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LIFE HISTORY OF THE QUETZAL

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The New World, for all its wealth of feathered life, boasts no family of birds at once so large and so ornate as either the pheasants or the birds of paradise of the Old World. The trogons are perhaps the most gorgeous avian family that the Western Hemisphere possesses, although they are a group shared with the eastern world. Trogons display glittering metallic plumage in far larger expanses than any hummingbird, and the colors of the males are usually brilliant and contrasting. Most, however, are devoid of ornamental plumes. An exception is the Quetzal, which in this superb family is easily first in splendor. It is certainly one of the half dozen or so most beautiful birds in the Americas, and even in this select group may deserve highest rank.

Not only is the Quetzal a magnificent bird, but it is also one of the most widely known. Save possibly the Scarlet Macaw, this was the first Central American bird of whose existence I became aware. Like many another boy, I collected postage stamps; and an ornate Guatemalan issue, with its Quetzal in red and green, was considered a collector's prize. But it gave no just idea of the true splendor of the bird. Later, when I came to travel in Guatemala, I found its image very much in evidence, in the medallion displayed on the walls of most of the public edifices and in the center of the blue and white banner. I even carried *quetzales* in my pocket and disbursed them at sundry hotels and shops; for Guatemala has named her monetary unit for her national bird, as many of the neighboring republics have named theirs for famous men. The second city of the land bears the name of this bird—Quezaltenango, the place of Quetzals—but today one searches in vain for these trogons on the wind-swept plains and through the low oak woods in the vicinity of this metropolis of the West.

In selecting the Quetzal as their national emblem, the Guatemalans made a more than usually felicitous choice, a creature at once native of the land itself, ornate as a design, and refreshingly different from the belligerent birds, beasts, and mythological fire-breathers that adorn the coats of arms of so many other nations. And the Quetzal, no less than the soaring eagle and the rampant lion, has its appropriate legend, to illustrate its nobility of spirit and reflect that of the people it represents. Every Guatemalan will proudly tell you that the Quetzal will die of a broken heart if deprived of freedom. I have heard of Honduran and Costa Rican Quetzals that survived considerable periods of captivity; but I sincerely hope that none hatched on Guatemalan soil will ever be guilty of conduct so unworthy of the national traditions! It always makes us sad when an ugly experiment bears witness against a beautiful legend.

The Quetzal is something more than the living representative of a beautiful country of the present era; its human associations stretch back into antiquity. Possibly no other feathered being of this hemisphere, the Bald Eagle and the Turkey not excepted, has a longer history, as the philologist rather than the naturalist would use the term. This history is largely unwritten; and it is to be hoped that before long one who is at

once an archaeologist and an ornithologist will make good the deficiency. Still, Salvin and Godman, in the "Biologia Centrali Americana," have given us some glimpses of its antique importance. The long, waving green plumes of the male Quetzal's train were coveted objects of adornment of the Indian chieftains, as one may plainly see on many a modern restoration of ancient scenes. Their use was limited by law to royalty and the nobility. The male Quetzals were captured alive—it is stated with corn, as bait, which I rather doubt—and after being despoiled of their proudest ornaments, released that they might grow them afresh and continue to propagate their kind. Thus the brown aborigine, later so despised and crushed into the dust, proved himself more far-sighted than the white invaders who overcame him. The bird was described by some of the early historians of the Conquest; but it soon grew so rare in all the more accessible portions of the Spanish Kingdom of Guatemala that its very existence came to be doubted in Europe, some ornithologists even classing it among the birds of fable. In the nineteenth century, it was rediscovered by Europeans; and soon its skins began to flow across the Atlantic for museums and the cabinets of collectors. This nefarious trade reached such proportions that the Quetzals might well have been exterminated had not so many of them dwelt in wild mountainous regions which even today are most difficult of access and scarcely explored. Most of these trade-skins originated in the Alta Vera Paz in Guatemala.

One other legend about the Quetzal seems worth repeating here, especially as it had much to do with fomenting my own desire to study the bird in life. As often as they tell the traveller that the Quetzal invariably dies in captivity, the Guatemalans volunteer the information that its nest cavity in a decaying trunk is provided with two opposite doorways, so that the male when he comes to take his turn on the eggs may enter from one side, perform his spell of incubation, then depart by the other, all without being obliged to turn around to the detriment of his gorgeous train. Few Guatemalans have actually seen the Quetzal's nest, for the birds survive only in the wildest, least inhabited regions of the Republic. Osbert Salvin (Ibis, 1861:66) tells of a nest in what was taken to be an old woodpecker hole. It had a single doorway, and he believed that the female alone incubated.

The foregoing is, briefly, what I had been able to learn about the Quetzal up to the early half of the year 1937. I had already given attention to the habits of Central American birds during seven nesting seasons, and I had learned something about the breeding habits of one more kind of trogon during each of these years. But of the Quetzal I had enjoyed only fleeting glimpses on two or three occasions, in the highlands of Guatemala and Costa Rica. To complete my studies of this family, I needed observations upon its most famous and most resplendent member. I wanted to decide for myself between the conflicting accounts of its nesting, but everything I knew about trogons inclined me to believe that, in whatever kind of a nest, the male shared in incubation.

I was fortunate enough to rent an unexpectedly comfortable cottage in a wild region still largely covered with forest, in which Quetzals were abundant. The adequacy of the dwelling was important, for even sheltered as I was, it was at times difficult enough to withstand the depressing effects of the cold rainstorms that continued scarcely broken for weeks on end, with hardly a gleam of sunshine. The point where I studied the Quetzals was at an altitude of 5500 feet, about two miles below the hamlet of Vara Blanca, on the northern side of the Cordillera Central of Costa Rica, along the old trail leading from Heredia across the continental divide down through the forests to the Río Sarapiquí, an affluent of the San Juan. My period of residence there extended from July,

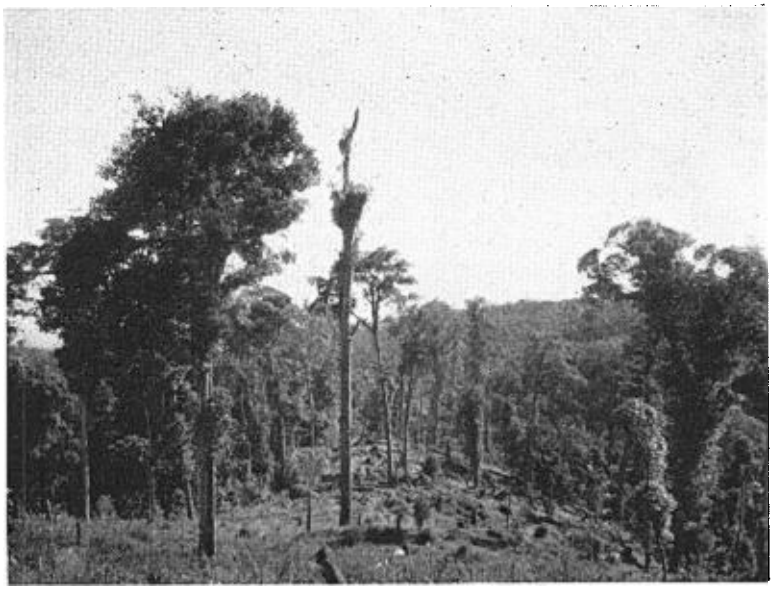

Fig. 36. A clearing in the forest near Vara Blanca, 5500 feet, Costa Rica. A pair of Quetzals nested at the edge of the forest at the lower end of this clearing; July, 1938.

1937, to August, 1938, with less than two months of absence between November and January. If I did not learn more about the ways of the Quetzal, it was not because of any lack of these birds in the neighborhood, but rather because a wealth of birds of other kinds offered too many temptations to divagate.

THE ENVIRONMENT

The Quetzal (*Pharomachrus mocinno*) ranges through the mountains from the Mexican state of Chiapas to western Panama. In this thousand-mile stretch of territory —Central America in the proper geographic sense—there are two areas of highlands, separated by the belt of lowland that crosses the isthmus along the Rio San Juan and Lake Nicaragua. As with so many other birds of corresponding range, the Quetzal shows geographic variation on the two sides of the gap. The northern form (*P. m. mocinno*) is distinguished by the greater length of its upper tail coverts; it ranges from Chiapas to northern Nicaragua. The southern race (*P. m. costaricensis*) dwells in the mountain complex of Costa Rica and western Panama. Other members of the genus are South American.

