upset. A few days later a motmot spent the night in the burrow, and there was evidence that incubation had begun.

Of the race *M. m. bahamensis* in Trinidad, Belcher & Smooker (1936) wrote: "Excavation of the nesting-tunnels, which are usually in fairly high banks, but not more than a few feet above ground-level, begins long before the eggs are laid. Trial holes are made only to be abandoned. The tunnel with eggs may be from five to fourteen feet long, and not all in one line. Probably holes are used more than once, and excavated farther each time. May is the laying month . . ."

The motmots' eggs are laid on the earthen bottom of the nest chamber, for no lining is carried in. As incubation proceeds, the shards of beetles and other indigestible parts of insects, regurgitated by the parents, accumulate and are compacted into a hard floor.

### THE EGGS

The nest which I opened in the Motagua Valley of Guatemala on 17 May 1932, held nestlings beginning to become feathered. The eggs from which they hatched had evidently been laid early in April. In the valley of El General in Costa Rica, 2,000 to 3,000 feet above sea level, one pair laid about 8 March, and the latest broods of which I have records flew from the burrow about 17 May. Here eggs are laid chiefly in March and April, as the dry season passes into the wet season.

I have seen the contents of only two burrows, of which one held three nestlings and the other three white eggs. In Trinidad, Belcher & Smooker (1936) found two c/3. They described these eggs as "broad, roundish ovals, of a pure glossy white, smooth and hard-shelled". The measurements of six eggs given by them average  $33.4 \times 27.4$  mm.

### INCUBATION

Both sexes incubate. At the nest in the roadside bank behind our house in 1961, I studied the pattern of incubation throughout the last ten days before the eggs hatched. Each day I watched the bird leave in the dim early light, by standing quietly close beside the burrow where it could not see me until it was already outside. On a number of mornings I watched, from a hide, the other partner enter a little later, and on several days I witnessed the change-over soon after noon, likewise from a hide. During most of this ten-day interval, the little sticks I set upright in the burrow's mouth remained undisturbed for hours together.

At this burrow, the two birds could be distinguished, for one of them had completely lost one of the racquets on the end of its tail and retained only a fragment of the other racquet, while both those of the other partner, though badly frayed and dishevelled, were still present. The latter sat through the night and may have been the female; but it is not impossible that in motmots the male attends the nest by night, as in woodpeckers, some cuckoos, and other birds.

These two partners replaced each other on the eggs according to a very simple schedule, which reduced movement at the burrow to a minimum, at the price of very long and patient sitting. There were only two change-overs in the course of a day. In the dim light of dawn, when other birds were beginning to sing, the single motmot who slept in the burrow flew out silently and without any warning. On ten mornings, its time of departure varied from 5.21 to 5.34 hours. At the earliest, there was not enough light to distinguish its colours, at the latest, its colours could be only dimly recognized. After an interval that varied from 13 to 24 minutes, or at times ranging from 5.44 to 6.00, the mate entered the burrow; nearly always it went in before sunrise. There it stayed continuously for the next seven hours or a little more, rarely less. On the three days when the length of this morning session was most exactly determined, it lasted for 7 hours and 10 minutes, 7 hours and 9 minutes, and 7 hours and 32 minutes. On one day



the motmot, who had entered before 5.53, left before noon. On other days it flew out at times ranging from 12.30 to 13.45, or rarely later. The signal for its departure seemed usually to be the notes of its mate approaching through the woods in front of the burrow. Once, when I heard no call from the approaching motmot, it alighted on the bank about ten yards from the burrow, evidently to pick up food, and a minute later its mate flew from the tunnel, perhaps having heard the wing-beats of its partner. After a careful survey of the surroundings, the newcomer entered in a few minutes, to remain with the eggs until the following dawn, or for about 16 hours.

