TROPICAL WILD LIFE
IN BRITISH GUIANA

Photo by W. B.

NESTLING HOATZIN CLIMBING WITH FINGERS AND TOES

TROPICAL WILD LIFE

IN BRITISH GUIANA

ZOOLOGICAL CONTRIBUTIONS
FROM THE TROPICAL RESEARCH STATION
OF THE NEW YORK ZOOLOGICAL SOCIETY

BY

WILLIAM BEEBE,
DIRECTING CURATOR

G. INNESS HARTLEY AND PAUL G. HOWES
RESEARCH ASSOCIATE RESEARCH ASSISTANT

WITH AN INTRODUCTION BY
COLONEL THEODORE ROOSEVELT

VOLUME I.

Photographs and Other Illustrations
by the Authors

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To

The six gentlemen whose generosity made
possible the first year's existence of
the Tropical Research Station

C. LEDYARD BLAIR
ANDREW CARNEGIE
CLEVELAND H. DODGE
GEORGE J. GOULD
MORTIMER L. SCHIFF
AND THE LATE
JAMES J. HILL

This volume is dedicated by the Authors.

"Let men stew in their cities if they will. It is in the lonely places, in jungles and mountains, in snows and fires, in the still observatories and the silent laboratories, in those secret and dangerous places where life probes into life, it is there that the masters of the world, the lords of the beast, the rebel sons of Fate come to their own."

H. G. Wells.

INTRODUCTION

The establishment of the Tropical Research station in British Guiana by the New York Zoological Society marks the beginning of a wholly new type of biological work, capable of literally illimitable expansion. It provides for intensive study, in the open field, of the teeming animal life of the tropics.

One pleasant feature of the station is the cordial hospitality it extends to all naturalists. Jealousy is regarded as utterly unworthy, and the whole effort of the station is to secure, from whatever source, the most thorough research possible. Every original investigator fit to work in the field is sure of an eager welcome and of all possible aid in his studies.

The time has passed when we can afford to accept as satisfactory a science of animal life whose professors are either mere roaming field collectors or mere closet catalogue writers who examine and record minute differences in "specimens" precisely as philatelists examine and record minute differences in postage stamps—and with about the same breadth of view and power of insight into the essential. Little is to be gained by that kind of "intensive" collecting and cataloguing which bears fruit only in innumerable little pamphlets describing with meticulous care unimportant new subspecies, or new "species" hardly to be distinguished from those already long known. Such pamphlets have almost no real interest except for the infrequent rival specialists who read them with quarrelsome interest.

Of course a good deal can still be done by the collector who covers a wide field, if in addition to being a good field naturalist and a close and intelligent observer; and there must be careful laboratory study of series of specimens of all kinds. But the stage has now been reached when not only life histories, but even taxonomic characters can normally be studied better in the field than in a museum—or at least, when, although both types of study are necessary, the field study is the more important; and when intensive study in the field, as carried on at this station, yields more important results than can normally be achieved by the roaming collector.

In addition, it must always be remembered that the really first class naturalist whose observations are to bear most fruit, must possess the gift of vividly truthful portrayal of what he has possessed, the vision clearly to see in its real essentials. The best scientific books, from Darwin and Wallace to Bates and Waterton and Audubon, are those which possess such vision and are so interesting to intelligent laymen that they are often to be found in the libraries of cultivated people who are not professed scientists. Mr. Beebe has the wide horizon of interest, and the happy art of expression, which entitle him to go in this class.

This gift of expression is of value because it is based on a really phenomenal gift of both wide and minutely intensive observation. The fundamental differences between the quality of his study and the quality of the study of the average closet museum worker can be illustrated by his observation of those queer South American game birds, the tinamous.

Closet naturalists have long known that some of the tinamou had rough, and some smooth, tarsi. This fact awakened no curiosity in their minds, no desire to find out whether it was correlated with any difference in habits or life history. They simply treated it as justifying a terminological decision as to whether it marked a genus or a subgenus; and examined the tarsus of each specimen with only sufficient care to enable them to decide the specimen-drawer into which it should be thrown.

Beebe was a different kind of observer, and he was working in the birds' haunts, in Demerara. The small tinamou has smooth tarsi; its nesting habits are extraordinary, for the male makes the nest, stays with it until he can persuade a roving female to drop an egg in it, and then hatches the egg and rears the chick, while the female goes off; and as soon as the chick is fairly grown the male finds another temporary mate of advanced feministic views. The big tinamou has more normal nesting habits, although the male hatches and rears the family. This tinamou has rough tarsi.

Beebe found that there was always dust or dirt in these rough tarsi; one day he sterilized some earth, by heat, scraped the dirt from a rough tinamou tarsus into it, and reared the culture. Various plants came up, and all of them were arboreal. Inasmuch as during the daytime the big tinamou, like the little tinamou, was a ground bird, this seemed to indicate that it roosted in the trees at night. Cautious inquiry of the Indians (so made as not to indicate that a given answer was expected) drew forth the statement that at night the little tinamou roosted on the ground, the big one in trees. Finally, watching from a shelter one evening, Beebe actually saw a big tinamou ascend a tree and squat lengthwise on a branch, just before darkness came on.

The invaluable studies on the various stages of the breeding habits, the nestling development, the molting changes of hoatzins, toucans, anis, jacanas, not to speak of the studies of the strange swarming insect life, and the mammalian life, could only have been made by trained field observers working with intensive observation out in the field at the tropical station. Mr. Beebe and his associates, Messrs. Hartley and Howes, have not only done a first class job, but they have pointed out the way into what is probably the most fruitful field for original and productive biological investigation.

THEODORE ROOSEVELT.

Sagamore Hill,
December 10, 1916.

PREFACE

In this volume my object is two-fold. First, to delineate as concisely and vividly as lies in my power, the general aspects of the tropical jungle and its animal life as far as these came under our observation, and to emphasize the manifold interest and the paucity of dangers which it offers to the scientist or nature-lover. To put it in another way, I have attempted a résumé of the grosser, more apparent characteristics of the region which we have been studying, to form a background, however sketchy and unfinished, for the more intensive, concrete investigations which follow, as well as those which may be undertaken in the future.

Secondly, I present the studies which my two co-workers and myself have been enabled to carry on during six months of the current year, 1916, from March to August inclusive, at the Tropical Research Station established under the auspices of the New York Zoological Society. It thus represents that portion of the first year's work, which is available for present publication.

At the request of Prof. Henry Fairfield Osborn I took charge of the Tropical Research Station as Directing Curator. With me went G. Inness Hartley as Research Associate, Paul G. Howes as Research Assistant and Donald Carter as Collector. Two artists, Miss Rachel Hartley and Miss Anna H. Taylor completed our party. Whatever success has attended this first year of work is due to the unselfish interest and thoughtful co-operation of all the members.

Compared with the problems still to be solved and the researches of the future, our efforts seem like the scratch of a single dredge along the bottom of an unknown ocean. This contribution is intended to arouse interest in dynamic and sustained field observation in the tropics, and to dispel some of the groundless fears which, in the minds of intending visitors, invest these wonderful regions. It will, I hope, supplement and add to the value of museum zoological work, just as this tropical field research must, in turn, rest upon a firm foundation of laboratory investigation. I desire that this volume be considered as the joint contribution of Inness Hartley, Paul Howes and myself.

In detail, Mr. Hartley's researches have been concerned chiefly with the gathering of ornithological data and with problems of embryology, while Mr. Howes has confined his work to entomology. The photographic illustrations are from negatives taken by Mr. Howes and myself. For the pastel of two trumpeter chicks I am indebted to Miss Persis Kirmsé.

WILLIAM BEEBE.

Kalacoon House,
Hills Estate,
Mazaruni River,
British Guiana.

August 10, 1916.

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By WILLIAM BEEBE
DIRECTING CURATOR

CHAPTER I

THE ESTABLISHMENT OF THE TROPICAL RESEARCH STATION

Within one month after our party left New York City the Tropical Research Station of the New York Zoological Society became an established fact, and the succeeding season's results proved the wisdom and success of the undertaking. As in all types of exploration the dominant factor in this work was uncertainty; the impossibility of knowing what each day would reveal of error or achievement. But our own single-mindedness of purpose combined with the unanimous good-will and sympathy of the people of Guiana left no doubt of ultimate success.

The most difficult thing throughout was to resist the lure of many openings and invitations which seemed to offer opportunities almost equal to the conception with which I had set out. Grenada embodied one's ideal of a tropical island, and when a short walk revealed rhinoceros beetles and hummingbirds' nests and an abundance of strange birds, it seemed well worth while to spend a month there. Trinidad was still more of a temptation. Here were zoologists—most hospitable and as full of the joy of scientific work as ourselves, and here was a great island which I knew from former experience to be teeming from sea-beach to mountain top, with interesting forms of life. But after all, it was an island, and the headlands of Venezuela were in sight.

My ambition for the Zoological Society's Station was to have a continent to draw upon. So with real regret we continued our voyage and reached Georgetown. The big kiskadees shouted welcome from the unlovely corrugated roofs of the stellings, just as they had seven years before. And during all this time the Botanical Gardens had lost no

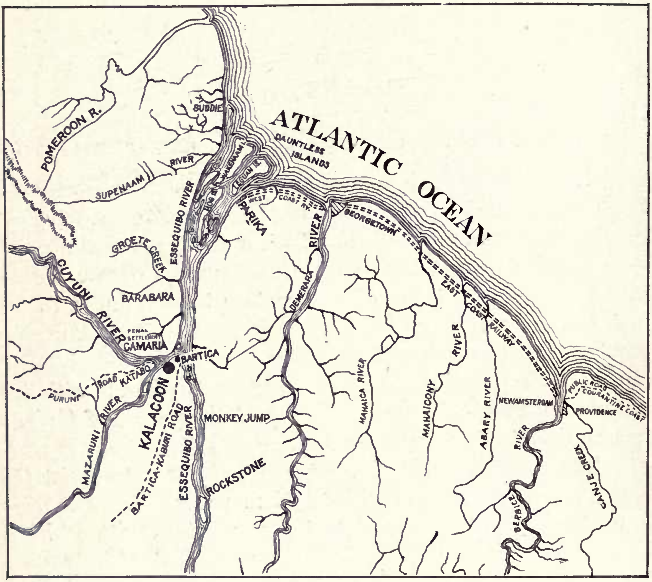


FIG. 1. MAP OF COASTAL BRITISH GUIANA

whit of beauty, nor the people aught of their whole-souled sympathy and generous hospitality.

We found a house and servants awaiting us, and here we made our headquarters. We began work in the Gardens, but soon found that this and the surrounding country, however well adapted to certain forms of life and to sugar plantations, offered too limited a field for our investigation. I undertook a series of short trips in various directions, radiating from Georgetown as fingers radiate from the palm of a hand. And again came the temptation to select one place or another as being almost all we could desire. We found interesting Indian villages up the Demerara with good secondgrowth jungle close at hand; far beyond the Essequibo

Photo by W. B.

FIG. 2. STREET IN GEORGETOWN

River we motored to the end of the Pomeroon Trail, where great moras and kakarallis towered overhead, and we were almost persuaded. Then one day, in a down-pour of rain I followed an old river trip of mine, made years ago, up the Essequibo to Bartica. Here I knew at last that the Station would find a worthy home at least for this season. I returned at once, purchased a houseful of furnishings, and without a moment's delay we packed up again and trekked inland. So swiftly did we work, that even in this slow moving tropic land we were able in three day's time to entertain our first guests, Colonel and Mrs. Theodore Roosevelt and Mr. and Mrs. Withers.

To make our manners properly to all those who have aided us would be equivalent almost to a roster of the inhabi-

Photo by W. B.

FIG. 3. VICTORIA REGIA IN BOTANICAL GARDEN TRENCH, GEORGETOWN

tants of Georgetown. I cannot refrain from mentioning the names of the Governor, Sir Walter and Lady Egerton, Hon. and Mrs. Cecil Clementi, Hon. J. J. Nunan, Prof. Harrison, Mr. Rodway, Mr. and Mrs. Hayes and Mr. Cunningham in Georgetown, Mr. Beckett in Berbice and Mr. Frére and Mr. Withers in the vicinity of Kalacoon. To Mr. Withers, through Robert Simpson, President of the Bartica Agricultural Estates, we are indebted for Kalacoon itself, on the Hills rubber estate, rent-free. For this and a score of other kindnesses, words fail to express adequate appreciation. We prefer to feel that the gift is one to science, which we, the benefiters, can repay only by the hardest, most sincere work of investigation, of which we are capable.

Kalacoon is a very large, two-storied house, built on a rather abrupt hill, some two hundred feet above the Mazaruni River. The laboratory room alone, on pillars fifteen feet above the ground, was thirty by sixty feet with sixteen windows. Two miles below the house the Mazaruni entered the equally large Essequibo, while the mouth of the Cuyuni River was the same distance above. All three rivers were visible, together with nine islands. To the East lay the rubber plantation of Mr. Withers, and across the river the tiny group of compact, attractive buildings of the Government Rest House and the Penal Settlement. Beyond these and toward all other points of the compass solid jungle covered the rolling hills.

No more central spot could be found, nor one more delicately balanced between the absolute primitive wilderness and those comforts of civilization which mean continual health and the ability to use body and brain to the utmost. Three times a week a little steamer brought ice, fresh vegetables and mail. Georgetown could be reached in five minutes by telegraph and New York half an hour later by

Photo by W. B.

FIG. 4. KALACOON HOUSE

Photo by P. G. H.

FIG, 5. CORNER OF LABORATORY IN KALACOON HOUSE cable, while the steamer trip to Georgetown occupied only seven hours. Yet no one passed us, save an occasional government official, or a dug-out of negro gold-diggers or diamond seekers, or the wood-skin of an Indian. Throughout all the months our Indian hunter found an abundance of meat for the table within a mile or two of the house, and I was one day charged by a jaguar only a few hundred yards away. I shall reserve for other articles an account of the more common creatures which surrounded us; but these few facts emphasize the extremes of life at Kaïacoon. The shortest walk often furnished material for days of research. For longer expeditions we had launches at our disposal, for ascending the rivers to the rapids and falls, while Mr. Wither's Ford car climbed the most impossible hills and found its way along trails which otherwise were traversed only by naked Akawai and Carib Indian hunters.

For those who think of the tropics as a place of constant danger and disease, I may say that mosquitoes and flies, malaria and other fevers were absent. A cool breeze blew most of the day, the temperature varying from 68 to 93 degrees. At night a heavy blanket was a necessity. A few poisonous snakes were found, but only after prolonged searching. A lantern, turned low, kept away the vampires. and while bête rouge were annoying, they were easily guarded against. Under such conditions it was possible to work hard day after day, month after month, and remain unpoisoned, unbitten and in good health.

The one terrible disadvantage, the one thing which no planning, or finance or forethought could alter was the pitifully inadequate ability of each of our human brains to cope properly with a tithe of the specimens which accumulated, or to understand and translate into logical explanation more than the merest fraction of the mass of strange facts and phenomena which filled our minds and note-books.

Photo by P. G. H.

FIG. 6. RUINS OF THE OLD DUTCH FORT, KYK-OVER-AL

CHAPTER II

HISTORICAL BARTICA

Today we find Georgetown with sixty-odd thousand people, with trams and railroads and motor cars; with dozens of sugar plantations scattered along the coastland, employing thousands of coolie and negro laborers. Two score miles of river travel up the Essequibo bring us, as I have said, to Kalacoon House near Bartica, from which we see only jungle, save for the small Penal Settlement, a bungalow or two at Katabo Point, the Hills rubber plantation and an old Dutch arch-way on a little island. But this ruined arch of bricks is reminiscent of very different times.

When Georgetown was unknown, when the coast of British Guiana was only one great swamp and marsh inhabited by cannibal Caribs, then this arch-way echoed to the clank of old-fashioned muskets and the boom of flare-mouthed cannon. Commanding the junction of three great rivers, the Dutch chose this tiny island, built a fort on it and named it Kyk-over-al, and like Kalacoon House today, it literally "looked over all." It is said that the Dutch when they first came, found traces of still earlier Spanish occupation of this islet. If true, this was clear evidence of the visit of Raleigh or some of his lieutenants in their search for the mysterious El Dorado. The succeeding history of this region is not strictly germain to the purpose of this volume, but a few notes on the vicissitudes of man's occupation are well worthy of record.

The fort on the island was built by the Dutch over three hundred years ago, in 1613, but during the succeeding few years we know little of what happened, except that fifty-five years later all this region was desolate, whether due to the attacks of Indians we shall never know. In 1670

Hendrik Rol took charge at Kyk-over-al, as Governor, Captain, Storekeeper and Indian Trader, and soon there were three plantations on the surrounding points of land. A visitor to one of these reports that their "reception was very cordial, the dinner being perfect, consisting of five different kinds of roast meat, including deer, fowl, duck, turkey and pigeons besides made dishes of labba and waterhog. The drinks were mum, wine and brandy, with which they kept themselves merry until the evening when they returned to the fort full and jolly (*vol en zoet*)! So much for social life two hundred and fifty years ago in this region.

In the year 1678 the West Indian Company of Zeeland had four plantations, Vryheid on the present site of Bartica, Duinenburg and Fortuin near Kalacoon and Poelwyck on Caria Island. Succeeding history tells of a constant succession of petty quarrels and bickerings among the Dutch themselves, varied by periods of prosperity, at the height of which they were usually captured and plundered by French and English corsairs or pirates. One account remains, recorded by Mr. Rodway. On October 18, 1708, a French privateer under Captain Anthony Ferry, with three vessels and three hundred men, came to Essequibo for the purpose of plundering the colony. They took the Brandwagt (guardhouse) at the mouth of the river, which was garrisoned by only three soldiers, before the Commandeur could send assistance. Immediately on the report of the arrival of the enemy, van der Heyden tried his best, by sending a few soldiers down the river, to stop their progress, but the Brandwagt having been already captured, the soldiers returned to Kyk-over-al. The enemy proceeded up the river, burning a few Indian villages that lay on the banks, and came to Bartica Point without the slightest opposition. Here the manager of Plantation Vryheid tried to oppose their landing with the aid of his slaves and what friends he could get together from the immediate neighborhood. He sent to the Commandeur asking for help, but it appears that van der Heyden was possessed of more discretion than valor, for he kept within the fort. The manager of Vryheid, with his few slaves was quite powerless against such a number of disciplined, well-armed men, and it therefore soon followed that the French were masters of the Point, driving away its defenders with a loss on their part of two killed and several wounded. Being now landed, Captain Ferry commenced a series of raids on all the neighboring plantations, plundering them of everything portable, the managers and planters taking refuge in the fort. Here everything was in confusion, the Commandeur being blamed by the planters for allowing their estates to be plundered, when he ought to have gone to their assistance. He excused himself by insisting that his fifty soldiers were useless against such an enemy while it was his duty to defend the fort and so prevent the loss of the whole colony. No attempt was made to storm Kyk-over-al, but Ferry sent an officer under a flag of truce to demand ransom, with threats that if it were not paid all the estates would be burned and destroyed. To preserve the Colony the Commandeur capitulated and entered into negotiations with the enemy. Finally Ferry undertook to leave the Colony unmolested on a payment of fifty thousand florins. This amount was paid in slaves at three hundred florins per head, meat and other provisions, besides one thousand pieces of eight in cash for the Captain and his officers. One third of this ransom had to be paid by the almost-ruined owners of the private estates, while the remaining two-thirds was settled by one hundred and twelve of the Company's slaves.

With the realization that the soil of the interior was not nearly as well suited to the raising of sugar-cane as that of the coastal lowlands, there began, about 1721, a migration toward the coast, which eventually resulted in the dyking and settlement of that region and the relinquishment of all the interior part of the Colony. The last authentic note of this period of man's occupation is that in 1764 Fort Kyk-over-al was partly torn down to furnish hewn stone

Photo by W. B.

FIG. 7. BARTICA WITH ITS SINGLE STREET

for the sugar mill of the Plantation Duinenburg—this being of interest because the plantation was exactly on the site of the present Kalacoon House.

After the desertion of Kyk-over-al and Vryheid, the jungle closed in once more, and for more than one hundred years we hear nothing further of this part of the country. Then began a brief religious era, and in 1829 a mission station was established at the place known to the Indians as Bartika or Red Earth.

I offer without comment a seriously written paragraph from a volume by the Rev. W. T. Veness on "Ten Years of Mission Life in British Guiana." It is written of the region immediately around Bartica. "The sky is clear, the air exhilarating and balmy, the climate delightfully equable and the face of Nature most charming; but what a catalogue of horrors when you step forth to make an intimate acquaintance within the beauties so lavishly displayed on every side. The bête rouge almost drives you to distraction, the wood-tick torments you horribly, the snakes frighten you out of your life, the bat will hardly allow you to sleep for dread of being drained of your life-blood, and the chigoe threatens you with a prospect of amputation. Such are some of the delights of a life in the wilds of Guiana. Let no timid man attempt it."

With missionaries who could believe and write such absurdities it is hardly remarkable that im Thurn, visiting Bartica in 1878, writes that Bartica Grove, once a flourishing mission station, is now reduced to a few wooden huts, used as stores, a church recently half restored from a most ruinous condition, a few small living houses and some timber sheds. These latter, he adds, are picturesque buildings, consisting of a few upright posts supporting roofs of withered palm leaves. Under their eaves colonies of gigantic green spiders, as large as thrushes' eggs, watch their webs, undisturbed from year's end to year's end. The whole sleepy, beautiful village lies under the shade of an avenue of large mango trees. From this avenue the view riverward is of an enormous stretch of water; the view landward is of a tangled shrubbery of flowering bushes, from which rise groups of graceful palms, and is bounded in the distance by the edge of the forest. The ditches and paths in the village are choked by great masses of maidenhair ferns and silver-backed gymnograms.

A few years after the decadence of the mission station came a second El Dorado, when the discovery of gold and diamonds up the Mazaruni and Cuyuni rivers brought hosts of blacks and bovianders. The only changes which the succeeding two score years have wrought in im Thurn's description of Bartica, are an increase in small houses to accommodate the several hundred inhabitants, and unlovely telegraph, police and post offices, besides a stelling for the

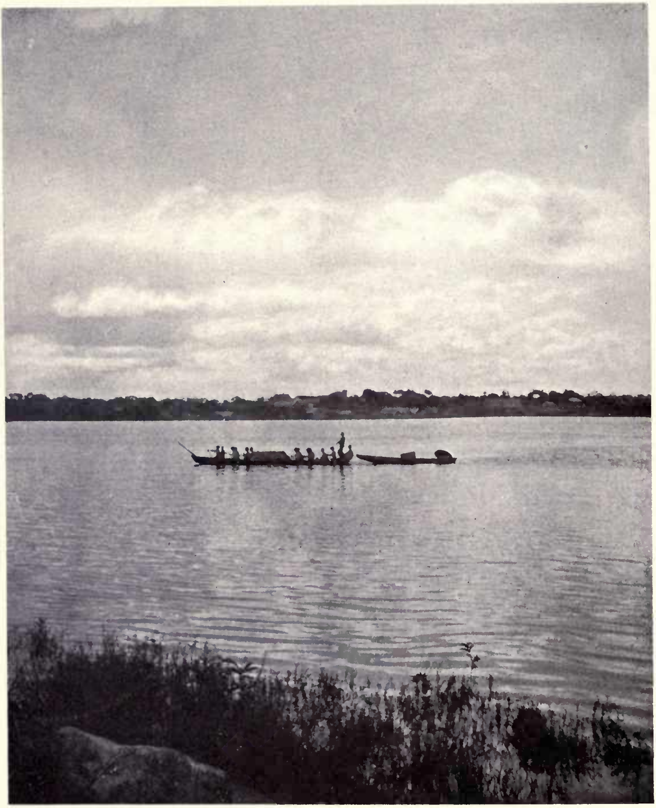


Photo by W. B.

FIG. 8. GOLD-BOAT LEAVING BARTICA FOR THE UPPER MAZARUNI

tiny steamers which come up river thrice a week. It is still a very sleepy, useless village and a very attractive one to the casual observer.

And so we find the little part which this Bartica district has played in history framed in gold, beginning with the El Dorado of Raleigh and ending today with the humble washing pan of the boviander. Instead of boats loaded with gallant courtiers sweeping upriver to sands of pure gold and rocks fretted with precious stones, I hear from Kalacoon House the chanty of the black paddlers, and soon around Bartica Point comes the bargeful of gold-diggers, off on their half year's journey, happy if they can bring back a little bagful of the glittering grains, or a few dozen dull diamonds in the rough.

Standing today on Kyk-over-al, in the shadow of the old brick arch hung with vines and draped with orchids, we have left British Guiana as the world knows it, far behind us, along the distant sea-coast. Facing toward the great hinterland we know that nothing but jungle lies before, with two narrow Indian trails as the only means of entrance to this unexplored, unmapped region, besides the alternative of toilsome paddling against swift currents and laborious portages around innumerable falls and rapids.

Some day, motor tracks and a railroad will be pushed inland, fretting this region, so tiny on the map of South America, so tremendous when one stands deep hidden in its jungles. Then the great wealth of the interior of British Guiana will become apparent, whether it be to forester, miner, lapidarist or planter, or like ourselves, to mere seekers after truth by way of the lives of beasts and birds and insects.

CHAPTER III

THE NATURALISTS OF BARTICA DISTRICT

The part which Bartica district has played in science is of considerable interest. Humboldt, Wallace and Bates left Guiana unexplored. Waterton's researches were confined to the lower Demerara River. As early as 1776 serious books on the natural history of British Guiana began to appear, but like Bancroft's "Essay" these are of only casual interest, although their accounts of "torporific eels" and "woods masters" make delightful reading.

On September 25, 1835, Robert Schomburgk arrived at Essequibo Point, later to be called His Majesty's Penal Settlement, and spent about ten days collecting botanical specimens, and preparing for his long expedition up country. During the next decade both he and his brother touched occasionally at Bartica. Richard Schomburgk in the first volume of his "Reisen in Britisch-Guiana" tells of a short sojourn at Bartika-Grove in 1841, and of the capture of a sloth with its young on the neighboring island of Naikuripa or Keow Island as it is now called. Nineteen months later he returned to Bartika, where he captured a beautiful green whip snake *Dryophis catesbyi*, and noted that the Penal Settlement had been established.

In volume III of this same work, Schomburgk gives a list of *Mikroskopisches Leben* as found at Bartica in successive layers of soil uncovered in a seven-foot hole.[1] The remaining groups which he treats in these volumes. mollusca, insects, birds, mammals and plants, are identified only with general regions or physical zones, and with no more

[1] These are *Polygastrica—Gallionella distans*
Phytolitharia—Amphidiscus rotella
Lithasteriscus tuberculatus
Lithostylidium clavatum
Lithostylidium crenulatum
Spongolithis acicularis
Spongolithis fistulosa
Spongolithis foraminosa
Spongolithis fustis
Spongolithis obtusa

exact indication of their distribution. His list of birds numbers 418 species.

In 1837 William Hilhouse made a trip up the Cuyuni in search of orchids, and writes: "I reached Calicoon Creek in the Massaroony River on the first of March, and had to return to town for craft and supplies, as I found literally the whole population without bread."

A naturalist and botanist who was intimately associated with this particular region was Carl Ferdinand Appun, who spent twenty-three years in Venezuela and Guiana, being sent out by King Frederick Wilhelm IV of Prussia on the recommendation of the great Humboldt. The summary of his many years of travel in British Guiana is given in the second volume of his "Unter den Tropen." This is a conscientiously but stolidly written work, with a few quaint but charming illustrations from pencil by the author. Two of the originals are in the Georgetown Museum. The second chapter of this volume is devoted to his excursions in the vicinity of the Penal Settlement and Bartica. He spent two years there, 1857 and 1859, but his fifty pages of observations could quite easily have been made in a month's time. Fourteen years later we find the following pathetic entries in his journal, written when at Kaiateur Falls and reproduced in the Royal Gazette at Georgetown.

June 15—Returned to Hymyyeug. We were not received very pleasantly, the old Pankoo seemed to be quite disappointed that we were not killed during our expedition to the top of the fall. The Indians have a suspicion that we are looking for gold; an old tradition of the Indians of British Guiana is, that when the white man digs for gold in their territory, the Indian race will be destroyed forever. Commenced to paint the view of the upper fall.

June 16—Painted on the picture; a general consultation among the Indians about our looking for gold.

Monday, 17—Painted the whole day, no sleep during the night.

Photo by W. B.

FIG. 9. PENAL SETTLEMENT FROM KALACOON

Tuesday, 18—Painted the lower part of the picture, chiefly the forest. Received a large *Trigonocephalus atrox*. The Accawai Edward building a hut near us. How long we shall live, God knows, our end is near.

Wednesday, 19—Painted all day and spent a miserable day. We have no way of escape, as we have no corial or boat of any kind.

Thursday, 20—Painted and nearly finished the view of the upper part of the Kaiateur falls, seeing no way of escape, I am determined to meet my fate.

June 21—The last day of my life! This night all will be over. They come! I take poison."

Although frightfully burned with carbolic acid, his companion brought Dr. Appun down river to the Penal Settlement, where he died after two days. His fears of the

Indians were only partly real, most of the danger being purely imaginary.

Lloyd, an amateur naturalist, who has written pleasantly in Timehri, lived for some time at Kalacoon, and im Thurn in his "Among the Indians of Guiana" gives the excellent pen picture of Bartica Grove, written on the occasion of his visit in 1878, which I have already reproduced.

Henry Whitely, an English collector of bird skins, spent some time between the years 1879 and 1884 at Bartica Grove and there collected two hundred and fifty-four species. His complete British Guiana collections combined with these of Schomburgk number 616 forms. These are enumerated in the various volumes of the British Museum Catalogue of Birds, and in several articles by Osbert Salvin published in the Ibis for 1884. Whitely is the only bird collector who has done any extensive work in this vicinity.

In 1909 I paid a visit to this region and ascended the Cuyuni and the Aremu Rivers, and subsequently published my observations on the fauna in book form, "Our Search for a Wilderness." Carl Eigenmann in his recent technical volume on the "Fresh-water Fishes of British Guiana" remarks on page 30, that "a series of collections in fresh water was made at sea-level . . . . Wismer, Malali and Bartica." He himself did not visit the latter place, and the only other note is a list of thirty-three species recorded from Bartica.[1]

[1] *Callophysus macropterus*
Pimelodus clarias
Hemidoras carinatus
Trachycorystes obscurus
Loricariisthys griseus
Bivibranchia protractila
Anisitsia notata
Anostomus plicatus
Leporinus nigrotoeniatus
Leporinus friderici
Leporinus maculatus
Leporinus alternus
Leporinus fasciatus
Tetragonopterus chalceus
Moenkhausia grandisquamis
Moenkhausia shideleri
Moenkhausia lepidurus
Creatochanes affinis
Creatochanes caudomaculatus
Astyanax essequibensis
Holobrycon pesu
Chalcinus rotundatus
Metynnis hypsauchen
Myloplus pacu
Myloplus rubripinnis
Myloplus rhomboidalis
Serrasalmo rhombeus
Stolephorus guianensis
Stolephorus suranamensis
Pachypops furcroeus
Geophagus surinamensis
Crenicichla lugubris
Colomesus psittacus

The fish fauna of the Mazaruni and the Cuyuni Rivers has never been investigated.

A boviander who worked for me, Robert Cozier, collected skins in this vicinity for Mr. James McConnell. An annotated list of the skins in this gentleman's collections is being at present published, under the editorship of Charles Chubb. The first volume of the "Birds of British Guiana" has already appeared. From the Tinamous to the Woodpeckers inclusive, three hundred and forty-nine forms are recognized.

CHAPTER IV

THE GENERAL FIELD OF WORK

In central British Guiana, about forty miles from the coast, the Essequibo river receives its mightiest tributary—the Mazaruni, coming in obliquely from the west. At the apex of the peninsula formed by this junction is the village of Bartica. Its chief reason for existence is as a rendezvous for black gold and diamond miners, who here fit out and here return from the hinterland of the Mazaruni and the Cuyuni rivers. Aside from this the village is negligible and interests us only in name.

Within three miles of Bartica is a lime plantation and another of rubber, the latter, the Hills Estate, operated by G. B. Withers. On the opposite bank of the Mazaruni is the Penal Settlement and a government Colony House. A mile upstream is Katabo Point at the junction of the Mazaruni and Cuyuni rivers. Here is located the supply bungalow of the Peters Mine Company. Except for occasional Indian and Boviander clearings this constitutes the human occupancy of the region. All else is untouched jungle or "high bush." The needs of this tiny community are catered to by a little steamer which makes three trips each week between Georgetown and Bartica. Our Research Station was situated at Kalacoon House, a recent addition to the Hills Estate. This is two and a half miles south-west of Bartica, on a two hundred-foot hill overlooking the Mazaruni River.

With the exception of occasional trips to the first falls of the Mazaruni and Cuyuni rivers, across to the Penal Settlement and down to Keow Island, all our work during 1916 was done within two miles of Kalacoon House. In fact, one-half square mile of the jungle south of the Station

Photo by W. B.

FIG. 10. KALACOON FROM THE EAST, LOOKING UP THE MAZARUNI TO ITS JUNCTION WITH THE CUYUNI

would cover the area of four-fifths of our researches. And now at the end of our stay, as we look back over the results of this new experiment in tropical scientific work, we realize that with all our efforts we have made only the merest beginning, and that many men could spend their lives in profitable research at this spot.

Kalacoon House faces the junction of three mighty rivers, hundreds of miles from their sources in the highlands of Venezuela and Brazil; at our back door begins a jungle through which one might wander as far as San Francisco from New York without meeting a human being. Our province in general is a colony less in size than Colorado, and our chosen plot for research is of equal area with Central Park in New York City.

The geology of Bartica district is not of great interest. Indeed, looking at the panorama encircling Kalacoon House, one is unconscious of any evidence of earthly inorganic structure; vegetation fills the landscape. We have passed the low, marshy alluvial coastal zone, and have not yet reached the mountainous hinterland. Here we have rolling hills covered with dense high jungle, trisected by the navigable waters of the three great rivers, and veined with many small creeks. When we come to examine the rocks which here and there protrude through the foliage or become visible at low water, we find that the general aspect of the skeleton of the country is not unlike that around New York City.

At low tide, bare rocks are visible almost in mid-stream, stretching directly across the bottom and several miles up the river, where this great belt of grey granite here and there breaks through the evergreen mass of vegetation. This is one of the most recent of the basal igneous rocks of the colony. No fossils are found anywhere, even in the sandstone farther down river. The rocky islets off Bartica are a dark hornblende-schist. This completes the tale of the stone, except for an interesting vein of quartz extending across a tiny stream near Kalacoon, which has been found

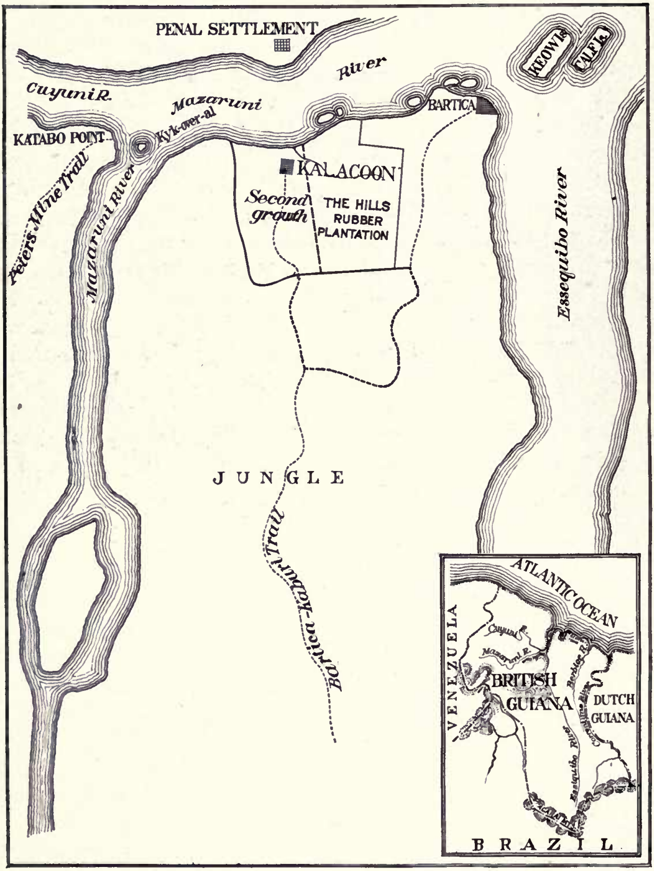


FIG. 11. MAP OF THE GENERAL FIELD OF WORK IN BARTICA DISTRICT

auriferous, carrying about thirty-six grains of gold to the ton. Meagre as is this percentage, it is exciting to a passing naturalist and tempts one always to pick up a bit of the

Photo by W. B.

FIG. 12. OUTCROPPING OF AURIFEROUS QUARTZ NEAR KALACOON

glistening stone in hopes of a nugget. The pay dirts are farther up river, where good gold deposits and diamonds are occasionally found in close proximity.

The surface soil in the jungle is of course the usual black vegetable mould, but the sub-soils are clayey and sandy in character. It is surprising to see how close together the two may be found. A pit dug in one spot will show red and yellow clay, and be quite water-tight, filling up with the first rain, while ten feet away the spade will throw up almost pure white sand, fine and porous, which proves a veritable sieve. The clays and gravels are quite sedentary, the result of intense leaching of decomposed rocks by the rain and the acid soil waters of these jungles. The origin of the white sand is a moot question, excellent authorities being quite divided in their explanation. One theory and

Photo by P. G. H.

FIG. 13. MAZARUNI RIVER FROM NEAR KALACOON LANDING

probably the correct one, is that it is wholly sedentary like the clays and gravels. What would seem more reasonable to an ungeological observer is the theory that this series of great successive sand dunes is a relic of ancient seashores, although close search yields no trace of seashell or coral. And this we may note as the first of a host of deceptions practiced upon us by the tropical elements and animals—these dunes of the finest of white sand deep hidden within these mighty forests, whose grains have never danced at the roar of pounding breakers nor felt the slithering rush of salt water. Here the white sand lies beneath the ebony mold of the jungle, undisturbed except when flung into the light by the wrenched-up roots of a falling tree, or when scratched up by armadillos, or patiently borne to the surface, grain after grain by indefatigable ants.

So this particular region, although so near the Atlantic coast and so distant from the Andes, in ages past began as volcanic or igneous upthrusts of rock, and not by the gradual accumulation of sediment brought down by rivers and held in tenure by the clutching fingers of mangroves and courida. But that time of mineral dominance is long past, and today we find the underlying structure, whatever it is, clothed with running water and with vegetation, in the shelter of which animal life teems, while mankind has merely begun to paddle painfully along the rivers, and to follow narrow trails—molewise—through the jungle.

Photo by P. G. H.

FIG. 14. LOOKING SOUTH FROM KALACOON COMPOUND, SHOWING DENSE SECONDGROWTH EXTENDING TO THE EDGE OF THE JUNGLE ON THE HORIZON

CHAPTER V

THE OPEN CLEARING AND SECONDGROWTH

The area in which we worked during six months of 1916, from March to August inclusive, may conveniently be divided into two very distinct zones;

First, the Clearing and Secondgrowth.

Second, the Jungle itself.

I shall give a brief résumé of the general ecology, and the significance of distribution of the more abundant forms of life in these two zones. The abrupt transition from the Clearing and the Secondgrowth fauna to that of the Jungle was one of the most striking phenomena which came under our observation.

Eight years ago in the vicinity of the Research Station, the jungle extended quite down to the banks of the Mazaruni. Now, for the distance of many acres along the shore, a clearing for the rubber plantation had been made. Six hundred and fifty acres of jungle had been cut and burned and planted with rubber trees which were just beginning to be tapped. Another five hundred and fifty acres were cleared three years ago, but were allowed to revert to secondgrowth which already had reached a height of twenty feet and more.

These two are the areas which I am considering together as open clearing and secondgrowth. More detailed study would reveal still finer distinctions or subdivisions, such as grassy fields, open swamp lands, the course of a swift-flowing creek and the banks of the Mazaruni itself. I include within this zone the fauna of a small open swamp on Keow Island off shore.

In the heart of the rubber plantation proper was the house of Mr. Withers, and in the midst of the secondgrowth stood Kalacoon, which, as I have said, by the courtesy of Mr. Withers, we used as the Research Station. The presence of these two houses has had considerable effect on the fauna of the immediate neighborhood. Through the rubber plantation extended several roads, and a wide trail made by ourselves ran from Kalacoon straight back through the secondgrowth to the jungle. It was along these that much of the life of clearing and secondgrowth was observed.

This zone began then at the banks of the Mazaruni River and extended back for about one mile. Here, visible from almost any distance, stood the jungle—a great cliff of foliage which rose sheer, high above all the new growth, majestic, sublime.

Not a moment did man dare rest upon his labors. Day and night without cessation the jungle sent forth upon the wind, or with the aid of birds and other agents, untold myriads of spores and seeds which soon sprouted and laid the foundation of a living vegetable talus, a stealthy outreaching finger which, if left unheeded, would soon have strengthened into a hand, whose grip was not to be broken without much toil, by hours of tiresome labor with cutlass and hoe.

It was no light matter to attack a tropical jungle in its full might and power and to hew out hill after hill of open agricultural country. One by one the great giants were felled—mora, greenheart, crabwood—each crashing its way to earth after centuries of slow upward growth. The undergrowth in the dark, high jungle is comparatively scanty. Light-starved and fungus-plagued, the brush and saplings are stunted and weak. So when the large trees were down it was an easy matter to cut out the thin smaller growth. The great stumps were left standing and now the erstwhile jungle showed only a shambles of raw wood and shrivelled foliage. After a time fire was applied, and quickly, as in the case of resinous trees, or with long, slow smol-

Photo by W. B.

FIG. 15. NEWLY CLEARED JUNGLE

derings of half-rotted, hollow giants, the huge boles were consumed.

For a period, utter desolation reigned. Charcoal and grey ash covered everything. No life stirred. Birds had flown, reptiles and insects had made their escape or succumbed. Only the saffron-faced vultures swung past, on the watch for some half-charred creature. Almost at once, however, the marvellous vitality of the tropical vegetation asserted itself. Phoenix-like, from the very heart of the ashes, appeared leaves of strange shape and color. Trees whose tissues seemed wholly turned to charcoal sent forth adventitious shoots, and splintered boughs blossomed from their wounds. Now was the lowest ebb of the jungle's life and the Planter took instant advantage. All the half-burned debris was cleared away and in the wonderfully rich soil between the fallen trunks and stumps, he planted his spindling rubber yearlings.

Not for a moment must the new growing tangle be allowed to smother these tender growths, and today the coolies scrape the ground clean at frequent intervals. In the course of time the rubber will dominate all other growths, becoming trees in reality and like a second jungle begin to interlock its branches high overhead. The shade which it casts makes easier the labor of clearing, and this tiny scar—tiny in comparison with the enormous expanse of jungle round about—comes wholly under man's dominion, and day by day yields its quota of merchandise to the world's marts. In place of the lofty jungle which for unnumbered centuries covered this area, we have orderly ranks upon ranks of white-barked rubber trees, radiating park-like over the rolling hills, while the white sandy roads wind about them, having nothing in common with the animal and Indian trails which such a short time ago, zigzagged over this very ground.

I have gone thus into particulars to show the reason for the arising of a fauna, wholly foreign to that of the jungle, and this not after years and decades, but almost at once, synchronously as it were, with the change of vegetation; coming from long distances, sometimes singly, sometimes with a sudden rush of numbers.

The five hundred odd acres which, after being cleared had been allowed to grow up undisturbed, were of even greater interest to the naturalist than the more open part of the clearing. The destruction of the jungle was here also complete and the very thorough burning had evidently destroyed all jungle seeds. In their place sprang up at once a maze of weeds, vines and woody shrubs, reeds, ferns and grasses, all foreign to the dark jungle and whose nearest congeners were miles away. Yet here were their seeds and spores, baffling all attempts at tracing their migration or the time they had lain dormant.

Photo by W. B.

FIG. 16. PURE CULTURE OF NEW GROWN CECROPIAS

The meagre data I was able to gather concerning the succession of vegetable growth in this area suggests the tremendously interesting facts which a trained botanist could record. The first things to appear were grasses or grass-

Photo by W. B.

FIG. 17. THICKET OF REEDS GROWING ON CLEARED JUNGLE LAND

like plants and prostrate vines. These latter climbed over the fallen tree-trunks and covered the charred stumps with a glory of blossoms. As soon as semi-woody shrubs shot up, the vines ascended still higher and by their rapid growth

Photo by W. B.

FIG. 18. FLOWERS OF THE GUIANA (*ALLAMANDA*)

sometimes covered these plants with alien bloom, before their own flowers had had time to appear and develop.

Soon, however, another type of plant appeared with hollow and jointed stems, pushing out fans of fingered leaves, swiftly, wasting no time in branching, but content with a single spike piercing up through strata of grass and reeds, through shrubs and bushes until it had won to the open sky. This was the cecropia or trumpet tree, falsely appearing firm and solid stemmed, but quite dominant during the first few years of the neglected secondgrowth. It formed a pure culture in most places, crowding out, by a monopoly of the sunlight, most other growth. It had many decided qualities, some visible at a glance, others revealed only to those who became intimate with it. It was extremely ornamental and provided a cool, dense shade. Every section of

Photo by W. B.

FIG. 19. THICKET OF SECONDGROWTH OVERRUN BY A TANGLE OF RAZOR GRASS

the stem was a sanctuary for scores of a certain species of small stinging ant which rushed out when the stem was split with a cutlass. The leaves in turn formed the favorite diet of sloths.

Differences in soil which were not apparent when the great jungle covered everything, now became of much importance and gave rise to very distinct zones of vegetation. We found high sandy spots where the cecropias did not get that flying start which they needed for their vertical straightaway dash. Here a community of hollow reeds or bamboo grass appeared from no one knows where. They grew and multiplied until their stems fairly touched one another, forming a dense, impenetrable thicket of green, silicious tubes eight to twelve feet in length. These were smooth and hard as glass and tapered beautifully, making wonderfully light and strong arrows with which the Akawai Indians shot fish. Wasps of sorts searched for broken tips and industriously gathered therein hordes of delectable spiders.

Early in this struggle, white convolvulus blossoms gleamed everywhere, but later, pale yellow flowers became dominant, and orchid-like, violet butterfly peas which, at first, blossomed among the ashes on the ground, but climbed as soon as they found support. Little by little a five-finger vine flung whole chains of bloom over stumps, logs and bushes, a beautiful blood-red passion flower, whose buds looked like strings of tiny Chinese lanterns.

Whatever the character of the new vegetation, whether a tangle of various shrubs, a grove of young cecropias or a serried phalanx of reeds, the terrible razor-grass ran over all. Gracefully it hung in emerald loops from branch to branch, festooning living foliage and dead stump alike, with masses of slender blades. It appeared soft and loose-hung as if one could brush it away with a sweep of the hand. But it was the most punishing of all growing things, insidiously cutting to the bone as one grasped it, and binding all this new growth together with bands more efficient than steel. One had painfully to cut every yard of trail in order to penetrate into the higher parts of the secondgrowth, which was infinitely more difficult of access than any thorn thicket or tangle of bush rope in the jungle itself.

With the destruction of the jungle went its animal life. No voice of goldbird or woodhewer rang out, no heliconias fluttered past, no accouri or monkey fled at our approach. One day a small ground dove swung by, circled about and alighted on a dead stub, craning its neck at the strange sight, and the following day it was feeding on the seeds fallen from a weed pile which the coolie workmen had left. After some such inconspicuous fashion the new world of life was inaugurated. How the word was passed miles down river, or far off to other clearings we shall probably never know, but doves, tanagers, grassfinches, kingfishers, rails, orioles and kiskadees soon gathered, found certain definite niches for themselves and settled down permanently.

If we had had time and strength we could doubtless have duplicated the evidences of this peculiar new type of fauna in every group of the animal kingdom, but birds were the beings which we studied most intensely. Within sight of Kalacoon House we noted sixty-five species which in no sense could be termed jungle birds. They were never observed within the jungle and with very few exceptions were recent arrivals, their presence being coincident with and quite dependent on the clearing and secondgrowth.

Kalacoon House itself yielded the first examples of adaptation to new conditions. When we arrived we found a small colony of grey-breasted martins firmly established. They were roosting and nesting indoors, gaining admittance by means of broken window panes, and several of the sheltered tops of posts below stairs also held nests. We put up a bird box on the summit of a pole and at once a battle ensued for its use, the successful pair breeding immediately. In a single, isolated palm tree in the front compound were five nests. Four were of successive broods of moriche orioles, the fourth being still in use. The fifth was the nest of a palm tanager. The palm and blue tanagers were almost as domestic as the martins, flying in and out of the house all day, picking spiders from the beams overhead.

The bushes at the edge of the compound teemed with bird life all foreign to the jungle at our back. Whenever we went to the Hills we listened to the jubilant, rollicking songs of the Guiana house wrens, but these were never heard at Kalacoon. This was the case for several weeks, but one morning we heard, not one, but several birds singing at once. A wave of wrens had overflowed Kalacoon during the night, and now in the early morning were feeding, and singing, and climbing about the grass stems perfectly at home. We had witnessed the arrival of a new species, old birds and several full-grown young. Within three days they had dispossessed some finches, nest, eggs and all, and had begun nests of their own.

The arrival of wrens at Kalacoon was an event slight in itself, but which seemed to me full of significance, when I realized that in such fashion birds extend their ranges over the surface of the earth. It was quite different from the small flock of sandpipers which appeared suddenly along the creek. They were migrants, here today, off to the far north tomorrow. But the house wrens of Guiana are permanent residents, and once they have taken possession in their fierce little masterful wren fashion, they elect to remain until the traces of man's labors have wholly vanished. Many years ago in this very region I have recorded[1] how these God-birds, as the natives call them, often cling to a deserted Indian clearing until the jungle has choked it from existence. The coming of the wrens truly typified the advance of a species, one step in that progress which has peopled every continent with its thousands of species of birds.

From the lofty outlook of Kalacoon compound a tremendous sweep of sky was visible, and it was very seldom that this was wholly free from bird life. Most of these aerial species were not peculiar to the clearing, however, but hawked about over the jungle as well, and probably roosted somewhere within its confines. Exceptions to this were barn

[1] Our Search for a Wilderness, pp. 307-308.

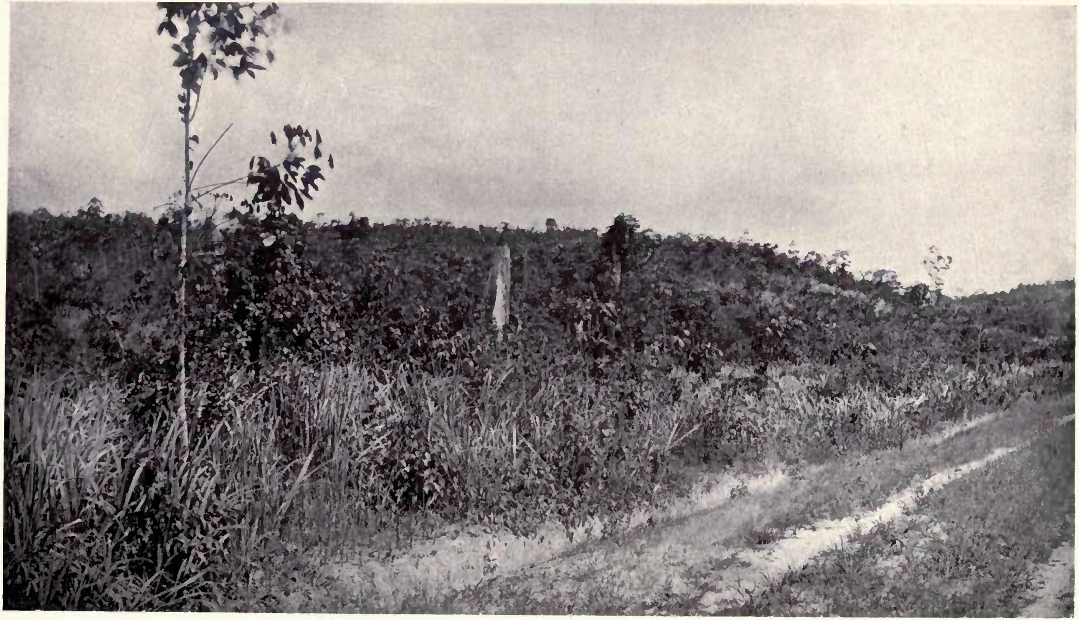


Photo by P. G. H.

FIG. 20. GRASSY AREA OF SECONDGROWTH; HOME OF RAILS AND SEED-EATERS

swallows and purple martins, migrants from our own United States. The martins vanished early in March, but we saw barn swallows until mid-June. The brown martins were a puzzle. They were not uncommon in early March, but they vanished with the purples and did not appear again. The swifts and kites and vultures—masters of all the air—were bound by no question of mere jungle or clearing. They wandered wherever they found good hunting.

Along the edge of the rubber plantation, between it and the secondgrowth, and extending on each side of the wide sandy roads, was a large area which was overrun by a tall, dry, reed-like grass, about three feet in height. This little world had its own particular forms of life which spent most of their time in or near it. I can speak only of the bird citizens, which numbered nine species. Two were rails, the white-necked and the cayenne, which nested in the heart of the dense growth or scurried along the road ahead of us. The remaining birds were finches—all tiny grassbirds; jet black glossy grass-quits, the black-headed pygmy, black and white and chestnut-bellied seedeaters, and the two little great-billed finches known through the colony as twatwa and twatwa slave.

Near the center of the open clearing the creek spread out in a wide space between two rolling hills, forming a marsh, and here, and along the course of the creek itself lived more than a dozen species, attracted and held there by suitable feeding grounds, either fish or crayfish, or the worms and snails which hid in the muddy shallows. Here, on our arrival, were four migrant waders, Esquimo curlew, yellowlegs, solitary and spotted sandpipers. These soon left for the north, although the latter lingered singly and in family groups for many weeks. Of native marsh birds there were cayenne snipe, spur-winged jacanas, Guiana green herons, little boat-tailed grackles, red-breasted blackbirds and the beautiful white-shouldered water tyrants. The jacanas were nesting on Keow Island. A small colony of seven or

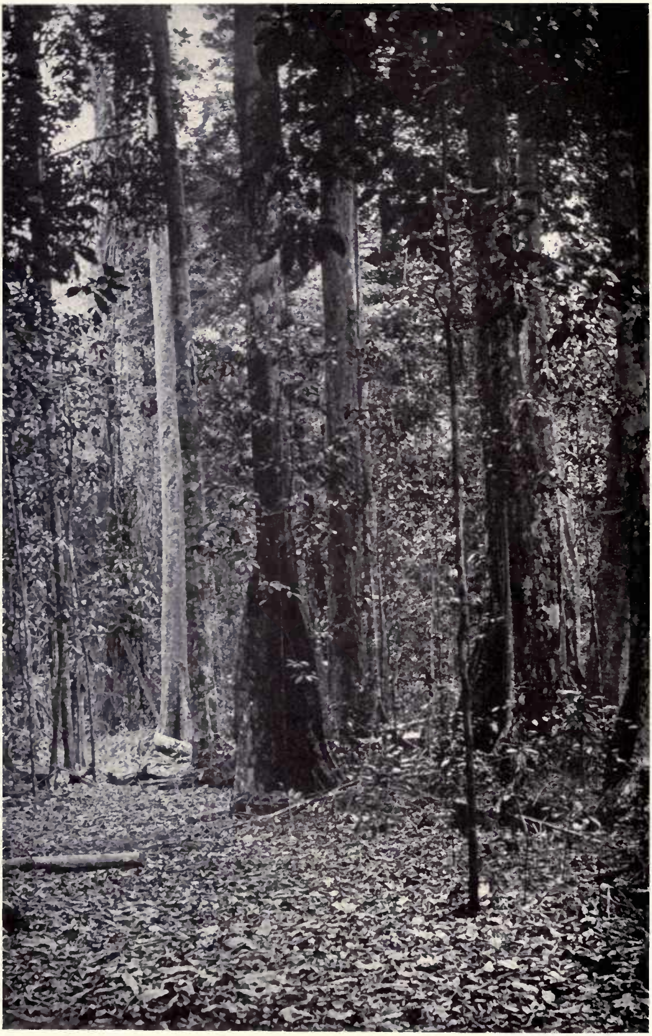


Photo by P. G. H.

FIG. 21. JUNGLE AT THE EDGE OF THE SECONDGROWTH

eight of the blackbirds had established themselves, but the yellow-heads, always associated with them on the coast, had not yet found their way hither. Four kingfishers drew sustenance from the little creek, the great grey and the great green, the pygmy and the spotted. Ground doves were ubiquitous and perhaps the most abundant of the clearing birds, but their favorite haunts were the sandy roads, where they trotted along in droves, two species of them, the grey and the talpacoti ground doves. Here, too, the white-necked nighthawks came at twilight and called their lonesome *who-are-you,* and performed their weird dances in the moonlight, sometimes fifty or more together.

Passing down to the banks of the Mazaruni and the extent of sand and muddy beach exposed at low tide, we surprised the great-billed terns occasionally flying over, or stopping to snatch at the host of winged termites rising from some dead stump. Snakebirds perched along the edge or dropped off and swam half-immersed. Five herons and an ibis fished along shore, the cocoi, little blue and agami herons, American and snowy egrets and the curious Guiana ibises. Two swallows were essentially fluvicoline, the variegated and the half-belted, but their frequent excursions to the clearing in pursuit of insect food, gave them a right to inclusion in our list.

There remained the dense shrubbery and the secondgrowth itself, and indeed the rubber trees also, where these had waxed tall and strong. In such places there dwelt an interesting assemblage of more than twenty-five species of birds found nowhere else in this region. The only subdivisions I can make are superficial and unequal. One was a bird of prey, one wholly terrestrial, and another nocturnal. The first was the four-banded sparrowhawk, which hunted both in the rubber and the secondgrowth. The ground bird was the pileated tinamou whose plaintive trill rang out night and morning. The bird of night was the giant goatsucker or poor-me-one.

Photo by P. G. H.

FIG. 22. JUNGLE FROM THE MAZARUNI, SHOWING HEIGHT OF GIANT MORA.

Besides these, two pigeons made this their home, the rufous and the grey-fronted, feeding on the fruit of small berry trees and building their nests among the tangles of razor-grass. The little guan or hanaqua sang its chorus in pairs in the early morning. Rufous cuckoos slipped silently through the branches and their cousins, the smooth-billed anis or witch-birds almost typify the clearing to our memory, so ubiquitous and individual were they. Of the passerine birds, the dominant forms were flycatchers and we counted nine species as quite characteristic of the clearing. Three were kiskadees, the great Guiana, small-billed and the lesser. Then came grey-headed kingbirds, streaked and varied flycatchers, yellow-breasted elanias, and the grey and the spotted tody-flycatchers. Yellow warblers, apparently identical with those of our northern woodlands, sang and fed in company with black and lesser white-shouldered tanagers, brilliant moriche and black-throated orioles.

Lastly came a few forms of great interest, strays from the jungle, which, after becoming specialized and adapted to a wholly aboreal, scansorial life, had, during late generations, undergone a readaptation to a perching existence. These were the brown and the yellow-throated synallaxes or spinetails, aberrant forms of the woodhewers of the jungle. The checkbird had also long deserted the haunts of its numerous antbird cousins and taken up life in the semi-open.

This completes the tale of the peculiar birds of this area, a hasty review which will serve to emphasize the radical departure from the jungle types so close at hand. As to their songs and courtships, their nests and eggs, their molts and their personalities in general, we made a beginning; an excellent beginning. In the future we hope to complete these life-histories and to record all that a human being may learn through keen and sympathetic observation.

Photo by P. G. H.

FIG. 23. OPEN JUNGLE SHOWING INDIAN TRAIL.

CHAPTER VI

THE JUNGLE AND ITS LIFE

Three popular misconceptions exist in regard to tropical jungles:

First, that the heat and dangers are excessive.

Second, that animal life is scanty or almost absent.

Third, that "eternal summer" reigns.

In our homes in the North we glean these *idées fixees* from travelogues written at second hand or censored with an idea to continuous and intensive sensation. Indeed, it is not surprising that the tropical jungles should be thought so unhealthy and barren, for the people who live just without their borders hold the same beliefs. The native of the city of Georgetown who has not visited the "bush" deems it to be filled with serpents and noisome fevers, while he who has been up country will still tell you that the jungle is all but devoid of life.

Without further preamble I would like thus early in this volume to emphasize the falsity of these erroneous, world-wide ideas, speaking from many years of experience in tropical jungles; in general of India, Ceylon, Malasia, Borneo, South China and Mexico, and in particular of the jungle or bush of British Guiana.

First, the heat of the jungle is not oppressive even at high noon. The difference between bearable, even comfortable temperature, and the gasping point of altitude of the thermometer quicksilver, is exactly that between shadow and sunshine.

It was full noon when one day in May I seated myself on a fallen log at the very edge of the jungle which I had chosen for intensive study. I was wholly in shadow, but I could reach my hand out into full sunlight. My thermometer in the shade at my side registered 78 degrees. Without moving my seat I shifted the instrument a yard, thirty-six inches of horizontal space, and the mercury straightway climbed almost seventy vertical degrees. In five minutes the metal frame had become too hot to hold and the silvery column came to rest at 147 degrees. With such heat less than a yard away I was comfortable in the shade, and in the dim, cool depths of the jungle I could walk or write for hours without feeling any due oppression. The highest shade temperature known in the colony is 93 degrees, not unworthy of comparison with the 105 degrees which I have seen more than once in a Nassau Street business office. The minimum temperature of coastal Guiana is 67 degrees and the average for the region about Bartica 78 degrees. The nights are cool, and one, sometimes two blankets were always necessary. Re calories, our first misconception, *q. e. d!*

As to dangers in the jungle, unfortunately we cannot deal with statistics or definite degrees or figures of any sort, so that whatever I write may be thought discounted by personal bias. I may say at once that in the last six months I have been very near death—once—and the rest of the time the danger has been equal to that of going black-berrying in a New England pasture. Rarely, very rarely, I saw a poisonous snake, and with leather puttees this danger is quite negatived. If one thrusts one's hand into every hole or rotten log, in the course of time one will be bitten by a scorpion or centipede or tarantula. If one's blood is in good condition a few days of painful swelling will follow. If one tastes all the delicious looking nuts in the trail, or the delectable appearing mushrooms, illness is certain to follow sooner or later, while a good draught of amber jungle water will as likely as not bring amoebic death. But if one avoids these senseless actions and is too much absorbed in exciting pursuit of bird or beast or insect to think of dangers, one may, as we have done, walk, or crawl or squirm one's way day after day through the heart of the jungle, along dry hill-sides and through stagnant swamps, and return tired, perhaps exhausted, but safe and sound in body, limb and skin.

As I have written many times before, the greatest danger of tropical jungles is from falling vegetation, nuts, seeds, leaves and trees themselves. But to deny oneself the enjoyment of this wonderful world of life for such a reason, would be exactly equivalent to avoid going out on the streets of New York because automobiles kill on an average of one person a day. I never saw a person killed by a falling nut or tree, but I have occasionally heard these crashing down, and have seen nuts like cannon-balls embed themselves in the soft mold. In a recent official report of deaths among gold diggers in the interior of the colony, an equal number —five—was reported from malaria and from falling trees.

Our work doubtless lay in a particularly favorable locality, but in my experiences in tropical jungles both in the Far East and in South America, I would substitute the word inconveniences for dangers. In Bartica district, for month after month, mosquitos and flies were practically absent. Throughout the dry and the rainy seasons we waded swamps and pools and saw fewer mosquitos than came into my room in a single night in Georgetown or New York, and these few were neither Anopleles nor Stegomyia. Bête rouge was abundant and enthusiastic, although not worse than on some parts of Long Island and never nearly as bad as I have known them on the coast of Virginia. Crab oil is a preventive, and a saturated salt solution an effective cure. Jiggers and ticks were absent. Twice we were stung by small wasps and many times by angry ants. At Kalacoon House we slept without nets, but at first kept a lantern burning low. This effectively prevented molestation from vampires which were abundant and flew freely through the house. Later we dispensed with the light, but were never molested. Perai were common in the river, but everyone hereabouts bathed, and there was no record of a person having been bitten. Howes and I were once charged by a jaguar within

Photo by P. G. H.

FIG. 24. BASE AND ROOTS OF GIANT MORA TREE.

a short distance of the house. The animal came full speed to within eight feet of us, but swerved and swept aside when he saw we were not deer or other expected prey.

I find nothing further to write about dangers or inconveniences, because—there is nothing more to be written. When I recall the breathless, hot nights of a New York summer, the malignant malaria which at times spreads over the suburbs of the same city, when I remember the copperheads and rattlers of the Palisades, the mosquitos and black flies of our northern forests, the biting green flies of our shore resorts and the jiggers of the southern states, the all but complete absence of corresponding sources of annoyance seems all the more remarkable in the rank jungles in which we worked, a jungle overflowing with animal life of every description.

The second misconception, that of the scarcity of the various forms of life in tropical jungles would, from its absurdity, seem hardly to deserve refutation, were it not that it is constantly reiterated, and that by persons of intelligence who have recently made long trips through these regions. Its sole inspiration lies in the method of observation, the casual looking about as one passes up the rivers in a woodskin, or glances to right or left when walking along a trail.

The operation of protective coloration, the effectiveness of warning pigments and patterns, of mimicry, these and other expedients of wild existence—the very distinction between life and death—all depend, at the crises of their fulfillment, on the two alternative factors of movement and inactivity. This is one of the most pronounced laws of the jungle. Clad in white or in any conspicuous color, you may successfully hunt the wariest of jungle creatures, provided you select some suitable spot and remain quiet. Garbed in leaf green and the most invisible of khaki, the common agouti and the trustful trumpeter bird will easily escape you if you

Photo by W. B.

FIG. 25. JUNGLE FUNGUS.

persist in walking about, or moving some part of your body or hands.

Thus it is that, passing in a canoe with noise of paddles, or tramping a trail to the accompaniment of crackling twigs and leaves, it is not strange that the jungle seems deserted, a place of distant, unattached voices or a region of lifeless silence. As well complain of the paucity of bird life in a country which you have just traversed in a swift motor car, or of the lack of botanical knowledge to be gleaned from an aeroplane! When walking in the jungle in single file with a number of people, I have often dropped back and squatted motionless, and less than two minutes after the last figure passed from view, the hidden creatures began to reveal themselves, first vocally, then optically, until normal conditions settled down, and insects, reptiles, birds and beasts again resumed their natural activities. So much for what we might call the mechanics of observation.

Argument such as the present is always strengthened and reinforced by the inverse ratio of the area considered. So I will take as an example—given more in detail elsewhere in this volume—the area in which we actually carried on our researches. This was a patch of jungle of about the size of Central Park in New York City. During the first week I made no attempt at careful observation, but walked around and through the selected zone, mapping it and deciding on its outlines. My lists of birds observed on these days were small indeed. Could these meagre notes have been seen by my pessimistic friends who had prophesied a dearth of jungle life, their convictions would have been strengthened. And yet, when we had settled down to careful study and watching, our lists grew out of all proportions. We were not collecting. Many and many a day I spent in watching a certain group of birds without shooting one. We made no concerted attempts at the shooting of tree-top birds in the hope of adding a new name to our list. We collected only what we needed for material for definite problems, and yet hardly a day passed when we did not find one or more species new to us. At the end of our stay we had made observations on two hundred and eighty-one different species. And on the very last day of our work—when I had finished packing and took a last farewell tramp, I saw two birds which I could not identify with any which we had seen or shot before. In this same area, quite incidentally, we observed about fifty species of mammals, embracing all the important forms of north-eastern South America, while with Whitely's birds which he gathered in this same locality, our neighborhood was proven to be the home of three hundred and fifty-one different species.

As to still more restricted tropical areas I must refer to the week's census of a single tree and the examination of four square feet of jungle mold which I recently made in Pará, Brazil.[1] My experience in tropical jungles has shown, not that they contain a paucity of various forms of life, but *au contraire,* taken in the aggregate, they possess a much richer fauna than any type of region where I have studied. But this infinity of organisms is not blatantly revealed. They are not as apparent to the casual observer as the soaring hawk or the flock of blackbirds in the open. Guarded jealously by their colors, patterns, shapes and their fear of the death which awaits them on every hand, they remain concealed until the intruder, motionless, identifies himself with the harmless vegetation, or makes his way, moccasin shod, clad in dull, neutral garb, quietly, silently, with the soft step of the Indian.

Skirting the coasts of these tropical lands, or steaming or paddling up the rivers, the eye always encounters the same general view, a mighty wall of green vegetation. Whether the month be January, May or September, the sun beats warmly down and the great cliffs of emerald foliage rear their heads on high. "Eternal summer reigns" says the guide-book, and the bromidically inclined traveller echoes the statement.

However, as soon as one begins to study the jungle and day after day looks out upon it, and, walking through and through it, makes daily notes of the changes overhead and beneath his feet, the realization comes that spring and summer are quite distinct, autumn and winter easily differentiated. And this is true even of those places, like Bartica district, where the dry seasons are not times of drought, but merit their name only in comparison with the intensity of the rainy periods.

The first thing, however, that an observer learns in the tropics is that no law can be laid down as absolute. The continual warm weather and humidity, and the tremendous competition between the multitude of organisms results in

[1] Zoologica, II, Nos. 3 and 4, pp. 55-119.

Photo by W. B.

FIG. 26. HOLLOW TREE, USED FOR OBSERVATION AND AS SHELTER FROM RAIN.

activities of every phase of life through the year. So that while there is not a single week of all the fifty-two when blossoms and fruit, caterpillars and butterflies, larvae and wasps, eggs and molting birds cannot be found, yet my thesis holds good when we consider life in the aggregate.

Photo by P. G. H.

FIG. 27. IN THE HEART OF THE JUNGLE, SEARCHING FOR A TOUCAN'S NEST AMID THE TANGLE OF A FELLED TREE.

But this is only half the story. Not only is there a normal sequence of seasons, but there are two series of these seasons, unequal, but well-defined. This is a factor which adds immensely to the complexity of research, but is of such significance and importance that I expect to devote much time in the future to its study. In the north we have a burst of apple blossoms in the spring, when the tree puts forth its might and produces a cloud of color and perfume, and later the glorious residue of fruit. But we must also have noticed that in the autumn when all thoughts of summer are past, when the katydids are slowing down, and the leaves have yellowed and fallen, that traces appear of a brief, false spring. Some of the winter buds unfold, and produce a scattering of brave blossoms. The violets among the dying grass stems send up a pitiful showing of flowers, strangely out of place. Then comes a blasting frost and the farce is at an end. Indian summer—like the Ruby-throat—may be only a northern effort faintly adumbrating the tropical exuberance!

Here in this land of excess energy, the second summer is not a failure, although subordinate to the real spring. Plants flower and fruit, insects send out fresh broods, birds again pair and nest and again see their fledglings safe on the wing. This we already know, and study of these successive seasons will reveal much of importance. For the outward circling effects of this secondary cycle are not to be measured merely by the additional numbers. They reach out and control many factors which are seemingly concerned only with lives of creatures six months before or as many in the future.

There are no jungles in the world comparable in grandeur to those of the South American tropics, and this is true of many other aspects. The trees here are larger and higher—some reaching the really tremendous height of two hundred feet. The epiphytes are more abundant and striking than in any jungle of the East, the lianas are larger and more spectacular in their vegetable eccentricities, while the curtains of aerial roots are to be seen nowhere else.

Jungles have been written about in every book of tropical travel, but have been really described in none. And they will not be, any more than it is possible to give an accurate word picture of a volcano in eruption. When one enters the jungle for the first time, the feeling of awe and wonder, the apparent hopeless confusion and inextricable mingling of plants and animals, the juxtaposition of life and death, of growth and decay; these, with the magic of coloring and form, totally inhibit clear description. The plethora of adjectives and adverbs clogs all other grammatical forms. And afterwards, when the hidden harmony begins to become apparent by the following of some single thread, or the ends of the least tangled skein, then one is too close for perspective, one has become too intimate for correct delineation of the whole. It is equally difficult to describe at a glance the face of a stranger, and to portray the expression of one's most intimate friend. And with the jungle there seems no middle course. So from inadequate words and over-detailed photographs, one's image of the jungle must be mosaiced—unless one has, himself, enjoyed the supreme delight of walking in these wonder aisles.

I shall call attention only to a few details, which perhaps from their very obviousness, are usually overlooked. If one passes rapidly through the forest, the general effect is of a mist of delicate foliage sifting through all the immensities of twilight beneath the tree-tops high, high overhead. This leafage sprayed through mid-air is such as we see early in May in our northern woods. The principal difference is that with us the delicacy of foliage is due to immaturity, while here it is caused by the paucity of light.

An important character of the jungle is the almost complete absence of large, horizontal branches. Trees such as our oaks, beeches and maples are unknown, and this I believe is due solely to the abundance and deadly character of the lianas—those fast-growing serpents of the plant world which lie in wait both upon the ground and upon the loftiest tree-top, too weak to raise themselves unaided, seeking ever for some support upon which to rest, thus ultimately to reach upward to the coveted, unrestricted light and air.

We saw how in the secondgrowth the young cecropias shot upward with their single, smooth stem. Here, if a sapling dared throw out any heavy side branch, some insidious vine would be certain to curl over it, and to thicken until the weight would break the branch or bring down the young tree. For the same reason there are few or no leaning or bent trunks. All are straight as plummets—a dense fretting of vertical lines, in size ranging from the thread so fine that its source is lost in the twilight overhead, to the great trunks of mora and greenheart, yards in diameter.

For purposes of convenience in my bird work, I found it necessary to divide the jungle into four horizontal zones or strata; the Floor of the Jungle, the Lower Jungle up to twenty feet, the Mid-jungle as high as seventy and the Treetops from one hundred and fifty to two hundred feet above the ground. The floras and faunas of these zones are as distinct as is the abyssmal from the plankton, and these in turn from the surface life of the ocean. Finally the air above the jungle had to be taken into consideration as being the principal haunt of many forms of life, just as we have seabirds and flying fish and air-breathing cetaceans in the case of the pelagic simile.

The ground in the jungle was covered with the accumulated debris of centuries, all the immense mass of vegetation which reared itself on high, falling sooner or later, and returning to this globigerina ooze of the dry land. Fallen tree trunks lay here and there, some recent, with the swath of their descent still open and raw, others with semblance of wood and bark, but crumbling to mold at a touch. This was the home of fungi, mosses and lichens, in shapes and pigments unnumbered and unnamed. Day after day, dur-

Photo by P. G. H.

FIG. 28. BEESA MONKEY, AN INHABITANT OF THE TREE-TOPS.

ing the rains, my thoughts of birds and other vertebrates were momentarily erased by the sudden sight of fairy castles, laces, sunshades, pikes, spears, pagodas, spirals and scores of other forms of fungi for which no simile existed. Here, too, grew the variegated caladiums and other ground plants, and here were those wonderful buttresses which enable the trees to reach such stupendous heights with such slight girth of trunk.

In the low and mid-heights was found the soft mist of green foliage of the jungle undergrowth, springing from thin, twig-like branches and supported on marvelously slender stems. The chief zone of this undergrowth was between five and seventy feet, above which the tall, straight trunks of the larger trees were dominant, with no trace of branch or leaf until the luxuriant crowns were reached. There all the pent-up vegetative energy, all the suppressed functions other than mere altitude of barren trunks were released in a dense outburst of leaves, branches, flowers and fruit.

As one walked through the jungle, tinamou and partridges sprang up and whirred away, agoutis and armadillos scuttled from their feeding grounds. Tracks of deer, tapir, paca and various cats showed the movements of these animals during the preceding night. Grisons and, more rarely, small jungle mice and rats were observed. On fallen leaves tiny jungle frogs shrilled, and giant marine toads lived their sluggish life. Salamanders and serpents were rare. Once in a while a bushmaster, fer-de-lance, or some harmless snake was seen coiled or slowly slipping over the leaves. Now and then a big yellow turtle ploughed heavily along. All the greater and lesser fry of the underworld whose delight was in decayed wood, who called the mold home, were here—strange grubs and beetles, scorpions, myriapods, peripatus and all wingless, creeping things.

When I raised my eyes to the level of the low jungle—to my own height—an entirely new world appeared. That of two dimensions was left behind and one of three entered.

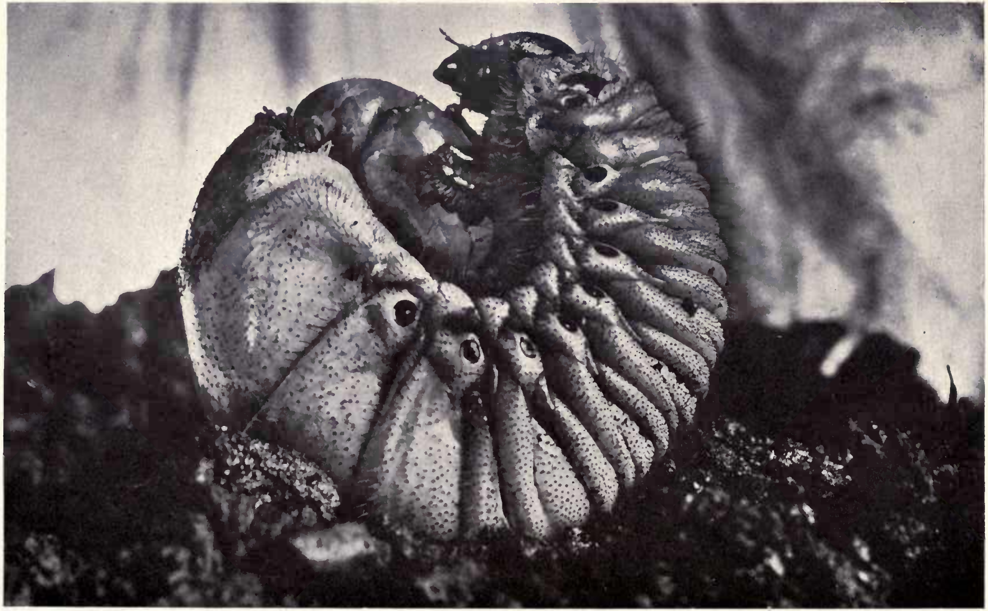


Photo by P. G. H.

FIG. 29. GIANT LARVA OF RHINOCEROS BEETLE, LIVING IN HOLLOWS IN THE TREE-TOPS.

Here began the domain of creatures of moderate flight and of limited climbing ability, which, unlike the tortoise and the tapir were not bound to the ground. Here I was always certain to find manakins of several species, and antbirds of still more. Here the trumpeters and jungle wrens uttered their characteristic calls. At night opossums wandered, while in the twilight of mid-day, morphos—those bits of quintessent pigment—flapped leisurely along, together with their opposites, the skeleton butterflies.

The mid-jungle was the heart of the tropical life. Here I could no longer feel myself on equal terms in height. I had most painfully to crane my neck upward, and to study the inhabitants of this suspended cosmos with glasses or shotgun. Here the big curassows and guans perched and nested, the great pigeons, the motmots, jacamars, trogons, goldbirds and a host of tanagers and flycatchers and strange tropic forms chirped, sang, fed, courted and nested. In the mid-heights the big tree-frogs boomed, and the sloths vegetated from birth until the claws of a harpy eagle gripped them. Squirrels were so rare as to appear strange forms, known chiefly from memory; marmosets and coatis usurped their place by day, while kinkajous climbed about by moonlight. Orchids, air-plants and lianas rioted, and unknown growths dropped a myriad plummets, a warp of aerial roots; threads until they reached the ground, then becoming in turn twine, cord, rope and cable. It was the great center of life of the South American jungles, a zone vibrating with a myriad forms suspended half-way between heaven and earth. Still it was a zone with decidedly earthward tendencies. Some of its inhabitants descended to sleep, others to feed or to build their homes. The majority, however, remained throughout their lives as they were born, plankton of the jungle.

Yet another continent of life remains to be discovered, not upon the earth, but one to two hundred feet above it, extending over thousands of square miles of South America.

Photo by W. B.

FIG. 30. MACUSHI INDIAN ON HIS SHOOTING PLATFORM, WAITING FOR GAME.

At present we know almost nothing of it. Up to now gravitation and tree-trunks swarming with terrible ants have kept us at bay, and of the tree-top life we have obtained only unconnected facts and specimens. For the most part my glasses showed forms silhouetted in black against the bright sky beyond. I could fire upward and with a heavily loaded choke bore usually bring down the bird I desired.

Or I could put my Indians to chopping down some of the great trees, and after hours of labor, if no interfering trees or binding lianas set all our work at naught, I could search among the mass of broken, bruised foliage, an almost hopeless task, for casual specimens. And what I found might often have been brushed down from the mid-jungle, or have been disturbed among the very leaves of the ground.

With my shot bird in my hand and my black silhouettes and my scattering of crushed specimens, I was very far from real knowledge of tree-top life. What of the tree-frogs, and butterflies and birds and unknown hosts of creatures which never voluntarily descend to the ground. There awaits a rich harvest for the naturalist who overcomes the obstacles —gravitation, ants, thorns, rotten trunks,—and mounts to the summits of the jungle trees. Another year we hope to begin this work, and to sit in hammocks or on platforms swung aloft among the toucans, macaws, parrots and caciques, the umbrella, the calf and the bellbirds whose strange distant notes or whose dead bodies were merely tantalizing invitations to the manifold secrets which intimate observation among the tree-tops is certain to reveal.

To show the stratified activities of a few typical groups of jungle birds and mammals, I have prepared the following rough diagram:

Ground	*Low Jungle* (0-20 feet)	*Mid Jungle* (20-70 feet)	
Partridges	Trumpeters	Curassows	Barbets
Tinamou	Antbirds	Guans	Jacamars
	Manakins	Pigeons	Puffbirds
	Wrens	Hawks	Goldbirds
	Thrushes	Owls	Mourners
		Motmots	Honey-creepers
		Trogons	

Tree-tops (70-200 feet)

Cotingas	Macaws	Parrakeets	etc., etc.
Toucans	Parrots	Giant Caciques	

(Groups found typically in more than one Zone)

Ground	*Low Jungle* (0-20 feet)	*Mid Jungle* (20-70 feet)	*Tree-tops* (70-200 feet)
Goatsuckers	Goatsuckers	Hummingbirds	Flycatchers
	Hummingbirds	Flycatchers	Hummingbirds
		Tanagers	Tanagers

Mammals permit a similar mode of representation of altitudinal distribution:

Anteaters	Opossums	Anteaters	Red Howlers
Armadillos		Sloths	Beesa Monkeys
Tapirs		Bats	
Peccaries		Coatis	
Deer		Squirrels	
Cats		Marmosets	
Dogs		Kinkajous	
Galictis			
Rodents			

Returning to the birds of the jungle. Accepting 1 to 10 as the gradation of light from the dimmest part of the jungle to full sunlight, and with the same divisions as a basis, we can form an interesting table of relative percentages of dull and brilliant birds:

Gradation of Light	ONE	THREE	FIVE	TEN
Percentage of Bright Birds	0	8	50	83

This by no means indicates that all the brilliant birds are conspicuous in their native haunts or that the dull ones are correspondingly protected by their pigment. A quadrille wren hopping about and filling the low jungle with its wonderful unearthly melody, is a most conspicuous bit of life in spite of its garb of brown and buff. A parrakeet with spots of yellow on vivid green, opalescent in the hand, is but one leaf among a million in the tree-tops.

Photo by W. B.

FIG. 31. AKAWAI INDIAN BRINGING IN PECCARY FOR OUR TABLE.

The scents of the jungle are manifold and our nostrils soon become cleared of city smells and more attuned to the new clean ones of the jungle. But at their best our senses are pitifully inadequate to cope with those of the wilderness folk. We would be hard put to it to learn anything without such mechanical crutches as enlarging lenses, powder and shot. Unseen blossoms, musk-carrying animals and insects, fungi, decaying wood, all have their individual odor which we can never hope to detect except in the coarsest way. Again and again we long to supplement our eyes and ears with the sensitiveness of a dog's muzzle.