The Quetzal is an inhabitant of forests of the Subtropical Zone. In Costa Rica, it is most abundant between 5000 and 9000 feet above sea level. Occasionally it is found as low as 4000 feet; I have a record of a single bird at this altitude, but doubt if it often ranges lower. Where forests of huge oak trees extend up to nearly ten thousand feet in the Costa Rican mountains, it is not impossible that the Quetzal accompanies them, although definite records appear to be lacking. In Guatemala, farther from the equator, the northern winter makes itself felt and the Temperate Zone replaces the Subtropical at a lower altitude. Here the Quetzal does not, at least at the present time, appear to extend upward beyond 7000 feet. The dense human population of the central highlands

may well have been responsible for the bird's disappearance from the few possibly suitable forests that remain above this altitude. With one exception, all the other Central American members of the trogon family dwell at altitudes lower than the Quetzal, although a few, as the Jalapa Trogon (*Trogon collaris puella*, and *Trogon aurantiiventris*, which seems to be a mere color phase of this species) overlap its range from below. The Mexican Trogon (*T. mexicanus*) is characteristic of the Temperate Zone in Guatamala and extends higher than the Quetzal.

The forests in which the Quetzal dwells are composed of crowded lofty trees, those that form the canopy ranging from 100 to 150 feet and even more in height. Oaks of a number of kinds occur throughout the Quetzal's altitudinal range, but they are more abundant toward its upper limit, where with huge boles and spreading crowns they dominate the woodland. Alders (*Alnus acuminata*) are abundant in many places, becoming nearly as tall, although not so massive, as the oaks. But more important for the Quetzals are the numerous members of the laurel family (Lauraceae), including the wild relatives of the avocado (*Persea* spp.) and species of *Nectandra* and *Ocotea*—variously called *ira* and *quizarrá* in Costa Rica, *tepeaguacate* in Guatemala—whose fruits are an important food of our birds. These forests are watered by abundant rainfall, and at all seasons they are bathed in cloud-mist much of the time. The constant moisture favors the development of an epiphytic vegetation of whose proportions one can hardly form a conception when he knows only the forests of the North Temperate Zone, or even those of the lowland Tropics. Each larger tree upholds a mass of vegetation which must be estimated, not in pounds or in hundredweight, but in tons. In the dense covering of mosses are rooted ferns, herbs, shrubs, and even trees of fair size. Especially noteworthy are the orchids of a myriad kinds, the cavendishias and related ericaceous shrubs, with their glossy leaves and heads of pink and white blossoms. The undergrowth is often dense, with tangles of slender-stemmed bamboos, ferns in bewildering variety, and shrubs and herbs, including many elegant members of the acanthus family and the Gesneriaceae.

Subtropical forest of this type appears essential to the existence of the Quetzal. While the bird will often venture beyond the forest to forage and nest in adjacent clearings, it is not known to occur in districts from which the heavy woodland has been shorn. The almost total destruction of the original forest over the central plateau of Costa Rica and nearly all of the *altos* or central highlands of Guatemala is responsible for the disappearance of the Quetzal from these regions, no less than the unremitting persecution of commercial plume collectors and less expert trophy hunters. But happily for the bird and those who admire it, there still exist, in the northern parts of the departments of Alta Vera Paz and El Quiché in Guatemala, but above all in Honduras and southern Costa Rica, great areas of subtropical forest on mountains so rugged and difficult of access that they must long defy the devastating invasions of man. Recent well organized attempts at road making through some of these mountains serve merely to emphasize the difficulties of conquering them. As I write, I look over the broad, forest-mantled flanks of the Talamancan Cordillera and like to think that for many centuries they will remain the inviolate home of the Quetzal, the Costa Rican Bellbird, the Black-faced Solitaire, the Costa Rican Chlorophonia, and all the birds that dwell with them in the subtropical mountains. Doubtless Quetzals must continue to owe their existence more to the inaccessibility of their haunts than to human laws, which, as that decreed a dozen years or so ago in Guatemala for their protection, are usually not made until the creature they would save becomes rare almost to the vanishing point.

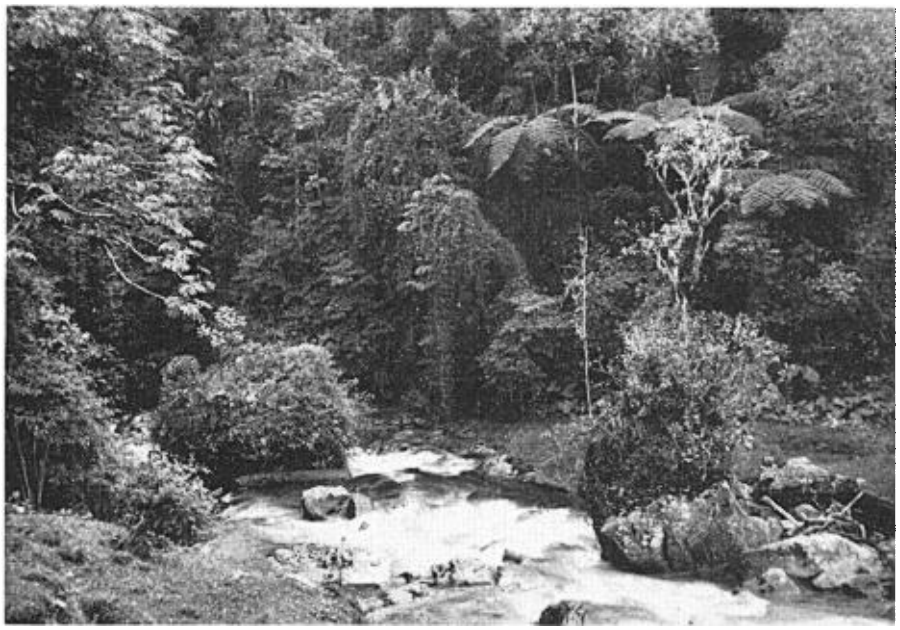

Fig. 37. Border of the subtropical forest, near the headwaters of the Río Sarapiquí, 5600 feet, Costa Rica; July, 1938.

APPEARANCE OF THE QUETZAL

Although a formal account of the plumage of the Quetzal may be found in Ridgway's "Birds of North and Middle America" and other standard works of descriptive ornithology, I shall give here, with only slight verbal changes, a word picture that I wrote in my journal on April 28, 1938, when I had the living birds daily before me: "The male is a supremely lovely bird; the most beautiful, all things considered, that I have ever seen. He owes his beauty to the intensity and arresting contrast of his coloration, the resplendent sheen and glitter of his plumage, the elegance of his ornamentation, the symmetry of his form, and the noble dignity of his carriage. His whole head and upper plumage, foreneck and chest are an intense and glittering green. His lower breast, belly and under tail coverts are of the richest crimson. The green of the chest meets the red of the breast in a line which is convex downward. The head is ornamented by upstanding bristly feathers which form a narrow, sharply ridged crest extending from the forehead to the hindhead. The bill is bright yellow, and rather smaller than that of other trogons, even those of inferior size. The glittering eye is black, and set directly among the green feathers of the face, without the white or bluish or golden orbital ring that so many trogons possess.

"The wing-quills are largely concealed by the long, loose-barbed, golden-green, plume-like feathers of the coverts, whose separated extremities, passing beyond the wings on to the sides of the bird, stand out beautifully against the crimson that shows between them. The ends of the black remiges are left uncovered by the covert-plumes and contrast with the green rump, upon the sides of which, when folded, they repose. The dark, central feathers of the tail are entirely concealed by the greatly elongated upper tail coverts, which are golden-green with blue or violet iridescence, and have loose, soft barbs. The two median and longest of these covert feathers are longer than

the entire body of the bird, and extend far beyond the tip of the tail, which is of normal length. Loose and slender, they cross each other above the end of the tail, and thence diverging gradually, form a long, gracefully curving train which hangs below the bird while he perches upright on a branch and ripple gaily behind him as he flies. The outer tail feathers are pure white and contrast with the crimson belly when the bird is beheld from in front, or as he flies overhead. To complete the splendor of his attire, reflections of blue and violet play over the glittering metallic plumage of back and head, when viewed in a favorable light.

"The female Quetzal is far less beautiful than her mate. She is the one female trogon I know whose upper plumage is green like the male's, instead of brown or slate-colored. Her head is dark smoky gray, sometimes slightly tinged with green, and bears no trace of the male's crest. Her bill and large eyes are black. Her back and rump are green, but less intensely so than those of the male; and the upper coverts of her wings and tail are green and elongated like his, but in less degree. The tips of the wing coverts scarcely extend beyond the margin of the folded wing, and the longest tail coverts at most but slightly exceed the length of the tail. Her chest is green; but the breast and much of the belly are dark gray and only the lower belly and under tail coverts are red, of a shade paler than these parts of the male. The outer tail feathers, instead of being pure white, are narrowly barred with black."