In approaching their burrow, these motmots were extremely wary. I had set my hide between 50 and 60 feet from its mouth, and I could not move it much nearer without upsetting them. Even after they had had several days to become accustomed to it, I was obliged to look through a narrow slit, for they would become alarmed if I watched them through a wider aperture. Only after the nestlings hatched could I open the window wide enough to accommodate my field glasses without keeping the parents away. After they entered their burrow, the motmots invariably remained within when disturbed, even when I threw a light on them and looked down the tunnel. If I happened to approach when one was near the mouth preparing to leave, it would back farther into the burrow rather than fly out, thus reducing the likelihood of betraying the nest's position at the price of increasing the risk of being trapped by an enemy. One morning the motmot was about to leave just as I arrived at 5.23. When I surprised it at the burrow's mouth, it retreated backward and stayed inside 13 minutes longer.

In the following year, 1962, when the burrow of this pair (or their successors) went deep into the neighbouring hillside, I did not see the eggs nor make long watches from a hide, but by setting twigs in the doorway and visiting the nest often, I followed the course of events. A motmot first slept in the burrow on the night of 7-8 March, and incubation evidently began about this time. After the first few days, the incubating pair followed much the same schedule as in the preceding year. On 30 March the twig was pushed over so often that I had no doubt that the parents were feeding nestlings, which must have hatched after about three weeks of incubation. This period agrees with that more accurately determined at several nests of the Blue-throated Green Motmot which had been prepared so that the eggs could be directly examined.

### THE NESTLINGS

In the short burrow in the roadside bank, all three eggs hatched within an interval of 24 hours, and I first saw the nestlings when the parent left the burrow at dawn on 16 April. They had downless pink skin and tightly closed eyes, as in other newly hatched motmots. For the first four or five nights after they hatched, they were brooded by a parent, who continued its old habit of flying from the burrow at break of day. Thereafter, although still quite naked, they passed the night alone. Diurnal brooding decreased very rapidly. On 18 April, the second day after I first saw these nestlings, they were brooded for a total of about 116 minutes during the first 300 minutes (5 hours) of the morning. One spell of brooding lasted at least 54 minutes and another at least 42 minutes. On 23 April, the week-old nestlings, whose pin-feathers were now sprouting, were not brooded at all during the first five hours of the morning. This early cessation of brooding reduces the risk that the parent will be captured along with its offspring by a predator that crawls into the mouth of the burrow.

I watched the nest during the first five hours of the morning on 18, 23 and 29 April and 5 and 11 May. The number of meals brought in each hour is given in Table 1. On a few occasions, the nestlings did not accept a meal which was taken into the burrow, evidently because they were not hungry, and the parent emerged still holding it, to eat it in my presence or to carry it out of sight. Thus, toward the end of the first hour on the nineteenth day, the nestlings refused three of the 11 items that were taken to them. But



such refusals were exceptional. There was a steady increase in the rate of feeding until the nestlings were 19 days old and fairly well clothed in feathers. But when they were 25 days old they received fewer meals than when they were 13 days old. Evidently their need for food decreased after their feathers had expanded. A similar decrease in the rate of feeding has been found in other birds with long nestling periods.

TABLE 1. *Feeding frequency of three nestling Blue-diaemed Motmots at various ages.*

Hour	AGE				
	2 days	7 days	13 days	19 days	25 days
5.45-6.45	4	8	4	11	7
6.45-7.45	3	3	2	6	6
7.45-8.45	1	2	7	4	3
8.45-9.45	1	5	8	8	3
9.45-10.45	7	3	5	6	5
Totals	16	21	26	35	24

One parent seemed to bring food somewhat more often than the other. On the last four of the five mornings when I watched, I credited 53 meals to the parent with both racquets on its tail and only 44 meals to the parent with part of one racquet; but on nine occasions the parent bringing food darted into the burrow without being identified. When the nestlings were 19 days old, the parent with both racquets brought at least 20 meals, the other at least 13 meals, and only two other meals were delivered. On the morning when the young were 25 days old, I identified the parent at every feeding, and the one with both racquets brought 14 of the 24 meals that were delivered. This was the bird who took charge of the nest through the night. Each meal, as far as I saw, consisted of a single article.