The sounds of the jungle are the most alluring of its attributes, fascinating because of their unusual character and because almost all are wholly unknown. The sense of actual discovery, as day after day, I traced screams and trills, chirps and bellows to their sources, was infinitely satisfying. A percentage of one in five, successfully solved, was about all that one could expect.

Bird voices were the dominant ones, far excelling in numbers and in unusualness all the others combined. One missed the sweet, simple songs and warbles of our northern woods. When, very rarely, a thrush uttered a phrase, it seemed wholly out of place. Sudden startling outpourings of sound were the rule—perhaps a single scream or wail, the trill of a tinamou or the sweet crescendo of a woodhewer, the solid silver resonating call of the goldbird or the incomparable anvils of the bellbird. Frogs and toads were a close second in every respect in the matter of voice, but the mammals were dumb or else spoke in whispers or scents.

As in the East, where the early morning resounded to the concerted calls of pheasants and the laughing chorus of gibbons, so here we were awakened by the chachalacas and the red howling monkeys—the "hanaquas and baboons" of the natives. Again and again I was startled by similar parallels between the two great tropics, separated by so many hundreds of miles of open ocean.

From whatever aspect we consider it, the tropical jungle is very wonderful; a storehouse full of secrets at which we can merely guess. To solve even the easiest requires punishingly hard labor of body and mind, hours of quiet watching and slow creeping through dense tangles. But there is no more inspiring and completely satisfying feeling in the world than to roll into one's hammock at night, with note-book, photographic plate or sketch book filled with a sincere, however slight, addition to our knowledge of the evolution of life on this planet.

CHAPTER VII

BIRD LIFE OF BARTICA DISTRICT

Any attempt at thorough monographic treatment of the birds of Bartica district after only a single season's observation is of course impossible. Our species catalogues show hundreds of more or less related facts; in one case we have learned of the nest building and incubation, in another of the gradual change of plumage from nestling to adult. But, reserving these for future consideration, there is still possible a review of the whole field, a bird's-eye-view which is interesting, and in some respects quite significant. From this point of view I offer this account of bird life as observed in the vicinity of Bartica, British Guiana.

In the space of five months, from March on through July, within a rectangle of clearing and jungle measuring two miles by one-half mile we became acquainted with two hundred and eighty-one species of birds. In the same general area of jungle, Whitely, some years ago, collected two hundred and fifty-four forms. The two lists yield for this limited district, a total of three hundred and fifty-one species. This is about one-half (45 per cent.) of the birds recorded from the whole colony of British Guiana, considering these as numbering seven hundred and fifty-two, as given in the latest list of South American species.[1]

If I compare my observations of bird life day after day in the tropics with the memory of corresponding study in our northern woods and fields, I realize at once that both daily and in the aggregate, a greater number of species and individuals were observed in the tropical field of work. There were curious cross resemblances and differences in the two places—these tropical jungles and the woods of New

[1] A list of the Birds of South America, Bradbourne and Chubb, London, 1912.

York and New Jersey. Here it was unusual to find an isolated bird, kingfishers and hawks excepted. Either its mate was with it, or it was companioned by a small flock of birds of unrelated but friendly species. In the jungle, which I am so often assured is well nigh devoid of life, I found birds much more abundant than in temperate regions. To formulate a still more definite statement, whenever I returned after a long tramp in the jungle, whether along animal or Indian trails, or by compass or sun through the untracked "bush," I recalled more birds than would appear in an average walk in northern woods. Besides actual preponderance of numbers, the breeding season had something to do with this. The period of nesting varied so much in different species, that in any month, certain forms were found free from nesting cares and gathered into flocks, and these, whether gleaning from the very highest tree-tops or from midgrowth, filled the jungle with movement and sound. In the rubber clearing where weeds and grass seeds were a perpetual crop, bird life was even more abundant, and at times the finches flew up before one like crowds of grasshoppers.

No niche or stratum of jungle was free from birds. Some species roamed through and over it at will, others were confined to certain definite areas. Some spent their life on the ground and never perched on twig or branch. Others clung to bark from birth to death, their road in life a never-ending series of vertical ascents; some spent the hours of light in mid-air so high that to them the jungle must have appeared as a lawn of grass does to us. There were birds which penetrated the jungle only at the demand of sleep or honey, as certain swifts and hummingbirds, others sped thither at the summons of carrion. Some attended the course of army ants, content to be guided by the erratic migration of these insects. Finally there were those unrepresented in any northern zone which lived out their existence among the highest tree-tops, courting, nesting, feeding, sleeping in an aerial world which at present is all but unknown to us. To emphasize by reiterating what I have written, in other words we drag a tiny dredge along the ocean bed, and painfully draw to the surface a few fragmentary organisms, which often burst in our rarified element. We see a company of fluttering forms high overhead—one to two hundred feet above the ground—and our guns bring down a swirling, bedraggled fluff which was a bird, whose throat uttered one of the strange songs which we just heard, whose nest and eggs or young are somewhere far aloft. We hold in our hand an instant's cross-section of an exceedingly interesting life, which in the jungle played a part full of significance. And we realize that until we offset gravitation and establish stations of observation in the tops of some of these giant trees, our ignorance of this roof of the jungle must remain complete.

Future work will reveal some very interesting facts in regard to the home ranges of jungle birds. For the first week or two all seemed more or less confused, and the time and place of meeting with definite species a matter of luck. But little by little clarity came from the twilight, and I began to perceive system and regularity. A certain bend in the trail always revealed a quartet of white-capped manakins, regardless of their breeding season, and toward dusk I was certain of finding them working their way toward a dense tangle of bush ropes. In the mid-day heat, on the contrary, they almost invariably perched in a certain medium tree, open to the east at the edge of the jungle. Parrots were even more definite about the time and place of roosting, but their feeding habits were less sure. The wandering flocks of small birds seemed to be the least definite, they appeared to wander at will, but comparing accumulated notes I began to see a certain rhythm of direction, an orientation to points of the compass and to the beginning and the end of the day which assuredly had some meaning. When I think of the searchers for carrion, of the weaving flight of swifts insect-hunting in the open sky, of the followers of army ants, it is quite unreasonable to attempt to explain their daily movements by any controlling factor but that of the chance of appeasing hunger and of the meteorologically influenced dispersal of insects. But the search for food once past, the life of the bird came under some more definite control again, and a succession of more or less predicable reactions. These, I think, will be very worthy of study and tabulation, as important factors in the evolution of the ever-changing adaptations and readjustments, which have resulted in the complex of life as we find it in the jungle today.

In the case of a fixed, occupied nest, the range of the owner often differed from corresponding conditions in the north, by reason of the excessive altitudinal zones. Both parents may have spent their free time almost directly overhead, and yet so high up as to have been almost unrecognizable. I have sat and watched a nest for an hour without seeing any trace of the bird until I happened to glance upward where both were seen at once, revealed by their action, identified with the high power stereo glasses. In the course of extensive observation it will I think be possible in time to plot certain daily, if not hourly habits—wanderings, courtship areas, feeding zones, points of lookout. Yet I do not mean in any way to depreciate the free will and individuality of birds, only that their lives, like those of ourselves, are regulated by many factors, known and unknown, whose detection will be useful to our great ulterior purpose. The home range points this belief.

The daily migration may be taken as an excellent example of the diurnal rhythm of which I have spoken, the pliable yet more or less set mold within which the day's activities take place. These regular diurnal movements of birds I have termed migrative because they were concerned with colonies, or flocks, or at least included large numbers of birds rather than pairs of individuals. They were instigated by two impelling motives, the search for food for the young birds of a breeding colony, and the flocking and flight to definite roosting places.

For some unknown reason many birds were not satisfied to search for food near their nests or community breeding places. This was particularly true of species which nest in company. I remember the brown pelicans, which breed on Pelican Island in Florida, regularly flew over great stretches of good fishing area, to some chosen distant spot, perhaps twenty to forty miles away up the coast. Caciques and other tropical birds which breed in colonies have a similar habit. Not far from Kalacoon a colony of red-backed caciques had been established for many years, directly over an Indian benab. These birds flew inland diagonally up the Mazaruni to some part of the jungle to which I was unable to trace them. One could take one's stand along this route and be certain within a few minutes of seeing a cacique going or returning. The path was a definite one, over some trees, beneath the top-most foliage of others, in one place through an immense hoop-like loop of liana. This was quite different from the food migrations which I shall soon mention. These birds were carrying food, both vegetable and animal, to their young, and only a firmly fixed habit of taking the same path had perpetuated this unnecessary consumption of time and energy. The sharp outlines of the aerial trail frayed out in the vicinity of the colony, and birds approached their nests at will. But a hundred yards away, all converged sharply, focussing on the narrow pathway high in air.

The roosting flights of tropical birds will ultimately demand separate special treatment. I shall touch only upon the habits of three or four species which roosted in the clumps of bamboo near the river bank and close to the house in the rubber plantation. The habit was as regular and inflexible as any seasonal migration, and in those species which associated in dense flocks, the birds seemed to lose all individuality and to become imbued with a united flock spirit, which influenced all simultaneously, synchronously, as one bird.

The phenomena was more complicated than at first appeared, for it was not always a mere gradual assembling of birds at some favorite roost, where one by one they arrived, selected a perch and put their heads under their wings. This is the habit of the English sparrow, in New York City, where some maple tree may become the nightly roosting place of many hundreds. After the breeding season is past the giant caciques approached most closely to some such method. They fed singly during the day, but even toward afternoon the individual showed no gradual sign of ceasing to feed, or thought of roost, until, without warning, the bird suddenly took to flight and, following a direct line, set out for the distant mango tree or clump of bamboo. As he flew, another and even a third bird would probably come in sight, headed for the same point, but there was never any recognition or effort to turn aside to join the fellow species. Singly the great black and green birds came in, and singly they settled to roost on the swaying bamboos, whose smooth stems precluded attack from any terrestrial creature, and whose proximity to the clearing and human habitation eliminated the other dangers to which they would be exposed in a jungle tree. An interesting detail was the wariness of these giant orioles in the day time. Except during their nesting season it was very difficult to approach within gunshot. But as dusk settled down, other emotions—the anxiety for a safe roost, the tempered desire for the companionship of their own fellows during the long tropical nights—these increased, and gradually inhibited the fear of man to such an extent that the birds choose a roost at his very doors.

Another point of interest in the evening gathering of the clan of giant caciques was the derivation of the various members. As well as I could determine, about a score of birds gathered every night. It was an easy matter to watch them come in, as they were visible a considerable distance away, and from their size and flight not to be confused with any other species. Most came from up the shore, three or four due north from the distant forest, and three—probably a single family—flying west from Keow Island. Two months ago, there was a colony of nine inhabited nests in a single tree on this island, so this trio of birds must have been strongly affected by some reason or habit, to desert their brethren wherever they may have roosted, and fly to so great a distance every evening.

An advance in roosting ceremonial was presented by the smooth-billed anis. Shortly before sunset when these birds were scattered about the clearing, they ceased feeding and in the small flocks or family groups in which they are always found, they collected at the tops of the low shrubs. Here they climbed about in their aimless way, fluttering awkwardly, whalooping to one another, until dusk had begun to close down. One by one they then began their loose-jointed, steady, beating flight, and if another lot of anis was seen below, the first group would often stop and alight. Then there would be more confusion, more chatter, more aimless clambering about the branches, around and even over each other. At last the roosting flight would be taken up again, this time direct, and the flock of black cuckoos would tumble headlong into the bamboos, to begin another period of fuming and perpetual readjustment, before darkness put an end to the day's activity of these weird, inexplicable creatures.

To parrakeets, going to roost was a rite, not to be performed singly as with the caciques, nor lightly and with lack of dignity ani-fashion. Toward late afternoon the small companies of these birds, which since morning had been alternately feeding and screeching high up in the tree-tops of the jungle, ceased from their two chief activities and rising as if at the word of command, whirred swiftly toward some unusually high tree. I found three of these junctions or assembling places, and at first, thought I had discovered the real roost of these birds. Two of the trees were gigantic moras, whose topmost leaves must have been little short of two hundred feet above the jungle floor. But these places were only recruiting or half-way stations. One tree was not far from the edge of the jungle south of Kalacoon House. To this, about five o'clock, or earlier if the day were cloudy, the parrakeets began to come in flocks of six to twenty. But no matter what the size of the flocks, it always consisted of an even number of individuals, and although the birds flew sometimes so compactly that their wings almost touched, it was invariably possible to detect the still closer segregation which indicated mated pairs of these affectionate little beings. Flock after flock dashed into the tree, silently as a rule, with individual bickering and chattering after they had alighted. When many had arrived from all directions, even from the edge of the jungle, toward which their ultimate flight would again take them, a period of silence ensued, and the sharpest scrutiny failed to distinguish a single bird among the green leaves. Then at an instant's signal, some reaction to a stimulus too delicate for our senses to detect, the whole company of several hundred birds was up and off like a whirlwind, all screaming their hardest. To an observer below, they were out of sight in an instant, but on other days I observed the same lot of birds from a hill-top in the clearing and could then watch their subsequent actions. They did not fly direct, but mounted high in air and made severed magnificent circles, a half-mile or a mile in diameter. The spirit of the flock would seem to have complete possession. Occasionally, when a few parrakeets would dash downward toward the bamboos, if the majority willed to go on, these would swerve upward again for another great whirling circle. Finally as if drawn into an irresistible vortex, all banked sharply and spiralled downward and into a tall tree near the bamboos. This was the last resting place, and after a few moments, the mass of parrakeets again rose and pitched into the bamboos for the night. Not a rustle of leaf nor the slightest whisper marked their presence when once they had entered the dense foliage. Sometimes several large flocks came one after the other, and each evening a dozen or more individuals appeared flying steadily across from the opposite shore of the Mazaruni.

The details of daily habits such as these, which we found strongly developed in many birds other than caciques, anis and parrakeets, may prove ultimately of fundamental significance in working out the origin of more extensive migrations, whether considered as tropisms or conscious actions.

During the winter months about thirty species of birds migrate from the United States or farther north to British Guiana. In the Bartica district we observed only seven of these, the Esquimo curlew, yellowlegs, spotted and solitary sandpipers, yellow warblers, purple martins and barn swallows. The purple martins and all the waders, except the spotted sandpipers left early in March, but the yellow warblers lingered until April 10. Families of spotted sandpipers were teetering along the Mazaruni shallows in early May—the young still in unspotted garb, although the adults had completed their spring molt. The barn swallows lingered amazingly late, and those which we shot on June 1 were in perfect condition and ready to nest in the near future. The last one flew past on June 16, making its way leisurely in a northward direction. These late birds—we saw probably a dozen in June—were certainly neither cripples nor abnormal as to breeding condition. The one exception was a spotted sandpiper shot on July 9, which was emaciated although in good plumage, and the only abnormal condition was inflammation of some of the ovarian tissue.

I can speak less certainly of the seasonal migration of native birds, as at least two successive years and much more than five months are necessary for exact data on this point. The few examples I shall mention serve chiefly to point our ignorance of these more or less local movements. I shall refer to them again under breeding season. In the case of birds nesting alone there is, not uncommonly, between the rearing of successive broods, a short migration quite away from the nesting locality. When we arrived at Kalacoon House early in March a pair of moriche orioles was nesting in a royal palm a few feet from our laboratory windows. There were two eggs in the nest, one of which we took, as it was new to science. The other hatched and the young bird flew. After this another nest was built and the two young were reared. Accompanied by both young, the moriches then left suddenly and for three weeks were not seen. Then quite as abruptly, the three birds returned and spent much time about the palm and during the latter half of June and early July remained in and about the clearing. About mid-July they began again to gather materials for a nest in the palm.

In some cases birds which nest in colonies leave simultaneously and scatter singly over the country. Other species keep together and drift about, guided only by the search for food. This synchronous impulse to leave the colony is so strong that it may result in a number of the young being left to starve in the nests, the flocking and migrating instinct overcoming that of the parental. Food is an important cause of local migration and may operate over a few miles, where the birds concentrate on some one fruit tree, or it may influence all the members of certain species or families in the country, which then shift over large areas of the colony. The movement of parrots and parrakeets coastwards in the mango season is an excellent example of this.

Nowhere in the world do we find such extremes of the social instinct as among birds of the tropics. And not only among birds considered as a class, but even within the limits of small groups such as genera. When we have sufficient data to make a thorough résumé of the social instinct, we doubtless shall find that any one species may run the gamut from a solitary life, to the close association of a mated pair, and finally become a member of a compact flock, all within a few months. But considered in general, certain types of birds fall naturally into various groups of relative sociability.

This means that month after month, in the course of many encounters, I came to think of this species as essentially solitary, of that as always being within sight or sound of its mate, while a third would never be seen except in a flock of its fellows. For the purpose of this classification I divided the birds of Bartica into about sixty tentative groups, which fell into four categories, first, those which were essentially solitary at least for many months of the year, and in their habits of feeding and roosting; second, those which appeared to be paired throughout the year and were usually seen in couples or in company with one or two young birds; third, birds which spend much of their life in small flocks, usually nesting in colonies of moderate size and always feeding in company; fourth, a few notable species which were eminently gregarious and usually nested and fed and roosted in large flocks:

SOLITARY

Tinamou	Owls	Jacamars
Jungle Pigeons	Kingfishers	Puffbirds
Terns	Nighthawks	Goldbirds
Waders	Hummingbirds	Cotingas
Herons	Trogons	Woodhewers
Snakebirds	Motmots	Quadrille-birds
Vultures	Cuckoos	
Hawks	Barbets	

PAIRS

Rails	Kites	Wrens
Curassows	Macaws	Thrushes
Guans	Parrots	Vireos
Chachalacas	Toucans	Honey-creepers
Partridges	Woodpeckers	Tanagers
Ground Doves	Antbirds	Orioles
Caracaras	Manakins	Flycatchers

SMALL FLOCKS

Anis	Swallows	Giant Caciques
Swallow Puffbirds	Finches	Grackles
	Jays	

LARGE FLOCKS

Trumpeters	Swifts	Fork-tailed Flycatchers
Parrakeets	Smaller Caciques	Blackbirds

This association of grades of social instinct had many more points of interest than the mere statistical appearance would indicate. I shall discuss one only, that of voice, which had a close bearing upon the relative gregariousness.

Of the twenty-two groups with solitary habits, seven were decidedly inhabitants of open country, where they could readily see one another, and in these the voice was more or less negligible. Two out of the seven, vultures and snake-birds, lacked it altogether, while the Guiana representatives of terns, waders, herons, hawks and kingfishers seldom made themselves heard. Hummingbirds, while usually silent, had considerable vocal possibilities for their size, but their marvelous power of flight doubtless usurped many of the necessities of loud intercommunication. Of the fourteen remaining groups all were inhabitants of dense jungle and without exception possessed of remarkable vocal powers. These had an interesting generic resemblance in that the tones of the songs or calls were uniformly loud and, in the majority of cases staccato, or with an insistent rhythm. To anyone familiar with these birds in life it is sufficient to mention tinamou, jungle pigeons, owls, goatsuckers, trogons, motmots, cuckoos, barbets, jacamars, puffbirds, goldbirds, cotingas and woodhewers, to recall memories that first are aural and then optical. To this the quadrille-bird must be added, a wren whose jungle life and solitary habits have divorced it from the rest of its diminutive fellows, and lent to its voice the startling staccato quality so characteristic of jungle birds, without depriving it of any of the sweetness which characterizes the songs of other wrens. It is worthy of note that the members of three of these groups were nocturnal, the cause of reduction of visual communication here being astronomical, not vegetative!

The birds which lived in pairs and families were, for the most part, well provided with vocal organs, which they used to good effect. Their songs and call-notes had, however, not so much penetrating quality, intended to cover great distance, as characterized the voices of the solitary ones. In almost none was there the sustained repetition or rhythm found among the birds of the first category. Chachalacas were an exception, but proving the rule, for they were truly arboreal, and only by their adaptive ability had they drifted from the jungle and taken instant advantage of the secondgrowth. The chief point of interest in this series was the distinction between the bird notes of the jungle and those of the clearing. The indescribable vocal outbursts of guans and caracaras, the emotional expression voiced by macaws, parrots and toucans need only to be mentioned. On the other hand ground doves, wrens, thrushes, vireos, tanagers and orioles—most of them representative of temperate groups of birds—filled the clearings with sweet calls and sustained musical songs, reminiscent of northern fields and woods and sharply contrasted with the more primitive sounds produced by birds typical of the tropical jungles.

The voice was little developed among birds living in flocks, both smaller aggregations such as rails, anis, swallow puffbirds, swallows, finches, giant caciques and jays, and those associated in large communities such as trumpeters, swifts, smaller caciques, fork-tailed flycatchers and blackbirds. Notable exceptions were parrakeets which sometimes seemed to be all voice. The swallow puffbirds had departed from the habits and mode of life of their jungle relatives and usually lived in small colonies, and the fork-tailed flycatchers, showing no unusual traits during the nesting season, developed most remarkable gregarious habits immediately afterwards, and during the molting season roamed about the country in flocks of hundreds, roosting in some specially selected spot, but during the day drifting about wherever there was good hunting. A solitary trumpeter or parrakeet or red-breasted blackbird was an unthinkable phenomenon, although at least in the case of the first two, the birds remain paired for life.

There is another type of sociability, that between different species, and in the jungle this was one of the most common phenomena and has been noticed by almost everyone who has spent any time there. The hosts of species of small and medium sized birds drifted together when their nesting season was past and roamed the jungle in small bands. It was remarkable how many different kinds were to be found in each little gathering. Sometimes when such a flock worked toward and across a glade it was possible to make an approximately complete census. I have counted twenty-eight birds in a flock of this kind, including twenty-three distinct species. The association reminded me strongly of birds migrating at night. There was the same steady drift in one direction and the same constant intercourse by means of soft chirps and twitters, woodhewer calling to flycatcher, and manakin to antbird.

Reviewing the whole host of Bartica birds, we are impressed with the tremendous extremes, not even approached by the avifauna of a corresponding temperate region. In size, for example, our specimens ranged from the pygmy amethyst hummingbird less than three inches from beak to tail, which probed the corollas for tiniest of insect food, to the great harpy eagle over a yard in length, with talons capable of striking down any sloth or monkey of the jungle.

A word as to color, more to indicate our line of investigation in this direction than to provide any satisfactory thesis for the solution of this tremendously interesting factor of life. Working with the same methods with which I judged of protective coloration among the pheasants, I was able to divide the Bartica birds into graded groups with a fair degree of assurance. My estimate of protective coloration was based on the action of the birds themselves at the approach of danger. A bird which flew at once, either to a point of vantage where it could see clearly about it, or flying on out of sight was plain evidence of lack of protective coloring, at least in its own instinctive estimation. If it squatted or "froze" either for a moment or until we had crept up to within a few feet, I felt that it unconsciously, but surely, counted upon being overlooked, or confused with its surroundings. This to my mind, is the only infallible test which we may apply with confidence to the consideration of this much discussed phenomenon. Again I offer a division of the same bird groups based on this distinction:

UNPROTECTED	MALES UNPROTECTED	PROTECTED
Terns	Bellbirds	Tinamou
Jacanas	Cotingas	Curassows
White herons	Finches	Guans
Vultures	Honey-creepers	Chachalacas
Caracaras	Tanagers	Partridges
Hawks		Jungle Pigeons
Kites		Doves
Macaws		Rails
Kingfishers		Waders
Swifts		Sun-bitterns
Hummingbirds		Colored herons
Anis		Owls
Toucans		Parrots
Swallow puffbirds		Parrakeets
Woodpeckers		Motmots
Flycatchers		Goatsuckers
Swallows		Cuckoos
Wrens		Trogons
Caciques		Barbets
Blackbirds		Jacamars
Orioles		Puffbirds
Jays		Antbirds
		Woodhewers
		Manakins
		Goldbirds
		Thrushes
		Vireos

It was of considerable significance to analyze the various causes which sustained, if indeed they had not brought about, the lack of necessity for protective coloring. Among the twenty-odd groups enjoying this freedom there were six very evident factors which compensated the birds for conspicuousness. Caracaras could revel in almost solid black, kites in black and white and hawks in all sorts of pigments and patterns, since they themselves were pursuers, and hence all but immune from serious danger of direct attack. Degenerate offshoots from these, the vultures claimed shameless immunity by reason of their odor and unpalatability. Size and strength enabled the egrets to thrive while garbed in snowy white, and the terrible beaks of the macaws rarely failed to defend them against whatever peril was aroused by advertisement of their harlequin plumage. Sheer pugnacity stood a number of the groups in good stead, the terns, isolated as they were up these rivers, the spur-winged jacanas, a single female of which I have seen standing off repeated darts of a small falcon; kingfishers and woodpeckers whose beaks function normally in such unlike mediums, yet are united in virile and successful defense. Orioles and jays are proverbially good fighters, while flycatchers are the policemen of the bird world and scream to scorn every approach of falcon or hawk.

Numbers were brought to bear in the case of trumpeters, toucans, caciques, anis and blackbirds, although as a matter of fact the two latter could offer but little concerted attack and usually preferred flight to valor, diving headlong into bushes or reeds. The aberrant swallow puffbirds escaped by swift, skillful dodging, appearing to outdistance any hawk with ease, and the swifts, swallows and martins did the same, while the active little wrens were comparatively safe in their underbrush preserves. Hummingbirds lived in a veritable fourth dimension of safety, thanks to their insect-like flight.

Twenty-seven groups of birds I classed in general as protectively colored, that is, I have seen numbers of each of these groups freeze motionless as I passed by, or when a hawk or some other direct source of danger appeared. Some of them, when held in the hand or examined in a museum case, would never be considered as protected by pigment, and in these instances the marvelous kaleidoscope of the jungle, plus absolute motionlessness, was their safeguard.

Of birds directly protected by their pigments and patterns, tinamou, partridges and goatsuckers were saturated with the brown and buff essences of the jungle floor. Woodhewers had drawn over themselves the screen of reddish-brown and dull lichen spots of the tree-trunks. The black and white contrasty shadows of the dim mid-jungle sheltered the curassows, guans, jungle pigeons, sun-bitterns, owls, goldbirds, manakins and thrushes. Finally the green foliage of the jungle roof was reflected from the plumage of parrots, parrakeets and vireos. In the clearing, chachalacas, ground doves, rails and cuckoos were protected in their various niches of life, waders and colored herons less well concealed, put their trust far more in immobility.

The remaining jungle birds, although not plainly environmentally colored, yet trusted their lives to a long chance of being passed unobserved. Among these I found motmots, trogons, barbets, jacamars and puffbirds. To take one of these from a museum drawer would leave no option but to call it conspicuous. To see it quail momentarily as I pretended to pass and to realize the very apparent difficulty of detecting its white spots or metallic back or yellow sunlit breast in this optical tower of babel was to feel certain that other creatures desiring its death more than I, must also have difficulty in distinguishing it. The great group of antbirds was fascinating in the individuality of its members and collectively defied any specific classification. Some, like the flycatchers of the clearing, were self-appointed guardians of the jungle, and with bravery and unlimited curiosity examined any stranger and commented on all his doings. Others froze motionless until one had passed from view; others flew at once to the tree-tops or to some distant safer part of the jungle.

Still other groups exhibited a sexual distinction and in considering them as protected or unprotected I had to consider the rights of both males and females. These gave added emphasis to the correctness of my theory of protective coloring, for the actions of the two sexes were in perfect accord with their diversity in coloration. It was an easy matter to creep beneath a tree where a female or young male bellbird was calling. Natural selection or whatever we may call it, has striped the plumage green, and with such a protection the bird can and does concentrate its whole attention on those mighty utterances. But a snow white male bellbird is too wary for more than a glimpse. Other cotingas, such as the pompadour chatterer and many honey-creepers and tanagers, came under the same class. Manakins, although the frequent invisibility of the parti-colored males demanded their inclusion with the protected birds of the mid-jungle, yet shared this section too, as one saw far more of the females and young males than of the adult cocks, although there was not the slightest reason to think that there was any actual numerical disparity in the sexes. In the open clearing, the grassbirds and finches illustrated the same sexual distinction, and one could measure by yards the facility of close approach to the little drab-colored hens, in comparison to the readiness with which the black, white and chestnut cocks took to wing.

Omitting hawks, owls, vultures and five piscivorous groups, the remaining forty-eight, in the matter of food, fell into three unequal divisions; twelve per cent were wholly vegetarian, feeding chiefly on nuts, seeds, berries and forest fruits. These were jungle pigeons, ground doves, macaws, parrots, parrakeets and toucans. More than fifty per cent were carnivorous, including both seeds and insects in their diet; while less than thirty-eight per cent were wholly insectivorous. It is unquestionable that a more thorough study of the birds would add others to the carnivorous list. One of the most interesting things about tropical birds was their catholic diet, the failure of flycatchers to be satisfied with flies or grassbirds with the seeds of grasses. It was quite hopeless to attempt to identify more than one or two of the many nuts and seeds which I found in crops, although some were of remarkable shape and structure. The names of many of the largest forest trees themselves are not known to botanists, and their flowers and fruit were wholly unidentifiable. "Fleshy green fruit with small yellow currant-like seeds" must suffice, until some method is found for the botanist to overcome gravitation and do his collecting in the tree-tops. On the jungle floor we found only a maze of fallen blossoms, berries, seeds and nuts which might have been the product of tree, liana, air-plant, or some nearby shrub rooted in a lofty earthen-filled hollow.

No trace of a butterfly or moth was found in any of the four hundred stomachs examined. Once I saw a martin attack and disable a freshly emerged green and black day-flying moth (*Urania boisduvali*), but I am in doubt whether this was done for food, or from nervousness, as the bird was driving all martins and other flying creatures away from a nestling which had just climbed out upon a perch. Iridescent beetles were not uncommon items of diet, and green and brown mantids were present in a half dozen instances. Adult elaters formed the principal food of innumerable nighthawks, and stagbeetles of the poor-me-one. The yellow-throated caracara instead of being a scavenger as he is reputed, sated himself with seeds and insects. Two great eagles, one the harpy, had been feasting on monkeys, and a trio of swallow-tailed kites which were slain because of their suspected ornithophagous habits, proved a complete alibi and insured sanctuary for their successors by their last meal, which consisted of small wild fruits and large grasshoppers.

As in the jungles of the Far East, the uplands of Burma and the coastlands of Ceylon and Java, termites or white ants formed the dominant food of many of the insect-eaters. And at the beginning of the rains when the toothsome, slow-flying winged males and queens came forth in their myriads, bird life seemed to increase many fold, and the anis and fly-catchers and wrens forgot all fear in their excitement at the new found manna.

I have already mentioned the remarkable food migrations, both local and on a large scale. When we have more carefully correlated data we shall find that this phase of life—the search for food—well deserves the first place in the three great objects of organic existence on the earth.

Problems were opened up in every direction. For example, the vulture's search for food: These birds were exceedingly rare and never by any chance did careful search of the sky reveal one. But when we had killed and skinned sloth or howling monkey or hacka tiger, deep in the jungle, within two or three days the vultures would be gathered together in the dimness of the jungle floor. If a king vulture were present, even in the juvenile black plumage, all the others waited patiently. If he were absent, two or three yellow-necked birds would be pulling at the carcass. Experiments which I have made in the past [1] seemed to prove conclusively that these birds practically lack the sense of smell. But in these cases the carcasses were absolutely invisible from any angle of the sky. Did the birds hear the buzzing of flies? Did they mark the direct droning flight of the great blue scarabs? This year's observations revealed no clue.

I have noticed no such friendly association of birds and animals in the South American tropics as exists between the pheasants of the Far East and the small deer and other harmless jungle creatures. Even the trumpeters kept to themselves and the agoutis—those rabbits of the jungle—were solitary feeders. The friendly flocking of different

[1] New World Vultures, *Zoological Society Bulletin,* No. 32, 1908, p. 467.

species of small birds of which I have written elsewhere was, as usual, very marked, and this free-masonry and mutual warning of danger made a fraternity of all the lesser birds of the forest. Tropical birds react to squeaking as quickly as those of any temperate region, and when one member of a flock, such as a toucan or antbird, fell, its companions often followed and fairly mobbed one. In the jungles of the East the babblers made stalking most difficult by announcing to all within earshot the presence of an intruder. Here the caracaras were the self-appointed watchmen, with macaws ably seconding their efforts. But the caracaras had the impudence and fearless naiveté possessed by vultures without the dumbness of those birds. Fortunately they were not abundant, but when one was watching or creeping toward some interesting nesting or feeding bird, the air was sometimes rent with the fearful shrieks and screams of a family of caracaras. Then some inquisitive antbird was sure to investigate and the object of one's search was very likely to move suddenly elsewhere.

Of two score species of mammals which inhabited our small area of observation, about half included birds, their young and eggs in their diet. Ten groups of birds were themselves ornithophagous, lizards and iguanas took nestlings and eggs on every possible occasion; monster toads doubtless longed for the opportunity which Nature denied them of climbing nestwards, while perai snapped at drinking swallows and fishing kiskadees and dragged wounded birds under water, the instant they touched the surface. Crabs, tarantulas, ants and giant water-bugs all claimed a certain share. I have known ants to kill nestlings within the space of an hour's absence on the part of the parents. Even the bête rouge took toll, collecting by the thousand on the necks of birds such as tinamou, where they produced bad sores, and besides made the lives of many nestlings miserable. The elements caused a far greater percentage of deaths than did wind and heat and rain in temperate regions. Besides this, wholly unexpected tragedies occurred, great leaves falling upon and blotting out eggs and young, fruit growing into the nests and smothering the nestlings. And as if this were not enough, parents occasionally left their healthy young without apparent reason and commenced a new nest nearby, the first brood perishing miserably in full view of their callous, unnatural parents. Cuckoos and cowbirds were always waiting the opportunity to parasitize suitable nests, and not infrequently birds would wantonly destroy each others' nests or those of other species.

These and a host of other dangers, resulted in a percentage of mortality which was appalling. Toward the end of my stay, when I wished a photograph of eggs and nest, I never dared leave them for a day, but took them home if the camera had been left, and replaced them at my next visit. This mortality fell into place with the notes I have made in past years in distant parts of the tropics, and gained tremendously in significance when I considered it in connection with such subjects as breeding seasons and numbers of eggs and young.

The roosting places of birds are little known and yet, since I have begun to devote considerable time to discovering and studying them, I have found that they possess significance in many ways other than being the nearest branch on which to rest in sleep throughout the night. I have elsewhere mentioned the interesting change of habits of such birds as parrots, parrakeets and caciques, which at nightfall desert the jungle for a safer roost in the open clearing near human habitations. In another chapter I have taken up in detail the importance of arboreal and terrestrial roosting habits of the two genera of tinamou found near Bartica. Of the roosting of many groups of birds I know nothing. The dusk of the jungle would shut down and until they began calling and feeding early next morning, they ceased to exist as far as I was concerned.

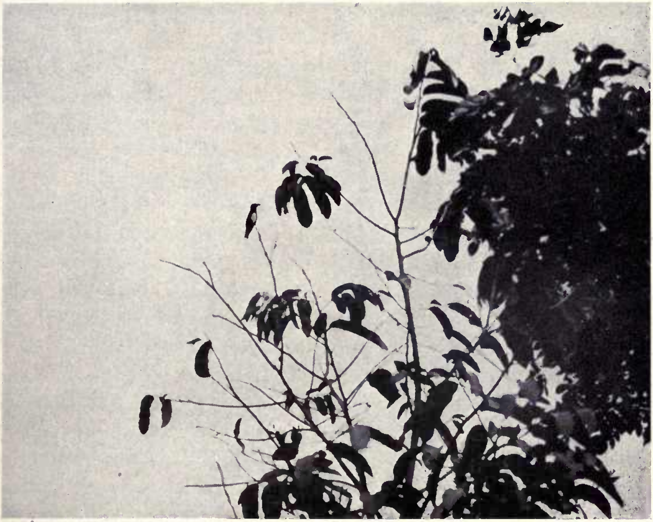


Photo by P. G. H.

FIG. 32. GREAT JACOBIN HUMMINGBIRD (*FLORISUGA MELLIVORA*) ON ITS ROOSTING PERCH.

Curassows and guans roosted high up in the forest and judging by sign, they resorted to the same place week after week. Rails, during the nesting season, selected a place flat among the reeds, immediately behind the nest and facing away from it. Thus the bird which was not on the eggs was able to watch for danger from the rear. The terns hereabouts roosted singly on rocks in mid-stream. Late one evening in the last rays of light I saw one of them settle down with head under wing on a rock which, a few hours later, would be overlapped by the rising tide. I wonder what happened when the bird felt itself gently lifted from its support. If the water were as quiet as when I last saw the bird it would hardly have been awakened. In the season of migration the little families of sandpipers kept the terns company and swayed all night on one leg in the center of the great Mazaruni. The nighthawks, reversing things, spent their days on the ground, but the poor-me-ones, as I discovered many years ago, kept, like the owls, to the thicker branches of low trees.

Crouched in the heart of a great hollow tree I learned that tropical swifts sought shelter from both heat and rain in the same place where they roosted. It was a wonderful sight to see the bats leaving as the swifts eddied downward through the foliage, silhouetted against the afterglow. At mid-day there was always much squeaking of bats and chattering of swifts as the birds whirled downward for their siesta and disturbed the slumbers of the flittermice.

Hummingbirds, like butterflies, roosted, perched to the tips of very slender twigs, usually in some shrub or vine bare of leaves, and they made no secret of their couch, but sat and twittered volubly to the world before they followed the habit of the great harpy eagles and tucked their heads behind their absurd wings. They roosted singly, each atom of feathers isolated in the great closed amphitheater of the jungle's mid-growth, never more than two or three on one shrub. Anis on the contrary, crowded to roost in a dense mob, sometimes two and three deep, as if there were not room enough in this tropical universe. Toucans, like most birds which nested in holes, preferred to roost outside, where they folded themselves up like a paper parcel, first the monstrous beak laid lengthways along the center of the back, then the inner edge of the wings flapped up against it for side packing, and lastly the gaudy, hinged tail folded back over all. Thus the rain was not shunted off but apparently was aided in soaking the plumage; the bird became a feathered ball, and all the nocturnal requirements of these strange birds were fulfilled—which is the same as saying that we haven't the faintest idea why this remarkable habit exists!

Neither do we know why kiskadees and most other flycatchers roosted singly or at most, two or three in a tree, while fork-tailed flycatchers crowded into a single mango until every branch was trembling with their flutterings. The caciques, like the rails, prefer to roost near home, and just to use up surplus energy the male would build a separate dummy nest, without an egg cavity, or else a little awning of interlaced fibres at one side of his rightful nest. Here he would sleep while his mate brooded deep in the purse below. I believe the moriche orioles did the same thing, but I had only half-proofs of this.

The nesting season and the broods of tropical birds are fraught with significance, and I have chosen to treat separately of them, delaying publication until my notes are rounded out and my theories vindicated.

The completion of my fragmentary notes on these many phases of bird life in the tropics will, I trust, yield data of still greater importance, and wider application. My notes on courtship and fighting this year were exceedingly meagre. The most common courtships which we noticed were the wing-plays and dances of jacanas, the dignified pheasant-like display of the sun-bittern and the contortions of the giant caciques. In the clearing one never tired of watching the comical bouncing dance, with vocal accompaniment, of the little pee-zing grassbird. My isolated notes hint that there are many courtships as complicated and worthy of investigation as that of the powies or curassows.[1]

As to fighting, from the point of view of rivalry, the hummingbirds easily held first place. Two seemed hardly ever to meet without a passage at arms, often clinching in mid-air and whirling around as they fell, like a single wounded bird. When all the hummingbird world seemed gathered at the flowering of the cashew trees, some of them would forego feeding hour after hour, so busy were they, driving away others from the tree. Certain species seemed to hold in especial hatred certain other species, while still others, both larger and smaller, were allowed to pass and feed un-

[1] Our Search for a Wilderness, pp. 332-338.

molested. The animosity was racial or specific, not indiscriminate. When striving for the possession of the nesting box, two martins sometimes fell with a thump to the ground, locked tight together, and lay there, disheveled and with flying feathers, pecking viciously at one another.

All tribes of Guiana Indians have certain beliefs and legends concerning birds. The goatsuckers and owls are considered birds of ill omen, their calls presaging illness or death. Others, such as bellbirds, kingfishers and eagles, are thought to predict rain. Brett gives two stories which are supposed to account for the present colors and patterns of birds, a short cut to evolution which, on days of discouraged investigation, we would heartily wish were true!

An Arawak hunter captured a vulture, daughter of Annuanna. This latter, so Roth tells us in his account of the Animism and Folk-lore of the Guiana Indians, is the carrion crow or caracara. The vulture laid aside her feathers, appeared before him as a beautiful girl, became his wife, carried him above the clouds, and after much trouble, persuaded her father and family to receive him. All went well until he expressed a wish to visit his aged mother, when his new-found family discarded him and set him on the top of a very high tree, the trunk of which was covered with formidable prickles. He appealed to all the living creatures around. Finally, spiders spun cords to help him, and fluttering birds eased his descent so that at last he reached the ground in safety. Then followed his efforts, extending over several years, to regain his wife. At length the birds espoused his cause, assembled their forces, and bore him, as their commander, above the sky. At last he was slain by a valiant young warrior, resembling him in person and feature, who turned out to be his own son. The legend ends with the conflagration of the House of the Royal Vultures. The kiskadee flycatcher, though a valiant little bird, disliked the war, and bandaged his head with white cotton, pretending to be sick, but being detected, was sentenced to wear it continually. He is noted for his hostility to hawks and other large birds, which he attacks incessantly when on the wing. The warracabra or trumpeter bird and the sakkasakkali, a kingfisher, quarreled over the spoil and knocked each other into the ashes. The former arose with patches of grey, while the other became grey all over. The Akawai Indians add to this that the trumpeter flew down into an ant's nest and before he could escape, his legs, which formerly had been fat and plump, were picked quite clean. On the same occasion the marudi or guan, thinking some glowing hot embers to be an insect, swallowed them and so got his fiery throat. The owl discovered among the spoil a package done up with care, which he found to contain darkness only; since which he has never been able to endure the light of day.

Another story relates in a most convincing manner the method by which birds got their present plumage. Once upon a time there was a water serpent, a huge creature with a most brilliant skin of red, green, black and white in extraordinary patterns. He became such a terror to all other living creatures that the men and birds, who were friends in those days, combined forces to destroy him, and the creature's skin was promised to the first one who made him come out of the pool. But all were afraid to tackle him except the snakebird, who darting down into the water, drove an arrow through his neck—an arrow fastened by a string to a tree on the bank, by means of which he was finally drawn to land, where he was skinned. Snakebird claimed the skin, and the warriors, never thinking he would be able to carry it away, told him he could have it. He nodded to the other birds, who, each seizing part of the edge, managed to lift it off the ground and bear it to a secluded spot, where Snakebird told them they could divide it among themselves, each to take the part that he had just helped to carry. Each bird carried his load home on his back, and ever since has been marked by hues which the section of serpent's skin that he carried, happened to bear—

Photo by W. B.

FIG. 33. NUPEE, OUR AKAWAI INDIAN HUNTER, BRINGING IN AGOUTIS AND CURASSOWS.

parrots green, macaws scarlet and gold, and so on. But Snakebird, as his share, got only the snake's head with its sombre tints; however, he remained content with this.

The usefulness to man of native Guiana birds may be divided into three heads—ornaments, pets and food. Thanks to most excellent laws which have been passed and are well enforced, all exportations of plumage for millinery purposes have ceased, although for some birds almost too late, for scarlet ibises are a rare sight even on the coast. The ornamentation then is confined to the Indians of the interior who decorate their arrows, head-dresses and medicine bags with brilliant feathers. The birds whose plumage is chiefly used are macaws, Amazon parrots, curassows, toucans, the inner wing plumes and iridescent breasts of trumpeters, cocks-of-the-rock and the rich wine-colored pompadour cotingas. About Bartica the Indians are too busy working cassava or getting sourie nuts or fishing, to pay much attention to unnecessary decoration.

As food, the birds of Guiana form an important item in the dietary of the Indians or indeed of anyone living in or travelling through the interior. During four months of one period of work at Kalacoon House, one Indian with a double-barrelled, twenty-eight gauge shotgun easily kept us in meat, and meat which to our palate was far superior to the supplies which at first we had sent up from Georgetown. He worked in a radius of only a mile or two, and yet seemed to make no impression on the amount of game still present in this area. Sixty per cent of this game consisted of birds, of which tinamou, curassows, guans and trumpeters formed the chief items, these birds being better known colonially by the names of maams, powies, maroudis and warracabras. Among the mammals the most valuable for food were deer, peccaries, monkeys, tapirs and pacas; agoutis or accouris are the rabbits of the tropical jungles. After we had shot over fifty in this limited district their numbers seemed to be as great as ever. Keeping in mind the carefully preserved shooting grounds of our Eastern States, the elaborate licenses, the delicately estimated head of game allowed to each hunter, it seemed too good to be true, to find in the world, only a possible eight days from New York, such an unspoiled hunting ground, with enough and to spare. The game hog is unknown, as there is no market for his ill-gotten wares. We never wasted a single specimen. Besides its flesh for the mess, each bird was weighed, measured, examined for molt and parasites, skinned, sexed and its food recorded, and whenever desired, parts of the skeleton and soft anatomy preserved. Surely no killed specimens more fully fulfilled their destiny of usefulness to man! The flesh kept us in good health, and the entrails went to feed our captive animals and birds of prey.

Any question of taste in food is too individual for general discussion, but we could never decide which of the principal types of birds we preferred. The game-birds of Guiana are excelled by no pheasants of Asia nor grouse of Europe.

The question of extermination of wild birds is hardly likely to arise in British Guiana as long as the present very strict laws are in force. The conditions on the licence to collect wild birds for scientific purposes read as follows:

The Holder of this Licence is required:

(1) To submit all birds collected for inspection by the Director of Science and Agriculture as well as at the Museum by the Curator.

(2) To furnish the Director of Science and Agriculture with a statement showing the kinds of birds and the number of each kind obtained, and the localities in which they were collected.

(3) To specify the persons to whom, or the institution to which, his birds have been sold or forwarded, whether in the Colony or abroad.

(4) To keep books for inspection by the Director of Science and Agriculture, the Inspector General of Police or any officer deputed in writing by either of them to do so, showing what kinds of birds have been killed, the number of each kind, and the localities in which they were collected; where the birds' skins have been removed to, and how; and the final disposal of such birds' skins, supported by receipts or acknowledgments from the purchasers.

(6) This licence must be returned to the Secretary of the Board of Agriculture at the expiry of the period for which it is issued or when an extension of its period is sought for.

The law for the protection of wild birds recognizes two classes, those absolutely protected and those protected only during a close season. I present the two lists as being of importance to anyone interested in the preservation of wild life.

BIRDS PROTECTED THROUGHOUT THE YEAR:

Ant Thrushes and Bush-shrikes
Babbling Thrushes
Barbets
Black Witches
Bunyas and Mockingbirds (except Rice birds)
Campaneros
Carrion Crows
Cassiques
Cocks-of-the-Rock
Cormorants
Cotingas
Cranes
Creepers
Cuckoos
Ducklars
Egrets
Falcons and Hawks
Finches
Fin-foots
Flamingoes
Flycatchers
Frigate Birds
Gannets
Goatsuckers
Grass Birds
Grebes
Ground Doves
Hawks
Herons
Hoatzins
Hummingbirds
Jacamars
Jays
Kingfishers
Kiskadees
Kites
Manakins
Martins
Motmots
Owls
Parrakeets
Pelicans
Petrels
Rails and Crakes
Screamers
Sugar Birds
Sun Bitterns
Shrikes
Sparrows
Swallows
Swifts
Tanagers
Thrushes
Toucans
Terns and Gulls
Trogons
Troupials
Tyrant Shrikes
Vireos and Greenlets
Vultures, (except in villages)
Warblers
Woodhewers
Woodpeckers
Wrens

BIRDS PROTECTED FROM APRIL 1 TO SEPTEMBER 1:

Bitterns
Chachalacas
Curassows
Curlews
Guans
Jabirus
Limpkins or Caraows
Parrots and Macaws
Plovers
Quail and Partridges
Snipe
Spoonbills
Spur-winged Jacanas
Storks
Thick-kneed Plover
Tinamou
Trumpeters or Warracabras

BIRDS PROTECTED FROM APRIL 1 TO JULY 1:

Ducks (except in rice fields)
Doves (other than Ground Doves)
Pigeons

BIRDS PROTECTED FROM JANUARY 1 TO SEPTEMBER 1:

Ibises

There is a curious psychological agreement among a number of important South American birds, so pronounced and uniform that it is difficult not to consider it as being a link between them, although structurally they are quite dissimilar. This is an acceptance of captivity, or rather a voluntary association with man, which is astounding. If one finds a curassow or trumpeter chick, kills its parents or frightens them away and then carries it part-way toward camp, it will willingly follow the rest of the way. From that time on, it becomes a familiar of the household or barnyard. This I have seen in the case of Indians, and I have, myself, achieved it with curassow chicks. At Kalacoon we had a number of curassows, guans and trumpeters and all exhibited this total lack of fear. In the heart of the jungle one will come across a temporary Indian benab with a flock of some or all of these birds running and flying about, never offering to go back to the jungle.

This is in strong contrast with pheasant chicks and other Eastern gallinaceous birds, which retain their wildness to the end of their life, never becoming more than semi-domesticated. With these facts are correlated others which seem only to emphasize them. The trumpeters and curassows, which at once become so ridiculously tame, even troublesomely so, seldom or never lay eggs or breed in captivity. Year after year passes with no sign of approaching breeding season, except now and then a feeble attempt at courtship on the part of the curassows. No nests are built, no eggs laid, even when tall trees are available and the sticks provided which might suggest or tempt this performance. The pheasants, peafowl and partridges, on the contrary, too wary ever to allow any caress or even a near approach, usually lay promptly, and if undisturbed, will incubate and rear their broods. We have no explanation of this. It is a fascinating problem for the future.

I was interested in seeing the various ways in which the Indians secured wild birds. A breech-loading gun, such as that which I loaned to our Akawai hunter, was almost unknown, and he hunted *de luxe,* the envied of all the Indians he met. They sometimes were the proud possessors of an old-fashioned muzzle-loader, or in lieu of this they used bows and arrows and blow-pipes. They seemed poor trappers and would choose rather to wait for hours at some likely place than to set springes or nooses.

Next to any scientific research, my chief desire was the gathering of live vertebrates to send north to the New York Zoological Park. When the coolies heard of the horde of pence and three-pences and bits available, they came in day after day with all sorts of specimens, and in this way we got a number of interesting birds. Others were purchased from Indians, young ones we collected from nests, and brought up by hand, while the majority were trapped in cages or caught with lime sticks. It was exciting work, for we never

Photo by W. B.

FIG. 34. SHIPPING CRATES OF LIVE MAMMALS, BIRDS AND REPTILES FROM KALACOON LANDING.

knew when some especially desirable and rare specimen might not be brought in by an Indian. And then we had to dissemble our interest and look upon the creature with indifference and but slight desire, so that the market prices should not soar, and a precedent be set which would put future treasures beyond our financial reach. Then there came the feeding and care, the boxing and shipping, from our tent-boat to the river steamer, then across Georgetown to the great ocean liner which would transport them north.

The most searching and the fairest test of the success of any live animal collecting is the record of the creatures which arrive safely and become adapted to life in their new surroundings. So I present the lists only of those which reached New York and the Zoological Park in health.

Although this phase of work was wholly subordinate to the scientific investigation which was the main object of the Station, we were able to add over three hundred mammals, birds and reptiles to the collection of the Zoological Park. These represent a total value of well over one thousand dollars. They were as follows:

31	Mammals	16	Snakes
154	Birds	8	Tortoises and Turtles
3	Alligators	80	Frogs and Toads
10	Lizards	13	Fish

Without going into too great detail, a few of the more interesting specimens may be mentioned. Three species of opossums were obtained, several pacas, a yaguarondi cub, agouti, ocelot, a very interesting wild dog, and some jungle rats which have not been identified.

Thirty-four species of living birds were sent to the Zoological Park, of which seven had not previously been exhibited. The most important was a cock-of-the-rock (*Rupicola rupicola*), an uncommonly fine specimen, in full adult male plumage. Few cocks-of-the-rock have been exhibited alive in North America, and none at all for more than twenty-five years. The species is alleged to be delicate and short-lived in captivity, but this specimen has as yet given no evidence of frailty.

The cock-of-the-rock belongs to the family Cotingidae, all the members of which are rare in captivity. The pompadour cotinga (*Xipholena punicea*), so far as records go, has never been exhibited alive before the arrival of the specimen sent to New York from the Tropical Station. This is a superb species, the adult male clad in gorgeous claret, set off with snow-white wings. Little is known of the wild habits of this bird, but even less of its viability and conduct in captivity.

Rails are always welcome additions to collections of living birds, because of their activity and hardiness. The white-necked rail (*Porzana albicollis*) although uncommon even in museums, was very abundant about Kalacoon, and three living specimens were sent to New York. Dusky parrots (*Pionus fuscus*), lavender jays (*Cyanocorax cayana*), a black-faced hawk (*Leucopternis melanops*) and Guiana motmots (*Momotus momota*) complete the list of first accessions. Among others were a number which have not been exhibited for several years, including Dufresne's Amazon parrot, red-breasted and yellow-headed blackbirds, smooth-billed anis, besides yellow-headed vultures, curassows, moriche orioles and a host of small tanagers and seed-eaters.

Many unusual frogs and toads were secured, one of which was a huge specimen of the marine toad. The grotesque sharp-nosed toad is as brightly colored as it is rare. The coppery-red five-fingered frog resembles our bull-frog, but the nursing frogs which carry their tadpoles on their back, are quite unlike any of our North American forms. Others, of whose habits we know little or nothing, are the mustached, the long-snouted and the white-headed frogs. A five-foot electric eel was caught in the Mazaruni almost in front of Kalacoon and successfully shipped north in a metal-lined case. When received full force, the shock from its batteries was almost sufficient to knock a man off his feet.

CHAPTER VIII.

A LIST OF BIRDS OF THE BARTICA DISTRICT.

A compilation of the list of the Tropical Research Station of the Zoological Society and the Whitely list reveals a total of three hundred and fifty-one species. Those marked with a star are new to the Colony of British Guiana. The numbers are those of the birds of South America by Brabourne and Chubb:

TINAMIFORMES

10	Guiana Great Tinamou	*Tinamus major* (Gmel.)
22	Pileated Tinamou	*Crypturus soui soui* (Hermann)
37	Variegated Tinamou	*Crypturus variegatus* (Gmel.)

GALLIFORMES

74	Crested Curassow	*Crax alector* Linn.
93	Lesser Olive Guan	*Penelope marail* (Gmel.)
94	Greater Blue Guan	*Penelope granti* Berlepsch.
104	Little Chachalaca	*Ortalis motmot* (Linn.)
130	Guiana Partridge	*Odontophorus guianensis* (Gmel.)

COLUMBIFORMES

149	Splendid Pigeon	*Columba speciosa* Gmel.
152	Rufous Pigeon	*Columba rufina rufina* Temm. & Knip
156*	Plumbeous Pigeon	*Columba plumbea plumbea* Vieill.
161	Purple-tinted Pigeon	*Columba purpureotincta* Ridg.
175	Larger Grey Ground Dove	*Chaemepelia passerina griseola* Spix.
179	Talpacoti Ground Dove	*Chaemepelia talpacoti* (Temm. & Knip)
191	Grey-fronted Dove	*Leptoptila rufaxilla rufaxilla* (Rich.&Bern.)
204	Red Mountain Dove	*Geotrygon montana* (Linn.)

RALLIFORMES

230	Cayenne Wood Rail	*Aramides cajanea* (P. L. S. Müll.)
239	White-necked Crake	*Porzana albicollis* Vieill.
251	Cayenne Crake	*Creciscus viridis* (P. L. S. Müll.)

LARIFORMES

319 Great-billed Tern........................*Phaëtusa chloropoda* Vieill.

CHARADRIIFORMES

381 Collared Plover........................*Charadrius collaris* Vieill.
391 Esquimo Curlew........................*Numenius borealis* (Forst.)
398 Yellowlegs ....*Totanus flavipes* (Gmel.)
399 Solitary Sandpiper........................*Tringa solitaria* Wilson.
400 Spotted Sandpiper........................*Actitis macularia* (Linn.)
414 Brazilian Snipe........................*Gallinago braziliensis* Swains.
419 Cayenne Snipe........................*Gallinago undulata* (Bodd.)
427 Common Jacana........................*Jacana spinosa* (Linn.)

GRUIFORMES

433 Sun-bittern ....*Eurypyga helias* (Pall.)
436 Grey-winged Trumpeter......*Psophia crepitans* Linn.

ARDEIFORMES

445 Guiana Ibis........................*Theristicus caudatus* (Bodd.)
448 Cayenne Ibis........................*Harpiprion cayennensis* (Gmel.)
461 Cocoi Heron........................*Ardea cocoi* Linn.
463 American Egret ....*Egretta egretta* (Gmel.)
464 Snowy Egret........................*Egretta thula* (Molina)
465 Little Blue Heron........................*Florida caerulea caerulea* (Linn.)
468 Agami Heron........................*Agamia agami* (Gmel.)
472 Yellow-crowned Night
Heron ....*Nycticorax violaceus* (Linn.)
473 Boat-billed Heron........................*Cochlearius cochlearius* Linn.
475 Pileated Heron ....*Pilherodius pileatus* (Bodd.)
476 Guiana Green Heron............*Butorides striata* (Linn.)

ANSERIFORMES

499 Muscovy Duck........................*Cairina moschata* (Linn.)

PELECANIFORMES

554 American Snakebird..............*Anhinga anhinga* Linn.

CATHARTIFORMES

566 King Vulture........................*Gypagus papa* (Linn.)
567 Southern Black Vulture.......*Catharista foetens* Wied.
568 Southern Turkey Vulture *Cathartes aura aura* (Linn.)
570 Yellow-headed Vulture.........*Cathartes urubitinga* Pelz.

ACCIPITRIFORMES

574 Yellow-throated Caracara .... *Ibycter ater* (Vieill.)
575* Red-throated Caracara .... *Ibycter americanus* (Bodd.)
580 Yellow-headed Caracara .... *Milvago chimachima* (Vieill.)
588 Lined Hawk .... *Micrastur gilvicollis* (Vieill.)
606 Four-banded Sparrow-hawk .... *Accipiter bicolor bicolor* (Vieill.)
623 Shining Buzzard-Hawk .... *Asturina nitida* (Lath.)
625 Large-billed Hawk .... *Rupornis magnirostris* (Gmel.)
631 Brazilian Eagle .... *Urubitinga urubitinga* (Gmel.)
636 White-collared Hawk .... *Leucopternis albicollis* (Lath.)
641 Black-faced Hawk .... *Leucopternis melanops* (Lath.)
646 Guiana Crested Eagle .... *Morphnus guianensis* (Daud.)
648 Harpy Eagle .... *Thrasaëtus harpyia* (Linn.)
650 Black and White Hawk-Eagle .... *Spiziastur melanoleucus* (Vieill.)
651 Manduit's Hawk-Eagle .... *Spizaëtus ornatus* (Daud.)
653 Tyrant Hawk-Eagle .... *Spizaëtus tyrannus* (Wied.)
655 Swallow-tailed Kite .... *Elanoides forficatus* (Linn.)
656 Everglade Kite .... *Rostrhamus sociabilis* (Vieill.)
664 Double-toothed Hawk .... *Harpagus bidentatus* (Lath.)
665 Plumbeous Kite .... *Ictinia plumbea* (Gmel.)
671 White-throated Bat-falcon .... *Falco rufigularis* Daud.

STRIGIFORMES

688 Spectacled Owl .... *Pulsatrix perspicillata* (Lath.)

PSITTACIFORMES

734 Scarlet Macaw .... *Ara macao* (Linn.)
735 Green-winged Macaw .... *Ara chloroptera* Gray.
750 Yellow Conure .... *Aratinga solstitialis* (Linn.)
829 Golden-winged Parrakeet .... *Brotogeris chrysopterus* (Linn.)
833 Mealy Amazon .... *Amazona farinosa* (Bodd.)
841 Yellow-headed Amazon .... *Amazona ochrocephala* (Gmel.)
844 Dufresne's Amazon .... *Amazona dufresniana* (Shaw.)
857 Blue-headed Parrot .... *Pionus menstruus* (Linn.)
868 Dusky Parrot .... *Pionus fuscus* (P. L. S. Müll.)
877 Caica Parrot .... *Pionopsitta caica* (Lath.)
881* Scopoli's Parrakeet .... *Urochroma batavica* (Bodd.)
883 Purple Guiana Parrot .... *Urochroma purpurata* (Gmel.)
889 Black-headed Cacique .... *Pionites melanocephala* (Linn.)

CORACIIFORMES

895 Great Grey Kingfisher........*Ceryle torquata torquata* (Linn.)
898 Great Green Kingfisher......*Ceryle amazona* (Lath.)
899* Little Green Kingfisher......*Ceryle americana americana* (Gmel.)
901 Spotted Kingfisher..................*Ceryle inda* (Linn.)
902 Pygmy Rufous Kingfisher *Ceryle aenea aenea* Pallas.
908 Guiana Motmot..........................*Momotus momota* (Linn.)
922 Giant Goatsucker.....................*Nyctibius griseus griseus* (Gmel.)
923 Long-tailed Goatsucker.......*Nyctibius longicaudatus* (Spix.)
935 Semi-collared Night-
hawk ....*Lurocalis semitorquatus* (Gmel.)
948 White-necked Nighthawk..*Nyctidromus albicollis albicollis* (Gmel.)
964 Dusky Nighthawk...................*Caprimulgus nigrescens* Cab.
969 White-banded Swift................*Streptoprogne zonaris albicincta* (Cab.)
971 Short-tailed Swift....................*Chaetura brachyura* Jard.
975 Spine-tailed Swift....................*Chaetura spinicauda* (Boie)
979* Cherrie's Swift..........................*Chaetura chapmani virridipennis* (Cherrie)
985* Fumigated Swift.......................*Cypseloides fumigatus* Streub.
988 Cayenne Swift...........................*Panyptila cayennensis* (Gmel.)
1008 Cayenne Hermit.......................*Phaethornis superciliosus* (Linn.)
1033 Longuemare's Hermit............*Phaethornis longuemareus* (Less.)
1038 Red-vented Hermit.................*Phaethornis ruber* (Linn.)
1041 Bishop Hermit..........................*Phaethornis episcopus* Gould.
1048 Broad-shafted Sabrewing...*Campylopterus largipennis* (Bodd.)
1058 Great Jacobin...........................*Florisuga mellivora mellivora* (Linn.)
1107* Trinidad Erythronote............*Saucerottea erythronota* (Less.)
1127 Guiana Sapphire......................*Hylocharis sapphirina* (Gmel.)
1133 Blue-chinned Sapphire.........*Chlorestes notatus* (Reich)
1172 Venezuelan Wood-
Nymph ....*Thalurania furcata fissilis* Berl. & Hart.
1193 Swainson's Hummingbird...*Avocettula recurvirostris* (Swains.)
1194 Violet-tailed Mango...............*Lampornis nigricollis* (Vieill)
1205 Shaw's Golden-throated
Hummingbird ....*Polytmus chrysobronchus* (Shaw)
1208 Crimson Topaz........................*Topaza pella* (Linn.)
1404 Black-eared Fairy...................*Heliothrix aurita* (Gmel.)
1412 Long-billed Star-throat.......*Anthocenus superba* (Shaw)
1418 Pygmy Amethyst......................*Calliphlox amethystina* (Gmel.)
1438 Guiana Coquette......................*Lophornis pavoninus* Salv. & Godm.

TROGONES

1458 Collared Trogon.........................*Trogon collaris* Vieill.
1460 Black-throated Trogon.........*Trogon rufus* Gmel.
1461 Green Trogon.............................*Trogon viridis* Linn.
1470 Black-tailed Trogon...............*Trogon melanurus* Swains.

COCCYGES

1475 Dark-headed Cuckoo........*Coccyzus melacoryphus* Vieill.
1481 Chestnut Cuckoo........*Piaya cayana cayana* (Linn.)
1489 Black-bellied Cuckoo........*Piaya melanogaster* (Vieill.)
1490 Little Rufous Cuckoo........*Piaya rutila* Illiger.
1494 Rufus-winged Cuckoo........*Neomorphus rufipennis* (Gray)
1496* Brown Cuckoo........*Tapera naevia* (Linn.)
1498 Peacock Cuckoo........*Dromococcyx pavoninus* Pelz.
1499 Common Ani........*Crotophaga ani* Linn.
1500 Great Ani........*Crotophaga major* Gmel.

SCANSORES

1508 Black-spotted Barbet ....*Capito niger* (P. L. S. Müll.)
1527 Red-billed Toucan........*Ramphastos monilis* Müll.
1535 Sulphur-and-White-breasted Toucan........*Ramphastos vitellinus* Licht.
1543* Black-necked Aracari........*Pteroglossus aracari aracari* (Linn.)
1561 Green Aracari........*Pteroglossus viridis* (Linn.)
1569 Guiana Toucanet........*Selenidera culik* (Wagler)

PICIFORMES

1582 Paradise Jacamar........*Urogalba dea* (Linn.)
1584 Common Jacamar........*Galbula galbula* Linn.
1592 White-billed Jacamar........*Galbula albirostris albirostris* Lath.
1597 Black-billed Jacamar........*Brachygalba lugubris* (Swains.)
1606 Golden Jacamar........*Jacamerops aurea* (P. L. S. Müll.)
1608 Collared Puffbird........*Bucco capensis* Linn.
1609 Long-billed Puffbird........*Bucco macrorhynchus* Gmel.
1615 Cayenne Puffbird........*Bucco tectus* Bodd.
1622 Cayenne Spotted Puffbird *Bucco tamatia* Gmel.
1649 Black Puffbird........*Monasa niger* (Müll.)
1657 Swallow Puffbird........*Chelidoptera tenebrosa tenebrosa* (Pall.)
1677 Yellow-throated Green Woodpecker ....*Chloronerpes flavigula* (Bodd.)
1687* Swainson's Green Woodpecker ....*Chloronerpes rubiginosus* (Swains.)
1704 Red-fronted Woodpecker...*Melanerpes rubrifrons* (Spix.)
1731 Cassin's Woodpecker........*Veniliornis cassini* (Malh.)
1746 Hellmayr's Woodpecker......*Celeus hellmayri* Berlepsch.
1747 Spix's Amazonian Woodpecker ....*Celeus jumana* (Spix.)
1757 Chestnut-winged Yellow Woodpecker ....*Crocomorphus flavus* (Müll.)
1760 Red-necked Woodpecker....*Campophilus rubricollis* (Bodd.)
1762 Black and white Woodpecker ....*Campophilus melanoleucus* (Gmel.)

1770 Lineated Woodpecker........*Ceaphloeus lineatus* (Linn.)
1794* Scale-eared Piculet........*Picumnus minutissimus* (Pall.)

PASSERIFORMES

FORMICARIIDAE

1852 Amazonian Ringed Gnat-eater........*Corythopsis anthoides* (Pucher.)
1854 Rufus-fronted Ant-catcher*Cymbilaimus lineatus lineatus* (Leach)
1861 Crested Bush-Shrike........*Thamnophilus viridis* Vieill.
1889* Sclater's Amazonian Bush-Shrike........*Thamnophilus amazonicus* Sclater.
1908 White-barred Bush-Shrike........*Thamnophilus doliatus* (Linn.)
1941 Ashy-backed Bushbird........*Dysithamnus spodionotus* Salv. & God.
1947* Slate-colored Bushbird........*Dysithamnus schistaceus* (d'Orb.)
1952 Mouse-colored Bushbird........*Dysithamnus murinus* Scl. & Salv.
1954 Saturnine Bushbird........*Dysithamnus ardesiacus saturninus* Pelz.
1959 Cinereous Bushbird........*Thamnomanes caesius glaucus* Cab.
1961 Pygmy Antbird........*Myrmotherula pygmea* (Gmel.)
1967 Rufus-bellied Antbird........*Myrmotherula guttata* Vieill.
1969 Brown-bellied Antbird........*Myrmopagis gutturalis* (Scl. & Salv.)
1982 White-flanked Antwren........*Myrmopagis axillaris axillaris* (Vieill.)
1988 Long-winged Antbird........*Myrmotherula longipennis* Pelz.
1993 Grey-breasted Antbird........*Myrmotherula cinereiventris* Scl. & Salv.
2000 Spotted-tailed Antbird........*Herpsilochmus sticturus* Salvin.
2032* Pied Antwren........*Rhoporchilus torquata* (Wied.)
2039 Ash-vented Antwren........*Terenura spodioptila* Scl. & Salv.
2045 White-bellied Antwren........*Rhamphocaenus albiventris* Sclater.
2050 Grey Ant-Wren........*Cercomacra cinerascens* (Sclater.)
2053 Bogota Antwren........*Cercomacra tyrannina* Sclater.
2068 White-fronted Antcatcher.*Pithys albifrons* (Linn.)
2074 Rufous-fronted Ant-catcher........*Anoplops rufigula rufigula* (Bodd.)
2098 Spotwinged Antcreeper........*Sclateria leucostigma* (Pelz.)
2109 Cayenne Antcreeper........*Myrmoderas ferruginea* (P. L. S. Müll.)
2120 Warbling Antcreeper........*Hypocnemis cantator cantator* (Bodd.)
2125 Spotted-backed Ant-creeper........*Hylophlax poecilonota poecilonota* Cab.
2130 Schomburgk's Antcreeper *Hypocnemis leucophrys angustirostris* Cab.
2139 Black-chinned Antcreeper *Hypocnemis melanopogon* Sclater.
2142 Spotbacked Antcreeper........*Hypocnemis naevia* (Gmel.)
2152a Woodcock Antbird........*Rhopoterpe torquata torquata* Bodd.
2155 Black-faced Ant-thrush........*Formicarius colma colma* (Bodd.)
2202 Little Ant-thrush........*Grallaria brevicauda* (Bodd.)
2209 Spotted-breasted Ant-thrush........*Grallaria macularia* (Temm.)

DENDROCOLAPTIDAE

2321 Guiana Spinetail........ *Synallaxis guianensis guianensis* (Gmel.)
2332 Yellow-throated Spinetail *Synallaxis cinnamomea* (Gmel.)
2441 Pelzeln's Automolus........ *Automolus turdinus* (Pelz.)
2447* Olive-backed Automolus..... *Automolus infuscatus* Sclater.
2448 Olive-capped Automolus...... *Automolus cervicalis* Sclater.
2464 Cinnamon-rumped Philydor .... *Philydor pyrrhodes* (Cab.)
2471 Dusky-vented Philydor........ *Philydor erythrocercus* (Pelz.)
2489 Brown-tailed Xenops........ *Xenops genibarbis genibarbis* Ill.
2497 Black-tailed Leafscraper.... *Sclerurus caudacutus* (Vieill.)
2505* Lesser Black-tailed Leaf-scraper .... *Sclerurus rufigularis* Pelz.
2516 Little Wedge-billed Woodhewer .... *Glyphorhynchus cuneatus cuneatus* (Licht.)
2520 Vieillot's Woodhewer........ *Dendocincla fuliginosa* (Vieill.)
2527 Red-vented Woodhewer ...... *Dendrocincla merula* (Licht.)
2534 Long-tailed Creeper........ *Deconychura longicauda* (Pelz.)
2539* Spotted Woodhewer........ *Xiphorhynchus guttatoides* (Lafr.)
2547 Chestnut-rumped Wood-hewer .... *Xiphorhynchus pardalotus* (Vieill.)
2548 Spotted Woodhewer........ *Xiphorhynchus polystictus* Salv. & God.
2559 Picine Woodhewer........ *Dendroplex picus picus* (Gmel.)
2594 Fulvous-throated Wood-hewer .... *Picolaptes albolineatus* (Lafr.)
2605 Guiana Curve-billed Wood hewer .... *Campylorhamphus trochilirostris procurvoides* (Lafr.)
2617 Black-banded Wood-hewer .... *Dendrocolaptes plagosus* Sal. & God.
2621 Buffon's Barred Wood-hewer .... *Dendrocolaptes certhia* (Bodd.)

TYRANNIDAE

2686 White-shouldered Water-Tyrant .... *Fluvcola pica* (Bodd.)
2690 White-headed Marsh-Tyrant .... *Arundinicola leucocephala* (Linn.)
2743 Grey-headed Flatbill........ *Platyrhynchus griseiceps griseiceps* Salv.
2752 Golden-crowned Flatbill.... *Platyrhynchus coronatus coronatus* Scl.
2759 Pelzeln's Flatbill........ *Rhynchocyclus sulphurescens assimilis* Pelz.
2771 Rufous-tailed Flatbill........ *Ramphotrigon ruficauda* (Spix.)
2773 Grey Tody Flycatcher........ *Todirostrum cinereum cinereum* (Linn.)
2784 Spotted Tody Flycatcher.... *Todirostrum maculatum* Desmarest
2834 Helmeted Pygmy Tyrant.... *Colopteryx galeatus* (Bodd.)

2892 Oily Flycatcher........*Mionectes oleagineus oleagineus* (Licht.)
2910 Grey-headed Flycatcher......*Phyllomyias griseiceps* (Scl. & Sal.)
2918 Mouse-colored Flycatcher..*Phaeomyias murina incomta* (Cab. & Hein.)
2921 Hartlaub's Flycatcher..........*Ornithion inerme* Hartl.
2927 Latham's Flycatcher..........*Tyrannulus elatus* (Lath.)
2935 Guiana Tyrantlet..........*Tyranniscus acer.* (Salv. & God.)
2938 Yellow-vented Flycatcher..*Elaenia flavogaster* (Thunberg.)
2961* Berlepsch's Crested Flycatcher..........*Elaenia guianensis* Berlepsch.
2964 Golden-crowned Flycatcher..........*Elaenia flavivertex* Sclater.
2977 Little White-necked Flycatcher..........*Legatus albicollis* (Vieill.)
2981 Small-billed Kiskadee..........*Myiozetetes cayennensis cayennensis* (Linn.)
2986 Sulphury Flycatcher..........*Myiozetetes sulphureus* (Spix.)
2992 Guiana Kiskadee..........*Pitangus sulphuratus sulphuratus* (Linn.)
2996 Lesser Kiskadee..........*Pitangus lictor* (Licht.)
3002 Streaked Flycatcher..........*Myiodynastes maculatus maculatus* (Müll.)
3004 Solitary Flycatcher..........*Myiodynastes maculatus solitarius* (Vieill.)
3017 Whiskered Flycatcher..........*Myiobius barbatus barbatus* (Gmel.)
3025 Red-tailed Flycatcher..........*Myiobius erythrurus erythrurus* Cab.
3040 Little Brown Flycatcher....*Myiobius fasciatus fasciatus* (Müll.)
3050* Leotaud's Dusky Flycatcher..........*Empidochanes fuscatus cabanisi,* Leot.
3085 Fierce Flycatcher..........*Myiarchus ferox* (Gmel.)
3098 Varied Streaked Flycatcher..........*Empidonomus varius varius* (Vieill.)
3103 White-throated Kingbird....*Tyrannus melancholicus satrapa* Cab & Hein.
3107 Fork-tailed Flycatcher........*Muscivora tyrannus* (Linn.)

PIPRIDAE

3111 Orange-headed Manakin.....*Pipra aureola aureola* (Linn.)
3116 Golden-headed Manakin......*Pipra erythrocephala erythrocephala* (Linn.)
3120 White-Crowned Black Manakin..........*Pipra leucocilla leucocilla* Linn.
3132 Yellow-bellied Manakin.......*Pipra suavissima* Salv. & God.
3136 Green Pygmy Manakin......*Pipra virescens* Pelz.
3152 Green Manakin..........*Piprites chlorion* (Cab.)
3169 White-throated Manakin....*Corapipo gutturalis* (Linn.)
3171 Crackling Manakin..........*Chiromachaeris manacus manacus* (Linn.)
3184 Ridgway's Manakin..........*Scotothorus turdinus olivaceus* Ridgw.

COTINGIDAE

3200 Black-tailed Tityra..........*Tityra cayana* (Linn.)
3214 Little Psaris..........*Platypsaris minor* (Lesson.)

3232 Black-capped Thickbill........*Pachyrhamphus atricapillus* Merrem.
3238 Goldbird........*Lathria cinerea cinerea* (Vieill.)
3243 Red-breasted Mourner........*Laniocera hypopyrrha* (Vieill.)
3246 Greyish Mourner........*Lipangus simplex* (Licht.)
3251 Schomburgk's Attila........*Attila brasiliensis* Lesson
3253 Cayenne Attila........*Attila spadiceus* (Gmel.)
3267 Red Chatterer........*Phoenicocircus carnifex* (Linn.)
3291 Purple-breasted Chatterer.*Cotinga cotinga* (Linn.)
3293 Cayenne Chatterer........*Cotinga cayana* (Linn.)
3297 Pompadour Chatterer........*Xipholena punicea* (Pallas.)
3307 Dusky Chatterer........*Idopleura fusca* (Vieill.)
3310 Purple Fruit-crow........*Querula purpurata* (Müll.)
3317 Calfbird ....*Calvifrons calvus* (Gmel.)
3318 Bare-necked Cotinga........*Gymnoderus foetidus* (Linn.)
3319 Bellbird........*Casmorhynchos niveus* (Bodd.)

HIRUNDINIDAE

3326* Bank Swallow........*Riparia riparia* (Linn.)
3327 Variegated Swallow........*Tachycineta albiventris* (Bodd.)
3331 Barn Swallow........*Hirundo erythrogaster* Bodd.
3332 Purple Martin........*Progne subis subis* (Linn.)
3335 Grey-breasted Martin........*Progne chalybea chalybea* (Gmel.)
3336 Brown Martin........*Progne tapera tapera* (Linn.)
3337 White-banded Swallow........*Atticora fasciata* (Gmel.)
3342 Half-belted Swallow........*Atticora cyanoleuca* (Vieill.)

TROGLODYTIDAE

3415 British Guiana Wren........*Thryothorus griseigula* (Lawr.)
3443 Guiana House Wren........*Troglodytes musculus clarus* Berl. & Hart.
3449 Schomburgk's House
Wren ....*Troglodytes rufulus* Cab.
3455 Black-capped Wren........*Henicorhina leucosticta leucosticta* (Cab.)
3462 Quadrille-bird........*Leucolepia musica musica* (Bodd.)
3469 White-banded Wren........*Microcerculus bambla* (Bodd.)

TURDIDAE

3519 White-throated Thrush........*Planisticus phaeopygus phaeopygus* (Cab.)
3536 Sabian Thrush........*Planisticus fumigatus* (Licht.)
3538 Common Thrush........*Planisticus albiventer* (Spix.)
3551 Grey-cheeked Thrush ....*Hylocichla aliciae* (Baird.)

VIREONIDAE

3562 Moustached Vireo........*Vireo calidris* (Linn.)
3565 Chivi Vireo........*Vireo chivi* (Vieill.)

3571 Grey-bellied Woodbird........*Pachysylvia griseiventris* (Berl. & Hart.)
3574 Guiana Woodbird........*Pachysylvia muscicapina* (Scl. & Salv.)
3589 Orange-fronted Woodbird..*Pachysylvia luteifrons* (Sclater.)
3597 Bonaparte's Vireo........*Vireolanius chlorogaster* Bonap.

MNIOTILTIDAE

3620 Yellow Warbler........*Dendroeca aestiva aestiva* (Gmel.)
3637 Small-billed Waterthrush...*Seiurus noveboracensis* (Gmel.)

FRINGILLIDAE

3714 Brazilian Blue-Grosbeak....*Cyanocompsa cyanea* (Linn.)
3719 Brown-breasted
Pygmy Grosbeak........*Oryzoborus angolensis brevirostris* Berl.
3722 Thick-billed
Pygmy Grosbeak........*Oryzoborus crassirostris crassirostris* (Gmel.)
3743 Chestnut-bellied Seedeater*Sporophila castaneiventris* Cab.
3745 Pygmy Seedeater........*Sporophila minuta minuta* (Linn.)
3769 Lined Seedeater........*Sporophila lineola* (Linn.)
3770* Black-headed Seedeater.......*Sporophila bouvronides* (Less.)
3790 Glossy Grassquit........*Volatinia jacarina splendens* (Vieill.)
3796 White-throated Kernal-
eater ....*Pitylus grossus* (Linn.)
3798 Scarlet Kernal-eater........*Pitylus erythromelas* (Gmel.)
3799 Olive Kernal-eater........*Pitylus canadensis canadensis* (Linn.)
3803 Great Saltator........*Saltator maximus maximus* (Müll.)
3941 Red-crested Finch........*Coryphospingus cucullatus* (Müll.)
3952 Black-throated Cardinal.....*Paroaria gularis* (Linn.)
3957 Pectoral Sparrow........*Arremon silens* (Bodd.)

COEREBIDAE

4021 Guiana Bananaquit........*Coereba guianensis guianensis* (Cab.)
4061 Turquoise Honey-Creeper..*Dacnis cayana cayana* (Linn.)
4067 Black-backed Honey-
Creeper ....*Dacnis angelica* Bonap.
4077 Blue Honey-Creeper........*Cyanerpes cyaneus cyaneus* (Linn.)
4080 Purple Honey-Creeper........*Cyaerpes caeruleus caeruleus* (Linn.)
4085 Green Honey-Creeper........*Chlorophanes spiza spiza* (Linn.)

TANAGRIDAE

4119 White-vented Euphonia........*Tanagra olivacea olivacea* Desm.
4122 Violaceus Euphonia........*Tanagra violacea* (Linn.)
4133 Cayenne Euphonia........*Tanagra cayennensis* (Gmel.)

4136 Plumbeus Euphonia .... *Tanagra plumbea* (Du Bus.)
4165 Spotted Tanager .... *Tangara punctata* (Linn.)
4188 Chestnut-headed Tanager... *Tangara gyrola* (Linn.)
4197 Yellow-bellied Tanager........ *Tangara mexicana mexicana* (Sclater.)
4138 Blue-bellied Tanager........ *Tanagrella velia* (Linn.)
4270 Blue Tanager........ *Thraupis episcopus episcopus* (Linn.)
4280* Eastern Palm Tanager........ *Thraupis palmarum palmarum* Wied.
4297 Silver-beaked Tanager........ *Ramphocelus carbo carbo* (Pall.)
4329 Black-headed Toothed
Tanager .... *Lanio atricapillus* (Gmel.)
4333 Black Tanager........ *Tachyphonus rufus* (Bodd.)
4334 Lesser White-shouldered
Tanager .... *Tachyphonus luctuosus* d'Orb. & Lafr.
4339 Fulvous-crested Tanager... *Tachyphonus surinamus surinamus* (Linn.)
4342 Golden-crested Tanager........ *Tachyphonus cristatus intercedens* Berl.
4429 Black-and-white Shining
Tanager .... *Lamprospiza melanoleuca* (Vieill.)
4432 Magpie Tanager........ *Cissopis leveriana* (Gmel.)

ICTERIDAE

4445 Great Black Cacique........ *Ostinops decumanus decumanus* (Pall.)
4446 Great Green Cacique........ *Ostinops viridis* (Müll.)
4454 Yellow-backed Cacique .... *Cacicus cela cela* (Linn.)
4460 Red-rumped Cacique........ *Cacicus haemorrhous haemorrhous* (Linn.)
4466 Rice-grackle........ *Cassidix oryzivora oryzivora* (Gmel.)
4474 Glossy Cowbird........ *Molothrus atronitens* Cab.
4488 Red-breasted Blackbird........ *Leistes militaris* (Linn.)
4512 Moriche Oriole .... *Icterus chrysocephalus* (Linn.)
4516 Black-throated yellow
Oriole .... *Icterus xanthornus xanthornus* (Gmel.)
4530 Little Boat-tailed Grackle. *Holoquiscalus lugubris* (Swains.)