HABITS AND VOICE

While perching, the Quetzal, like other trogons, assumes a very upright posture, its tail directed downward or even inclined slightly forward under the perch. If alarmed, agitated or suspicious, both sexes have the habit, widespread among trogons, of rapidly spreading the tail feathers fanwise and closing them again, sending forth flashes of white from the outer rectrices, which to one viewing the bird from the rear are usually concealed by the dark central feathers and the coverts. In quitting his perch, the male commonly drops off backward, instead of flying straight forward in the usual manner. Thereby he avoids dragging his train over the branch each time he takes wing, which would in the course of months fray it greatly through friction against the rough bark. My notes are not explicit as to whether the female, lacking the train, takes off in the same fashion; but my impression is that she does not.

The flight of the Quetzal is undulatory, but less strongly so than that of some of the smaller trogons. Its method of plucking small fruits from a tree is the same as that of the other members of the family. Starting from a resting position, it darts up to a cluster of berries, seizes one in its bill, and detaches it by throwing its weight against it as it drops away, all without alighting. Such fruit-catching is spectacular with all trogons; and with the magnificently attired male Quetzal it is indeed a striking display. The cottage at Vara Blanca stood on the cleared back of a narrow ridge, with forest on either slope a short way down. From the porch I sometimes watched a pair of Quetzals foraging in the crown of a great *ira rosa* (*Octotea pentagona*) that grew in the pasture on the slope to the west, its upper boughs on a level with my eyes. The birds would emerge from the forest, snatch a few of the big, green fruits in their usual dashing way, then dart down into the wooded ravine whence they had come.

From my arrival at Vara Blanca in July until the last days of February, I had attributed only a single kind of call to the Quetzal. This was a loud, startled-sounding *wac-wac, wac-wac* that they often voiced in flight. The call bears a certain resemblance to the notes of alarm of the smaller trogons, most of which have a startled, cackling character, but are less powerful than the corresponding utterance of the Quetzal. But

in late February, as the mating season approached, I began to hear notes of a very distinct kind. During March, the Quetzals called much; and it became clear to me that they had a rather varied vocabulary, including sounds of rare beauty. They were most vocal in calm, cloud-veiled dawns, and late on misty afternoons; in bright weather they called less, and on windy days rarely broke silence. Their notes reminded me somewhat of the utterances of the clearer-voiced of the small trogons, as the Mexican, Jalapa, Gartered (*Chrysotrogon caligatus*), and Graceful (*Trogonurus curucui tenellus*), yet were quite distinct from any of these. The Quetzal's voice, at its best, is softer and at the same time deeper, fuller and more powerful than that of any other trogon I know. The notes are not distinctly separated, but are slurred and run into each other, producing a flow of mellow harmony. Even as the Quetzal surpasses his kindred trogons in splendor of plumage, so he excels them in mellowness of voice. The female, on rare occasions, was heard to utter a clear-voiced call resembling that of the male, but in far weaker, more subdued tones.

At times, especially at the outset of the season of nesting, the Quetzals voiced notes of a whining, complaining character, which appeared to be mating calls. I could not then make sure whether both sexes used this sound or only one, nor which it was; but I sometimes heard it when they were together at the edge of the forest. Later, when they were incubating, both male and female would deliver nasal or whining notes of a rather similar character as each came to relieve the other on the nest. In May I became aware of an utterance very distinct from all these, a high, soprano, sliding *whooo*, not especially loud—a surprising performance which, when first heard, I was inclined to attribute to a mammal rather than a bird.

The flight-display of the male Quetzal is accompanied by an utterance all its own that is obviously a modification of the flight-note already described. From time to time, in March, April, May, June and July, the male rises on wing well above the tree tops, circles around in the air, then descends again into the shelter of the foliage. His flight on these sallies is strong, swift and direct, often with little of the usual undulatory motion; but if he goes very high, it may at the end become pronouncedly wavy and jerky, suggesting that he has about reached the limit of his endurance. As he soars up into the air, he shouts loudly a phrase which at various times I set down as *wac-wac, wac-wac, wac-wac*, but as often *very-good, very-good, very-good.*

On a number of occasions, I saw the male, when relieved of his long turn on the eggs by the arrival of his mate, set forth directly from the doorway of the nest on one of these flights, calling loudly as he went. Such aerial sallies are not rare among birds of open fields and low thickets, as the Skylark and the Bobolink, or, to take closer neighbors of the Quetzal, the Baird Yellowthroat (*Geothlypis semiflava*), the Streaked Saltator (*Saltator striatipectus*) and the Lawrence Elaenia (*Elaenia chiriquensis*); but they are decidedly uncommon among denizens of heavy forest. I know no other trogon, nor any bird of the tropical rain-forest at whatever altitude, which indulges in such exercises. The gliding flights of the guans (*Penelope cristata* and *Chamaepetes unicolor*), in the midst of which they produce drumming sounds with their wings, are of quite distinct character.

One afternoon in early March, I watched in a narrow clearing in the forest, in the midst of which stood a tall decaying trunk, where a pair of Quetzals were interested in a possible nest site. As the sun sank low, I heard mingled mellow calls and whines float out of the bordering woodland. Presently the male rushed out into the clearing, flying in a wild, dashing, irregular fashion, his long, loose, green, wing-covert and tail-covert plumes vibrating madly, shouting *wac-wac-wac-wac way-ho way-ho*. This ap-

peared to be a distinct kind of flight-display, accompanied by a somewhat altered call.

I have heard tell of flocks of Quetzals in the Costa Rican highlands, but have never seen such an aggregation. When I arrived at Vara Blanca in early July, the Quetzals were probably still nesting, although I found no nests until the following year. I saw a number, chiefly single individuals, during that month; but in August and early September I met none, and I began to suspect they had migrated from the region. But in the second fortnight of September I encountered two. Yet from August to the following February they were very little in evidence; and the few that I saw were mostly silent and alone. It was not until late February or early March that Quetzals appeared to become abundant in the vicinity. It is not impossible that there had been an influx of individuals into the locality, but I suspect that their apparent increase in number resulted from their greater activity, and above all, the more frequent use of their voices. The Quetzal, for all his glittering splendor, is not easy to detect as he perches quietly among lofty boughs smothered in air-plants.

By the first week of March the birds seemed quite generally to have paired. Once I saw four flying through the shady pasture together, but these appeared to be rivals rather than members of a flock. Possibly the Quetzals at times gather in numbers about a tree that offers an abundance of fruit, and in the mating season, several rival males may call from the same part of the forest, as with other trogons. Nevertheless I doubt if they form true flocks, which appear not to exist among the American members of the family.

THE NEST AND EGGS

The Quetzal nests in a hole in a decaying trunk, upright or slightly leaning. This may be situated within the forest, or in an adjoining clearing, sometimes as much as a hundred yards from the woodland border. The six nests I found in 1938 ranged from 14 to an estimated 60 feet in height above the ground. In size and form the cavity closely resembles that of the larger woodpeckers, as the Guatemalan Ivory-bill (*Scapaneus guatemalensis*) or the Pileated Woodpecker (*Ceophloeus lineatus*). The single entrance at the top is irregularly circular, about 4 to 4½ inches in diameter. One hole which appeared to be freshly carved—the man who showed it to me said he had seen the birds at work—extended to the depth of only 4½ inches below the lower edge of the doorway. This contained eggs, although they had been broken before I saw the nest. A second nest, which was very old and weathered when the Quetzals began to use it, extended 11 inches below the sill of the doorway and was 6 inches in width. Although the other nests were inaccessible, I believe that most of them had a depth well in excess of the 4½ inches of the shallow one I measured; this opinion is based on the positions of the birds when incubating or feeding nestlings within them.

In form, the Quetzal's cavity is quite distinct from that of the other trogons' nests I have seen (Skutch, Auk, 59, 1942:341-363). Some trogons lay their eggs in cavities they carve in termites' or wasps' nests, others in decaying wood. But of the other trogons that dig into wood, the Mexican, Jalapa and Graceful trogons are content with shallow niches that leave much of the incubating bird exposed to outer view. The Baird Trogon (*Trogon bairdii*) carves deep into the trunk, forming a completely enclosed chamber entered through an obliquely ascending tube.