The food given to the nestlings consisted largely of winged insects, which were often badly mangled, and caterpillars. Of the former, those which I recognized were chiefly beetles, but there were also a few cicadas, grasshoppers, and dragonflies. When the young motmots were only two days old, a parent took into the burrow what appeared to be a dark-coloured snake at least six inches long, and since it was not brought out again, I assumed that a nestling had eaten this object much longer than itself. Other elongate objects taken to the young were flat and might have been slugs. When they were a week old, a parent entered the burrow with a large, white, downy feather, apparently from a domestic chicken, but this was still in its bill when it emerged a few minutes later. When the nestlings were 13 days old, they were given the only avian victim of a motmot that I have seen. It was a small, mangled, unidentifiable bird whose long tail feathers indicated that it was an adult, or at least not recently fledged. Other animal food that I recognized in the parents' bills included a few spiders, a millipede, and a small lizard. At a nest of this species in Guatemala, several lizards were given to the young.

Beginning when they were 13 days old, the nestlings received, in increasing quantities, large red seeds which I traced to a slender tree of *Compsooneura sprucei* that grew just within the edge of the forest, separated from the nest by a pasture about 200 yards wide. Each seed of this tree measures about  $1\frac{1}{8} \times \frac{7}{8}$  inches, and seemed to be a very large mouthful for a nestling. Even the adults appeared to open their bills as widely as they could in order to grasp a seed between the tips of their mandibles. Rarely, instead of bringing a whole seed, a parent came with a detached aril or piece of one. When the young were 19 days old, eight of the 35 meals given to them in the course of the morning consisted of seeds or pieces of their red arils. These brilliant seeds were certainly not the nestlings' favourite food, since I frequently found one of them lying in the burrow in front of the young. Once a parent took in an insect and emerged with a red seed, which it had apparently picked up from the floor. It returned to the burrow with the seed, which was evidently accepted, for when the adult again flew out its bill was empty. Only the thin arils of these seeds were digested, the seeds themselves being regurgitated.



I never saw a parent remove waste or excreta from the burrow; yet even after a month's occupancy by the nestlings, scarcely any odour emanated from its mouth. Although hard rains fell and soaked the earth around the young while they were growing up, their fresh new plumage remained remarkably clean; but their bills, and doubtless also their feet which I could not see, became caked with mud.

Since I did not take these nestlings in hand, I could not follow their development closely. When they were five days old, I first noticed feather rudiments pushing through their pink, downless skin; at 13 days, they bristled with long pin-feathers; at 16 days, the feathers began to escape these horny sheaths, on their backs, shoulders, and heads. The expansion of the feathers was rapid, and three or four days later, at the age of about 20 days, the young motmots in the burrow were well covered on all those parts of their bodies that I could see; but they remained in the nest for another ten days. (Compare Skutch 1945, 1947.)

Contrary to what one would expect in view of the parents' extreme caution in approaching the burrow, the nestlings who inhabited it were far from silent. When they were a week old, they made a rapid, low, throaty rattle or trill when I threw a beam of light upon them at dawn. At this time, one ran forward toward me, opening and closing its mouth with a grasping motion, as though to take food; but before it had come halfway down the tunnel it discovered its error and rejoined its siblings in the nest chamber. They did not again mistake me for a parent. After they were feathered, the nestlings frequently uttered a soft, rippling "who-o-o-o", which seemed to have developed from the trilling or purring sound they had made while they were younger. If I stood quietly to one side of the burrow's mouth, I sometimes heard, emerging from it, sharp "wac's" and other harsh notes, which suggested that they might be squabbling with each other.