CORVIDAE

4540 Lavender Jay........ *Cyanocorax cayanus* (Linn.)

CHAPTER IX

AKAWAI INDIAN AND COLONIAL NAMES OF BIRDS AND MAMMALS OF BARTICA.

As Akawai is the common vernacular in use among Indian hunters and those who have no knowledge of English, it is important to be able to identify, with as much exactness as possible, the names in the two languages. I obtained the words and pronunciation from the most intelligent men I could find, and then tried them on other Indians without warning, getting in every case the instantaneous reaction and recognition which is proof of their correctness. My anglicization has been with the sole idea of ease of repetition and pronunciation, with no attempt at correct linguistic voweling or phrasing. The shortcomings of the English tongue often compelled awkward syllabication. The *l* and the *r* of the Akawai pronunciation are in many cases very difficult to distinguish, and sometimes seem quite interchangeable. Unless otherwise marked, the *a's* are as in *father*. The *r* is almost invariably rolled.

AKAWAI NAMES OF BIRDS

Guiana Great Tinamou	mărū
Pileated Tinamou	orri′-orri′
Variegated Tinamou	sūlimă
Crested Curassow	powēēt
Greater Blue Guan	ōkla
Lesser Olive Guan	camalasac paláka, yowyan
White-crested Guan	kūyóu
Little Chachalaca	camallīewa
Guiana Partridge	coolweet
Splendid Pigeon	hurrutwema
Mountain Dove	warrámee
Ground Dove	hellwoe
Cayenne Wood Rail	goatsala

White-necked Crake	soroit′cho
Finfoot	wowwing′
Great-billed Tern	wanawánalee
Esquimo Curlew	alaka′
All Sandpipers	mateéweeteé
Common Jacana	parraweek′
Sun-bittern	maler
Grey-winged Trumpeter	yacamee
Guiana Ibis	kō′rōk-kō′rōk
Scarlet Ibis	youmaree′
Snowy Egret	analao′ (=white)
Little Blue Heron	caraow
Guiana Green Heron	ōnōrāy′
Boatbilled Heron	why′a
Muscovy Duck	mike-quack
King Vulture	hangwan′na
Yellow-headed Vulture	coolūng′
Red-throated Caracara	kīaou′-kīaou′
Chimachima	mow-wat
Guiana Black Hawk	purraleek′a
White-collared Hawk	wooktaut′a
Harpy Eagle	wēlūmī′ma
Laughing Falcon	peéung
Swallow-tailed Kite	kūmalak′
Spectacled Owl	wook-naa
Scarlet Macaw	kalala′wa
Green-winged Macaw	whya′la
Yellow and Blue Macaw	tao′wa-tao′wa
Yellow Parrot	cüyük′say
Mealy Amazon Parrot	sōrō′ma
Blue-fronted Amazon	kōōrāywaklee′
Yellow-headed Amazon	palawa
Short-tailed Parrot	woerō′-wāy
Blue-headed Parrot	kooleek′-why
Dusky Parrot	sallie-sallie
Hawk-headed Parrot	anakee′ok
Scopoli's Parrakeet	malang′
Black-headed Cacique	paleekē′a
Great Green Kingfisher	gutoorang
Little Green Kingfisher	sakī′ka
Pygmy Rufous Kingfisher	morōpleek′a
Guiana Motmot	mutook
Giant Goatsucker; Poor-me-one	haláwœ
White-necked Nighthawk; Who-are-you	tōcōyow
Dusky Nighthawk	taowaroo

White-banded Swift	cowchick
Short-tailed Swift and related species	camaria
Cayenne Hermit	whyawhya
Red-vented Hermit	mārūmārū
Broadshafted Sabrewing	tapeeyüt
Great Jacobin	lāymœt
Green Trogon	ŏŏrūkŏŏa
Black-tailed Trogon	anakōk
Dark-headed Cuckoo	macheecūtteretree′
Greater Chestnut Cuckoo	apeek′-wa
Little Chestnut Cuckoo	cheeleek′a
Groove-billed Ani	wœnoie
Great Ani	woœmeek
Toco Toucan	küru
Red-billed Toucan	kya′bōk
Sulphur-breasted Toucan	krüma
Black-necked Aracari	katchsing′
Green Aracari	pālāflek
Guiana Toucanet	kama′ta
Paradise Jacamar	kwēī′ma
Common Jacamar	koomalawatōmba
Golden Jacamar	wānekpü
Collared Puffbird	salerōk-werka
Long-billed Puffbird Cayenne Spotted Puffbird	towī-towī
Black Puffbird	wīlyot-pēchōrō
Swallow Puffbird	whydaymāla
Little Black Woodpecker	sabā′letek
Spix's Amazonian Woodpecker	warōkō
Red-necked Woodpecker	kīpa′rak
Lineated Woodpecker	wakŏw′-a
Cayenne Antcreeper	matelülü
(No name for antbirds)	
Little Wedge-billed Woodhewer	ilyatchēkong
Long-billed Woodhewer	tschēcoit-tschēcoit
Guiana Curve-billed Woodhewer	yīwok
Lesser Kiskadee	beeklōroit
Guiana Kiskadee	mēēatōbick
White-throated Kingbird	beekleabeek
Fork-tailed Flycatcher	cockyock
White-bellied Sharp-bill	achē′lü
Orange-headed Manakin	walook′ye
White-crowned Black Manakin	pāymōke
Crackling Manakin	cockkōbüe
Black-tailed Tityra	quā′kīke

Goldbird	pīpīchō
Red Chatterer	tarana′
Purple-breasted Chatterer	talēka
Cayenne Chatterer	wa′na
Cock-of-the-Rock	kow-wona′rū
Pompadour Chatterer	pakŏk
Purple Fruit-crow	pā′w$^{\bar{o}}$k
Calfbird	ōtal′wa
Bellbird	parang′tarā
Variegated Swallow	kataquack
Grey-breasted Martin White-banded Swallow	whychōlō
Guiana House Wren	kamarachick′-kōrō
Quadrille-bird	rūēētong
Scarlet Kernal-eater	ŏnnŏntōwŏn-pēpa
Olive Kernal-eater	terū′pēou
Black-throated Cardinal	palēsalambō
Pectoral Sparrow	pasū′ka
Guiana Flower-pecker	kamarangchick
Turquoise Honey-creeper	napwē′
Blue Honey-creeper	lüēē′
Purple Honey-creeper	pārūwhy′ōk
Green Honey-creeper	tātock′sāy
Violaceous Euphonia	rameek
Western Paradise Tanager	tacūbē
Blue Tanager	hawalayakü
Palm Tanager	sākwē
Silver-beaked Tanager	palükē′a
Fulvous-crested Tanager	krītschalaou
Black-and-White shining Tanager	wāykōkō
Magpie Tanager	qualē′pia
Great Black Cacique	kōpa′wa
Great Green Cacique	keenōtōlee
Yellow-backed Cacique	sāylāy-wa
Red-rumped Cacique	’tsakow
Rice-grackle	ōnoi
Glossy Cowbird	kōsōlēka
Red-breasted Blackbird	carakpischūwāy
Moriche Oriole	waīour′a
Black-throated Oriole	mōrōmō′-ta
Lavender Jay	katool′ka

AKAWAI NAMES OF MAMMALS

Common Large Opossum	yawa′rrie
Murine Opossum	salkow

Great Anteater	walee′cheema
Tamandua	oh-youā
Little Anteater	
Two-toed Sloth	qualang
Three-toed Sloth	nūpi
Giant Armadillo	mow-oorī-ma
Peba	kikong
Little Armadillo	mū rū!
Tapir	maipurie
Black Peccary	pī-inka
White-lipped Peccary	pakeela
Small Brown Deer	karriouku
Large Red Deer	kūsali
Manatee	
Porpoise	sotsotqueea
Jaguar	kīkūschee
Puma	saliwarra
Jaguarondi	walwan′na
Ocelot	marakīya
Crab Dog	
Crab-eating Raccoon	roótūroó
Kinkajou	walee
Red Coati	ēwōō′nōtō′
Black Coati	quashi
Hacka	arrī-wok
Guiana Squirrel	kalē
Mice and Rats	moomba
Otter	mapa′lwa
Capybara	parūāna
Paca	oorana
Agouti	accū
Pygmy Tailed Agouti	accūswhy
Guiana Tree Porcupine	arrū
Vampire and small bats	marūpack′
Fruit Bat	attoowow-wong
Squirrel Monkey	sackawinki
Capuchin Monkey	walka
Beesa Monkey	yareek′ee
Red Howler	arau′ta

NATIVE GUIANA NAMES OF BIRDS AND MAMMALS.

Most of the following names I have taken from my former volume on British Guiana, together with a few additions made on the present trip. A list like this is often of the utmost importance in learning of the identity or haunts of certain birds and animals from the natives other than red Indians:

COLONIAL NAMES OF BIRDS

Guiana Great Tinamou	Maam
Small Tinamous	Little Maam
Curassow	Powis
Guan	Maroodi
Guiana Partridge	Duraquara
Chachalaca	Hanaqua
Hoatzin	Canje Pheasant
	Stinking Anna
	Sea-corner Anna
	Van Battenburg's Turkey
Purple Gallinule	Coot
Guiana Wood Rail	Killicow
	Bush Fowl
Spur-winged Jacana	Spur-wing
Skimmer	Scissor-bill
Sun-bittern	Sun-bird
Trumpeter	Warracabra
Scarlet Ibis	Curri-curri
Jabiru	Negrokop
Wood Ibis	Nigger-head
Tiger Bittern	Tiger-bird
Herons	Chow
	Shypook
Cocoi Heron	Crane
	Hanora
Horned Screamer	Mohuca
Grey-necked Tree-duck	Vicissi
Snakebird	Ducklar
	Darter
Black Vulture	Carrion Crow
Orange-headed Vulture	Governor Carrion Crow
Red-throated Caracara	Bush Carrion Crow
Chimachima Hawk	Hen Hawk
Owls	Night Owl
Hawk-headed Parrot	Hya-hya Parrot
Spectrum Parrakeet	Kissi-kissi
Motmot	Hutu
	Houtouli
Great Green Kingfisher	Saxacalli
Little Green Kingfisher	Bottom Ridge
Goatsuckers and Nighthawks	Jumby Birds

Hummingbirds	Doctor Birds
Four-winged Cuckoo	Wife-sick
Great Ani	Jumby Bird
Smooth-Billed Ani	Old Witch
Toucan	Bill-bird
Checkered Antbird	Dominique or Check-bird
Cinnamon Spinetail	Rootie
Pompadour Cotinga	Wallababa
Bellbird	Campanero
Goldbird	Greenheart-bird
	Pipi-vo
Cinereus Becard	Woodpecker
White-shouldered Ground Fly-catcher	Cotton-bird
Southern Scissor-tailed	Scissor-tail
Guiana Kiskadee	Kiskadee
White-throated Kingbird	Madeira or Grey Kiskadee
	Kiskos
White-headed Marsh Flycatcher	Parson bird
	male, Maharaj
	female, Maharanee
Cinereus Tody-flycatcher	Pipitoorie
Yellow-breasted Eleania Flycatcher	Muff-bird
	Muffin
Guiana House Wren	God-bird
	Guard-bird
Necklaced Jungle Wren	Quadrille Bird
White-throated Thrush	Thrush
Yellow Warbler	Bastard Canary
Thick-billed Pygmy Grosbeak	Twa-twa
Brown-breasted Pygmy Grosbeak	Toua-toua
	Twa-twa Slave
Blue-backed Seedeater	Blueback
Pygmy Seedeater	Fire-red
	Red Belly
	Grassbird
Stripe-headed Seedeater	Crown-head
Plain-headed Seedeater	Plain-head
Lineated Seedeater	Ring-neck
Pee-zing Grassquit	Pee-zing
	Zero
Black-throated Cardinal	Wakenaam Sparrow
Honey-creepers	Hummingbirds
Yellow-bellied Calliste	Goldfinch
Black-faced Calliste	Bucktown Sackie

Violaceus Euphonia	Bucktown Canary
	Yellow-belly Canary
	Jumby Canary
Blue Tanager	Blue Sackie
Palm Tanager	Palm Sackie
	Cocoanut Sackie
Silver-beak Tanager	Cashew Sackie
White-lined Tanager	Black-sage Sackie
Olive Saltator	Tom-pitcher
Little Boat-tailed Grackle	Blackbird
Guiana Cowbird	Corn-bird
	Lazy-bird
Black Parasitic Cacique	Rice-bird
Yellow-backed Cacique	Yellow Bunyah
	Yellow-backed Mockingbird
Red-backed Cacique	Red Bunyah
	Red-backed Mockingbird
Little Yellow-headed Blackbird	Yellow-head
	Reedbird
Moriche Oriole	Cadoorie
Yellow Oriole	Yellow Plantain Bird
Guiana Meadowlark	Savannah Starling

COLONIAL NAMES OF MAMMALS

Red Howling Monkey	Red Baboon
	Baboon
Spider Monkey	Quata
Ring-tailed Monkey	Capuchin
Squirrel Monkey	Sackiwinki
White-headed Saki	
Red-bellied Saki	Grey Hurua
Beesa Monkey	White-faced Hurua
Vampire	Colony Doctor
	Doctor Blair
Paca	Labba
Agouti	Accourie
Pygmy Tailed Agouti	Adourie
Capybara	Waterhaas
	Waterhare
Jaguar	Tiger
Black Jaguar	Black Tiger
	Black Jaguar
	Maipurie Tiger
Puma	Deer Tiger
Jaguarondi	Hacka Tiger
Eyra	Wild Cat

Ocelot	Tiger Cat
	Labba Tiger
	Margay
Wild Hunting-dog	Warracabra Tiger
	Bush-dogs
Jungle Jackal	Rough Fox
	Crab-dog
Crab-eating Raccoon	Crab-dog
Black and Red Coatis	Kibihee
	Quashi
	Coati
Kinkajou	Potto
	Night Monkey
Grison	Grison
Galictis	Hacka
Otter	Water Dog
Tapir	Maipurie
	Bush Cow
Collared Peccary	Bush Hog
	Black Bush Hog
	Abouyah
White-lipped Peccary	Bush Hog
	Kairuni
Jungle Deer	Wellibicirie
Savanna Deer	Deer
Red Deer	Deer
Manatee	Water Cow
	Sea Cow
	Water Mama
	Quemow
Dolphin	Porpoise
Three-toed Sloth	Grey Sloth
	Ai
Two-toed Sloth	Brown Sloth
	Unau
Small and Medium Armadillos	Yesi
	Tayouay
Peba	Yesi
Great Anteater	Ant-bear
	Tamanoir
	Baraim
Common Opossum	Yawarri
	Crab-eating Yawarri
White-faced Opossum	Quica

CHAPTER X

METHODS OF RESEARCH

To settle down in a strange country and to study successfully the wild creatures which inhabit it, demands a few of the elements of real warfare, combined, however, with a large percentage of luck, the chances of a gamble. But this last comprises, after all, much of the formula of all organic research, the factor which imbues it with the peculiar fascination absent from more mathematically precise phases of work.

With steel traps, guns and cartridges, nets and seines, there is no difficulty in accumulating a host of dead and captive specimens, but this any professional collector could do, and do better, than we. We had to contend with the problems concerned in discovering, watching and finally, if necessary, securing dead or alive, *certain definite* species or groups of organisms. And this was a very different matter, and of all places difficult here in the tropics, where a single glimpse of a certain species might be all that was vouchsafed for many months.

In studying any one group we found it necessary to work out correlated associations with other phases of life, or to watch meteorological conditions. Certain insects emerged only immediately after heavy afternoon rains. If we wished to find birds such as fork-tailed flycatchers during the molting season, we carried the sequence of events one link farther. After heavy rain we searched for a flight of termites in the open, and there we were certain to find the birds. To depend on indirect signs became almost second nature.

Were we desirous of learning the alarm note of the white-fronted antcatcher? That spry little bird of the jungle undergrowth with its erect halo of snow-white plumes could always be counted on in the van of an army of driver ants. But to locate the ants themselves in the jungle was easy only after we had learned to listen for the mingled chirps of the smaller, more voluble species of antbirds which had adopted this easy method of securing a supply of insect food.

We came with a supply of small mouse traps and larger steel ones, and, after we arrived, made box and figure-of-four traps. But we had overlooked the fact that this was a world of hungry ants, and for a time our collector had poor success. For the most easily trapped mammal would hesitate at a delectable bait, when it was covered three deep with stinging ants. Then elaborate ant-proof contrivances were evolved, guarded by moats and slightly raised platforms and zones of sticky sap. But this brought the bait to the notice of stray vultures and after that we were kept busy releasing the yellow-headed scavengers which came down from the heart of the sky to the new-found manna. A study of ant diet revealed certain items for which they did not care, and these, chiefly vegetable, were successful, being inedible alike to ant and vulture.

Mice and rats of the jungle were exceedingly difficult to capture. Now and then while out on other work we caught glimpses of them, but they utterly refused to enter the most open trap, set with the most enticing bait. And I was disappointed in the showing of frogs and toads which I wanted to ship north alive. We could hear them at night, and their tadpoles were abundant in the creeks and pools, but a long evening's work with flash and net often yielded a bare half dozen, all perhaps of the same species.

As was more than once the case, my ultimate success in these directions was due wholly to chance, and not at all to any careful planning or invention. I had a deep hole dug at the southern edge of Kalacoon compound, intending to

Photo by W. B.

FIG. 35. JUNGLE PIT NO. 5 WHICH TRAPPED MANY MICE AND AMPHIBIANS.

fill it with refuse. The day after the coolie workmen completed their part I looked in and, to my surprise, saw two frogs of a species new to me, sitting and blinking at one another, while on the opposite side of the bottom of the pit, a wild rat of a rich rufous color was vainly trying to conceal himself beneath a fallen leaf some three sizes too small. I had been uninventive enough never to think of this plan, but at least I did not need a second hint and immediately I set my Indian boys to work, at what was doubtless sheer insanity to them, digging a line of pits along the convict trail which led southward, and several more in the jungle itself. After this, one of us always made a morning's round of pits, as the Canadian hunter visits his beaver and marten traps. Sometimes we made excellent hauls which were all the more enjoyable because our booty was not mangled and half-dead, but alive and well.

Huge beetles and thousand legs blundered into the pits, but we never found a snake or lizard in them. These seemed to feel their way too carefully to be entrapped in any such blatant fashion. Some of the pits were in clay, others in white sand; some caught every heavy rain and had to be provided with life rafts of small pieces of bark so the inmates could keep themselves afloat. The sand pits were eaten away from above by the rains and required redigging every little while. Altogether it was an easy and exciting method of obtaining certain of the lesser ramblers of the night, of whom we otherwise should have learned nothing.

To the nests of solitary wasps, which were one of our chiefest desires, there was little clue except by direct search. Many were found accidentally, and more by seeing the wasp arrive with a load of mortar or a spider. It was tantalizing to watch an interesting species busily at work on the damp clay of one of our pits, making trip after trip to some fascinating cell, and yet to be unable to trace her more than a few yards as she sped swiftly through the maze of vines and leaves. The longest tramp in a distant part of the jungle might result in nothing, while on one's return, if the key had been removed from the microscope case on the table, a new species of wasp would not impossibly be found enthusiastically building in the lock!

Owing to the dullness of our senses and the unwieldiness of our bodies, to study successfully the small folk of the jungle we had to resort to many artificial means, usually some method of causing them to assemble at a desired spot. We have seen how gravitation was used in the case of the pits. We also used scent, such as exposing the female of some insect in an open cage and waiting for males of the same species to come up wind. Or we placed dishes of partly dissolved sugar made still more irresistible by the addition of a little gin, along the trails and seldom failed to find great blue morphos and other butterflies and bees drinking to repletion. A less pleasant but quite as effective method was to carry a jar of carrion to the jungle and there unstopper it, and the host which gathered could be numbered by the score of species. Or the body of a red howling monkey revisited after several days, would furnish such varied specimens as king and yellow-headed vultures, rare and beautiful butterflies and giant-horned scarabs all in blue and copper mail.

The sense of sight was resorted to by placing the wings of a metallic morpho in the band of one's helmet, as a miner carries his lighted lamp, when any of these wary butterflies within sight would usually deflect their flight and descend to within easy reach of the net.

A third sense—that of hearing—was a fertile source of profit. The old, old trick of squeaking like a young bird in trouble was as effective in the tropics as elsewhere, more so perhaps, for it never failed to elicit some response from the smaller pugnacious people of the jungle. From an apparently deserted part of the forest I have summoned a noisy flock of many species, coming from nest or food. Even when they arrived within sight, they could not but continue to believe that somewhere there was a friend in trouble and some of the smaller ones would come within a foot or two of my face. After a suspicious bird had given the alarm and all had scattered, a wait of ten minutes would restore perfect confidence in the deceit.

Much more interesting than any of these artificial methods was to learn the secrets of the jungle and find some outburst of blossoms or wholesale ripening of a treeful of fruit or berries, or the maturing of a harvest of nuts on some forest giant. For these were magnets which drew creatures, often in hundreds, from miles in every direction. A blind built in such a place was well worth occupancy for many hours. Favorite roosting trees were another source of observation and of netting the birds, which lost much of their fear of man as twilight approached. Finally, and most delightful of all, it was a joy to find an occupied nest, such as that of some little jungle manakin, low down in an accessible spot. With this as a localized lure, a magnet which for a time bound two birds to a single spot in space, one merged oneself as much as might be into the surroundings and keenly watched all the matters of home life which were vouchsafed to the mere outsider.

Only when we encountered such singular creatures as the hoatzins, which, to their peculiar physical and hereditary interests add a static mode of life and habitat which is almost vegetative, do we appreciate the difficulties of finding and keeping under continual observation other more active organisms—cursorial or volant.

A colony of vampires had long been in possession of a hollow under the roof of Kalacoon. We left them undisturbed for we desired to watch them and learn something of their habits. Their wings swept our faces throughout the night, but they never molested us even when we ceased to keep the vampire lantern alight. We began our campaign for securing young bats by the crude method of waiting with a 22-calibre rifle for them to alight on a favorite spot on the lofty rafters. This resulted in the indiscriminate killing of several, but left us still in complete ignorance as to the young.

A second plan was immediately successful and in quite a wholesale way. In the late afternoon we suspended a light net from the outside eaves, so that it hung downward over the entrance to the "battery." In an hour vampires began to fly out and become entagled in the meshes. One after the other we freed and examined them, liberating all but the very young ones. The net was later removed, the colony remained intact, and we had achieved our desires.

These and scores of other tricks of the trade were learned by constant experience. At first all we could do was to walk silently through the underbrush or squat motionless at the foot of some great tree in a likely looking spot. And even after years of jungle observation I still resort to these two methods again and again. They are the ones where pure luck enters in, and every carefully taken step is a gamble, every passing minute of waiting is filled with expectancy. Silence and apparently lifeless surroundings may be the reward, or suddenly there may be perceived some new strange creature or some unimagined habit. It was while taking shelter from the rain in a great hollow tree on the present expedition that I first saw a tinamou—one of the large species—mounting a slanting tree-trunk. And this was the final proof which was all I wanted to put the seal of certainty upon the careful investigation which I had undertaken.

NOTE—Jungle pit No. 5 (Fig. 35, page 149), was the scene of the wonderful ant battle which I have described elsewhere (*Atlantic Monthly,* April, 1917, page 514).

Photo by P. G. H.

FIG. 36. CANJE CREEK, SHOWING MUCKA-MUCKA AND BUNDURI PIMPLER, HOME OF THE HOATZIN.

CHAPTER XI

FURTHER NOTES OF THE LIFE HISTORY OF HOATZINS

The hoatzin is a bird of such unusual interest that whenever my travels take me near its haunts I spend every possible moment in observing it. So thoroughly does it seem to embody the spirit of past bird life on the earth that I have an *idée fixe* that if only I can watch it long enough, with sufficient keenness and controlled imagination, some significant hint of avian evolution is certain, sooner or later, to be revealed. More than anything of which I know, this strange bird is to me an inspiration to keep hoping and working for more light on this fascinating phase of terrestrial evolution.

I have already published in an early number of Zoologica my observations on the hoatzins of Venezuela and of Abary Creek, British Guiana.[1]

During the present year I found it advisable to establish our Tropical Research Station in the interior of the country, far from the haunts of the hoatzins. In spite of my utmost efforts I could get nothing but conflicting statements as to the nesting season. At last I decided to visit Berbice in the hope of accomplishing three distinct things; to photograph young hoatzins in the acts of climbing, walking and swimming, to obtain material for a group of these birds for the American Museum and to attempt to bring living specimens north to the New York Zoological Park.

On May 25, with Hartley and Howes, my two assistants, I took train at Georgetown and in four hours traversed the coastal front of British Guiana, ending our journey at New Amsterdam on the Berbice River. Here, with headquarters at the Government Colony House we remained for three days, making trips to various sugar plantations and up

[1] *Zoologica,* I, No. 2, 1909, "Ecology of the Hoatzin," pp. 45-66.

Canje Creek and the Berbice. Then sending my companions back to Kalacoon I remained a day longer to attend to the packing of the group material and to complete the photography of the young birds. Thanks to the intelligent sympathy and great assistance of Edgar Beckett we were quickly oriented and able to make use of every moment of our time. In this brief visit I successfully achieved the first two objects which I had in mind. The third I was compelled to postpone until another year.

In addition to the observations I recorded seven and eight years ago, I succeeded during this last visit in noting certain new habits which help to round out the life history of these strange birds.

These I have assembled in the following section, reserving for a third the more general notes which I have chosen to present in much the same form as I wrote them in my journal in the field. The desultory character of the notes is due to the shortness of the time I was able to spend with the birds. Most of the observations are new and add to our general knowledge of these strange creatures, and to the material, which at some future time I shall assemble in monographic form.

The flight of the hoatzin resembles that of an overfed hen; its voice is no more melodious than the cry of a peacock, and less sonorous than an alligator's roar. Its grace is batrachian rather than avian, while the odor of its body resembles that of no bird untouched by dissolution. Still the hoatzin remains the most remarkable and interesting bird living on the earth today.

It has successfully defied time and space. For it, the dial of the ages has moved more slowly than for the rest of organic life, and although living and breathing with us today, yet its world is an affair of two dimensions—a line of thorny saplings threaded along the muddy banks of a few tropical waters.

Photo by W. B.

FIG. 37. MUCKA-MUCKA, CHARACTERISTIC GROWTH OF THE HOATZINS' HAUNTS.

A bird in a cage cannot escape and may be found month after month wherever the cage is placed; a stuffed bird in a case may resist dissolution for a century. But when we go to look for the bluebirds which nest in the orchard they may have flown a half-mile away in their search for food; the plover which scurries before us today on the beach may tonight be far away on the first lap of his seven-thousand-mile flight to the southward. The hoatzin's status lies rather with the caged bird. In November, in New York City, an Englishman from British Guiana said to me, "Go to the Berbice River, and at the north end of the town of New Amsterdam in front of Mr. Beckett's house you will find hoatzins." Six months later, as I drove along a tropical river road I saw three hoatzins perched on a low thorn bush at the river's edge in front of a house. And the river was the Berbice, and the house that of Mr. Beckett.

Thus are the hoatzins independent of space as all other flying birds know it, and in their classic reptilian affinities, voice, actions, arms, fingers, habits, they bring close the dim epochs of past time and renew for our inspection, the youth of bird life on the earth. It is discouraging even to attempt to translate facts of such tremendous import, habits fraught with so profound a significance into words, or to make them realistic even with the aid of photographs.

We took a boat opposite Beckett's house and paddled slowly with the nearly flood tide up the Berbice River. It was two o'clock, the hottest time of the day. For three miles we drifted past the chosen haunts of the hoatzins. All were perched in the shade, quiet in the violent heat, squatting prostrate or sleepily preening their plumage. Now and then we saw a bird on her nest always over the water. If she were sitting on eggs she sat close; if young birds were in the nest she half crouched, or perched on the rim, so that her body cast a shadow over the young.

The vegetation was not varied. Mucka-mucka was here and there in the foreground, with an almost solid line of bunduri pimpler or thorn tree (*Drepanocarpus lunatus*). This was the real home of the birds, and this plant forms the background whenever the hoatzin comes to mind. This growth loves the water and crowds down so that the rising of the tide, whether salt or brackish, covers the mud in which it grows, so that it appears as aquatic as the mangrove which, here and there, creeps out alongside it. The pimpler bears thorns of the first magnitude, often double, recurved and at such diabolically unexpected places, that like barbed wire, it is impossible to grasp anywhere without drawing blood. Such a chevaux-de-frise would defend a trench against the most courageous regiment. The stems were light grey, greening toward the younger shoots, and the foliage was pleasantly divided into double lines of locust-like leaflets. The plants were in full flower, dainty, upright panicles of wisteria-like pea blossoms, pale violet and white with tiny buds of magenta. A faint, subdued perfume drifted from them through the tangle of branches. The fruit was ripening on many plants, clusters of green, semi-circular, flat, kidney pods. The low branches stretched gracefully waterwards in long sweeping curves, and on these at a fork or at the crossing of two distinct branches, the hoatzins placed their nests, and with the soft-tissued leaflets they packed their capacious crops and fed their young.

Besides these two plants, which alone may be considered as forming the principal environment, two blooms were conspicuous at this season; a deep calyxed, round blossom of rich yellow—an hibiscus, which the Indians called makoe, and from the bark of which they made most excellent rope. The other flower was a vine which crept commonly up over the pimpler trees, regardless of water and thorns, and hung out twin blossoms in profusion, pink or pinkish-white, trumpet shaped with flaring lips—an Echites of sorts.

The mid-day life about this haunt of hoatzins was full of interest. Tody-flycatchers of two species, yellow-breasted and streaked were the commonest birds, and their little homes, like bits of tide-hung drift, swayed from the tips of the pimpler branches. They dashed to and fro, regardless of the heat, and whenever we stopped, came within a foot or two, curiously watching our every motion. Kiskadees hopped along the water's edge in the shade, snatching insects and occasionally splashing into the water after small fish. Awkward Guiana green herons, not long out of the nest, crept like shadow silhouettes of birds close to the dark water. High overhead, like flecks of jet against the blue sky, the vultures soared.

Green dragonflies whirled here and there, and great blue-black bees fumbled in and out of the hibiscus, yellowed with pollen and too busy to stop a second in their day-long labor. This little area held very strange creatures, some of which we saw even in our few hours' search. Four-eyed fish skittered over the water, pale as the ghosts of fish, and when quiet, showing only as a pair of bubbly eyes. Still more weird hairy caterpillars wriggled their way through the muddy, brackish current—aquatic larvae of a small moth which I had not seen since I found them in the trenches at Pará. The only sound at this time of day was a drowsy, but penetrating *tr-r-r-r-p!* made by a green-bodied, green-legged grasshopper of good size whose joy in life seemed to be to lie lengthwise upon a pimpler branch, and skriek violently at frequent intervals, giving his wings a frantic flutter at each utterance, and slowly encircling the stem.

In such environment the hoatzin lives and thrives, and thanks to the strong body odor has existed from time immemorial in the face of terrific handicaps. The odor is a strong musky one, not particularly disagreeable. I searched my memory at every whiff for something of which it vividly reminded me, and at last the recollection came to me—the smell, delectable and fearfully exciting in former years—of elephants at a circus, and not altogether elephants either—but a compound of one-sixth sawdust, another part peanuts, another of strange animals and three-sixths swaying elephants. That to my mind, exactly describes the odor of hoatzin as I sensed it among these alien surroundings!

As I have mentioned, the nest of the hoatzin was invariably built over the water, and we shall later discover the reason for this. The nests were sometimes only four feet above high water, or equally rarely, at a height of forty to fifty feet. Six to fifteen feet included the zone of four-fifths of the nests of these birds. They varied much in solidity, some being frail and loosely put together, the dry dead sticks which composed them, dropping apart almost at a touch. Usually they were as well knitted as a heron's, and in about half the cases consisted of a recent nest built upon

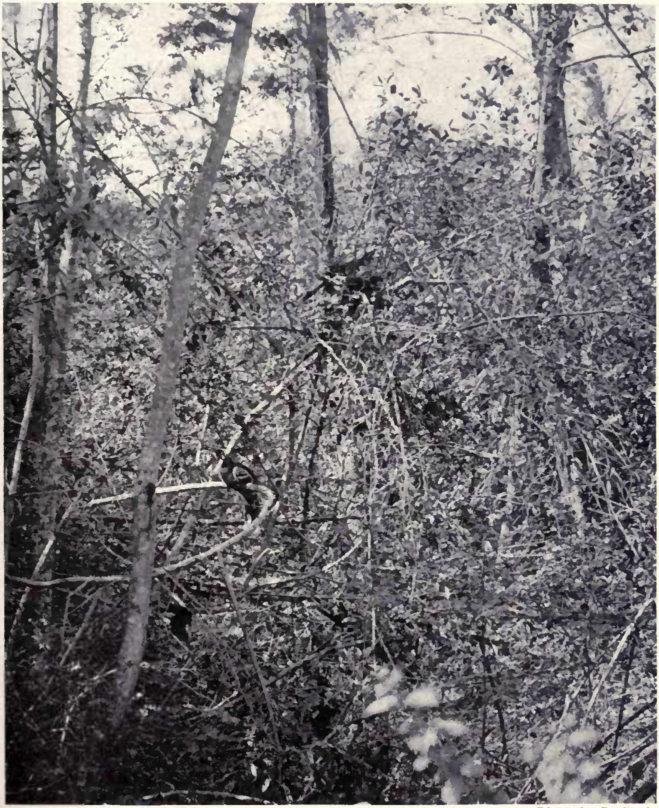


Photo by P. G. H.

FIG. 38. BUNDURI PIMPLER TANGLE, SHOWING THREE NESTS AND SIX HOATZINS.

the foundations of an old one. There was hardly any cavity at the top and the coarse network of sticks looked like a precarious resting place for eggs and an exceedingly uncomfortable one for young birds.

Photo by W. B.

FIG. 39. NEST OF THE HOATZIN BUILT ON A MANGROVE OVER THE WATER.

When we approached a nest the occupant paid no attention until we actually came close to a branch or shook it. She then rose, protesting hoarsely, and lifting wings and tail as she croaked. At the last moment, often when only a yard away, she flew off and away to a distance of fifty feet or more. Watching closely, when she realized that we really had intentions on her nest she returned and perched fifteen or twenty feet away, croaking continually, her mate a few feet farther off, and all the hoatzins within sight or hearing joining in sympathetic disharmony, all with synchronous lifting of tail and wings at each utterance. The voice of the female was appreciably deeper than that of the male, having more of a gurgling character, like one of the notes of a curassow. The usual note of both sexes is an unwritable, hoarse, creaking sound, quite cicada or frog-like. Their tameness was astounding, and they would often sit unmoved, while we were walking noisily about or focussing the camera within two yards. If several were sitting on a branch and one was shot, the others would often show no symptoms of concern or alarm, either at the noise of the gun or the fall of their companion. A bird which may have been crouched close to the slain bird would continue to preen its plumage without a glance downward. When the young have attained their first full plumage it was almost impossible to distinguish them from the older members of the flock except by their generally smaller size.

But the heart of our interest in the hoatzins centered in the nestlings. Some kind Providence directed the time of our visit, which I choose against the advice of some of the very earliest inhabitants of New Amsterdam. It turned out that we were on the scene exactly at the right time. A week either way would have yielded much poorer results. The nestlings in seven occupied nests, observed as we drifted along shore, or landed and climbed among the thorns, were in an almost identical stage of development. In fact the greatest difference in size occurred between two nestlings of the same brood. Their down was a thin, scanty, fuzzy covering, and the flight feathers were less than a half inch in length. No age would have showed to better advantage every movement of wings or head.

When a mother hoatzin took reluctant flight from her nest, the young bird at once stood upright and looked curiously in every direction. No slacker he, crouching flat or awaiting his mother's directing cries. From the moment he was left alone he began to depend upon the warnings and signs which his great beady eyes and skinny ears conveyed to him. Hawks and vultures had swept low over his nest and mother unheeded. Coolies in their boats had paddled underneath with no more than a glance upward. Throughout his week of life, as though his parents' and their parents' parents' lives, no danger had disturbed their peaceful existence. Only for a sudden wind storm such as the week before had upset nests and blown out eggs, it might be said that for the little hoatzin chicks life held nothing but siestas and munchings of pimpler leaves.

But one little hoatzin, if he had any thoughts such as these, failed to count on the invariable exception to every rule, for this day the totally unexpected happened, and fate, in the shape of enthusiastic scientists, descended upon him. He was not for a second disconcerted. If we had concentrated upon him a thousand strong, by boats and by land, he would have fought the good fight for freedom and life as calmly as he waged it against us. And we found him no mean antagonist, and far from reptilian in his ability to meet new and unforeseen conditions.

His mother, who a moment before had been packing his capacious little crop with predigested pimpler leaves, had now flown off to an adjoining group of mangroves, where she and his father croaked hoarse encouragement. His flight feathers hardly reached beyond his finger tips and his body was covered with a sparse coating of sooty black down. So there could be no resort to flight. He must defend himself, bound to earth like his assailants.

Hardly had his mother left when his comical head, with thick, blunt beak and large intelligent eyes appeared over the rim of the nest. His alert expression was increased by the suspicion of a crest on his crown, where the down was slightly longer. Higher and higher rose his head, supported

Photo by P. G. H.

FIG. 40. HOATZIN ON NEST CONTAINING TWO NESTLINGS.

on a neck of extraordinary length and thinness. No more than this was needed to mark his absurd resemblance to some strange, extinct reptile. A young dinosaur must have looked much like this, while for all that my glance revealed, I might have been looking at a diminutive Galapagos tortoise. Indeed this simile came to mind often when I became more intimate with nestling hoatzins. Sam, my black tree climber, kicked off his shoes and began creeping along the horizontal limbs of the pimplers. At each step he felt carefully with each calloused sole in order to avoid the longer of the cruel thorns, and punctuated every yard with some gasp of pain or muttered personal prayer, "Pleas' doan' stick me, Thorns!" At last his hand touched the branch, and it shook slightly. The young bird stretched his mittened hands high above his head and waved them a moment. With similar intent a boxer or wrestler flexes his muscles and bends his body. One or two uncertain, forward steps brought the bird to the edge of the nest and at the base of a small branch. There he stood and raising one wing leaned heavily against the stem, bracing himself. My man climbed higher and the nest swayed violently. Now the brave little hoatzin reached up to some tiny side twigs and aided by the projecting ends of dead sticks from the nest, he climbed with facility, his thumbs and fore fingers apparently being of more aid than his feet. It was fascinating to see him ascend, stopping now and then to crane his head and neck far out, turtle-wise. He met every difficulty with some new contortion of body or limbs, often with so quick or so subtle a shifting as to escape my scrutiny. Once he even chinned himself. The branch ended in a tiny crotch and here perforce, ended his attempt at escape by climbing. He stood on the swaying twig, one wing clutched tight and braced with both feet. Nearer and nearer crept Sam. Not a quiver on the part of the little hoatzin. We did not know it, but inside that ridiculous head there was definite decision as to a deadline. He watched the approach of this great strange creature, this danger, this thing so wholly new and foreign to his experience and doubtless to all the generations of his forebears. A black hand grasped the thorny branch six feet from his perch, and like a flash he played his next trick—the only remaining one he knew—one that set him as apart from all modern land birds as is the frog from the swallow.

The young hoatzin stood erect for an instant, and then both wings of the little bird were stretched straight back, not folded, bird-wise, but dangling loosely and reaching well beyond the body. For a considerable fraction of time he leaned forward. Then without effort, without apparent leap or jump he dived straight downward, as beautifully as a seal, direct as a plummet and very swiftly. There was a scarcely noticeable splash and as I gazed with real awe, I watched

Photo by P. G. H.

FIG. 41. NESTLING HOATZINS PROGRESSING ON ALL FOURS AND PREPARING TO CLIMB OR TO DIVE FROM THE NEST.

the widening ripples which undulated over the muddy water —the only trace of the whereabouts of the young bird.

It seemed as if no one, whether ornithologist, evolutionist, poet or philosopher could have failed to be profoundly impressed at the sight we had seen. Here I was in a very real, a very modern boat, with the honk of motor horns sounding from the river road a few yards away through the bushes, in the shade of this tropical vegetation in the year nineteen hundred and sixteen, and yet the curtain of the past had been lifted, and I had been permitted a glimpse of what must have been common in the millions of years ago. It was a tremendous thing, a wonderful thing to have seen and it seemed to dwarf all the strange sights I had seen in all other parts of the earth's wilderness. I had read of these

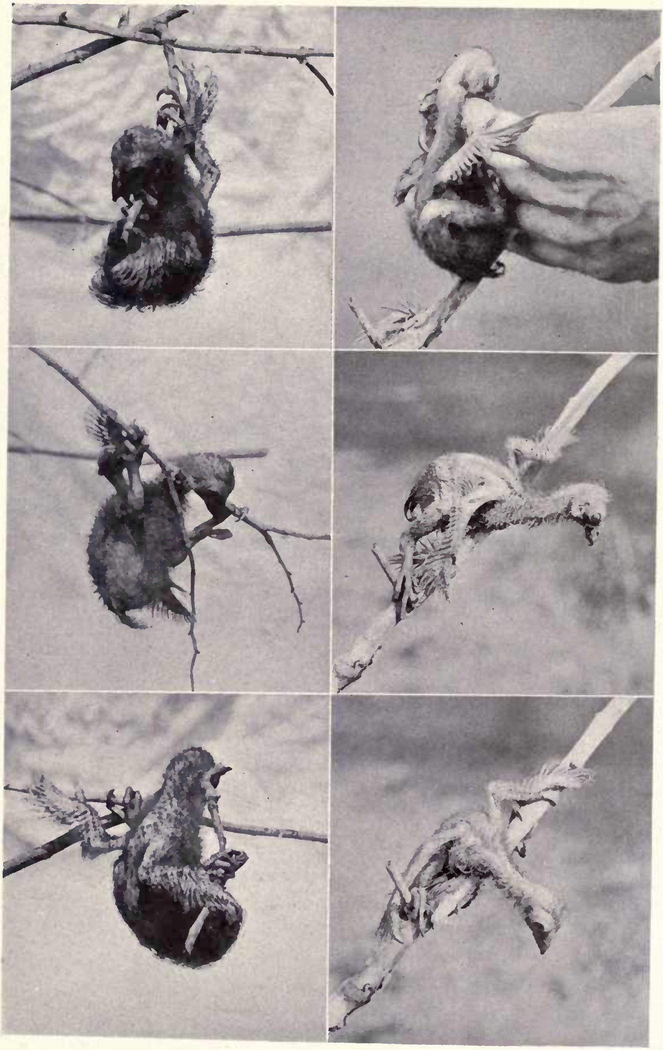


FIG. 42. YOUNG HOATZINS CLIMBING BY MEANS OF NECK, FINGERS AND TOES

habits and had expected them, but like one's first sight of a volcano in eruption, no reading or description prepares one for the actual phenomenon.

I sat silently watching for the reappearance of the young bird. We tallied five pairs of eyes and yet many minutes passed before I saw the same little head and emaciated neck sticking out of the water alongside a bit of drift rubbish. The only other visible thing was the protruding spikes of the bedraggled tail feathers. I worked the boat in toward the bird, half-heartedly, for I had made up my mind that this brave little bit of atavism deserved his freedom, so splendidly had he fought for it among the pimplers. Soon he ducked forward, dived out of sight and came up twenty feet away among an inextricable tangle of vines. I sent a little cheer of well wishing after him and we salvaged Sam.

Then we shoved out the boat and watched from a distance. Five or six minutes passed and a skinny, crooked, two-fingered mitten of an arm reared upward out of the muddy flood and the nestling, black and glistening, hauled itself out of water. Thus must the first amphibian have climbed out, shaken the water from its eyes and gasped in the thin air. But the young hoatzin neither gasped nor shivered, and seemed as self-possessed as if this were a common occurrence in its life. There was not the slightest doubt, however, that this was its first introduction to water. Yet it had dived from a height of fifteen feet, about fifty times its own length, as cleanly as a seal leaps from a berg. It was as if a child should dive two hundred feet!

In fifteen minutes more it had climbed high above the water and with unerring accuracy directly toward its natal bundle of sticks overhead. The mother now came close and with hoarse rasping notes and frantic heaves of tail and wings lent encouragement. Just before we paddled from sight, when the little fellow had reached his last rung, he partly opened his beak and gave a little falsetto cry—a clear, high tone, tailing off to a gutteral rasp. His splendid courage had broken at last; he had nearly reached the nest and he was aching to put aside all this terrible responsibility, this pitting of his tiny might against such fearful odds. He wanted to be a helpless nestling again, to crouch on the springy bed of twigs with a feather coverlet over him and be stuffed at will with delectable pimpler pap. Such is the normal right destiny of a hoatzin chick and the *wheee-og!* wrung from him by the reaction of safety, seemed to voice all this.

I have more than once emphasized the extremely sedentary character of the hoatzin, which is not surprising when we correlate the factors of weak flight and exceedingly limited aboreal environment. Twice I have seen interesting episodes which were significant from this very viewpoint. In the Berbice River and still more in its tributary, the Canje Creek, floating islands are not uncommon. Indeed, some distance up where the creek is quite narrow, these wandering bits of vegetation occasionally extend from bank to bank. At such places the river disappears wholly from view and one sees only two parallel rows of bushes and trees with a green, level lawn spread between. These floating masses are constantly breaking up and drifting out to sea. Usually they are composed of three distinct plants, a sort of floating Polygonum, a Panicum locally known as Missouri grass and a Pontederia. The latter is the most attractive as it bears pale flowers like little hyacinths. Occasionally boughs or full-sized trees are seen passing down stream with the current.

Twice I have seen hoatzins, a single bird in one instance and two at another time, perched in branches which, low in the grassy mass, were floating steadily down and revolving as they went. In the case of the two birds I was in a particularly favorable place for observation and could command at least a half mile of creek, and from the time they appeared until the great mat swept around the farthest curve, the birds did not move. If they did not fly ashore before they reached the Canje bridge, a few miles below, they must have been carried out to sea.

We must assume either that this was a voluntary migration, which would be retraversed by many a slow, painful, flapping flight, or that the birds were young, newly mated and actually shifting their haunts from far up stream to nearer the mouth. The latter view is much the more probable and would go far toward clearing up the problem of the distribution of these birds. Schomburgk, in the second volume of his *Reisen in Britisch Guiana,* writes that "Die westliche Kette des Canuku-Gebige endet sich in den 2,000 Fuss hohen Curatawuiburi," and near here he found an isolated colony of hoatzins. Wilgress Anderson reports another on the Takutu River, a northern tributary of the Amazon, between British Guiana and Brazil, while H. C. P. Melville, Magistrate of the Rupununni District, writes that while hoatzins are plentiful on the Takutu, they are not found on the Rupununni, although conditions on both rivers are very similar. In the lower reaches of the Abary River, twenty-five miles northwest of the Berbice, hoatzins are abundant, and elsewhere in Venezuela, Brazil and other portions of the birds' range I have observed this peculiar nodal occurrence. The most reasonable explanation would seem to be a migration of one or more pairs in some such way as I have described, which would readily account for the hiatus of intervening territory, devoid of hoatzins while environmentally it may be perfectly suited to their needs.

Judging by the reports of other observers and from the opinion of Edgar Beckett who has lived for many years in New Amsterdam, the hoatzins are holding their own and are not decreasing either on the Berbice River or along the banks of Canje Creek. The birds are on the First Protected List which means that they are not allowed to be shot at any time, and in addition there is a special fine of five pounds sterling for killing one of them.

The nesting season of hoatzins has been variously stated to be in January, April, July and October. I found evidence that the birds of this region, like many other tropical species, have two periods of breeding. In every small flock of hoatzins I observed immature individuals in adult plumage, but of considerably smaller size, which I estimated to be about six or seven months old. In late May, I found a few nests with eggs, but the great majority contained young of about two weeks of age. These facts would indicate that the beginning of the two breeding seasons was in November and April. While the birds may, as individuals, nest off and on throughout the period from November to May, yet from what I saw of the two very distinct stages of nestlings and three-quarter grown birds, the two annual breeding seasons are quite clearly defined.

As to the relative number of eggs and young, seventy-five per cent of the nests contain two eggs, while three eggs are found in about one-quarter of the nests. When the young birds have reached the age of two weeks, the relative numbers already show the effect of some inimical factor in the environment. One-half of the nests now contain only one young bird; forty per cent hold two young, while those with three young amount only to ten per cent of the whole. In fact, I found only two broods of three young, and it was interesting to observe that in both cases three nests were superimposed one upon the other, as if the same pair of birds had been unusually successful in establishing their home year after year in the same place. And the full complement of young bore testimony to the fact of their parents' ability to meet the difficulties and cope with the dangers of the breeding season.

As I have stated elsewhere, the nests are invariably built over the water, but two which I found were so placed, that at low tide the mud of the river's edge was exposed directly beneath. This was decidedly an error of judgment on the part of the parent birds. Whenever a nest was threat-

Photo by W. B.

FIG. 43. NEST AND TWO EGGS OF THE HOATZIN.

ened and the nestling hoatzin found its retreat to the upper branches cut off, without hesitation it dived into the water below. But when I alarmed the young birds of these two nests, the youngsters all but dislocated their necks by diving headlong into the soft mud. One fairly stuck, legs in air, head down in a crab's hole for a few seconds. They then wriggled free and in frantic haste scrambled and slithered on all fours and belly to the edge of the water. The pitiful, whole-hearted trust, instinctive though it was, which they placed in their parents' judgment was most interesting.

These birds of two weeks were in excellent condition for showing to the best advantage their famous ability of quadrumanual climbing and skillful diving and swimming.

One point interested me keenly. When the wings of the nestling were closed, the claws of the thumb and fore-finger pointed down and inward, lying closely apposed to the wing, and well out of harm's way. They were sheathed, as it were, between wing and body. The movement of extension caused the claws to be released and at the same time to revolve in a full quarter of a circle, pointing thus directly forward and inward. This becomes of dominant significance when we recall the position of the claws in the fossil specimens of Archaeopteryx. Recently, when reviewing the characters of this wonderful creature with a view to restoration, I was in great doubt about accounting for the position of the claws in the partly spread wing. It seemed almost as if the forward, inward pointing claws had been accidently crushed into that position by pressure after the bird's death, or by some flexure of the muscles and tendons after decomposition. But when I saw the automatic rotation of the claws in the young hoatzin as its wing spread, I realized that the conditions were identical in the two forms, and that the unusual posture of the claws in Archaeopteryx was, after all, quite normal. It is a position wholly unlike that in the wing claws of any other bird. The twist occurs chiefly in the phalangial joint, but partly as well in the basal joint of the thumb.

I was surprised to learn how exclusively arboreal were these nestling hoatzins. I once saw an adult bird alight on the ground, but rather from inability to fly farther than of its own intention. When Schomburgk, in the third volume of his *Reisen in Britisch Guiana,* writes that he saw a flock of several hundred which "chased each other from branch to branch, while others ran about upon the ground," he was either romancing or else confused these birds with trumpeters. They do not run nor even walk upon the ground.

My young hoatzins were as helpless as seals on solid ground, their toes crumpling up and their feet practically useless for progression. In attempting to go ahead the bird fell forward, extended its wings wide and clawed vigorously at the ground, pulling itself awkwardly along, while the feet

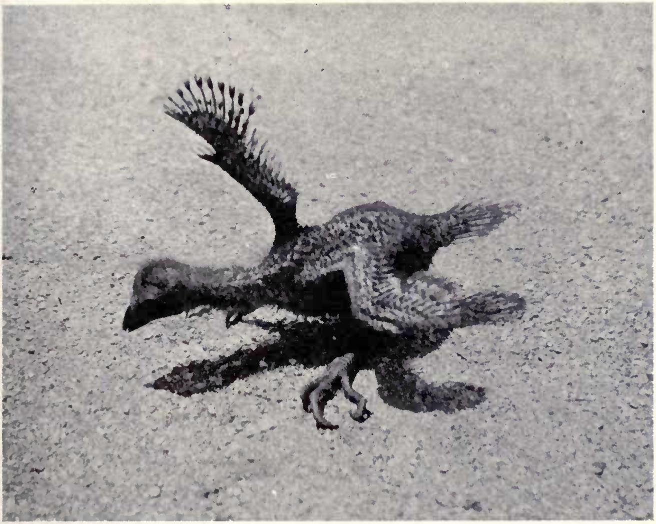


Photo by P. G. H.

FIG. 44. YOUNG HOATZIN ATTEMPTING TO PROGRESS ON SOLID GROUND.

kicked out helplessly behind. In this mode of progress it closely resembled a sloth on solid ground.

If a single straight twig were brought within reach, the head was crooked over it to such an extent that the bill was upside down and the upper neck bent into a complete circle. With this grip once secured the bird hung suspended, and reached frantically upward with feet and wings, the feet nearer the head, the wings farther away. Usually a claw on the fore-finger was the first to catch. This secured, the long middle toe of the opposite foot curled around the stem.

Straining steadily, the little bird chinned itself and for a moment stood upright. The head loosened and rose in mid-air, the wing claws uncurled and the skinny pinions reached toward the sky. It was an epitome of its past evolution; it was a bird at last.

But the victory was momentary. A frantic wave and clutch at the empty air, and it pitched forward and hung upside down. This time it was suspended by the toe grip, which, useless upon level ground, was its strongest safeguard among branches. It was almost impossible to pull a fledgling hoatzin from the branch when once its feet had obtained a firm hold. Each toe had to be uncurled in turn. The second righting was a quicker matter, more skillfully achieved. The chin hold was taken at once and the wing claws followed. If a well-twigged branch were now placed within reach, the bird easily retained its upright position and climbed with facility, wing over wing.

The illustrations from drawings, of the young hoatzins, which for many years have done duty in volume after volume of our ornithological literature, are almost without exception incorrect. To consider only one instance, the widely copied drawing by Baldwin, which first appeared in the publications of the United States National Museum, errs in representing the young bird as gripping a twig in its mandibles. In all my experience I have never observed this, although the chin hold is the most common method of beginning a climb. It is this habit, which, carelessly observed, led to the mistaken idea that the bird actually grasped the twig in its beak. In the same drawing the second hoatzin nestling is shown as standing almost flat-toed on the upper surface of a branch, a position which, as we know from its inability to stand for a moment upon flat ground, is impossible.

In the water I found that the young hoatzin displayed two very distinct methods of progression. If dropped into a deep basin or tub, it always landed head first, even when it had to turn partly over in mid-air to accomplish this. Almost at once it came to the surface, the head, neck and tail-feathers projecting, and the back being flush with the surface. It would start to swim immediately, easily but slowly. It held its wings extended loosely on each side so that they

Photo by W. B.

FIG. 45. YOUNG HOATZIN SWIMMING TOWARD THE RIGHT: HEAD, WINGS, BACK AND TAIL SHOWING.

were just flush or occasionally a little above the surface. The feet alone furnished the means of progression, moving with alternate kicks, the toes reaching out on the forward movement and curling around when the back stroke was made.

If I moved my hand suddenly toward the bird, or even if the shadow cut it off for an instant from the direct sunlight, it dived at once, the first dip carrying it four to six inches beneath the surface. The feet became passive, dangling uselessly and quite relaxed, back of the tail, while the wings, moving together with graceful, synchronous beats, swept the bird forward with strong, rhythmic strokes. Twelve to sixteen inches were covered with each submarine wing beat, the movement and general effect being that of a diminutive penguin.

Photo by W. B.

FIG. 46. YOUNG HOATZIN CLIMBING, SHOWING USE OF THUMB AND FOREFINGER WITH THEIR CLAWS.

The nestling hoatzin could see distinctly beneath the surface and never bumped into submerged branches nor the sides of its small pool, but avoided them with a quick turn. This was achieved either by a stronger stroke of one wing, or by a sudden flick of the long feather sheaths of the tail. Several times I saw birds turn well over on their sides, careening sharply as they banked on some short turn to the left or right. Twenty feet was the greatest distance I saw them swim, but were they forced to do so they could undoubtedly cover several times this distance.

Nothing has been definitely recorded of the method of feeding of the young hoatzins, but this time at a distance of less than fifteen feet, I was able to watch the parent feeding the nestling by regurgitation. It was quite a leisurely affair. The old bird would rise on the nest and without further shifting her position, reach down beneath her and open her bill. The nestling craned his neck upward and thrust his head well down her throat, where he pecked and fed for ten to twenty seconds. Then she righted herself, swallowed several times, shook her head and the feeding was ended.

The keel of the breastbone of these birds is greatly reduced by the abnormally large crop, but the small extent of keel which does succeed in reaching the skin is in constant use as a perching cushion. Even in the nestlings it is splayed out and the skin over it somewhat calloused by the constant pressure of the bird's body against the twigs and branches.

A fact which was quite new to me was the molting of the wing claws. In the two weeks' old nestling these were as curved and sharp as the claws of a cat. Examination of young birds in various stages of growth showed that the claws on both thumb and fore-finger are shed at least twice in the first eight months. This reminded one of the several renewals of the flight feathers in the first few months of life of some other birds, and the cause is doubtless the same —the constant use of the claws and the feathers resulting in considerable wear in a very short time, which for the safety of the young bird must be compensated by constant activity in the renewal of these structures.

When we find the claws in a three-quarter grown bird worn to stubs with no trace of the hooked tip remaining, or perhaps with one claw just shed, and then in fully adult birds with the fresh, sharp, curved talons deep hidden among the long wing feathers, it seems as if Nature had for once nodded, and preserved a character beyond the scope of its usefulness.

The first volume of a book on "The Birds of British Guiana," by Charles Chubb has just appeared. Mr. Chubb has not had the opportunity of observing living hoatzins and this enforced writing at second hand has resulted in a number of errors which should be corrected. First as regards the two figures. That of the head of the bird shows the waving crest too flattened. The bird seems to have little or no control over the dermal cranial muscles, and the long, disintegrated crest feathers are always raised, standing almost erect and giving to the bird a wild, startled appearance, even when it is sleepy and about to put head under wing. Figure twelve, the wing of the young bird, is quite wrong in anatomy, both in the number of claws, the position of the thumb and the general proportions. In the measurements of the adult bird the total length is taken evidently from a dried skin, as it is given as 555 millimetres. Even a three-quarters grown bird measures at least 590 mm., while a fully adult hoatzin is not less than 620 mm. in length. In his extralimital range Chubb makes no mention of either Venezuela, Dutch or French Guiana, in all of which countries hoatzins are well known to occur.

The nestling hoatzin shown in my frontispiece photograph was about two weeks old and was taken in a nest on the lower Berbice River on May 26. The following notes characterized all the young birds of this age which I observed or photographed. The short down already showed the pigment patterns of the adult, the sides and flanks being distinctly chestnut, while the secondaries and tail feathers showed the buffy-white markings. The remainder of the down was a dark brownish black, paler on the chin and throat.

There were three thumb feathers in the alula, extending almost to the tip of the claw, but these interfered not at all with its use, as it worked forward and inward, reaching out at right angles to the claw of the first finger. The tail feathers were the longest and strongest of all of the sprouting plumage, this precociousness unquestionably having to do with their rudder function.

The upper mandible was brownish black, the lower greenish horn; the iris, olive-brown; the legs and feet black. These were very large in proportion to the size of the bird.

Thrashing about with their flight feathers through the thorny branches, the plumage of these birds suffers unusual wear and tear, and it is seldom that an individual can be found with perfect wing and tail. The six months' old hoatzins were, however, in full molt. The molt of the five pairs of tail feathers is peculiar, beginning almost simultaneously with the outer and inner pairs and progressing evenly toward the third pair. One bird showing this particularly well had the following retrice formula, the right and left sides corresponding:

1st tail-feather (inner)	three-quarters grown
2nd pair	blood sheath
3rd pair	old, unshed
4th pair	one-quarter grown
5th pair (outer)	new, nearly full-grown

This same individual showed the primaries about half through their molt, which was progressing outward:

1st primary (inner), and 2nd	new, full grown
3rd	nearly grown
4th	blood sheath

5th to 10th	old, unshed, the shafts lined thickly with mallophaga eggs.

The secondaries showed two nodes of molt. Beginning with the 10th a molt was progressing outward, and with the 1st (outer) another molt had commenced inward:

1st secondary (outer)	one-half grown
2nd to 7th	old, unshed
8th and 9th	blood sheaths
10th	one-half grown
11th, etc.	old, unshed

CHAPTER XII

THE HOMES OF TOUCANS

If toucans did not exist, an account of their characteristics, of their form, their color and actions would be considered as the result of a disordered brain, or the wilful representation of a cubist artist, worthy to be depicted as perching on the same branch with a phoenix. But we must accept them as living, breathing birds, whose vivid patterns and penetrating voices announce their presence in abundance in the Guiana jungle. Their legs are short and their arboreal progression is by an absurd hopping; their long tails, frequently in the daytime and always in sleep, are cocked at a seemingly impossible angle over their back; their enormous beaks should belong to birds four times the size of the owners; while through the center of this beak extends a slim, feather-like tongue, occupying the same relative space as would an umbrella-rib in a balloon. All these and other less obvious characters have made of toucans objects of acute interest to ornithologists, and subjects of mirth and wonder to laymen for the two hundred odd years since these birds became fairly well known.

The details of their first discovery are lost to us, but we know that as early as 1599, the old Italian naturalist Ulisse Aldrovandi had distinguished the toucan as Rhamphastos, which means that he was thinking in Greek of its curved beak. In the word toucan, we are speaking, more happily, in the native tongue of South American Indians, who knew these birds and used their plumage for decoration long before Columbus shattered the barriers of their peaceful isolation. There is no doubt but that the skins of the toco toucan were among the first birds to be sent to Europe after the discovery of America.

There are about seventy forms of toucans alive on the earth today, and their home is in the tropical jungles of the New World, from the lowland forests of southern Mexico to the outlying palm groves of northern Argentina. The bill is the dominant character in these birds, occasionally exceeding the body in length and almost equaling it in bulk. In most forms these exaggerated mandibles of horn, together with the bare skin of the face, are stained and splashed with the most brilliant and glaring of pigments. The plumage itself is parti-colored, marked on various parts with patches and bands of bright color.

In spite of the interest—both popular and technical—which these birds have aroused, and the papers and monographs which they have inspired in ornithological literature, their life history has remained almost a blank. Our meagre knowledge of these bizarre forms of life was summed up over a century ago by Levaillant in a single sentence: "Les kouliks sont fort communs a Cayenne, a Surinam, et dans toute la Guyane; ils vivent dans les bois, nickent dans des trous d'arbres, et frequentent les lieux cultives, ou ils causent beaucoup de degate aux fruits."

They thrive well in captivity, but show no inclination to nest or lay eggs. The sole exception is the instance of a toucanet (*Selenidera maculirostris*), which in July, 1913, hatched one young in the London Zoological Gardens. No details were recorded of this interesting occurrence. A supposed egg of the yellow-billed toucan (*Pteroglossus flavirostris*), collected by Indians in Peru has been described several times.[1]

In their tropical haunts toucans are among the most conspicuous of birds, both to the eye, as when a pair flies slowly overhead, or a small flock is seen hopping awkwardly

[1] The most recent reference to this egg is in the Catalogue of Birds' Eggs in the British Museum, III, 1903, p. 137. It is described as "elliptical in shape, the ends being somewhat pointed, moderately glossy, and plain white. The shell is smooth, but is covered with shallow pores and longitudinal furrows or grooves, extending more or less from one end of the egg to the other. It measures 1.3 by .92 inches."

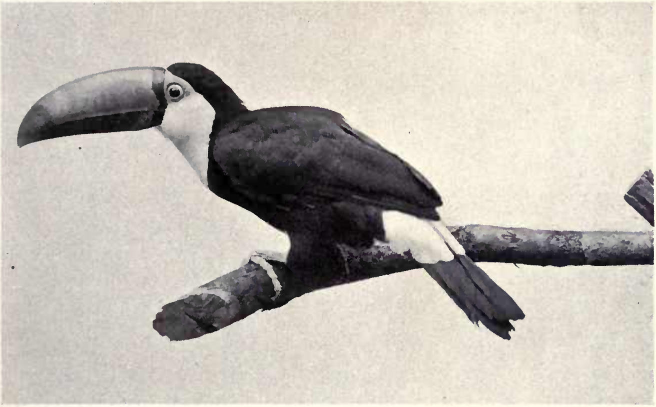


FIG. 47. RED-BILLED TOUCAN

among the branches; and to the ear, as their voices rise above all the usual jungle sounds, both in timbre and in insistant reiteration. And yet toucans might well be as mythical as the phoenix or the roc, for all we know about their home life in the top of the jungle. Up to the present time no definite account exists of the finding of the nest or the eggs and young of any species of these birds. In common with many explorers, I frequently have seen these birds enter and leave holes high up in gigantic forest trees and have longed for the opportunity of looking inside, of learning something more of their intimate lives than a glass and a gun could reveal. So when I planned for a half year or more of intensive study in one tropical locality I placed the discovery of the nest of these birds well up on the list of things which I intended to accomplish.

The excitements, false alarms, disappointments and ultimate successes which marked our effort, would alone fill an entire volume. In the limited area of Bartica District

Photo by P. G. H.

FIG. 48. DEAD TREE SHOWING NESTING HOLE OF GREEN ARACARI TOUCAN

to which we confined our studies we found the following five species of toucans:

Red-billed Toucan	*Rhamphastos monilis* Muller
Sulphur-and-white-breasted Toucan	*Rhamphastos vitellinus* Licht.
Black-necked Aracari	*Pteroglossus aracari* (Linn.)
Green Aracari	*Pteroglossus viridis* (Linn.)
Guiana Toucanet	*Selenidera culik* (Wagler)

Between the dates of March 15 and May 10, we had evidence, either direct, or indisputably circumstantial, of the breeding of all five species, and had secured both eggs and young birds. But these results came only after days and weeks of hard, unremitting search, of long tramps wholly in vain, and of many consecutive hours of steady watching through heat and rain.

GREEN ARACARI TOUCAN
Pteroglossus viridis

On the eighth of March, Hartley returned to Kalacoon with the exciting news that he had seen small aracari toucans entering a hole high up in a dead tree. This was the commonest species of toucan in Bartica district, and this observation was the first to arouse the hopes of an occupied nest. The dead tree stood at the edge of the jungle about a mile away, and was one of the many which had been killed by direct exposure to the sun's rays when the clearing had been made nearby. Its barkless branches stretched high above the surrounding massed foliage, bleached, chalky white, and seasoned hard as iron. On one of the uppermost angles this pair of toucans perched, and worked in alternate shifts at an old woodpecker's hole. They propped themselves against the tree, thrust their great beaks within the hole, and presently drew out and dropped bits of loose, rotten wood. Thus began the nesting of the green aracaris on March 8.

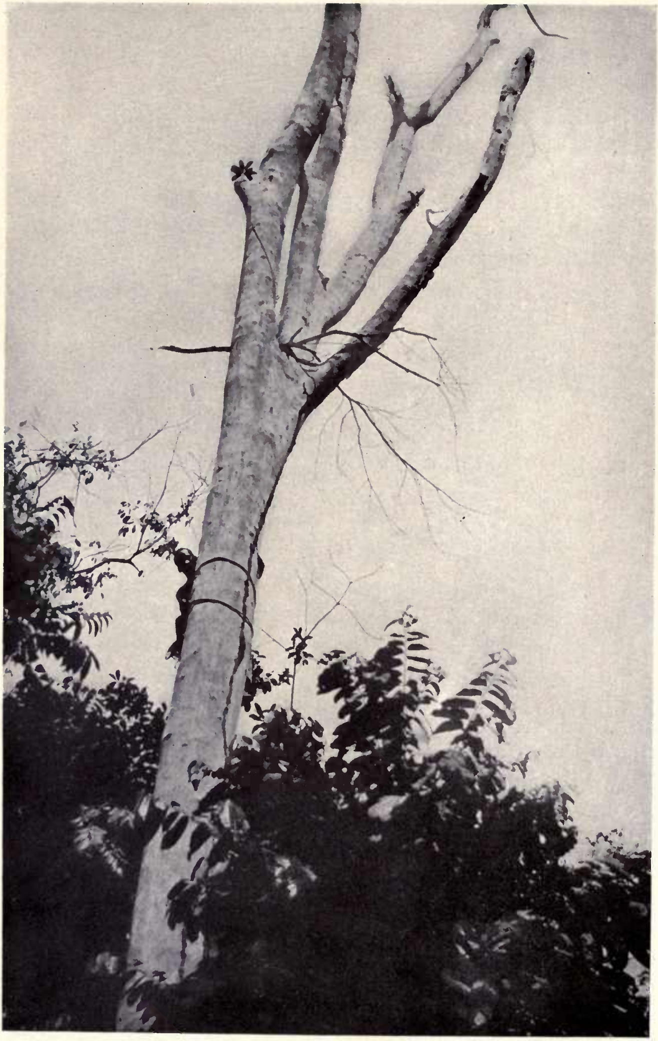


Photo by P. G. H.

FIG. 49. SAM, OUR NEGRO CLIMBER, SIXTY FEET UP TOWARD THE FIRST LIMB OF THE GREEN ARACARI TREE

Two days later one of the birds spent considerable time in the nest, appearing only when its mate approached. At such times she (thus sexed by courtesy) sat with projecting bill, and chattered in low, raucous accents, or accepted offerings in the shape of berries of sorts from her mate's bill. A week later she seemed even more preoccupied and seldom was seen outside. The male now flew direct to the hole and fed her as she sat inside the nest. When within hearing he occasionally uttered a low cicada-like note, repeated three times, *deweeda-deweeda-deweeda,* given with the bill either open or shut.

The tree was a favorite perching place for birds of many species and besides the nest of the toucans, two other holes were occupied, both by red-fronted woodpeckers (*Melanerpes rubrifrons*), whose brilliant black and scarlet forms flashed about the tree all day, or clung like dark shadows to the side of the whitened bole. One of the woodpeckers' nests was only two feet above that of the toucans.

Two weeks after the discovery of the birds' nesting activities we felled the tree. It was an all-day job, and it took our arboreal, all but quadrumanous negro boy Sam several hours to ascend to the first branch and attach a guy rope. His method of climbing was unique and effective, but most laborious. He made two loose slip nooses about the trunk of the tree, and a small hanging loop in each in which he put his feet. With a guy rope tied to his belt, he put his full weight on one loop, and clasping the trunk with one arm, he hitched the second rope up a foot or two and shifted his weight to its loop, the force of the oblique downward pull holding the noose in place on the trunk. Then rope number one had to be pulled and jerked up to the level of the second. And so, foot by foot, this wonderfully muscled and persistent youth hitched and caterpillared his way over sixty feet upward to the lowest branch, guyed it and slid down.

The iron quality of the seasoned trunk turned the edge of two axes, but at last the topmost branch, one hundred

Photo by P. G. H.

FIG. 50. TALL, STRAIGHT NESTING TREE OF RED-BILLED TOUCAN

and fifty feet above the ground, swayed and swept downward. Just before the tree fell and after it had quivered and resounded for hours to the blows of the axe, both toucans entered and left the nesting hole. Exhilarated by this emphatic circumstantial evidence we searched eagerly and found the remains of the hole. We enlisted the aid of a score of coolies, we examined every leaf and blade of grass in the glade, every chip and splinter passed under our scrutiny, but in spite of the most minute examination of the ground, no trace of shell or young was ever discovered. The male bird which we then secured was in full breeding condition, but our first toucan quest, fostered by many days of vivid anticipation, ended in complete failure. There was no shred of doubt that the birds had not yet deposited eggs in the nest which they had so laboriously prepared, and for two weeks had occupied almost constantly.

GUIANA TOUCANET
Selenidera culik

These little green toucans were not common, and it was by sheer accident that we learned anything of their nesting. Whenever I passed near any benab or small hamlet of Indians, usually Akawais, I always asked for news of the various toucans, all five of which they knew well, and for which they had very definite names. As my boat was passing along the west bank of the Mazaruni one day early in April, I saw some Indian women squatting on a sloping rock, vigorously pounding clothes. I sang out and asked in succession for "katching, palaflek and kamata." At the last word an old, old squaw called something, and landing, I found that an Indian in a neighboring benab had two young birds in his possession. A girl consented to show the way, so we entered a narrow trail in the deep jungle and walked several hundred yards to a thatched benab, from which swung two hammocks, and which at this moment sheltered an old tooth-less man, three dogs, two women and four children, two trumpeters, a parrot and a curassow. I looked eagerly about for the young toucanets but the benab held no other visible living creatures than those I have enumerated. Upon inquiry I found that both birds had died that very morning and had been thrown into the river, where of course the perai fish had devoured them at once. I asked to see the nesting tree and was led to a tall palm with a good-sized hole in the western side of the trunk, about thirty feet up. At the edge of the cassava clearing, three toucanets were calling and flying restlessly about, and the Indian woman pointed to these as the owners of the hole. The young birds, the squaw said, had no feathers. This was April 15th, and sums up our experience with nesting toucanets.

A month later we found this species in full molt, shedding not only the body and wing feathers, but scaling off pieces of the beak as well.

RED-BILLED TOUCAN
Rhamphastos monilis

The fates were quite impartial in their distribution of favors, and the next toucanine thrill came to Howes as he was passing along a trail with mind and eyes concentrated on no higher forms of life than wasps and bees. From almost the first walk I had taken in this part of the jungle I had observed and tried to mark down some of the half dozen big red-billed toucans which fed, and called and climbed hereabouts. But they continued to climb, or call or feed as the case might be, and utterly refused to reveal any interest in a possible mate, or nest, or young. Yet the fact that day after day they did not roam widely, but kept within sight or hearing of the trail was suspicious enough to keep alive our constant interest.

Sitting quietly among the undergrowth near the trailside, Howes was endeavoring to follow the gyrations of a small wasp whose actions seemed to indicate that her cell was nearby. Happening to glance upward, he saw a toucan, one of the red-billed species, sitting on a branch close to a hole in a great tree about forty feet from the ground. The bird slipped quietly from sight almost at once, but the evidence was extremely strong. The tree was a kakaralli (*Lecythis* sp.), not of great girth, but tapering so gradually that, sixty feet up, its diameter seemed hardly less than at the ground. While lacking the wide, sweeping buttresses of the morass, it yet gave the impression of tremendous strength and longevity. From its upper branches depended a whole nexus of intertwined lianas, themselves in some cases, as large as good-sized tree trunks.

This was on March 27, and for three days we watched silently and in turn, and at last were satisfied that this was indeed the home of the red-billed toucan. No creature short of a monkey or squirrel could have scaled that great trunk, so on the third day at six o'clock in the morning in a fairly hard rain, we started out on our third toucan adventure.

We cut in turn as usual, five minutes of the punishing effort being all that our muscles and soft palms would stand. The leaves dripped on all sides; they shone and glistened; every twig was black with moisture. Now and then in the midst of the downpour, at an unusually loud ring of the axe, a goldbird called—silvery, piercing, thrilling—a call full of pent-up virility and wildness. Fortunately for us the majestic tree was soft at the heart, else the raw blisters would have compelled us to wait for another day.

The last few cuts were always wildly exciting. A shout from one of the watchers at a distance, warned me that the end was near, although from my place close to the butt no swaying was perceptible. Then I bit deeply with the axe and a faint snap was heard—like the snap of a small twig—the beginning of the death rattle of the splendid giant. There was no need of another cut, the deciding fibre had

Photo by P. G. H.

FIG. 51. NEST OF RED-BILLED TOUCAN SHOWING ENTRANCE AND BASE, THE LATTER OPENED OUT WITH AX

Photo by P. G. H.

FIG. 52. EGGS AND NESTING MATERIAL OF RED-BILLED TOUCAN

been cleft. No human power could now undo the harm already wrought, yet for a few seconds which seemed minutes, there was no movement, no sound. Even the rain had ceased. The goldbirds were silent.

Then, still without a sound, the great trunk gently leaned away, and slowly, very slowly, began its final descent. A huge liana cable, half way up, snapped with a sharp report, then there were no more isolated sounds, but a gradually ascending roar, like the sudden onslaught of a great hurricane. Trees, saplings and palms, whole riggings of lianas, and finally shrubs and tree-ferns went down like grass before the terrific impact of the tree. With a deep reverberating boom the trunk struck the ground and rebounded. It was a hollow, subdued explosion of sound as of some subterranean catastrophe, and was plainly heard at the laboratory, two miles away. The trunk then settled and was at rest.

The work of rain, and sun, and protoplasm, through all the days and months, the years and centuries, was ended. The myriad of seedlings all about, would now for a space have renewed life, until some one of them gained a slight advantage, and the rest bowed their heads in defeat, drawing what moisture and light they could, and beginning their long wait for another accident such as this.

For a few minutes we danced about helplessly, not daring to rush in, for long after the tree had fallen a perfect hail of branches, leaves, nuts and torn lianas hurtled down. When it was comparatively safe we ran to the hole. Swiftly we relieved one another with the ax and cut deep into the hollow. The entrance was through an old, decayed knot-hole, the butt of a branch long since dead and fallen. This opening was three by six inches in diameter and the cavity turned abruptly downward. When we had widened it, I could just get my hand inside, but by dint of much wriggling I forced my arm down to the elbow, but could find no bottom. Sounding with a pliable bush rope I found that the base of the cavity was about a yard down the trunk. We cut out a slice at this point and found a large quantity of mold, mixed with various pits, and nuts and seeds. Some of these were quite fresh, others had sprouted in the darkness, showing ghostly white stems and rootlets.

For a time we turned this over and over in vain. Not so much as a feather rewarded us, and as failure again loomed ominously before us, we became poignantly aware of our bleeding hands and sodden clothing. Then from the midst of the mold shone a gleam of white and no pocket of nuggets ever drew from any discouraged group of miners, a more joyful chorus of yells than burst from us. And no pile of jackstraws was ever more carefully disentangled than was that mass of mold, and wood and seeds. One by one we removed the particles of debris, and when we finished

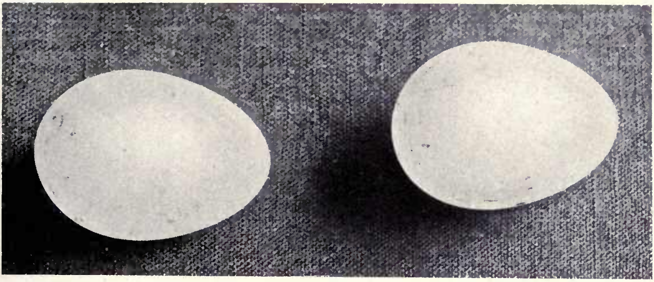


Photo by P. G. H.

FIG. 53. EGGS OF RED-BILLED TOUCAN
Natural size.

we had found the vaguely reputed two eggs, one punctured in two places, the other quite perfect.

Blisters, rain, ant stings, tired muscles, all became subconscious. We trudged happily home, forgetful of the three hours of toil in the realization of one of the chiefest of our desires, jubilant with the thrill of having solved one of the little mysteries of the earth, a mystery of such slight moment to practical humanity at large, but so satisfying to the seeker of *la vérité vraie.*

When we came to examine our treasures, we found the eggs to be white or pinkish white, the tint being that of the contents showing through the shell. They were somewhat stained by contact with the mold and the acid moisture from the decayed wood. The small end was blunt, the general shape being that of a diminutive hen's egg. The two were identical in measurement, each being 37 by 27 millimetres. They contained living embryos of about a week old. The shell was without gloss and sparsely covered with small pits. Slight but plainly visible grooves extended down the central portion of the shell, irregular lines connecting many of the pits. To the naked eye the lines showed as very faint colorless striations, and required a close glance to detect.

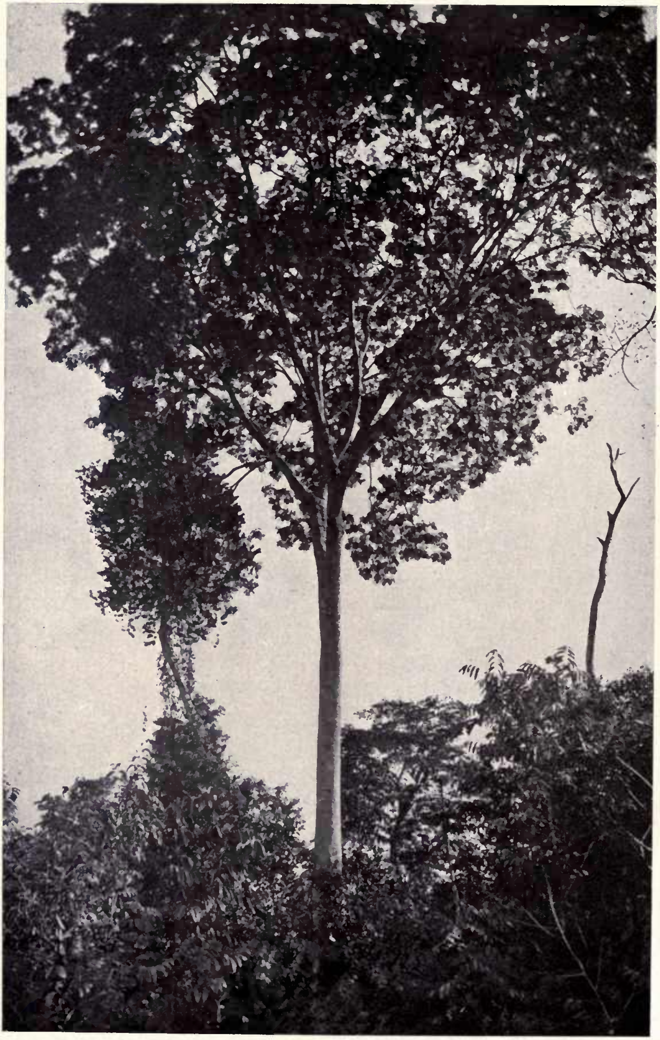


Photo by W. B.

FIG. 54. TREE WITH NESTING HOLE OF BLACK-NECKED ARACARI

From March to July the notes of the red-billed toucans were one of the commonest of jungle sounds, but by August the birds seemed to have become much more quiet, and we seldom had our attention drawn to them. At this time they were usually seen in trios—doubtless parents and a single young, or in flocks of five or six.[1] The molt was completed in a number of individuals as early as the first week in July.

BLACK-NECKED ARACARI
Pteroglossus aracari

Across the Mazaruni, just beyond the limit junglewards of the Penal Settlement clearing, we noticed that a pair of these toucans haunted the vicinity of a tall, unknown jungle tree. Its white trunk rose smooth and straight as a palm, high above the surrounding bush, and at a great height from the ground burst into a wide-branched mass of foliage. The birds did more calling and climbing about this tree than seemed consistent with mere distinterested search for food.

Just above the first branch a blackened knot-hole was not quite free from suspicion and we set up an amiable murderer and a pleasant burglar to watch the hole while his companions cut firewood in the vicinity. Hope, one of the trusties, an interesting forger, and a particular friend of ours, at last brought word that the birds were entering and leaving, and he volunteered to fell the tree single-handed. This he did in three hours on the morning of April 15. To cut down such a tree anywhere else in the world would have been nothing less than criminal. Here, as a giant among a continent of giants, it was of no more consequence than the breaking of a blade of grass.

As the cutting went on, the parent toucans hopped silently about in the neighboring trees, silent except for the occasional loud whirr of their wings. When at last they

[1] See the notes on this species which I published in "Our Search for a Wilderness," 1910, p. 327.

Photo by P. G. H.

FIG. 55. FRONT VIEW OF TEN-DAY-OLD ARACARI

were convinced that we actually intended an assault upon their home, they became greatly excited and went through a series of remarkable gymnastics. They drew themselves up to their full slim height, then bowed low and jerked their tails flat upon their back. They continually uttered their alarm notes, a creaky psssssssk! pssssssss! This activity produced an indiscribable display of color, the great black and yellow beaks never quiet for a moment, the black upper parts set off by the saffron breast and belly, which half way down were slashed across with scarlet. When the tree fell, the birds disappeared, and only by careful search were we able to find and secure them.