The trunk in which the Quetzal nests is sometimes in the last stages of decay. One nest cavity was situated at a height of thirty feet in the top of a massive but very rotten stub standing in a pasture. Since I had not at the time of finding this seen any lower nest, I made a determined effort to glimpse its contents, standing on the next-to-

highest rung of a tall ladder and holding a mirror at the doorway, still above my head, while the interior was illuminated by an electric bulb. While I was engaged in this foolhardy venture, a visiting naturalist looked on and prophesied disaster. I could see nothing, yet dared not step upon the topmost rung and depend for support upon the trunk alone. But later, after the nestlings had flown, we put a rope about this trunk, cut some of the supporting prop-roots, and pulled it over; for I wished to examine and measure the cavity. Upon striking the ground, the upper portion fell into a formless heap of rotten wood. It was not even possible to distinguish the point where the chamber had been! We had a similar experience with a trunk containing an empty eighteen-foot-high nest, which we pushed over in the forest for examination. After it struck the ground, there was nothing left to examine. Not infrequently, a woodpecker hole will remain perfectly intact and sound after falling from twice or thrice the height of these Quetzals' nests. The lowest nest chamber, to which I devoted so much attention in July and August, was covered in front only by the bark of the decaying stump, a large sheet of which seemed on the point of falling away and exposing the eggs. I thought it prudent to hold it in place by encircling the trunk with cord.

I did not in any instance see Quetzals actually carve their nest chamber. The three nests in which first broods were raised seemed old and weathered when I found them. But the shallow cavity already mentioned gave every appearance of having been freshly carved in decaying wood still considerably sounder than that which collapsed into a heap when it fell. This nest was shown to me by Don Moises Larra, in front of whose cabin it stood. He told me that he had seen the male and female Quetzals taking turns at carving it out. This, of course, is the way in which most if not all kinds of trogons make their nests.

Early in March, a pair was interested in a tall, branchless, decaying trunk that stood in a pasture near the edge of the forest. While I watched, the female clung upright in front of an old, long-abandoned woodpecker hole near the top of the stub. She spread her tail and braced it against the trunk, revealing the white outer feathers narrowly barred with black. Clinging so, she bit at the decaying wood about the rim of the doorway, tearing off fairly large flakes of the soft substance and letting them drop to the ground. She continued this occupation for a minute or less, and while she was so engaged I heard soft, full notes, but could not make sure whether they arose from her or from the male who perched near by. Upon dropping away from the tree, she rejoined her waiting mate and both returned to the forest. Finally, this pair nested in an old hole in the top of another dead trunk not far off.

At Vara Blanca I found no breeding woodpecker whose hole could accommodate, without alterations, a bird as large as the Quetzal. The Hairy Woodpecker (*Dryobates villosus*), Acorn Woodpecker (*Balanosphyra formicivora*), Green Woodpecker (*Piculus rubiginosus*) and Oleaginous Woodpecker (*Veniliornis oleaginus*) were the only resident species—all considerably smaller than the Quetzal. Likewise, the Prong-billed Barbet (*Dicrorhynchus frantzii*), whose nest cavity closely resembles a woodpecker hole, is not nearly so large as the Quetzal. Before a Quetzal could nest in a hole carved by any of these five species, it would have to enlarge it, especially the doorway. I believe that this is what the pair I watched had started to do, but thereafter something was found that could be made to serve with less effort. Whenever an old hole of their own remains from a former year, still sound enough to contain their eggs and even if in a precarious state of decay, these trogons appear to use it again. When still available, the cavity that served for the first brood is made to do duty for the second after the bottom is cleaned out. When they can find nothing ready made, the Quetzals appear

to carve their cavity from the beginning, in soft, decaying wood, in the manner of other trogons. At lower elevations, where their range overlaps that of the Ivory-billed or Pileated woodpeckers, the Quetzals may find cavities of adequate size all ready for them; but over most of their range, they can hardly avoid a certain amount of hole-carving.

The Quetzal's eggs rest upon the loose fragments of wood in the bottom of the cavity, for no soft lining is taken in. I saw only two sets, one in May and the other in June. The eggs in the May nest had been broken before I was taken to see them. Feathers scattered about pointed to the work of some predatory animal. There had been at least two eggs, light blue in color. The one still whole enough to be measured was 38.9 × 30.2 mm. The June nest also contained two light blue eggs, which I did not deem it prudent to remove from their deep, rather dilapidated cavity. In a high, inaccessible nest to which I devoted considerable attention, at least two fledglings were reared.

INCUBATION

On April 6, 1938, I wrote in my journal: "Two mornings past, I saw a female Quetzal, then a male (of the pair, I believe, that had earlier begun to enlarge the entrance of the old woodpecker hole in a neighboring trunk) cling upright in front of a large, round hole at the very top of a tall, massive and much decayed trunk which stands at the edge of the forest at the lower end of the pasture. The hole is to all appearances an old one, the wood about its rim much weathered; and I have passed beneath the trunk so often that I think I should have seen the Quetzals at work had they made it recently. Each, after clinging a few seconds there, flew back into the forest.

"Yesterday morning, when I passed by, I saw the male sitting in the cavity. *He sat facing outward, with his head and shoulders projecting through the aperture.* His tail was at the back of the cavity, but *one of the long feathers of the train was bent double and projected through the entrance,* above the bird's left shoulder. Where, then, is the Guatemalan story of the nesting cavity with two entrances, so that the male Quetzal's tail can project through the rear one? Or the Costa Rican version that the bird sits in the nest head inside and tail dangling from the single doorway?

"When the Quetzal noticed me beneath him, he flew forth from the hole. I did not deem it prudent to return later in the day. This morning, at six o'clock, I saw the female enter the hole; but at ten o'clock it was unoccupied. Apparently the birds have not yet begun to incubate."

On April 8, the male Quetzal was in the nest at 7:40 in the morning, but he flew out and rose above the tree tops as I approached. That same afternoon, at 2:20, for the first time I found him actually covering the eggs. I approached very quietly so that he did not hear me and look out. All that I could see of him was the ends of the two long feathers of his train. These, bent forward and pressed against the upper edge of the doorway, projected the better part of a foot into the open. Had the trunk been covered with epiphytes, as it would have been if it had not been too rotten and crumbly on the outside to afford them a root-hold, the projecting feathers might have been mistaken for the green fronds of a fern.

On subsequent visits to this and two other nests I found a little later, I learned that I could always detect from a distance the presence of the male Quetzal in the nest by the projecting ends of these two long central tail coverts. They extended from six inches to a foot into the outer air and waved gracefully in the light April breezes. Although all the remainder of the bird was quite concealed in the bottom of the deep

cavity, and I could not actually see the position in which he covered the eggs, the visible portions of these plumes indicated that he sat facing forward, with his tail held upright against the rear wall. This is actually the posture assumed in incubation by the Mexican, Jalapa and Graceful trogons, which are readily seen as they sit in their shallow cavities. But the male Quetzal's long train continued upward, then bent outward, and pressed against the upper side of the doorway which held the flexed ends in an almost horizontal position.

It was early evident that both sexes took substantial shares in the incubation of the eggs. In order to learn in more detail how they divided the day between them, I devoted about fifty-eight hours to watching the nests during incubation. Records covering all hours of the day were made while my first pair incubated both their first and second sets of eggs and while my second pair were hatching out their second brood. I usually made continuous vigils of from five to seven hours, beginning in the middle of the day, watching until nightfall, and when the weather was not too adverse, resuming the vigil at the following dawn and continuing to the middle of the day. In addition to these long records, a number of briefer observations were made in order to time the morning and evening nest-relief. Although the first nest was high, I watched it from concealment. But the pair at the second, low nest gradually grew so accustomed to my presence that they showed no concern when I sat quietly beneath a tree in view of them. While feeding their nestlings they finally became so tame that I was able to photograph them at the nest, at close range, without using any form of concealment.

The records for all three nestings showed substantial similarity in the division of the day between the male and female. There was a basic pattern of incubation; but this was subject to considerable variation from nest to nest, and on different days at the same nest. The fundamental pattern was this: the female incubated every night and during the middle of the day; the male took a long turn on the eggs in both the morning and afternoon. Each sex was responsible for the nest twice during the cycle of twenty-four hours. But their periods of responsibility might be interrupted by brief absences, during which the eggs were left unattended. There is no reason to suppose that the female did not sleep continuously in the nest through the night; for the Quetzal, like other trogons, appears to be strictly diurnal in its activity. The variations in the daily program we shall now consider.