On a nocturnal visit to the burrow when the nestlings were a week old, I found, at the entrance to a hole in the bank about two feet from their burrow's mouth, a huge, brown, hairy spider, of the kind reputed to kill birds and to bite horses and cows, causing a great swelling which suppurates for days. I marvelled that the spider had not already attacked the nestlings, who now slept alone, and I dispatched it to protect them and the horses in the adjoining pasture.

After the nestlings were well feathered, I could rarely see more than two when I looked into their burrow. The third seemed to be hidden behind them. On 15 May, 29 days after hatching, the two that I could see were farther back in the chamber, whence I inferred that one had left. These two were still present on the following day. At 6.00 hours on 17 May, only one remained in the burrow, facing the rear wall instead of with its head outward, as I had nearly always found the young motmots in the past. An hour later it was in the same position, but by 9.30 this last fledgling had flown. Two of the young had remained in the nest for 31 to 32 days, and apparently one had left at the age of 29 to 30 days. This may be compared to the nestling period of 29 to 31 days for the Blue-throated Green Motmot, and of 28 or more days for the Turquoise-browed Motmot.

On the day of its departure, I found one of the young motmots in the road in front of the burrow. It was alert, and as I came in view it flew into the neighbouring thicket, where I saw the parents, one with food in its bill. The fledglings resembled their parents in plumage, but their eyes were brown rather than red. Neither the parents nor the young returned to sleep in the burrow, which is in accord with my earlier conclusion that burrows are not used as dormitories.

In the following year, when the parents had begun to carry food into the burrow by 30 March, the last nestling did not leave until 7 May, when it could not have been much less than 38 days old. When I found it in the roadway opposite the burrow on 7 May, it was wary and flapped over the ground ahead of me until it reached the safety of the neighbouring thicket, but it could not fly. Its plumage, especially on the top of its head



and hindneck, was caked with mud, as was its bill; and its short tail was frayed. This fledgling's retarded development, compared with the brood of the preceding year, may have been due to the very wet weather, which kept the ground soaked during its last fortnight in the burrow. Possibly, also, food was scarcer in 1962 than in 1961.

Neither in these burrows nor in others where the parents had apparently nested successfully was a second brood attempted. I am fairly certain that in El General the Blue-dia demed Motmot rears a single brood each year. After the young are fledged, the adults moult, dropping their badly worn tail feathers. Since it requires some weeks for the long central rectrices to grow out and lose their vanes from the subterminal part where they are narrowest, at this season one rarely sees a motmot with racquet-tipped tail feathers.

### SUMMARY

Over a wide geographical and altitudinal range, extending from sea level up to at least 7,000 feet in Costa Rica, the Blue-dia demed Motmot has adopted a great variety of habitats.

It lives in pairs through most, if not all, of the year.

Its food consists of a variety of insects, especially beetles, and small fruits.

Pairs or trios apparently engaged in courtship hold pieces of green leaf or other fragments of vegetation in their bills, although they never take such material into their nests.

Nesting burrows, up to 7 feet long, are usually dug from the side of a hole in the ground, rarely in an exposed bank where the entrance is conspicuous. Excavation begins in the wet season, from late August to October, and may continue for 2½ months, chiefly in the late morning and early afternoon, when the soil is driest, at an average rate of little over one inch per day. Until the beginning of nesting at the end of the following dry season, the burrow is not used for sleeping and is rarely visited.

In March or April, three white eggs are laid on the bare floor of the nest chamber. Both sexes incubate. One enters the burrow soon after noon and stays until the following dawn. After 15–30 minutes the mate enters and sits for about seven hours. The incubation period is about three weeks.

The nestlings hatch completely naked. The nestling period is 29–32 (once 38) days. Brooding, even at night, ceases before the young are a week old, although they are still naked. Both parents bring them a variety of insects, chiefly beetles, small fruits, and occasionally a small snake, lizard, or bird. At one nest the rate of feeding increased up to the nestlings' nineteenth day, when each was fed 2.3 times per hour.

After the nestlings' departure, neither parents nor young sleep in the burrow. The species is single-brooded in Costa Rica.

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