The great head of springy branches brought the trunk to rest more gently than is usually the case with a falling tree. Hope went to the hole, thrust in his hand and drew

Photo by P. G. H.

FIG. 56. SIDE VIEW OF TEN-DAY-OLD ARACARI

forth two nestling toucans. These were the first that any ornithologist had ever seen, and as some facetious layman later observed, it seemed hardly worth the trouble! They were quite naked, a sickly leaden in hue, hideously wrinkled, their movements vermian rather than birdlike. And as if the ocular offensiveness were not sufficient, they gave utterance unceasingly to a raucous, irritating cry, long drawn out and querulous.

To us, their weird, uncouth characteristics made them the more desirable. For years we had longed to lay eyes upon nestling toucans, and now we found them with characters beyond our utmost expectations. The rather psychic fact that their penchant was for ugliness was only incidental. Had they been equally beautiful they would have been no less interesting.

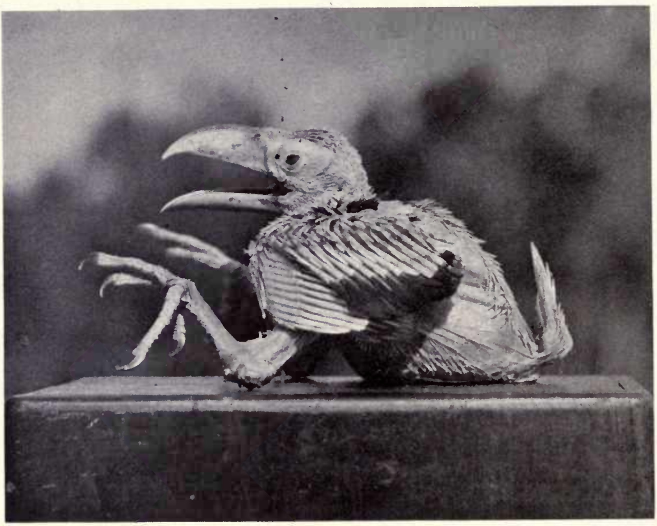


Photo by P. G. H.

FIG. 57. SIDE VIEW OF SEVENTEEN-DAY-OLD ARACARI

We placed them in an artificial cavity, fed them with a varied assortment of fruits and berries, and in due time chloroformed them for preservation and future study. Their fatal fault was youth; their doom immaturity. Had they been full-grown they would not have been disturbed, or would have been brought to live out their long span of years at the Zoological Park. But youth is evanescent and the youth of these birds can teach much of the genealogical tree up which their more or less toucanesque ancestors hopped their way through the checkered eons of evolution. But that is a story for another volume.

In the course of many years of exploration in various parts of the tropics I have cut down scores of trees to get at nests containing eggs or young birds, and it is a source of never-ending astonishment how seldom these are injured.

Occasionally an egg is cracked or a nestling is lamed, but usually they are in perfect condition.

So in the present case, after falling from a height of fifty feet, knocking and banging around a deep cavity and at the last rebound being flung almost out of the entrance, the nestling toucans were quite unharmed. Never for an instant did they cease their cries for food. This kept up all day and at intervals throughout the night. From four o'clock in the morning it was unceasing, and we had to banish the young birds to a distance in order to work without distraction. Only the brain-fever bird of India excels the hunger call of a young toucan in sheer maddening, irritating reiteration. It was a never-varying, raucous *auuuuuk! auuuuuk! auuuuuk! auuuuk!* repeated over and over. When food was given the harsh cry was broken into series of more liquid gurgles. Then followed a moment of silence as the beakful of berries was swallowed, and the next instant—*auuuuuk! auuuuuk!* began again.

If one of the hourly feedings was missed, the young toucans went into fits of rage and flung themselves about, biting one another or the lining of the artificial nest. Their usual position was resting on the heel-pads with the feet and toes held up helplessly in mid-air, the wings dangling at the sides, the back humped and the bill pointing forward. Most absurd was the tail, as innocent of feathers as the rest of the bird, which was slanted upward and forward until it fairly touched the back. When disturbed and nudged, the beak was opened, raised obliquely, and repeatedly stabbed upward with the blind confidence that food would be forthcoming from exactly that point in all space. Simultaneously, the tail wagged vigorously. It is easy to describe the separate motions. It is quite impossible to convey the weird unbirdlike effect of the whole performance.

The helpless condition of the feet was the most inexplicable thing about these birds. They invariably rested on the hind part of the body and on the two heel-pads, a tri-

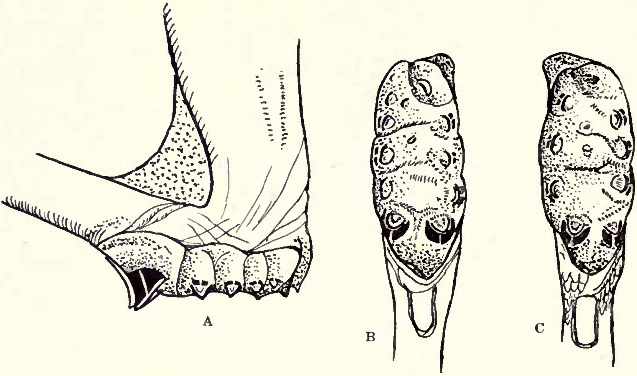


FIG 58. HEEL-PAD OF TEN-DAY-OLD ARACARI TOUCAN

a. Side view of pad on left leg. *b*. Bottom view of left pad. *c*. Bottom view of right pad.

podal position from which it was impossible to shift them. They absolutely refused to make any use of the feet or toes. Indeed, any considerable change of position was impossible, the patagium or web of skin between the tibia and the tarsus being stretched at such tension that the leg could not be extended more than at a right angle or a little over ninety degrees.

While the nestling hoatzin is a true quadruped, the young toucan is just as certainly a tripod, at least during the first weeks of its existence.

On the day I secured the two birds I estimated their age at about ten days. There was little or no difference in size between them. One which I kept under close observation showed almost no hint of the coloring of the adult. The mandibles were dark slaty horn color along the upper and basal margins, paling toward the cutting edges and at the tip to a light yellow.

The bare, wrinkled skin of the body was pinkish flesh with the feather tracts showing leaden blue. The feet and legs were bright yellowish green. The skin-covered sheaths

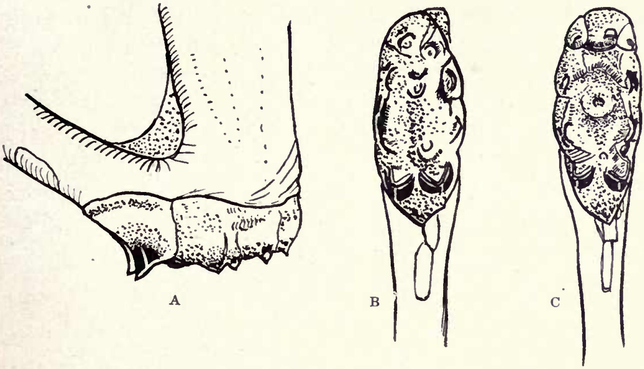


FIG. 59. HEEL-PAD OF SEVENTEEN-DAY-OLD ARACARI TOUCAN
a. Side view of pad of left leg. *b.* Bottom view of left pad. *c.* Bottom view of right pad.

of the body feathers were bluish with the exception of those of the under parts. At a point half way down the neck, the feather tract bifurcated, one of these pectoral branches ending beneath the wing and the other continuing down the inside of the thighs. I mention these because of their pale yellow pigment, prophetic of the adult coloration. A hint of red pigment was visible on the breast feathers, corresponding, however, only to the half-concealed line of scarlet which, in the full-grown birds, lies between the black and yellow of the under parts. There was no trace in the nestling of the very conspicuous scarlet belly band and the patch of the same color on the lower back. These are characters which have evidently been evolved rather recently.

Ten primaries were well sprouted, the 1st much the shortest, the 6th longest, although the 3rd, 4th, 5th and 6th were of almost equal length (1st, 7 mm.; 6th, 18 mm.). There were fourteen remaining flight feathers grading in size from the outer secondary inward (outer, 14 mm.; inner, the 24th, 2 mm.). The secondaries were uniformly stouter than the primaries. The coverts were short, not projecting beyond the hinder edge of the wings. The pelvic wing[1] was well marked, and extended from the anterior border of the thigh back almost across the patagium. It consisted of eighteen feathers in an ascending line. The 2nd to the 10th had lower coverts, eight in all.

Five pairs of tail feathers were well developed, and at first glance there seemed to be only four pairs of upper coverts. Closer observation showed a tiny fifth pair. The coverts had been pushed up until the two central pairs of tail feathers seemed to be quite covertless.

I have mentioned the heel pad at the ankle joint. This is a serrated or more properly, toothed pad of horn, capping the joint between the tibio-tarsus and the tarso-metatarsus. It fits like the elbow pad of a football player, and during the period when the feet are helpless, it serves as a secondary set of toes, on which the nestling can rest, and awkwardly stump about the nest cavity.

As the egg-tooth of the common chick and indeed of the toucans as well, is a purely embryonic character, so this heel-pad is wholly concerned with the nestling period. It has been briefly described in other birds such as woodpeckers.[2]

The pad is roughly oval and in general appearance recalls the molar tooth of an elephant. The cusps are variable, there being twelve on the left pad and eleven on the right. The rim of the structure is pale bluish. The bases of the cusps are yellow, while the face of the large anterior cusps is very hard and pigmented with brownish black. It is remarkable how close the resemblance is to blunt claws or actual teeth. The two anterior ones have sharp, projecting cutting edges which catch and hold anything which touches them.

[1] Vide "A Tetrapteryx Stage in the Ancestry of Birds," Beebe, *Zoologica*, II, 1915, pp. 39-52.

[2] Proc. Zool. Soc. London, 1913, pp. 1095-1096.

The eyes, at this stage, are hardly open, being mere watery slits. The cutting edge of the mandibles is straight for three-fourths of the entire length, when it curves abruptly downward. This is very unlike the gradual downward curve along the entire length of the mandible which is shown in the bill of the old bird.

One of the young toucans was kept for two weeks, until the feathers had broken well out of their sheaths. Another year, when the intermediate stages are obtained, both of embryos and fledglings, we may hope to glean some real light on the ancestry of these remarkable birds.

SULPHUR-AND-WHITE-BREASTED TOUCAN
Rhamphastos vitellinus

My experience with the nesting history of this splendid toucan, the fifth and last species which we observed, was rather an anti-climax to the success which crowned our work with the preceding species.

I was in the midst of the jungle on the 19th day of May, watching a yellow-billed jacamar hawking after insects from a monkey-ladder, when my glance went upward to a patch of sky across the brilliant sunshine of which a deluge of rain drops seemed to be pouring. Another glance told me it was a cloud of winged ants, and soon I saw the sharply defined limits of the swarm, myriads upon myriads of the insects drifting like motes through the upper reaches of the jungle.

My ear was next assailed by a subdued, raucous sound, a sound strangely familiar. It was some minutes before I could recall where I had heard this, but at last the memory of the two young toucans, which we had kept at Kalacoon, came vividly to mind. Two weeks before, they had given us no peace and none of us was likely to forget that irritating eruption of sound which scarcely ceased day or night. Another voice now joined in and I knew I was listening to

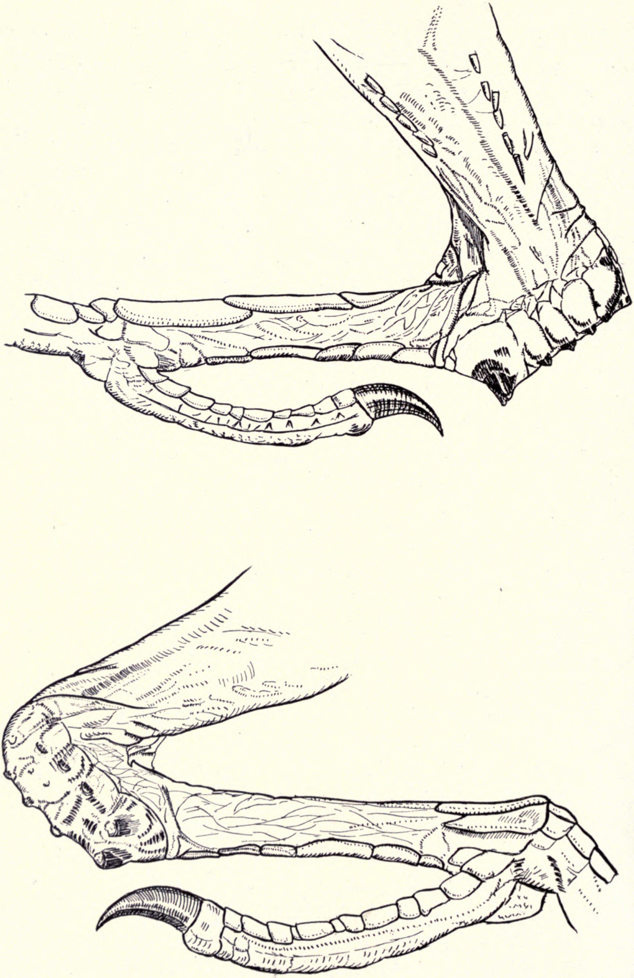


FIG. 60. LEFT HEEL-PAD OF TEN-DAY-OLD ARACARI TOUCAN, SHOWING RELATION TO LEG AND TARSUS

the hunger cries of a pair of nestling toucans, hidden in some hollow high overhead.

Fifteen minutes passed before a toucan appeared, a big sulphur-and-white-breasted one, who instantly discovered me, scolded for a minute and vanished. Before the morning passed, a troop of red howling monkeys made their way leisurely along the topmost branches. Both toucans appeared and mobbed the monkeys, following them for some distance. I got no clue, for any momentary delay on the part of a monkey appeared to arouse the same anxiety in any one of a half dozen great trees.

On the following day we came with three Indian axe-men. Guided by the cries we chose a tree and felled it, but the several hollows contained nothing more exciting than giant tree crickets and equally huge grubs of rhinoceros beetles. The voices of the young birds had ceased at the first axe stroke, so we had no further guidance. A second tree yielded nothing, and we were forced to desist, for the mass of tangled branches and lianas made all movement impossible. The jungle kept this secret inviolate from us.

Photo by P. G. H.

FIG. 61. MID-JUNGLE HIDING UNDISCOVERED NEST OF SULPHUR-AND-WHITE-BREASTED TOUCAN

CHAPTER XIII

ORNITHOLOGICAL DISCOVERIES

By William Beebe and G. Inness Hartley

In the course of our season's search for the young birds which we required for certain problems, we came across many interesting nests. Some were of unusual architectural construction, others were remarkable because of their adaptive form or coloring, still others possessed the distinction of being undescribed, quite new to man's scientific record. The majority of the notes made upon all of these classes have been filed awaiting publication when further details and more complete information as to their method of construction or reason for requiring protection, are secured.

It seems desirable to record the nests and eggs which have not heretofore been described or are almost unknown, especially as I am able to supplement the descriptions with photographs. The species are as follows:

Talpacoti Ground Dove	*Chaemepelia talpacoti* (Temm. & Knip.)
Red Mountain Dove	*Geotrygon montana* (Linn.)
White-necked Crake	*Porzana albicollis* Vieill.
Cayenne Crake	*Creciscus viridis* (P. L. S. Müll.)
Dusky Nighthawk	*Caprimulgus nigrescens* Cab.
Guiana Tyrantlet	*Tyranniscus acer* (Salv. & God.)
Oily Flycatcher	*Mionectes oleagineus oleagineus* (Licht.)
Varied Flycatcher	*Empidonomus varius varius* (Vieill.)
Cinereous Bushbird	*Thamnomanes caesius glaucus* Cab.
Rufous-fronted Antcatcher	*Anoplops rufigula rufigula* (Bodd.)
Quadrille-bird	*Leucolepia musica musica* (Bodd.)
Orange-headed Manakin	*Pipra aureola aureola* (Linn.)
Brown-breasted Pygmy Grosbeak	*Oryzoborus angolensis brevirostris* (Berlepsch)
Chestnut-bellied Seedeater	*Sporophila castaneiventris* Cab.
Black-headed Seedeater	*Sporophila bouvronides* (Less.)
Blue Honey-Creeper	*Cyanerpes cyaneus cyaneus* (Linn.)
Moriche Oriole	*Icterus chrysocephalus* (Linn.)

Photo by P. G. H.

FIG. 62. NEST AND EGGS OF TALPACOTI GROUND DOVE

TALPACOTI GROUND DOVE.
Chaemepelia talpacoti (Temm. & Knip.)

We found the nests of this common little ground dove usually in low bushes, seldom more than six feet from the ground. The nest was nothing more than a thin platform of small twigs or grass stems, varying according to the individual. It had no true inner lining but the material for the nest hollow graded in fineness. The whole structure was about 10 cm. long, and the slight depression for the eggs 2 cm. deep.

The two eggs were pure glossy white with measurements averaging 22.5 x 18 mm. Two was the usual normal number, but one and very rarely three were found in a nest. It was one of the commonest nests to be discovered during the months of February, March and April, and seemed especially marked as a prey for nest ravagers. Not more than half the young ever reached maturity, which made it very probable that the parents raised more than one brood a year.

RED MOUNTAIN DOVE.
Geotrygon montana (Linn.)

Though one of the common jungle residents, the red mountain dove was seldom seen, for it merged so completely with its surroundings that one passed it by, time after time, without ever knowing that such a bird existed. If it were discovered, careful watch had to be kept or it would seemingly disappear where it sat. The nest was equally difficult to find and usually could only be discovered by frightening the bird from the eggs. If it thought there were a chance to escape undetected, the parent would quietly slip from the nest to the ground, run a few steps and noiselessly flutter to a protecting branch without the hunter being aware of its presence.

The nests were built away from the ground, the distance varying from a foot to five feet. The bird usually

Photo by P. G. H.

FIG. 63. NEST AND EGGS OF WHITE-NECKED CRAKE

selected the head of an old rotted stump or the fork of a low outhanging branch, or possibly the horizontal surface of an old gnarled liana that ran close to the ground. The nest itself was a concave platform of twigs lined with leaves on which rested the two dark, cream-colored eggs. The nest in the accompanying illustration (Fig. 62) was lined in the same way, but some of the leaves were green and freshly picked so that the whole structure had an effect of not existing at all in the green mass of foliage that grew around it. The habit of mingling green leaves with brown was doubly significant from the fact that other nests found on stumps and lianas, where there was no surrounding green, were lined only with dead brown leaves which made them just as hard to see in their individual locality. The coloring of the eggs was no aid, for they nearly matched the leaves on which they lay.

The main nesting season was during the months of April and May, though it possibly commenced earlier. The average measurements of the eggs were 26.5 x 19.5 mm.

WHITE-NECKED CRAKE.
Porzana albicollis Vieill.

Many nests of this species were brought in by coolies who were clearing the grass from among the trees of the rubber estate. They were always placed on the ground between clumps of the tough savannah grass and often near the base of an old stump that survived as a memory of former forest days, sheltered by its projecting roots. The nest was a large open bowl-shaped affair built entirely of coarse dried savannah grass roughly woven together with perhaps a few dead rubber leaves to strengthen the weak places. It was about 20 cm. in diameter by 10 cm. high, the nesting cup being 10 cm. wide and 5 cm. deep.

The number of eggs, in the dozen or more sets examined, varied from two to three, though it has been said that the bird sometimes lays as many as six eggs. There was great variation in size and shape, some being long, oval and sharply pointed at the small end, while others were much shorter and nearly round. The range of variation was about 12 per cent. The ground color also varied from a light pinkish cream to almost white, with the large end usually heavily marked with fine spots of chocolate brown and lilac grey. The lighter eggs as a rule had fewer spots sparsely scattered over the whole surface. Some few had no spots at all and were hard to distinguish from the following species. The average measurements were 34 x 26 mm.

The nesting season was at its height in May, though eggs were brought to us from February to July. It is probable that some nests could be found during every month of the year.

CAYENNE CRAKE

Creciscus viridis. (P. L. S. Müller)

The home of this exceedingly tame little rail differed greatly from the one just described. It was round and looked like a large baseball, from which the cover had been torn to show the weaving of the threads, hanging among the reeds or low bushes in overgrown clearings. The rather large entrance was on the side beneath the domed roof, and the walls were woven around the several thick stems that supported the nest. The bird used much the same material in construction as did *P. albicollis*—grass blades, leaves and a few weed stems, but the nest was a much stronger and more skillful piece of engineering. It measured about 20 cm. in diameter with a depth in the inner cup of about 6 cm.

The Cayenne crake remained on the nest until the searcher was within a few feet, and, if it thought it had not been observed, would remain until the nest had been touched. Then there was a quick flash of bright red legs and the bird disappeared into the surrounding cover. While it remained on the nest filling the opening, it so blended in color with

Photo by W. B.

FIG. 64. NEST AND EGGS OF CAYENNE CRAKE

the grass that no entrance could be seen and the whole affair looked like an ordinary ball of dried material that had chanced to lodge among the reed stems. Upon its disappearance, however, the white of the eggs in the light of the entrance made a guiding mark for the observer.

The eggs, as in the former species, varied much in size and shape, but were rather glossy pure white without any spots. The average dimensions were 32.8 x 25.7 mm., though, among the several sets examined, there was a variation of 11 per cent. The number in each set was two to three, three being the usual number.

We secured nests from February to August, but May was the chief nesting month. Probably a few birds nest throughout the whole year.

Photo by P. G. H.

FIG. 65. EGG OF DUSKY NIGHTHAWK

DUSKY NIGHTHAWK

Caprimulgus nigrescens. Cab.

Like other members of its family the dusky nighthawk laid its one egg on the ground. It was naturally a bird of the forest, where, from time to time, it flushed almost from under one's feet, but it also took advantage of the work of man and could be seen in the overgrown Indian clearings hiding among the rank weeds that grew there. When frightened from its egg it limped away like many another species and crouched in a conveniently exposed spot to attract the attention of the hunter to itself and from its home. Even then the bird was hard to see, for no matter where it rested, the outlines of the body melted into the surroundings. The egg, if anything, was still harder to detect, and our experienced hunter often searched for many minutes before he succeeded in locating it. Though there was no nest built one could sometimes find the egg by looking for a faint ring of smooth earth which had been swept clean of fine debris by the movements of the sitting bird.

A well incubated egg was discovered on April 26, near a trail that led to the jungle through an old, burnt-over clearing. Both parents were there close together, one crouching on the egg and the other a few feet away. I picked up the egg, examined it and placed it back in the same position, with the idea of returning soon to take it. Two days later I visited the same spot and again flushed the two parents, but at first could not find the egg though its position had been marked. It seemed to have disappeared, but a prolonged search at last located two lichened pieces of wood about a yard away. One proved to be the egg, the parents evidently having moved it. The lichen acted as a counter imitation of the markings of the shell.

The ground color was a light pinkish buff, sparsely covered with scrawled blotches of chocolate brown, which

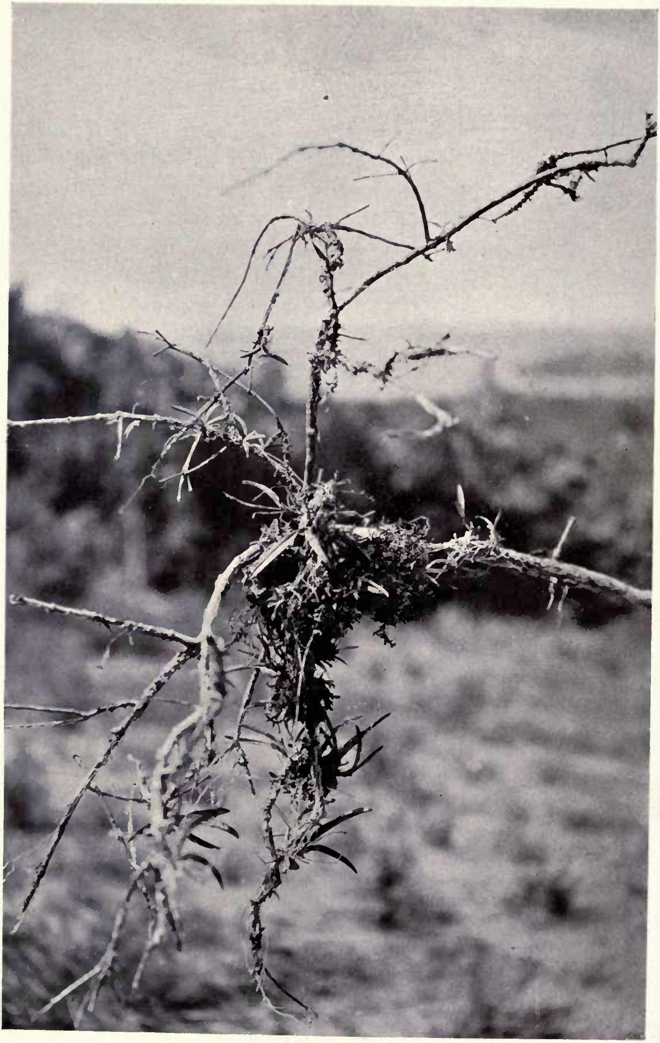


Photo by P. G. H.

FIG. 66. NEST OF GUIANA TYRANTLET

overlaid larger spots of greyish purple and lilac. The measurements were 26.5 x 19 mm.

GUIANA TYRANTLET

Tyranniscus acer (Salv. & God.)

I had returned from a hard walk in search of trumpeter chicks—in vain, and had been straightway recompensed by the discovery of the nest of a sunbittern, and the flat platform and single white egg of a splendid pigeon. The day's work seemed ended, and I lay on my back waiting for the dugout to return from a trip up river. Idly I watched a tiny bird—a flycatcher—flitting about high overhead, in the very summit of a mango tree. Presently it dived into a bunch of moss, one of a dozen on some dead branches, but did not immediately appear again. I waited and still it remained invisible. From a condition of lazy inattentiveness, I sat up, imbued with concentrated interest, and felt for my glasses, my eyes never leaving the tuft of moss. The closest scrutiny revealed nothing, and I was half tempted to believe that the bird had eluded me. But the insatiable, inexplicable will-to-learn, the fluid life, as Bergson would have it, overcame the sloth of the material body, and up I went. I climbed swiftly, so that I might keep beyond the ever-increasing area of irate ants, and finally touched the branch. My flycatcher shot out, and raising his diminutive crest, scolded me roundly for my unwarranted intrusion. The nest was most ingeniously hidden and I could not find the entrance until I had carried it to the ground and examined it carefully. The owner was a Guiana tyrantlet, one of the most inconspicuous of his great flycatcher family, and one of the smallest, less than four inches in length. He was olive and grey, with his wing feathers touched with yellow; and his voice was sharp, unmelodious, and several sizes too large.

FIG. 67. NEST OF OILY FLYCATCHER

But what he lacked in splendor of garb and sweetness of tone was more than compensated by his skill in architecture.

The nest was composed chiefly of fresh growing moss intermixed with the green calyxes of mango blossoms. The whole was bound together with interwoven tendrils of young vines. The interior lining of the deep cup was made up of five consecutive layers of material, making with the bird on the nest, an absolutely waterproof pocket. The outer layer was of coarse fibre, the second of animal hair, the third of wild cotton, the fourth of animal hair, and the fifth, the inner, of wild cotton. The inner layer was very thick and at the bottom formed an exceptionally soft bed for the eggs.

The outside diameter of the nest was 10 cm., with a depth of 8 cm. The interior cup was 4 cm. in diameter at the top, by 6 cm. deep.

The two, small, dull-white eggs were rather heavily marked at the larger end with small spots of chestnut, underlaid with specks of lilac, the tendency being to form a ring. A few tiny specks were scattered over the entire shell, but were so small as to be scarcely noticeable. The shell was very thin. The two eggs averaged 16 by 12.5 mm.

OILY FLYCATCHER

Mionectes oleagineus oleagineus (Licht.)

The nest of this species was really a duplicate of other forest flycatcher hangnests—*Colopterus, Rhynchocyclus* and probably many others whose nests are unknown. Hanging from small vines in the densest forest, usually close to the ground, it looked like some large, mossy, cornucopia-shaped fruit, fastened pear-like by its little end. The entrance, near the bottom and to one side, was hidden from sight of the casual observer, by overhanging tendrils of living moss which acted effectively as a curtain. Upon entering its home the bird found itself in a narrow, upward slanting tunnel that led to a hole in the roof of the cave in which rested the eggs. It was necessary for her to push through this opening and to drop gently, with the utmost care, upon the eggs below. The parent was then within a tiny cup of a room whose walls were thickly lined with soft hair, backed by fine shreds of jungle bark.

The body of the nest was composed entirely of living tree moss skillfully woven together to form a waterproof mass. Scattered through this were a few small roots and strips of bark to give stiffening to the structure. The inner lining was composed entirely of this material, closely packed together until it formed a soft and impenetrable mat. Within this was the lining of animal hair, thicker at the bottom, upon which the two or three white eggs were deposited. The whole nest was about 30 cm. high and 13 cm. wide at the bottom. The entire interior room had a depth of 9 cm., but the nest cup proper was only 5 cm. deep with a diameter of 4 cm.

When placed very low in the undergrowth the nest of the oily flycatcher was very hard to find. It agreed so thoroughly with its surroundings in the dull jungle twilight that one would pass it by again and again without noticing the outlines against the dark green background, or, if seen, it would be taken for an over-large, naturally drooping bunch of moss.

The first nest I discovered was hanging from a small liana about 18 inches from the ground in a dark thicket. My knee accidentally struck against it, but I would have passed on without noticing if the mother bird, startled, had not flown up, seemingly, from beneath my feet. I cautiously moved back behind a conveniently thick bush not ten feet away and waited for her to return. She did so in a very few minutes and quickly disappeared into the hidden tunnel of her home. A few quick steps, and with my hand over the hole she was my prisoner. This occurred on the last day of March.

There were three eggs in the nest, all of a dull glossless white, and rather pointed at one end. The shells were thin and had small striations or corrugations running from the middle to the small end. They measured 21 x 14.5; 21 x 14.5; 20 x 14.5 mm.

VARIED STREAKED FLYCATCHER
Empidonomus varius varius (Vieillot)

Though the eggs of this species have been collected, no description of the nest has been given. The genus *Empidonomus* is very closely allied to *Tyrannus,* so one would expect corresponding nests. They proved to be somewhat similar, but the nest of *Tyrannus* though rather a shabby affair, was much more specialized than that of the bird in question. In *Tyrannus* the nest hollow was cup-shaped and well lined with grass, and the whole structure was more skillfully put together with a more careful gradation of material.

A nest of the varied flycatcher was taken on April 20, from one of the outer branches of a small dead guava tree. At first sight it appeared to be merely a weak flimsy platform of twigs fashioned like the nest of a dove and placed in an exposed position. If the parent birds had not been seen, it might easily have been taken for the nest of a dove. It was built in a small fork and was partly supported by a dead branch that grew close by. Every puff of wind caused it to sway and shake, and it was difficult to believe that it would not soon fall to pieces. The basic material was small twigs and vine stems. In the center was a shallow depression for the eggs, which was lined sparsely with coarse stems of a common weed that grew hereabouts. The depth of the depression was 2 cm. and the whole platform was 13 cm. in diameter, by 8 cm. in height.

There were two eggs in the nest, one of which was infertile. Measurements averaged 23 x 16 mm.

Photo by P. G. H.

FIG. 68. NEST AND EGGS OF CINEREOUS BUSHBIRD

CINEREOUS BUSHBIRD

Thamnomanes caesius glaucus Cab.

The cinereous bushbird, though one of the commonest inhabitants of the Guiana jungle, like many others of its kindred is but little known. It had no particular preference of locality but could be heard adding its voice to the general chorus in any of the small groups of ant-thrushes that continually worked their way through the jungle. During the nesting season—from February to May—each pair selected a certain portion of the forest undergrowth and floor for the home site and hunting ground. At this time they did not greatly mind the inroads of other birds on their property and at the voices of a passing company would occasionally join in and follow for some distance, but the approach of man was hailed with shrill cries of alarm, an angry flutter of wings, and a fierce snapping of bills. Their food consisted entirely of insects—chiefly ants and beetles.

Judging from the number of nests found in March and April it would seem as if these were the two main nesting months. The nests were placed in the forks of low bushes, usually in the densest jungle and seldom more than five feet from the ground. They were bowl-shaped and open, but always protected by a roof of dried leaves placed across the branches six inches above.

The nest itself was composed entirely of more or less rotted leaves, held together by a few fine root fibres. It was lined with fresh dried leaves and often with a very thin lining of the finest roots. The whole structure had a very flimsy appearance, and looked like a plain mass of leaves accidentally collected in a low bush. The outside diameter was about 11 cm., but the interior cup was only 6 cm. across at the top and 4.5 cm. deep.

The birds sometimes gathered their building material a hundred yards or more from the nest. It was interesting to watch them carefully select a leaf from the thousands

Photo by W. B.

FIG. 69. NESTING STUB OF RUFOUS-FRONTED ANTCATCHER

that lay about. They would fly to the nearest log with it in their bill, and pound it against the hard wood until it became pliable and suitable for building purposes. Then it was a matter of but a few moments to carry it to the nest, place it and return for more.

The two eggs were a very pale pinkish white, thickly covered at the larger end with brick red, hessian brown and lilac blotches which were scattered more sparsely at the smaller end. The measurements of two were 20 x 15; 21 x 15 mm.

RUFOUS-FRONTED ANTCATCHER
Anoplops rufigula rufigula (Bodd.)

I had been milling in the depths of the jungle for many minutes, around and around a tangle of lianas which a great fallen tree had brought down from the upper reaches. A nestling had eluded me and now a sudden mid-day downpour drove me to the sheltered side of a smooth-barked tree, a tree which leaned just enough to give me a dry roof. As not a living thing was visible I sought in my game bag for sundry reading matter on the adventitious magazine leaves which I carried for wrapping up birds. I enjoyed five minutes of a damp, but delightful review, by Lawrence Gilman of the "Research Magnificent." Then the sun burst out and illuminated every falling drop.

I stepped forth upon the drenched moss, and as I turned to regain the animal trail I had been following, my eye caught a glint of white, and deep in a broken hollow stub were two white eggs, white with a heavy coating of spots and splashes. They were dry, but there was no trace of owner, nor in the succeeding ten minutes did any bird appear. I left at once—blazing the trees as I went. This was on June 23, and it was not until five days later that we saw the bird and knew it for a rufous-fronted antcatcher.

Completely concealed behind a clump of bushes about twenty feet distant, a half hour's patience was needed before the brown parent appeared flitting through the underbrush close to the ground, clinging always to upright stems, and circling warily about the nest. A single movement frightened it away, and another half hour passed before it again was seen. When secured it proved to be a male bird. It was an inconspicuous seal-brown above and dark buffy below with a rich rufous orange throat. The most obvious character was the fleshy, prominent eye ring, these bluish-white areas of skin being quite dominant both in front and profile.

The nest on June 28, contained a single addled egg and a nestling about a day old. The dead and broken stub was about six inches in diameter and three feet in height. It was hollow from the top down to the nest which was placed about nine inches from the ground, just below the opening

Photo by W. B.

FIG. 70. NEST AND EGG OF RUFOUS-FRONTED ANTCATCHER

of the stump. The nest was a little concave affair of small twigs and vine stems, and lined with a few pieces of coarse fibre. It was only about three inches in diameter. As we looked into the cavity we could see the one light egg and a round white circle, which upon closer examination proved to be the border of the gaping mouth of the young bird.

The egg was of a warm pinkish ground color, with numerous dashes, spots and blotches of purplish red, lilac and lake, the largest spots at the large end, and only smaller dots beyond the middle, although these reached sparingly the small end. It measured 21.5 x 17 mm., and weighed three grams.

The nestling was leaden brown, with eyes and wing tracts black; the bill black with enormous, milk-white lateral jowls, in width more than twice the length of the bill. The femoral tract showed two rows of feathers, eight flights and five coverts, extending at right angles to the femur. The inside of the mouth was bright lemon yellow, with a milk-white border. The nestling uttered a weak but penetrating squeak.

The region around the eye in the adult was bare, swollen and pale bluish-white, becoming quite blue above the ear, where it merged with the brown feathers. The mandibles were black, paler at the tips; the legs and feet were pale pinkish white.

	Weight	Length	Wing	Tail	Bill	Tarsus	Middle toe & claw
Adult male	29 grams	150mm.	78	50	19	27	24
Nestling	2.5 grams	44mm.	6.5	—	6	8.5	7

QUADRILLE-BIRD

Leucolepia musica musica (Bodd.)

I had been crouching, well hidden, for over fifteen minutes watching the antics of a flock of black-headed cacique parrots (*Pionites melanocephala*), feeding noisily high up in the top of a great jungle tree on the big sunflower-shaped fruit that hung there, when, from a little beyond, there was a great shaking of branches and a single red howler came swinging along, first with a scramble out onto an overhanging branch, then a jump through mid-air, a hasty grasp at rapidly passing twigs with hand or tail, another scramble, a short run, and then one more jump. This rapid transit soon brought him to the now silent parrot tree up which he

Photo by P. G. H.

FIG. 71. NEST AND EGGS OF QUADRILLE-BIRD

climbed with most amazing speed. The little parrots gazed silently down at him with twisting necks and with longing last looks at the luscious meal they must now forsake, they flew screaming away.

I placed my hand against a small sapling to steady myself, while watching further developments, and carelessly gave it a little shake. The flash of a tiny pair of wings almost in my face was the result, and the view of a little brown bird as it rapidly disappeared into the undergrowth. I looked at the sapling and saw a small bundle of leaves resting upon a small branch about four feet from the ground. It had passed unnoticed in the excitement of watching the parrots and the monkey. Then from the bushes came a few cheerful notes from the most wonderful musical instrument of all, the throat of the quadrille-bird and I felt that I really had discovered something worth while.

As my hiding place was too close to the nest, I chose another position and sat down to await what would happen. From behind a friendly screening bush the nest looked like a leafy vase held by a twist of the funnel-shaped neck over a supporting branch. The wily little bird was fully two hours in making up its mind to enter its curious home, but it could be seen dodging in and out among the bushes close by, always too wary to take any chances while the enemy was about. It did not scold as they usually do, but every few minutes burst into song as if thus to find a vent for its increasing excitement. Finally, about noon, when a heavy shower of rain commenced, it entered to protect the eggs from a wetting.

The nest was composed almost entirely of leaf skeletons bound tightly together with fine fibres and a few blades of coarse grass. The entrance passage was quite large and opened upon the small inner cavity near the top. The cavity in which the eggs lay, was lined with several big feathers of the large Guiana great tinamou and the Guiana partridge.

The whole structure was very compact and neatly put together, the leaf veins giving it a very strange appearance.

The two fresh eggs were pure white with little gloss. Their dimensions were 22 x 15.5 mm.

The nest was found on July 5, at the height of the great rainy season. I think it probable that they nest twice a year as several newly vacated nests, apparently of this species, were found during March.

ORANGE-HEADED MANAKIN

Pipra aureola aureola (Linn.)

These charming little birds were abundant, and often seen in the jungle, either in pairs or in company with small flocks of other birds. But their life history as noted in our records was as fragmentary as the brief glimpses we had of them. Then came a series of lucky birds' nesting days and we discovered four nests of the orange-headed manakins.

The first was close to an animal trail in heavy reedy second growth about a mile from Kalacoon. The nest was in a small, slender-stemmed bush, only three feet from the ground, in the fork of a branch. There were two eggs, and as we did not get a chance to secure the female we disturbed neither eggs nor nest.

Three days later the bird left as we approached. Backing off some distance we squatted and waited for her reappearance. In five minutes she returned, settled on the nest, caught sight of us, and flew up scolding harshly. She was uniformly dark olive-green, with lighter throat, dark bill, and bright red legs and feet. At this moment, without warning, a full-grown jaguar rushed us, growling, turning aside when about eight feet away, only when we stood up and he perceived that we were other than deer or whatever jungle prey he had evidently expected. After the excitement had passed, one of our number shot a bird from near the nest, only to find that he had killed a helmeted flycatcher by mistake. Ultimately the rightful owner returned and was secured.

One egg had disappeared. The nest was vireo-like, cup-shaped, suspended from the forked twigs. It was not very firm, light showing through it everywhere. The material was coarse grasses and thin rootlets. Cobweb was used where the nest was in contact with the twigs, and several dead leaves were loosely attached with this material to the outside of the nest. The diameters of the nest were, 70 mm. outside, and 50 mm. inside; the depths, 50 mm. outside, and 40 inside.

The egg measured 21 by 15.5 mm. The ground color was dull yellowish white, with numerous pale brown and lilac markings, mostly linear, running lengthways, and more numerous around the larger end.

Two days later, on March 10, I sat down in a small glade near the same animal trail. It was early morning and the sun was not near its full strength. I listened to the chirps of birds drinking at a black jungle creek near by, and watched a hummingbird pick cobweb in the intervals of violent battle with another species. Then a female manakin whirred past and I followed her as she fed on small berries near the tops of some saplings. After fifteen minutes of this fitful occupation she swooped downward, straight to a tiny nest which to this moment had been invisible to me. Here, suspended from a slender fork just over a pool of black water she brooded two eggs.

A week later the young birds hatched, and on March 20, I photographed and examined the three-days-old young. One of them, a female, was reddish flesh color, with yellow gape and yellowish brown legs and feet. The eyes and the upper surface of the wings were dark leaden.

The down was sparse, long and whitish grey in color; there was none on the hind leg, but a line of six, strong feather sheaths with long down attached along the outer aspect of

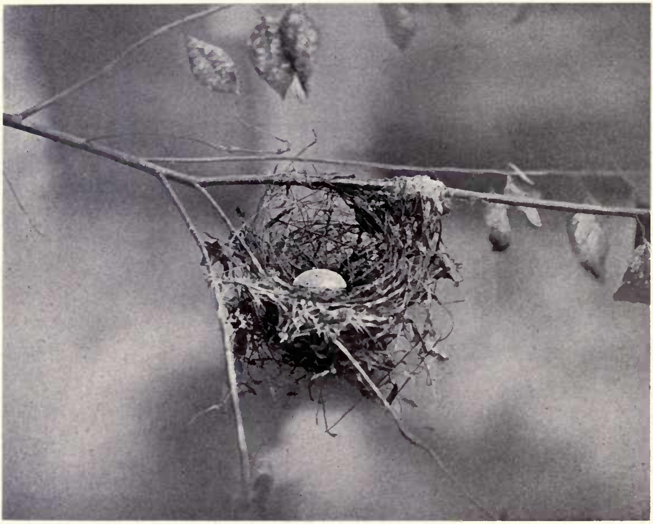


Photo by P. G. H.

FIG. 72. NEST AND EGG OF ORANGE-HEADED MANAKIN

the side of the body, with traces of at least three covert sheaths. These all lay along the femur.

Ten primaries were apparent, looking like small, nearly straight claws, giving to the posterior side of the forewing a saw-like appearance. The outer four feathers were somewhat larger and perfectly straight; the succeeding six were quite distinct, being curved forward. Only a single claw-like feather tip appeared on the thumb.

In the crop of the nestling were two kinds of small, fleshy seeds, two-inch worms and a small, brilliant green beetle.

A week later, on March 27, I examined the second nestling, a male. It sat silently crouched far down in the nest until disturbed when it uttered a shrill chirp. The flight feathers were almost full grown, but quite unbroken from their sheaths. Even a kingfisher does not exhibit such long continued sheathing. In the crop was a single, sharp-studded, flattened, circular seed with the flesh all dissolved away.

	Length	Bill	Wing	Tail	Tarsus	Middle toe and claw
3 day nestling	37	5	9	—	10	7
Adult	110	10.5	52.5	32	20	15

SEED EATERS

Whenever one walked through the cultivated fields near Georgetown or through any of the clearings near the coast of Guiana, one was invariably surprised at the great number of little finches that would start up at his approach. They were present in endless numbers wherever the weeds grew rank and the crabgrass went to seed, and that was nearly everywhere. Perhaps the two most common were the little brown-breasted pygmy grosbeak (*Oryzoborus angolensis brevirostris*), or twa-twa slave—locally named from its habit of accompanying its elder brother, the twa-twa (*O. crassirostris*), and the tiny chestnut-bellied seedeater (*Sporophila castaneiventris*). They were usually seen in large flocks.

Familiarity breeds contempt. There could be no truer saying than where these little finches were concerned. In spite of diligent search through all the few reports and excerpts on the subject, no description of the home or eggs of these birds could be found, and yet, in April and May, their nests were everywhere.

We commenced finding nests of the twa-twa slave about the middle of March. The number gradually increased until in May one could scarcely walk fifty feet through a clearing without seeing one. In June, the number rapidly decreased and in July, we saw none.

The birds usually chose a low bush or stiff weed-stem with a fork strong enough to bear the light weight of their tiny cup, though one nest was found eight feet from the ground on the low branch of a mango tree. The whole structure was not more than 10 cm. across and contained a

Photo by P. G. H.

FIG. 73. NEST AND EGGS OF BROWN-BREASTED PYGMY GROSBEAK

deep cup about 6 cm. in diameter by 5 cm. deep. The material used was surprisingly uniform in character, and all the finches in one locality seemed to utilize only the one kind. It consisted of fine weed stems rather loosely woven together so that light could be seen through the crevices. No other interior lining was used.

The number of eggs varied from two to three, one number being as common as the other. Their ground color was pale bluish green, thickly covered with lilac and brown blotches, interspersed here and there with spots and streaks of black. The shell was very thin and the eggs varied greatly in size and shape, some being long and others almost round. The average dimensions were 17.5 x 13.5 mm.

The little chestnut-bellied seedeater (*Sporophila castaneiventris*), built a larger nest and was not so particular about the material used. It invariably selected a low bush so that the sitting bird was never more than eighteen inches from the ground. The nest was perhaps a little better built, for the walls were thicker and there was a slight lining of finer grass on the inside. Sometimes they decorated the nest. The top of one found in Georgetown in February was covered with white downy cotton obtained from the pods of a weed growing nearby. It gave the nest the appearance of a white cotton ring hanging in the bush.

They laid from two to three whitish eggs, thickly spotted with brown and lilac, and more or less covered with fine, irregular lines of black.

A third and rarer finch, and one whose nest and eggs has not been described, is the black-headed seedeater, (*Sporophila bouvronides*). They were more rare at Kalacoon than the others, but scarcely a day passed that we did not see one in the clearing about the house. Finally, about the middle of June, a pair built a nest on the frond of a young royal palm, a few yards from the house and about six feet from the ground. It was similar to that of *O. brevirostris,* slightly larger and not so deep. Two eggs were laid.

Photo by P. G. H.

FIG. 74. NEST AND EGGS OF CHESTNUT-BELLIED SEEDEATER

BLUE HONEY-CREEPER

Cyanerpes cyaneus cyaneus (Linn.)

This graceful creeper fulfills all the ideals of one's thoughts of tropical birds. We know it chiefly as an inhabitant of the tree-tops and seen against the bright sky it showed only as a slender, thin-billed, little black bird. But when we saw it against foliage, its plumage blazed out in all its brilliance. With a body scarcely four inches long it glowed a brilliant purple blue, with feet of scarlet, crown of pale blue, back and wings of blackest jet, the latter splashed within by pigment of brightest gold.

We watched them in the jungle—the brilliant cock birds and the dull-striped hens of olive green. In early July, they came in numbers with the hummingbird hosts to the honey-laden blossoms of the cashew trees. But their life otherwise remained a mystery until we found a nest on the seventeenth day of July. And both nest and eggs sustained the admiration which we felt for the adult blue honey-creepers.

The nest was a fairy network suspended over the water, as thin and evanescent as the shadow of an oriole's purse, and the eggs were the strangest of all eggs in the world—they were black. The home of the honey-creepers was delicately caught in the base of a great heart-leaf of a water arum, the mucka-mucka, beloved of hoatzins, and it swung in every breath of air barely four feet above the surface of the river's edge. It was exceedingly thin-walled, every detail of the eggs and the setting bird being plainly visible. And yet it was most durable and quite impossible to tear or even appreciably alter in shape, for it was composed of fine, but very strong thread-like rootlets, all of a uniform dark brown or black color. The small round opening was at the top, obliquely facing one side. The nest itself was 17 cm. high, and 8 cm. across, while the nest hollow within measured 4 cm. in diameter by 7 cm. deep.

There were two eggs, astonishingly black or purple-

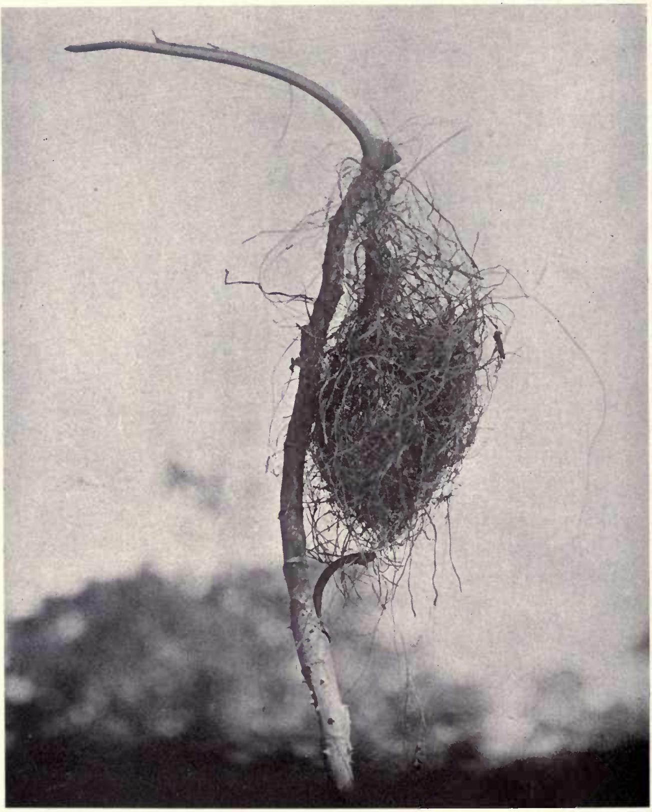


Photo by P. G. H.

FIG. 75. NEST OF BLUE HONEY-CREEPER

black. Closer examination showed faint traces of the pale lavender ground color, distinctly revealed at the small end, and in irregular streaks and minute interstices as far as the middle of the shell. They measured 20.5 x 14 and 20 x 14 mm., and were quite fresh.

This is the sum of our knowledge of the blue honey-creeper, whose appearance is such a delight to the eye, and whose habits but whet the desire to know more of the intimacies of life of such strange, graceful little beings.

MORICHE ORIOLE
Icterus chrysocephalus (Linn.)

One of the first birds to greet us at Kalacoon was the moriche oriole. These birds were unusual in their charm, for they were satisfying both to the eye and ear. From dawn until the passing of the swift tropical twilight their black forms, crowned and shouldered and booted with gold, looped palm with palm, or glanced in the sunlight as they sped away to the denser secondgrowth in search of insect food. And hardly ever did they perch without giving utterance to the silvery thread of warbling notes which, while individual and distinctive, yet with no less certainty declared their oriole relationship.

Late in February, upon our arrival at Kalacoon, we discovered no less than five nests of this oriole in the single royal palm in the compound in front of the house. We soon found that only one pair of orioles occupied the tree, and each day it became more and more probable that this pair was the architect of all five nests.

Two of the nests were complete and apparently several months old. Three were unfinished and upon two of these we saw the birds working intermittently. One of these nests contained two eggs, one of which we took as it had apparently never been described.

The nests were placed on the under side between the leaflets of one side of the frond, about two feet from the tip. They were made entirely of shreds of the leaves themselves, which the birds tore from a particular frond, a frond which through their industry had become almost denuded. The green fibre was woven with the bill and the process was not

Photo by P. G. H.

FIG. 76. NEST OF MORICHE ORIOLE

a simple one. The nest was a fairly deep cup, held in place by the rim and sides being woven into several separate leaflets. The leaves were split with the bill, and the shreds of fibre then woven in and out until the leaf was safely bound to the side of the nest. In the case of two of the nests the sewing was very finely done, not unlike the work of the tailor bird of India. The divided row of leaflets formed a perfectly water-proof cover. The entrance to the nest was invariably at the end toward the trunk of the palm. Here a pair of leaflets was held slightly apart by a thick mass of woven fibres, a thick frame, which also acted as a sort of perch or landing stage for the old birds in entering or leaving the nest. The nests were of coarse materials outside, but lined with very fine, soft shreds.

The nest with the two eggs when completed, measured, outside, 12 cm. in length, 8.2 cm. in diameter and 6.5 in depth. Inside it was 8.5 cm. in length, 5.7 cm. in diameter and 5 cm. in depth.

The egg was rather sharply pointed and measured 25 x 18 mm. Its ground color was creamy white, marked with spots and small blotches of various shades of dark brown, umber and sepia. These were very sparse about the small end and the center, but abundant at the large end, the blotches forming a rough wreath about it. At this end, too, there was a hint, in the faintest markings, of the scrawl-like figures so characteristic of the eggs of many orioles.

On March 23, the birds began building still another nest, and laid in it before it was quite completed. On April 28, a young moriche hatched, and for the next two weeks both parents kept busy feeding the young bird with insects. Most of these they secured at the blossoming cashew tree. While the birds were incubating they were rather silent, singing but seldom, and quite wary, slipping away quietly whenever we appeared. During the weeks of feeding, however, the constant labor was lightened with frequent singing, and both birds became exceedingly tame, quite regardless of our near presence.

On May 15, the young moriche left the nest and with the two parents disappeared. No sign of them was seen until a month had passed, when on June 14, all three returned. Within a day or two the old birds began overhauling one of the half-finished nests and soon occupied it.

Painted by Persis Kirmsé

FIG. 77. YOUNG GREY-BACKED TRUMPETERS

CHAPTER XIV

YOUNG GREY-BACKED TRUMPETERS

The grey-backed trumpeter (*Psophia crepitans*), was fairly common in the jungle about Kalacoon. About every second trip through the woods these birds would either be seen or heard.

I have scanned ornithological literature and have gathered together all our scanty knowledge concerning these interesting birds, and this year I had hoped to solve the mystery of their nests and eggs and young. But in this I was only partially successful—the nests and eggs must remain unknown until another season, and my monograph of these birds will consequently be delayed until then.

From Cozier, a reliable boviander bird collector, I got the following data, the accuracy of which time alone will prove. Trumpeters, or warracabras, as they are known throughout Guiana, lay two white eggs. They nest in small colonies, one nest in each adjoining tree, five or six nests in each group. The female takes the young by the wings or back and carries them down to the ground. Cozier said he had seen this accomplished. The nesting season lasts until June, eggs being found as late as that month. The nest is twelve to fifteen feet up, well built of twigs and leaves, deeply hollowed so that the bird sits in it. Both parents share the duties of incubation, and they will desert neither eggs nor young even after being disturbed many times.

So much for second hand knowledge. The facts I accumulated at first hand had to do only with the adults and young birds.

Whenever the old birds were alarmed, they would run a short distance and then take refuge on low branches, mounting thence by easy stages until they were quite near

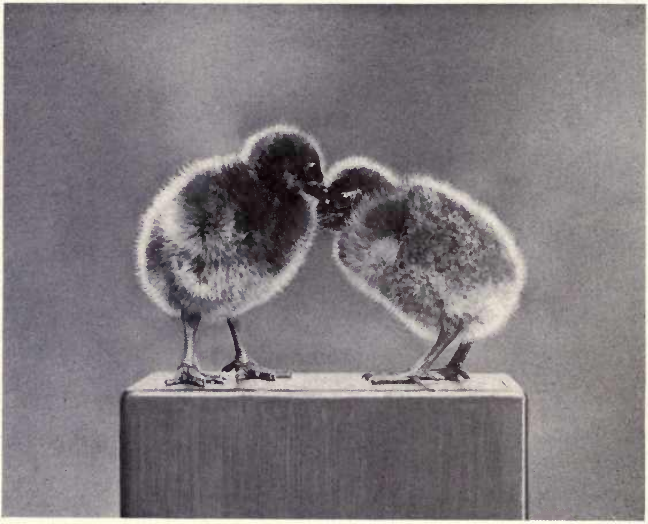


Photo by P. G. H.

FIG. 78. YOUNG TRUMPETERS FOUR DAYS OLD

the tree-tops. There they would sit and cackle to one another. If suddenly flushed and terrified they flew at once, slanting slowly downward as their power of flight weakened, and then ran rapidly until a good distance away. If approached quietly they could be shot on their perches, and one shot seldom alarmed the rest.

Our Indian hunter, in four months' desultory shooting, brought in twenty trumpeters from a comparatively restricted area. And yet at the end of our stay, there seemed no diminution in the number of families or flocks which we observed from day to day.

The sexes of these trumpeters showed a preponderance of females of about two to one. The food of these birds was chiefly vegetable and exceedingly varied. For instance, the crop of one bird contained a thorax of a large, green beetle, and fragments of several small beetles and orange ants, besides numerous red seeds, skins of berries and several chestnut-shaped, hard, greenish seeds. This was typical of many birds examined, the proportion of vegetable to animal matter being about eighty to twenty per cent.

We secured three young birds in the downy stage. One of these was about a week old, and was one of four of equal age, which were in company with three old birds, a male and two females.

On April 21, we secured two very young trumpeters about four days old (Fig. 78). These were associated with a flock of ten or twelve adults and eight or ten nestling birds, cheeping on the ground in all directions.

The downy trumpeter had the characteristic shake of the head and nervous wing-flapping of the adults. Its note was a sharp peep like that of a chick, until called or stroked when it changed to a plaintive, sibilant *twe, twe, twe, twe,* or when more excited, *chuwee! chuwee!* This reminded one of the whistling squeak emitted by a rubber doll.

The chicks roosted at night on the highest perch, and during the day preferred always the darkness of the coop to the bright light outside where the young curassows and guans spent their time.

When first placed with these other young birds, the downy trumpeter became quite excited, flicked its wings and bowed, quite like the old birds of its own species. It could not as yet boom, but when greatly agitated, as when caught in the hand, it uttered the prolonged cackle of the adults, together with the high, shrill note.

It invariably perched on one foot, and this rested chiefly on the middle toe, with the big basal pad behind the perch, the central toe curled around it, and the other two spread laterally along the top. The hind toe was quite useless in roosting, being raised high above the perch.

The pattern of the young trumpeter was very complex and wholly unlike that of any other downy chick with which

Photo by P. G. H.

FIG. 79. YOUNG TRUMPETER TWO MONTHS OLD

I am familiar. (Fig. 77). In a week-old chick the lores, sides of the crown, face, chin and throat were dark seal brown. The eartuft and two sprouting zones of breast feathers, jet black. Entire sides of neck and foreneck dark smoky brown. Belly, abdomen and inner thighs buffy white.

A broad line down the center of the crown, splitting apart on the hind crown and nape, and coalescing again on the hind neck, was pale cinnamon. A complex series of crescents on the upper and mid-back, two latero-dorsal lines extending quite to the tail, and an elaborate pattern on the sides of the body and the outer thighs were cinnamon, the thigh markings paler, more buffy.

The background of the lower neck and upper back was black. The background of all the remainder of the plumage—two lateral crown lines as far back as the lower neck, the mid and lower back, rump, sides and outer thighs—all were cold, grizzled grey, varying from cinereous to plumbeous.

The wing feathers, which were sprouting strongly, were almost concealed by the long, fluffy cinnamon down. This down was very evenly distributed on the sprouting barbs, each stem of down usually resting firmly on an individual barb. Ten primaries were sprouting, slightly longer than the secondaries. All ten were black. The 6th was the longest, measuring 61.5 mm. Sixteen secondary flights had sprouted, the outer five unusually strong and black in color. The 6th was slightly tinged with grey, while the succeeding ten were wholly grey and diminished rapidly in size, from 43.5 to 11 mm.

The iris was hazel brown. The bill black with restricted areas of ivory white along the culmen, lower edge of upper and tip of lower mandible. Inside of mouth, pale flesh, except for posterior palate which was black. Legs and feet chaetura drab, paler on larger scales, darker on soles.

When the chick was two months old the down still persisted on the head, neck and posterior dorsal areas.

As typical of an adult in full molt, I present the details of wings and tail of a bird shot on July 20.

The three outer primaries were old.

4th nearly full-grown.

5th a quarter grown sheath.

All the remaining primaries new.

Secondaries all new, full-grown, except from the 8th inward which were still growing.

RECTRICES

Left 5	4	3	2	1	1	2	3	4	5 Right
Old	New full-grown	New sheath	New full-grown	New 1-3 grown	New 1-3 grown	New full-grown	Old	New full-grown	Old

Formula of tail molt: $\left.\begin{matrix}4\\2\end{matrix}\right\rangle$ 1—3—5

COMPARATIVE MEASUREMENTS

	Weight	Length	Bill	Wing	Tail	Tarsus	Middle Toe and Claw
5 day chick	78 grams	176	14	22	—	32.5	32.5
60 day chick	1 lb.	266	22	107	15	52	46
Adult	2 lbs.	540	40	270	115	122	95

CHAPTER XV

THE WAYS OF TINAMOU

Some day an entire volume will be written about these birds and every word of it will be fascinating reading. For they are surcharged with exciting and unexpected habits and ways of life. Their appearance and voice, roosting, flight, nesting and courtship—all are unexpected, often inexplicable, always thoroughly absorbing. They have somewhat the appearance of bob-tailed partridges and in the tropical jungles almost usurp the place of the quail, partridges and grouse of our northern forests. For these latter birds are of true northern origin and the scattering of forms which have made their way thus far to the south are only hardy pioneers, of small size and laying but few eggs, barely holding their own among the intensive dangers of this region.

The tinamou are the dominant ground birds of the Guiana jungles. They are so specialized for a terrestrial life that they have unshipped their feathery rudder—their tail-feathers have softened, shortened and merged with the rest of the body plumage. Their flight is thus direct, and is seldom sustained over fifty yards.

By squatting at the sign of danger they unconsciously offer conclusive proof of the concealing character of their garb of browns and greys. At a nearer approach they boom up into the dim air of the mid-jungle, hurling themselves off through the trees with an astounding roar of wings, and then scaling on a long, slowly descending slant, to the ground far beyond view.

In physical make-up they are dual or triple personalities, for they are fowls or pheasant-like from some angles and quite ostrich-like from others. To scientists, tinamou are as yet the most casual of acquaintances. We know only

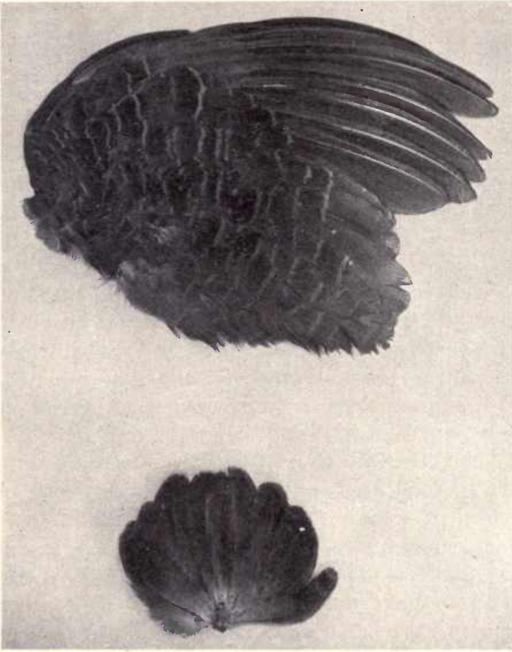


Photo by W. B.

FIG. 80. ROUNDED WING AND DEGENERATE TAIL OF TINAMOU

the most superficial facts concerning them and their lives from birth to death.

I shall point this chapter with one of these facts, one concerning a mere physical character, small in itself, but which I shall try to make significant. For I shall consider it as typifying the future work which I wish to carry on at the Research Station, the sort of work which can only be done in the field, and yet which is initiated and controlled by the knowledge derived from books and museums. And I shall take it up in detail as an illustration of one of the many methods of research, in part deliberately planned *a priori,* in part seeming like luck.

There are eight species of tinamou in British Guiana, three of which are found in the vicinity of Bartica. These are divided into two genera, *Tinamus* and *Crypturus.* Etymologically, there is neither logic nor reason in these names as terms of differentiation; both groups are tinamou and both deserve the name of "hidden-tail." These genera are recognized throughout the world, and whenever any specimens of these particular birds are received in museums they are at once classified as one or the other. The actual character of differentiation is the scaly part of the leg or tarsus. In *Tinamus,* the rear part of the leg is exceedingly rough, the edges of the scales projecting and forming a series of rugged corrugations. In *Crypturus,* the hinder aspect of the tarsus is quite smooth. These two distinctions have been recognized for many years—*Tinamus* for more than one hundred and thirty, and *Crypturus* for a hundred and six years, and during all this time ornithologists have accepted this character without thought or question. The needs of taxonomy having been satisfied, there was no danger of confusion even if a pile of skins of the two groups were thoroughly mixed up. So the birds have been labelled and catalogued and put away in their respective cases and the incident—the casual, nominal affair between Hermann and Illiger versus *Tinamus* and *Crypturus*—was considered closed.

But this is unworthy of the very name of science and ornithology. It is as if we should meet a person with an infinite capacity for life-long friendship and should wilfully turn away after merely hearing his name.

Soon after the first tinamou sprang up from under my feet in the jungle, or when Nupee, the Indian hunter, brought me the first of the many whose flesh were to form so excellent a part of our food, the old, old question forced itself upon me, the question from which I can never hope nor desire, to escape; the question which makes all science

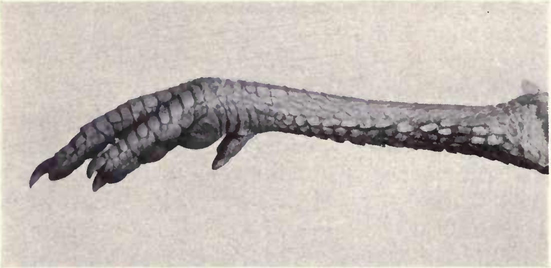


Photo by W. B.

FIG. 81. ROUGH TARSUS OF *TINAMUS*

worth while; the question, Why? The names *Tinamus* and *Crypturus*, became naught but names. All significance fell from them, and running my fingers over the rough tarsus of one bird and the smooth, shining scales of another, I asked again and again, "Why?"

I noticed that in every instance the rough-backed tarsus was coated with dirt. Often the interstices were completely choked with fine mud and debris or with fibrous mold. The legs of the smaller birds were as clean as they were smooth. With only a half-framed theory in mind I thoroughly washed off the dirt from the tarsi of several birds and sprinkled it on a pot of earth, which previously I had thoroughly baked. In the course of the following weeks I reared an interesting little assortment of mosses and small arboreal plants, but which, after all, formed only circumstantial evidence.

Nupee, the Akawai hunter, was an excellent observer and, as I had tested on a number of occasions, a truthful reporter of what he observed. But to make more certain of the result, I put my questions indirectly and negatively, so that to tell the truth he would have to go against my apparent assumption. All but strictly honest natives and savages will readily fall into this little snare, and will offer

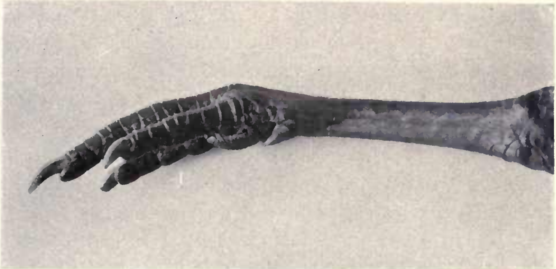


Photo by P. G. H.

FIG. 82. SMOOTH TARSUS OF *CRYPTURUS*

sacrifice to the favor of "Marster" or "Sahib" or "Tuan," rather than to the most elusive goddess of all hierarchy.

To Nupee, *Tinamus,* or the great tinamou, was known as maru; the two *Crypturus,* the pileated and variegated tinamou, were respectively orri-orri and sulima.

Our conversation was brief and to the point, running somewhat as follows:

"Nupee, you know orri-orri?"

"Yes, marster."

"He sleep in tree?"

"No, orri-orri sleep on ground."

"Does sulima sleep in tree?"

"No, sulima sleep on ground."

"You know maru?"

"Yes."

"Then maru sleep on ground, too?"

"No, maru sleep in tree."

Then, in the course of the next few days:

"Nupee, you say maru and sulima sleep on ground?"

"No, maru always sleep in tree, ever' night."

This was pretty good for exhibit B of proof. But such a habit was so startling, so unlike what we should expect of birds extremely specialized for terrestrial life, that I could not be wholly convinced.

Late one afternoon I was some distance from Kalacoon when a sudden downpour of rain came on. I had many snug retreats and shelters scattered through the jungle of which I made use whenever I was caught with a camera in one of the occasional afternoon showers. I ran at once to a huge hollow tree, whose splayed buttresses arched far outward, and whose great hollow trunk vibrated alternately day and night with the humming wings of swifts and the softer swish of bats. During the course of the rain I found many things to watch, for the life of the jungle is often most interesting at unusual moments. The incident which dwarfed all others, however, was a great tinamou, a *Tinamus,* a maru, which stepped past with quick, dainty strides and half leaped, half fluttered awkwardly up to the base of a leaning tree, and with wildly balancing wings, made its way forty or fifty feet still higher to a large horizontal branch. Here without hesitation, backed close against the trunk, the bird squatted. and facing lengthways of the branch, rested on its tarsi, which were applied closely to the rough, mossy bark.

The third and conclusive phase of the quest of the "Why?" had come. Now, indeed, we could return to *Tinamus* and to *Crypturus*, and resurrect them from the tomb of meaningless terms, of hollow names, of inarticulate *raison d' être.* Our answer to the "Why?" has made them significant, surcharged with a reality of difference, and has aroused a desire to carry the interrogation farther, striving to learn the reason for the tree roost.

GUIANA GREAT TINAMOU
Tinamus major (Gmelin)

This big, olive greenish tinamou was the most abundant of the three Bartica species, and it was seldom that one took a walk in the jungle without observing or flushing several birds. They were equally common on both banks of the Mazaruni and up the Cuyuni. The early morning and late afternoon were the periods of their greatest activity and the times when their calls were more frequently heard. On cloudy days, however, they would call at any hour, and on moonlight nights, throughout the night. They were essentially birds of the jungle and never left the deep woods to come into the secondgrowth. Like all tinamou they were solitary birds, and I never saw even a pair together, although occasionally several would be temporarily drawn together by the abundance of fallen fruit beneath some great jungle tree.

When feeding, they would squat at the first hint of danger, but at the second alarm, if the source of danger approached gradually, they would bend low and attempt to sneak quietly away. This was the usual view one got of these birds if he was picking his way quietly through the jungle. To watch them, one must crouch at the very first hint of their presence and have patience to wait for a half-hour to quiet their suspicions. When on the nest they did not leave until discovery seemed inevitable, when they burst up with a disconcerting whirr of wings, almost a booming, which, coming unexpectedly made accurate observation very difficult.

I have never heard a cry of alarm or danger, nor any call to chicks nor content note, neither have I seen them in the act of uttering their trill. This call, which was a summons to the mate or mates—for this species is polyandrous—was a true trill, steady and rolling, sustained on the same note with the following intervals:

——————————— ———— ———— ———— ————

In February or early March the courtship was at its height, judging from the loudness and persistency of the long, drawn-out calls. About the second or third week in March the breeding season began, and in mid-April, it was in full swing.

The nest was invariably placed at the base of a tree,

Photo by P. G. H.

FIG. 83. NESTING SITE OF GUIANA GREAT TINAMOU

between two small projecting buttresses. The trees selected were small and the nests were usually on the side away from the prevailing heavy rains. One such nest found on the third of April was close to the base of a young mora tree in light undergrowth. The six eggs, burnished, spheroidal, were lying in a deep depression of the thick layer of dead leaves which covered the whole of this part of the jungle floor. Several large leaves hung directly over the nest, sheltering it from view above. We found it by accident, while we were searching for the nest of a big black-breasted ant-thrush, which persisted in wandering aimlessly about, once or twice fairly walking over the tinamou's nest. This was one of the most beautiful and graceful of the ant-thrushes, large and partridge-like, forever pattering with dainty steps over the leaves and dodging under hanging vines. Now and then she uttered a shrill, querulous chatter, and between times dipped her tail sandpiper-like. The male flew almost at my first movement and did not return. The female walked about, keeping apparently away from her own nest and ultimately blundered into and flushed the tinamou.

As we leaned over the nest, held by the beauty of the great, blue spheres, we came under the suspicion of a world of midgets. First came a pair of cinnamon hummingbirds whose nest must have been close by, for they bullied everything in sight. Insect-like, they came within arm's-length of my face, where they whirred, and hung suspended, and flicked back and forth. Then they had a mimic battle with one another, chirping loudly, and this outcry brought a pair of diminutive flycatchers to the scene, and two equally tiny ant-thrushes. Like most small birds, all were absurdly tame and all vented their wrath upon us as we photographed the tinamou nest. A few minutes afterward, several yards away, I surprised a beautiful ocelot lying on a log. This was down a deep gully close to tumbling rapids. The cat hesitated long enough to mouth a silent snarl, then noiselessly sprang back into the jungle. Last of all, as we left

Photo by P. G. H.

FIG. 84. NEST AND EGGS OF GUIANA GREAT TINAMOU

the glade with our colorful treasures, an equally brilliant, blue morpho butterfly flapped slowly past. Such were some of the surroundings of this tinamou nest of early April.

There seems to be much variation in the number of eggs of this species. Eight is not uncommon, but the sets of ten and twelve which have been reported are very unusual. I found several instances where sets of four and six were being incubated. The shells were spheroidal, highly burnished, as in all tinamou, and light turquoise blue in color. The average measurement was 57 x 47 mm.

The eye of this tinamou was dark hazel, and its facial skin leaden blue. The legs and feet were a peculiar green-blue grey or in young birds a clear celandine green; the bill was a dark bluish horn, with the lower mandible lighter. An average bird showed the following measurements: bill, 34 mm.; wing, 247; tail, 87; middle toe and claw, 41 mm.

The females averaged slightly larger than the males, the extremes being 420 and 477 mm. The sexes were equal in weight, from 1.5 to 2.75 lbs. The food was wholly vegetable, consisting chiefly of seeds swallowed whole, pink, green, brown or yellow, resembling acorns or nuts of various shapes. The favorite food was the seed of the monkey-pots (*Lecythis*).

When the skin was removed, the flesh was of a strange greenish-grey color, most unhealthy in appearance, but delicate and delicious when cooked.

There seemed to be but slight difference between the sexes. The males were, as a rule, more rufous and less olive than the females. In full-plumaged males the forehead and crown were blue-black with the chestnut nape and hind crown sharply set off. In a large series of females the blackened area extended over the whole crown and forehead.

Even the birds in most perfect plumage, showed signs of the serious effect of the bête rouge. The nape and back of the neck of almost every bird, like the cheeks of the agoutis, were bare and mangy, and dotted with scarlet clumps of

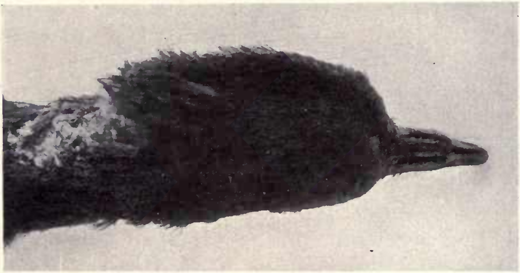


Photo by W. B.

FIG. 85. HEAD OF GUIANA GREAT TINAMOU SHOWING PATCHES OF BÊTE ROUGE

these pests. These were larvae of some species of *Trombidium,* probably one of the large members of the subgenus *Dinothrombium.*

There were very few mallophaga on the body or wings, but among the chin feathers I found many specimens. These were of two species. One was small and narrow, *Lipeurus longipes,* which has been recorded from several other species of these birds, although nothing is known of its relationships. The second mallophaga, which was of large size, broad in proportion, and quite hairy was *Goniodes albiceps.* This has been found on *Tinamus robustus* and *T. tao.* The genus as a whole has been recorded from gallinaceous birds and from penguins.

A bird of the year had a feather-fly upon its plumage. This strange, flat insect flew off several times, but after each excursion returned to the feathers of the dead bird. Failing to catch it, I wrapped the whole bird in a butterfly net, placed it in a chloroform box, and finally shook the dead fly from the plumage.

The molt of the tail seemed almost as irregular, as the structure of the feathers is degenerate. The most usual shedding of the five pairs of rectrices was as follows: 5, 4, 2, 3, 1. The molt of the primaries was normal, from the inner toward the outside pairs, but the fifth secondary was always the first to be dropped.

PILEATED TINAMOU
Crypturus soui soui (Hermann)

The voice of this bird was one of the commonest nocturnal sounds which we heard from Kalacoon house. It was but rarely heard even at the edge of the jungle, never from its heart, but was confined wholly to the secondgrowth and the still more open clearing of the rubber plantation. At one time or another it could be heard during every one of the four and twenty hours; seldom, however, during the day, and only during cloudy weather. From eight to nine in the late evening, at midnight, and again from five to six in the early morning were three very pronounced vocal periods.

The trilling differed from that of the great tinamou in being of shorter phrasing, and less high and sweet. Usually only a single phrase was uttered, this being repeated after a few seconds, or after another bird answered. But occasionally, especially during the midnight period, the birds gave voice to what was the acme of their vocal efforts. The sweet trills rose higher and higher in shortened, excited cadences, until they ended abruptly on the highest note of what was really a secondary trill.

This may be visualized thus:

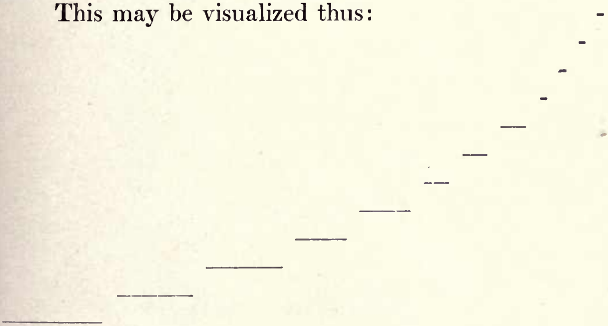
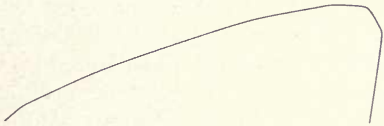


Photo by P. G. H.

FIG. 86. EGG OF PILEATED TINAMOU

The usual trill was of this linear cadence:



The latter was the call which aroused the excited ascending trill, so it was probably peculiar to one or the other sex.

It is not remarkable that we are ignorant of which utterance characterizes the males, for the breeding habits of these birds are so strange that no transference or assumption of qualities would be surprising in their sex.

While with most birds the breeding season is confined to a fairly well marked season, with the pileated tinamou, the nesting period seemed interminable. From the beginning to the end of our stay the birds never ceased to call, and they apparently nested assiduously throughout the entire six months. Unlike the great tinamou which deposits a number of eggs, broods them, cares for the chicks and has done, the pileated deposits but one egg. At the vocal solicitation of the male, the female approaches; she deigns to lay her single egg, and then departs, whether to perform the same rite for another male, we do not know. The male takes charge, and it was at this period that I found him on the fifth of May, incubating, in solitude, his single clay-colored egg. There was no nest, the egg being laid on the dead leaf debris in a recently weeded field of rubber. It was quite fresh, measured 40 x 31 mm., and weighed 21 grams. Two eggs have been found in a closely related species in Costa Rica, but hereabouts only a single one was deposited. The handicap of number was compensated by continuity of brood, and barely did one young pileated reach the age of discretion, when another female was summoned and another egg began to fulfill its destiny. One can only wonder; one cannot even theorize as to the why and wherefore of such strange habits, apparently so wasteful of valuable energy.

Pileated tinamou were to us an almost disembodied, although omnipresent voice. Living as they did in the impenetrable secondgrowth, laced and bound up with the warp and woof of razor-grass, we scarcely ever caught even a glimpse of them, and the specimens we desired had to be secured with quick snap shots, whose success was rather luck than accurate shooting.

They were much smaller than the big tinamou, and a breeding male weighed only half a pound, and measured 235 mm. in length. The female was of the same weight, but averaged larger, about 268 mm. The two favorite items of diet were a nondescript, greenish seed, and another flat, round and woody, with yellow flesh. The females showed more of a rich chestnut color than their mates, whose feathers—poor wretches—were usually worn from constant setting.

VARIEGATED TINAMOU

Crypturus variegatus (Gmelin)

The third member of this strange, terrestrial fraternity lived altogether in the jungle, where it was almost as abundant as the Great Tinamou. Its small size enabled it more often to escape observation. Its voice was less often heard, and it was the sweetest of all the tinamou. The first drawn-out phrase was higher than the steady rolling of the large bird, and this was followed by six or eight short, separate trills, an ascending staccato, which ended suddenly on the highest note.

Like the pileated, this tinamou deposited but a single egg, and we found males, attended by one three-quarters grown chick, beginning to incubate a new egg. Such devotion would be hard to equal. The egg was discovered on June 17, and it contained an embryo of about four days.

In a breeding female the iris was amber; the mandibles black, the lower yellowish-white toward the base; the legs and feet warbler-green. The length varied from 285 to 325 mm., and the birds weighed about three-quarters of a pound. The food was dominantly seeds and nuts of various kinds, some like acorns, others resembling cherries in color and pits. Two birds only had eaten insects, small beetles and wire worms.

Judged by the day-to-day shooting for the pot by the Indian hunter, the average proportion of the sexes was eight males to each female, and without exception, the latter were in much finer plumage. Curiously enough, however, all the chicks and half-grown birds were females.

The difference between the true juvenile and the adult plumage is abrupt and striking. In the first plumage, the head is chestnut rather than black, and the feathers of the upper parts instead of being black, cross-barred with buff, are rufous, with black centers and white tips. Beneath, the reverse is true and in place of the plain rufous and white of the old bird, we find warm buffy feathers barred with black and white.

A few weeks later another molt takes place. The head becomes black as in the adult, but the body plumage is intermediate between the juvenile and the adult. This molt does not include the wing feathers which change abruptly from juvenile to adult pattern. In this wing molt the primaries are replaced regularly from within outward. The seventh and eighth secondaries fall almost simultaneously, and from these the molt proceeds both outward and inward. Both juvenile and adult primaries are dark colored, but the secondaries show very marked changes in the two plumages.

Photo by P. G. H.

FIG. 87. EGG OF VARIEGATED TINAMOU

The juvenile secondaries have the exposed parts of the vane of a rich chestnut color, while in the adult these feathers are black with more or less regular barring of yellowish-buff.

A chick of about two weeks of age had ten half-grown, juvenile rectrices, the outer pairs nearly grown, the inner mere sheaths; the molt being thus centripetal.

A comparison of measurements shows the relative growth.

	Length	Bill	Wing	Tail	Tarsus	Middle toe and claw	Weight
2 weeks chick	160	17	105	28	30	20	¼ lb.
Adult	298	27	155	48	40	28	¾ lb.

CHAPTER XVI

WILD LIFE NEAR KALACOON

I

The laboratory room at Kalacoon possessed sixteen windows and, standing as it did, on an isolated eminence, two hundred feet above the Mazaruni river, and the intervening jungle, it is no exaggeration to say that a zoologist could spend many weeks in worthwhile observation without descending to the ground outside, and years of study would be well repaid in the compound itself.

I attempt in this chapter only the presentation of desultory notes, but they each possess some *raison d'être* and as a whole, suggest the wide field for research offered by even this limited area.

I arose usually before daybreak and divided many of the early morning hours between writing and watching from the windows the gradual awakening of the day's life.