The male Quetzal began his morning session at times ranging from 5:52 to 7:27 a.m.; but he inclined toward the former hour as the eggs neared the point of hatching. If he appeared early, the female might continue her long night session until he arrived to replace her. But usually she flew out still earlier, from 5:35 to 6:00, and if her mate did not appear fairly promptly, she returned in from 5 to 14 minutes to await him on the eggs. The male's period in charge of the eggs during the morning was of variable duration; the shortest that I timed lasted 2 hours and 13 minutes and was continuous; the longest was for 4 hours and 30 minutes, broken by one spontaneous absence of two minutes, and another of 21 minutes when he was frightened from the nest by a passer-by. One male took charge of a nest for 3 hours and 15 minutes, with three short recesses totalling 38 minutes.

The female's midday period began at times varying from 8:21 to after 11:10 a.m. Since I usually watched from midday to nightfall and from dawn to midday, I timed in full only two periods. One began at 9:35 a.m. and lasted until 1:14 p.m., 3 hours and 39 minutes, broken by a single recess of 7 minutes, from 11:03 to 11:10 a.m. The second, at the same nest, began at 8:21 a.m. and continued until 12:49 p.m., 4 hours and 28 minutes, interrupted only by a brief absence of 11 minutes, from 12:23 to 12:34.

The male's afternoon session began at times varying from 12:53 to 4:36 p.m. Four sessions that I timed lasted 52 minutes, 1 hour and 9 minutes, 2 hours, and 3 hours and 3 minutes. All were uninterrupted. Each of the two males is to be credited with one long and one short session.

On a wet, mist-shrouded afternoon soon after her eggs were laid, the female at nest 1 resumed charge at 2:14 p.m. and remained in sole charge until the following morning, with brief recesses from 4:18 to 4:27, and from 5:48 to 5:58 p.m. But this was unusual. As a rule, the male sat until about 5:30 p.m., then left the eggs uncovered until the female returned for the night, from 5 to 41 minutes later. The female at nest 1 arrived consistently earlier than her neighbor at nest 2. Her two evening returns which I witnessed took place at 5:30 and 5:53. The other female entered at 6:09, 6:01 and 6:07, when the daylight was growing faint.

The noon-to-noon record of the first nest shows that the male incubated a total of 7 hours; that of the second nest credits him with 6 hours and 7 minutes, out of approximately 13 hours of total daily activity.

Compared with other, smaller trogons, the Quetzal sits for brief periods. The fundamental pattern of incubation among trogons is the same as for pigeons; there are only two shifts in each twenty-four-hour cycle, the male sitting through the middle of the day, the female from the middle or late afternoon until the early half of the following morning. This is exemplified by my records of the Black-headed (*Trogon m. mellanocephalus*), Graceful, Jalapa and Baird trogons. Because I usually begin and end my observations at midday, I have not often watched through the complete session of a male trogon of the smaller kinds. But once a male Baird Trogon sat for exactly six hours, without once showing his head in the doorway of his well-enclosed nest; he and his mate kept the eggs continuously covered. So did a pair of little Graceful Trogons in Panama, the noon-to-noon record pointing to uninterrupted incubation by the male for about eight hours. The male Black-headed Trogon, sitting in his termitary, takes sessions of corresponding length; but he and his mate do not always wait for each other before going off to hunt food.

In contrast to the female Quetzal's impatience to depart from the nest in the early morning, I have known a female Mexican Trogon to extend her night session through the entire morning and until 1:10 in the afternoon, never once leaving for food. A female Jalapa Trogon sat continuously from 4:51 p.m. until 11:27 next morning, refusing her mate's offer to relieve her at the unusually early hour of 7 a.m. Why the Quetzal should incubate so much less assiduously than its smaller cousins is not clear. Most trogons nest in lower and warmer regions. The Mexican Trogons dwelt at a far greater altitude; but all were not so patient in incubation as the female to which we have referred. With other families, as with the trogons, size has little to do with the length of a bird's sessions on the eggs.

Upon arriving to replace the mate on the nest, both male and female Quetzal would often, but by no means always, utter whining or nasal notes while perching near by. At the same time they flash their white outer tail feathers with a momentary fanning of the rectrices, then twitch the tail upward—a typical trogon gesture. Sometimes the partner in the nest would come forth upon hearing the summons, but again it might disregard them. Its response doubtless depended upon how eager it was to leave. If the bird in the nest did not come forth, the one arriving might fly up in front of the doorway, but always veered aside and went to a perch when it saw that the hole was occupied. This move usually caused the other to quit the eggs. At times, the new arrival would fly up to the doorway in this fashion with no previous announcement of its pres-

ence. Each of the males, but especially that of the second pair, was sometimes guilty of calling his mate from the eggs, then flying off with her as she departed, leaving the nest unattended until either he or she returned to take charge of them. The female more rarely did the same thing. Thus there was no set ceremony of nest relief. Less closely synchronized than mated birds of many other kinds, one of the pair might come before the mate was ready to go; or one would go before the other was ready to come. Yet in spite of inconsistencies, they managed to get through their three-shift day without leaving the eggs exposed for many minutes. After incubation had well begun, the nest was rarely left unattended for more than half an hour at a stretch, although once both members of the pair at nest 1 were absent for 67 minutes, and on another occasion for 51 minutes.

For many kinds of trogons, the entry into the nest is a very protracted procedure. They cling before the doorway, peering cautiously from side to side, often for several minutes, before slipping inside. If they espy something that excites their suspicion, they dart away to return a little later and go through the lengthy performance again. The Quetzals entered in a less hesitant fashion, often hardly delaying in front of the doorway, or at most making only a brief survey from this position.

Upon quitting the nest, the male, as already recorded, would sometimes rise into the air in a flight-display, shouting as he went. I saw one of the males do this six times, the other thrice. These spectacular flights were made at any hour of the day; one of the males left the nest in this manner when his mate relieved him at sunset. Even when frightened from the nest by a passing man, the reckless bird might soar up and make himself conspicuous to all the neighborhood. Or at times he would give loud calls as he flew off, without rising above the trees.

While I watched them, the Quetzals were not often called upon to drive intruders from the vicinity of their nests. On April 10, not long after they began to incubate, male and female of my first pair joined in giving chase to a trespassing female of their kind. Later, I saw this male pursue a Blue-throated Toucanet (*Aulacorhynchus caeruleogularis*), which would have enjoyed eating their eggs, and twice a Tityra (*Tityra semifasciata*), which seemed to be prospecting for a nest cavity in the same trunk. Another pair of Quetzals was worried by a pair of Sulphur-bellied Flycatchers (*Myiodynastes luteiventris*) building a nest near their own. Once while the male Quetzal was brooding the nestlings, a strange female flew to the doorway, with no food visible in her bill. One of the flycatchers gave chase to her, and the Quetzal, emerging from the nest, also darted at her, but without touching her. She flew directly away and I saw her no more.

CARE AND DEVELOPMENT OF NESTLINGS

Only at the second nest of my second pair of Quetzals could I actually see the eggs and determine the period of incubation. The nest was in a low, rotting stub in a shady pasture beside a little-used pathway. I feared betraying its position to passers-by and through an excess of caution did not set up a ladder and look in with a mirror until I was sure that incubation had begun. At this late nest the birds began to incubate on June 24, or possibly even on the 23rd, and the nestlings hatched on July 11, giving an incubation period of 17 or 18 days. This agrees rather closely with the periods available for other trogons: 18 or 19 for the Mexican Trogon, 19 for the Black-headed Trogon, 18 for the Graceful Trogon.

Like other newly-hatched trogon nestlings, those of the Quetzal bore no vestige of down upon their pink skin. Their eyes were tightly closed. Each bore a prominent white egg tooth near the tip of the upper mandible, which was slightly shorter than

the lower. Their heels were studded with the short, papillate protuberances typical of nestlings that grow up in a nursery with an uncarpeted floor. When I first saw the two newly-hatched nestlings, only a few fragments of the blue egg shells remained on the bottom of the nest.

During their first few days of life, the young Quetzals were brooded much of the time. They were nourished almost if not quite exclusively with small insects; it was not until later that fruits became an important element in their diet. The parents at first kept the nest perfectly clean, removing all the droppings, which apparently they swallowed, for I saw none carried away in their bills. On the nestlings' fourth morning, I heard their mother scraping and scratching in the nest, doubtless to clean it out. This attention to sanitation was eventually to be relaxed. Still, Quetzals are considerably in advance of their relatives in this respect, for the Mexican Trogons, Graceful Trogons and Jalapa Trogons that I studied did not even remove the empty egg shells and the bottom of their nests soon became foul.