Perhaps the most noticeable thing was meteorologic—the calms of early morning. They were unvarying. No matter how tempestuous the evening before or the night, the dark just before sunrise and the hours of early morning were always calm and quiet. Not a breath of air stirred. The tide flowed silently up or down, or for a short time held itself motionless. Rarely, at the high tide, the river surface was broken by porpoises, or manatees or a leaping lukananni. While the calm was unvarying, the atmosphere might be clear to the horizon, so that the distant range of the Blue, and the Pull-and-be-damned Mountains were sharply defined, or on the other hand, the air might be so drenched in mist that the nearest shrubs were quite invisible.

Sound seemed to carry farther at these times of quiet. If it were dark the trill of the pileated tinamou, the loud cry

Photo by W. B.

FIG. 88. THE OPEN CLEARING OF KALACOON COMPOUND

of the who-are-you or the indescribably mournful wail of the poor-me-one, echoed from the darkness at the edge of the compound. Or later, in the half-light, these were replaced by the harsh squawks of caracaras, the shrill scream of parrots or macaws, an early risen kiskadee, or the never-absent duets of the little guans or hanaquas.

II

Many mornings I made notes on the awakening of tropical life, as I observed it through the senses of sight and hearing, beginning at daybreak, at 5:30 A. M., and continuing it for a half or a full hour. I print three of these tables of observation, made respectively in March, May and July.

MARCH 26, 1916:

5:30—Just light enough to write; baboons howling across river; martins chirping sleepily.
5:35—Hanaquas start S. E.
5:38—Second hanaquas start S. Twa-twa slave sings constantly.
5:39—Third hanaquas start E. Jungle pigeon coos.
5:40—Yellow warbler sings. Several finches sing.
5:41—Palm tanager flies down from thorn palm.
5:42—Wren sings.
5:43—Pigeon coos loudly.
5:44—Moriche oriole leaves nest in thorn palm.
5:45—Fourth hanaqua N. E. (close to edge of compound). First hanaqua answers. First martin flies.
5:46—Hanaquas calling in three directions. The poor-me-one calls. The midnight song of the variegated tinamou.
5:49—Wren's voice still dominant, with hanaquas at intervals. Six o'clock bee cicada starts. Flycatchers of several species sing their harsh songs. Thrush far in the distance, very sweet.
5:55—Second moriche oriole leaves nest.
5:57—Twelve or fifteen martins appear in sky, coming from jungle. Twa-twa slave mounts bush and sings violently; wheechew! wheechee! etc.
6:00—Martins increase in number and continue feeding. Beetles drone past, and big bees appear.
6:01—Three *Pitangus lictor* begin chasing each other. Caracara uproar in distance.
6:04—Kiskadees appear at edge of clearing and sit silently on twigs. Martins and high-perching flycatchers busy, insects are flying high.
6:06—Flock of katydids come into clearing and a dozen flycatchers and finches chase them wildly.
6:07—Blue tanager passes.
6:10—Chorus has died out, birds busily feeding. Kiskadees call for first time in distance.
6:13—First hummingbird feeding.

MAY 16, 1916:

Clouds in East. Faint light.

5:30 to 5:45—Howlers, poor-me-one, tinamou, who-are-you, wife-sick, all heard during this period. Bats, hawk over roof.
5:48—Wren singing.
5:50—Palm tanager leaves palm. Jungle pigeon bells.
5:51—Dragonflies out.
5:52—Hanaquas E. and S.
5:52½—Hanaquas S. E. ones answer.

Photo by W. B.

FIG. 89. FAWN OF SMALL GRAY DEER

5:52¾—Hanaquas S. E. E. ones answer.
5:53—E. ones answer.
5:54—New hanaqua couple S. S. E.
5:55—White-throated kingbird goes to thorn-bush perch and catches first insect. First martin leaves nest.
5:56—Six more martins.
5:57—Six pairs hanaquas calling.
5:58—Kiskadees and streaked flycatcher hawking. Indoor martins leave.
5:59—Every high bush has its flycatcher now, dozens all over cecropia forests, flying up and feeding. First butterfly out.
6:00—Pigeons belling in three directions; courting. Seedeaters still asleep. Moriche orioles leave palm nest. Harsh cries of flycatchers dominant for the last ten minutes. Sun rises in clouds.
6:03—Amazon parrots leave roost.
6:04—Tinamou in distance; then one close to compound. First small flocks of swifts from jungle toward river.
6:06—Twenty swifts hawking very high in the air.
6:07—Grass-finches appear and sing.
6:08—Heavy mist blowing from forest, clouds whole sky.

6:09—Finch songs now dominant. Woodhewer heard in distance.
6:10—More swifts.
6:11—Finches and ground birds become dominant and have their hour.

JULY 2, 1916:

Sky clear except for few fleecy clouds, and a few mountainous island-clouds along the bright east. One star straight overhead. Everything drenched with dew, valleys filled with mist. Light enough to write easily.

5:30—Wren in full song. Jungle pigeon in distance, and baboons howling. First chatter of martins. Two species of finches singing.
5:32—Two hanaquas S.
5:32½—Two hanaquas N. E.
5:33—Two hanaquas S. E. (near).
5:33½—Two hanaquas N. W. (near).
5:35—Dragonfly hawking.
5:35½—First two martins going to river to drink. Palm tanagers leaving nesting place. Moriche oriole leaves palm.
5:36—Young martins chirping in box.
5:36½—White-throated flycatcher makes first catch and goes to thorn tree perch, calling.
5:37—Rooster flaps and crows twice.
5:38—Tinamou trills. Second pair of nesting martins go toward river for drink. Eight dragonflies hawking. Hanaquas end chorus, each pair having called three times.
5:39—Two wrens have sung almost continuously.
5:40—Woodpecker pounds in the jungle to the south.
5:41½—Indoor-nesting-martin feeds young.

Photo by P. G. H.

FIG. 90. YOUNG CAICA PARROTS

Photo by W. B.

FIG. 91. CASHEW TREES NEAR KALACOON

5:42½—Amazon parrots leave roost going to forest. Four more martins hawking high up.

5:43—Eastern island-clouds touched with rose.

5:44—Tinamou in clearing calls.

5:44½—Four-winged cuckoo utters double note. Four medium-sized swifts overhead.

5:45—Wrens singing less, feeding among grasses.

5:47—Indoor martins feed. Eleven swifts overhead.

5:47½—Tinamou calls. First big bee drones past.

5:48—Box martin leaves.

5:48½—Returns with food.

5:49—Indoor martin feeds.

5:49½—Sixteen giant swifts come from roost near river, going junglewards.

5:50—Several flycatchers appear.

5:51—Indoor martin feeds. Box martin feeds. Male comes for first time, looks in and flies off. Synallaxis calls.
5:52—Many small swifts going towards forest. Clouds all alight with brilliant rose.
5:53—Box martin feeds.
5:53½—Box martin feeds a large adult ant-lion to young.
5:54—Box martin feeds and cleans nest.
5:54½—Box martin feeds.
5:55—Tinamou trills. Aureole of gold in sky.
5:56—Box martin feeds. Wrens' song still the dominant one.
5:56½—Tinamou calls continuously.
5:57—Fifteen martins come from river toward forest.
5:58—Pee-zing finch begins dance.
5:59—Indoor martin feeds.
5:59½—Box martin feeds.
6:00—Sun a ball of gold comes out of grey cloud. Box martin feeds.
6:01—Tinamou still calling persistently.
6:02—Box martin feeds. Sun too bright to look at. Indoor martin feeds.
6:04—Box martin feeds and cleans nest. Toucan calling in distant jungle. Bird voices dying down.
6:05—Macaws leave nest in jungle and fly over it.
6:06—Synallaxis calling loudly and continuously.
6:06½—Hummingbird at flower spike of air-plant.
6:06—Flock of twelve tanagers, palms and blues, going toward cashew trees.
6:09—Caracara voices in distant jungle.
6:10—Rufous pigeon calling.
6:11—Male box martin feeds and rests on perch at box for thirty-one minutes. Its plumage is drenched after a bath in the river.
6:11½—Six blue tanagers on way to tree.
6:13½—Synallaxis still trilling. Pee-zing still going.
6:15—The coolies' soft Hindustani is heard as they go to work. Indoor martin feeds. Parrakeets leave roost, going straight to forest in three distinct bands, all coming from the same bamboos.
6:18—Female martin feeds and cleans.
6:20—Two very long-winged swifts toward clearing.
6:22—Finches feeding in numbers among grass.
6:23—Fog has shut out river and is surging across clearing. Valley mists slowly rising.
6:26—Box martin feeds and rests for a moment.
6:26½—Box martin feeds and rests a few seconds. Male still perching; as since 6:11.
6:27—Giant caciques leave roost.
6:29—Tanagers at intervals passing to cashew tree. Sharp voices of hummingbirds heard now and then.
6:32—Wrens begin singing again.
6:35—Synallaxis trills. Nothing heard but chirps of finches.

Photo by P. G. H.

FIG. 92. GIANT MARINE TOAD

6:40—Mists gone from valleys. River a solid mass of fog.
6:42—Giant swifts in pairs high up. Male box martin leaves perch, catches insect, returns at once and feeds:
6:42½—Then perches again and feeds.
6:45—Male box martin leaves for another quick capture and returns. Feeds.

As I was about to leave, I saw a large bird alight in a great cotton tree between Kalacoon and the river. My glasses showed it to be a mealy Amazon parrot. I watched it carefully and could see every movement. It lifted a foot, scratched its head, pushed its wing down and preened its plumage. Now and then it ducked as one of four palm tanagers dashed at it. In fact, it was mobbed by these birds as enthusiastically as if it had been an owl. It craned its neck and watched with interest as the Government steamer left the Penal Settlement and started down river. A final concerted attack by the palm tanagers drove it to leave its perch and fly junglewards.

III

Our study of the two dry and the two rainy seasons has only begun. This first year we were able to make only the merest beginning. As a hint of one method of work, however, as well as putting on record many incidents of interest, I shall print the daily calendar which we kept from June 15 to August 6. The specimens are all kept for ultimate identification.

June 15th—Weaned fawn of large deer captured. White-throated thrush breeding. Allied crested tanager with two nearly grown young.

June 16th—Amazon parrots in flocks. Camaria lepidoptera at lowest ebb; only three species of morphos.

June 17th—Capuchin embryo 4/5 developed. Variegated tinamou, nest and one egg; an embryo of four days. Spot-winged ant-creeper with full-grown young.

June 18th—Lizards courting and mating (green-headed striped species; grey). Fresh brood of banded morphos.

June 19th—Fork-tailed flycatchers in full molt.

June 20th—Big black bumble bee beginning to burrow. Tree-top flocking of birds almost at highest point of numbers. Blue honey-creeper in full molt. Lace-winged wax insects freshly emerged on trunks.

June 21st—Immense brood of small fireflies. Several young howlers just able to climb alone.

June 22nd—Ten peccaries with five young, (2, 2 and 1). Two curassow chicks two weeks old.

June 23rd—Grey-headed flatbill nestling leaves nest. Phaethornis hummingbird in height of courtship and battle.

June 24th—Large brood of a jungle ichneumon fly, mimicking diptera. Young caica parrots nearly in adult plumage.

June 25th—French cashew fruit begins to ripen and fall. Silver-beaks seen in trees.

June 27th—Tree-top flocks reach highest number. Phaethornis nesting begins. Red-legged digger wasp begins second nesting season.

June 28th—Rufous-throated ant-catcher hatches young.

June 29th—Sackawinki monkeys three-quarters grown. Large brood of blue butterflies with black circles.

June 30th—First big thunder storm of season.

Photo by W. B.

FIG. 93. CATERPILLAR OF SPHINX MOTH

July 1st—Big brood at evening lights, of small, white-spotted June-bugs. Nocturnal skipper at lights in Kalacoon.

July 2nd—Bellbirds appear on Bartica road. Brood of tiny red jungle butterflies.

July 3rd—Morphos along trails become fewer and very ragged. Large colony of lesser green sand hornets at height of nesting on plantation road.

July 4th—New broods of sphinx larvae in compound. First big chorus of marine toads heard.

July 5th—Quadrille wren's eggs one-quarter incubated.

July 6th—Last white-necked crake's nest and two eggs found far out Convict Trail. Many pairs of small, short-horned grass-hoppers mating.

July 7th—Smallest kingfishers feeding one young.

July 8th—Five new species of butterflies in rubber clearing, especially *Junonia*. Third day without rain, heat so great at noon that twenty bats creep out from eave holes and hang outside. Two storms in evening; first ones.

July 9th—Spotted sandpiper with diseased ovary tissues, shot on the shore.

July 10th—Fresh brood of red-spotted heliconias sleeping close together. *Tinamus major* has almost completed wing molt.

July 11th—Third young martin from the box nest flies for the first time.

July 12th—New broods of small butterflies in the forest; small white heliconias and small whites. A nestling of pygmy wedge-billed woodhewer leaves nest. A nestling of cayenne wood rail caught.

July 13th—White-necked crake chick ready to hatch.

July 14th—Hundreds of lizards about one-third grown appear suddenly.

July 15th—Baby howler seen, only a few days old. Summer is surely here, butterflies increasing daily in species and numbers.

July 16th—Orange-plant papilios out. A single nestling of Leotand dusky flycatcher just flown.

July 17th—Nest and two eggs of coereba; eggs purplish black; in mucka-mucka near water across Mazaruni. Last night many curious micro-lepidoptera came to light in Kalacoon, one with enormously elongated hind-legs.

July 18th—New brood of banded blue morphos. Moriche oriole nesting again in palm.

Photo by P. G. H.

FIG. 94. MOLE CRICKET AND YOUNG

July 19th—Sphinx moths hatched.
July 20th—Trumpeters nearly through molt.
July 21st—Partridges two-thirds through body molt, but with four young, one week old. Large number of honey-creepers and manakins in second growth after the second crop of choke-cherry berries.
July 22nd—Small, very sweet, green blossoms, which were in flower in early March along Convict Trail, are now in second season of bloom.
July 23rd—Fork-tailed flycatchers have completed molt.
July 24th—Large flocks of several honey-creepers, helmeted and oily flycatchers in second growth.
July 25th—Giant caciques half through wing molt, that of the body and tail not begun.
July 26th—Fork-tailed flycatchers still roosting by the hundreds in the mango trees.
July 27th—Partridge half through wing molt.
July 28th—Male crickets most numerous around lights in evening.
July 29th—Volatinia in height of nesting. Many nests near Kalacoon.
July 30th—Migration of yellow pieris all day, N. W. to S. E., past and near house.
July 31st—Mosses at the height of their fruiting.
Aug. 1st—Butterfly migration still on, even in all day rain.
Aug. 2nd—Double-toned Chinese music cicada begins singing. Honk-honk frog begins behind Kalacoon.
Aug. 3rd—Sabian thrushes of the year just beginning to sing.
Aug. 4th—New poor-me-one begins singing close to Kalacoon.
Aug. 5th—Very large brood of pearly-white butterflies (*Anartia jatrophœ*).
Aug. 6th—Sulphur butterflies still migrating.

CHAPTER XVII

THE ALLIGATORS OF GUIANA

Floating branches and logs are a common sight on the waters of the creeks and rivers of Guiana, and about one in every three of these logs is an alligator. Common in many places and actually abundant in a few, these great saurians are far less conspicuous than their infinitely smaller relatives —the lizards which everywhere scamper up tree-trunks or barge clumsily through the fallen leaves. Several negroes in Georgetown make a living collecting and stuffing young alligators and one man who had constantly followed this line of work for twenty years had acquired a very thorough knowledge of the ways of life of these giant reptiles. Among the natives generally, they are feared and avoided, and are (mistakenly) accredited with great longevity, of one or two hundred years.

Caimans or crocodiles are not found on the coast, and in fact live only above the first falls or rapids on the rivers whence mythical giant crocodiles are occasionally reported by the Indians.

Alligators occur in most of the rivers, creeks and even trenches along the coast, and nests are found in Georgetown itself, about a hundred eggs being gathered in the Botanical Gardens each season. The female alligators, when full grown, measure from three and a half to five feet, while the males, in exceptional cases, attain a length of nine feet.

The actual nesting season begins in May and reaches its height in June. Nests and eggs are still to be found in lessening numbers in July and August, but no eggs have been taken either in April or September. The number laid by each female varies from twenty to forty, each weighing about three ounces. They require at least seventy-five days

Photo by W. B.

FIG. 95. TUBFUL OF NEWLY-HATCHED ALLIGATORS

to hatch. The little 'gators are about eight inches long, a whole inch of which is gained within a few hours after breaking the shell.

Three weeks before actual laying commences, the female alligator gathers together a pile of water-soaked or decayed vegetation, pulling it up and carrying it in her mouth to some secluded spot on the bank of a trench or creek. Here she piles it and mats it down rather firmly in a rough heap about two feet in height. When alligators have been much bothered or persecuted, they will often select a pegass trench and make their nest on the floating vegetation in the center, out of the reach of any passing native.

When several weeks have passed, she tears the nest open and lays her eggs in the center of the hot steaming mass. Unlike the turtles which lay their eggs in the sand banks of the neighboring rivers, she does not desert the nest, but remains most of the day somewhere in the vicinity. She does not feed there, however, but daily swims to some more distant place. Her food consists of fish, frogs and snakes, with whatever small animals or birds can be captured, while dead creatures and even carrion are eaten without hesitation. If the feeding ground is at a considerable distance it is an easy matter to open the nest and examine the eggs undetected, but if the alligator does not have to go far, she will return at the slightest sound.

Alligators differ considerably in their courage. Some will leave the nest after a few weak protests, while others will obstinately remain sprawled over their precious rubbish heap and have to be killed before their nest can be robbed. The mother alligator remains faithfully at her post until the time of hatching, in which process she gives material assistance. The two and a half months of alternate drenching and baking by rain and sun often cakes the nest mound with a hard-baked crust through which the gatorlings would find it impossible to force their way. So the parent bites into the nest, tossing the outer shell to one side until the pipped eggs or the newly hatched young are exposed. When this is done she rolls out the pipped eggs and pressing upon them with one of her front feet, she cracks them and liberates the young 'gator. The eggs which are still whole she rolls back among the debris and leaves until the low, nasal, squeaking grunts announce that more are ready to emerge. The young are able to hatch by themselves, but it is usually a very long operation and many die in the shells.

I examined one which had had his little pugnosed snout thrust through the end of the shell for twenty-four hours and was just about to break a bit away from the hole when the little reptile shot forth like a jack-in-the-box, freeing himself completely except for his tail. He sprang from my

Photo by W. B.

FIG. 96. YOUNG ALLIGATORS MOUNTED FOR SALE

hands into a basin of water, where he dived and swam frantically, the banging of the tail-suspended shell against the tin frightening the newly hatched reptile, and conveying a first impression of the world as a fearsome, undesirable place. He blinked, rose to the surface, shook off the egg shell, and turning sideways snapped at a spot of sunlight. For a day and night, the past twenty-four hours, only the snout had projected. In three seconds more the whole being of the perfect gatorling was functioning, fully launched on what would normally be a long and checkered career.

The mother alligator goes to the nests with the young, and while some swim away and are lost, or forage for themselves, yet many female 'gators are seen at other times of the year accompanied by small ones of two distinct sizes, which the hunters believe are the remnants of the breeds of the two past years, still more or less attendant upon her.

The watchfulness of the parent is of course a trait inherited through long past centuries, and is in no way consequent upon the very recent, desultory robbing of the nests by man. But it is curious that their worst enemy at present is that most terrible pest introduced by man, from India, the mongoose. The only autochthonous foe is the big tegu, known locally as salimpenta. Both of these enemies wait until the parent alligator has gone away and then dig their way down to the eggs. The big yellow-tailed snake has been seen trying to force its way through the crust of the rubbish, but in vain.

The mating season begins in April and is announced by the females calling the males. The proportions of sexes is very unequal, there being twenty or more females to every male. The cry of the female is a subdued, but very strong and penetrating grunt, often repeated. The male's voice is a bellowing or roaring, and when this is heard in the trench, every female within hearing rushes toward him, ten or fifteen sometimes surrounding him at once. After mating, each goes off to her respective nest, where she deposits the entire number of eggs at one laying, afterwards covering them carefully.

The male never goes near the nest, except under very unusual circumstances, and it is in this connection that my alligator hunter indulged his belief in a romantic yarn, which he was convinced was true. I recount it rather as a pleasant bit of negro imagination, than as an addition to reptilian psychology. My hunter said that now and then he came across maimed and crippled females which yet had well-built nests full of eggs. One such was an animal which had three feet bitten off, leaving only one hind leg. She could not get up the trench bank without support, and yet her nest was on the top. After trapping her, the hunter con-

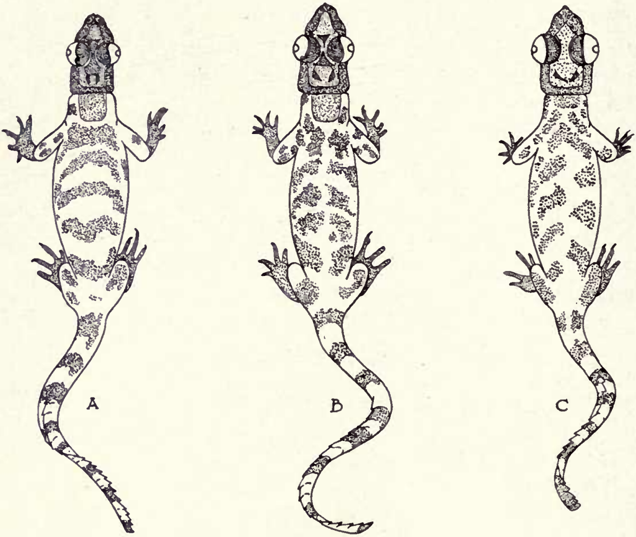


FIG. 97. GUIANA ALLIGATORS, ONE DAY OLD
a. Gooseway *b.* Abary *c.* Goomasaka

cealed himself and called, and was surprised to be answered by a big seven-foot bull 'gator which came out of the water to the nest. In this and several other instances, so my hunter argued, the male must have built the nest, as well as helping the female to get out of the water whenever she returned to it.

When an alligator is trapped or caught in the hand it utters loud chirping squeaks, not unlike the distress cries of some birds. By imitating this, all the alligators within hearing will answer and approach, most of them being females, with now and then an occasional male.

Every season my alligator hunter collects more than three thousand eggs, of which sometimes only about eight hundred hatch. In every 'gator's nest there are always a number of infertile eggs, ranging from five to twenty per cent. In a six weeks' nest, these can already be detected and thrown away, but in a nest where the eggs have been deposited only three weeks, the fertile cannot be told from the infertile ones. The fertile eggs remain white, but the bad ones soon turn yellow, at first in spots and later all over. In a healthy egg with a four-weeks' embryo, the two end thirds of the egg are pale pink or flesh color. The surface of some eggs is almost smooth, but usually the lime incrustations resemble the convolutions of brain coral.

The hunters recognize three kinds of alligators, both young and adults of which they can distinguish on sight. These are known respectively as the Abary, the Goosway and the Goomasaka (Fig. 97). The principal distinguishing characters between the three are the black dorsal markings. Between the front and hind legs there are four, rarely five, transverse black bands. In the Abary most of these bands are interrupted in the middle line of the back; in the Goosway, they form solid, continuous transverse zones of pigment; while in the Goomasaka, the bands on each side of the back line alternate, the lateral halves of one side being opposite the lighter interspace of the opposite side. Every individual 'gator of any one brood always conforms to one or the other of the types, but breeds of intermediate types are occasionally found, and these are considered as the result of inter-breeding of two of the forms.

The Abary and Goosway are the common forms and found over most of the coastal area, while the Goomasaka is very much rarer and confined chiefly to Berbice. These are also reputed much fiercer than the others, more ready to attack any intruder, and to be able to stay for a much longer time under the water. When adult there are four long teeth in the lower jaw which project through the bone and skin of the upper. The Abary and Goosway on the contrary, have teeth which are much more even.

Few living alligators are sold. The eggs are gathered, sorted as to degree of development, and kept until hatched in boxes filled with vegetable debris. The alligators are confined in tubs of water and within a day or two are killed and stuffed, standing in absurd postures, erect on their hind legs. Forever after they gaze through shoebutton eyes, and hold their little fore arms stiffly out to receive the card tray for which their future destiny intends them. Tourists, with unbelievable eagerness, purchase these atrocities at a shilling each, doubtless to repose beside wax flowers or to share some dusty northern shelf with a conch shell or a sandalwood box. In spite of this the 'gators of Guiana are holding their own. The toll of infants to be metamorphosed into ornaments is less hurtful to the race than the sacrificing of the skins of the adults for satchels.

PART II

ORNITHOLOGICAL

By G. INNESS HARTLEY
Research Associate

CHAPTER XVIII

NOTES ON THE DEVELOPMENT OF THE JACANA

An examination of several stages of development in the growth of the jacana brings to light many interesting and perhaps significant facts that so far have been overlooked. There are several curious external characters which cause the adult bird to stand apart from others as an example of great specialization. These are chiefly due to a gradual change of conditions which called for a development of certain characters and a degeneration or loss of others. The enormous toes and claws enable it, one might almost say, to walk on the waters, and the great shield on the forehead must have some special use which is still unexplained. The claw of the thumb has degenerated to a mere remnant and that on the finger has quite disappeared, while a huge spur has developed at the wrist and doubtless is of great value as a means of defense. By this interchange of characters the bird has become fitted to its present environment so that it stands out above many others as an example of adaptation. In the embryo we find many characters which have long since disappeared from the adult, and in the growing chicks we note the development of many that have been more recently acquired.

PTERYLOSIS

In the half developed embryo the feather tracts are indicated by elongated papillae, which in reality are developed feather sheaths, and in which may be seen traces of pigment. Those of the tail are the most advanced, the sheath buds of the rectrices and their coverts being nearly a millimeter long and full of pigment. On the flank, running from just above the knee and directly in line with the rectrices, is a single row of pigmented sheaths, superimposed by another row of covert-like sheaths. These are of special interest as representing the pelvic wing recently demonstrated by Beebe.[1]

A later embryo, probably not more than twenty-four hours older, shows a further development of the tail and body tracts. The spinal tract has become pigmented with a light brown color, its sheaths being especially developed along the dorsal region, where some equal the rectrices in length. No other pterylae are pigmented or much elongated.

The spinal tract is quite wide and divided by a long cleft above the dorsal and sacral regions which unite at the neck and lower pelvic. The femorals, accentuated by the line of pigmented sheaths and their coverts, are large. They join the crural or leg tract to form a continuous field, which extends over the upper two-thirds of the crus and joins the spinal pterylae behind the humeral tract above, and the ventral just below the point of the sternum.

The two scapular tracts are broad as in the adult and the sternal is divided into two narrow bands, one on each side of the keel, the space between being very narrow and extending from the point of the sternum to the upper throat. The pectorals are wide and extend from half way between the wing and the crus to the shoulder, where they join the sternal.

The embryonic pterylosis of the jacana more nearly approaches the Limicoline type than that of the Fulicariae as claimed by Nitzsch. In speaking of the adult birds, Forbes says[2]: "In their possession of well-marked firm rectrices, in the weakness of the lumbar tracts, and in the tendency to a division of the dorsal tract into an anterior and posterior fork, the Parridae differ from the typical Rallinae, and approach the Limicoline type." These facts are in the

[1] *Zoologica,* Vol. II, No. 2.

[2] Notes on the Anatomy and Systematic Position of the Jacanas (Parridae). Proc. Zool. Soc. London, 1881, page 640.

main true of the embryo, except in regard to the weakness of the lumbar or femoral tracts. While it cannot be said that all are very strong, portions are especially well developed and the sheaths are nearly as well marked and firm as the rectrices. In this respect they approach the Columbine type.

Forbes goes on to say: "The same relationship is indicated by the inner, or main, pectoral (sternal) tract, though very narrow, consisting, at least at its commencement, of two or three rows of feathers in the Parridae, as well as in the Charadriidae; whereas in the typical Rallidae, according to Nitzsch, it issues from the branch as only a single row of feathers." This is also true of the embryo. The fact that the lower tracts all join and fuse together throughout the lower ventral half of the body, though probably of ancestral origin, strengthens the supposition that the bird belongs to the Limicolae, as this condition is very nearly duplicated in the woodcock.

The first embryo shows eight rectrices developed, with two outside papillae still to lengthen; the later stage shows ten. They are divided into two groups, one on either side of the medial line with the intervening space very wide and including the long, blunt end of the uropygium. The longest rectrices are central, and the shortest—mere buds—outside. Both upper and under coverts are well developed and are as long as the rectrices, the under ones, however, being without pigment. The primaries and secondaries show only as papillae, ten for each, while on the uropygial gland there are traces of undeveloped feathers.

An examination of the three-day chick shows that the rectrices have moved together at the center so as to make an unbroken line, though the outer feathers, as in the embryo, are only half as long as the central. The upper coverts—of which there are now five pairs instead of four—are the same length as the rectrices and so close to them that they seem scarcely separable. The uropygial gland is feathered.

The primaries and secondaries at last have commenced to grow. They consist, like the tail, of down feathers, but are very short, though the secondaries are only three-quarters as long as the primaries. A most noticeable point is their great weakness and smallness as compared with the tail.

In a third, slightly older bird, the tail, which must have grown rapidly, is comparatively long; true feathers have taken the place of the down, which still adheres to their tips. The relationship of the outer feather to the center is about the same as in the preceding chick, but the tail as a whole has far outstripped any other feathered portion of the body. The coverts are still very close to the rectrices and the uropygial feathers are greatly lengthened.

Practically no growth has been made by the primaries; the secondaries, however, have forged ahead and are half again as long as the primaries. They are very short near the wrist, but grow longer as they approach the elbow. None of the wing feathers are more than half the length of the tail.

When the young jacana is half way to maturity its tail is nearly full adult length, though the feathers are not quite so strong and heavy as in the mature bird. The primaries have now broken from their sheaths and a few even surpass the secondaries in length. They are still very short, however. Except for the thumb, on which there are several well developed sheaths, the pinion otherwise is practically devoid of feathers. The primaries are divided into two sets: the first, on the carpal portion of the hand, consisting of four short and rather weak feathers of equal length; the second set, or outer set, is embedded in the digital portion of the pinion. Beginning at the sixth, which is nearly twice as long as the preceding four, they gradually shorten as they approach the tip so that the outer primary is only as long as the four on the carpals. The outer six are much stronger and heavier than the others. (See Fig. 98.)

This gradual arrested development of the outer feathers undoubtedly is a remnant of the long forgotten ages, when the jacana was a tree climber. As in the hoatzin and the pheasant—though to no such extent—the shortening possibly carries back to the time when the young nestling made its unsteady way from branch to branch, reaching and clinging with clawed fingers to whatever would lend a firm wing hold. Now the claw at the tip of the wing is gone and only a mere trace, in the shortening of these feathers, is left to hint of those early habits.

The reason for the curtailing of the four carpal remiges still remains unsolved, though possibly it is due to certain undetermined present day causes.

At this stage the secondary coverts are very long and extend beyond the secondaries for nearly four times their length. They form a temporary, secondary wing of sorts, and are fully matured in length. (See Fig. 98.) The acceleration must be due to some fairly recent cause and undoubtedly they are of great aid to the young bird essaying its early flights. The wing rapidly changes to its normal appearance between half maturity and maturity, so that by the time the chick attains its full juvenile plumage, the primaries, secondaries and their coverts have assumed their natural adult condition.

Embryos are supposed to retain throughout their early stages some at least of their ancestral characters, which later disappear. Some characters are especially prominent at first and then die out, while others remain to disappear more slowly at later stages in life. Thus the rapid growth of the tail in the jacana, both in the embryo and immature bird, would seem to be an ancient character which has been checked toward maturity in the modern bird through lack of use or some other cause. Its advanced development in the young embryo shows that it is one of the oldest ancestral feather characters and must have played an important part at some time. This being the case, the tail was probably, at some

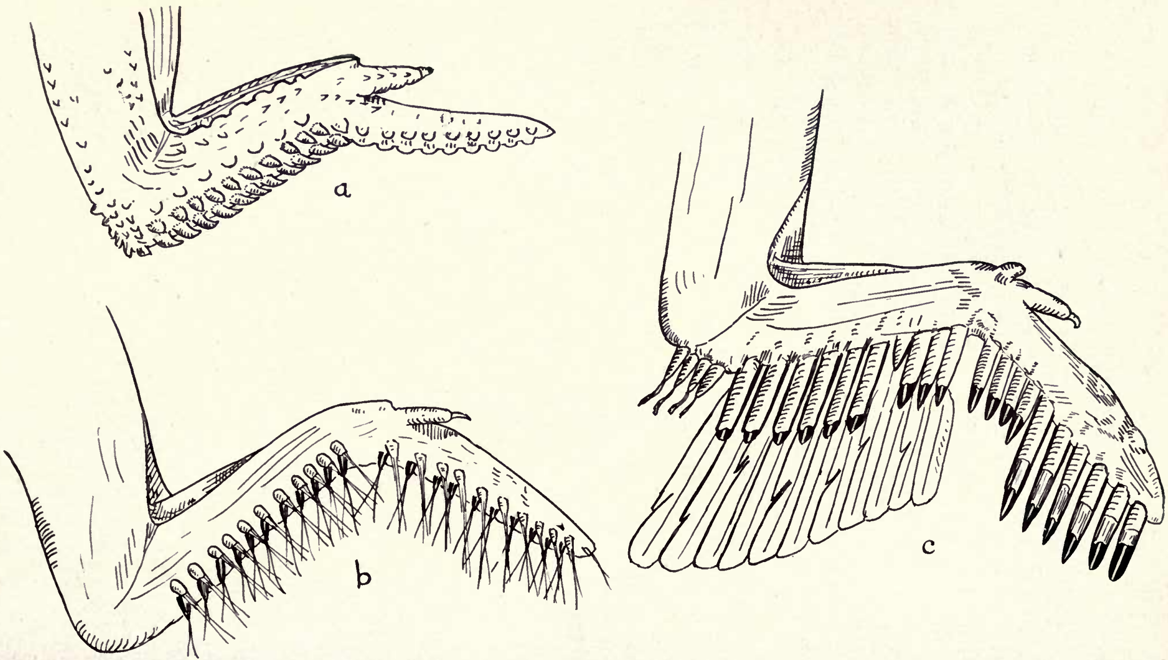


FIG. 98. DIASTATAXY OF THE WING OF THE YOUNG JACANA

a. Partially developed embryo. *b*. Normal development of feather sheaths in three day old Jacana chick. *c*. Wing of half-grown jacana chick. Observe the great length of secondary coverts; the poorly developed fourth secondary; the long outer primaries.

period, of much greater size than it is today. Thus we can imagine an ancestral bird with clawed thumb and finger that nested in trees; probably with a stronger flight, and certainly with a better balanced and longer tail than at present.

DIASTATAXY

A crowding and reduction of the fourth secondary occurs in the young chick, which in some way may be due to the diastataxy of the wing. There are ten secondaries and eleven coverts in the embryo, the extra covert being placed between the fourth and fifth. It is small and raised slightly out of line from the others, there also being a slight shifting out of place of the one above. Here, however, the shifting appears to cease and the coverts above remain in their regular positions.

At hatching time or a little later, the extra covert falls directly into line and now regularly becomes the fifth, while the original fifth becomes the sixth, and so on. There is, however, no fifth secondary to which it may become a covert. All the down secondaries are in line. (Fig. 98.)

Now comes a curious phase in the growth of the secondaries themselves. As they commence to grow rapidly, the fourth is left far behind as a mere little bud, crowded and pushed up out of line as was once the extra covert. After a period it manages to regain the line and, at first very slowly, to lengthen. Later, however, when the secondaries are nearly grown it more than recovers the strength it once lost and, pushing quickly ahead, overtakes the rest before they are fully matured. (Fig. 98.)

It is hard to account for this condition, though the diastataxy of the wing may have something to do with it. It is possible that some particular stress exerted by the movement of the changing coverts, may have caused it to be drawn up, though why the down sheath should be in line and not the main sheath, can be answered only by a more thorough examination of other specimens. That it is of regular occurrence in the young chicks is assured by the fact that its presence was noted in several birds at different stages of growth.

A FEW POINTS CONCERNING THE EMBRYONIC HEAD

The embryonic bill is short, with a blunt end, somewhat compressed, and both mandibles are of the same length. There is a small "egg-tooth" on the tip of the upper mandible. An examination of several specimens for the length of bill as compared with the adult shows a steady uniformity in the growth of that organ as compared with the age of the chick.

The nostrils do not appear through the thick membrane of the nasal fossa until near hatching time. In the three-day chick they are small round apertures, 7 mm. from the tip of the bill. As the bird grows older, they gradually increase in length, becoming oval, until in the adult they are twice as long as broad and lie parallel to the culmen.

The skin flap about the bill extends far up between the great eyes of the embryo, and fills the entire space between them. It consists of a long, soft, loose flap of tissue attached to the base of the bill. In the hatched chicks it hardens and becomes much shorter, taking on the shape and proportionate size of the adult wattle.

TOES AND CLAWS

The extraordinary length of the claws is of special interest in this bird. The claw of the hind toe greatly lengthens as the bird matures until it far surpasses any of the others. In the embryo it is very little longer than the rest and composes about one-third of the toe. The other claws are of normal size, blunt at the end and extend straight out from the toe with a slight downward curve.

After the jacana is hatched the hind claw commenees to grow rapidly while the others remain stationary, except that they all become pointed with a more noticeable downward curve. (Fig. 99.) By the time the chick is one-third grown the hind claw measures exactly one-half of the hind toe. The forward claws commence to elongate slowly, but still remain slightly curved. After several days of steady increase, however, the curve straightens out and the second and third claws are nearly two-thirds as long as the hind claw. This last is still growing, but more slowly, and composes only a little more than half the toe. The rapid growth of the front claws is of short duration and at maturity the first claw is greatly lengthened again, far outdistancing anything else, so that it finally makes up about two-thirds of the hind toe. The other claws gradually straighten and thicken, their development during the later stage being toward strength rather than length.

There can be but small hesitancy in declaring that the claws are not a product of ancient acquirement; the last doubt is swept aside by the fact that in the embryo, and even the young nestlings they are small and practically like those of other birds. The long toes, on the other hand, are of more ancient origin, for only in the very early embryonic stages are they short. In later stages and at the time of hatching, they are of enormous size and do not change proportionally during the entire growth to maturity. When one sees the jacana stalking in stately fashion from lily pad to pad—with the pad often slowly sinking, but not too fast, because of the evenly applied weight, one easily understands why these characters exist; that their development is due to a specialization of habit.

Continually driven by some water-fearing animal or other cause to seek safety and food on the lily pads, it soon became a habit with the jacana to remain there. Because the weight was applied more evenly to a larger space on the pads, it followed that the bird with the longest toes could travel farther, and glean more, and run less danger of falling into the water, possibly to be devoured, than those less for-

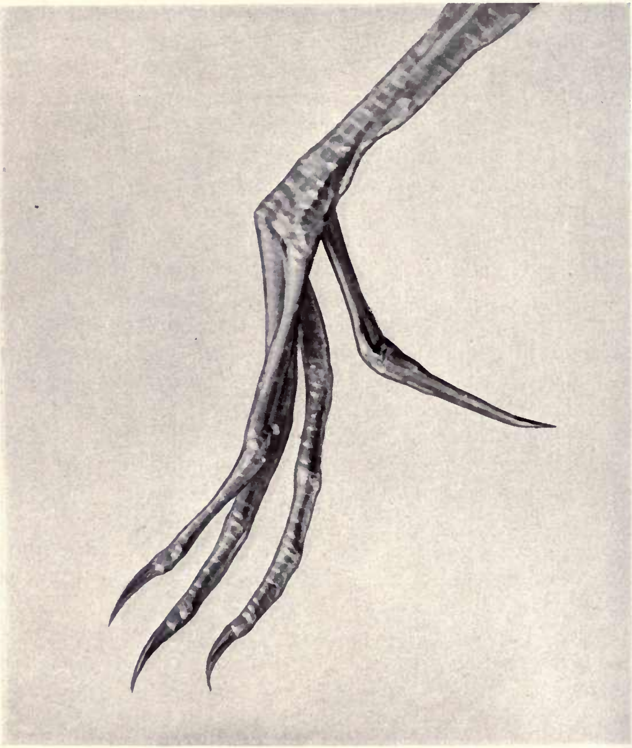


Photo by P. G. H.

FIG. 99. CLAWS OF THREE-DAY-OLD JACANA SHOWING CURVATURE

tunately provided with shorter toes. Thus a useful tendency was fostered and, through long past ages of gradual selection, the lengthened toes slowly evolved.

SPURS

Quoting from Forbes, we find that: "The 'spur' in *Parra jacana* at least, consists of an external, translucent, yellow epidermic layer, which invests a central core of compact fibrous tissue, this in turn being supported by a long projection developed at the radial side of the first metacarpal." The first metacarpal, which in most birds has a projection on its radial surface, has become elongated to form a base for the great spur. It is first noticeable as a very slight enlargement of the bone in the newly hatched chick. As the chick becomes older, the projection continues to grow, but the epidermis does not commence to harden until the bird is at least half grown. Up to that time it is only a bony knob covered with ordinary soft skin. From now on, however, it begins to take the form of a spur, but does not become a sharpened point until the bird reaches full maturity.

Forbes failed to mention the second spur, if spur it may be called. It is a small blunt protuberance situated just below the large spur and consists of an "external, translucent, yellow epidermic layer." It is supported by a small bony ridge on the ulnare which extends up across the inner side of the wrist. In the young bird the ulnare possesses a ridge on its inner posterior surface, caused by an enlargement of the third metacarpal on which the ulnare rests. Although late to ossify, the ridge finally becomes a base for the secondary spur. It is doubtless used to strengthen the larger spur as a means of defense.

SOME ONTOGENETIC VARIATIONS

In Figure 100, the body length of an adult is taken as a constant and the bodies of chicks and embryos of various stages are proportionally raised to that size. Thus, if the body of an embryo were as large as an adult, the wing and leg would be as long as in the blocked figure. By this means, an idea may be obtained of the relationship, throughout different stages of development, of the several limbs to the body.

The embryo shows a fairly well defined balance between the leg, wing and body such as one would ordinarily expect

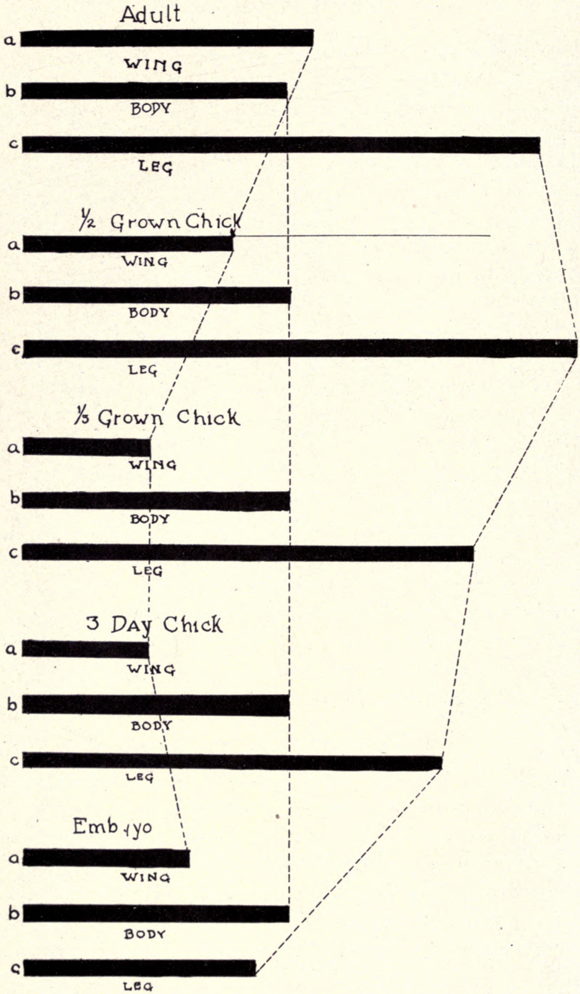


FIG. 100. CHART OF RELATIONSHIP BETWEEN LEG, BODY AND WING OF THE GROWING JACANA

to see in a bird with an evenly balanced use and development of both limbs, as is found in many Passeres and others. The leg commences to grow with rapidity, however, before the embryo hatches, so that in the very young chick we find it almost proportionally as long as in the adult. The elongation at this time is greater than in any long-legged bird I have examined.

As time advances the legs continue to lengthen until the chick is more than half grown; then comes a slackening, while the wings commence to elongate and put on their flight feathers. Until shortly before this period, they had remained practically at a standstill—little insignificant, useless, downy appendages. The little brown-striped bird with gigantic legs, having until now no need for wings, successfully hides among the stalks of rice and heavy matted grass that cover the savannah, or plunges into the thickets of reeds that line the inland pools.

The necessity for flight at length arises, for the bird must hunt farther afield in search of food, and the dense grass impedes its progress. With its increasing size and somewhat awkward gait the nearby vegetation does not always offer such a safe retreat as before; so the wing grows and with it the feathers for flight; and the flight, though never strong, serves its purpose well.

Thus in the development of the jacana, from hatching to maturity, there are two significant phases: the first, where the chick is practically wingless; the second, where the wings play their functional part. Here again Nature's hand is apparent and because of environment, color, habits, need for strong legs and apparent lack of use for wings, these members remain small and weak through the earlier stages, and strengthen later only as need requires.

THE WING

The accompanying curve, (Fig. 101), is drawn to show the variations that take place in the three constituent seg-

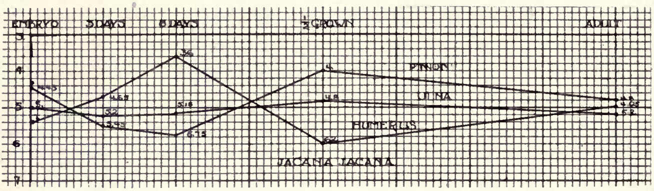


FIG .101. DIAGRAM OF ONTOGENETIC VARIATIONS OF THE WING OF JACANA

ments of the wing during the development of the chick. The wing of the mature bird is this time used as a constant to which those of immature stages are proportionally raised, so that in every case their wings equal those of the adult in total length. Thus if the embryonic wing equalled the parent in actual size, the relative proportions of its segments would be as indicated in the curve.

The curve shows the directly opposite growth of the arm and pinion throughout the whole developing period. The forearm remains constant and takes a course midway between the two. That the growth of the arm and pinion should directly change about in the short period of time between the first quarter and the half-grown stages must be fraught with some meaning of which at present we have only gleams of understanding. The lengthening of the pinion or hand takes place during the early days of the chick, when there are still traces of ancient climbing habits and possibly it may be numbered as another disappearing arboreal character. The decrease of the arm may also be placed as a declining character, for it finds an exact parallel in the young hoatzin, that living echo of the past. The great decrease of the hand in the half grown fledgling, when the wing begins to prepare for flight, and the corresponding increase of the arm further parallel the hoatzin and make one feel sure that at one time this bird spent much of its time in trees or at least reared its clawed young there. But this was long ages ago, before the wing became a practically useless appendage to the young nestling.

CHAPTER XIX

NOTES ON THE DEVELOPMENT OF THE SMOOTH-BILLED ANI (*Crotophaga ani*)

PTERYLOSIS

The series of embryos examined embraced several stages in the development of the down feathers in their papillae state. The different tracts were found in their most simple and primitive form, presenting excellent opportunities for the study of their development in regard to the rate of growth, pigmentation and transition to the adult stage.

When the embryo has passed through about half its incubation period, the papillae containing future down sheaths show scarcely any pigmentation. None of the sheaths, except the rectrices and their upper coverts, as yet are pigmented. The rectrices, eight in number, are divided into two groups by the pygostyle, the sheaths being 2 mm. long and most heavily pigmented at their bases. The coverts are smaller and less developed, the central pair being pigmented the most densely.

All the feather tracts are pigmented in the embryo of about thirty-six hours later development. The rectrices are still the longest, though the femoral and humeral tracts have made a rapid growth. The femorals are indicated by a single row of sheaths directly in line with the rectrices and appear to be a continuation of them. Proceeding anteriorly, they divide into several rows and form a triangle, one side of which is parallel to the spinal tract. The single row contains more pigment than the remainder. (Fig. 102.)

The spinal tract is narrowly cleft over the sacral and dorsal portions, closing at the neck and lower pelvis. It consists of a double line of sheaths which run together into a single line over the scapular region, and where the cleft

Photo by P. G. H.

FIG. 102. ANI EMBRYO SHOWING PIGMENTATION OF THE FEMORAL TRACT

closes at the neck, into a triple row, which becomes weaker as it approaches the head. In the adult this portion becomes more pronounced and is cleft below the base of the head with a branch running above each eye. The cleft in the main tract is shorter and is joined over half the sacral portion, between the two main branches, by a middle row of feathers.

The pectoral tract consists of a double row running parallel to the upper ventral and connected with it by a few undeveloped sheaths. In the adult these feathers are fully developed and completely fill the space between the outer pectorals and the ventrals, thus forming a complete tract. To this, outside and parallel to the ventral, runs a single row of feathers, which, in the embryo, is nearly absent and, only about twenty-four hours before hatching, commences to be noticeable. (Fig. 103.)

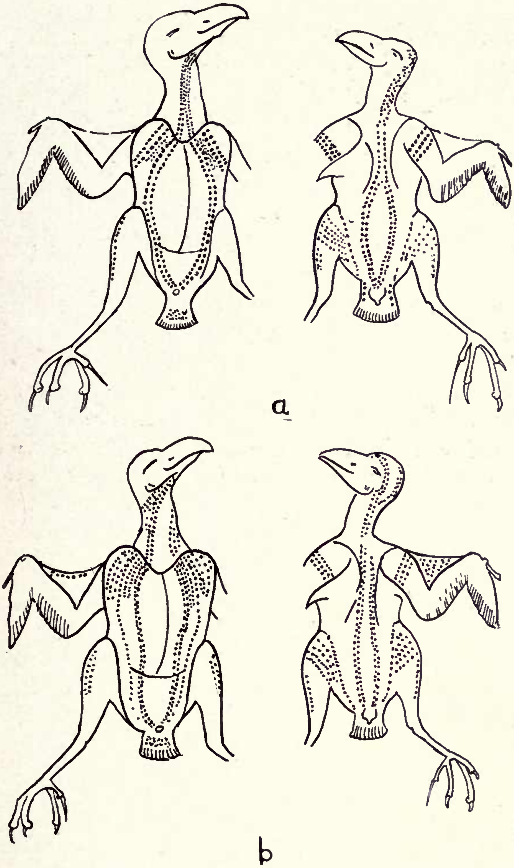


FIG. 103. PTERYLOSIS OF ANI
a. Embryo. *b*. Adult.

DEVELOPMENT OF PADS ON THE WING

The adult ani has two small horny growths on the wing, one at the tip of the pollux and one at the tip of the second

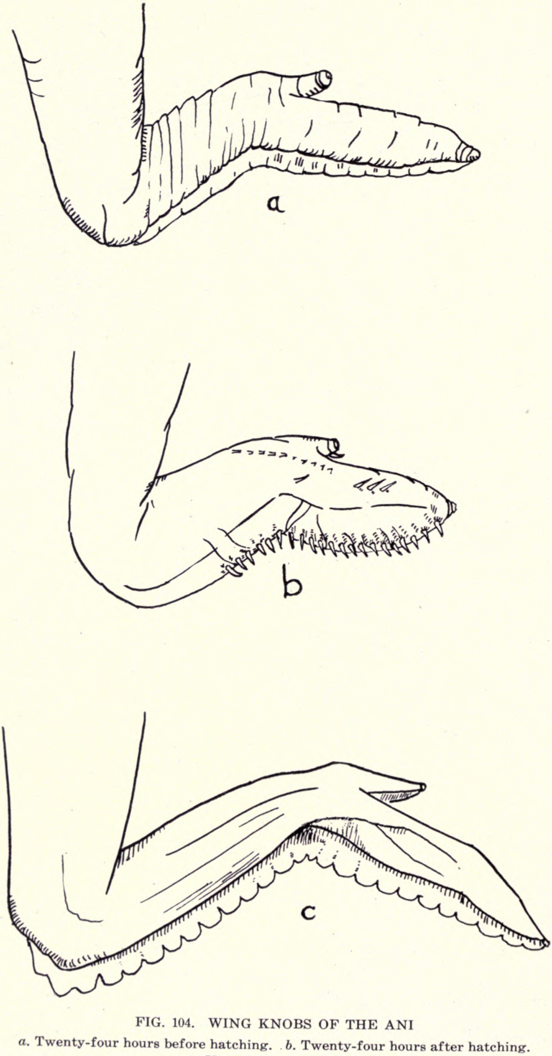


FIG. 104. WING KNOBS OF THE ANI

a. Twenty-four hours before hatching. *b.* Twenty-four hours after hatching. *c.* Upon leaving the nest.

digit. They are scarcely noticeable in the adult, but, if we examine some of the earlier stages in the growth of the wing, we find them large and evidently playing a part in the life cycle.

The first sign of any protuberance is found in the early embryo when it is about two-fifths developed. They take the form of a fleshy hook on the pollux and a fleshy hook-like knob at the tip of the wing. There is no sign of an extra phalanx at either place. As the embryonic development advances the hook on the pollux becomes blunter and rounder until, twenty-four hours before hatching, it is a large, rounded, fleshy knob covering the whole tip, though mainly on the ventral side. (Fig. 104a and b.) The knob on the second digit, also mainly on the under side, is larger and rounder and covers the tip. Both growths have hardened and become calloused. After hatching they grow smaller and at the same time harden until, at the time the bird is ready to leave the nest, they are very small and almost bony. (Fig. 104c.)

The fact that the knobs are entirely dermal, though of claw-like appearance in the young embryo, shows that they are a later specialization of what in former times probably were well developed and functional claws. The egg shell of the ani is of very great thickness and the egg-tooth of the embryo is comparatively small. Therefore, after the shell has been cracked, some comparatively strong force must be brought to bear upon it to pry it apart for the escape of the little chick. Consequently the wings and feet must be used for this purpose after the manner of hatching chicks of the domestic fowl. But, in this case, the shell being much thicker proportionally, the wings are especially equipped for pushing and prying and are undoubtedly of much use in this first great effort. This is borne out by the fact that the knobs are larger and much more developed at the time of hatching than either before or after.

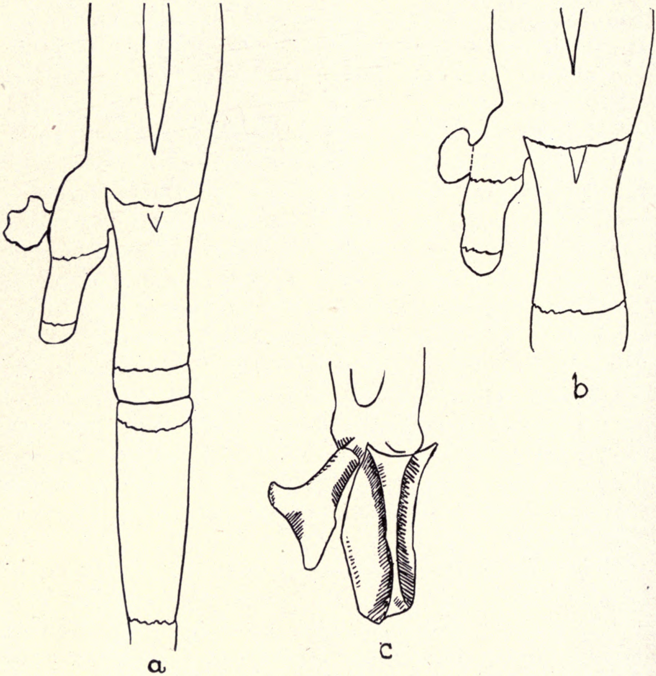


FIG. 105. DEVELOPMENT OF THE THIRD DIGIT OF THE ANI
a. Partly developed embryo. *b.* Twenty-four hours before hatching. *c.* Adult.

DIGITUS

The bone structure of the digitus presents several interesting features. Two points especially stand out on account of their being peculiar to this bird or its near relatives. First is the curious horizontal flattening of the third metacarpal. It appears almost to be divided into two bones running parallel to each other and connected by a very thin transparent layer of bone. At the proximal end, where it is ankylosed to the second metacarpal, it is broadly flattened and slightly concave, the two parallel bone centers clearly showing. Distally it gradually decreases in width and the heavy portions run together until just before connection with the upper carpal, it narrows suddenly to extreme thinness so that it is flattened vertically at this point.

A study of the embryonic wing shows the metacarpal in question to be a strong, though somewhat smaller bone than the one above it. It is round and shows no sign of flattening. Upon examining an older embryo I found that, when the bone begins to ossify, the ossification is weaker above and stronger at the sides. The endochondral bone takes the form of a scroll with the fissures running to the right at the distal end. After the bird hatches and ossification of the shaft approaches completion, the bone still remains rounded, though the metacarpal has commenced to broaden slightly and to become thinner at the time the bird leaves the nest. When the adult state is attained we find the bone flattened as above described.

The second and more interesting point is the strange T-shaped form of the third digit. It really is composed of two elements at an early embryonic stage. The stem is separate from the cross piece. It is an irregular rounded body resting against the cross piece, but not a part of it, as shown by its dividing line. It appears in the embryo, twenty-four hours before hatching and long after ossification has set in, as a rounded knob partly ankylosed to the main digit. The ankylosis is complete at hatching time, but actual ossification does not commence until the bird is several hours old. Up to this time it has only been in a weak cartilaginous state. (Fig. 105.)

Other evidence of a fourth digit has been found in the early embryos of a tern and the hoatzin, while W. K. Parker, in his two papers, "Fowl's Wing"[1] and "Morphology of Opisthocomus,"[2] states that there is a projection on the

[1] Phil. Trans. Zool. Soc., London, 1888.

[2] Trans. Zool. Soc., London, 1895, pp. 69-71.

proximal portion of the third digit which may be the rudiment of a fourth. In examining this bone in an embryonic king vulture, I found, as in the ani, that there is a partially free protuberance near its proximal end. Unfortunately, however, having no younger embryo, I cannot say if the protuberance is ever entirely separate in this bird.

All things considered it would seem, in the ani, as if this projection is the remnant of a fourth digit or one of its carpals that at one time was separate, but now has become attached to the third. That it is not a later specialization of the third is shown by the fact that only at a fairly early embryonic stage is it at all free. If it were a specialization, it never would have been entirely so.

On the other hand, figuring that the stem of the T is the remnant of a fourth digit it would seem as if there might be some significance attached to the flattening and near division of the third metacarpal. This does not seem to be true, however, as up to the time the chick is several weeks old, the bone remains round and does not really commence to flatten until the bird is able to fly. It is a recent specialization caused, possibly, by some individual movement of the wing and does not have any direct bearing on the irregular structure of the third digit.

GROWTH OF THE WING

A significant fact about the wing is the rate of growth of the various elements of the hand. The hand is divided into two component parts, metacarpus and digitus. Compared with the human hand, the metacarpus represents the palm, and the digitus, the thumb, first and second fingers, or as some will have it—the first, second and third fingers. Let us call the parts of the wing in question the palm and the index.

Figure 106a is a curve drawn to represent the growth of these parts starting with the half grown embryo. The length of the adult wing is used as a constant of measure and all other lengths are proportionally increased to it.

We see, from the curve, that, in the half-developed embryo, the palm is nearly twice as long as the index. A few days later the rate of the index growth has increased so that now it is about three-quarters as long as the palm. Twenty-four hours before hatching they again diverge and the palm makes the more rapid growth. Forty-eight hours later, or twenty-four hours after hatching, the index, having increased its rate of growth, is practically the same length as the palm. From now on they continue to grow evenly until the adult stage is reached.

If embryonic characters are any indication of characters of past ages, the early preponderance of the palm would indicate that at some time it played a more important part than it does now. A glance at archaeopteryx would make it appear as if this might be the case, for that ancient reptile-bird bore most of the primaries on its palm. Archaeopteryx, however, cannot be taken as a criterion, for it was as highly specialized along certain lines as our present day birds and may not necessarily have been the true ancestral type of the modern bird. The probabilities are that the ancestral ani had a longer metacarpus than the modern representative, which was a survival of the long metacarpals of the lizard, and possibly it held more remiges than at the present day.

Figure 106b is a curve of the growth of the wing parts, all measurements being increased to adult size as before. The humerus makes a rapid growth until near hatching time when it suddenly changes to comparative slowness, and later, to fair rapidity, which keeps up until adult. The ulna at first grows rapidly at the same rate as the humerus, but, after the embryo is half developed, is delayed until after hatching. Then it grows approximately at the same rate as the humerus. The pinion is delayed, on the other hand, in the embryo until it is about three-fifths developed. Its rate of growth takes an intermediate path between the other two

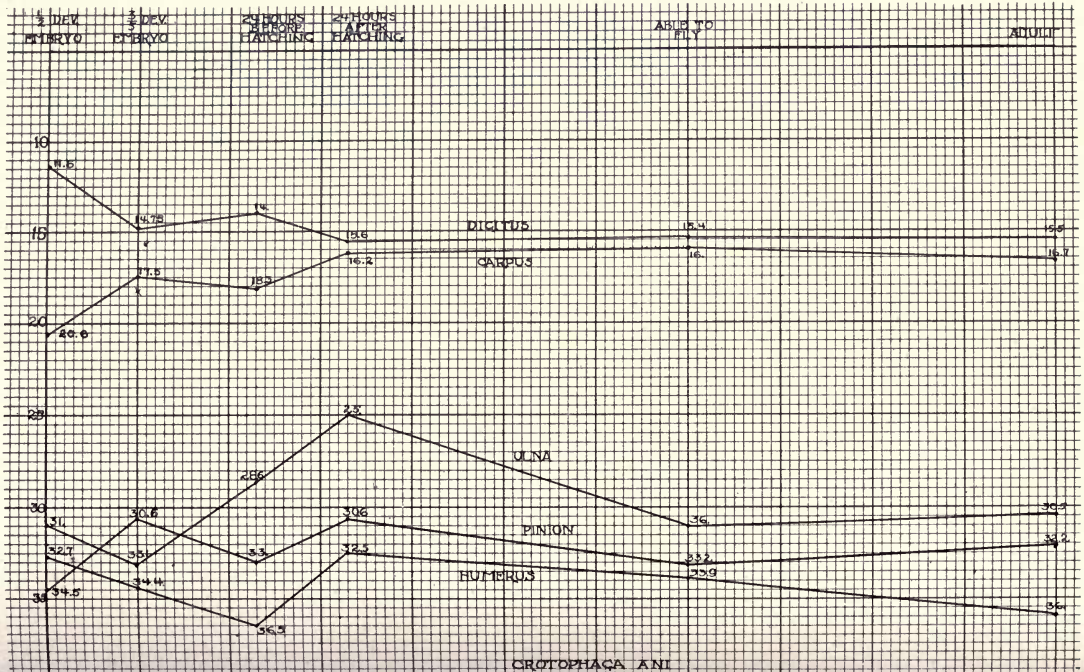


FIG. 106. DIAGRAM OF ONTOGENETIC VARIATIONS OF THE WING IN THE ANI

a. (Upper diagram) Curve of growth of hand parts. *b.* (Lower diagram) Curve of until soon after hatching and then parallels them to the time when the bird is able to leave the nest. Both ulna and pinion then show a slight decrease in growth as compared with the humerus.

A curious condition exists just before and after the chicks emerge from their shells. A few hours before, the growth of the three bones becomes retarded and remains so until at least twenty-four hours after hatching. Then they again commence to grow rapidly. The retardation is probably due to the immense amount of energy used up by the chick in forcing its way out of the shell. Its wings play an important part in this operation and are constantly in use, thus consuming the energy which otherwise would have been applied to their growth. The slight retardation of the ulna and pinion after the young bird leaves the nest is due to the more violent use they are put to in flying—especially the pinion—and possibly to the fact that these bones hold the chief flight feathers, which make a stronger growth than any others on the humerus. To prove the former statement I kept a young ani, taken just upon leaving the nest, in close confinement for over a month, where he could not use his wings. At the end of that time the ulna growth remained about the same, but the pinion had increased at exactly the same rate that it had been growing, up to the time the bird was able to leave the nest. It was longer in actual measurement than in the adult. The humerus, on the other hand, was slightly retarded.

Another point that may be worth touching upon is the opposite or alternate rate of growth of the ulna and pinion in the embryonic stages. The ulna slackens when the pinion makes a rapid growth. Then seeming somehow to have gained the ascendency, it commences a rapid growth, the pinion immediately decreasing its rate in the same proportion. They both decrease, about twenty-four hours before hatching, when the delayed stage for the whole wing commences. There seems to be a definite connection between the two, wherein the growth of one detracts from the growth of the other and definite stages seem to have been arranged for each to lengthen, so that, in the end, one will not far outdistance the other.

FEMUR

In the embryo the femur is proportionally much stronger than in the adult. Its diameter is 18 per cent of its length, whereas in the adult, it is less than 8 per per cent. As the embryo develops, the bone grows thinner, but is large even in the fledgling and for several weeks after the bird leaves the nest.

TIBIO-TARSUS

The ossification center of the shaft is, as usual, in the middle of the bone and works out in both directions. The ridges are drawn together at this point and form a kind of narrow waist, which makes it appear as if the bone were composed of two elements grown together. (Fig. 107.) At the upper end the ossification divides on the inner side and forms two points like the points of a writing pen. At the distal end it is greatly expanded with a deep groove on the upper side. This is the groove between the two distal condyles and, in the embryo, commences very near the middle of the bone shaft. Both condyles are long and much bent back.

The embryonic fibula is longer and rather thicker than in the adult. It is 37 per cent as long as the tibia, while in the adult the proportion is only 25 per cent.

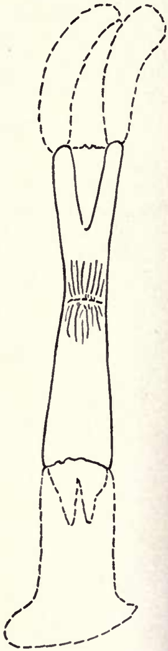


FIG. 107.
OSSIFICATION OF THE TIBIO-TARSUS OF THE ANI

TARSO-METATARSUS

The mature tarso-metatarsus is curiously ridged and grooved, the fourth metatarsal being flattened so as to form a ridge above the other bones. The second metatarsal is much flattened and seems almost to be separated from the others, being connected, particularly on the proximal half, only by a thin, transparent sheet of bone. In the embryo, however, this is not true. As late as the period when the bird leaves the nest all the metatarsals, though totally fused, are still rounded. There is just a slight broadening of the bones and a commencement of the grooves, with no flattening of the fourth metatarsal.

BILL

The exaggerated development of the culmen takes place only after the fledgling has left the nest. In the newly hatched chick, the bill is short and swollen, but in all respects typically cuckoo-like. The culmen is angled instead of curved, but as the bird grows older the angles decrease and curves take their place. The commissure is greatly curved until the culmen begins to ridge up and then straightens as the ridge forms. The lower mandible is much shorter than the upper and the gonys is narrow and very angular. The projecting hook of the upper mandible gives the young bird a rather hawk-like appearance. The gonys lengthens very slowly, so that at least three months pass after flying before the bird attains its full culmen ridge and its wide flat gonys, which pushes forward so as almost to fill the notch caused by the curved tip of the upper mandible.

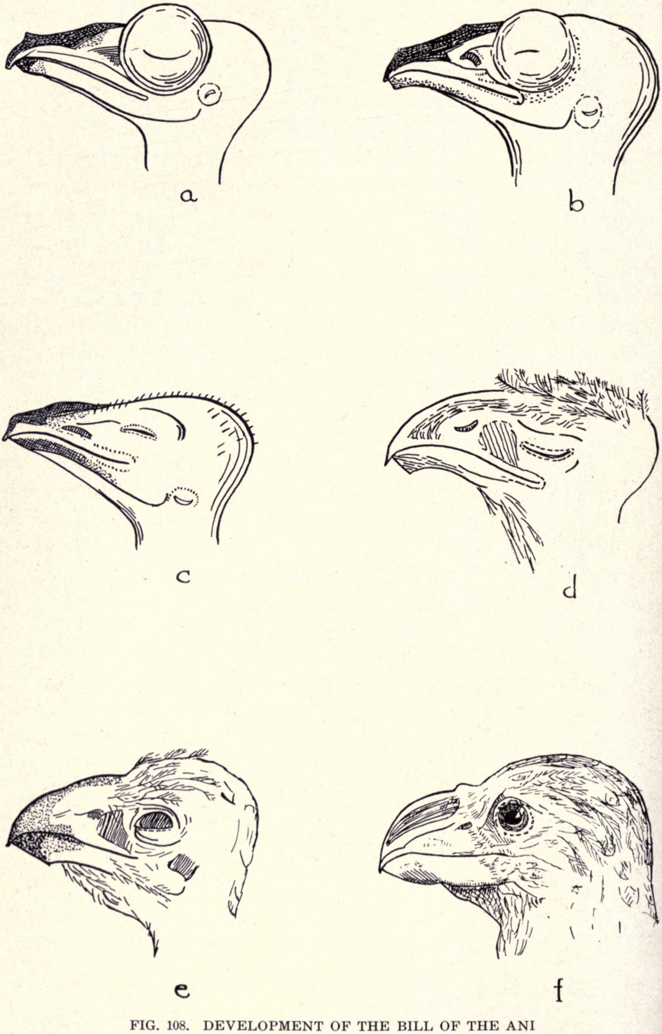


FIG. 108. DEVELOPMENT OF THE BILL OF THE ANI

a. Half developed embryo.
b. Twenty-four hours before hatching.
c. Twenty-four hours after hatching.
d. Just able to leave the nest.
e. Six weeks after leaving nest.
f. Adult.

CHAPTER XX

NOTES ON A FEW EMBRYOS

I

A NEARLY MATURED EMBRYO OF THE DUSKY NIGHTHAWK *Caprimulgus nigrescens* (Cab.)

PTERYLOSIS

The several feather tracts are marked by long violet-brown down sheaths. The sheaths of the wing, tail, tarsus and femoral tracts are more advanced than the rest, averaging about 4.5 mm. in length, and are more thickly clustered than at any other place on the body. The rectrices with their upper and under coverts are well developed and long. The femoral tracts consist of several rows of long sheaths which grow close together and make a large patch. These, together with the rectrices and their coverts give the embryo a very heavily feathered appearance on the posterior portion. The feathering of the leg and the especially heavy feathering of the tarsus, which is feathered in front with a thick tuft of sheaths that extends to the base of the third toe so that the tips of the sheaths extend past the second joint, add to the heavy posterior coating. (Fig. 109.)

The wing sheaths are equally as long and as thickly patterned as the others. Those on the forearm in particular are very numerous, the secondaries being buried beneath a thick mass of coverts, which, though the rows are a trifle irregular and rather indiscriminately placed, are all heavily represented. The primaries have single coverts with a sparse scattering of sheaths above.

The dorsal tract is at no point very dense. Over the pelvis it consists of a triple row of rather closely placed sheaths. Above the sacral region the middle row disappears

Photo by P. G. H.

FIG. 109. EMBRYO OF THE DUSKY NIGHTHAWK

and the two outer rows diverge slightly to come together at the base of the neck, where they continue parallel to the head.

The inferior tracts consist of two thick rows of sheaths extending along either side of the abdomen, which come together above the furcula. A dense patch fills the apterium over the lower sternum and upper abdomen.

The head is more or less regularly covered with rows which extend to and surround the nostrils. The eye is encircled by a widely separated double row of long feathers which connect with the nostril ring by a single row, and the eyelid is fringed with short sheaths. From the nostrils, running along the groove above the eye, is a double row, and midway between the eyes a triple line which extends straight back until just in front of the parietal region, where the outer lines diverge and gradually round together again to enter the spinal tract. The middle line passes into the open space thus formed, where two other rows run parallel with it to the spinal tract. A single line runs behind the auditory aperture and joins the ventral tract. The aperture itself is margined with short feathers. (Fig. 110.)

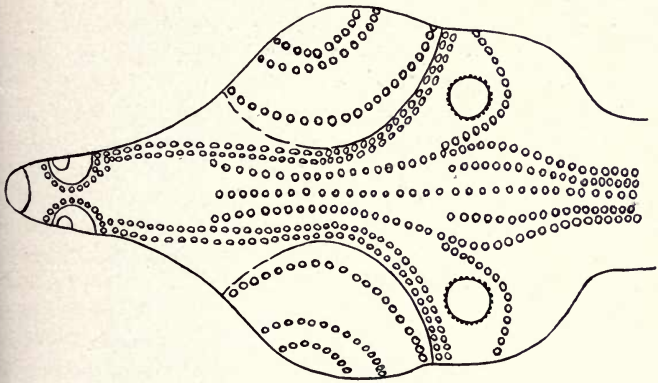


FIG. 110. HEAD PTERYLOSIS OF AN EMBRYO DUSKY NIGHTHAWK

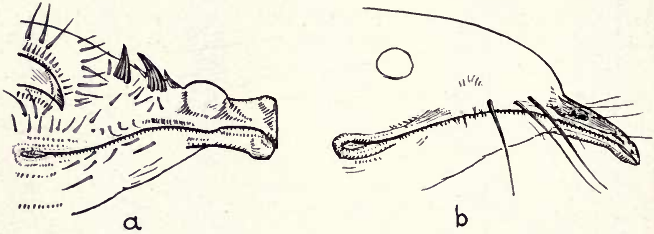


FIG. 111. DEVELOPMENT OF BILL OF THE DUSKY NIGHTHAWK
a. Embryo. *b.* Adult.

EXTERNAL CHARACTERS

The embryo has the general appearance of being tufted and spotted with down sheaths. The feathering of the head, wings and feet, and the curious shape of the bill give it an individuality of its own. The auditory apertures are large, pear-shaped and very close to the gape, the knob-like nostrils being placed rather near the tip of the upper mandible, which, with its rounded "egg-tooth" and curved end, looks very different from that of its parent. The bill is more compressed than depressed and its frontal half is very narrow with the gape extending below the center of the eye. The lower mandible is enlarged at the tip, but there is no lower "egg-tooth" as in pigeons.

The nasal apertures are round and point directly outward. They are placed in the lower portion of large, rounded, fleshy protuberances which arise on either side of the mandible. Midway between the nostril and the tip of the bill is a patch of black pigment which is directly above a similar spot on the lower mandible. The upper mandible also is slightly pigmented along its cutting edge.

From the above it may be gathered that the embryonic bill varies much in external characters from the adult. It is much narrower, much more compressed and the gape is not so deep. The nostrils are round, protrude, and are fringed with down sheaths, instead of being flattened with the protuberance reduced. There is no trace of feathers about them in the adult. (Fig. 111.)

The feathering of the tarsus is much heavier than in the adult, this area, in the embryo, being one of the most heavily feathered portions of the body. The scutation of the hind tarsus is very sharply defined, the scutes being clear cut and overlapping one another like fish scales.

The wing has a claw on the thumb and one at the tip. Both claws are long and well developed. In this character the embryo differs entirely from the adult which, so far as I have been able to determine, is entirely without claws.

II

Guiana Kiskadee *Pitangus sulphuratus sulphuratus* (Linn.)

PTERYLOSIS

The first signs of any pigmentation of the feather papillae in the embryonic stages may be found when the embryo is about three-fifths developed. The longest papillae belong to the dorsal tract, though only the posterior portion of this shows. Commencing in the pre-sacral region it immediately divides into two single rows of sheaths which follow the line of the ilia and come together in the post-sacral region near the naked eurypygium. These sheaths are also the longest on the freshly hatched bird and reach a length of 15 mm., while the remainder of the tract is represented only by undeveloped papillae. The sacral space is narrowed down to a narrow cleft.

What at first appear to be rectrices in the earlier embryo are really the highly pigmented upper coverts. The rectrices are present only as mere shadows of papillae. In the hatching bird the upper coverts are very long while the rectrice sheaths are just beginning to peep forth. As the bird grows older, however, the rectrices grow rapidly and soon overtake their coverts.

A third tract of large development is the femoral tract. Here the sheaths are nearly as long as those of the spinal tract and pigmented. A slight darkening and lengthening of the scapular tracts may be observed in the young embryo and there are a few long sheaths in the occipital region which, in the later period of hatching, become very long and prominent. In the space between the eyes there are two single rows of long, dark sheaths running along the eye grooves. All inferior tracts are indicated only by papillae, there being no noticeable pigmentation or lengthening.

III

Varied Streaked Flycatcher *Empidonomus varius varius* (Vieillot)

PTERYLOSIS

Unfortunately I have been able to secure only two embryos of this bird, both of which are about half developed, though one is apparently a few hours more advanced than the other. Only small papillae are present, there as yet being no sign of pigmentation. Some of the papillae, however, are more prominent than others, and, from the examination of a newly hatched chick, I find that they are the ones that develop into the main down sheaths.

The positions of the papillae tracts are very similar to those of *Pitangus sulphuratus* of a slightly more advanced stage, except in regard to the growth of the rectrices. In the present bird these papillae may be seen in their proper place with a corresponding row of coverts above, both showing the tiny specks at their tips which are the first indication of pigmentation. The rectrices, themselves, are much larger than their coverts. Directly the opposite is the case of *P. sulphuratus* in which the coverts develop first, attaining a good length and a dark pigmentation before the true rectrices appear plainly as papillae. In the young chick of

E. varius, however, we find that, like the other species, the coverts exceed the rectrices in length and development, though the latter are present and more advanced than in the other.

The sacral cleft of the spinal tract is slightly wider and longer in *E. varius* and extends beyond the sacral region forward into the scapular area. In the newly-hatched bird the difference is a little more marked, the arms of the tract being narrower than *P. sulphuratus.* In other particulars the pterylosis of the two birds is similar.

CHAPTER XXI

NESTING HABITS OF THE GREY-BREASTED MARTIN

Progne chalybea (Gmel.)

English:
Grey-breasted Martin.
Portuguese:
Andorinha grande.
Dutch:
Gewone Witbuik Purper-Zwaluwen.
French:
Martins a' ventre blanc.

A small bird about 6 inches in length. Similar in size to *Progne subis*. The male is a deep purple blue above, grey on the throat and breast, shading to white beneath. The female is similar with the back duller. The young are duller than the females, the back being a decided sooty grey or black. The young males, in the second year, resemble the adult females.

Range: Southern Mexico southward through Central America and South America to Peru, Bolivia and southern Brazil; island of Trinidad.

In all civilized districts from Rio northward this is the first bird to greet the traveler. As the steamer warps up to the pier there are always a few perched on the ridge of a nearby roof or garrulously hovering over the deck. Proceeding inland by water or on foot one will see them always present, where human habitations exist.

The grey-breasted martins, like their relatives of the north, thrive wherever there is a house and a clearing. They are one of the many birds that have adapted themselves to the advances of civilization and, like others, find the new conditions congenial. They are extremely tame and unafraid and because of this courage and pugnacity they are one of the most useful birds that gather about the homestead. No low flying hawk will for long withstand the vicious onslaughts of the many martins that gather about him. Thus the life of many a seed-eating finch and caterpillar-destroying wren has been preserved.

The windows of Kalacoon house always remained open and soon after our arrival several martins took advantage of this to roost on the rafters over our heads, entering through a window close beneath the peak of the roof. On the rare occasions when it had to be closed on account of the rain which poured through in gusts, the birds gathered outside in numbers, some on the sill and others on the eaves above, and tried to express their troubles in a loud bubbling and chatter. Though there were other open windows nearby, they never used them, but always, if their own private entrance were closed, sought other roosting places for the night. They roosted in pairs and never allowed a third to encroach upon what they considered their own territory.

Later on, near the end of March—the middle of the short dry season—mating instincts became uppermost and the martins commenced to consider sites for their nests. Unfortunately for us, one pair decided that their roosting place on the rafters was an ideal situation; so for the next few weeks there was a continual shower of sticks and straws from above. Fortunately they gave it up after a month of vain attempt and sought a new spot.

A small box with four compartments had been erected a short time before, on a pole, with the hope that some of the birds would take advantage of it. Immediately a pair of palm tanagers took possession. This was too much for our pair of martins, which at once—incited by jealousy and need for a new home—drove away the tanagers and appropriated the partially completed nest as their own. The occupation was not accomplished, however, without many a scuffle with the original tenants and other pairs of martins who had nesting ideas of their own. The building did not commence immediately after possession had been obtained, but, either to make sure that the new house was safe—it swayed very much in the wind—or more firmly to establish their right, it was well on toward the middle of May before the mother laid her first egg.

In the meantime other pairs had commenced to build, selecting various portions of the huge beams that acted as plates for Kalacoon house. The nests were composed of sticks, straws, dried grass, string, cloth and anything that would act as building material. They were placed back from the edge of the beam usually in a corner next to a floor joist. The spot, where the birds had been regularly roosting, was usually selected for the home site, for when they find an ideal location they remain there all their lives, or at least until conditions change. Unlike the purple martin, the too near company of others was not desired and it went hard with the individual who inadvertently overstepped his neighbor's territory. In this respect they resembled some human beings.

The Kalacoon martins commenced to lay about the first of April. Every bird had been busy for the two preceding weeks collecting material, courting, and fighting. Sometimes a dozen or more would gather on the ground in front of the house and sort over the little twigs and dried grass blades lying there. This always was attended with perfect harmony until two birds would decide that they both liked the same stick. They resorted then to force in the dispute that followed, and the fight would go on up in the air or down on the ground, until both were exhausted. In the meantime the object of their differences was usually spirited away by a third party. At any rate they always forgot what they were fighting about and never returned to the spot to look for it. Again, one would be sitting alone, awaiting her mate by the prospective nest. Suddenly, after many beautiful evolutions in the air, he would join her, and their admiration for one another was shown by wide open bills and a perfect babble of warbles. They would sit thus for a few moments each with its mouth open, or they snapped bills at imaginary insects, as if one were urging the other to feed it. Then each would seek to relieve its feelings in flight, only to return later to repeat the whole performance.

After eight or ten days of repeated journeys to and from the gathering grounds, the bulky nests were about finished and the females made ready for their household duties. The several homes beneath the house soon held their full quota of little white eggs. Two held three and another five. During the period of incubation, which lasted from fifteen to sixteen days, the male showed much solicitude for his mate. He sat for hours by her side near the nest and chirped and twittered in low sweet tones as if striving to enliven the monotony of her somewhat irksome position. Several times each day, though only for a few minutes, she took journeys in search of food.

At hatching time a busy season commenced for both birds. The business of carrying food to the youngsters went on all day long, from early morning till late at night. The little flesh colored babies with tight shut eyes and gaping mouths needed much looking after, for their demands for food never abated. After every third or fourth trip, one of the parents cleaned nest with its bill, carrying away the excrement incased in its thin shiny sack, to drop it at a safe distance from the home so that the prowling marauder might find no tell-tale evidence. (Fig. 112.)

When a week old, the nestlings presented a curious appearance with their half-open eyes, vast stomachs, and shining transparent skin thickly studded with the black sheaths of young feathers—for there is no down until about the tenth day, when the feather sheaths break. Their food consisted entirely of insects—flying ants, termites, ant-lions and dragon-flies. Sometimes a dragon-fly was brought of too large dimensions to be easily swallowed whole. Then the wings were severed, one by one, from the body, which was well crushed by the bill of the parent. The youngster would seize it fiercely and swallow it with incredible rapidity, undergoing

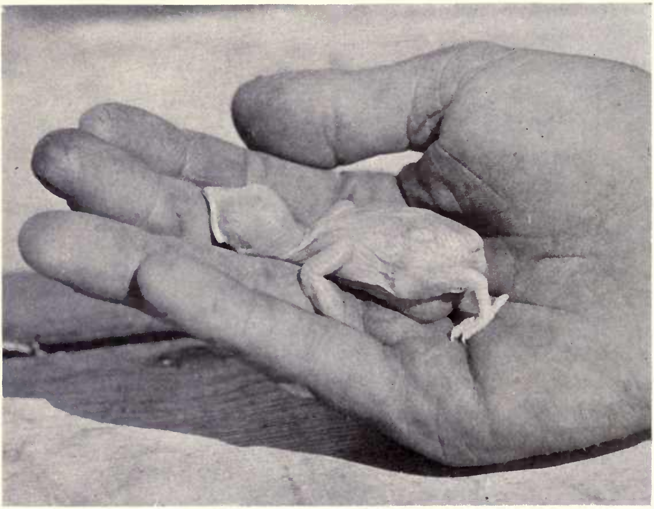


Photo by P. G. H.

FIG. 11?. GREY-BREASTED MARTIN, THREE DAYS OLD

terrible contortions, gasping and choking for several minutes after it had gone down.

The young birds were lined up at the edge of the beam, twenty-two days after hatching, ready to begin their trials of flight. They returned to their nests for a few nights and then, having partly learned to care for themselves, departed elsewhere to roost. Every morning, together with others that had been reared in less auspicious places, they gathered on the roof of the house with their parents. Invariably at 6:15, at a seemingly preconceived signal, they launched forth into the air with one great rush and chatter, swooping and sailing about the house for a few minutes before departing over the bush to seek their morning meal.

The art of catching their meal did not come quite so easily as the first flights. They had to be fed for a week or more after they were dodging and darting about in the air, and some even clamored for food after their parents were nesting again. The old birds at first perched beside their offspring, to feed them, but soon—the young birds, learning to grasp the insect with their bills, instead of having it crammed down their throats—hovered above and forced the young to reach up to seize it when they passed by. Becoming expert in this and being greedy, the youngsters quickly learned to sally forth to meet their parents and take the food from them in the air. It gradually dawned upon them, as time went on, that they might secure their food themselves, as well as from their parents. But this came only after the elders had dropped one or two insects which made the youngsters scramble to secure them before they escaped.

A few days later the old birds were nesting again.

To return to the martins of the bird-house: the young hatched, they were cared for in the orthodox fashion. The entrance to their home was a round opening about two inches in diameter. A cross stick, that projected a foot or more beyond the side of the box, was nailed there, about an inch below, for a perch.

I watched for the three little ones to make their first appointed trip into the air on the twenty-second day. One finally perched in the doorway and looked about in a dazed fashion at this new world never before discovered. Casting a look downward, he decided that it was beyond his ability to ever trust himself to the great emptiness beneath. It was far too perilous to attempt the scramble and climb that were necessary to gain the outer perch. So there he remained, while his two brothers or sisters vainly pushed and squeezed to get a glimpse, too.

The parents hovered about, chirping and urging him to chance it, but he remained immovably placed and answered all entreaties with weak little noises. They gave it up and brought food. When he had received a full share, they tried

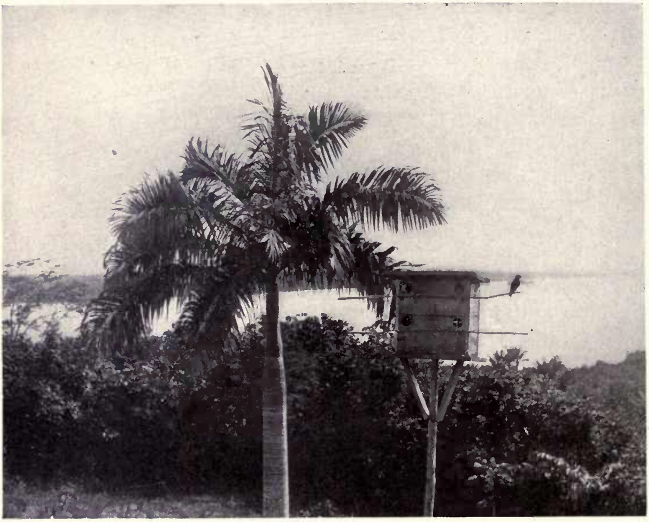


Photo by W. B.

FIG. 113. NESTING BOX OF GREY-BREASTED MARTINS

to push him back into the nest, so as to make room for another, but he would not be pushed. They fed him some more until, filled to repletion, he rejected what they brought; but still, regardless of the protests of his hungry brethren, he blocked the passage, filled with wonder at the new outlook of life. He remained thus for nearly two hours, when a change of mind suddenly came over him, and, through no forcible persuasion, he suddenly backed into the hole. His place was taken at once by another, who relinquished it to the third, only after taking his fill of the outdoor surroundings. The third remained to be fed for the space of ten minutes or so, and before it could do more than look around, was violently replaced by the first claimant for the position, who squeezed into the opening and pushed his companion down into the nest. He held the position most of the day, except when the others, driven to desperation by hunger succeeded in ousting him for a few moments. (Fig. 113.)

The performance was repeated daily for several days, a youngster always being at the entrance. The strongest spent most of his time there. His parents tried every means in their power to inveigle him forth, but for a long time without avail. They brought him nice large dragon-flies, which were held tantalizingly a few inches away; they called to him to follow them as they moved farther and farther along the perch; and finally, clinging to the edge of the hole, they fluttered to the perch to show how easy it was. As his courage increased he gradually leaned farther out of the door to follow their movements or to make an attempt at securing the morsels they brought. One day—the sixth—he leaned too far, and lost his balance. With an effort he managed to clutch the stick and with a mighty flutter of wings found himself safe and sound on the out-hanging perch. At first he scarcely dared to breathe for every little movement upset his equilibrium, and it was only by hard fluttering that he could regain his balance. He commenced uncertainly, after the first fright wore off, to preen his feathers of the small flakes of down still adhering and to stretch his wings. The mother bird sat close by, chirping to give confidence, or made short flights to instruct him in the first rudiments. The father busily fed the others, for the mother had no time to spare.

Soon the little martin commenced to take interest in his surroundings and looked about with much craning of neck, glancing this way and that, both up and down. Once he lost courage and scrambled back to the hole, but soon returned as if thoroughly ashamed of himself. At last, upon casting a convulsive look downward, he lost his balance, and away he went, bravely struggling to keep in the air, at a slant toward the ground. Suddenly the knowledge seemed to come, and he rose above the bushes, a little uncertainly at first, but acquiring more confidence as he progressed. And, before disappearing from sight, he had essayed the first wavering soar.

Instead of making for the nearest perch, he flew around and around for more than ten minutes, always gaining in skill and steadiness, so that it was a hard matter to tell their flight apart when he returned accompanied by his mother. He alighted on the roof of the box, for the perch, at first, looked too difficult, and made that the base for other practice flights. Finally time arrived to seek the nest, but then came the perplexing question, Which of the four holes was it? Two laborious attempts at wrong ones at length pointed out the right one.

The second bird left the nest on the following day, but several more days elapsed before the third made its escape, having remained in the nest for more than a month.

The general delay undoubtedly was due to the environmental change in locality of the nest. They are ordinarily placed in such a position that the young may at least sit on the edge of the nest and exercise their wings preparatory to the first flight. In this case, in their cramped quarters, there was no such advantage, and, at flight time, the young birds were entirely unprepared for the new problem that confronted them. They awaited, therefore, their full strength and feather growth before making the attempt, and, when flight time did come, it was not a weak flutter to a nearby roof or friendly bush, but a strong sally which almost rivaled that of their parents.

For ten days or more the birds used the box as their home and doubtless would be using it yet if, while they prepared to rear a second brood, the elders had not driven them away. During their short occupancy I became interested in their evident inability to remember, or disregard of which of the four openings in the box really was their true home. Even after a week of exploration and investigation the question seemed to be somewhat in doubt, for they seldom, until near the end, made their way directly to the proper spot, but first tried several other holes as on the first day of departure. At length, after many trips, the proper method of approach suddenly dawned upon their consciousness, and thereafter they made it with unerring skill.

At that time there was, under the house, a second nest with three slightly incubated eggs, which I thought might be put to some use. By watching the other birds I realized that many actions were the result of newly acquired habits, and therefore might be influenced by outside agencies. How far, though, did these habits control instinct? Up to the present, evidence showed that young birds with undeveloped intellect, ignorant of the life struggle before them, even though homing instinct was predominant, were able, only by repeated trials, to recognize their home among several others of similar appearance. Similarly their parents, upon first taking possession, had carried straws to each of the four holes until they discovered that four nests were building instead of one; even then they would often carry to the next hole before discovering their mistake. At length after many trips, they became so used to the proper location that no further errors were made. Thus, even they were dependent upon a habit to point out their permanent home; a habit created by repeated trials through which the sense of exact location became, at length, indelibly fixed upon their brains.

The nest containing the three eggs in question, though placed out of any direct rays of the sun, was exposed to the light of day, so that the eggs were in plain view of the parent, when approaching the nest. One day, I carefully marked the eggs with blotches of black ink, leaving uncolored the large ends with their air chambers, and placed them back in the nest as nearly as possible in the same old position. At first the martins were much excited and looked at the eggs askance, peering this way and that, as if they might find the lost originals hidden away in some darkened corner. In a few minutes, however, deciding that, though they did look different, they were still the same eggs, one of the birds hesitatingly crouched upon them and the incubation proceeded as if nothing had occurred.

The following day I removed both nest and eggs, putting them in a prominent spot, only a few feet away from their original resting place. The parent bird, disturbed by my efforts, flew excitedly about, and the instant I left the ladder, flew to where her home had been. She almost upset herself in vain efforts to alight on the nest, where the nest was not. Only after crouching for a full minute among the few straws that were left, did she realize that it was gone. She rushed to the edge of the beam, looked around and then back to where the nest ought to be, dragging the straws about as if the nest might be hidden beneath them; then to the edge to look at the ground below, and then back. She repeated all these movements several times, and at last, thinking that some terrible mistake had been made, flew about for a few minutes before returning to repeat her former operations. Again she returned, this time with her mate, who in turn, showed excitement, and to whom the mystery was as inexplicable as to her. Finally they perched together on the beam edge. Their eyes searched in all directions, though chiefly downward, as if the nest had fallen and rolled to some obscure hiding place. Then they flew away only to return again and again, hoping each time to find the nest in its old position. The nest remained in plain sight, but, though they often passed close by, the idea never occurred to them to investigate it.

At last, deciding that it was not on the ground and not thinking to search elsewhere, they went to roost on the original site. Doubtless it was instinct that caused them to search below, but it must have been the habit of finding the nest in the same place day after day, which prompted them to seek only in the one spot above, although the nest stood in plain view before them.

Instinct and actual habit are so closely associated that at times it is scarcely possible to distinguish between them.

What often is taken for instinct really is a newly acquired habit which, under other conditions, might be altered. Thus it happened, on the following day, that the martins instinctively commenced to build a new nest, but, from habit, used the old site. From habit they roosted there, even though they knew some enemy to be abroad that had knowledge of their hiding place, and though an innate instinct must have urged them to choose another location.

I do not pretend to intimate that newly formed habit runs contrary to instinct among all birds and animals, for such is not the case. If it were, there soon would be no animals or birds left, nor other intelligent life. If the weak inoffensive bird in the bush did not instinctively change its abode after that abode had been pillaged, a second outrage from the same source would soon follow. The same prompting causes that bird to change its abode from season to season, for, if the home were permanent, it would not long survive the encroachments of its enemies and, once discovered, would immediately became a prey to repeated maurauding expeditions. On the other hand, there are certain birds, which, because they build in protected localities, have no need to change, and so, season after season, and year after year, return to the same spot to nest.

To such a class belong the martins. They have been protected for hundreds of generations, first by tree holes and then by the buildings of civilization. The instinct for protective change of home has gradually become dormant and the habit—now nearly an instinct,—of permanency has become dominant, just as the habits of civilization dominate our own savage instincts, which often burst forth in times of crisis. If repeatedly disturbed, the birds will change, often at terrible cost, as has been the case of many of our game birds, ducks and even song birds, and the old instinct of natural preservation against enemies, never really absent —only dormant—becomes uppermost. They will learn new habits with which to combat most effectively the new enemy and these habits, in turn, will finally become practically an instinct to them.

But to return to our martins; when I had destroyed the second nest a few days later, they did not attempt a third, but still continued to roost there each night. Penard tells us of taking four sets of eggs from the nest of a pair of these birds and still they would not leave. In this instance the habit of living in one place was supreme and clearly dominated the instinctive idea of seeking a safer home. Undoubtedly the idea would become uppermost if the persecutions kept up.

As has been said, individual habit and instinct are so closely allied that it is hard to distinguish between them, but, nevertheless, there are certain points where the line may be drawn, of instinct as subordinate to new habit. Thus the young martins, in spite of all their homing instincts, could not find their home until they had determined, through repetition, in which of the four holes it was located. Such knowledge was acquired only after many trials and trips, whereby a habit of arriving at the right point was created. The results of the experiment with colored eggs may be put down to either instinct or habit, yet, as the birds must have realized that the eggs were different, it may have been habit more than instinct that caused them to continue the incubation. There can be no doubt, however, that from habit only, they roosted and started a new nest in the same place, after the old had been destroyed. This habit would have proved costly, if the nest had been destroyed by an enemy which, after new eggs were laid, would have returned to repeat its performance.

Evidence also points out that a certain few of their daily actions in the round of life are due, not so much to inborn instinct as many believe, but to habits acquired from a youthful training by their parents, from experience, and from a wide sense of imitating their elders. For instance, the young bird has to be taught how to catch insects. He knows that they are his proper food, because he has so been fed from the time of hatching, and he finally learns how to catch them only after instruction by and imitation of his parents.

These observations show, in this bird at any rate,—though probably in many others—that certain habits have been acquired, due to the protection afforded by the advance of civilization which, if the bird were transplanted from civilization to ancient conditions, would be of great detriment to it. These newly acquired habits dominate its natural instincts.

CHAPTER XXII.

PRELIMINARY NOTES ON THE DEVELOPMENT OF THE WING

That the different sections of the wings of the hoatzin and the common fowl change appreciably in proportion during the growth of the birds has been demonstrated by Pycraft and others. These writers show that the changes taking place in each are more or less parallel.

The forearm of the newly hatched hoatzin is much shorter than the hand, though in the adult it is longer. In the embryo of about two-thirds development both are practically of the same length, the hand being a trifle shorter. The forearm, though now slightly larger, soon after hatching shortens to the same length as the arm, which it parallels until maturity. A glance at the following figures will show that the development of each is in a directly opposite direction:

Opisthocomus hoazin (Illiger)

	Arm	Forearm	Hand
Embryo (⅔ dev.)	73.6 mm.	69.6 mm.	68.2 mm.
2 day nestling	69. "	66.25 "	79.65 "
10 " "	63.6 "	63.6 "	82.6 "
14 " "	74.7 "	74.6 "	80. "
Juvenile	72. "	73. "	66.5 "
Adult	71. "	80. "	65. "

Note: All the dimensions in the above and preceding figures were obtained by using the adult measurements as a constant. The measurements of the young birds were increased so that if the birds were actually as large as the adult the length of their arm segments would be as in the above columns.

The development of the wings of the jacana and the ani are discussed in other chapters where the great amount of variation in both is shown. There is a similarity between the two; both show the lengthening of the immature hand

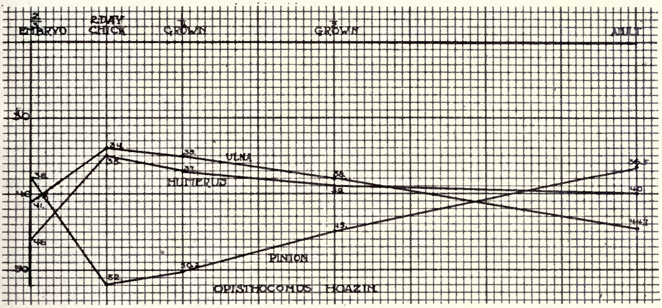


FIG. 114. DIAGRAM OF WING DEVELOPMENT OF THE HOATZIN

and its decrease at maturity. The great possible variability of the arm first becomes apparent in the jacana, the growth of that segment being quite the opposite of that of the hand, while the middle section remains practically constant throughout all stages.

Though the different portions of the wing are nearly equal in the adult blue-winged parrakeet, there is a considerable variation in the earlier stages of growth.

Psittacula passerina (Linn.)

	Arm	Forearm	Hand
24 hour nestling	26.2 mm.	20.7 mm.	24.4 mm.
3 day "	24.6 "	19. "	18.4 "
7 " "	23. "	22.4 "	17. "
Adult	21. "	20.5 "	21.5 "

Both the arm and the hand of the twenty-four-hour nestling are longer than in the adult, while the forearm is about the same. The arm decreases steadily to maturity through all stages. The whole wing, however, at three days, is shorter than in the adult, the hand in particular having greatly decreased until slightly smaller than the forearm and considerably shorter than the mature hand. By the seventh day it is still comparatively shorter, while the forearm has

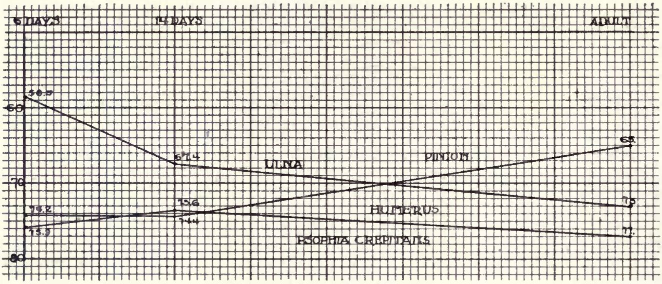


FIG. 115. DIAGRAM OF WING DEVELOPMENT OF THE TRUMPETER

lengthened until it is larger than in the adult. Thus in seven days the conditions of the hand and forearm directly alternate. They return to their former state at maturity, though the hand is not proportionally quite so large as it was in the newly hatched chick.

The longer wing of the twenty-four-hour nestling is probably a reminder of bygone ages, when the wing was longer at maturity than at present. The excess of length, it is evident, was chiefly in the upper arm, upon which some change of condition has acted, causing a gradual reduction without materially affecting the other portions of the wing.

Psophia crepitans (Linn.)

	Arm	Forearm	Hand
6 day chick	74.2 mm.	58.5 mm.	75.9 mm.
14 " "	74.4 "	67.4 "	73.6 "
Adult	77. "	73. "	65. "

There is a decrease of the hand in the grey-backed trumpeter (*Psophia crepitans*) as compared with an increase of the forearm. The arm also gradually increases, but to no such extent as the next section. Some of the shortening of the hand is doubtless due, as in the hoatzin, to the reduction of the claws, for in the young bird there are the remnants of two, one on the thumb and one at the tip of the wing. The trumpeter at one time probably owned at least two good, functional, clawed fingers as does the young hoatzin of today. That time, however, is passed, though the stage representing the young hoatzin may possibly yet be found in the embryo. The fact that trumpeters live principally on the ground—only roosting in the trees at night—and are essentially running birds, having lost most of their arboreal habits, may account for the reduction of these digits. Like the hoatzin they nest in trees, but, unlike them, as soon as the egg is hatched, the parent conveys the chick to the ground, where it soon learns to run about and hide as well as any newly hatched pheasant or partridge. It does not acquire its flight feathers as soon as the partridge and this lack of wing exercise may account in part for the relatively slow development of the hand and forearm.

The adult domestic pigeon has a longer arm than forearm. Both are practically of the same length when the embryo is fully developed, but the arm rapidly lengthens while the forearm relatively decreases in length when the egg hatches and the squab commences to grow. The development of the two segments in this case is also in opposite directions, but the directions are different from the preceding examples.

The development of the wing of the Guiana green heron (*Butorides virescens*) is peculiar because there is little of the variation between the growth of the forearm and the hand which is so characteristic of the other species mentioned.

Butorides virescens (Linn.)

	Arm	Forearm	Hand
10 day embryo	70.55 mm.	62.7 mm.	55.2 mm.
14 " "	69. "	63. "	57. "
3 " nestling	70. "	65. "	55. "
14 " "	66.3 "	66.3 "	57.2 "
Fully fledged	58.5 "	59.5 "	62.4 "
Adult	64. "	69.5 "	56. "

The proportions of the wing upon hatching are much the same as those of the adult, except that the arm is a little longer and the forearm a little shorter, while the hand remains about the same. The main variation during growth takes place between the forearm and the arm, the former increasing proportionally as the latter decreases. The hand parallels the forearm and increases slowly but steadily until the young heron is fully fledged. It greatly exceeds the adult in length at this time, but for the rest of the developing period—which lasts for several weeks—it decreases until the bird is mature. In this respect it closely resembles the hand of the hoatzin, though its excess of length is not so great, and there are no large claws to reduce.

Notwithstanding the fact that the young herons, like the young hoatzins, climb about the tree or bush where their nest is situated, before being able to fly, they have no wing claws. They are a curious combination of precocious birds and those that are born helpless. For the first ten days or two weeks after hatching they are as helpless in their nest as any nidicolous bird, but after that—long before they develop flight—they may be seen moving freely about among the maze of branches near their nest. They seldom use their wings to climb with, but rely chiefly upon their great widespread toes to carry them to safety from a chance pursuer. The erect position and great feet enable them to do by balance what the hoatzin has to do by crawling and clinging. If by rare chance, they do lose their equilibrium, the instinct of many forgotten ages comes to their aid and out go the wings to brace against the nearest hold as naturally as they did many thousands of generations ago. It is undoubtedly largely due to the acquired erect posture of body and therefore ease of balance, that the wings have lost their claws, for as the habit of balance increased, so must the use for functional fingers have decreased, until as useful members they became obliterated.

In one of the toucans at least, and in some of the Passeres, conditions appear to be different from the preceding cases. There seems to be a more or less regular variation between all three segments of the wing. The black-necked toucan (*Pteroglossus aracari*) presents the most perfect example of this.

Pteroglossus aracari (Linn.)

	Arm	Forearm	Hand
6 day nestling	45.2 mm.	54.6 mm.	39.5 mm.
21 " "	44.3 "	57.5 "	38. "
Adult	44. "	60.5 "	35. "

Each segment of the wing shows a steady relative variation through all stages of development to maturity. The arm lessens gradually; the forearm lengthens, and the hand decreases. Curiously enough the increase of the forearm, to all intents and purposes, equals the total decrease of the arm and hand.

The comparative shortness of the hand in the adult is worth commenting upon. If an embryo could be examined it would probably show a very differently proportioned hand than even in the six-day-old nestling. As it is, the length of this member is so much greater and the forearm so much shorter in the six-day-old bird that it is evident that at some former period, when the world was younger, the adult had a more evenly balanced wing.

The present shortness may be due to a steady decreasing need for this member as an agent of flight. The flight of the toucan is comparatively weak and one of the common sounds of the jungle is the heavy whir of their wings as they labor from tree to tree. Perhaps, when climatic conditions were different, they found it necessary to seek further afield than today for their food, which now may be found in almost every tree top. Individually, they appear now to live in one small section the year round and their total wing exercise consists of a few short flights from one tree to another during the day.

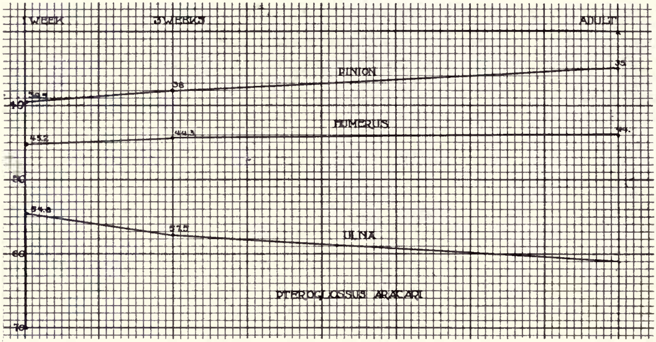


FIG. 116. DIAGRAM OF WING DEVELOPMENT OF THE BLACK-NECKED TOUCAN

The few passerine birds examined show two main methods of variation during growth, especially between the hand and the forearm. In one, the hand first increases in proportional length and then shortens to adult size, being offset in the opposite direction to some extent by the forearm. In the second, opposite conditions obtain; the hand of the nestling always is shorter [1] than the adult and the forearm longer.

Galeoscoptes carolinensis (Linn.)

	Arm	Forearm	Hand
Embryo	26.5 mm.	23.8 mm.	20. mm.
Newly hatched	25. "	20.7 "	23.5 "
3 day old nestling	23.8 "	20.3 "	26.2 "
6 " " "	22. "	22. "	25.8 "
Adult	20.2 "	26.6 "	23. "

A typical example of the first method may be found in the catbird of North America (*Galeoscoptes carolinensis*). There is a steady decrease in the length of the arm which commences in the newly-hatched nestling. The forearm increases at about the same rate, while the hand first in-

[1] The words "short" and "long" in the sense here used do not mean that the hand grows shorter or longer in actual length, but in proportional length only.

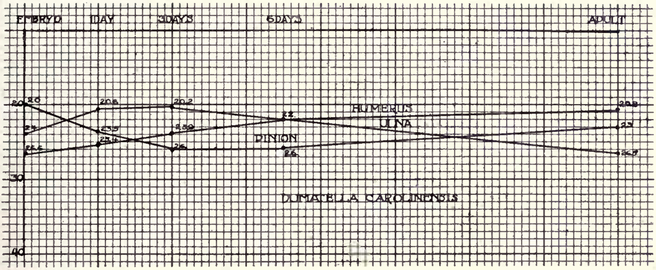


FIG. 117. DIAGRAM OF WING DEVELOPMENT OF THE AMERICAN CATBIRD

creases and then decreases, being in the adult practically the same as it was in the young chick. As in the case of the toucan the total increase and decrease in the development about offset each other.

The increase of the hand in the first few days may be less the shadow of an ancestral character than a preparation for the growth of primaries, which, at this date, are of great size. The bird has so long been reared in a state of helplessness that there appear to be but few traces of an elongated hand in the late embryo. The forearm and hand, on the contrary, show traces of an early weakening and shortening.

Cassicus cela (Linn.)

	Arm	Forearm	Hand
2 day nestling	35.5 mm.	41.5 mm.	37.3 mm.
3 " "	34.5 "	43. "	36.5 "
7 " "	34.3 "	41.8 "	37.7 "
Adult	33.8 "	44. "	36. "

The development of the yellow-backed cacique practically parallels that of the catbird, though the variations are not so large. It is a noticeable feature that in the three-day nestling, where there is a slight decrease in the hand, it is accompanied by a corresponding increase of the forearm.

In the half-fledged nestling of the Guiana spinetail (*Synallaxis guianensis*), the hand is quite appreciably longer than in the adult, while the other sections follow the same course as in the two preceding birds.

Among other birds of the same order there is another method of development in the wing, the difference being that the forearm lengthens and decreases instead of the hand as previously mentioned. In the half-grown fledgling of both the kiskadee (*Pitangus sulphuratus*) and the silver-beaked tanager (*Ramphocelus carbo*) the forearm is decidedly larger than in the adult.

Pitangus sulphuratus (Linn.)

	Arm	Forearm	Hand
Newly hatched	30.1 mm.	33.4 mm.	27.8 mm.
14 day nestling	28.4 "	36.2 "	26.6 "
Adult	29. "	33.5 "	29. "

Here again is a case where a sudden increase of one segment is accompanied by the decrease of another, though this time there is diminution of both the hand and arm. The total decrease of the two, however, equals the amount of extra length in the forearm.

The wing development of the grey-breasted martin (*Progne chalybea*) is slightly different from either of the two preceding methods of growth. This is due to its advanced powers of flight, which necessitates a rather lengthened hand, though both the forearm and hand are proportionally smaller in the younger stages than in the adult.

Progne chalybea (Gmel.)

	Arm	Forearm	Hand
3 day nestling	26.5 mm.	29.1 mm.	25.4 mm.
7 " "	24.1 "	27.7 "	29.2 "
14 " "	20.9 "	28.4 "	31.9 "
Fully fledged	19.2 "	30.5 "	31. "
Adult	20. "	29. "	32. "

There is a directly opposite variation between the hand and the arm, while the length of the middle segment remains constant throughout. The lengthened hand and shortened arm is undoubtedly a parallelism with the swifts, though it does not attain such extremes. The ratio of the wing segments of the giant swift (*Chaetura zonaris albicincta*) of the Guianas, commencing with the humerus, is 20-27-53, while that of the martin is 24.6-35.8-40 per cent. There is a vast difference, but the tendency is toward that of the swift.

It would be hard to imagine the albatross with its tremendously long humerus or, indeed, any other bird with a long arm, dodging and twisting through the air with the agility of a swift in pursuit of an insect. The laws of mechanics make it impossible for such a bird to move its wings with the rapidity necessary for an operation of this kind. On the other hand, a bird with a short humerus, because the bone has a lesser arc to describe, can do this with less expense of energy. Therefore the swift, from a need of having to follow its rapid and elusive insect prey on the wing, has a short arm, and to make up for this discrepancy, a proportionally lengthened hand. Their nesting habits are also conducive to a shortened arm—nesting as they do, in caverns and hollow trees or building great elongated tunnels that hang from palm leaves and cliff walls; but the habits are probably a result of and not a cause for the shortening.

The martin more or less parallels the swift in its general feeding habits and nesting sites. Though it does not have such supreme command over the air, still it makes a living catching its food by aerial pursuit, which necessitates a good control of the wings and great dodging ability. Thus the arm must have a tendency to shorten, and the hand to lengthen.

SUMMARY

Throughout the development of all the birds above mentioned there seems to be a certain balance kept between the different portions of the wing. Among the birds that are fairly strong fliers, when one segment increases proportionally in length, another decreases in the same proportion, or both of the others diminish to such an extent that the sum of their total loss equals the gain of the first. Furthermore, when there is a local change in one segment at a single period of growth, it is usually balanced by an opposite change in one of the other segments, or by the sum of the changes in both of the others. Thus in the hoatzin, the toucan and the cacique—three widely separated birds—we find that the balance is kept in all stages, though the proportionate lengths may greatly differ.

The blue-winged parrakeet is an exception to the general rule. In this bird both the arm and the hand increase in length as the fledgling grows older, while the forearm remains approximately the same. On the seventh day, however, the forearm shows a considerable increase over that of the adult and the hand a much *greater* decrease. While this does not bear out the second rule, it at least shows that there is a tendency toward it.

In some birds that use their feet more than their wings, the proportional growth of one segment remains about the same, while the others grow in opposite directions. In the heron it is the pinion; in the trumpeter, the arm; in the jacana, the forearm. The growth of the other two segments is opposite in each, the greatest variation taking place in the hand and the arm of the jacana.

Or more concretely:

A. Throughout the development of the wing of the hoatzin, Guiana green heron, trumpeter and jacana—birds that use their feet more than their wings—the proportional length of one segment remains constant, while the other two vary in opposite directions.

B. Throughout the development of the wing in at least one toucan and in several Passeres, a balance is kept between the different segments so that when one portion changes, another or both of the others change in an opposite direction; the variation of one equals the total variation of the others.

C. Throughout the development of the wing in all the birds above discussed, when there is a change of length in one segment at any particular period of growth, that change is balanced in the same period by an opposite variation of one or both of the other segments.

THE DEVELOPMENT OF THE PINION

To a great extent, the length of the pinion in many birds is regulated by their habits. It is interesting to note the various changes that take place in this member throughout the period that elapses from the embryonic stages to maturity. It is possible to trace in them some of the changes that have taken place through many generations, due possibly to the changes of environment which occurred during the later geological periods.

Commencing with the hoatzin we have the development of the hand, outlined as follows:

Opisthocomus hoazin (Illiger)

	Carpus	Digitus
Embryo	43. mm.	23.5 mm.
10 day nestling	34. "	32.3 "
14 " "	34.2 "	32.1 "
Adult	39. "	27.5 "

In the embryo the carpus—containing the metacarpals of the second digit—is very long, being nearly twice as great as the digitus or forefinger. The excess of length is a relic of past ages when birds were not so far removed from their reptilian ancestors as they are at the present day. It is undoubtedly a remnant of the elongated metacarpals of the lizard.

In the nestling the great carpus of the embryo decreases in length and the digit increases proportionally. This is at

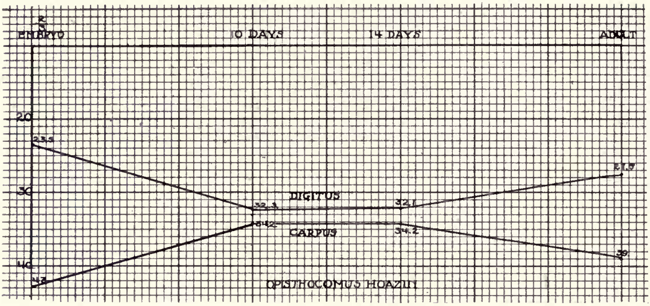


FIG. 118. DIAGRAM OF HAND DEVELOPMENT OF THE HOATZIN

the period when the claws of the hoatzin are at their greatest development. At maturity the conditions again change; the carpus elongates and the digitus shortens, but the difference is not so great as it was in the embryo.

Much the same condition exists in the young chick trumpeter. The carpus, in the six-day chick, is almost twice the digitus in length, but at maturity only exceeds it by a few millimeters. This increase of the digitus, however, does not, as in the hoatzin, equal the decrease of the carpus, though the delayed growth of one and the slight elongation of the other is significant.

Psophia crepitans (Linn.)

	Carpus	Digitus
6 day chick	37.5 mm.	22.8 mm.
Adult	27. "	23.5 "

A better maintained balance in the hand—as far as ascertained—is found to a more or less extent in passerine birds and others that do not have better than an average flight. The variation of each portion in the individual is diametrically opposite. This is especially true in nestlings, while in the embryo the variations are as a rule greater and opposite. Such is the case with birds like the kiskadee, yellow-backed cacique, giant cacique (*Ostinops*), silver-beaked tanager and blue-winged parrakeet, all with good average flights, but which have a small variation of the carpus and digitus during their development.

Pitangus sulphuratus (Linn.)

	Carpus	Digitus
⅔ Embryo	16.56 mm.	13.4 mm.
Newly hatched nestling	16. "	13. "
14 day nestling	16.5 "	12.4 "
Adult	17. "	12. "

Birds that have remnants of claws are doubtless, as a rule, the ones in which the fingers were functional most recently. Traces of this character have not yet been lost; so consequently the hands still function ontogenetically, to fit the requirements of fingers, as in the hoatzin. In most cases of altrical birds the loss of this character either antedated or paralleled their helplessness; otherwise there would have been little need for a change to the present state and we would still see all tiny nestlings crawling about the branches like little hoatzins. That this was true may be recognized from the great variation of these parts in the embryo of today.

The functional fingers being lost at this comparatively early date, it was natural for the parts of the hand to adjust themselves to the new conditions; and this adjusting is still

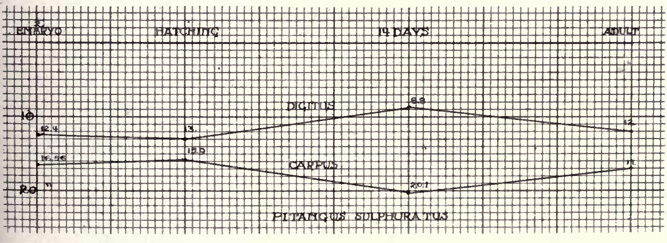


FIG. 119. DIAGRAM OF HAND DEVELOPMENT OF THE GUIANA KISKADEE

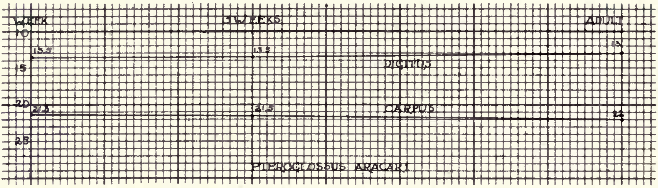


FIG. 120. DIAGRAM OF HAND DEVELOPMENT OF THE BLACK-NECKED TOUCAN

going on, as the flight of the birds gradually changes. Their flight in general is of about the same strength, and naturally it follows that they should develop along more or less parallel lines. There are exceptions to this—as will be shown—in which the power of flight has been either increased or decreased and a change in the development of the hand shows accordingly.

In such birds as the toucan, the ani, and the catbird, which do not greatly use their wings in their daily round of life, there is little or no variation in the growth of either of the hand segments. Though the actual proportion of the carpus to the digitus may vary somewhat in the different birds, due possibly to different ancestral or even present day habits, the actual method of growth remains practically the same.

Pteroglossus aracari (Linn.)

	Carpus	Digitus
6 day nestling	21.3 mm.	13.5 mm.
21 " "	21.5 "	13.5 "
Adult	22. "	13. "

Galeoscoptes carolinensis (Linn.)

	Carpus	Digitus
Embryo	13.8 mm.	9.2 mm.
3 day nestling	12.5 "	10.5 "
6 " "	13. "	10. "
Adult	13.5 "	9.5 "

The grey-breasted martin has a greater variation than most, but that it is due to the effects of later specialization is very well shown. In the very young nestling the difference between the carpus and digitus is well marked, but as it grows older these proportions approach each other in length until at maturity they are equal. The young stage is evidently a shadow of what the bird was in more ancient times.

Progne chalybea (Gmel.)

	Carpus	Digitus
3 day nestling	18.5 mm.	13.5 mm.
7 " "	17.6 "	14.4 "
14 " "	17.4 "	14.5 "
Just able to fly	16.5 "	15.4 "
Adult	16. "	16. "

The increase of the digitus is undoubtedly due to specialization of flight as in the case of the swift. As has already been shown in the case of this bird, a decrease of the arm is followed by an increase of the hand. The digitus must, therefore, be strengthened to support the strain put upon it by the rapid beat of wings necessary for swiftly dodging after insects. This, together with the increased use

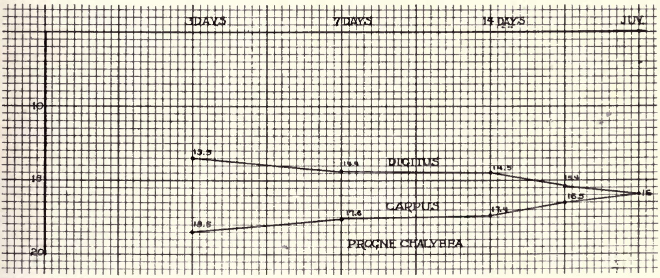


FIG. 121. DIAGRAM OF HAND DEVELOPMENT OF THE GREY-BREASTED MARTIN

of the outer primaries, which comes as a secondary result, makes it necessary to have a lengthened and stronger digitus to stand the new conditions. Until we can investigate the development of a swift or hummingbird it will be impossible to say how truly this parallelism has been carried out in the younger stages of the martin.

From the development of the few pinions described, it is an easy matter to see that their growth in general follows along certain lines. Whether the pinions of all other flying birds follow the same rule has yet to be ascertained. In all these the carpus has a tendency to grow in an opposite direction to the digitus. In some the variation is greater, but wherever there is any variation at all between the two the tendency is opposite, and usually the decrease of one equals the increase of the other.

In birds that show traces of clawed fingers in their nestling or adult stages, and which are more ancient in type, both the carpus and digitus have a large individual variation in their rates of development. On the other hand altrical birds—birds that are born helpless—have little or no variation of these portions except when the flight is highly specialized.

CHAPTER XXIII

NOTES ON THE PERAI FISH

NAMES

Systematic: *Pygocentrus niger* (Schomburgk).
English: Cannibal Fish, Carib Fish.
British Guiana, Colonial: Perai.
Portugese: Piranha.

The great family of Characins composes a large proportion of the fresh-water fishes of South America and, in British Guiana alone—according to Eigenmann, more than half. The Characinidae are divided into many subfamilies of varying habits, the members of which range in size from the most minute of the Hemigrammi to the large "pacu" of the rapids and the great "aimara" of the inland creeks. The subfamily Serrasalmo, to which belong the perai, is composed of three genera, *Pygocentrus, Serrasalmo* and *Pygopristis,* including, in all, eight known species of the Guianas, though, doubtless, many others still remain to be discovered. Very little appears to be known of them beyond the fact that they exist, are ferocious, and, in the case of the perai, are exceedingly dangerous to whatever living beast crosses their path.

". . . . the piranha is a short, deep-bodied fish, with a blunt face and a heavily undershot or projecting jaw which gapes widely. The razor-edged teeth are wedge-shaped like a shark's, and the jaw muscles possess great power. The rabid, furious snaps drive the teeth through flesh and bone. The head with its short muzzle, staring malignant eyes, and gaping, cruelly armed jaws, is the embodiment of evil ferocity; and the actions of the fish exactly match its looks."

Never found nearer to the coast than twenty miles, where the last defiling taint of salt water merges into the

Photo by P. G. H.

FIG. 122. HEAD OF PERAI

fresh, the perai swarm in countless hordes through many of the inland reaches. They thrive in equal numbers, above or below the rapids, though seldom in them, for they do not love the swish and swirl of hurried water, but seek rather the slower moving back currents and the long level stretches between the falls. The deep canals of the Amazon Valley and the quieter pools of swift running mountain streams a thousand miles inland, thousands of feet above the level of the sea, are as truly their home, as the inner fresh tide-waters, only forty miles from the sea. And everywhere they are a scourge both to men and beasts.

During our stay at Kalacoon the question several times arose as to whether the perai is a bottom fish or one that has no particular preference for its field of action. Observation shows the latter to be the case, though to catch them on a baited hook, the best results are obtained by allowing the bait to rest near the bottom. They may be seen at all times of the day leaping and playing about the surface, either close under the wooded bank or far out in the muddy current. Sometimes one will flash into the air for a second and then drop back with a small splash. But usually they swim near the surface, rippling here and there in a never ending search for food, or darting after some unwary denizen that unconsciously crosses their path, leaving ever widening circles behind them in their flight. Often the only sign is the scurry of a few tiny fresh-water flying fish scattering in many directions, flipping over the water as they go, all fleeing from those dreadful blood-thirsty jaws.

Hours sometimes pass without a movement in the water and then suddenly there is a splash, and you know that the perai are at work. If you toss a small lizard into the pool or a wounded bird drops into it, even though the water be as quiet and as innocent-looking as the sky above, you may be sure that one or more of the hungry pirates are lurking in its dark depths, ready to pounce upon whatever comes; and you may be sure that the poor victim will never reach the bank toward which it so vainly struggles. Suddenly the wild flutters stop, only to recommence with increased frenzy. There is a disturbance about with ripples running to the shore; the swimming creature strives vainly against some agency that pulls it down; then it disappears and the waters are quiet once more; only a few bubbles float upon the surface. Below, in the coffee-colored darkness, that which was but a few moments ago a living full-blooded reptile or bird, now fills the black maws of the demons of the pool.

Many gruesome tales come to us from the natives who live along the banks of the infested waterways. Some stories are true and many, doubtless, are the products of their inventive imaginations. But the fact remains that these fish, together with the sting-rays and the electric eels, make wading in these waters extremely dangerous and unpleasant. Yet in the vicinity of Kalacoon, the perai never made an attack upon man, and one could bathe with impunity. A few miles up river this would have been suicide. There is scarce-

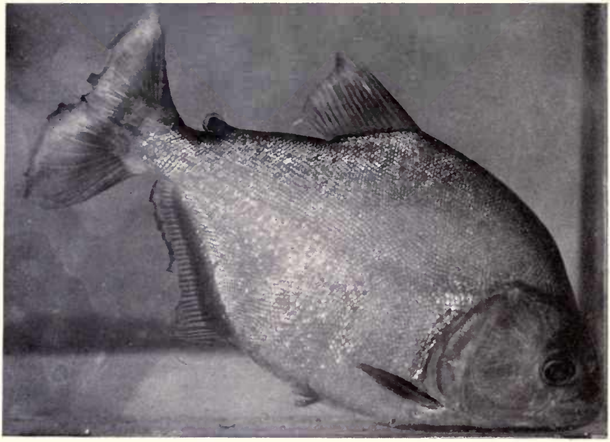


Photo by P. G. H.

FIG. 123. PERAI

ly a person who has traveled in South America, who fails to bring home some tale of their depredations. Col. Roosevelt tells how, in the Matto Grosso, various members of his party were bitten, and how wounded animals, even caymen, are often partially devoured before they can be recovered from the water into which they have struggled or fallen after being shot. Larger animals, peccaries and even tapirs, are attacked when wounded and often dragged down; and there are frequent cases, where persons, idly trailing their hands in the water from the side of a canoe, have lost one or more fingers from the cruel jaws. I have seen large wounded birds pulled under when only a few feet from the shore.

The tails of animals seem to be a great attraction. Perai have been known to bite the tails off dogs and many other beasts, while, according to imThurn, the tail of an iguana is a morsel of the utmost delicacy. Even alligators are not exempt. In places where ducks are kept it is said that only a short time elapses before the webs of their feet are eaten away and sometimes the feet themselves. Certainly the mortality must be great among young ducks, both wild and tame. Many birds are caught that rest too long on the water, where they pause to drink or snatch a pleasing morsel floating there. Kingfishers, darting after a small fish, must often go down never to come up, for it is the splash that attracts the perai instead of driving them away.

Some of the most common birds along the river front, near Kalacoon, are the various kinds of kiskadees. Perched on the topmost twig of the spider-legged mangroves, they peer up and down the river this way and that, and dart after swift fleeing insects that approach too near their point of vantage. The prey secured, they return, or, changing their minds, drop down to a spike of mucka-mucka and rest upon the broad leaves, where a closer view of the water as it drifts slowly by, may better be obtained. Occasionally their attention is attracted by a struggling insect that floats past, fighting to free its wings from the impeding water, into which it accidently has fallen, or, perhaps they see a tiny fish playing near the surface. Then there is a flash of wings, a slight splash, and the bird returns to its perch clicking its bill and swallowing contentedly.

The splash is often its undoing, for, at the sound, a dark body moves swiftly through the water and the kiskadee is dragged under with its prey still struggling in its bill. The remnants of birds have many times been found in the stomachs of perai, and, a short time ago, I took from one nearly the whole body of a freshly killed kiskadee.

Nor are the warm-blooded animals and reptiles their only prey. Not every day are they fortunate enough to seize a bird or to find some helplessly maimed animal floundering in the water. Their true food is living flesh and their craving must be satisfied. So naturally it follows that they war on the myriads of fish that swarm the rivers, both in the shallows of the mud-banks and sand-bars, and farther out in the brown water of the deep cut channels. Fish are the daily menu, while the incautious beast that comes within their reach, is a rare toothsome dessert.

The Indians, morning after morning, find only heads remaining in the gill nets, or, if they are fortunate, a few partly mutilated fish. Fishermen, returning from a day's sport, tell how there came a second strike, which nearly broke the line, when their captives were almost to the surface. They found, upon pulling in, most of the tail gone, a huge portion taken out just below the dorsal fin, or, possibly only the head of their catch left.

The perai war not only upon other fish, but also upon their own kind. This has been a rather disputed question. Some authorities claim that they will never attack one another; but many perai have the webbing nearly gone from their tails and are otherwise scarred about the body. I have caught many on the flesh and entrails of another. Where food is plenty this may not occur, but it certainly is true on the lower Mazaruni. If one, freshly killed, be gashed and torn so that the blood flows, it will be set upon and devoured as quickly as if it were a warm-blooded bird. If only wounded, however, its sharp teeth and strong jaws protect it until recovery or, worn out by the repeated sallies of others, until it succumbs.

The taint of blood in the water drives the perai blood-crazy and they become at once raging savage demons, blindly attacking anything, no matter what, from which comes the flow of blood. Thus the person who wishes to pass through infested waters does so at an increased risk if he has even so much as a small wound that drips blood. He must move quietly for loud splashing attracts, and they rush and strike on an instant.

The natives near Kalacoon, while they fear these scourges, are not afraid to enter the water, and the children play around the shores waist deep near places where the fish abound. They seldom or never are assailed, for the fish seem to avoid the bathing spots, though, perhaps a few yards away, many agitate the surface in search of food or play. The Indian always walks into the water with care and quiet. He is careful to make as little disturbance as possible until, deep water reached, he launches out to swim.

Flesh is not the only food of the perai. Dough made from rice or cassava and used by the natives to catch more gentle fry, is an article of relish. Pieces of bread, fruit and seeds have all been found in their stomachs. In one locality, on the Essequibo River, there is a large citrate factory, which daily uses many sacks of limes. When the oil is extracted and the juice squeezed out, the skins are thrown into a refuse heap and carted to the river edge. Each day, for more than a year, they have been dumped into the river at the same spot, where the water is shallow. But a large heap never accumulates there. Soon after the splash of the first basketful, thousands of fish gather from all directions and actually churn the water in mad struggles to get at the refuse. The seeds seem to be the main attraction, for they are the first to disappear; and then the pulp follows more slowly. Finally the rinds, empty, lightened of their load, drift away with the current.

Among the swarming fish dart the perai, for they, too, love the seeds and the pulp. They travel a clear path, for no fish cares or dares to face these marauders. If several "cartabacs" are wrangling over an inviting morsel, they drop it quickly without any hesitation, and the water pirate finishes the meal alone, and in peace; or perhaps, attacked by another of his kindred, he in turn drops it in the swift battle that ensues, and the stolen titbit is appropriated by a third. And so it goes until the limes are exhausted, and the first scatter to await another day.

Perai are welcome articles of food to the natives, but to the white man their flesh is rather soft, and has a slight muddy taste, while there is a great abundance of bone. Nevertheless, when desirous for a change from our flesh diet, one of us would take a rod and go down to the banks of the river to try fisherman's luck. The best way to catch the perai, we soon found, was to fish from a boat anchored a few yards from shore, where the mud bars shelved steeply down into deep water. The fish seemed to swarm along this steep bank, while fewer splashed about in the shallows nearer the forest clad shore. Usually the bait was the flesh and entrails of some bird or animal, though, excellent as any, were the entrails of the fish itself.

It was best to use a long line with the bait hanging within a few inches of the bottom. The usual procedure of the fish was to nibble feebly for a few moments and then strike and strike hard. Sometimes they would strike without any preliminary warning.

As a game fish it is not one that will, except possibly for a few moments, delight the heart of the angler. After the first few rushes the fight is over and the fish comes meekly to the surface. The fisherman must be careful to keep a taut line, for, at the slightest slackening, away goes the quarry; he must strike hard to make fast the hook for the perai has a mouth of bone, against which the point turns as if made of lead, or snaps off like the head of a match struck too hard against the box. A strong wire leader must be used. Even then, I have seen the villainous teeth click together on a piece of phospho-bronze and, as easily as a pair of wire nippers, snap it in two.

The fish in the boat is nearly as bad as the fish in the water. One must be very careful not to place any portion of his anatomy too near, or, with a flop, the perai will seize it. He seems to use a certain amount of cunning. If a finger touches his body he will not make a motion until it is within reach of his jaws. Then, with a twist or turn, he snaps, brings his teeth together with a sharp click, and it goes hard with the finger that is between them.

The Indian seldom uses a hook to catch them, for hooks fastened to ordinary line are quickly snapped off, and they are articles of too great value to be lightly thrown away.

He uses a different and more certain method, one in which his forefathers were adept hundreds of years ago. Paddling the canoe to a proper spot, he holds the entrails of a freshly killed agouti, tightly fastened to the end of a long stick, over the water so that the ends trail and the blood spreads away with the current. The perai, its appetite aroused by the thin taint of blood, rushes upstream until it reaches the dangling treasure, and greedily seizes it. Quickly then, for another instant would see the mass torn away from its hold on the stick, comes the twang of a bow-string; the fish is transfixed by a long, hollow, spear-like arrow, and suddenly finds itself, twisting and biting, with others of its kind in the bottom of the wood-skin.

There are other uses for perai beside food. A lower jaw with its saw-like row of teeth always dangles from the woven, pitch-covered baskets that act as quivers for poisoned darts. When a dart is prepared for action, its dark, poisoned tip is nearly severed against one of the sharp teeth, so that when it enters the body of its victim, the point breaks off and remains to do its work, even though the arrow be torn away.

PART III

ENTOMOLOGICAL

BY PAUL G. HOWES
RESEARCH ASSISTANT

CHAPTER XXIV

THE BEES AND WASPS OF BARTICA

In the following chapters, treating chiefly of solitary wasps, I have endeavored to give an accurate account of the more intimate aspects of the lives of certain of these insects. It is hoped that the fascination which the life stories of these insects holds for the writer, may be imparted to the reader not already familiar with them.

To those fortunate ones already versed in the events of wasp life, I can only say that Guiana is practically a new and unsearched field, teeming with wonders of life of which very little is known. In view of this fact, there should be something of interest in these pages both to the layman and to the experienced entomologist.

Before taking up individual studies it is fitting that I should give a brief outline of the conditions of wasp life in Bartica district, the general locality in which all of my insect observations were made. These observations cover a period of a little over five months and were not selected because of any particular facts that they may contain, but rather because they were just whatever I was successful in gathering. In entomology, one life appears to be as interesting as another. The tiniest creature and the greatest, are as one, in the secrets they hold for the observer.

During the period of actual field work, from February 15 to the end of July, I found one hundred and seven species of bees and wasps carrying on nesting activities. Sixty-eight of these were solitary wasps, nine social wasps, two apterous Hymenoptera, or species wingless in one sex, seven were solitary bees, ten social bees and eleven were undetermined bees and wasps.

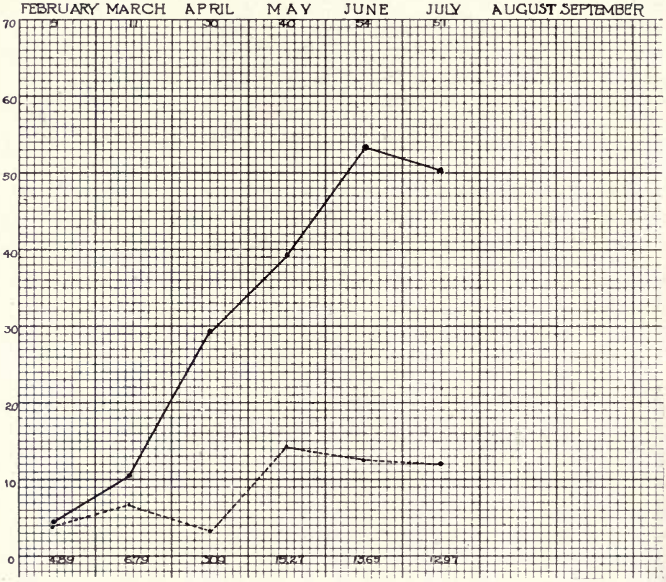


FIG. 124. CHART OF RAINFALL IN INCHES, AS CORRELATED WITH THE NESTING OF WASPS AND BEES IN BARTICA DISTRICT.

The number of nesting species increased steadily with each month, reaching the highest point in June, after which they receded gradually. In a measure they followed the course of the rainy season, being most numerous in June and July. As I was at Bartica only half the month of February, I cannot give an accurate figure of the nesting species. However, a very diligent search during the last fifteen days of that month revealed only five species, and while I am convinced that it is a low estimate, March showed but a slight increase and my figure may not be far out of the way.

The accompanying chart gives a rough idea of the number of nesting wasps and bees as they varied in relation to the rainfall. It will be noticed that in April, only 3.09 inches are recorded. This is far below the usual average of the month, and in a normal year the curve would rise steadily from February to June.

For convenience I have divided the one hundred and seven species into six general divisions according to their nesting habitats. It will be noted that the species belonging to all but the sixth division have, in one way or another, taken advantage of changes brought about by man, a fact that seems to me remarkable in view of the short time that has elapsed since many of these changes have occurred. The divisions and number of species belonging to each are as follows:

1.	Nesting only in trails	40	species
2.	Nesting in trails and forest	18	"
3.	Nesting in houses or outbuildings	18	"
4.	Nesting in houses and in open trails	2	"
5.	Nesting in houses, trails and in the forest	5	"
6.	Nesting only in forest	18	"

The nesting haunts of six species were undetermined.

No attempt will be made to give a list of these one hundred and seven species in the present work. They are mentioned only with a view to give an idea of the immense field of work open to the entomologist in Guiana. I have made observations of one kind or another on almost all of these species, but the data accumulated is not sufficiently complete to prepare more chapters than those which follow.

I found exquisite types of nests. Some were like tiny barrels of emerald moss, one was fashioned from wasp-made paper, layed on in strips of varied colors, others were inverted domes of sweet smelling resin. Here was one of forest mould, a tube-like structure with a flared entrance. There were tiny purses made of cob-webs, plant down and lichens. They hung on spiral stems from the under sides of leaves and in the eaves of outbuildings. Some nests were mere tunnels in the ground, but the greater number were of mud or clay. There were groups of cells of various shapes and dimensions, plastered in a great variety of situations. Many of them were plain, others elaborately decorated with hundreds of tiny spines, each fashioned of clay, or rounded domes that fitted into one another like the roofs of a pagoda. I found series of miniature earthen jugs, ten or twelve placed in an irregular line and often of colored clay, reminding one of a group of tiny pots ready for the baking. There were all styles, shapes and sizes and a great range of colors.

Thus working in Guiana I found these insects in a variety of roles quite new to me. Their nests were different; there were no cold seasons to affect nesting activities; nesting periods were more extended and the creatures themselves were far more numerous than I had found them anywhere before. It was often difficult to keep all the species under constant observation, and for all their abundance many troubles were experienced in following out their life histories.

Intensive insect study in the tropics is beset by many difficulties. To follow out a life history successfully, means not only securing sufficient material for study, but great care in the handling of that material. Mortality is very high among larval, or young wasps and bees. They are extremely tender and subject to sickness and death, from seemingly negligible factors. Moisture is a great danger. A certain amount is necessary, but the least bit too much in the grub's cradle when feeding or pupating often turns a healthy bit of life into a black putrid mass in a few hours. Too much heat or direct light, are other dangers to be reckoned with. Sometimes the wasplets are injured and grow abnormally from causes that I have often been at a loss to explain. Molds play a deadly part, but tiny red ants proved the greatest scourge in the nursery of my youngsters. They lurked about ever ready to swarm in over the nascent insects. They managed somehow to become suddenly numerous upon apparently inaccessible swinging shelves. They crawled in between the glass and cork of a bottle, tunneled by the back way into wasps' nests of solid masonry, wrecked the homes and carried off the inmates in a thousand separate pieces! They were a pest. It is the only word to describe these vile little creatures. If they would but ravage the pantry and leave my insects alone, what a comfort it would be!

My only course was to construct a tiny "incubator" with wooden legs set in pans of oil. In this the young wasps were kept in glass tubes with cotton stoppers. It proved to be the only device into which the minute pillagers could not set foot. At length after repeatedly having my work of days or weeks undone in a few moments; after many disappointments, I succeeded in rearing a few of my charges successfully. I watched the mysteries wrapped about their lives unfold, saw nature hurl them through her steeplechase called life and forgot the ants in the revelation.

My gleanings, however meagre, follow. If one had as a task, to count the grains of sand upon a glistening beach, what impression would one make in a day? A very shallow one to be sure, but deeper than the one I have made in the insect life of Guiana. Five and a half months have passed since we sailed up the Mazaruni River to Bartica, I to my wasps and bees, and like the Counter of the sand-grains, I had a hopeless sensation. Now it is late July. With the entire beach still before me I have counted—one!

CHAPTER XXV

TWO POTTER WASPS

Genus *Eumenes*

Fig. 125; 1-8

I have still to complete the life histories of these two wasps. Several facts are lacking, which is unfortunate. But on the other hand I have learned much of interest concerning them—sufficient, I think, to warrant the present chapter. Beginning with the red Eumenes, I will set down what I know of each species after a few preliminary comments.

The two wasps are potters, but of widely different tastes. The red or larger species is a finished artist fashioning from three to twelve tiny, flat-bottomed jugs each bearing a short neck and finished with a wide flaring lip. They are placed in straight or serpentine rows or in little circular clusters in a variety of situations. Commonly they are cemented to exposed timbers on the walls of buildings. Others produce weird looking swellings upon table-legs or window cords and occasionally one finds them plastered to a bit of clothing left unused for a day or two. Color in the jugs varies greatly. I have them in sombre grey, through many shades of yellow to a rich red. Their delicacy and beauty rivals that of hand-made pottery, but in form the jugs never vary.

The smaller or buff Eumenes is not an artist. Her jugs are for service rather than display. They are flattened objects shaped like a kernel of corn and placed one upon another in an irregular pile. Thus the finished nest, consisting of four or five of these rough cells, resembles an unkempt wad of clay. It is plastered to the underside of a leaf grow-

PLATE I

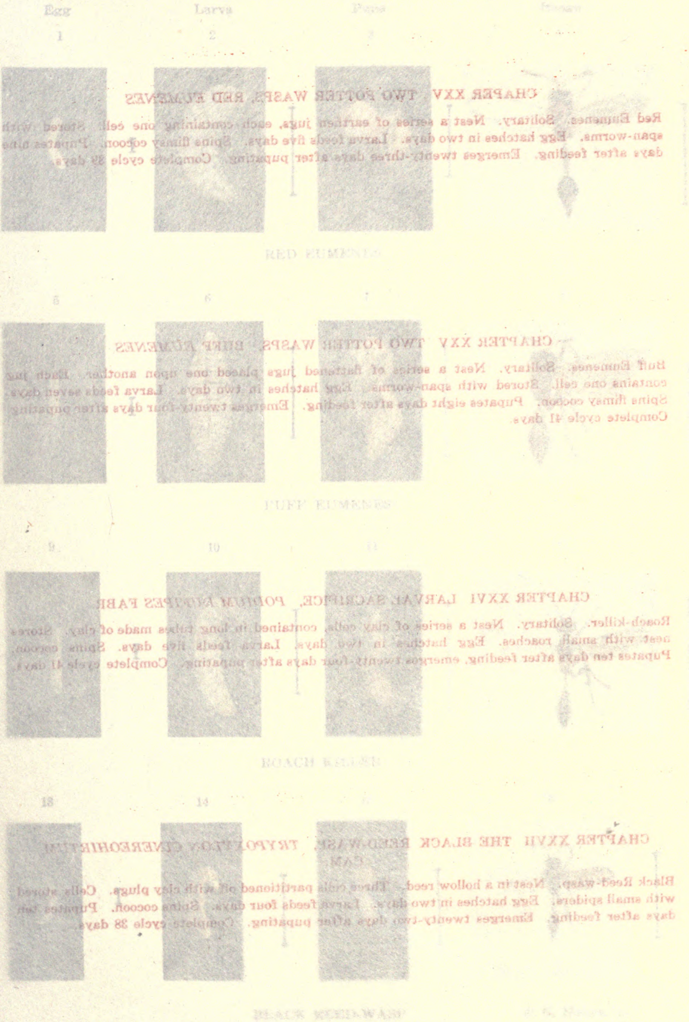


FIG. [illegible] LIFE HISTORIES OF [illegible] WASPS

CHAPER XXV TWO POTTER WASPS, RED *EUMENES*

Red Eumenes. Solitary. Nest a series of earthen jugs, each containing one cell. Stored with span-worms. Egg hatches in two days. Larva feeds five days. Spins flimsy cocoon. Pupates nine days after feeding. Emerges twenty-three days after pupating. Complete cycle 39 days.

CHAPTER XXV TWO POTTER WASPS, BUFF *EUMENES*

Buff Eumenes. Solitary. Nest a series of flattened jugs placed one upon another. Each jug contains one cell. Stored with span-worms. Egg hatches in two days. Larva feeds seven days. Spins flimsy cocoon. Pupates eight days after feeding. Emerges twenty-four days after pupating. Complete cycle 41 days.

CHAPTER XXVI LARVAL SACRIFICE, *PODIUM RUFIPES* FABR.

Roach-killer. Solitary. Nest a series of clay cells, contained in long tubes made of clay. Stores nest with small roaches. Egg hatches in two days. Larva feeds five days. Spins cocoon. Pupates ten days after feeding, emerges twenty-four days after pupating. Complete cycle 41 days.

CHAPTER XXVII THE BLACK REED-WASP, *TRYPOXYLON CINEREOHIRTUM* CAM.

Black Reed-wasp. Nest in a hollow reed. Three cells partitioned off with clay plugs. Cells stored with small spiders. Egg hatches in two days. Larva feeds four days. Spins cocoon. Pupates ten days after feeding. Emerges twenty-two days after pupating. Complete cycle 38 days.

PLATE I

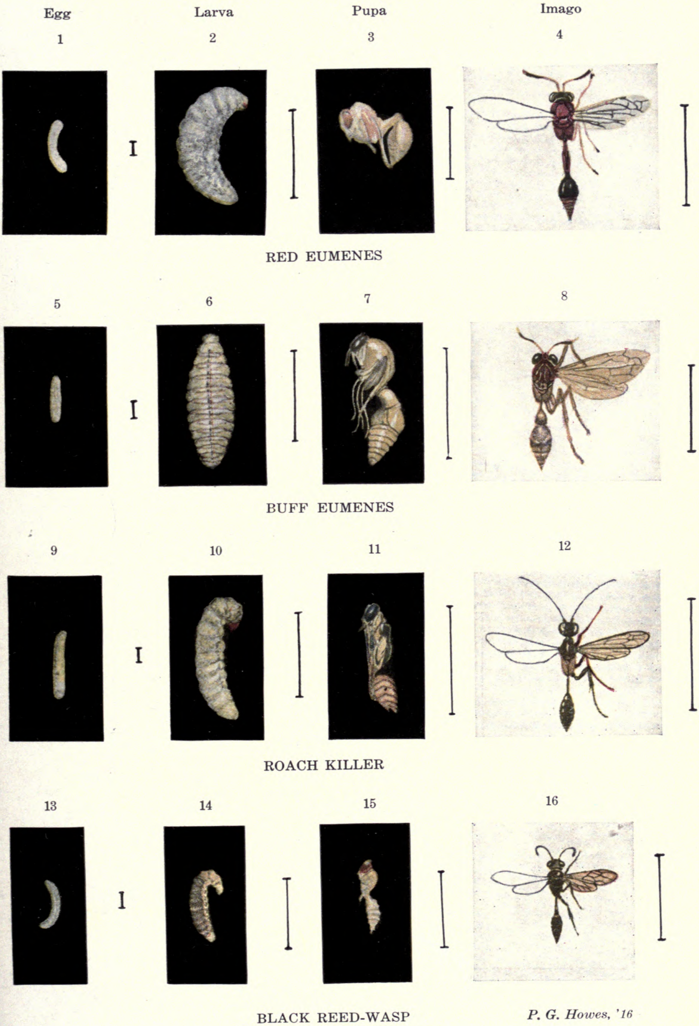


FIG. 125. LIFE HISTORIES OF BARTICA WASPS

ing in an open sunny trail or fashioned about a stem of razor grass, which swings here and there in the breeze. Like the finished jugs of the larger species, they are supplied with a flaring lip, but the neck is very short—in fact, negligible.

But let us return to the first mentioned wasp—the finished artist. This wasp requires one day to complete a single jug. That is to say, she does the actual building in four hours, but the remainder of the day must pass before provisions may be stored, in order that the storeroom may be perfectly dry. In building, the insect approaches the site, carrying a pellet of mud in her mandibles. At first she remains suspended in the air some two feet from the scene of operations. Now she flies here and there, up and down, to this side and that, always with her head towards the nest. Gradually she works up to it until an inch or less away. Here she suspends herself once more for a few seconds before finally alighting directly upon the building site.

The pellet is placed upon the surface and shaped into a tiny ring, one or two millimeters in height. From this foundation the remainder of the jug is constructed. After this initial ring or foundation is in place, the fresh pellet is always deposited on its inner surface, and after being somewhat flattened is modelled into a section of wall by the wasp's mandibles on the inside and her fore-legs on the outside. The method is as though one were modeling a miniature bowl between the thumb and fore-finger.

Each jug serves as a nursery for a single wasplet and is provisioned with ten span-worms. They are prepared by the wasp either by being stung into paralysis or what is more likely, are slightly crushed from end to end by the wasp's mandibles. The nervous system of the caterpillar is spread out through its numerous segments and would therefore be difficult for the wasp to reach adequately with her sting. I have seen a wasp alight with her prey and proceed to mouth it roughly in a dozen different places, but her sting was never brought into use. Further, the caterpillars are capable of

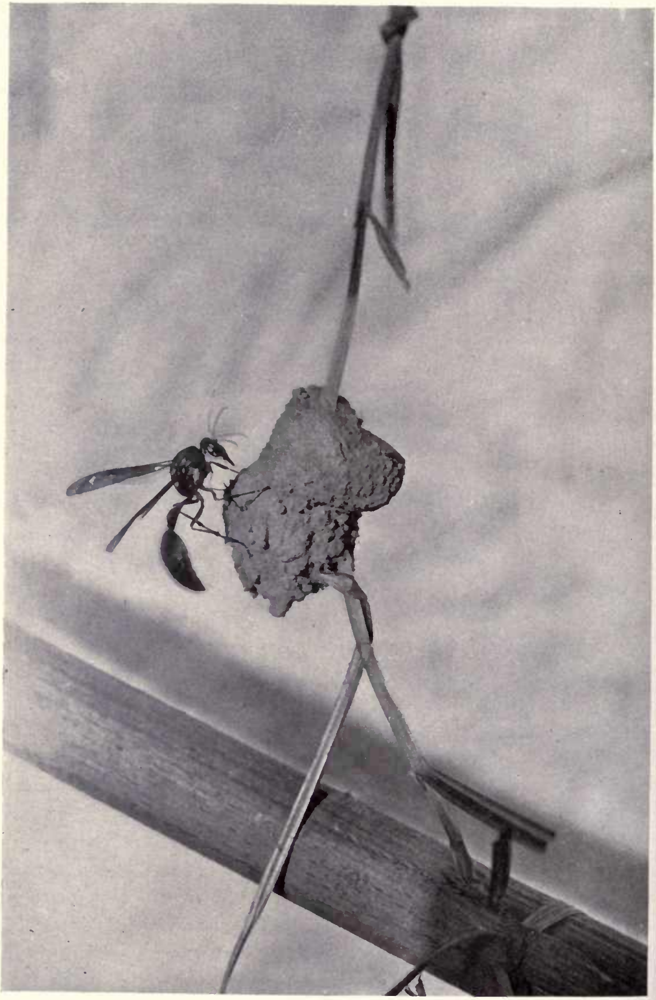


Photo by P. G. H.

FIG. 126. BUFF EUMENES RESTING ON HER NEST
Enlarged twice.

excretion even when stored in the jugs, a process which paralysis from her sting would be likely to prevent.

The span-worms are pushed into the jug entrance one by one from the outside. Two or three of the victims are always smaller than the rest. These are collected first and stuffed in next to the elongated bow-shaped egg, which is cemented by its posterior end to the wall of the base before it is quite finished. The process of storing requires several days and meanwhile the egg hatches and the young wasp, a footless maggot of thirteen segments, commences to feast upon the stores. These smaller caterpillars are doubtless very tender and therefore easier for the larva to consume during its first hours of weakness. The jug is not sealed by the parent wasp until the grub is at least a day old. In eating, the youngster consumes the entire caterpillar, scraping the interior of its victim's head as a delicacy and in its final greed consuming even its hard covering of chitin.

The egg hatches in forty-eight hours. At birth the grub measures three millimeters in length. It grows very rapidly reaching its full length of sixteen millimeters in five days. In shape it somewhat resembles the abdomen of a large wasp and is made up of thirteen segments. Its head consists of a pale yellow bead, slightly cleft in the center and bearing two heavy, red-brown mandibles protruding above the more fleshy parts of the mouth. In appearance the grub reminds one of a bull-dog with its protruding under jaw. For tenacity it surpasses even this king of the canine world, clinging to its victim with a grip that continues for five whole days, until there is nothing left to cling to!

When the feast is over, the larva lies quite motionless for twenty-four hours, before preparing itself to await pupation. These preparations are rather elaborate and require an entire day. First a heavy coat of silvery mucous is applied to the interior of the jug. It is brushed over every bit of the concave walls with minute care. Only the lower part of the grub's mouth is brought into use, the mandibles re-

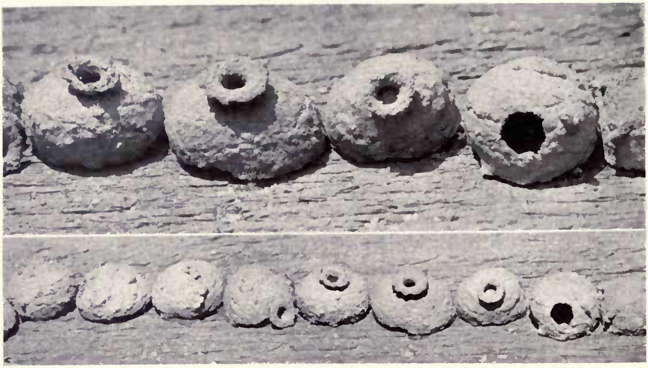


Photo by P. G. H.

FIG. 127. DETAILED VIEWS OF EARTHEN JUGS MADE BY THE RED EUMENES
Top, natural; lower one-half natural size.

maining unfolded, as though now obsolete. There is a strange motion to what might be termed the larva's lips, as the silvery fluid oozes out. The performance reminds me of a person rinsing the mouth and at the same time spurting out the water. The fluid hardens in contact with the air into a tough protecting lining. This process is followed by the spinning of a delicate cocoon, rather flat and oval in shape, which encloses the larva, and also excludes the excretia which, as I have said, the caterpillars were still capable of passing off. There are now three layers between the outer world and the larva. The jug becomes a fort in which the grub lies, protected by a wall of masonry and hardened mucous, followed by a covering of silken thread.

Eight days after spinning, pupation takes place. It is an oddly shaped creature which emerges from the larval body. In color it is lemon yellow. The thorax is horizontal, the petiole or waist oblique and the abdomen more or less perpendicular. This curious shape is entirely lost in the mature wasp, which is a normal insect, but its evidence in the pupa, which requires a much broader space than the common long and narrow type, not only explains why the larva spins its flat and oval cocoon, but also why the parent wasp requires these globular nurseries for her offspring.

Here I must drop the history of the red *Eumenes*. Although her rows of pots were everywhere about the walls and timbers of Kalacoon Laboratory, only one or two were occupied during the five months of our stay. The remainder were old ones from which the wasps had issued. From the abundance of old nests and the entire absence of their builders, I concluded that their chief nesting season comes somewhere between the months of September and February.

The smaller potter, the buff *Eumenes,* nests in March, constructing from four to five cells of yellowish clay. They are at first distinct, flattened jugs, shaped like an army water canteen. Later as additional cells are added, placed here and there at random, the individual jug loses its identity in the mass of clay and the nest becomes a very commonplace object.

This wasp flies to a point some distance above her nest, then in a spiral she descends with her burden. When building, this is a tiny pellet of clay which is deposited and very carefully kneaded into proper shape by the wasp's head and fore legs. Many stones and bits of hard material project from the mortar of the nest, making it an impregnable refuge for her young. She builds rapidly, every fifteen minutes, bringing a pellet, which is moulded so carefully into the growing nursery that save for its darker color, due to moisture, the new work could not be distinguished from the old.

A thorough inspection of her work takes place after every load of clay is incorporated in the nest. Every scrap of the edifice, the old as well as the new is gone over minutely doubtless in search of flaws, however tiny, that might afford an entrance for the ovipositor of the ever-ready parasites. Sometimes even the grass stem or whatever the nest support may be, is likewise closely inspected both above and

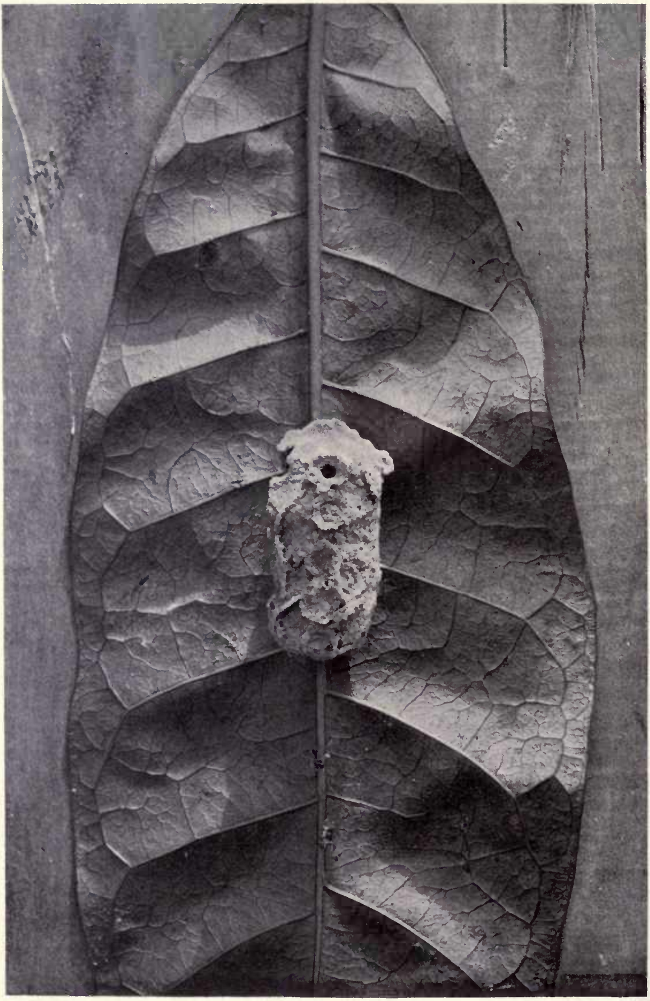


Photo by P. G. H.

FIG. 128. NEST OF BUFF EUMENES

Showing finished cells and one open and ready for storing. One and one-half *times* life size below the cells. This close scrutiny is observed throughout the labor of building. Nothing is left to itself—there is no tolerance of carelessness. Thus the insect's work in all its outward roughness, stands, a lasting monument to its maternal love.

A single jug or cell is completed in thirty hours. When two-thirds finished, an oily white egg is deposited and fastened to its inner wall. The cell is of necessity never finished until the egg is placed, but a few loads of mortar after the laying complete the body of the jug. The flared lip about the entrance is then fashioned from the outside, after which the nursery is ready to be provisioned.

The caterpillar victims are brought in one by one. There are twenty-two in all, of what I take to be larvae, either of Tinied or Pyralidina moths. They are pink or green, eight or nine millimeters in length and two millimeters thick, which is just the diameter of the hole left in the jug.

Storing the cell is a much more leisurely process than building. The wasp visits her nest about once an hour, usually bringing a caterpillar, which she stuffs into the cell with a motion similar to that of a dog nosing earth over a bone. Occasionally she returns empty-handed, and I wonder that it is not oftener. It is winter in the tropics and caterpillars are indeed scarce. One might hunt all day and perhaps find one, yet the wasp's sense of smell is so highly developed that she readily finds twenty-two for each of her cells.

The storing finished, the wasp sometimes stops work for an entire day. I have found her thus, with folded wings, quietly resting upon her nest. Indeed, there is no need of hurry now. If the egg within the cell hatches there is plenty of food for the grub, enough to bring it safely to maturity. There are dangers of course. Parasites, or ants would carry off the contents of the open cell, but her presence prevents attack. Later the hole is plugged with a pellet of mud flattened out until little trace of the opening remains. The wasp continues to visit her nest even when no more cells are to

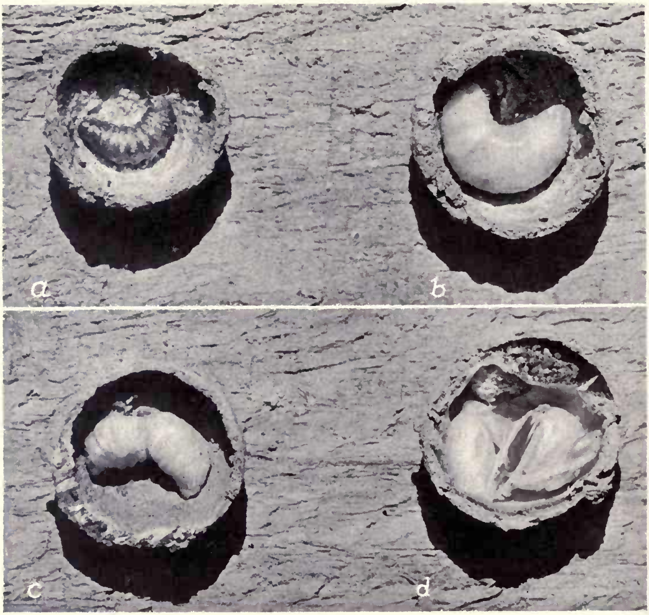


Photo by P. G. H.

FIG. 129. FOUR JUGS OF THE RED EUMENES OPENED TO SHOW CONTENTS
a. Half-grown Larva. *b.* Full-grown Larva. *c.* Larva changing to Pupa. *d.* Pupa.
Enlarged twice life size.

be constructed. This continues for a day or so, but at length she abandons it to the care of fate.

The egg hatches in forty-eight hours, giving place to the usual Hymenopteron grub of thirteen segments. It is rather transparent and of a yellowish white which rapidly turns to pink or greenish, according to the color of its food, and is later lost again. At birth its head is very round, and distinct from the body, being darker in color and supplied with mandibles that tear into the first caterpillar that comes handy.

It grows rapidly, doubling in size in three days, and in one week it is five times its original length and full grown. Twenty-two caterpillars in one week is not a bad feast for so small a creature, yet the bulk of the eater and the eaten is approximately the same.

Upon finishing the last caterpillar the grub rests for twenty-four hours before coating the interior of its cell and spinning its cocoon, a process quite similar to that employed by the other potter of this chapter. Transformation follows a week after spinning, bringing to light a yellow pupa not as oddly shaped as that of the red *Eumenes.*

Its thorax, waist and abdomen are a closer approach to a straight line. It therefore requires proportionally less room and its cell is flattened and otherwise constructed accordingly.

Here as with the red species, I must drop the wasp at pupation. With all my care and repeated trials I was unsuccessful in rearing the species to maturity. I found it simple enough to hatch the eggs, rear the grub and observe pupation, but beyond that point I remain in darkness. On the eve of emergence, my priceless pupae shrivelled and died, and who can say why?

CHAPTER XXVI

LARVAL SACRIFICE

Fig. 125; 9-12

It is strange what a vast array of facts are disclosed through the study of the unintelligent invertebrate. I am thinking particularly of insects, dominant creatures of the earth, into whose life-secrets and lore man, through his wretched span of years may scarce become a trespasser. They are set apart, almost in another world, vastly wise and ruled by an iron discipline that has wrought their world empire of today. My attitude toward the insect is that of a pupil under a great master, who, unable ever to reach the altitude of his mind, must be content to set forth his simplest teachings. No matter where I look, my master is there, a superior being who appears to have risen far above me. From his instinctive throne, he looks down pityingly upon my intelligence, I who must put two and two together and work my poor brain so hard to understand his simplest problems.

Words fail to tell adequately of what I see in the world of insects. Then again there is much that I fail to understand anyway, as a consolation for the missing words, but occasionally I have just a faint glimmer of what is transpiring before my eyes. Thus I shall skip briefly over the life history of a wasp I call the roach-killer, *Podium rufipes* (Fabr.), to the subject of this chapter.

The roach-killer is a solitary mason wasp, who has taken advantage of man's intrusion into her domain. His houses and buildings afford safer quarters for her nest, which originally she cemented to the concave sides of stumps or forest trees. Now she has partly abandoned the old sites for the immovable wooden shutters of tropical civilization, where her rough red columns of clay stand for years as monuments over the birth beds of her offspring.

The nest, a single column of clay two and a half to four inches in length and close to three-quarters of an inch in diameter, consists of a series of V-shaped layers placed side by side. The entrance to the nursery faces toward the ground. Inside it is divided into several ten by twenty millimeter cells, never exceeding four in number, which compared with the exterior, are quite smooth and polished.

Here is an interesting fact: If the wasp has chosen her original habitat among the stumps, she abandons it when finished as an inconspicuous grey blotch that blends nicely with its surroundings. In the forest she finds no red or orange clay for building material. The swamps yield a rich brown and the brook banks a shade of grey. The nest is of necessity sombre in color. On the other hand, the nests placed in the shutters of houses were all of rich, orange-red clay, collected from a nearby excavation in the trail. They were conspicuous objects to say the least, but the wasp quickly covered her fresh paint with a neatly arranged layer of termite's wings, cast off spider's skins and other bits of refuse. At first I put the occurence down as accidental, but careful examination leads me to believe that it is a regular habit of the wasp, in view of the fact that not a square millimeter of the underlying clay showed through the veil. When the nests were finished they appeared old and disused.