When the nestling Quetzals were two days old, the sheaths of both their contour and flight feathers began to push through their pink skin. At four days, there was slight change, save that the nestlings were considerably larger and their feather-sheaths somewhat longer. When they were five days old, their eyelids began to separate. At eight days, they could open their eyes, but most of the time rested with the eyelids closed. On the seventh day after hatching the contour feathers of the body were breaking from the ends of their sheaths, but not those of the head. The young were ten days old before the flight plumes of the wings and tail began to push out from the tips of the sheaths, a day after the wing coverts had reached the same stage. The bill and feet were now becoming blackish.

At this stage of development, the young Quetzals always rested side by side on the bottom of their nest with their heads supported against the side wall and their bills pointing almost straight upward. They did not appear to be comfortable unless their heads were in this position, for even when removed from the nest and placed where they could find no chin-support, they held them turned abruptly upward in this fashion. From time to time, when they appeared to be hungry, they stretched up their necks and at the same time opened their mouths and sharply closed them again, making a snap. Evidently, like young motmots and woodpeckers, they took food from their parents in this harsh, abrupt fashion, instead of holding their mouths passively open for the morsel to be placed in it in the manner of passerine birds.

Up to their tenth day, the young Quetzals were nourished almost entirely with animal food—indeed, I had not yet seen the parents bring them a fruit. On their eighth morning I was present when their mother came with a golden beetle (*Plusiotis aurigans*) about an inch in length. These coleopterans are certainly the most splendid I have ever seen; they are among beetles what the Quetzal is among birds.

When the nestling Quetzals were eleven days old, buffy spots began to appear on their wing coverts. When they attained the age of two weeks, their bodies were well clothed with feathers so long as they kept their wings folded. But the feathers of their heads had only the day before begun to escape the horny sheaths. The contrast between the well-clothed body and naked head was striking, and gave the little Quetzals a somewhat vulturine aspect. On their fourteenth day they were photographed for the first time (fig. 38).

From this age onward, fruits, especially those of the laurel family, became an increasingly important constituent in the diet of the nestlings and the large regurgitated seeds began to accumulate beneath them in the nest where the parents could not easily

Fig. 38. Female Quetzal at the nest, about to deliver a golden beetle to the nestlings; July 20, 1938. (Reproduced by permission of The Scientific Monthly.)

reach them for removal. Still, they had kept the nest sanitary for almost as long as young Black-headed and Mexican trogons remain in their uncleaned nurseries.

When the young Quetzals were sixteen days old, their mother began to behave in a most unaccountable fashion. She ceased to brood them during the night, although they seemed scarcely old enough to be left uncovered in that inclement weather, and by day she fed them less and less. In nearly five hours on their seventeenth day she came only thrice with food. On two of these occasions, she waited dully in the *poró* (*Erythrina*) tree in front of the nest, holding the morsel in her bill, until her mate arrived with food, and only then, as though stimulated by his example, did she go to the nest to deliver what she had brought. Even the preceding day, she had delayed nearly an hour, holding a green fruit until the arrival of the male caused her to take it into the nest. After this, I did not again see her in the vicinity.

To the male Quetzal, then, fell the whole duty of attending the two nestlings during their last five or six days in the low hole. With his plumage showing unmistakable signs of his strenuous activities and the long feathers of his train broken off short, he was indeed an Apollo in the service of King Admetus. He no longer brooded; but the young birds' cloak of feathers made this unnecessary now. Nor did he clean out the nest. As a result the growing accumulation of big, regurgitated seeds and other waste matter slowly raised the level of the floor and the little Quetzals stood each day higher

in the nursery, nearer the doorway, where it was easier for them to reach up for their food.

From the first, the male Quetzal had been a constant provider of food at this nest. Still, he did not feed very often; infrequent feedings are the rule among trogons. On the nestlings' seventeenth morning, he fed the two seven times during 4¾ hours. Sometimes he would bring one article of food in his bill, pass this to a nestling, then return to a convenient perch and regurgitate a fruit, which in turn was taken to the nest. The preceding day, for the first time, I had seen the parents pass food to the nestlings through the doorway without themselves going in. Now they regularly (the mother until she ceased to feed) delivered the meals while they clung in front of the entrance (see fig. 38) and did not pass through it unless the nestlings were very sluggish about taking nourishment. When hungry, the young jumped or climbed to the doorway, where from in front I could glimpse them momentarily at the instant when they were fed. Their higher floor, as well as their increased size and strength, made this feat possible. The little birds now uttered low, soft whistles as they awaited their meals.

On the nineteenth day, I again watched this nest for three hours. From six to nine o'clock the male made only seven separate visits to the vicinity of the nest. But on three occasions he rested in a neighboring tree after he had delivered the article he brought in his bill, there regurgitated a fruit, then went to the nest to deliver this, making ten feedings in all. This was not many, but he brought each time such substantial portions, always big fruits and frequently lizards, that the young appetites were soon satisfied. Already at half-past seven the nestlings were sluggish in taking what their father offered them. When hungry, they would appear in the doorway and snatch the food in a trice; but when satiated they remained in the bottom of the chamber, making a low sizzling noise as nourishment was presented to them. Then the male would enter and coax them to swallow what he had brought. But even when he went inside, he was not always successful in delivering the morsel. He would emerge, fly to a neighboring tree, and rest there, patiently holding the object in his bill for many minutes, while the digestive juices of his nestlings acted upon earlier contributions. After a while he would go again to the nest with the same article of food, and at length when the nestlings' hunger had reasserted itself, he would succeed in giving it to one of them.

Perhaps it will be of interest to record here the food of the two nineteen-day-old Quetzals. From six to nine o'clock on the morning of July 30, 1938, the male brought them the following in sequence: a big green fruit brought in his bill, and another in his throat; a small lizard; a small lizard; a big green fruit in the bill and another in the throat; an unrecognized object, which the nestlings were very sluggish in taking; a lizard; and a larva. After delivering the last item, he regurgitated a fruit, which he offered repeatedly over a period of twenty minutes before a nestling found room for it.

Altogether, the diet of the young Quetzals, which reflected that of their parents, was surprisingly varied. The edible objects I saw taken into this and other nests included: insects of numerous kinds, often green and of fair size, the most easily recognized of which were the golden beetle (*Plusiotis aurigans*) and even more numerous greenish-gold beetles of somewhat larger size (*P. boucardi*) [For the identification of these beetles I am indebted to Mr. C. H. Lankester]; green larvae; small green and yellow frogs; small lizards; small land snails, the regurgitated shells of which were found in the bottom of the nest; the hard, big-seeded, green-skinned fruits of the *ira rosa* (*Ocotea pentagona*) and other lauraceous trees. These last are structurally similar to the avocado but of course are very much smaller. They became increasingly prominent in the diet as the nestlings grew older. Other trogons I have studied brought few or no fruits to

their nestlings; this was true even of the Baird Trogon whose offspring lingered in the nest longer than these two Quetzals. Yet the adults of most species include at least some fruit in their diet.

The feeding of the young Quetzals by their father alone during their last days in the nest is not without parallel in my experience with trogons. Last year, a male Baird Trogon seemed to be in sole charge of the nestlings from the time they were a few days old. One perished early; but the second lived to fly from the nest, practically reared by its father. In this instance, I saw no evidence of gradually waning interest on the part of the mother; it seemed that she met some accident.

THE JUVENAL PLUMAGE

The course of feathering of the nestling Quetzals and their partial change in color during their final week in the nest was most interesting. When we last glimpsed them, they were three weeks old and fairly well clothed, except for their heads, so long as they kept their wings folded; this they did habitually at this age. Their upper plumage was then generally of a dull blackish color, relieved only by the buffy spots on the wing coverts which had become evident a few days earlier. But from the age of two weeks onward, green became increasingly evident in their plumage. This change in coloration was accomplished by the overlaying of the dull early plumage by brighter feathers of subsequent development.

The feathers of the anterior part of the dorsal tract lagged far behind those of the posterior portion of the same tract. Long after the latter had broken from their sheaths and spread over the surrounding bare skin, the anterior feathers of this tract remained tightly enclosed. Only when the young Quetzals were sixteen days of age did the tips of these feathers of tardy development begin to peep forth from the ends of their sheaths. They were golden-green in striking contrast to the plumage that surrounded them. At the age of eighteen days, green-tipped feathers were becoming evident among the scapulars, long after the blackish feathers in the same region had expanded. Green tips then began to push forth from the sheaths on the sides of the neck. A little later, the two green central tail coverts first became evident. Only on the nestlings' twenty-third day did I notice that green feather-tips were emerging from the lateral sheaths of the posterior half of the middorsal tract, a full two weeks after the neighboring, centrally located, blackish feathers had begun to expand. Green feathers were also just beginning to appear on the foreneck. Whereas the blackish contour feathers of early development were loose and fluffy, the green-tipped feathers of tardy appearance had firmer, more cohesive webs. The new feathers on the center of the back were a beautiful golden green; but their concealed basal portions were blackish, like the whole length of the early down feathers.