Each cell is usually provisioned with four wood roaches. Upon the last one placed in the cell a single white egg, with a yellow median line, is deposited. It is thrust under the fore leg of the roach, where the leg joins the insect's body. It is a tender spot where the young wasp, two days later, may easily bury its head in the creature's flesh. The number of roaches in a cell varies according to their aggregate. Thus a cell may contain two medium and one very large insect, or six small ones, and while there is variation in the number

FIG. 130. ROACH-KILLER

Showing gradual transformation of Larva to Pupa.

Twice life Size

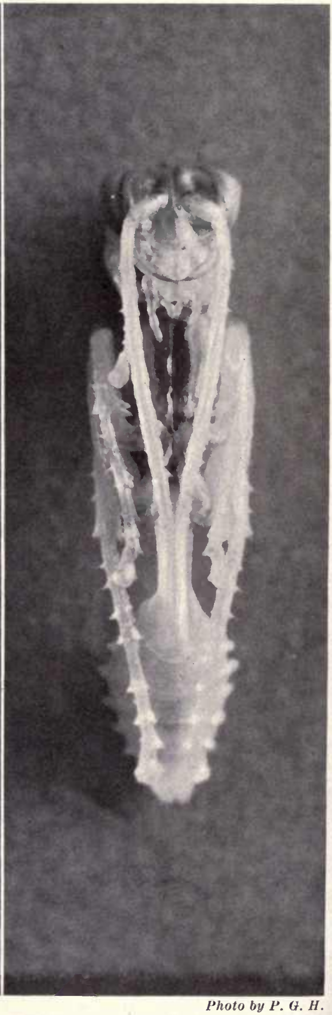


Photo by P. G. H.

FIG. 131. PUPA OF THE ROACH-KILLER

Just after the transformation from the Larva.

Six times life size

of victims, the total bulk and food value of each cell's contents remain the same.

Two days after the egg is deposited and the cell sealed up with clay, the young roach-killer hatches. It is but a tiny grub of thirteen segments, two millimeters in length, rather transparent and concerned only with its mouth and digestive tract. For two days it gorges, selecting only the tenderest, juiciest parts of its victims, leaving the legs and other less nutritious parts untouched. On the fifth day of its existence, it returns to these left-overs, going over and over them until all nourishment is gone.

One hears the glutton plainly at its feast. Sip-sip-sip, comes the rythmic sound. Its entire body throbs in unison as the greedy creature dives deeper and deeper into the grab bag of the roach's anatomy. In five days the feast is over. The wings, egg cases, shells of the heads and thorax, together with the hard limb skeletons of the roaches are left uneaten in the end. They lie about the cell in fine disorder as lasting evidence of the grub's revelry.

Immediately upon finishing the repast, the larva constructs a network of silken threads, just enough to prevent its rolling about. Within this cradle an inner cocoon is formed, composed of threads much more densely spun, and finally coated within with a reddish brown fluid that hardens in contact with the air, into a brittle skin. The process of spinning and coating requires eighteen hours for completion after which the larva excretes the waste from its five-day gorge in a single mass at one end of the cocoon.

Spinning over, there comes a ten-day pause in the creature's activity, during which time we shall witness the Larval Sacrifice. This process, known as pupation, is in many respects the strangest and most wonderful of all physiological transformations that take place in the insect world. We will see the grub which in reality is but the ancestral form of the wasp, transformed by what we might call a "second birth," from its lowly worm-like body into an utterly different and highly specialized member of the topmost order of modern insects.

We have traced the larva from the time the parent wasp deposited it as a tiny egg upon the roach's body. We have watched its growth from day to day and observed how it tackles one victim, consumes it, searches out a second then a third and fourth; how it eats the tender portions first and returns later to coarser fare. Its actions are almost those of a creature conscious of its life and appetite which thinks only of its stomach and so many good things to be consumed. But the minute the repast is over, and the cocoon spun, we see this energetic and ravenous bit of life cease all outward activities.

From young to full-grown larva, the creature is, in a measure, master of itself. It moves about in the cell of its own accord, feeds itself copiously and rests if need be, but thereafter it must surrender to an incomprehensible power, an invisible surgeon who will anesthetize the grub, tear down its old body and bring forth a new and better creature from the havoc of his scalpel.

During the operation, many of the larval organs and tissues are entirely done away with, and at the same time many parts of the new insect are derived from them. There is no spilling of blood, no suffering, no consciousness of what is taking place within the larval skin. From the exterior we see nothing to hint of what is transpiring. All is serene during the ten days that the operation requires for completion.

This strange process of "second birth," (I have no adequate term for it), is known in creatures other than insects. From the blood and tissue of the horse, the foetus is produced, and eventually born. It arrives quite like the parent except for minor details. Without radical changes it feeds, lives and grows to maturity. In the chicken we have the egg, then the young, different at birth from the parent, but rapidly growing to resemble it, upon the addition of food to the youngster's stomach. In the wasp we have an egg, followed by a grub that is unable, simply by eating, to become like its parent. Something more radical is necessary, a complicated bit of surgery which will knock down the larval house and raise an imago from the ruins!

Thus in ten days after the larva spins its cocoon we see a slight shrinking of the body. A depression just off center follows. There is a tremor, ever so slight, then slowly the whole perfect insect unfolds from the grub like a nascent flower from its bud. It may require a million years for processes of evolution to become established into a train of events, yet here in the course of a few days, by watching this wonderful transformation from grub to pupa, we have actually witnessed the ancestral form sacrificing itself to a modern one!

The processes that bring about such radical changes in the insect are known as histolysis and histogenesis. The former covers the breaking down and disintegration of the larval tissues and the latter the building of the new body, in part independent of the old material. There is little known of these strange performances, yet it appears to be the general belief that for the most part, the perfect insect is developed chiefly from the skin cells of the larva. Therefore, I shall set forth what I have been able to gather through the logic of observation, about this point. I make my statements guardedly—simply as facts that appear to have been overlooked.

A yacht is built and launched. She serves admirably as a pleasure craft and is quite satisfactory for that purpose. War is declared. She is commandeered by the government for patrol duty and must be altered to meet new requirements. She is dry-docked, fitted with guns, more powerful engines are installed and lastly she is painted battle color. Later the craft appears once more upon the water. Altered tremendously, the old hulk still serves the fundamental purpose. It is much the same with the insect. The larval wasp is commandeered by nature. She must be fitted to meet new conditions in order to perpetuate her race. Thus the task devolves upon Histolysis the wrecker and Histogenesis the builder.

During the period of larval growth, from the time it hatches until the provisions in the cell are entirely consumed, the grub rids itself of no waste matter whatever. Unlike the larva of the butterfly that excretes every few minutes as it eats during the days of its worm life, the young wasp waits until its stores are gone and its cocoon spun before passing off the waste of its five-day gorge. Even then it waits another day for the event, finally depositing it in a single mass at the lower pole of the cocoon. A few days later pupation takes place.

In the days which pass, between excretion and pupation, no foreign matter appears within the cocoon. The insect is motionless; its cradle, save for the hardened mass at one end is scrupulously clean. I remove this mass, float it out in a little water and subject it to a thorough inspection under the microscope. It contains bits of chitin, hairs and fragments of claws, all however, fragments of the deceased roaches. There is nothing unusual in the array, no bits of larval anatomy, no fragments of the grub itself. What then becomes of the material that Histolysis is supposed to dispoil? Are the skin cells all of the grub's anatomy that serve to build the wasp?

I cut open the body of a grub, three days after the cocoon is spun. The greater part of it runs through the incision as a smooth, pasty liquid amorphous in every way. At eight days, I open a second grub. Now it is partly paste, but mostly wasp!

The laborers of Histolysis are not altogether wreckers then. They are concerned more with tearing down the old timbers, removing the rusty nails, puttying the holes and handing them back to the equally skillful employees of Histogenesis, who in turn rebuild the house along more modern lines.

Twenty-four days after pupation the insect issues from the cocoon, drills a neat hole through the wall of its nursery and emerges into the sunlight a perfect insect. Behind her, she leaves a few, very tiny pellets of white excretia. These are the rusty nails from the old structure. They are all I can find of the larval body that is not incorporated in the new.

Fruit from the tree of instinctive wasp-love, the newborn insect is only an atom in the world, but what a bundle of unsolved mysteries to the humble student of her secrets! At her "second birth," she becomes her own mother! Not content with skin cells alone as building material, Histolysis and Histogenesis have rebuilt the Huntress from herself. She flies into the world with a fresh coat of paint, remodeled, a thing brought up to date, but somewhere underneath, lie the old timbers, reshaped and sawn to meet the new plan!

CHAPTER XXVII

THE BLACK REED-WASP

Trypoxylon cinereohirtum Cam.

Where man has felled the primitive forest, obliterating nature's labors of half a thousand years, he leaves a wound that is long in healing. Just as a wound in the flesh leaves a scar that stands out distinct from its surroundings, so the forest heals its injury with a new vegetation, distinct from itself, but a mask nevertheless to the ghastly wound lying beneath.

We call the mask secondgrowth. It is made up of trumpet trees, weakly shoots from fallen forest giants, great waves of razor-grass, briars, various types of undergrowth and here and there a patch of canes whose hollow stems are the natural nesting sites of the black reed-wasps.

Abandoning their natural habitat for the advantages afforded by Kalacoon, they flocked to our hospitable board, setting up their abodes in our pen-holders, in spools, nail holes, in the handle of my shaving glass and in fact, in anything that suggested a hollow tube with a tiny diameter.

To the general rule among Hymenoptera the black reed-wasps are an exception. That is to say, they are neither social, in the usual community sense of the word, nor are they solitary. They came in mated pairs in search of nesting sites, inspecting all the best holes in the house with great care and deliberation. Like so many newly married couples, filled with the enthusiasm of a novel project, they roamed about among the improved property that Kalacoon offered. To facilitate my studies of their life history, I placed several pieces of glass tubing, three or four inches long and a quarter of an inch in diameter, about the laboratory. I

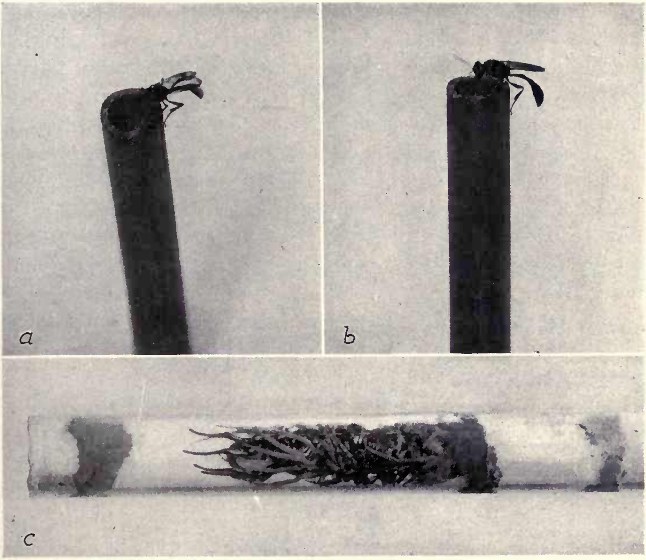


Photo by P. G. H.

FIG. 132. BLACK REED-WASP

a. & b. Male wasp guarding entrance to nest. *c.* Glass tube containing nest, provisions and egg
Natural size.

inserted the tubes, which were closed at one end, into pasteboard boxes, leaving the open end of each projecting, so that the entrances were in plain view, but the main part of the passages were quite dark, within the boxes. Thus I made conditions in the tubes exactly like those of the reeds that the insects naturally chose for their nests.

They were an instant success, and within an hour or two, all were occupied by enthusiastic couples. In the glass nests, I could watch everything that went on. All that was necessary for me to do in order to observe the occupants' behavior, was to remove the box covers, and replace them when I had finished.

True to the tradition of wasp history, the female proceeds with the hard labor of nest building and providing for her family. The male, while he never actually takes part in the work, sits menacingly in the entrance, during his mate's absence, guarding the nest from intruders of the same species that are ever ready unbidden to acquire a partly prepared home. He shows great interest in the work, following the female into the tunnel, watching closely whatever she may be doing and squeaking continually in a high pitched key by vibrating his wings. This is a common habit among many wasps during the work hours, but the species in question omits this strange little rasping sound during almost all of its occupations. I interpret it as an expression of pleasure or well-being, like a man who whistles at his job. The sound is never heard during fright or anger, but of this I shall treat in another chapter.

Upon occupying a tube, the female's first procedure is to place a plug of solid mortar in the end of it, doubtless to prevent parasites and ants from entering. This plug is two millimeters in thickness and composed of wet, light gray clay. It dries in a few hours, hardening into a tough cement. Next to this, a second plug, one millimeter in thickness, is placed, containing more moisture than the first and of a much darker shade. This is followed by a third one of the same description, placed five or six millimeters in front of the second plug, so that there is an air space between them which holds moisture in the nest. The tube is now provisioned with small spiders of different species, varying from five to eight in number, which are paralyzed by the wasp's sting and brought in one by one. They are packed tightly into the tube by the insect's broad head which is brought into use as a sort of ramrod. The tube is a tiny, muzzle-loader, into which she packs her living wads without mercy.

Upon the side or apex of the last, and usually the largest, spider's abdomen, she deposits a milky-white, bow-shaped egg, two millimeters in length. It is less than one-quarter as wide as long and closely resembles a sausage. The spiders and the egg are now enclosed in a substantial cell averaging twenty millimeters in length, by the insertion of a double plug of mortar, six millimeters in thickness, half of damp, dark-colored clay and half of the hard lighter material. The nest is now abandoned by the parent wasps who often start immediately to provision a second one.

In two days the egg hatches, bringing to light a yellow-white grub of thirteen segments. It commences feeding at once upon the spiders, a process which may be observed under the lens as a series of ripples or waves, commencing just behind the head and continuing the entire length of the body,—one wave being completed or spent, before the following one sets in. It grows rapidly, but very steadily, increasing each day in the same ratio until the last twenty-four hours of feeding, when it gains somewhat less than during the previous days. In all the larva or grub is full grown in four days from the time it hatches.

Upon finishing its meal, which lasts continuously for four days, the larva spins a flimsy net work of silken threads inside of which the cocoon proper is spun. This inner cocoon resembles a tiny torpedo, rounded at both ends and ten millimeters in length. It is very neatly constructed of delicate silk and coated all over the interior with a brown varnish that hardens in contact with the air.

Within this delicate cradle ten days later, the budding wasp undergoes pupation—that wonderful process described more fully in the previous chapter—by which the footless grub is transformed from a low and ancient form, to the highest order of modern insects. The actual change from gorged grub to a neatly folded, but colorless wasp is affected in ten days, but it still has three hundred and twenty-eight hours of confinement separating it from the light of day, hours which must be passed quietly, lest injury result.

As the hours go by, color at length flows through its body and appendages, transforming opaque yellow to glistening black. Then comes the final gift of nature, the power of motion. The nascent creature moist with birth, bursts its cocoon, gnaws through the plug of mortar and issues into the outer world, a perfect insect. Only thirty-eight days have passed since I placed the tubes in the laboratory, and since the parents of this new creature arrived, realizing their destiny.

There is an interesting problem to solve concerning the black reed-wasps. Their nests vary considerably in number of cells. Some are complete with one, others contain two, but the majority are complete only after an egg has been laid upon the stores in three separate compartments. The question arises, how will the wasps emerge as perfect insects without disturbing one another?

If the nest is to shelter three insects, the cell farthest from the entrance will naturally receive the first provisions collected, and it would seem, in due time, the first egg deposited. The remaining two cells would receive their respective contents in the order of their position, but the first egg laid, naturally hatches before the others. The grub, reaches maturity, pupates and is ready to emerge sometime ahead of its sisters in the other cells. What happens then? Does the issuing wasp burrow its way out through the cells in front, upsetting in its passage the vital condition of solitude that surround the younger insects? Does it burrow through the clay plugs, separating each nursery and as a final act of vandalism, leave the nest open, exposing its younger sisters to the first parasite?

So it would seem, but such a course would be contrary to all the laws of nature. She does not destroy her children needlessly, yet I wonder what happens in such nests as that of the black reed-wasp, whose oldest child seems farthest from the door to freedom!

Perhaps the parent wasp is gifted with the power of laying eggs that require varied terms of incubation. In the first cell provisioned she lays an egg that requires three days to hatch, in the middle cell one that requires two days and in the outer cell the egg hatches in a day and a half. The theory would straighten out the difficulty very nicely. The insects would emerge in turn without disturbing one another and all would be well, but a theory is no better than a guess. Moreover a little careful observation of the glass tubes yields the correct and simple answer to the question.

I watch a wasp entering one of the tubes carrying a spider which is held tightly beneath her body. She enters, stores the game, squeaks about it to her watching mate, and is off again in search of a second victim. She does not rest after placing eight spiders in the tube, yet this is the maximum number for a single cell. Instead, the work continues during most of the day without interruption.

In the afternoon I open the box containing her nest. The tube contains twenty spiders separated into three little groups by half partitions of clay. Upon the abdomen of a large spider in each group she has deposited an egg. Now I close the box and await her return. She arrives laden with a tiny ball of clay in her mandibles, enters the nest for a moment and then flies off minus her burden.

At the end of an hour the operation has been repeated twenty times. Now she commences to close the entrance with the same material. The job requires ten more loads of mortar, but it is completed rapidly. By evening she has left the nest, I presume for good and all, and for the last time I pry into her secrets.

It is all very clear. In a single day she has accumulated the entire amount of provision necessary to provide her three offspring and separated them into distinct groups. Further she has constructed half partitions that keep the stores separate, but still permit her to pass from one end of the nest to the other. Thus she is enabled to deposit her three eggs in different departments of the nest, all on the same day. The laying over, she has only to finish the half partitions with a few loads of clay, plug the entrance and her work is completed.

She has deposited all her eggs within an hour and they are safe in isolated cells. The three will pass through their metamorphosis as one. They will eat and grow and pupate together, and issue into the world almost at the same moment. Thus the black reed-wasp solves the problem very simply. She brings her offspring into the world as triplets!

PLATE II

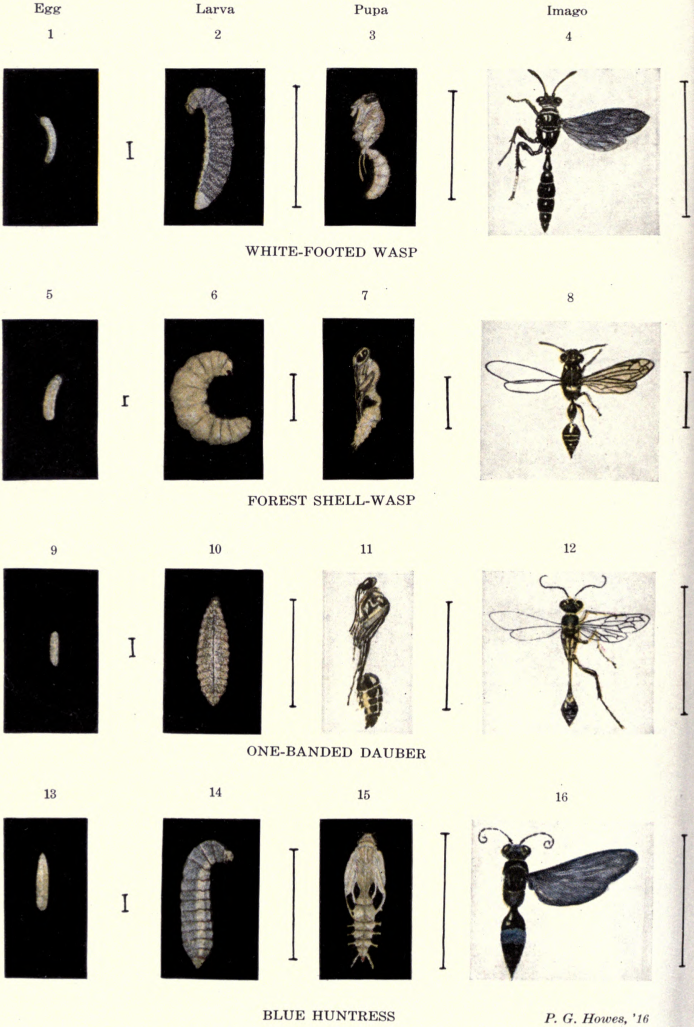


FIG. 133. LIFE HISTORIES OF BARTICA WASPS

CHAPTER XXVIII WHITE-FOOTED WASP. *TRYPOXYLON LEUCOTRICHIUM* ROHMER.

White-footed Wasp. Solitary. Nest in hollow reed. Three cells partitioned off with mud plugs. Each cell stored with four spiders. Egg hatches in two days. Larva feeds five to six days, spins cocoon. Pupates eighteen days after feeding. Emerges twenty-one days after pupating. Complete cycle 46-47 days.

CHAPTER XXIX FOREST SHELL WASP. *ZETHUSCULUS HAMATUS* ZAV.

Forest Shell Wasp. Solitary. Nest of moss. Two cells provisioned with caterpillars. Egg hatches in two days. Larva feeds five days. Spins no cocoon. Pupates twelve days after feeding. Emerges twenty-one days after pupating. Complete cycle 40 days.

CHAPTER XXX THE ONE-BANDED DAUBER. *SCELIPHRON FISTULARE* DAHLB.

One-banded Dauber. Solitary. Nest a group of mud cells, provisioned with spiders. Egg hatches in three days. Larva feeds six days. Spins cocoon. Pupates ten days after feeding. Emerges twenty days after pupating. Complete cycle 39 days.

CHAPTER XXXI THE BLUE HUNTRESS. *CHLORION NEOTROPICUS* KOHL

Blue Huntress. Solitary. Nest a group of coarse clay cells set one upon another. Each cell provisioned with one large spider. Egg hatches in two days. Larva feeds five days. Spins cocoon. Pupates ten days after feeding. Emerges twenty-one days after pupating. Complete cycle 38 days.

PLATE II

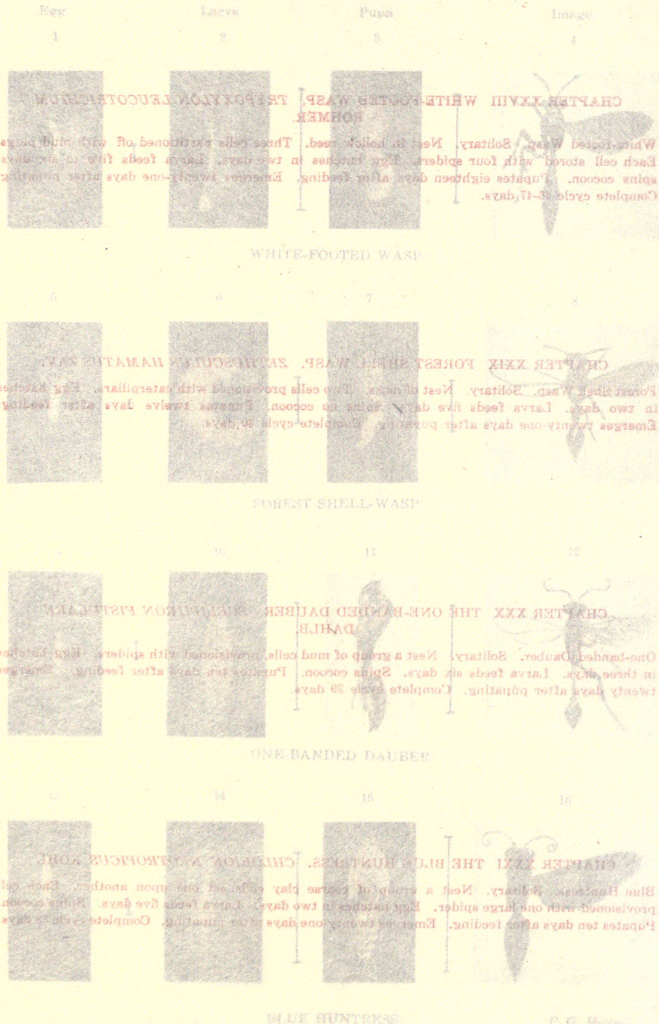


FIG. 138 LIFE HISTORIES OF HASTICA WASPS

CHAPTER XXVIII

THE WHITE-FOOTED WASP

Trypoxylon lencotrichium Rohmer

An alert business-like insect, deep steel blue with a white band encircling each of her hind tarsi, the white-footed wasp is readily recognized. She inhabits the hot open trails where bamboo grass has been slashed in clearing, leaving here and there a severed hollow stem hanging in mid-air and supported by the plant's shriveled leaves which catch among other foliage. These hollow tubes supply the insect's favorite nesting sites, unapproachable from below except by winged enemies.

The reed which the wasp had chosen had been severed by a knife slash so that its end was sliced off at a gentle angle. It hung four feet above the ground in a heavy patch of bamboo grass with its open end pointing toward the earth. Several other open reeds of the same character surrounded it, appearing to me very much the same. Not so to the wasp, however, she differentiated at once and upon returning from her journeys, flew directly to the reed of her choice. There was no uncertainty in her approach, no repeated trials to find the proper entrance. A straight, single flight from the outer world to her tube marked her arrival. What a contrast to the clumsy one-banded dauber who wastes her precious time!

I first found the white-footed wasp gathering a ball of soggy clay in a pitfall trap in the trail leading to the forest. Several of these holes had been excavated and for their intended purpose of catching frogs, toads and the smaller rodents they were perhaps less productive than they were of wasps. The pits, after a rainfall, often contained several inches of water. When bailed out, a pasty layer of clay would be left in the bottom of each. This material, a ready made mortar, proved attractive to a number of wasps, which used mud in the construction of their nests. Tiny little reed-wasps, medium-sized ones, big blue huntresses, daubers and a dozen others collected at this abundant public property. Here, side by side, they gathered their building material, all laboring in a great common design for the welfare of their race in the future.

The wasp brought several loads to her tube, scraping it up from the floor of the pitfall and carrying it in little globules to her doorway. Once within, a high-keyed squeaking and buzzing would continue until the clay was thoroughly kneaded into a safety plug at the upper end of the reed. Her trips between nest and pit were continued for nearly an hour, like a hod-carrier laboriously plying between mortar box and masonry. After many trips back and forth she disappeared, returning in a little less than half an hour with a limp, paralyzed spider.

The victim, a medium-sized creature, was richly colored and patterned in various shades of brown. Its body was quite small, measuring six millimeters in width, but the legs, all of which were intact, were long and rather cumbersome to the wasp. With her burden she flew directly to the entrance of her nest. She alighted with difficulty, then turning about and grasping the spider by one of its palpi she endeavored to enter the reed backwards. All went well for a time. The victim's cephalothorax and fore legs caused no trouble, but its abdomen caught at once upon the sharp edge of the reed, which tapered almost to a point. From this point the spider would not budge—and what is more, was in great danger of being punctured. Had the wasp pulled too hard it certainly would have been impaled on the reed and ruined for future use.

Here I witnessed a most skilful performance. Clinging to the interior of the reed with only her two posterior claws, the wasp lowered the spider very carefully and deliberately until its entire body swung free in the air. Here, clasped tightly in the wasp's strong mandibles, it was held by its two front legs, and rotated so that its abdomen came into the position so lately held by the cephalothorax. Then walking backward up the tube the wasp succeeded in bearing her victim to its last resting place.

As I have already stated, the wasp seeks out spiders which although of moderate size, possess long, slender legs, and there is a simple significance in her choice. The wasp's nest is a hollow reed whose smooth perpendicular walls end abruptly in space. Her front door gapes in the void and must be approached from below. The spider's body alone is considerably smaller than the diameter of the tube. Thus were the wasp to choose a short-legged victim it would drop from the nest at the instant of release. The long legs of her spider are doubtless burdensome, yet they are a necessity to the success of her work. In drawing them into the reed, their legs fold back between abdomen and reed, filling the intervening space so nicely that the entire creature remains wherever the wasp places it.

Four of these spiders are allotted to each of the three cells, which are separated as the wasp provisions them, with plugs of clay three millimeters in thickness. Upon the side of the largest spider in each cell, a three-millimeter egg is deposited. It is slightly bowed, just enough to fit the curve of the spider's abdomen, slightly elongated at one end and about the color of skimmed milk.

The three cells vary considerably in size. One measures three inches, another two and the third is an inch and three-quarters long. For these differences I can see no reason. So long as there are three cells in the tube the wasp is apparently quite satisfied to place her divisions at random.

The egg hatches in forty-eight hours, resulting in the characteristic wasp grub of thirteen segments. It commences feeding at once upon the stored spiders, first drawing off the soft parts and later returning to less delicate food. During the first day of its life the larva grows only two millimeters. On the second and third days it averages five millimeters each. On the fourth it goes back to two, grows eight on the fifth and finishes with a growth of one millimeter on the sixth and last day of its meal. The spiders are now entirely consumed and the grub measures twenty-six millimeters in length.

Without pausing for a moment to rest, the full-grown larva now sets about to lay the foundations of its elaborate cocoon. The insect is awkwardly placed at the outset, living as it does in a cell whose perpendicular walls are several times its own length, but fortunately at this period of its life it is endowed with an unusually tacky skin. This stickiness serves a special purpose, enabling the grub to remain safely in the top or center of its cell without the slightest danger of tumbling down to the mortar plug separating it from the cell below.

From its lofty position and in total darkness, the grub first throws out several bands of silk, fastening them in various places about the reed walls. It makes no choice of its own, but simply fastens each successive thread to the first point of contact. Some of the strands pass to points above the spinner, some below and still others across the middle of its body to the wall beyond. At length the grub finds itself more or less enclosed in a delicate silken net through the strands of which it may still poke its head.

Thirty or forty new threads are now extended from the top of the growing cocoon. They emerge from various points in a circle, and are fastened to the cell wall above. The larva now returns to its original network, within which it spins a firm torpedo-shaped covering, slightly wider than its own body, nineteen millimeters in length and open at the upper end. Through this opening a ring of silk is spun, two millimeters in height, with a scalloped edge, the point of each scallop forming one of the thirty or more strands extending above the cocoon. The open top is now closed and reinforced with silk, the strands crossing and recrossing in every imaginable direction so that the cocoon now appears in the shape of a stubby cigar with an inverted parachute at one end. The strings of the parachute extend above, where they are fastened to the reed, thus suspending the entire cradle in the center of the cell.

The cocoon is now strongly supported from above. It hangs perpendicularly in the hollow reed, head up, and no matter how the larva thrashes about, there is no danger of falling. Two or three hours after the last silken thread has been spun, the grub continues its work, this time coating the entire inner surface of its cradle with a transparent or slightly yellowish fluid. A certain amount of this is brushed directly upon the walls as it oozes from the creature's mouth, but for the most part, the grub expectorates it upon its own ventral surface. From here it is caused to flow over its entire body by a strange series of muscular contractions. The operation is repeated over and over until the writhing creature is thoroughly moistened by the secretion. As the grub expands, contracts and turns its segments, the liquid becomes incorporated with the silk of the cocoon, wetting it thoroughly on the outside.

It is a varnish with strange properties that the larva employs,—a sort of cement which will adhere only to certain objects. When secreted it is transparent or nearly so. It amalgamates at once with the silk and hardens in contact with the air into a skin, purplish brown in color and brittle, like the inner covering of a peanut. Strange to say it does not adhere to the larva, nor turn color until compounded with the other material of which the cocoon is made.

The entire process, of spinning and varnishing, requires two full days. The grub then expels a large pellet of waste, the accumulation of six days of feeding, in the bottom of the cocoon. This hardens rapidly into a solid cake in a few hours. Sixteen days later pupation takes place.

Now comes the period of absolute quiet during which time the insect receives its color, which appears first in the eyes and gradually flows throughout the body and its appendages. The process requires some fifteen days. This is followed by a six-day period before the perfect insect emerges, to lay the cornerstone of a new generation.

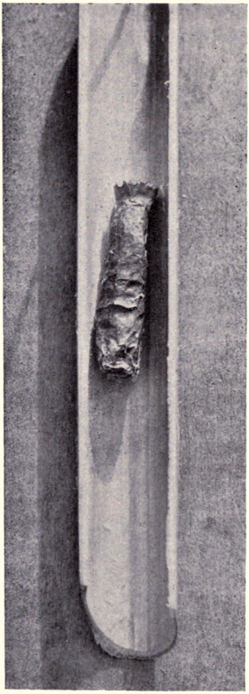


Photo by P. G. H.

FIG. 134. COCOON OF WHITE-FOOTED WASP, SHOWING ITS ELABORATE CONSTRUCTION. Slightly enlarged.

CHAPTER XXIX

THE FOREST SHELL-WASP
Zethucculus hamatus Zav.

Fig. 133; 5-8

How early one thing begins to support another in the jungle! Even the infant, thread-like air root, new born from the parent liana, sustains a spiral of fairy moss and later a tiny emerald wasp's nest, fashioned from the ribbon of the sporophyte. The great cool jungle reminds me of a jig-saw puzzle, the pieces of which are its life, entwined and ingrown, each using another for its own particular success and to complete its part in the great green picture. A giant liana supported by a still greater tree, thread-like offspring supported by the liana, fairy moss living upon the thread roots, wound in its turn into the hoop-like walls of an insect nursery. Here at least are five fragments of the great puzzle we see fitted together.

The nursery which belongs to the shell wasp of the forest reminds me of two algae-grown snails, one clinging to the slender stalk, the other to its sister's tapering shell. In reality, the two shells are the cells of the nest fashioned from the ribbon-moss which grows upon the air-root. It is very delicate material. One must look sharply in order to see that it is a thing separate from the mere thread that supports it. Peeling off the ribbon, the wasp winds it into little hoops, one upon the other and cements it together with her own personal glue. The building material, when dry, is tough and quite waterproof. Some twenty hoops, half a millimeter in width, complete each cell and the freshly made nest gives off an emerald sheen.

In each cell a stumpy, slightly bowed egg is laid, two and a half millimeters long and a third as wide. It is yellow

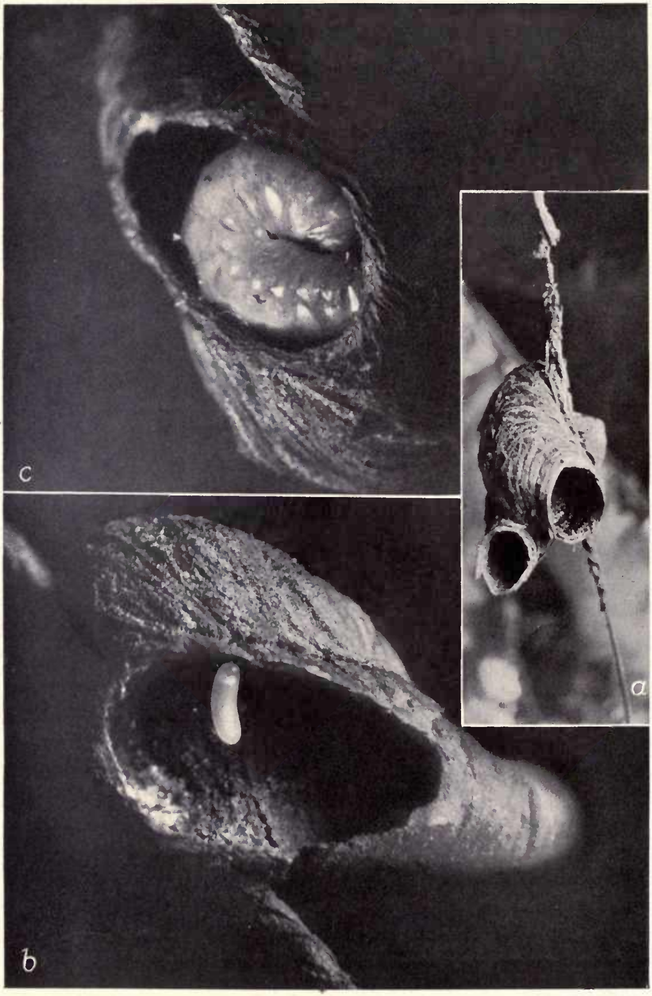


Photo by P. G. H.

FIG. 135. THE FOREST SHELL-WASP.

a. Nest suspended on a delicate air-root. (Enlarged about thrice). *b.* Opened nest showing egg. (Enlarged seven times). *c.* Full grown Larva. (Enlarged seven times).

in the center, fading to a transparent white at either end. The yellow center is in reality the young wasp, and the transparent end the extremities of the film-like egg-shell. The eggs are laid one at a time, that is to say, the wasp deposits in one cell, waits for it to hatch, then provides the young with sufficient food to bring it to maturity and plugs the cell with moss before laying the second egg.

Its chosen prey is doubtless small caterpillars, for I found three uneaten heads in a cell containing a full-grown larva. The egg is attached to the roof of the cell by its posterior end near the back, and hangs downward. Thus the young wasp hatches with its head in mid-air.

The mother wasp guards her cells closely during the period of incubation, often resting within the cell containing the new laid egg. She crawls to the entrance on the roof of the nest, then turning round, backs in, clinging to the underside of the roof. Her head peering out, with its antennae waving here and there, adds to the illusion of the nest being the shell of a snail.

The two nests on which this life history is based were found on May 14, in the deep forest. One of them I lost, but let us go back to that day and the remaining nest. If I leave it upon its swaying air root for further observation, I will probably never find it again. It blends perfectly with the emerald surroundings, a tiny object in a part of the forest that I have visited but once. Therefore I will carry it home to the laboratory just as it is, and put myself in difficulties at once.

The first cell contains a full-grown larva and the second is empty, save for a single, freshly deposited egg. The larva is quite satisfactory. It has finished its meal of caterpillars and will soon pupate, giving me much desirable information and no trouble. But what of the egg? If, true to the rule which is usual among solitary wasps, it will become a hungry living grub in forty-eight hours, how then shall I feed it? I have not given the parent wasp a chance to store provisions for her larva, yet I am responsible for the orphan.

The young of solitary wasps are fed on a variety of material, but spiders and caterpillars seem to be most frequently chosen as provender. This I know from experience gained in the examination of a great many nests. In the light of the present difficulty it may prove a valuable bit of knowledge. The victims are stored within the cells in a paralyzed condition from which they never awake. If they were killed outright, they would soon putrify in the cells, contaminate the budding wasp and turn the healthy nursery into a colony of lepers. Therefore instinct, the great teacher of insects, guides the wasp's sting only into the victim's nervous centers. The creature, so treated, passes into a comatose condition and lies powerless to move or struggle while the young wasp sucks at its viscera. This, then, is my grewsome course: I must catch, artificially paralyze and present living food to the shell-wasp's grub if I am to rear the orphan successfully.

A search for caterpillars of the proper description is entirely unsuccessful. They must be minute, soft and without hair upon their bodies or the youngster will die of indigestion. Moreover it is the off season for them and unlike the wasp I cannot find them by the sense of smell. Therefore as an experiment I substitute spiders for the proper diet of span-worms. Spiders are abundant and easily paralyzed.

The nervous system of a spider is concentrated in a mass of ganglions gathered about the oesophagus. It lies in the cephalothorax, or in that section of the creature which is foremost, there being but two divisions.

I secure my first victim from its web in the window corner. It is a long-legged creature with a good plump body, soft and unprotected. With a little chloroform, I anaesthetize it, just long enough to keep the creature quiet. As soon as it is still, I clip its legs off quite short, then with a very slender needle I stab the cephalothorax in two places, once from above, once from below. My object is to reach the ganglions mentioned above, thereby injuring them with my needle and producing a sort of paralysis in the spider. The experiment works well enough. The victim quivers for a moment, then lies motionless. With my crude sting, represented by the needle, I have imitated as closely as possible the methods employed by the parent wasp in preparing food for her offspring.

Now I place the spider in the cell just under the suspended unhatched egg of the wasp and await developments. In two days the young wasp emerges from the shell, and hangs head down, still attached at its anal segment to the cell wall. For several hours I keep close watch, during which time it pays no attention to the paralyzed spider. It scorns my work and the repast I have prepared and hangs helplessly, its mouth sucking rythmically at the air. Now I move the spider so that one of the stab wounds in its body comes in contact with the larva's mouth. It responds frantically, like a creature dying of thirst, to the liquid that oozes from the wound. It fastens itself by the mouth to its victim and there it clings like a suction pad, its entire body rippling as it drains the spider's life.

Much to my surprise the experiment is crowned with success. In a few hours a change is noticeable in the larva—it has grown and gained in strength. At length it pulls away from the walls of the cell and settles among the spiders I have provided. It is an experiment especially prolific in answering abstract questions and suggesting others. It proves that all larva are not entirely dependent on one certain article of diet. Doubtless a given species is invariably supplied by the parent with the same kind of food, yet we have positive proof that such a condition is not imperative. The larva has no more abhorrence for the spider than for its natural diet of caterpillars. If the mother wasp but knew the truth she might store her nest with the ever abundant spider in years of caterpillar scarcity.

Further, the experiment points out that in the wasp's victim, paralysis may be brought about by the thrust of the dart unaided by its poison. It is the stabbing and injuring of the ganglions that produces the effect, at least in the case of the spider.

Is the poison of the wasp a potion for prolonging life in the stores, rather than an agent for producing paralysis? Do wasps that attach their eggs to the cell walls, leave the doors open until the young wasps hatch, for any particular reason? These are questions that the experiment suggests. But let us go back to the insect's life history.

At birth the young wasp measures two and one-half millimeters. It is a milky white grub of thirteen segments counting the head, which is a round bead-like affair. As it feeds and increases in size the distinction of the head decreases. At first the head is nearly the same diameter as the body itself, but the latter soon takes on flesh and grows many times its original size, so much more rapidly than the head that it soon greatly surpasses it.

I continued to feed my orphan for five days, which is the average length of time spent gorging by the Guiana grub. During this time it consumed several small spiders that I paralyzed and placed before it, reaching in the end a length of seven millimeters and turning a pale yellow color much like clouded or partly sugared honey.

Now the grub lies motionless for three days, when a pellet of undigested bits of spider is deposited in the cell. No cocoon of any kind is spun; instead it lies upon the bare, hooped floor of the nursery, apparently quite contented. All wasps rid themselves of what waste has accumulated during larval life in this manner, a short time prior to pupation, the majority placing it in the lower pole of the cocoon, where it acts as a solid plug. When the waste matter is expelled the grub often loses its original color which is due only to the sewage showing through its transparent skin. In the case of the shell-wasp, it changes from a clouded honey color to white slightly tinged with yellow. It also becomes more opaque.

Ten days after excretion the insect pupates. Then comes another wait of three weeks before the final wasp issues from its cell.

During these twenty-one days, the pupa receives its finishing touches—at first, when the transformation from the larval state takes place, there is no dark pigment in the body. It is yellowish white and rather translucent. Color appears first in the eyes which turn light lavender, then brown and finally black. Next, the pigment appears in the remainder of the head. Then, as though coming through some hidden tunnel below the flesh, it appears as a mere dot of dark fluid in the center of the thorax. Slowly the dot expands, throwing out arms of color which later combine and fill the entire thorax with pigment, like a rocket that unfolds its display in the sky. Next the slender petiole of the abdomen becomes clouded. This soon gives place to darker color while its recent cloudiness appears in the abdomen itself. At length the entire insect turns black save for the three small orange-yellow patches on its abdomen.

This general dullness is due to the pupal skin in which the finished wasp is now resting. We see it through this delicate membranous covering which is immeasurably thin and fits the insect as closely as her own external skeleton. Under the transparent covering the insect appears dull, but otherwise quite normal except for her wings. Her legs and antennae are of proper length, her head and body neatly proportioned, yet her wings are but a third the natural size. They are hollow appendages intricately folded and held in place by the wing bags of the membranous covering. Later with the pupal skin of which they are a part, these bags are shed, releasing the true wings which unfold to their full extent under a pressure of liquid which flows into them from the wasp's body. Later the liquid is withdrawn and they dry as thin, brittle appendages.

When the pupal membrane is cast the wasp requires at least another day to rest and gain strength for her emergence. She does not issue into the world in the wet, weak condition of the butterfly, to rest and dry in the sunshine before flying to seek her mate. Instead she makes her toilet within the cell and waits for full strength before emerging. Then, everything ready, with knife-like mandibles she cuts a neat round hole through the mossy wall and casts herself to the lot of fate.

We see her as she emerges, all glistening with the youth of a new generation. A scant forty days have passed since the mother wasp fashioned the emerald nursery upon the swinging air root.

CHAPTER XXX

THE ONE-BANDED DAUBER
Sceliphron fistulare (Dahlb.)
Fig. 133; 9-12

The physiological phases of the dauber's life history naturally adhere to a set of invariable rules—the egg hatches in a certain length of time, the larva feeds until the spiders in its cell are consumed and in the course of certain definite periods the insect pupates and emerges. Her nest is of clay, her provisions spiders, but otherwise, in the remainder of her nesting activities, this wasp is a creature that follows no rule. Her nursery may be but a single earthen cell or it may boast a group of twelve. It may be fastened to a twig, to the side of a house, to a sheltering stone or on the edge of a narrow shutter slat—one nest is a long flat object humped at one end with additional cells and decorated with strips of variegated clay, another is top-shaped, dull in color with a well defined point, a third is egg-shaped; still another is but a single grey cell, half circular at one end and quite round at the other. They vary endlessly according to the energy and taste of the individual builder, therefore I cannot describe any one nest as the usual type—I may tell only of the building of a cell. It may be the first room framed in an elaborate plan, or the completed nest of the dauber, but my remarks will apply to any nest.

Upon a brick pillar supporting the laboratory the wasp laid the corner stone of her nest. Twelve loads of brown mud, tamped out into flat pies, side by side, sufficed for the foundation. The material was carried in little round pellets weighing one-tenth of a gram. They were borne in the wasp's mandibles from a moist spot in a flat clearing nearby. Each pellet was tamped and arranged with great care, dur-

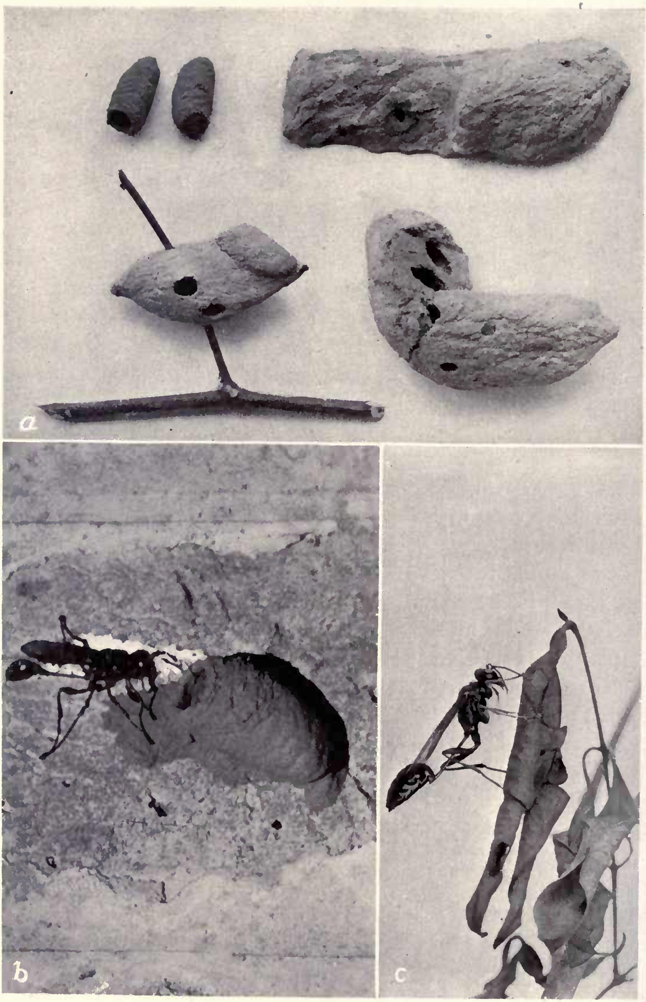


Photo by P. G. H.

FIG. 136. ONE-BANDED DAUBER

a. Four distinct types of nests. *b.* The Dauber at her nest. *c.* Newly emerged Dauber.
Upper picture about one third natural size. Lower pictures slightly enlarged.

ing which time the wasp buzzed continually and held her abdomen at the end of its long petiole high in the air, as a balance weight to her lowered head on the other end. The fore legs were used as much as the mandibles, thus her dumb-bell-like body swung pivoted upon the central pair of legs.

When the foundations were laid she proceeded with the cell itself, bringing thirty loads of mud per hour. In a little over two hours the cell was complete, a neatly rounded tube, thirty millimeters long and sixteen millimeters in diameter, the result of some sixty-five loads of mortar.

In fashioning the tube, the first few pellets were deposited side by side and raised into a semi-circular mound or half disk stood on end. Here again the work was accomplished with her mandibles and fore legs. The clay was pinched up between the tarsi and then shaped principally with the mandibles which acted like a pair of flattened tongs. When the disk was finished the successive loads of mud were pressed against its inner surface, usually at one side and then moulded into a narrow ridge running around its circumference. Thereafter each pellet was fashioned into a ribbon of plaster placed against the side of the preceding layer. When the job was finished these individual layers were quite visible so that the separate rings of which the nest was constructed, could easily be counted.

In coming to her nest the wasp often experienced great difficulty in locating it. She would approach the brick pillar with her mortar pellet, circle the column once and then alight, as a general rule, some distance above or below the nest. A thorough inspection of the spot to which her general sense of direction brought her, would follow. This inspection never extended beyond one or two bricks at most. Finding the cell missing, she would take wing, circle the pillar once more and alight in a new location. Sometimes this performance was repeated over and over, until at length she would come by chance upon the brick supporting the object of her search.

Different species of wasps vary greatly in degrees of accuracy in finding their nests. Some experience no difficulty whatever, others have slight trouble, while still others spend at least one-third of their nesting period searching for the elusive keyhole. So true is this among solitary wasps that they might be divided into several groups in the order of their respective accuracy. One group would contain the wasps which build nests in the ends of hollow reeds. The home doorway may be in the midst of a dozen others, yet the owner flies directly to her own threshold without an instant's hesitation. The long black reed-wasp and the white-footed wasp would be shining examples of this enlightened group. Again we have such wasps as the red-legged digger who locates her tunnel in the ground only after a series of circular flights in the air above it, much as a carrier pigeon hovers when released, before turning homeward. In the third group, the one-banded dauber might head a list of blunderers who find their cells only after a search, sometimes of great length, with the loss of much valuable time and energy.

I do not believe that sight is an important factor to be considered in any of the above cases. Insects do not see such small objects as their nests clearly from a distance. It is, to some extent, a sense of smell, after the main journey has been accomplished, but they rely chiefly on a sense of direction. Some have it more highly developed than others, just as the Indian finds his way in the forest unaided by compass, where another individual, a white man, would fail or perhaps blunder through to his camp. The one-banded dauber flies accurately enough to her brick pillar, but lacks that balanced sense of direction that lands the white-footed wasp in a single flight at her doorway.

In the wooden shutters of the Laboratory, I found further evidence of the dauber's stupidity. For a nesting site, she had selected in this case the narrow edge of a slat situated midway between the top and bottom of the shutter. Below her site were a dozen other slats each affording a building plot similar in every way to the one she had selected. Above her were as many more. This made her work difficult, as it finally proved, too difficult for her limited sense of direction. She laid the foundation of her nest in a maze of sites, each exactly like those above and below and in the end her design perished. Her pellets of mud were deposited upon four different slats, one below the other until four separate cells, three inches apart commenced to take form. Arriving laden with her ball of mud she would fly to the general location of her original foundation, but to distinguish which slat among so many similar ones supported her original masonry was quite beyond her. Thus she worked, vainly endeavoring to finish her nursery in the usual space of time, laboring the while unconsciously on four widely separated cells! Eventually she abandoned the job in despair and indeed it must have been discouraging. To return, hour after hour, laboriously carrying that heavy mortar to a house that refused to grow, might easily discourage a stouter heart than the dauber's.

That she concentrated her efforts entirely upon four slats was an interesting fact. It gives us some idea to what degree of perfection her senses of smell and direction are developed. The first slat bearing evidences of her workmanship was situated twelve inches above the fourth and lowest one. Now as the wasp always returned, with her pellet, to one of these four, it is logical to suppose that her sense of direction was developed accurately enough to bring her within twelve inches of the actual location of her nest. Observation of the insect whose nest I found upon the brick pillar strengthened the evidence. This wasp never returned directly to her nest at the outset, but at the same time never alighted with her burden more than a full twelve inches from it. From such a position she would walk about in a zigzag course, until at length the brick bearing the nest was reached. Once this "home brick" was located, the insect would walk straight to her nest. The dauber returned to the general locality without much difficulty, but actually to reach the cells she must feel about with curled antennae, and depend upon smell rather than a mere sense of direction.

To build a cell including its foundation requires between seventy and eighty loads of mortar. The freshly made nursery weighs about seven and two-thirds grams, but by the time it is ready to receive provisions, evaporation has reduced it to three. From these figures I conclude that to build a nest containing ten cells requires some seven hundred pellets of mud. In accomplishing her task the tireless, energetic mason carries 1,000 times her own weight in mortar and fashions it grain by grain into the abode for her progeny.

In storing her cells, the dauber shows a varied taste. I have before me, two open cells. One contains two large fat spiders that easily fill the store-room, the other is stored with a variety of victims, nine in all, including many grades of size and color. In these two cells I have at least three genera and five different species of paralyzed spiders.

Upon the side of the abdomen of the largest one in each cell, the wasp deposits a pale yellowish white egg, then she seals the nursery entrance with a few pellets of mortar and abandons the nest for good.

In seventy-two hours the egg hatches, or I should say, comes to life. Here is a strange process. Watching the erstwhile egg through the lense, a spasm suddenly takes place within its film-like shell, which is nearly transparent and allows a fairly clear view of what takes place within. This spasm is a sort of pumping wave, similar to the movement in a big fire hose under pressure from the engine. It starts at the anterior end of the egg and transverses its entire length, fading out as it reaches the opposite end from which it started. Thus does the new-born take its first mouthful of liquid food from the spider. There is no actual hatching and crawling forth from the egg, no empty shell behind the larva. Instead, its mouth appears first to eat a tiny opening through the film that encloses it, after which the grub finds its mouth flat upon the spider's abdomen.

As the pumping spasms continue, each one representing a swallowed mouthful of spider substance, the nursling increases very gradually in bulk. A few hours after taking its first draught of food stuff, the egg-film apparently splits along the center of the larva's back, one end of the breach traveling in either direction, exposing the actual skin of the young wasp. The breach spreads like a drop of oil upon water, only much more slowly, but twenty-four hours after the first spasm not a vestige of film remains. It appears to have been absorbed into the larva's body. Under the lens it vanishes slowly before my eyes, yet I cannot see where it goes, and when the process is over I can find no trace of it either on the larva or its spider host. The grub is a living dialyzer through whose delicate skin the egg-film appears to osmose. In other words, I believe that the film is absorbed into the insect's body in minute particles in much the same manner that food passes through the walls of the oesophagus to reach the distributing corpuscles.

It is possible that the larva eats the egg-film, but if so it is drawn into the mouth so gradually and with such skill that it is impossible to detect the operation. Therefore, I suggest that the process may be akin to osmosis. The action is so gradual, yet so smooth and uninterrupted that I can think of no other way to describe it.

At first the young wasp feeds only on liquid food. During the first few hours of its life its mandibles are of a very rudimentary character, in fact scarcely distinguishable until the grub is a day or more old—and are developed gradually to be in readiness later when substantial parts of the spider must be eaten. The fact that at birth the grub possesses no adequate appendages for chewing suggests an interesting question—How does the tender creature make the first incision through the mature wall of the spider's abdomen? Perhaps the parent wasp pricks it and uses the minute drop of fluid that oozes from the wound as mucilage with which to secure the position of her egg. The grub would come to life then with its infant mouth already upon the opening that its mother had drilled. Such, I believe is the case, but let it not stand as fact. Further observation will first be necessary.

The grub feeds for six days—during this time it goes about its meal in a thorough manner so that in the end not a hair of the stored spider remains. Further the larva has changed greatly in size. At birth it measures four millimeters, now it is seventeen millimeters long and ready to spin its cocoon.

Spinning is a laborious process requiring three whole days. A slight network of silk is first thrown about the cell, within which an inner cocoon of far more substantial character is then constructed. It is somewhat longer than the grub, torpedo shaped and reddish brown in color, which is due to the varnish, so commonly employed by the larvae of Hymenoptera, showing through from the inside.

The cocoon is in no way remarkable, in fact it is quite simple. I have seen other larvae build more elaborate ones in a day, yet the dauber requires seventy odd hours for so simple an operation. Its nature is sluggish from the outset, and throughout its immature life it is slow about its affairs. The egg requires three days to hatch, the grub feeds six days, therefore it logically follows that spinning should be a leisurely process. The grub therefore takes its time and is none the worse for it.

Seven days after spinning, pupation takes place. The creature now lies motionless in the usual quiet state that accompanies this condition. Colorless and stately, lying upon its back with folded arms in its tomb of masonry, the pupal corpse awaits a reincarnation that in twenty days brings forth a perfect insect.

Stupid affairs of the wasp world are generously heaped upon the dauber. Before me lies an oddly-shaped nest of her making which I have opened for inspection. It contains twelve cells and as many cocoons, ten of which have been burst open by the young wasps who alas, lie dead and shriveled in their cells. Their heads face the mortar-plugged doors of the prison which bear marks of frantic efforts to escape, yet each has died of starvation, unable to reach the outer world.

Herein lies the reward of stupidity. The dauber, whose life seems made up of errors, chose for her nest the first mortar that she chanced to find. It was not the soft grey mud from a puddle on the sandy orange surface of the clearing, but a pasty yellow clay. It kneaded admirably when soft and fresh but in hardening turned to rock. The offspring grew normally within, spun their cocoons and passed successfully to finished insects, but were unable to emerge. They hammered and gnawed and scraped at the mortar; the nest bore evidence of the effort put forth, but all in vain. The mortar resisted and the young wasps died. Thus on the very eve of their emergence the dauber's offspring were obliterated by her stupidity. I wonder, even if there were a tiny glimmer of intelligence in her little dome, whether she would see the error of her ways?

CHAPTER XXXI

THE BLUE HUNTRESS

Chlorion neotropicus Kohl

Fig. 133; 13-16

Close to the out-house, whose rough frame supports the nursery of the blue huntress, lies a heap of rich red-orange clay, thrown up from a pit on the trail to the forest. It attracts a dozen busy mason-wasps who arrive from far and near to gather up the pliable, ready-made mortar and bear it away to their nests. We are concerned only with a single member of the laboring crowd. She is at once distinct in size. Her rich metallic color attracts our attention and holds it over eleven less comely ones.

The cement which she is gathering is pliable like putty, but filled with tiny bits of stones that make its contents similar to that of very fine concrete. These tiny stones which are large rocks to the insect, lend themselves admirably to the needs of her nest. They lend a rough, rugged appearance to the three-celled nursery, but form an impregnable barrier against a host of enemies.

The building material is laid on in irregular heaps. They dry very rapidly as the work progresses, giving the nest the appearance of a bit of fairy hill country covered with a thousand disorderly loads, spilled helter-skelter from as many tiny dump carts. The wasp cares little for outside appearances which are of no account. She is concerned chiefly with finishing the interior, which is a far more serious matter.

Within, the cells are quite as smooth as they are rough without, a condition necessary in view of the delicate contents they are to shelter. The slightest projecting bit of stone work, even a sharp grain of sand overlooked, might injure the tender bodies of the insect's offspring. Thus we see her tamping a tiny pebble or a bit of hardened mortar, until it sinks into the smooth wall of the chamber. Over and over, she inspects her work, scraping, brushing, tamping, until the cradle bears no resemblance, except that of color, to the coarse, sticky substance from the pit. Her nest reminds me of a callow suburban home, terra cotta and jagged stones. Her taste is not cultured, but we may excuse her quite readily. She specifies these droll materials for a vital reason.

The huntress is a skilled worker—she is a prodigy, requiring but a single tool to fashion the mortar nursery. The tip of her abdomen is a veritable tool chest all in one, a universal appliance with which the work is done. True, she gathers and carries material with her mandibles, but the house itself is wrought by the last segment of her body. It is a modeler's gouge, with which she measures the cells, decides their contour, smooths their walls and fashions the entrances. Throughout the building one finds tiny, triangular indentures, where the tool has left its impression.

The finished nest consists of three tubes, placed one upon another. They are open at one end, where the entrances are slightly funnel-shaped like the mouth of a flower vase. The tubes or cells, measure thirty-four millimeters in diameter. There is variation to a slight degree, but the measurements are the average of several nests. The insect works energetically, completing the work in five days. One cell is constructed, provisioned and an egg deposited, before a second one is commenced.

As soon as a cell is finished, the wasp sets out in search of provisions with which to assure the successful life of her offspring. She travels the open sunny trails or the dark floor of the forest. One is as good as another, provided there are dead leaves or fallen branches that shelter her prey from less agile creatures than herself. We see her alight upon the ground and search diligently under every leaf and branch

Photo by P. G. H.

FIG. 137. BLUE HUNTRESS AT HER NEST
Natural size.

that chances in her path. Her antennae are curled over, so that the end of each forms a perfect loop. She thrusts them ahead of her and depends upon their sensitive pores to locate the big tawny spiders that constitute her prey. She is always nervously alert, her body tense and ready at an instant's notice to spring back out of danger. As she works, her big, steel blue wings quiver continually as though with excitement over the possibilities of each new leaf and shelter that she explores.

Her course is irregular. Here she searches for perhaps a minute followed by a longer investigation some fifty feet away. Now the hunt heads her back to the starting point and later to the intervening ground, which is searched minutely. At other times she walks in a zigzag fashion for a great distance, even though unsuccessful in the end. It is a surprise to me that she finds her elusive and protectively colored prey at all. You wonder why? Then search among the leaves for the spider that serves to provision her nest. You will scarcely find one, even in a whole day's hunt, yet the huntress is a dominant insect, seldom defeated in her quest.

At length the spider is found lurking beneath a brittle leaf. Her antennae telegraph the information to a tiny brain and instantly the wasp springs back as though surprised. A second later she recovers and thrusts herself into the spider's den. Her body bends under her so that the deadly sting protrudes almost beyond the head. At the first movement from the spider, she springs back again with quivering wings. The manoeuvre is repeated over and over until her prey is at length, forced unconsciously into a convenient position. Then like a flash she is upon the unfortunate. Her sting plunges deeply into the creature's nerve center and instant paralysis results.

The spider is not killed outright. In that case it would decompose and become dangerous fare for the young wasps. Instead, it is simply paralyzed. It will never move again to protest, or protect itself. Perhaps it may react automatically with a slight quivering of the legs when touched, but henceforth it will yield to whatever fate has in store for it. The victim will awake from unconsciousness only as a part of another living creature, when spider substance has been eaten to build the body of a wasp.

The spider is a larger creature than the wasp herself, yet she manages to fly laboriously to her nest, carrying her victim by one of its palpi, clasped between her mandibles.

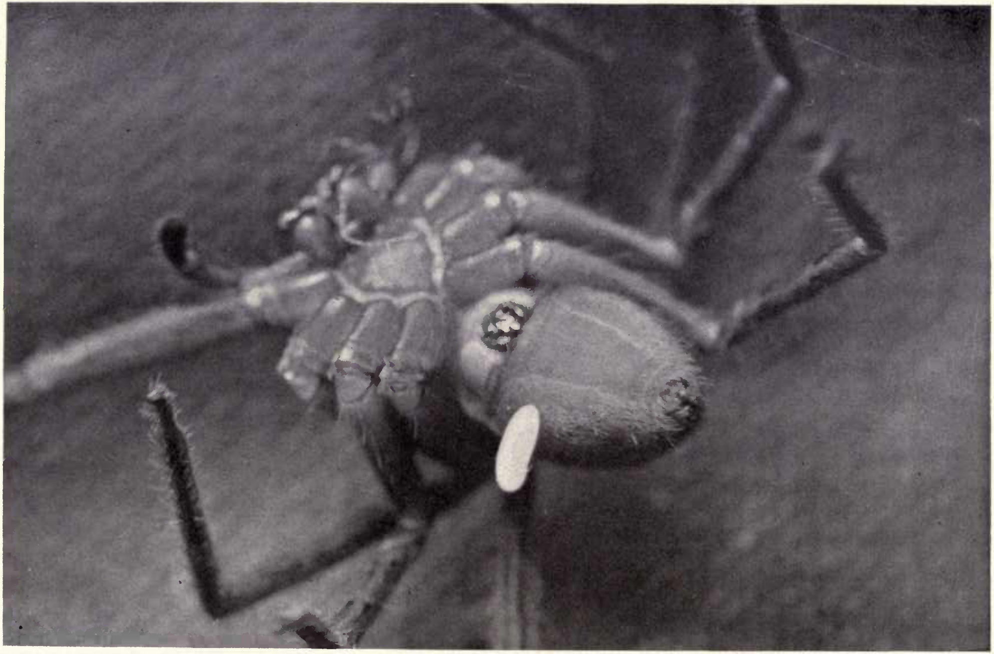


Photo by P. G. H.

FIG. 138. SPIDER REMOVED FROM CELL OF THE BLUE HUNTRESS, SHOWING EGG IN POSITION ON THE VICTIM'S ABDOMEN
Enlarged four times.

To gain acccss to her nest, she must enter the out-house through a slatted window, the lowest part of which is three feet from the ground. Once she missed the opening and tumbled with the spider headlong to earth. She was undismayed by the fall, never once relinquishing her hold, but I was struck by the difficulty she experienced in starting once more for the opening. It required the combined strength of legs and wings to drag the creature up the perpendicular wall of the building to the slats of the window.

Once within, the spider is dragged to the waiting cell, where it is left with head facing the entrance. A yellowish white egg, projectile shape, is now deposited upon the side of its abdomen. This accomplished the wasp returns to the outside of the nest. Now comes a thorough personal clean-up before continuing. The fore legs are drawn through her mouth and rubbed briskly over her head and antennae. The hind legs are used in cleaning the wings and abdomen and during the process the wasp stands almost upon her head. In a few minutes she is clean and bright. Doubtless the scrubbing refreshes her, as a bath puts new vigor into a tired man who has worked faithfully for his family and returned home with the sweat of labor still upon him.

But her work is not over with the storing of the spider. She has yet to close the cell with a seal that cannot be easily broken. The job must be done with care, and quickly. A flaw, ever so tiny in the masonry may jeopardize the helpless inmates. Wasplets are tender morsels, fine fare for many a parasite. The huntress must guard the results of her labor. I watched this interesting process which required an hour from the time the spider was dragged into the cell. It was only a tiny doorway, ten millimeters in diameter, yet during those sixty minutes, thirty loads of clay were brought to the nest and packed with minute care into the entrance. The tiny trowel and scraper, the tamper and smoother, all combined in the tip of her energetic little body must have been worn indeed when the task was finished. But there was no sign of fatigue. In fact, I believe she rejoiced at the close of a day, well spent in the interests of her race, without a thought for her own spent body, for such is the great spirit, altruistic even though unconscious, that rules the insect world.

The last cell provisioned and sealed, the wasp abandons her nest. She deserves a rest and a feast of nectar. Henceforth, nature will take charge of her offspring that she may spend her declining days unburdened.

Within the cell, the egg hatches in forty-eight hours. In place of the tiny albumen-filled projectile, we have a soft white grub. It is footless and quite unfitted for anything but the consumption of food. It possesses no sting like the parent huntress, and could not compete in battle with the most primitive insect, yet it feeds, immune from danger, upon the spider that lies limply within the cell. Like a foundling, the wasp in its infant state, is reared by a foster parent. Like the child, it lives only upon liquids, drawing them from the huge bosom of its spider wet nurse. As the draining goes on, the spider's body shrivels accordingly. In forty-eight hours the pap is exhausted, but now the grub is strong enough to partake of solid food. Its mandibles are capable of masticating what remains of the feast. In short, it sips the cream first and eats the porridge afterwards.

After five days of continuous gorging, the larva treats itself to a short rest before spinning its cocoon. During the five days, the spider has vanished so completely from the cell that only a microscope reveals a few uneaten hairs. These adhere to the larva's tacky skin, and thus escape the stomachward journey. I have never seen such a hog! Long after the feast is over, when the dishes have been licked clean, so to speak, the glutted one continues to Fletcherize upon the air.

The act reveals how hard and fast are the instinctive rules governing the insect's behavior. The larva hatches upon the spider's body. As soon as its mandibles become strong enough, they commence to tear and chew automatically. A bit more or a bit less provender in the cell is of no consequence whatever. Once started, the jaws continue to work for a certain set length of time that allows for variation in the bulk of the stores. Thus, if the spider be a bit large, it will be consumed readily enough. If a bit small the larva will simply continue, as I have said, to Fletcherize upon the air until the time limit set upon the active period of its mandibles is up. The insect is an automaton, a slave to a power that is not intelligence.

As an experiment I introduce two spiders into a cell where one is the normal provender. The larva consumes nearly all of the feast, grows to an abnormal size, but eventually dies. This would appear to contradict the existence of an invariable set of rules governing the insect's life, but such is not the case. I have interfered in the normal course of events and artificially changed those rules at the outset by doubling the amount of provisions in the cell. The wasp's life is like a chemical compound, the ingredients of which correspond to these rules and depend upon one another for the ultimate result. Thus if we alter the quantity of one ingredient the desired result is not obtained.

The experiment has in no way disproved that the creature's life progresses by hard and fast rules. On the other hand it confirms the statement, and further, points out that each rule depends upon the invariability of another for the ultimate success of the wasp. It also tells us that feeding is governed by the amount of provisions in the cell. Each mouthful stimulates a certain number of strokes from the mandibles. Thus, when the normal provender is consumed by the larva, it still continues to chew until the stimulus is gone. In the cell containing two spiders, the poor wasplet found no end of good things. It ate one spider. Its mandibles continued toward the limit of their working hours and came bump into the second spider. The stimulus was renewed, and its jaws commenced to work again eventually

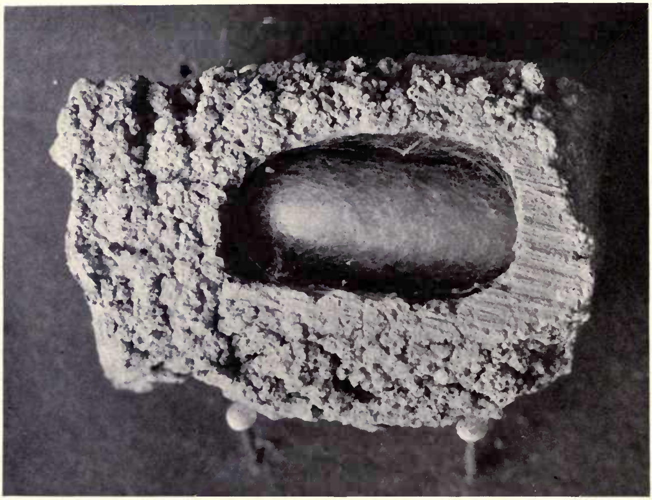


Photo by P. G. H.

FIG. 139. CELL OF BLUE HUNTRESS, OPENED TO SHOW COCOON
Enlarged two and one half times.

dragging the unfortunate larva into death at the hands of indigestion.

Thus we see the reason for hard and fast rules among insects. They are entirely dependent upon them for their existence. Even so slight a variation as my experiment provided, proves this to my satisfaction. I varied the rules in one small particular with the result that the larva was led unconsciously to its own destruction.

To go back: the larva upon finishing its spider, rests for a short period before commencing its cocoon. This rest may be necessary because there is nothing else to be done until the spinning fluid of which the cocoon is to be made, commences to flow. Once started, a network of strands is thrown across the cell. They pass for the most part under the spinner so that the grub rests upon a net, stretched midway between the top and bottom of the chamber. Later, upon this preliminary support, a neat tubular cocoon is spun. It is rounded at both ends, grayish yellow in color, glossy and rather transparent. It measures eight by seventeen millimeters, and only partly fills the roomy cell. As a final touch the interior is lightly coated with a pale, smooth varnish. The cocoon is finished in two days, after which the larva excretes a mass of waste matter in one end. This accomplished, it lies quietly awaiting pupation, which follows in eight days.

The pupa is yellowish white and beautifully folded so that its remarkably long posterior legs do not extend beyond the tip of its abdomen. Its head is armed with four spikes; upon either side of four of the six abdominal segments there is a "jack," or protruding T-shaped support, and protruding from opposite sides of the lateral segment is a pair of club-shaped appendages. (Fig. 140.)

At first I took these strange objects to be the remains of ancestral legs. I thought them inherited rather than acquired characters, but continued observation of the pupa within its cocoon proved the contrary. They have been acquired in order that the insect's heavy abdomen may be kept level or centered within the cocoon, no matter how it is shaken about or turns of its own accord. This is very important to the insect. It is not that the pupa would be injured by contact with the cocoon wall, but rather that the weight of its own abdomen which is joined to the remainder of its body by a very narrow waist, would have to be borne by the creature's tender legs. In such a case they would become partly crushed and, owing to their great delicacy at this period, would not develop properly. When the legs become strong and have received their steel-blue pigment, all the supporting appendages shrivel and are completely lost. This takes place three days before the huntress emerges from her cocoon. The supports are inflated with a watery fluid which disappears as soon as a breach occurs in the pupal skin. One may be cut off without seriously injuring the

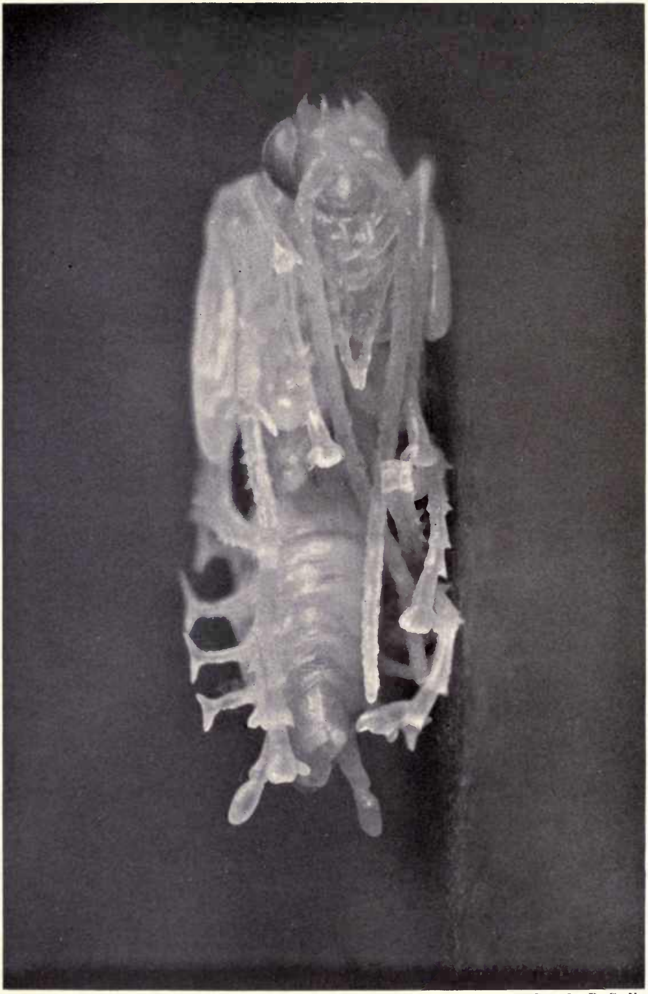


Photo by P. G. H.

FIG. 140. PUPA OF BLUE HUNTRESS SHOWING FOLDED LEGS AND ABDOMINAL BUTTRESSES WHICH PREVENT INJURY AGAINST THE SIDES OF THE COCOON.

Five and one half times enlarged.

wasp, but the removal of all, causes deformed legs owing to the abdomen sagging upon them.

Emergence from the cell as a perfect insect takes place twenty-one days after pupation. If the parent wasp lived she might witness the home building of her children thirty-eight days after she deposited them as eggs in cells of her own workmanship.

CHAPTER XXXII

PARALYZED PROVENDER

In the black chambers of a solitary wasp's nest lie six growing youngsters. They are greyish, maggot-like creatures, each consisting of twelve rings or segments surmounted by a more or less bony or chitinous head that in turn supports a pair of sharp incurved mandibles. Their bodies are plump and pudgy; they possess no adequate appendages for locomotion and in the light their skins glisten, as if moistened with liquid.

Each will eventually become a wasp, an active dominant creature with a delicate taste for nectar. But that is far off in the insect future, perhaps some forty days hence. They are concerned now only with the meals that are set before them, spiders that the parent wasp has selected as dainty provender.

In each cell of the nest the mother insect deposits her bowed egg among the mass of spiders that are paralyzed by her sting. She hunts them abroad in the forest or among the fallen leaves in the sunny trails, discovers their hiding place and swoops hawk-like upon the unfortunates. There is a struggle perhaps, a short one, the wasp's sting soon finds its mark, plunges home, and in an instant the spider lies limply upon its threshold. The victim is not dead, instead it is only plunged into a state of paralysis that instantly binds the muscles fast. It cannot move again in self defence, cannot command the power of its legs. It is still a living thing unconscious of life. Thus, slightly quivering from the shock and poison, it is borne to the victor's nest, deposited roughly in a cell with several other equally unfortunate ones, sealed forever from the light of day and abandoned as helpless living flesh for the young wasp to gorge upon.

In order to understand what has just taken place, let us examine the victim's anatomy and structure. In outward form spiders are divided into two distinct parts—the cephalothorax and the abdomen. We are concerned chiefly with the former, which is the first division of the creature, the head and thorax, as it were, combined in one. The central nervous system of the spider is, for the most part, concentrated in a mass of ganglions, clustered about the oesophagus. The oesophagus is a tube through which food passes from the mouth to the stomach. It lies in the central portion of the cephalothorax. That part of the central system lying above is the brain, from which the optic nerves and those of the biting and poisoning appendages arise. Lying below the oesophagus is the ganglion from which the nerves of the legs and palpi emerge.

Now, strange as it may seem, the wasp knows the above paragraph by heart. She was an anatomist long before man. She understood spiders long before man understood himself. Her teacher was instinct, an immortal master. Thus in stinging her spider she is like the master surgeon. With a single tiny wound above, with a single lance below, she accomplishes the desired end. Into the spider's nervous center instinct guides the wasp's poisoned dart. With precise strokes she reaches the ganglions of her victim and spills her venom. Henceforth no external outrage, however great, may be transmitted to the brain; no volition in return will command the forces of protest and defence. Like a party on a broken wire, the spider lies helpless with the central office paralyzed!

In preparing provender for the cells, the methods employed by the majority of solitary wasps are more or less the same. Yet the sting-poisons of different species produce two widely different effects on the victims. Both are doubtless forms of the same affliction; one, the commonest type, acts instantly as I have just described. It causes complete paralysis throughout the muscles that control walking, biting, excretion and all exterior movements of the cephalothorax, abdomen and its appendages. The respiratory system appears to be all that is left uninjured.

The second form, which is much more rarely met with, is a gradual type, commencing with the deadening effect of heavy sleep, finally giving place to paralysis, some time after the victim is stricken by the sting. Let us observe the two cases in question. As an example of the first we have a medium-sized spider that has been stung by the white-footed wasp. Of course different kinds of spiders are selected by different species of wasps. But this is of no consequence, and will not affect the essential facts of our observation. If the creature is a spider it matters not in the least whether it be *Gasteracantha, Filistata, Micrathena* or any other jaw-splitting species. Spiders are the common prey of many solitary wasps, a fact which is sufficient.

The victim lies limply upon its belly in the cell. Enclosed in a tomb of solid masonry, it is abandoned by the mother wasp to its fate. Upon its flank rests the glistening egg of the slayer. Thus the unconscious living incubator awaits the pleasure of the maggot. Its legs are limp and motionless, its palpi equally still. To all intents and purposes the dejected object is dead, but there is still a flutter of life in the outraged body. An occasional shudder, barely discernable under the lens, a labored rise and fall of the abdominal walls evidences the tiny spark still unquenched.

In two days the young wasp emerges from the egg, glues its mouth to the plump spider and commences to draw the victim, drop by drop, into its own body. In twenty-four hours a shriveling sets in. Like a punctured balloon in the sky, the spider shrinks before the maggot's onslaught. Later, in order to taste sweeter fare, the ravenous object plunges its head within the breach. It drinks, munches and revels in the spider's anatomy; eats from the inside to the out, chews up the bony walls, continues through the cephalothorax and finally consumes the legs. Then finding no more it pauses. After five days of orgy it is time to digest. Thus the spider is eaten alive, but from the first there is never a sign of protest, never a twinge of pain.

As an experiment, I secured several other spiders paralyzed by the same wasp whose grub I have described at its meal, and subjected them to various tests. One I denude of its legs, clipping them off at different lengths, thereby cutting through eight different nerves. From the second I clip the palpi, severing the nerves, and into the abdomen of the third I thrust a slender needle. Throughout these gross indignities the spiders lie quite motionless. There is no contracting of leg stumps, no drawing in of injured palpi, no quiver of punctured body. There is no response, no feeling in the creatures.

Such is the first condition of paralysis. We find it in a host of victims. The white-footed wasp, the blue huntress, the black reed-wasps and many others go in quest of the spider, another wasp takes frog-hoppers, still another, locusts, and there are many others that I will not mention. They are a merciful crowd. Under the respective jaws of their grubs, the victims lie completely paralyzed, relieved from the tortures of gradual execution.

The second form of paralysis is, as I have stated, much more rarely met with. At the present time I know of only two wasps that afflict their prey in this manner, but they will do very well as examples. One is the roach-killer (Chapter XXVI), which stores her earthen cells with wood-roaches, the other, a tiny wasp that supplies her maggots with a cricket each. Her nest is a hollow reed lying upon the ground, the end of which she plugs with a great quantity of wood—little chunks of charcoal from the can burnings, bits of reeds, tiny twigs and woodchips barricade her doorway. Therefore, for convenience sake, I will call her the lumberess.

The modes of life of the two insects are in most respects widely at variance. They build individual types of nests, provision them differently, choose different situations for the home site and go about their respective businesses in separate ways. It is important, however, that the two have a single habit in common. The roach victims of one and the cricket prey of the other are affected in the same manner by the stings of the two insects.

I have before me two crickets of the lumberess and a dozen roaches of the roach-killer. These I collected from the sealed nests of the insects. Therefore, to the best of my knowledge they have been stung by the two wasps. I find in the victims a physical condition entirely different from that existing in the spiders paralyzed by the white-footed wasp. So differently are they affected that I do not consider them paralyzed at all.

The roaches are capable of moving every pair of legs, they can turn the head from side to side, also move all the mouth parts and their antennae. But strange to say they lie motionless unless I touch them with a needle or the tip of my pencil. I place one of the roaches upon its feet. It lies absolutely still as though dead until I touch one of the protruding appendages at the posterior end of its body. As I do so it jumps foreward without much effort, in the act using each pair of legs. Now it waves its antennae back and forth for a few seconds, wriggles its mouth and settles back into its torpor. With the crickets I try a similar experiment with the same result. Much the same thing appears to take place in these victims as one observes in a sleeping dog, whose foot has been tickled with a straw. It is quite peaceful and unconscious, yet its nerves and muscles respond automatically to rid the animal of its annoyer.

Certainly then, the insects are not paralyzed at this time, any more than a sleeping dog, for paralysis means the loss of power to contract the muscles, an accomplishment of which both the roaches and the crickets are still capable.

Twenty-four hours later I experimented again upon my subjects with a result similar to that of the previous day. I let another twenty-four hours pass. This time, at the touch of my pencil point, the insect responded with a jump far less energetic than before. Every hour now brings a weaker reaction; at length there is little or no response to my efforts.

The sting of the roach-killer and that of the lumberess thrust their victims into painless sleep. The poison's action is not unlike alcohol. At first a powerful sleeping potion followed by a gradual, ever-increasing tying of the muscles, until they cease to move at all. Such is the second condition of paralyzed provender.