Thus, at the time of their departure from the nest, the young Quetzals wore a motley garb, blackish, brown, buff and green, but with the last-named color giving promise soon to overshadow all the others. The crown was dark brown, the hind part of the head brown of a lighter shade. There were dull green feathers on the lores and around the eyes. The sides of the neck and upper back were golden green. The lower back and rump were dull black, but with green feathers coming in. The two central tail coverts were green, with black tips and brown subterminal spots; the remaining upper tail coverts were dull black, with a brown subterminal spot on the next to the middle pair. The tail feathers were still very short but so far as visible the six central rectrices were dull black whereas the outer three on each side had white vanes and black shafts. The wing plumes likewise were dull black, with buffy outer margins on all but the outermost,

these becoming gradually more prominent on the inner secondaries. The wing coverts were black, variously margined with buff, except on the lesser coverts and the greater coverts of the primaries.

Turning to the under parts, the chin and throat were tawny buff, with some green feathers just sprouting in on the foreneck. The breast was buff with scattered green-tipped feathers, the flanks paler buff, and the center of the abdomen nearly white. The bill was black, the irides brown, and the feet plumbeous.

These two fledglings, of unknown sex, appeared very much the same as others I saw at a greater distance. Although they resembled neither parent, they were most like the female from which they differed most conspicuously in the far smaller amount of visible green, the lighter color of the chest and upper abdomen, the absence of red on the belly and under tail coverts, and in many other less conspicuous particulars.

It is instructive to compare the rate of feathering of the Quetzal with that of other trogons. The Baird Trogon offers the most illuminating comparison, since it has an approximately equal period of nest life. The feathering of the young Quetzals began on their seventh day and by their fourteenth they were well covered. But at the age of twelve days, the nestling Baird Trogons of the lowlands is still in pin-feathers. A day later, these begin to ravel off at the ends, exposing the true plumage. By its sixteenth day, the nestling is well clothed. Thus it is covered with feathers only a day or two later than the Quetzal; but the shedding of the horny sheaths begins far later and is a much more rapid process. The same earlier escape of the feathers from their sheaths is evident in the Mexican Trogon of the highlands as compared with the Black-headed Trogon of the lowlands. The contour feathers of the Mexican Trogon begin to expand at the age of a week and the little birds are well feathered when twelve days old. When two weeks old, young Black-headed Trogons bristle like porcupines with their long, unbroken pin-feathers; then a marvellously rapid transformation occurs and two days later they are well clothed and ready to fly from the nest.

A similar acceleration of feathering in a cooler climate is revealed by the comparison of the highland Blue-throated Motmot (*Aspatha gularis*) with the Turquoise-browed Motmot (*Eumomota superciliaris*) of the lowlands. During the month it remains in the burrow, the nestling Blue-throated Motmot changes its color even more completely than the Quetzal. At the age of ten days, the little motmot, hatched naked, is already practically covered with loose, fluffy down, dark gray on the upper parts and tawny on the sides and flanks. When it is four weeks old, its gray and tawny feathers are all covered over and concealed by green ones that develop more tardily. On quitting the nest, the young motmot closely resembles its parents, which are not to be distinguished from each other. The exact details of this change of coloration are slightly different in the motmot and the Quetzal; but the general process of overlaying the dull feathers of precocious development with bright ones that expand later is the same in both. The Turquoise-browed Motmot of the hot regions undergoes no such alteration. The feathers do not begin to expand until about the twelfth day and the nestlings in developing plumage at once display all the delicate beauty of the adults. I am familiar with no other bird, quite naked at birth, that changes the coloration of its plumage in this way during the period it remains in the nest. But it seems possible that in other tropical species which begin to acquire the adult colors soon after quitting the nest a similar process may occur.

Since coloration in itself can be of no importance to the safety of a motmot in its nursery at the end of a long, dark tunnel, and is probably of slight account with a Quetzal in a deep cavity in a trunk, one wonders why the nestlings do not array them-

selves in their brightest hues at the very outset. It seems important to these highland nestlings that they early acquire a downy vesture to protect them from the cold in their covered nurseries; but at the same time they guard their feathers of firmer texture from wear, keeping them enclosed within the horny sheaths until the date approaches when they will be needed; for upon quitting the nest, both the Quetzal and the Blue-throated Motmot enter a rainy world. The contour feathers of firm texture, which are not needed until later, are those which bear the green color. The change of coloration while in the nest appears to be incidental, and not in itself of consequence, save as an indicator of other alterations.

DEPARTURE OF THE NESTLINGS

On the morning of August 1 when the young Quetzals were three weeks old, I for the first time saw one of them stand on the sill of the doorway; it looked out for a few minutes after the father had given it food. Two days later, I removed one of the young from its nursery and placed it on a mossy log beside me while I wrote a description of its plumage. At first it made no attempt to fly. (Neither of the nestlings had tried to use its wings on past occasions when taken from the nest.) But after standing quietly

Fig. 39. Nestling Quetzal, 21 days old; August 1, 1938.

beside me for a time, it suddenly took to the air and flew about twenty-five feet in a horizontal course, coming to rest upon another fallen log. The father, who had been watching us from the *poró* tree in front of the nest, began to follow as soon as it began to move and darted down to alight close beside it on the log. After a minute here, he

moved to a low perch a little beyond. Then I approached to recover the nestling, who made no effort to escape me.

After completing the description of its plumage, I took up the young Quetzal to return it to the nest. I found the other in the doorway, looking out. As I mounted the ladder toward it, the bird flew forth and down the slope in front of the nest. On this its first flight it covered about 150 feet in a slightly descending course, and came to rest about twenty-five feet above the ground in a small *yos* tree. It flew well but slowly. The father, who meanwhile had returned to the *poró* tree in front of the nest, darted after the fledgling and followed it closely on its first aerial journey in the manner of parent birds of many kinds. For an hour, the young Quetzal rested quietly on the branch where it had first alighted; and here the father brought it food. While perching near it, he called many times in a clear but subdued voice, no louder than that of the Jalapa Trogon. Meanwhile, the other fledgling, which I had left inside, had climbed up to stand in the doorway of the nest, looking forth. At eleven o'clock, I left them in these positions.

When I returned at a quarter to two in the afternoon, I found that the second fledgling had departed and was resting in the *poró* tree in front, where it repeated over and over a beautiful, low, soft whistle. The other, which had flown first, had moved farther down the slope and perched high up in a tree at the edge of the woods. Here the father brought it food and rested close by it when not away foraging. Although this fledgling was given as much as it could eat, the other called and called in vain for attention. Yet its soft whistles carried faintly to the edge of the woods where its father perched. I watched all afternoon; it lingered in the *poró* tree, and the parent did not come near it.

At five o'clock, despairing of attracting attention where it had so long perched, the second fledgling suddenly took wing and flew down the slope in the direction where it had last seen or heard its parent. It came to rest in a small tree and continued to call tirelessly. It now began to vary its whistles, uttering some which were longer and slightly sharper than I had previously heard and others that sounded very pleading and mournful. Still no food was brought to appease its hunger.

At a quarter past five, the neglected fledgling continued down the slope to the edge of the woods, where it came to rest upon a branch of a cecropia tree covered over with a dense tapestry of climbing bamboo. But the other fledgling, accompanied by the father, had long before gone farther into the woods and neither was now in view. The abandoned young Quetzal continued ceaselessly to call, until at half-past five the male brought the big green fruit of an *ira*, which quieted its cries of hunger. For the next half-hour, the parent, doubtless tired by a long day devoted to hunting food for his children, rested quietly on a neighboring branch, without bringing any additional nourishment for the fledgling. At six o'clock he flew into the woods and left the young alone on the cecropia branch, where it still perched quietly in the gathering dusk and the light rain that was now falling. Here it passed its first night in the open. From the time of my arrival at a quarter to two, it had received no food, except the single fruit brought to it nearly four hours later. I doubt whether its father had given it anything else since the first fledgling left the nest at ten o'clock in the morning, for, exactly as had happened with a brood of Mexican Trogons that I had watched fly from the nest five years earlier, he was almost exclusively occupied with the first to take wing.

At dawn, I found the second fledgling on the cecropia bough where it had passed the night. The male arrived with food and led it deeper into the woods. Thus ended my long association with the Quetzals.

Going to examine the deserted nest cavity, I found that during the last nine or ten

days of occupancy, when the parents no longer cleaned it out, waste matter had accumulated to the depth of 3½ inches. The chief components of this debris were the seeds of the lauraceous fruit which the parents brought in such great numbers. These were ellipsoidal, measuring 1⅜ by ¾ inches. Mixed with them were the regurgitated shards of beetles and other hard parts of insects, a few snail shells, a few smaller seeds and much excrement.

The fledgling Quetzals which forsook the nest at the age of twenty-three days probably left prematurely as a result of having been removed for photography and examination. The lowness of the nest, with convenient trees in front, may also have encouraged their relatively early departure. At my first nest, which was high and inaccessible, the parents were first seen to carry in food on April 21. On May 14, I saw for the first time a nestling appear in the doorway. Two days later, both nestlings were glimpsed in the entrance at once. They departed between the 19th and 20th, when at least 29 days of age. At the higher first nest of the pair whose second brood departed at the age of 23 days, food was carried in as early as April 19, while the last nestling departed on May 20, indicating a nestling period of 31 days. Other available nestling periods of trogons are: Mexican Trogon, 15 to 16 days; Black-headed Trogon, 16 or 17 days; and Baird Trogon, 25 days.

INCIDENTAL OBSERVATIONS

Each of the three pairs of Quetzals to which I devoted most attention reared, or attempted to rear, a second brood. Incubation of the first set of eggs began in early April and the nestlings departed about May 20. At least two of these pairs, and probably all three, were successful with their early broods. In June, all three were incubating once more. The two whose sixty-foot-high holes were still available, laid their second sets of eggs in the same cavity as the first. I saw one of these pairs cleaning out the old nest but how thoroughly they performed this task must be left to the imagination. The pair whose thirty-foot-high nest we had the inspiration to pull over, after the departure of the fledglings, laid again in a lower hole fifty yards distant from the first, where at last I was able to see the eggs and follow the development of the nestlings whose history we have recorded.

While he incubated the eggs and attended the nestlings, the male Quetzal's ornamental plumes suffered severely from constant flexing and from friction against the rough edges of the nest's single entrance. The wear and tear began to tell even before the nestlings of the first brood were old enough to get along without brooding. As early as April 30, I found my second male sitting in his nest with only the short length of a single plume projecting from the doorway to show that he was within. Most of the males, I believe, suffered similar losses by the time the first brood was awing. The point where the plumes broke off was often a little beyond the tip of the tail proper. But at least one male proudly displayed both his banners before his doorway while he incubated the second set of eggs. Possibly he was a new mate of the female who attempted to rear a first brood in the same hole.

On all my visits to their nest, the parent Quetzals had never darted at me nor made any display to lure me from its vicinity. They merely perched close by to watch, nervously twitching their tails or at most darting excitedly from branch to branch. In this they agreed with all other trogons I have watched at the nest.

In no other region have I found the birds of nearly all kinds so fearless of man as in the forests of the more remote parts of the Costa Rican highlands. In this respect, they differed greatly from those I studied in the Guatemalan highlands, where the

human population is relatively dense. The Quetzals were by no means the most confiding of the birds; yet I never ceased to marvel that such large, brilliant wild creatures should be at all times so bold in the presence of man. In sharp contrast to the behavior of some other birds I have watched, the Quetzals' disregard of the human presence became most pronounced while they attended their nestlings. With the exception of a pair of Baird Trogons that nested last year in the forest near my house, I have found all the smaller members of the family far more wary. The Quetzals would as a rule go about feeding their nestlings while I stood conspicuously near by. Both of the males that I knew best were at first less trustful than their mates, but they grew more confiding in my presence as we became better acquainted. The nest of one pair was in the same trunk as that of a pair of House Wrens (*Troglodytes musculus*). The tiny, dull brown wrens were far more wary than the great, glittering Quetzals!

When I took leave of the Quetzals in August, after more than a year amid their beautiful but uncomfortably wet forests, they had become as silent as when I first found them and they wore only the tattered remnants of their full plumage.

SUMMARY

The Quetzal (*Pharomachrus mocinno*), one of the most magnificent birds of the Western Hemisphere, has a long history of human association. Its plumes were used for personal adornment by Indian royalty and nobility in pre-Columbian times. The bird is the emblem of the Republic of Guatemala, whose monetary unit has been named for it. A number of legends have gathered about the Quetzal.

The Quetzal is an inhabitant of the lofty, humid forests of the Subtropical Zone, ranging from 4000 to 9000 or 10,000 feet above sea level in Costa Rica, somewhat lower in Guatemala. Where these forests are destroyed, the bird disappears. It is at present protected by law in Guatemala, but owes its survival largely to the inaccessibility of its habitat. While making this study, the writer dwelt for a year in a part of the Costa Rican cloud forests where Quetzals were abundant.

The appearance of the Quetzal is described from notes taken while observing the living bird. The female is exceptional among trogons in the large amount of green in her plumage.

The bird eats many small fruits, which it plucks on the wing, in the manner of other trogons.

Its vocabulary is varied: a loud note, given in flight, was heard throughout the year; additional notes were heard during the mating and nesting periods.

In the breeding season, the male often rises above the tree-tops in a flight display, calling loudly as he goes. No other trogon, nor rain-forest bird of any kind, is known to make similar flights.

The Quetzal is found in pairs in the breeding season, and usually singly at other times. Flocks have been reported, but no trogon is known to be truly gregarious.

In the Costa Rican highlands, the nesting season extends from early April to July or August. Two broods are reared, where possible in the same nest.

The Quetzal nests in a hole resembling that of a big woodpecker, with a single round doorway at the top. Old woodpecker holes may be enlarged to serve its purposes, but at other times it appears to excavate a new cavity in decaying wood, male and female working alternately, in the manner of other trogons. No lining is taken into the cavity. The same hole appears to be used in successive years.

The eggs are light blue; there are apparently two in a normal set.

Male and female share the duty of incubation. Each takes two turns on the eggs in the course of twenty-four hours, the female during the night and the middle of the day, the male in the early morning and late afternoon. There is considerable variation in the actual times of nest relief, even from day to day with the same pair; but this general scheme seemed to be consistently followed by the two pairs studied in detail. Each sex may interrupt its period in charge of the eggs by one or more brief recesses. The male sits about six or seven hours each day. Quetzals incubate far less patiently than many smaller trogons.

Upon leaving the eggs at the end of a session, the male sometimes rises directly into the air in a flight-display.

The period of incubation is 17 or 18 days.

The nestlings are hatched with perfectly naked, pink skin and tightly closed eyes. The heels are studded with papillate protuberances. The pin feathers begin to push through the skin when they are about two days old. The contour feathers begin to escape their sheaths at about the seventh day after hatching; and by the fourteenth day the young birds are well clothed on the body but not on the head. The eyelids begin to separate at about the fifth day and by the eighth day the eyes can be opened.

During the first ten days, the nestlings were fed almost exclusively on insects and other small invertebrates. From this age onward, fruits became increasingly important in the diet, especially the large, hard, green fruits of the laurel family (Lauraceae). The diet of the young Quetzals was amazingly varied, including beetles and other insects of many kinds, larvae, small frogs, small lizards, land snails and hard fruits. Feedings were infrequent; but the portions were substantial.

Empty egg shells were promptly removed by the parents, who kept the nest clean during the first ten days or so of the nestlings' life, in this respect differing from other trogons. After that, waste matter began to accumulate. The big, regurgitated seeds formed the chief bulk of this debris, which raised the level of the floor 3½ inches, before the departure of the fledglings.

One of the females became inattentive while her nestlings of the second brood were growing up. After the seventeenth day she was not seen at the nest. During the last six days in the nest, and so far as seen after the departure of the fledglings, the male was the sole attendant.

The nestlings, dull blackish on the upper parts when first clothed with feathers, became increasingly green after they were two weeks old. This was accomplished by overlaying the down feathers by green-tipped contour feathers whose development had at first lagged behind that of others in the same tract. The expansion of the feathers of highland trogons and motmots begins earlier than with their lowland relatives but may be carried out more gradually. This appears to be an adaptation to the cooler climate of the highlands.

Two nestlings, which had been removed for photography and examination, flew from their low nest at the age of 23 days. In two high, inaccessible nests, the nestlings remained for about a month.

The first fledgling to leave the nest received at first the whole attention of its father while during four hours or more the second called in vain for food. At the end of the day, the parent returned to feed the second fledgling.

Finca "Los Cusingos," Quizarrá de Pérez Zeledón, Costa Rica, December 14, 1943.