Let us now endeavor to discover the causes leading to these two distinct types of paralysis as we have observed them in the prey of solitary wasps. Having already glanced at the spider's anatomy, it will be well for the sake of comparison, to look into the anatomy of the roach. In the first place the two belong to different phyla; one is an arachnid, the other an insect. Therefore they will differ physically.

In the spider we find the ganglions clustered about the oesophagus, concentrated into one particular section of the body and easily accessible. In the roach they are spread, more or less, throughout the insect. There is a brain, three pairs of ganglions in the thorax, followed by six pairs in the abdomen, a problem indeed for the wasp who would paralyze such a complicated creature.

I have not been fortunate in observing either the roach-killer or the lumberess in the act of stinging their prey, but here is what I believe to be the case in view of the facts. To reach the isolated nerve centers at the outset, to bring instant and complete paralysis to her victim, the wasp would find it necessary to drive her sting into as many different places as there are ganglions. Judging from the condition of the prey it is a feat quite beyond either the roach-killer or the lumberess. Therefore they must depend upon one or two thrusts to stun the insects. As the sting plunges home it ejects a tiny drop of poison which gradually spreads throughout the victim's body, bringing on, in due time, the gradual paralysis that we have observed.

Gradual paralysis would appear to be dangerous to young wasps. They are very tender creatures. A cricket or roach thrashing about within the cell would soon cause fatal bruises, but nature has looked out for them nicely. If undisturbed, the roach and cricket lie quietly enough. Upon their lower surfaces lie the wasp's white eggs, but they are motionless. In forty-eight hours the wasplets emerge, tiny creatures, three millimeters in length, whose baby mouths do not disturb the sleepers. In another day they begin to really chew their hosts, but by this time paralysis has set in.

There is no significance in the two types of paralysis. They are present in the spider and the roach, simply because of the physiological difference existing between the two. Thus the grub of the roach-killer and the lumberess and those of the spider hunters live much the same. One is as safe in its respective cell as another, so there we shall leave them.

CHAPTER XXXIII

CONTROLLED PUPATION

There is a tree in the Guiana forest which, for lack of a better name, I call the vermillion-nut. This tree ranks high in the scale of giants. It towers above one, reaching more than a hundred feet above the forest floor where it throws out its rather flattened boughs that bear a thick mass of foliage, and in April, a vermillion fruit. This fruit is lime shaped, two inches in length by one and a quarter inches wide and consists of a moderately tough, pubescent vermillion shell, guarding the soft, greenish inner pulp that surrounds the true nut. The pulp is soft and quite sweet, but incipient and the nut is as hard as a fresh almond and slightly over twice as large. Even to botanists its name is unknown.

Troups of howling monkeys make daily visits to these trees, gorging themselves for hours on the juicy pulp and throwing the shells, bearing their teeth marks, to the ground below. One must either lie upon the back or suffer a cramped neck to observe them feeding in the top-most branches. Even then they are often screened from one's sight by the masses of heavy foliage that characterize the vermillion-nut.

Other animals find the food to their liking also. Agouti, smaller species of monkeys, and a host of wild bees feed daily beneath the everlasting twilight of these branches. One might spend a year studying the creatures that feed upon the fruit which is often scattered abundantly among the rotting vegetation on the ground for a hundred feet in every direction.

In the latter part of April, I came upon a band of howlers feasting in one of these trees. They were easily one hundred and twenty-five feet from the ground, yet, quite unconscious of the dizzy height, they reached here and there for the fruit, seldom clinging to the branches with other than the hind legs. They ate with great relish and greed, plucking far more than they could possibly eat. Consequently many nuts were dropped quite untouched, and wasted. Curious as to the quality of the fruit, I picked one up and split it apart. To my surprise it contained eleven light yellow maggots, that writhed about actively and tried to escape from their late prison. They had eaten the soft pulp entirely away, leaving only a mass of brown excretia and the inner nut, which was free and rattled about when I replaced the shell which had been cut away. Thus by chance I discovered the subject of this chapter in its strange cradle among the tree-tops, where it has doubtless fed in its larval state since the first vermillion-nut blossomed in the branches of its parent. This is a new species of fly belonging to the family, *Trepetidae* and the genus *Spilographa.*

When and how the mature insect deposits her eggs within the nut is beyond me. It would be necessary to live in the loftiest branches to ascertain such a fact. One glance at a vermillion-nut tree would stand as evidence of its infeasibility. One thing we do know; the insect is a fly, as shown by the larva, a typical fly maggot, with eleven segments counting the head. It tapers from a well rounded segment at the posterior end, almost to a point at the head, which is supplied with two hooks turned downwards like the claws of a cat. It is transparent yellowish white and through its entire body one may trace a pair of respiratory tubes with one set of openings in the head and the other in the last segment of the body. These orifices, two in front, two behind, stamp the creature as a young or larval fly.

The eggs are probably deposited when the fruit is still soft and immature or perhaps the scent of the tree's blossoms beckon to the insect. I can but surmise. Later the eggs give place to tiny wiggling larvae whose movements depend upon contractions of their muscles, for they are devoid of feet. They feast like gluttons upon the nascent flesh of the ripening fruit until it comes time to pupate.

From what we know of many other flies, we have seen that it is natural for them to pupate within the ground, or at least in a position from which they may work their way to the light of day when nature has transformed them into perfect insects. The larval flesh fly burrows below her carrion to transform in the damp soil beneath, the house fly in its bed of manure finds escape an easy matter, the mosquito transforms in the water, but what of our flies born within a tough-shelled nut, in the highest forest branches? How are they to release themselves from such a prison after the feast is over? As we have seen, they reach the ground by falling, when the nut is plucked by some roaming monkey or as it falls anyway when ripe, carrying its living burden earthward. But that is not answering the question. The larvae must burrow into the forest soil to transform and issue successfully as a perfect insect. How then is this feat accomplished?

The nut which I cut open contained eleven larvae. They appear to be full grown and ready to pupate, at any rate there is no more pulp left for them, and if they are hungry they must eat again that which has already been digested once. No, they simply wriggle about frantically, as though searching for an opening, and swarm to the hole I have cut.

I remove two of them to tubes of soil slightly dampened. The remainder are locked once more in their prison. In the tubes conditions are, as near as I can make them, like those of the forest floor. The larvae move here and there from fright in their new environment for a minute or two, but presently one thrusts its pointed head into the soil and commences to burrow. Soon it is followed by the other larvae in their respective tubes. In twenty minutes all have disappeared below the surface.

Two days later I remove the material from the tubes in search of the larvae. They have burrowed slightly over half

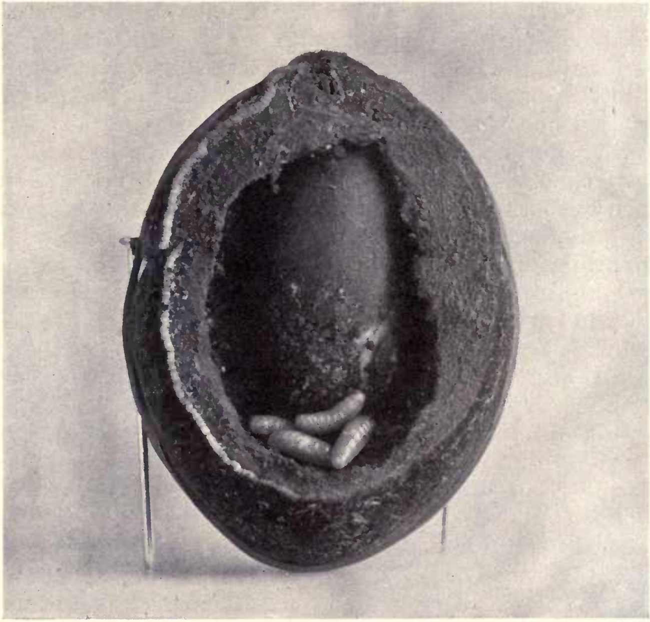


Photo by P. G. H.

FIG. 141. VERMILLION-NUT OPENED TO SHOW IMPRISONED LARVAE OF VERMILLION-NUT FLY.
Enlarged twice natural size.

an inch below the surface and all have transformed into little yellow kegs with ten red hoops running around them. Under the lens these hoops appear to be tiny bands of stitches like those in the cover of a baseball. In these pupae we have convincing evidence that our fly naturally transforms below the ground, especially so in view of the fact that the larvae left within the nut are still strictly larvae in every sense of the word.

I remove two more of the imprisoned ones from the nut to freshly prepared tubes of earth. Two days later I have the same result from my experiment. Those within the tubes have transformed to pupae, but those imprisoned in the vermillion-nut still writhe in the larval form. I keep the prisoners in their cell from April 20 until the twelfth of May. Still there is no change from the larval form, yet any day I may remove one to a tube of earth and forty-eight hours later recover it as a pupa! It is a strange condition indeed, but I think I see its significance.

When I open the fruit on the tenth of May, I note that the true nut within has sprouted ever so slightly. Each day the cotyledons of the new tree are swelling within the shell that holds them, pushing upwards in response to the light which beckons. Were the nut lying naturally upon the moist floor of the forest, the young tree's progress would be even faster. As length the pressure becomes too great for the nut's outer shell to bear. It yields to the vortex of a new life, splits open and at the same time the imprisoned larvae find the long-waited-for exit to the friendly mould of the forest.

Here is a condition among insects previously unknown to me. It is a remarkable adaption to the condition of the creature's strange habitat, that has brought about a deviation from the rule. In short, the young flies may hasten or postpone pupation at will! I would have hesitated to set forth such a statement, even as a remote possibility, were it not for my experiments that cannot be denied. One learns to expect the unexpected in nature, but who would go so far as to accuse her of running even so tiny a creature as this nascent fly, without a schedule? She is forced to surrender here to conditions self-imposed. If her children within the vermillion-nut lie imprisoned without food for a fortnight or more, it matters not. When release comes they are none the worse for their experience. If they are spilled roughly on the ground from a freshly broken nut a month before their brothers, so much the better. They have no set time for pupation. They will become flies just the same! Thus Nature has endowed them with ability to meet successfully, the strange circumstances in which she herself has placed them.

Let us see what has happened to the larva that has burrowed beneath the surface of the ground. Why must such an active creature entomb itself again upon being liberated from its original prison?

Unlike ourselves or animals and birds, insects pass through a series of stages, one might say, almost by jumps. At first we have an egg, quite helpless, but deposited with due care and forethought by its provident bearer. In a day or so, this helpless egg has become a ten-ringed maggot with a head, appendages for drawing in its food and possessed of a primitive but efficient set of organs. It is not an actual hatching as we see it in a hen's egg that has brought this strange creature into the world, but a fading of egg into maggot. There is no empty shell when the process is finished, no spectre of the creature's former self. The process is like that of a moving picture which fades before one's eyes from one scene to the next which is widely different.

In its newly acquired form, the insect feeds as we have seen upon the vermillion-nut pulp, remaining unchanged except in size, until fate releases it upon the moist forest floor, when with a haste that is almost frantic it immediately imprisons itself once more, this time in the ground wherever it chances to find itself. Forty-eight hours later we discover it as a tiny yellow keg banded with red stitches, as though it had buried itself for good in a self-fashioned coffin.

Has the insect become so accustomed to the blackness of prison life that it cannot live in a world of sunlight? Must it live the life of a mole because it has only once seen the brightness of day? No, there is a far deeper reason than these that send it so hastily into the ground. It is about to undergo its last and greatest transformation, one during which it will be once more utterly helpless against the slightest odds. It must lie very still as though in death, lest the beautiful process within be interrupted and the design shattered.

Up to now, the insect has resembled its ancestral family, less highly developed worm-like creatures of another day. Just as we have developed from less perfect creatures, so has the fly. Within the little yellow keg a wonderful change is in process.

At first the maggot, so recently an active definite creature, is seized upon by a host of nature's strangest forces. We cannot see them or give them any definite form. Nevertheless they are there, like a great group of wreckers, carpenters, masons, painters and decorators. The larva or maggot, the ancestral form, is torn down and reduced to a disintegrated mass of fluid. From this utter wreck of what was so lately a crawling, organized creature, the final insect is resurrected. From old tissues, new ones spring, from what was old and out of date, a more modern creature is erected. The yellow keg is no longer a coffin, but a factory where a host of raw materials are to be transformed into the finished product!

The process is comparable to tearing down an old fashioned house and erecting a modern one on the old foundations. Much of the old material is used and that which must be replaced by new is burned or otherwise disposed of. So it is with the tissues of the maggot. From the old house we save the plumbing, the wiring and the kitchen range, which corresponds in the maggot to the reproductive glands, the nervous system and the heart, which are left intact, or at most altered and attended to.

At length it becomes time for the painters and decortors. Nature employs a vast army of these. In the keg, after ten days, the milky white and partly transparent, but otherwise perfect insect commences to receive its color. It appears first in the eyes with an influx of emerald green pigment studded with golden, microscopical dots, which are followed in forty-eight hours by the appearance of black patterns upon the legs and wings, due to more or less dense hair upon these appendages into which the color gradually flows. Upon the back of the head there is a pattern of hairs and another of longer ones upon the thorax, while the abdomen likewise suddenly appears clouded with pubescence. Further than this no ground color or markings can be seen, owing to the color being much like the shell of the keg itself.

In another forty-eight hours, fourteen days after pupation, the fly emerges by splitting the head of the pupal keg in two equal parts. This is a simple operation as the shell is not too substantial, but the new-born fly has yet another task before it will be free. It has yet to dig a passage from its tomb to the light of day. It must be done quickly, lest the wings fill and dry too small and their usefulness be lost.

For this purpose the insect is supplied with a battering ram, which protrudes between the eyes at birth from the pupal case. It is a transparent sack-like appendage which may be expanded or contracted at will by the fly. It contains no apparatus of any kind, but is apparently the forehead of the insect capable of expansion. To watch the operation of this strange appendage is remarkable. First it swells like a toy balloon when air is blown into it, until it protrudes two or more millimeters in front of the insect's head, pushing the sand or earth in front of it as it increases. This is followed by a rapid deflation of the ram which leaves an indentation into which the fly struggles with great effort. Now the first operation is repeated; the second indentation made and again the insect wedges itself into it. Thus, after an hour, if the fly is fortunate, it reaches the surface of the ground, where it rests for a time to recover its strength, before launching into a new and sunlit world once more to search out the vermillion-nut, this time as a nursery for its own offspring.

PART IV

SUPPLEMENTARY CHAPTERS

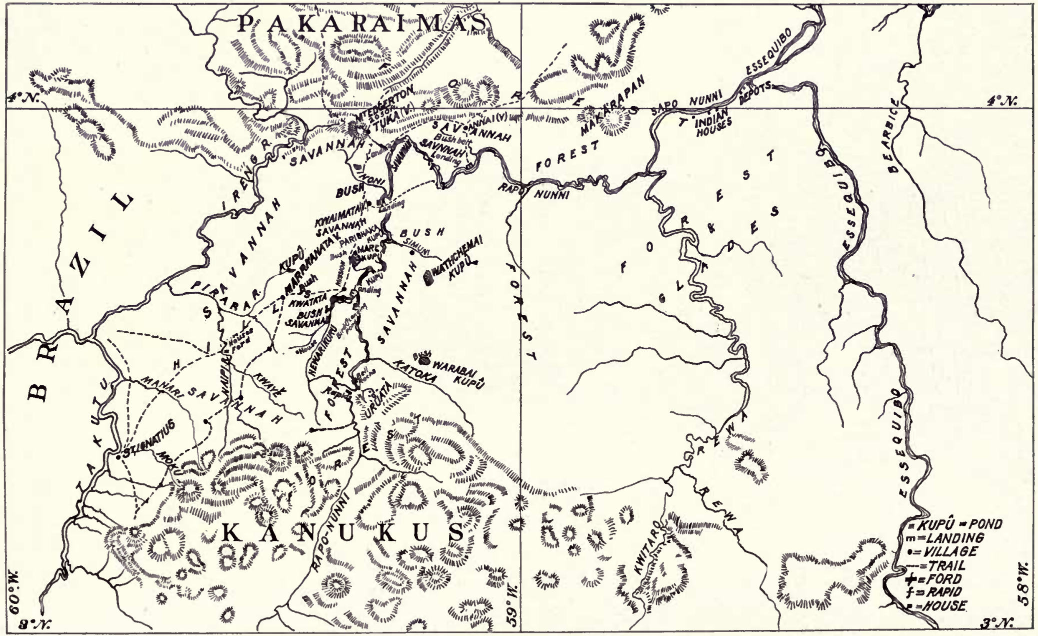


FIG. 142. THE HINTERLAND OF BRITISH GUIANA LYING ALONG THE UPPER RAPO-NUNNI RIVER

CHAPTER XXXIV

NOTES FROM THE HINTERLAND OF GUIANA

By the Rev. Walter G. White, F. R. G. S., B. E. N. A.[1]

In responding to Mr. William Beebe's invitation to contribute a chapter to the book he intends to publish, my object is, simply to stimulate interest in a little-known corner of the Colony. It is hoped that, hereby, someone may be led to pitch his tent and to study wild life there, before existing species of the fauna and flora follow in the wake of the many Indian customs, and become as extinct as the dodo.

Just prior to our recall from this inaccessible district, there was published, in England, in a leaflet of the British Empire Naturalists' Association, an offer of mine, to give a naturalist a free passage up in the missionary's boat, free quarters, food, the use of a small tent-boat with sleeping accommodation, the loan of horses, guides, interpreters, and a free passage down, after some months of research. In return, the visitor was expected to impart some of the information collected, and to afford my wife and myself help in acquiring a sensible knowledge of the natural history of our environment. The mention of this abortive attempt may, perhaps, inspire others to find similar ways of furthering scientific research, which is so greatly hampered by the cost of special outfits and transport to distant places.

I am flattered by the invitation to contribute notes to such a book as this, as I lay no claim to scientific training. Years ago I knew every bird to be found in North Oxon, by its flight, song, nest, (if it bred there) and eggs—all, or any. In this Colony very few of the names, popular or scientific, of species are known to me. I know the musical

[1] B. E. N. A.—British Empire Naturalists' Association.

Indian names (many of which are onomatapoetic) of the various creatures. Mr. James Rodway has done his best, upon insufficient particulars, to furnish me with scientific names and those popular names which I had not discovered. To give only Makuchi names would serve little purpose: so it is necessary to afford some sort of guide to readers by means of the scientific names.

One of my first duties was to learn the Makuchi language, and to make translations. Natural history records were, until latterly, of a rough and ready kind. It was found that a knowledge of the language enabled me to tap a mine of information, as the Indians, collectively, though not individually, know the outer life history of most forms of wild life in their country. An Indian interpreter cannot get this information, as he has no personal knowledge of the subject as handled by scientists. A European, with some personal knowledge of natural history, can do better when he has a working knowledge of the language.

General nature of the country: The district under mention lies between Latitudes 3 and 4.20 N., and is enclosed by Longitudes 58 and 60 W. In the North are the Makarapan and the fringes of the Pakaraimas. The South is walled by the Kanukus. The Essequibo forms a natural boundary, on the East; the Takutu and the Ireng, on the West. The district is drained by the Rapo-nunni, with its tributaries the Katoka, the Thewarikuru, the Binoni, and the Rewa, with the Kwatata and the Kwitaro, which are affluents of the second and the fourth named. The Mokamoka and the Manari are tributaries of the Takutu; while the Piara flows from the fabulous Lake Amuku into the Ireng, receiving its affluent, the Napi, entering from the South. Numerous other creeks need not be named. Most of them have no continuity during the dry season, at that period, but a series of disconnected ponds and swamps. The traveler should be provided with water ere setting out across the savannahs, especially in the dry season, for it is possible to walk fifteen, or even twenty miles, in certain directions, without finding anything drinkable.

Taking the region between the Pakaraimas and the Kanukus, the Rapo-nunni and the Takutu, one may describe it as, principally, savannah. There are levels, some of them bare, at the foot of the Pakaraimas, and other levels, mostly dotted with stunted growths, at the foot of the Kanukus. The intervening country is rising ground, extending from the Takutu to the Rapo-nunni, the higher parts being towards the latter river. These low hills are dotted with stunted trees, and carry a coarse grass, which grows in tufts. There are intervening hollows with swamps, or swampy ground, according to the season. These damp patches are, usually, outlined with kwai, or ita palms. Here and there are nullahs blocked with thick growths and trees. Lake Amuku does not exist. There is a small pond during the dry season, and the levels about it are flooded during the rains, giving the appearance of a large lake. Examination shows trees growing through the water, in the middle of the "lake." An important pond, in respect of size, is Mare-kupu (Mare—gravel; kupu—pond), secreted in the Mare-pupu bush. Tawrong Thamu Pethaku Kupu is a pond surrounded by swampy land, thus presenting a considerable expanse of water. Other ponds of interest are the Parishara, the Steamed and Warabai. Throughout the course of the river are many backwaters, some of which appear to be old ponds which were tapped by the stream, on its way. The Indians call them all kupu. They are splendid hunting-grounds for fish. The smaller ones are dammed, or staked, to prevent the escape of fish, and are poisoned, by beating out the roots of the atha, along the brink and from woodskins paddled criss-cross over the surface. The stupefied fish show white and rise to the top, where the larger ones are shot with bow and arrow, and the smaller ones are picked up by hand. If left for a time, or if placed in fresh water, the fish recover. Taking his hammock and slinging in the open, at night, a naturalist will find much profit in accompanying a fish-poisoning expedition, in the form of a two-days' picnic. The savannah region described above is broken up by some extensive woods, or bush. The important ones are: The Maru-kupu bush, extending from the Rapo-nunni, at Karenampu, several miles westward, enclosing the pond, on its way; the Binoni bush, to the north of the famed Kwaimata village; the Marakanata bush, about fifteen miles to the west of the Pokaru, and the Kwatata bush, which screens the creek of that name and a portion of the Warikuru.

Examining the region of the Rapo-nunni, extending across the Rewa to the Essequibo: There is savannah land, broken by narrow lines of low bush, along the left bank of the river, from Masar Landing to just past Anai Landing. Thence to the Essequibo is big forest. On the right bank of the river, from Katoka creek to Simuni creek, is savannah, with ponds, swamps and tangles here and there. Aback from the Simuni to the Rewa is big forest. At the bend, opposite Massara Landing, is more savannah. East of this savannah, passing the mouth of the Rewa, to the Essequibo, is more big forest, broken up with glades, in which the grass grows rankly. The whole of this stretch, save for a few isolated Indian houses, near the mouth of the Rapo-nunni, and the depots, at the mouth, is uninhabited. For convenience of reference we may speak of the Rewa forest, the Bend savannah, the Simuni bush, the Katoka savannah, and the Uruata forest. The last begins at the Katoka creek and extends to the Kanakus, on both sides of the Rapo-nunni.

From the site of the old Kwatata village, along the depression which makes a bed for the creek, extending westwards beyond Marakanata village is a wonderful grove of kwai palms. At the southern foot of the hill upon which Marakanata stands, the grove expands and encloses a pond. The thousands upon thousands of palm trees make a magnificent picture. There is another long belt of kwai palms, running almost parallel with the Tukutu, near to this river.

My meteorological records, carefully maintained at the Mission for over two years, give the following results, which may, with advantage, be noted by anyone intending to settle in the district for any length of time to study wild life.

1914	Total rainfall,	20	inches,	25 parts
1915	"	60	"	62 "

In the former year rain fell upon 161 days, and in the latter year, upon 176 days.

Temperature between 6 and 7 A. M. varied from 68 to 75 degrees Fahr., during 1914, the lowest being recorded during the period January-March.

Temperature between 6 and 7 A. M. varied from 69 to 75 degrees Fahr., during 1915, the lowest being reached in February only.

Minimum temperature, taken with instrument supplied by Government, was 62 degrees Fahr. in January, and 58 degrees Fahr. in December, 1915, only. I found traveling during the latter part of 1915, required taking a *thick* blanket. The cold, in the early hours of the morning, frequently awoke me.

The maximum shade temperature, between the hours of 1 and 2 P. M., was 94 degrees Fahr., in 1914. (October.)

The maximum during the same hours, was 103 Fahr., in 1915. (August.)

True maximum, shade, day-time, reached 105 Fahr., in August, 1915, upon one occasion only.

I found, by experience, that true maximum for any day was, usually, recorded *after* 2 P. M.

The coolest months of the year were shown to be December, January, February, and the early part of March. There were some close days, during the December and January rains, which caused little, or no flooding, and no inconvenience to traveling by land. After the heavy rains of May-July, the days are close and clammy, until the strong winds set in, from about the middle of October. Strong winds occur before, intermittently.

During the heavy rains, serious flooding of the district occurs, in normal years. In spite of the myriads of mosquitoes and kabouri flies, which come as one of the Plagues of Egypt, the naturalist should not flee the country, for he will see things, now, which hide away during the drier months. Jaguars and other animals and snakes are driven from the nullahs and low lands, and may be seen, caught, or shot, as they wander, homeless, about the higher ground. Fish are migrating upstream, and are scattering through the creeks and ponds and even with the floods, to mate and to spawn. And insects come forth in cosmopolitan crowds, especially when lights are shown, at night.

The elevation of the district is surprisingly low if the traveler considers the number of falls and rapids he has left behind, on his way up the rivers. Somewhat to the west of Masara Landing is Mt. Egerton, named after His Excellency, Sir Walter Egerton, who visited the Hinterland and ascended this hill, in 1913. Its elevation is given as being 2,050 feet. This is the highest point at the southern end of the Pakaraimas. Mr. C. W. Anderson gives the average elevation of the savannahs as 300 feet. This cannot be applied to any parts save the depressions. Mt. Egerton (2,050 feet) is not 1,700 feet above the savannah level. The district therefore, may be said to comprise the low lands of the interior. The high lands exist about the Upper Potaro and extend towards Roraima.

The prevailing winds are the northeast trades. Most of the rain is brought by them, and the falls are ushered in with quasi-hurricanes, which shake the houses. The cloudbank rises over the Essequibo and, generally splits, when approaching the Makarapan. One pack sweeps along the Pakaraimas, perhaps bursting out as far as Mare-kupu bush, the other pack passes over the Rewa forest to Uruata forest along the Kanukus. A diagonal belt, which includes most of the open savannah land, with the rising Theopokarukuru (Theopokaru-hill) receives less rain than the regions to the north and south, towards the mountains. Strangely enough, the Roman Mission, on the Takutu, comes into this belt. A map indicating isotherms would reveal the fact that the average temperature of this zone is higher than that of the zones to north and south, although I have known it to be so hot upon the Masara savannah as to cause an Indian drogher to be nauseated continually, as he walked in, to Tuka Village. Upon the savannahs, so much depends upon whether one faces, or travels with the wind, or the set of the air. Those who intend to do research work would be well advised to make quick marches outward, when investigations take them to leeward of their camp, and to work back against the wind. The extra comfort and the comparative freedom from savannah flies are worth securing. Those who wish to track animals, will, for other reasons, work against the wind.

How to reach the district: It is possible to take an ocean boat up the Amazon, proceed up the Rio Grande, and take a launch up the Takutu (so called) to the Ireng. The journey from Georgetown is made by steamer to Wismar and train to Rockstone (one day's journey), thence, by launch, to Potaro Mouth (another day's run). The usual custom is, for the passengers to take this course, and for the captain, bowman, and crew to start from Rockstone, where the boats are loaded. Nearly a week will elapse between the time of their leaving Town, and arriving with the laden boat at Potaro Mouth. The launch to Potaro Mouth sometimes has to make several attempts before it succeeds in crossing Crab Falls. We left Town and stayed at Wismar, while the boat was being loaded; thus we were a week in reaching Potaro Mouth.

At the present time, occasional travelers may obtain free passage up to Rapo-nunni Mouth in a balata boat, going up empty, to bring down balata. These opportunities occur at the end of the rains. Goods will be taken up in these boats at the rate of three cents a pound, from Rockstone, or Potaro Mouth. At the beginning of the rains, and before the rains—January to May—boats go up full, with laborers and provisions, and often return empty. At such times it is possible to send down packages from Rapo-nunni Mouth. The boats of the two Missions might, also, render some services, when running, which is not often. It might be found advisable to hire a boat for the whole period, for crews for the down-trips can be collected upon the savannahs. Some might prefer to buy a new boat, fitted according to requirements. The cost would vary from $130 to $180, complete, with fittings. Through the Protector of Indians it would be possible to procure a crew, with captain and bowman, from the savannahs. These Indians would scatter to their homes, upon arrival; they need not be maintained nor paid during the following months; and they, or others, would be available when it was desired to send the boat down again. To take a crew from Town would entail much more expense, and would be less satisfactory. Incidentally, the Indians can hunt and fish, on the way up, and can procure a needed change of diet. From Potaro Mouth to Sipruni Mouth occupied us just a week. Another week had fled when we reached Inkapati, not far from the confluence of the Rapo-nunni and Essequibo. To the Mission Landing from Inkapati may be anything from six to nine days, according to the state of the river. We took exactly a month from Georgetown to the Mission, in October, 1913. The journey up the Essequibo is made over many rapids and falls. It is arduous and dangerous. The traveler is probably more interested in the experiences and delighted with the scenery than oppressed by a sense of danger. At Rewa Mouth, the kabouri flies begin to be troublesome, and a supply of citronella oil, for anointing the exposed parts of the body, will be appreciated.

A portable motor can be used over two stretches, between the rapids, on the Essequibo, and, unless the river is very low, it will serve from the Mouth up to the Landing. The usual means of propulsion is the paddle. Where the water is shallow, the Indians pole-stick, or punt: this assures better progress than the paddle. From the depots up to Rewa, and sometimes, up to Anai, a sail may, upon occasions, be used with great advantage.

Our down trip from the Mission occupied exactly fourteen days. When the river is in flood, this trip may be accomplished in nine days. The best time for either journey, up or down, is just after the heavy rains—August and early September.

General Health: Good health may be maintained if three grains of quinine be taken regularly, daily, whether one feels ill or not. When a feeling of lassitude comes on, double the dose. Avoid constipation carefully. The water of the main rivers is, generally, harmless. That of the creeks and of the ponds should be boiled and allowed to cool. The new arrival should not expose himself to the heat of the sun between the hours of eleven and two. After six months, the ordinary person, who eschews liquor, may move about, at any hour of the day, with impunity. In fact, he may roam the open savannahs from six A. M. to six P. M., without taking harm. Should dysentery attack, while on the river, the bark of the taparauu, resembling the bark of a guava, may be boiled, and drunk. If upon the savannahs, it is well to know that the inner bark of the sand-paper tree, which is common everywhere, treated in a similar way, is an almost instantaneous cure for the dread disease. The Indians know over a dozen emetics. I would strongly recommend everyone to carry the pocket lancet, in a case, with a ready supply of permanganate potassium, at the opposite end, which may be bought for eightpence, or a shilling.

MAMMALS

My task is, to afford something in the nature of a dhoby's list: not to pretend to a scientific description of the wild life of the district. Some little service may be rendered by mentioning the localities, thus affording some idea of geographical distribution; but it must not be taken that the localities mentioned are the limits of such distribution in the district.

In the giant forest, about the upper Thewarikuru and over the Kwaye to the Kanukus, there would appear to be animals not yet listed, if the Indians' reports are reliable. The accounts were given, in good faith, by old and tried yakamanna thamu (hunters). They assert that seven large, carnivorous animals, are to be found in this forest. Here are the names, with a rough description.

Emennu—Very large, black. (Probably the black jaguar.)

Wathamaiku—Large, dark, with light markings.

Chirirume—Blackish with ruddy stripes and spots.

Anuntume—Very large, ruddy, (puma).

Prauya—Blackish, white on fore-shoulders. Called the white tiger.

Wairarima—Dark, takes to the water.

Kaikuchi—Large, light color with black markings. (Spotted jaguar.)

Kaikuchi sometimes took one of our heifers, or a young bull. Once, this jaguar came to within a hundred feet of our house, on the outskirts of the village, and killed a heifer. We heard a cry, and saw a stampede of calves, at night, and, on the following morning, vultures circling overhead, or perched, as sentinels, upon the low trees, told that there had been a kill. In this instance, as in others, the prey had been thrown on to its right side, and dragged to a depression, under a bush. The drag was about thirty yards. A hollow helps to hide from view, and a bush, or tree, affords a ready means of taking top-dog position, should necessity arise. Close scrutiny failed to trace any wound other than the large opening, over and behind the left shoulder, where the flesh had been torn off, exposing two ribs. It was, probably, the jaguar which had taken out the heart. Kaikuchi does not, as I have proved, return to its kill. It would find scarcely anything of a meal left, if it did, for Nature's sanitary party is early at work. The maikang arrives even before daylight, and the vultures and krakras are busy, with the break of day. Kaikuchi is to be found in the Thewarikuru Bush, Marekupu Bush, and Marakanata Bush. I have the skin of one which was shot close to the last-named Bush. It is that of a young animal, measuring three feet ten inches from the nose to the root of the tail. The markings resemble, somewhat, the beast's own pugs. The spotted jaguar would seem to prefer the open country, where it can hunt deer, and, in these days, cattle. Both the spotted and the black jaguar are known not to despise fish; and it is said that they will lie in wait for turtles coming on to sand-banks, to lay eggs, and successfully turn them, and extract the flesh.

The ocelot may be found in these woods, also. It and kaikuchi are reported as abounding in the Simuni Bush.

There is another carnivorous animal, called iworo, which is diurnal as well as nocturnal, in habits. One came to the corral, at mid-day. It decamped when an Indian ran off for a gun. This animal has always evaded me, so that I am unable to describe it, or to identify it. Christopher Davis calls it a wolf, though it is solitary. One moonlight night, we saw an iworo cross the wide road which we had made and cleared, and go to the pineapple corral, where, finding no fruit, it uttered its uncanny cry. Then it recrossed the road, went off to another pine enclosure, repeating its cry, as if to mark its disgust. This creature, although carnivorous (it carried off a sitting turkey) relishes pineapples, and few were the fruit we got from our two corrals. The Indians' fields, upon the savannahs, suffer from its depredations. When one is alone, upon the savannahs, at night, the cry of the iworo is blood-curdling.

Christopher Davis is a Negro, who has lived upon the savannahs for a score of years. He has married an Indian woman, and keeps cattle, at Tuka. He possesses a fund of information with regard to the forests and savannahs and the

Indians; but he has declined several offers of money for the folk-lore he can give. He is there to teach the Indians to be Christians; not to waste his time in telling devil-stories. He would be useful to a naturalist, for he has no objection to discoursing about God's creatures.

A smaller animal than the iworo, also diurnal and nocturnal, is the maikang, or savannah fox. A specimen brought to me measured 2 feet from the nose to the root of the tail, the tail was 1 foot long, rather bushy, and the animal's height was 17 inches. A black line ran down the back, from the neck to the root of the tail, and along the tail, irregularly. The body was speckled burnt-sienna and greyish-cream, the head being similarly colored, and the underparts were dirty white. The nose was very pointed. The maikang is audacious, coming into the village, in the daytime, in search of fowls. It took a sitting hen from under our house, having to force its way through a kissing-gate in the stockade, which enclosed the house. It was, probably the same maikang which was found, soon after, as the day broke, in our verandah, where it had come to enjoy some bananas. The fruit had been brought in from the distant field the night before and had been left upon the floor, to be hung the next day. It is of interest to find two carnivorous animals partial to fruit. There is, upon the savannahs, a bush, which bears a pretty, red berry, which is called maikang-pimi-u, because the maikang feeds upon it. Pimi is the Makuchi name for the small, red pepper. Iu means food. Maikang-pepper-food. During flood-time, the maikang were much in evidence upon the hill, where the Mission stands. Its eerie cry, like the long drawn-out wail of a person in agony, could often be heard, as darkness fell. The maikang makes a hole, generally in a *mona,* and, in this, it has its young.

A still smaller animal, having a long tail and a pointed snout, is the queer creature called, by the Indians, kuachi. It is the coati, to which Colonel Roosevelt referred, in his account to *Scribner's* of his travels in Brazil. The Indian boys delight to tie strings to the waist and to race the kuachis against each other. These animals are to be found on the low ground, to the west of the Mission, about Kwatata Creek.

The accouri, adouri and labba, are to be found wherever there is an extent of Bush. I have seen them in Uruata Forest, and they have been shot in Thewarikuru Bush. The holes of the accouri may often be seen—perchance a camudi has taken possession of the hole, and the accouri family is lodging within the camudi!

Uruata Forest is the home of the armadillo and the porcupine and the sloth. I caught a glimpse of an armadillo and was given some spines of the porcupine. In this big forest, droves of peccary trample, making a varied diet of yellow hog-plums, which may be found scattered over the ground, in places, during the season, and of snakes which come in their way. The Indians name five distinct kinds of peccary, although only two appear to be known to science. The Indian names are:

Abuya (Abouyah *Dicotyles tajacu*).
Poingga (Kairuni *Dicotyles peccari*).
Paraka.
Karuata.
Iwawtaw.

Allusion is made to the karuata in the opening stanza of a song which accompanies the Parishara Dance:

"Karuata wai ke U yipu i e." (With the call of the karuata, I come.)

I have not made records of the localities in which the different species may be found; but I know that poingga have been shot while skirting the Anai Savannah; paraka have been brought in by Indians from Mare-kupu Bush; and abuya have been shot in Uruata Forest. The Karuata, I am told, is found in the forests which clothe the Pakaraimas.

Deer are reported to be diminishing rapidly, in the savannahs, since the Indians have taken to the buck-gun. The deer are most plentiful about the Napi and upon the Katoka Savannah. Here, again, the Indians differentiate four species of deer:

Waiking (*Odocoileus virginianus*).

A smaller Savannah deer (*Mazama americana*).

Usari (Wirriboceri)—(*Mazama simplicicornis*), a bush deer, such as we used to shoot in the Upper Massaruni Forest.

Karithauku—Also a bush deer, darker in color, with white front, smaller than the Usari, which, by the way, has white spots about under parts.

The bush deer are to be found in Uruata Forest. Not much was seen of opossums, for they keep to the trees, hiding amongst the foliage and in their holes. A small variety was discovered in a tool-box, under our house, at the Mission. It was about six inches long, and its tail was as long as its body. Its large, black eyes seemed to be out of proportion to its narrow head, and its dark-brown ears protruded prominently. The creature snarled and snapped and showed a lot of fight. Mr. Rodway identifies this animal as *Didelphys murinus*. Mouse-lila.

A yawarri, also a pouched animal, was shot by me, in the same store-room. It showed its teeth and uttered its gurgling growl in a terrifying manner. This creature is partial to fowls' eggs, and will play havoc with young chickens.

Monkeys are common in all the bush. The kwata (quattor—*Ateles paniscus*) has given its name to Kwata-ta, which means Kwata-place (ta being an abbreviation of pata, place), and to the knob of land, Kwata-pubai, or Kwata-head. I have seen a party of a dozen of these animals, making their way from one big bush to another, using, as their highway, the low scrub, which, at that place, fringes the savannah, at the river's edge. They would not cross a long extent of country upon the ground. The red howler affords the listener daily and nightly entertainments, in these forests. To describe the noises made is impossible. The cadence from fortissimo to mezzo-forte is not unpleasing. One would miss these howlers, in the wilds. *Mycetes seniculus* conveys no picture of the howler. The Sakiwinkie, with its olive and yellowish tints about the head, makes a pretty pet. And the black and fluffy marmosette is also in demand. I have seen both of these monkeys leaping and scrambling amongst the trees, at Uruata, or swarming up the trunks. As the Indians eat seven species of monkey, it is clear that I have not seen all there are to be seen.

The maipuri or tapir is a splendid diver. It travels long distances by water. I have seen it swimming the Essequibo, where its width is a full mile. Two boats gave chase. Wounded with an arrow, the maipuri dived and remained under water for nearly five minutes. For three-quarters of an hour it kept the boats moving about and doubling, as it would sink in one place and re-appear forty or fifty yards away. I have met with it upon several occasions in the Rapo-nunni. Its feet are worth notice.

Below Anai, I shot a water-horse. It sank and was carried below the branches of a fallen tree, and was lost to us.

The water-dog, or otter, has learnt to fish where shallows meet the deeps. These animals may be seen treading water, to raise their heads and yap at an approaching boat, taking care to keep at a respectable distance. Should one hear an uproar of conflicting cries—turara, turara, turara, turara—there is no need for alarm, though, through the forest the noise is, at first, startling. A family of otters is expressing its delight over some fine fish which has been brought to bank by father or mother otter. The larger species of otter, the Indians call turara (*Pteronura sandbachi*); the smaller one they call, saro (*Lutra brasiliensis*). Both may be found in the Rapo-nunni.

Is it really necessary to mention that rats and mice exist in the Hinterland? Though they annoyed us considerably in the house, it was entertaining to watch them run up and down a post, opposite to a suspended bunch of bananas, and, finally, leap off, a distance of two feet, on to the fruit.

Bats, also, troubled the fruit, until we made a wire net fruit room. Vampires and other bats took up their abode in the palm thatch of our house, and divided their attention between the bananas and the litters of puppies, which periodically appeared. The bitches kept by the Indians lose nearly all their pups, owing to the attacks of vampires. The mothers know how to roll over and to brush off the horrid creature; but they are helpless to free their pups. Our pet would run backwards and forwards, from her yelling pups to our bed-room door, whining for us to come and remove the attacking horror. Fowls must be carefully protected, at night, in wire-net houses. Calves suffered severely. They became emaciated, and some of them succumbed, ere they could grow to be large enough to withstand the continual lancing. The Negroes call the vampire Dr. Blair, after a famous surgeon-general, who was much given to employ the lance. Upon the occasion of my trip to the diamond fields of the Upper Massaruni, in 1902, I was attacked by a vampire, during sleep. I knew nothing of it until the morning, when my attention was called to a large patch of blood upon my hammock. Examination of my feet showed a round hole about three-eighths of an inch in diameter and one-eighth deep, in one of my big toes. The edge was regular. I felt no ill effects, until it became necessary to wade creeks and lunge through swamps of pegass, when, foreign matter getting in, my foot was poisoned. Should a traveler not fear mosquitoes, he should, in certain districts, have a net to his hammock, as security against bats. Indians wrap themselves up in their hammocks. At the entrance to the bush, between the Mission House and the River Bank, I saw about a dozen bats, of a large size, for a few weeks only, during the heavy rains of 1915. They would seem to measure about two feet across the wings. They were feeding, not upon fruit, but were catching insects. These large creatures reminded one of the frugivorous flying-foxes, which one so often saw in Burma.

REPTILES

The Indians gave me the following names of distinct species of turtle, to be found in the Rapo-nunni; warara, matamata, traekatha, pitura. Tortoises, or land-turtles, of which names were given to me, are: wathamuri, kaika, murru, kapachi and one forgotten.

The warara, which measures five feet in length, requires that a man shall be skilled and strong if he desire to turn it. An Indian who brought in one of this size suffered a severe scratching, from the sharp nails, and sustained a rupture. Between January and April turtles' eggs may be found, by the score, in exposed sand-banks. A lay may be discovered by following the turtle's track, easily distinguishable from a boat, and scooping the sand for a depth of eight inches. Should rain have obliterated the track, eggs may be found by probing where a suspicious indentation of the sand appears. The egg-shells, being of parchment texture, are not easily broken. A smaller turtle, tarekatha, may sometimes be seen by the fifty, or the hundred, together. I counted over fifty emerging from Parishara Pond. Their necks were craned, to enable them to eye the passing monster (our boat), and their whitish throats gave the appearance of a strew of lily-buds, upon the placid surface of the water. Moonlight nights are suitable occasions for watching turtles come forth, to lay. They always return upon the same track, leaving only one mark for the double journey from and to the water. They are able to manage this, because they rotate, when digging the hole for the eggs. It is observable that the bodies of the tortoises are not so flattened as those of the turtle. Tortoises may be found in the Uruata Forest. I have seen specimens brought in by the Indians; but, unfortunately, none was brought after I began to make sketches and records, so that varying species could not be noted. The markings upon the shell of the wathamuri are imitated by the Indians as a pattern in Indian bead-work. It is effectively shown in a bi-colored design.

The Rapo-nunni teems with alligators, and every stream and pond of any size knows them. Their heads, like the ends of gnarled logs, may be seen, stationary, or almost imperceptibly moving, in mid-stream, or near the bank. *Caiman niger* mounts guard over every landing, and looks out for unwary dogs, thoughtless children, and careless adults. Two children have been carried off at the Mission: one at Rapo-nunni Landing and the other at Thewarikuru Landing. One of these was the child of the late, famous Makuchi Chief, John Bull, who came to Town to meet us and to escort us to the distant Mission. A woman, also, was dragged under, and was drowned, ere she could be rescued. Towards the end of 1915, one of our women, visiting Tawrong thamu pethaku kupu, in search of young birds, was attacked. A large part of one calf was taken off, and an ugly wound was made in the upper leg. The flesh, in parts, rotted and had to be cut off. With careful attention she recovered, and she was able to walk down to bid us farewell, when we left. These few instances, out of many others, go to show that the alligator or the crocodile is not to be treated with contempt.

There would seem to be more than one species in the district. We saw creatures varying from three to twelve feet, in length. Some are reported to be longer. They seem to prefer back waters to running water. The Kwatata bush, which encloses and domes the creek, making it necessary to cut a way for one's canoe, is a favorite breeding-place for them. Their roaring grunts may be heard, as one intrudes, from amongst the big roots. Members of a crew, left to sleep in a boat, at the landing, were unable to endure the noise and the proximity of the alligators, as they snouted the sides of the boat, and they fled, in undisguised alarm; though it is doubtful that an alligator could, or would, climb into a boat. Indians bathe with apparent indifference; the indifference is only apparent. The eggs of the alligator, thirty or forty in number, are thick, rough, dirty white. They are buried under a big heap of earth and leaves, well hidden in the bush, away from water. The nest might be mistaken for an ant-heap.

That foe of the alligator, the iguana, may often be seen, upon the bank of the river, sunning itself. Sometimes it lies along the root, or trunk, of a tree, from which its greenish skin is hardly distinguishable.

The pokaru is a good place for studying snakes. We killed two camudies, taken from the Church. One measured fourteen feet, the other six. Labarias would pay an occasional visit. Rat snakes were found in our bath room, bed room and sitting room. A small snake, about two feet in length, with a rufus head and throat was twice seen, near to the house. I killed both. In the bush, through which the new water-side line passes, we saw a green labaria; and, crossing a side road, with a frog in its mouth, a black snake, about four feet in length, passed in front of us. The green labaria is known as *Lachesis bilineatus.* Another green snake, the *Corallus caninus,* or parrot-snake, lurks in the branches of trees, waiting for unwary birds. The grey-green and chrome rattlesnake is common upon the savannahs, although the ordinary person may walk for miles without seeing one. Between the Napi and the Takutu, it is abundant—there I saw it—and, upon the Tuka Savannah, one of our Indians was killed by the bite of a rattler. This snake is known to be viviparous. It is said to bring food to its young, until they are old enough to hunt for themselves. The traveler must beware of tussocks of grass, at the side of a track. I have heard of, but have never seen, snakes' eggs.

AMPHIBIANS

Of these I cannot write. That frogs and tree-frogs of many sizes and voices exist all over the country, one knows. I did not meet with a Surinam Toad.

BIRDS

I do not pretend to give a complete list of all the birds we saw. For over a year, no records were kept, and records of a scientific nature were not begun until just prior to our departure. There was no time for comparisons: so I am unable to list separately those birds which are not to be found on the coast lands. Those who know the birds of the coast may be interested to note familiar friends which are to be encountered in the hinterland.

It may be well to begin by calling attention to Tawrong thamu pethaku kupu (The Birds' Landing Pond), where the woman was attacked by the alligator, because it is here that a remarkable number of birds of different varieties assemble to breed. Cranes, egrets, the common duckla and the collared duckla, ibises and storks and negro-cops, and a host of smaller water birds are amongst those that breed here. The ducks do not breed at this pond.

Mare-kupu is a large pond, of which the margins are overgrown with long grass and weeds, making wading difficult and dangerous (lurking foes), and approach by boat troublesome. This pond, the Parishar and the Warabai are visited by three varieties of ducks: The common vicissi (so called from its cry—vicissi, vicissi, vicissi), *Dendrocygna discolor;* the larger bird, the Bahama duck, *Poecilonetta bahamensis;* and the magnificent bird, of which the drake is gloriously colored, *Cairina moschata*. Some people call this the Muscovy or king duck. There is a fourth duck, occasionally brought in by the Indians, the white-faced vicissi, *Dendrocygna viduata*. We have shot both varieties of vicissi, amongst one sweep, or regiment. So closely packed are these birds, when going through their aerial evolutions, that one cartridge, with BB, has been seen to bring down fourteen birds. I have known sixteen to be brought in by a yaggamana, who has expended only one of three cartridges he had taken out with him. The Indian name for the large duck is maiwa, they call the vicissi wawing, while the teal is known as ropong. It is well to know these names, when one is seeking the assistance of the Indians to find the different species. The vicissi and the king duck, as I shall call *Cairina moschata,* seem to be commoner than the Bahama duck, for we seldom saw, or secured the last-named. The king duck can always be detected, in flight, by the broad bars of white which flash from its wings. The Indians stalk these ducks in a marvellous way, wading through water, with body bent nearly to the surface, taking cover behind bushes or grasses, with the gun held a few inches from the water, and brought, with a sloth-like movement to the present, when at close range. The Indian is a wonderful hunter, but he dislikes taking a sporting shot. He will not take a bird on the wing. I achieved a nine days' notoriety by taking a monster king duck, as it rose from the river, at a distance of just over forty yards. It was the largest specimen I saw, not magnified by lenses of the Ego brand! Where the river passes through forest belts, as at Uruata, Simuni, and Rewa, the king duck may be found in some quiet spot, besporting himself with his wives and family, of two, or perhaps, three. It would seem that ducks lose a considerable number of their young, ere they reach maturity. Their foes are legion. The perai and the tiger-fish are ever on the look-out for a duckling, and even for a full-grown bird. The alligator, too, makes a meal of them. And the cat tribe is ready, whensoever they are ashore. The king duck nests in the hollows of trees; while the vicissi makes its nest amongst reeds and grasses.

To the north of the Mission, upon the savannahs, cranes, negro-cops, ibises, flamingoes and spurwings may be observed. Along the river banks egrets are often to be seen. Storks, also, are common, making a pretty picture when they settle upon the top of an overhanging tree, after having been disturbed at their piscatorial operations. The egret might be endowed with an aesthetic sense, as it is so frequently to be seen standing at the water's edge, against a background of deep green grasses, its white form reflected in the glassy surface, which mirrors also the deep blue of the sky overhead, and the fleecy clouds drifting. Companies of spurwing sweep along, and pipers run about the sand-banks at the river's brink. Two species of kingfisher are easily distinguishable, at river, or pond, for one is large and the other is small. Closer observation leads to the discovery that there are four species, including a collarless, green one. Others have white collars, rufus-brown waistcoats and blue-green uppers, wings and tails. The presence of a kingfisher may be told, not only by its darting flight; but, also, by its peculiar note, which may be described as *pebclacking* (pebble-clacking). I observed kingfishers flying overland at a considerable distance from water, and this has led me to wonder if we have a species, like one in Burma, which has forsaken fishing for hunting. Flying with the kingfishers are the woodpeckers, or carpenter-birds. Some handsome birds may be seen throughout the region. A large bird, with a crimson crest, is to be found at Uruata; the smaller one, with a red head, is common about the Mission. The muscular action of the woodpecker's neck, with a maxim-like rapidity of blows, is an interesting study; and the bird's undulating flight can hardly escape attention.

From the thickets, along the river bank, the hubbub of gurgling bevies of old-witches may be heard. The larger old-witch haunts the more open ground, and its plaintive note sounds upon the savannah levels, where there are bushes, not far from water.

Large hawks are to be seen almost anywhere in the savannahs, perched, sentinel-like, upon some solitary trunk, denuded of leaves and branches, or at the summit of the tallest tree at the edge of a wood. One evening, as we were returning from the North Savannah, up the hill to the Mission, we heard a cicada, as it traversed our direction, high in the air. Two hawks were poised, nearby, examining the woods, on either side of the trail. One of them swooped at the cicada and carried it off in its talons, protesting loudly the while. Truly the great do not despise small things! A smaller hawk-bird, called by the Indians, enthaking, hunted in the village, ever on the watch for the beautiful pets kept by the Indians, or for stray chickens. A large bird, in appearance like a hawk, hunts with the vultures. It has a white head and collar. The Indians call it krakra. It does not kill its food; but feeds upon grubs and worms and carrion. Probably, it seeks carrion in the rotted meat. About the rocky hills, at Tuka, the kite is to be admired. It nests in bushes amongst the rugged boulders.

At the Mission I shot a large hawk, with feathers barred black and white, and black and rufus-brown. It was a handsome bird, and measured exactly four feet from tip to tip of wings.

A hill, about a mile to the northwest of the Mission is named after the smaller curassow, which is said to have abounded hereabouts, though, now, it is seldom to be seen. The large curassow is common in the big forests of Rewa and Uruata. Certain thickets, along the river, are its favorite haunts, and it was noticed that when a bird had been shot at one of these the spot was occupied by a successor, not long afterwards. The booming ugm, ugm . . . . ugm, ugm, ugm, (twice, then thrice), rouses the Indians to a pitch of eagerness, while the boat is yet a long way off. Stalking is difficult, as it is almost impossible for even an Indian to make way through a thicket of underbrush without snapping a single twig. At the first sound of snapping, the booming ceases. There is a very long pause before it is resumed. Should more snaps be heard, a little nearer, those who are expectantly waiting in the boat, hear a loud beating of wings, as the alarmed bird bursts through the foliage and makes way. The curassow is often tamed. Its crest of black feathers, its glossy black back and wings, its immaculate white waistcoat, and its bright gamboge bill, make it a handsome pet. Another pet is the maroudie, or bush turkey, with its blood-red wattles. The thakami, or trumpet bird, is more than a pet; it is a companion. Its antics are very amusing, two or three, together, have round games, leaping over each other and tossing stones, leaves, and twigs. Its brilliant dicky of cobalt blue, Prussian blue, and ultramarine (such a blending of blues!), is well set off by its grey mantle, falling over wings and the place where its tail ought to be, being edged with dull yellow-ochre. This bird fearlessly attacks and kills snakes. In the Upper Massaruni, I have seen it ferret out a yackman, or whip-snake, and attack it. Whenever we killed, at the Mission, the meat and blood always caused great excitement amongst our trumpeters.

They are easy to keep, for they are omnivorous. Maams and maamus are to be found in the big forests, where the thakami dwell, and in the smaller woods, where the trumpeter disdains to live. The hanaqua, inquiring, What o'clock? What o'clock? at dawn and close of day is ubiquitous, and abounds upon the outskirts of savannahs and clearings. Toucans of several kinds are common in the bigger woods. Their plumage is prized by the Indians, for decking their persons. Three macaws may be seen—the wathara (crimson and blue), the kuyari (green and yellow), and the karawa (red-breasted). These birds frequent the trees which provide them with food. At the Mission there is a tree called kuyari iu, the (kuyari's food tree). Three parakeets are caught and kept: small green, paraki; green, with long tail, kaikai; orange, red about the eyes, greenish-yellow tail, kuyese. The chiriki is the love-bird, also a parakeet, of course. Parrots are everywhere swarming. I have not listed the varieties. Only once did I hear a tiger-bird.

It was at Uurata where, also, I heard the white bell-bird for the first and the only time. Hummingbirds are plentiful; their delicate nests were often seen. In the thickets and tangles, to the south of Kwatata creek, the jacamar (*Galbula viridis*), breeds. As it somewhat resembles a hummingbird, though it is much larger, the Indians call it Tuku-i yung, or hummingbird's father; just as they call the thumb, thantha yung, the finger's father. This bird must not be confused with the long-toed jacana, which may occasionally be seen, standing upon the immense pads of the Victoria Regia, one of the original homes of which is the Thewarikuru, in its lake-like expanses, at the southern foot of the Mission Hill, from the summit of which hill this waterway is so effectually screened by the thick bush. The Indians name their Reception dance after the hummingbird, Tuku-i; and their Great dance, the Parishara, is called after the prim crimson-headed finch, which is to be seen, flitting from bush to bush, along the banks of the Rapo-nunni, almost anywhere in its course.

As I have returned to a mention of the river, we may as well take note of the duckla. Some call this the snake-bird, a nickname which should belong to the trumpeter, as I have shown. Singly, in twos, or in threes, it may be seen, perched upon some tacouba, or an overhanging branch, looking for fish. When disturbed, it has the peculiar habit of dropping low and dragging its tail in the water, as if wounded; then it rises and makes off. The duckla with the white collar is rare. The Indian name is saia. Of great beauty is the sun-bittern (*Eurypyga helias*), also fairly common upon this river. I have not seen more than one at a time. The bird makes a beautiful display of the coloring and marking of its tail and wings, when it alights, spreading the tail and wings so as to form a fan. The shades of browns, golds, and greys, are wonderful. It frequents the sunny banks, and, generally, alights upon an open patch, when the sun is shining. Then it runs and secretes itself where the bushes are thick.

On the banks of the Rapo-nunni, in the Rewa forest, I have heard the piercing call of the pi-pi-yo, or gold bird, alias greenheart-bird. It is supposed to be found only in greenheart forest. Mr. C. Wilgress Anderson, F.R.G.S., Forestry Officer, tells me that no greenheart is to be found in the Rapo-nunni district. Indians say some exist in the Rewa forest.

Tyrants, of the kiskadee family, need no special mention, nor do cotton birds, manakins, tanagers, and cotingas —after which the Cotinga River, ceded to Brazil, is named. Perhaps an exception should be made in the case of the scarlet-breasted tanager, (*Pithys erythromelas*), two specimens of which were noticed in a cashew tree, near to our house at the Mission. In that tree I saw, upon another occasion, a dark bird with a crimson collar and a crimson under-tail, which Mr. Rodway suggests may have been *Lathria streptophora,* a cotinga, which, he says, is not mounted in the Georgetown Museum. The so-called American robin may be seen upon the savannahs, at Tuka. And from the hills, beyond, the Indians bring that gorgeous plumed and sweet songster, the troupial. We bought several and let them loose, after a short spell in the cage. They would fly about the village and come in at meal-times and feed from the hand. Early in the morning they would appear at our window and carol forth, then search the house for insects. When full-grown, the male assumes an almost crimson hue, so different from the yellow of his youth. The head becomes a deep black, matching the wings and the well-shaped tail. The wings have bars of white. These birds attracted a pair of yellow birds, with brown wings, barred with white. They would join our pets upon the verandah and feed and bathe with them. The Indians call them chiwitaw, they may be the yellow-crested troupial, *Icterus croconotus.* The black-crested, the far handsomer bird, is called *Icterus vulgaris.* Farther westward along the Pakaraimas the brilliant cock-of-the-rock has its habitat. I have seen the skins of two, which were used by the Indians as ornaments of clothing. Upon one occasion, we heard a troupial singing loudly from the top of a tree, on the river bank, near to Kwimata Landing. Its nest was discovered, high up in a bush, overhanging the water, upon the opposite bank. It was a grassy structure, elongated, fixed in a fork, with an entrance on the leeward side. I suspect that this bird and its mate had escaped from Indians at Kwimata.

Where river banks are steep, sand-martins may be found making use of the numerous holes. Whether for roosting or nesting, I have not determined. Over the savannahs, common martins, swifts of two sizes, and swallows cannot be overlooked. Scissor-tails, also, are plentiful; and an occasional screech owl may be disturbed from amongst the thick foliage of an ancient tree. Pigeons are plentiful. There is a tree in which they delight to place their platforms; on this account the Indians call it wakokwa-the, or pigeon's-tree. Its leaves are long and narrow, and its trunk is as straight as a mast. The copper-colored pigeon, also, is plentiful; and the ground doves rise in patches, from any open ground. I disturbed a ground dove upon its nest, near a tussock of grass, upon the Tuka Savannah, near the foot of a hill. There was one white egg. A night-jar, mothering a solitary young, was found, upon the hill, on the outskirts of the Mission Village. Upon moonlight nights, night-jars were busy. They settled on the ground, at the side of the roads, wheezing and beating their wings, periodically. Then they would rise and gyrate, and sweep along, just over the grass, and beat their wings as they passed. The object of this may be, to cause their prey to betray its presence, by a sudden movement. At sunset, during the later months of the year, we used to hear a bird which uttered seven notes, descending the scale in thirds. It was not seen, nor identified. This was at the Mission. From my little shelter in the Bush, near the Mission, I have watched the black-faced wren come forth from hiding and warble its powerful song. The bird's technical name is *Thryothorus coraya.* The common wren haunts the tangles upon the savannahs, as well as the big forest. It is a homely bird. The quadrille bird, perhaps the finest songster in the world, may be heard in Uruata Forest. My first meeting with this bird was in the Upper Massaruni. Its voice-production is a perfect art; I know of no bird with a sweeter note, not even the nightingale, nor the black-cap of Europe. When one has heard this bird, the other two wrens mentioned, the local thrush, the troupial, and the kadouri—to mention some only of our sweet songsters—one no longer believes the traveler's yarn that the tropical countries have birds of bright plumage but no birds of song.

I do not class the bunyahs as songsters; but I must not forget to mention that colonies of them may be found upon the river banks, their nests being suspended from trees overhanging the water.

This haphazard catalogue will afford some idea of the birds to be found in the district. Travellers may walk miles over the savannahs and through the forests and report that few are the birds to be seen and heard—noisy parrots, macaws and kiskadees, vultures, doves and pigeons. If they *walk* they will see little more. Those who desire to see and to hear, must learn to stand or to sit still. Half an hour's patience-exercise will be amply repaid: it is astonishing how many forms of wild life reveal themselves to the silent watcher. They seem to spring to life as by the magic of a fairy's wand. Creatures which are preyed upon learn that their safety consists in sitting still, when danger threatens. This instinct, exercised in the very face of an enemy, causes that inaction which some would attribute to hypnotism. Any boxer knows that he must watch his opponent's eyes, so as to be able to tell when and where his next blow will fall. There is no need for fancy theories with regard to birds and beasts and reptiles.

FISH AND CRUSTACEANS

I have seen two of the three kinds of crabs, named to me by the Indians, as being found here. They tell of two shrimps, and of forty-eight different fishes. Fish migrate from the Essequibo to the Upper Rapo-nunni, to spawn.

The lukanani is said to carry its eggs in its mouth, and the female to transfer them to the male, when she desires to feed. The warapaima makes a bed at the bottom of a deep hole. This fish grows to an immense size, sometimes scaling over a hundred-weight. It may be seen rolling its back at the surface of the water; and the noise of its splash, when it returns from a high leap into the air, may be heard half a mile off, upon a still night. The Indians do not like the flesh. I have seen them catch one and leave it untouched, although we have, at the time, been without any other flesh for our evening meal. Owing to carelessness on the part of those who have taken Indian names before they have learnt the language, this fish has come to be called the arapaima—*Arapaima gigans* is the name in full. When the freshets come down, the striped tiger-fish may be detected waling the surface, as it dashes up the shallows. (*Pseudoplatystoma fasciatum*). A common fish is the arawona, which has an almost vertical mouth opening at the top. It feeds upon the hard, green fruit, of a tree, which is plentiful near the water. The Indians place some of the fruit in baskets, at the surface of the water, and, as the fish rise to feed, they shoot them with bow and arrow. I have seen Indians dash in amongst arawona, drive them over the shallows, towards the bank, and pick them up in their arms. Perai and their four cousins abound, some marked with red and others with gold. They are ravenous fish, and attack any wounded thing which falls into the water. They will attack persons swimming. The electric-eel, or numb-fish (*Electrophorus electricus*), I have seen swimming near the bank, at the Bell-rocks.

Our Indians have caught two species of the sting-ray, in the Rapo-nunni. The brownish one, hardly distinguishable from mud and sand, near Katoka Creek; and the grey one with gold and silver markings, upon a granite boulder, in the lower river. The second one cannot easily be detected when lying upon granite, with the sun's rays playing through the liquid prism. The "stings" are barbs, lying one above the other, upon a slender tail. They turn them over the back, as a scorpion does its tail. Many were the Indians who came to me for a dressing, after entering the water to find a passage for the boat, or to push it over a shallow. At the mouth of Uruata Creek, I saw some long, narrow fish, not quite a foot in length. The Indian name for them is mawri kuratu, or blow-pipe fish. Savannah Indians do not use blow-pipes. Pata-kai is the Makuchi name for a fish which scatters over the savannahs and into the creeks and ponds, when the floods come out. The name means, "The country over," pata being place, or country, while kai is short for kaichure, evenly, equally. When the floods subside, many of these fish fail to return to the river in time, and they may be found in puddles, which, in course of time, evaporate. In the dry bed of Uruata Creek, I have seen a small shoal of them flapping and floundering in a few inches of water. The Indians picked them up and threaded them upon a stick, against their breakfast. The maikang-fish has dog-like teeth; and the barbels of the little thaki are imitated in a design for the Indian fan, which is used for shaping and turning the cassava cakes, sometimes known as wooden-bread. These fish are most curious.

The Indians tell how, in ages long ago, the Inchkirang, one of their ancient Heroes, plucked leaves from the moka-moka, and scattering them in the Rapo-nunni, turned them into sting-rays, in order to prevent his younger brother from following him on his journey, after the giant snail, to the floor of the mighty ocean.

ARACHNIDA AND MYRIOPODA

Scorpions, olive-green, black, and ruddy-brown, have been found. The first were under the loosened bark of a tacouba, which we had adopted as a seat, at the far end of an afternoon stroll. Spiders would need a chapter to themselves, for they include the giant, hairy terrors (wrongly called tarantulas), the ant-like spider, the jumping spider, and the spider which skilfully hides itself behind an X, spun in the middle of its web. Long centipedes are everywhere. And millipedes, measuring five inches, may often be seen in the bush.

INSECTS

It was at Thewarikuru Landing that I saw and heard the musical butterflies (*Ageronia feronia*). Their music resembles the crackling of grass under fire. The insects were mottled in shades which appeared to be drabs, greys and browns. They should measure about three inches across the wings.

We saw more varieties of butterflies in the bush than upon the savannahs. Wherever a road, or a sirahi, is cleared, through bush, there numerous butterflies are to be seen—some at any time of the day; others only at morn and eve. The large, black butterfly, whose wings are panelled in bright gamboge, we saw only when the rays of the sun came slanting through the leafy canopy overhead, making patches and bars of light and shade, as they filtered through. In such places the butterfly might, when still, escape detection. This species allowed me to stroke it; and our baby boy could put his finger to within an inch of it, without disturbing it. We did not allow him to touch it, as he would have poked. A butterfly similar in size, panelled with deep green, was noticed, also. And a smaller, black butterfly, with crimson. This was always seen hovering about a special kind of sapling, or suspended from its leaves or leafless twigs. We never saw it in repose, upon a leaf, or branch. Another butterfly always alighted upon the trunk of a particular kind of tree, from the bark of which it was hardly distinguishable. Indians would not detect it, until I pointed it out to them. This fact, with some others of like nature, suggest that the Indians are quick to see things which interest and concern them—as one woman will take in the details of another woman's attire, at a glance—and that they are not keenly observant in other respects.

When crossing the savannahs, between the Napi and the Manari, upon two occasions, I disturbed a tiny butterfly, settled upon the kanju flower, of which it was the same color. The wings were the size of the petals of the flower, which is a blue mauve, almost lavender. The kanju is an herbaceous growth planted by the Indian maidens, who rub the juice of the flowers upon their faces, to make themselves attractive to the Indian youths. A popular name for this butterfly might be, The Kanju.

Moths, beetles, stick-insects, leaf-insects and grasshoppers, I shall not attempt to list. A few locusts were to be seen, occasionally, upon the savannahs, to the West of the Mission, flying at an altitude of about forty feet. Some alighted close to us, thus enabling us to examine them.

The six-o'clock bee may be heard, and there is another cicada which rasps in the middle of the day. Its shrrr-shrrr is given forth from a slit in the thorax in quick two-time. The Indians reproduce the noise by means of certain seed-cases strung and affixed to a stick, which they shake. It is an accompaniment to the tuku-i dance. In the hills, aback of Tuka, during October, I have heard the drone-bee, the call of which might lead a stranger to think that a miniature engine was running amongst the hills.

One day, when breakfasting at Mare-kupu, I noticed a bee-hive, in an old tree, at a height of five feet six inches from the ground. I have seen other hives as low as this, which had been cleaned out by some wild animal. The large hole, whence the branch had fallen, was built up with mud, not wax. I broke away the alighting platform, in order to get a view of the interior. Upon the tree were several kushie warrior ants, one of which, observing bees settling upon the trunk and wandering about in search of an entrance, dashed up to the attack. As a bee settled, the ant would rush at it; a nip would be audible; and the bee would fall to the ground. Over a dozen were treated in this way. When a bee hovered, the ant followed its movements, and this gave other bees time to find the entrance and crawl in. These bees were the ruddy pimiro, named after a small, red pepper, similar to the pimi. I have seen five honey-bees, for each of which the Indians have names.

It cannot be a common experience to have a plague of butterflies. Each June, our store-room was invaded by a large, dark butterfly, which would swarm over the bananas (before we had the wire room), and rise in a cloud from the sugar-tin.

Galaxies of yellow butterflies, having pale-green under the wings, may be seen anywhere, on the river. When settled upon the sand at the brink of the water, they have the appearance of a bed of leaves erect. Mingled with these companies are some others of a deep orange hue.

Of ants there is no end. Tuka and Thepokaru are tunnelled by the kushie, which interfere seriously with attempts at cultivation. In the bush about the Thewarikuru is a long, black ant, which whistles or produces a sound in some way, when disturbed—s-s-s-s-s-s-s-s. Ants swarm over the ground and the trees. In size they vary from the pin's head miku thamu, to black insects, almost an inch long. To the west of Kwatata Savannah is a stretch of country which might appear to be a burial ground of the ancients, with many steles standing yet. According to the nature of the soil, they are terra cotta, brown, or grey. These are the mona, or nests of the wood-ants; they may be two feet or five feet high. A tribe of Indians takes its name from these monas—the Pata-monas of the Upper Potaro. Pata—place; mona—the ant's nest.

No one can know the district without knowing the kabouri fly. We encountered it just above Rewa Mouth. It has been said that this pest is not to be found more than a hundred yards away from water. We found it troublesome in our house, half a mile in a straight line from the water, and we have found it farther afield. It is a blood-sucker, which marks one as with fine pocks. Besides this fly, we had an angular, or greenish-black blood-sucker, which skulked under the chairs and tables and attacked one's legs and ankles. My wife has a lump resulting from a bite received over a year ago. I sent a specimen to Mr. Rodway, who identifies it as *Lepiselaga cerripes.* It is plentiful at Rewa Mouth, amongst other places. The Indians say it dwells in holes in trees and tacoubas. A large, green and amber fly annoyed the cattle and horses a great deal, after the heavy rains, in 1915. Those animals which ventured down the hill to the savannahs would come racing in with swarms of these flies, and the common cow-flies, buzzing about them and sucking them. These flies would seem to lay their eggs in the sandy banks of the river, close to the roots of the trees and shrubs. I saw myriads of them, as they buzzed about the bank, or settled and scratched the sand. This was in October. Mr. Davis has described a fly which occasionally attacks his cattle. It would seem to be rare. When an animal is attacked, it is seized with terror, and dashes to the nearest stream, with its tail erect and head askew. I have not seen the fly, which, if not previously listed, might be called Christie's Fly. Swarms of tiny flies cover the savannahs. They buzz irritatingly in one's ear, unlike the kabourie, which makes no noise. I am told that there are two species of kabourie; *Simulium guianense,* and *Simulium amazonicum.* I seem to have noticed two species on the Rapo-nunni, the second (if there be no mistake), could hardly be the *amazonicum.*

As for marabuntas or wasps, their nests are abundant in the bush, behind big leaves.

We did not find that the timbers of our house were attacked by ants, but by two borers, similar in form, though one is larger than the other. They bored into and hollowed out the wood, scattering a fine dust over the ground, or the floor. I have the Indian names of those woods which the borers do not attack. I began to press leaves and to make sketches of them, with notes. When building a house care should be taken that the Indians are made to search for the right wood, or they will bring in the first that comes to hand, although they know it is liable to attack and will not last a year.

It was interesting, when digging, to find the rhinocerous beetle, embedded in earthen cases, at a depth of eighteen inches from the surface of the soil. This was in an old ant-heap. Some of the beetles were pale yellow, as if only just hatched. Others were rufus-sepia. And others, again, were almost black.

CHAPTER XXXV

INDIAN CHARMS

By

JAMES RODWAY,

Curator of the Georgetown Museum

To the native Indian his beenas are of the utmost importance—he can do nothing without them. They assure success in all his undertakings, and must have done much to make him happy. There is a tendency in other races to depend on fate, good luck, charms, amulets and prayers, but only the South American Indian has adopted beenas. Failure in attaining some desirable object drives other people to curse, and find fault with something or somebody; the Indian is hardly ever angry. His failure to shoot a labba or deer is due to something connected with his beenas for those animals. Perhaps their virtue has been exhausted and he must reinoculate himself to restore it, or a woman may have touched those he used. But he does not abuse or scold his wife, dog or gun, but tries quietly to put the thing right. He is not much of a thinker, and yet he chooses a similar course to that of a rational man. A blundering, passionate fellow vents his spite on all around, but the man with a well balanced mind tries to find out the cause of a failure. Of course we may say that the Indian's way is absurd, but it is not nearly as absurd as that of the fault-finder or the scold.

Some of the ideas connected with beenas are pretty and almost poetical. Take, for example, the sololio or swallow beena. It is a caladium with white dots, suggesting flights of birds, in fact it recalls the line of the poet,

"When the swallows homeward fly."

The idea of the sociability of these birds does not come to the Indian from Europe, but has no doubt been spon-

FIG. 143. CALADIUM BEENAS, OR INDIAN CHARMS

taneously evolved. People in all countries love to meet their relations and friends; they write letters and send out invitations. The Indian can do nothing but use his swallow, or the other beena, if his friends do not come back, at the time when the last hole of the stick, left behind on their departure, is clear from the cord. This stick has been treasured; every day the thread is removed from one hole and every day their return comes nearer. But, something happens and they don't come; they may be delayed from many causes some of which are well known. There may be uneasiness, but the Indian does not feel any real distress. He does not neglect his duties or sit down and groan; he is never downhearted. He may, however, have hung up a "leaf of life," and as this has sent out some young sprouts, he is assured that all is well with his parents or friends. Nevertheless, something more may be done, and he therefore inoculates himself with the swallow beena to make them come all the quicker. Perhaps they may return next day, and of course the beena has proved itself a success.

The love beenas are also pretty and suggestive. An old man wants to marry a young girl—she can be charmed even when she has expressed a dislike to her suitor. He uses the special beena, which is the caladium with a crimson suffused centre an inch or two in diameter. The girl knows that she is being charmed and drawn to the man. Something bad for her will happen if she resists and therefore she consents to the marriage. The man is proud of his beena and the girl excuses her love on the ground that she was charmed. We do not find such marriages entirely failures.

The girl, however, may get somewhat tired of her old husband and turn her eyes towards a younger man. The old man is sharp enough to see that he must do something. But, he does not abuse, strike or chop her like some of the other races, but gets the beena which he believes will help to retain her love. This caladium has a broader suffusion than the love beena, and perhaps suggests that there are wider sympathies between man and wife than exist with lovers. The wife sees her husband rub the beena upon her bead apron and as a matter of course, her love is retained. She is not annoyed, but takes it as a matter of course.

A marriage without offspring is never complete. This is accepted by all primitive people and is conspicuous among the Indians. Here we get the woman's special beenas, which she keeps in her own domain, the cassava field. The most striking is perhaps a species of *Calathea* which has many offshoots from the base of the stem, something like those of arrowroot; they suggest the idea of offspring, and are cooked and eaten by the woman. If this beena fails she may resort to the bush and get the pretty birds'-nest fungus.

The boy and girl lovers carry on a kind of courtship where the father of the girl demands proofs of the boy's proficiency in manly accomplishments. Perhaps the old man is not entirely pleased with the proposed match, and will put obstacles in the way. Then the youth must get a favor beena and steep it in crab oil, with scent. This is rubbed over his hair and skin before he presents himself to his future father-in-law. A tiny piece of the beena must also be placed between the lips. The sheepish lover before entering the benab spits out the beena and rubs it into the ground with his foot, this is supposed to insure a favorable answer to his suit, and possibly does so because the old man believes also in the charm. This is not acrid like the caladiums, and therefore can be chewed.

Presuming that he is allowed to go on with his courtship he gets the laugh bush and gives some to the girl. Both are pleased with each other and want to be happy in company. That they are so must surely be credited to the beena and their belief in it.

And so we might go with the man as hunter and fisherman. Every game beast, bird and fish has its own charms, either general or particular, and each inspires hope and confidence because the man has faith in them. He does not curse the game when it escapes, nor does he blame his gun or dog; they also must be charmed with special beenas.

There does not appear to be any connection with either good or evil spirits, except perhaps in the case of the water-mamma or manatee, which is supposed to upset the corial and carry people down to a kind of fairyland beneath the dark waters. It can easily be understood that the dark coffee-colored river or creek is a mystery. It is not transparent, and therefore is unlike clear mountain streams; its depths are impenetrable. The cayman, perai or sting ray may be there, but they are not visible. These dangers are known, but it is quite possible to the Indian that some strange creature may be at work about the rapids to produce whirlpools and cross currents. Then again, there are submerged rocks and masses of those clinging weeds, which hamper a swimmer, as well as hooked palms, which may hold and upset a small corial. The real dangers are mixed up with the siren, until they form one being, who may be perhaps mischievous, but hardly evil. It may be repelled or propitiated by rubbing the bulb of the red lily over the corial before encountering the danger. It may be safely stated, however, that in this as in other cases, the use of the charm does not make the paddler less careful.

The tiny element of superstition in the idea of the water-mamma suggests something similar in the Kinaima. The avenger of blood is a reality, but his supposed preternatural capabilities are mythical. He carries out a duty which is often most painful and arduous, and as might be expected is assisted by a beena.

No one can tell the real thoughts of another; we are often at a loss to explain our own. We cannot understand the meaning of many words which are common in our mouths. It is not therefore to be supposed that we can get a true theory of the beena cult. We may say they are charms to promote good luck, medicines or ordeals. It has been said that the word means to attract, but this does not cover all their uses. There is nothing malicious about them, and we may safely state that they are harmless. The cuts and scratches do not fester, for the caladiums act as styptics; it is therefore not real inoculation. It has been hinted to me that perhaps there may sometimes be septic matter on the tuber. Possibly this may be so, but it must be very rare. The acrid principle of the beena is antiseptic, and as in the case of moka-moka, which is allied to the caladiums, the juice is decidedly useful in cuts and wounds.

We may say that beenas are medicines. If a man fails in his hunting and fishing, there is something wrong; he is weak and requires a "pick-me-up." This is at least part of the work of the beena, for it stimulates the man to put out all his energies and to overcome difficulties. They are the foundations of hope and trust.

Beenas differ from charms and amulets in the fact that they are not worn by Indians; they are rubbed on the skin, with or without cutting, taken with food, or, as in the case of the nose beena, used as ordeals. The poor dog has to suffer much before it can become proficient as a hunter. The majority are varieties of *Caladium bicolor,* those lovely plants which are suffused with crimson, blotched and spotted with white, red and violet, or lined on the veins. They vary in shape from sagittate to ovate and generally peltate. On their forms and markings depend their "signatures."

This idea of "signatures" seems to have belonged to primative man; it was prominent in Old World Medicine. The idea, as formulated by the herbalist, was that every medicinal plant was marked in such a way that, if we could only perceive the sign, it would tell us its use: For example, the adder's-tongue evidently pointed to its virtue against snake poisoning, as does the labaria plant to our Indians. The "signature" is not always so plain as in these cases, but can often be discovered when a hint is given. Many of the beenas have suggestive forms and markings that might be thought purposive.

In some the front of the animal's face is indicated, the lobes of the leaf resembling the ears, then we have the spots and suffusions, the sheen and the form. A *Xanthosma* has a malformed leaf at the back supposed to indicate the musk gland of the peccary for which it is the beena. Then we have *Acontias helleborifolius;* the digitate leaves indicating the barbels of the fish for which it is used. *Cipura paludosa* is either a medicine or a beena; its red bulb is sufficiently like a swollen and inflamed ear-lobe to account for its being an ear-ache remedy.

Many of our frogs are prettily marked and some of them are beenas. One of the most handsome is *Phyllomedusa,* a beena for the tapir, but I can find no signature in this or any other of the frogs. The tiny species that is swallowed alive is a general beena and recalls the fact that a live frog, was once administered in Europe for what was called "frog in the throat." Some insect larva that stings may perhaps be one of those moths which produce much irritation if accidentally touched, but I have never seen a specimen. This may be an ordeal rather than a beena, but there is no line of demarcation, for wasps, ants and scorpions are beenas as well as tests of courage and endurance. A man or even a boy would be ashamed to cry out when stung.

It may be presumed that there is a beena for every game animal, whether beast, bird or fish. The charm may perhaps generally be used to attract, but there is also an idea that beenas repel noxious creatures. If the snake beena is used it certainly cannot be supposed to attract a labaria, but rather to protect from its bite. I have been shown a jaguar beena, but it is rather doubtful. My lists include specimens from Mr. Penard, Surinam (Carib); Dr. Roth (Arawak and Carib); and from the Upper Demerara (Arawak) as well as some from creoles. In a few cases the same beena is reported as used for different animals in two or three localities, but there is a general consensus in many cases. We should not expect absolute uniformity in different tribes.

The game beasts represented in our collections are monkeys, tapir, water-haas, labba, accouri, adouri, peccary (2 species), deer and armadillo; the fox and kibihee have beenas, but these may be intended to repel. Reptiles and turtles and their eggs, snakes and alligators; birds, powis, maam and macaws. There must be many other birds with special beenas, even if we admit that a general charm covers beasts, birds and fishes. Our beenas for fishes include ten species; probably there are many more. We may safely presume that we do not know a quarter of them; yet I have thought it well to make a provisional list. The subject is so curious and interesting that possibly some people may be induced to go farther towards completing the collection.

Bovianders, as may be expected, believe in the Indian beenas as do some of the creoles in town who have adopted the notion. But they do not appear to scarify themselves for they are not so much inclined to test their own power of endurance. Love charms are in vogue, and even educated people have inquired for them. The good-luck seed (*Cerbera thevetia*), is in almost every market-woman's purse or wallet, but I cannot find that this is an Indian beena, although it is much used for belts and anklets in dances. It may be suggested that possibly anatto may be an Indian beena, although I cannot find that it is called so; it is, however, supposed to be protective against insects and may, perhaps, when rubbed all over the skin, with oil, ward off chills.

A very pretty caladium with white blotches is often grown outside a window in town; this is the money or good-luck beena. The signature suggests silver, but it is supposed to be more effectual if a sixpence or shilling be planted under the tubers. A man told me that he once, when a boy, stole the shilling his mother had planted to insure good-luck. There is another caladium with red and white spots which is also grown to promote good luck; it is fairly common. I cannot find that these are rubbed over the body; they are more of the nature of charms, the possession of which is sufficient to insure success in any undertaking.

Balata bleeders and gold diggers believe in luck, and sometimes carry beenas in the handkerchiefs tied around their waist. I never heard of inoculating or even rubbing on the skin in their cases. The wood-cutter, however, rubs a beena on his arms before commencing to haul timber and the women who carry loads of wood on their heads put a leaf under the pad. I have been told of a kind of bush-rope, used as a fighting beena; it is rubbed on the arms after scarifying and is supposed to strengthen them and assist in gaining the victory. The woman whose husband is cutting timber uses a beena if she wants him to come home. She keeps it in a bottle and shakes it, after which he is supposed to have an impulse to leave his work and respond to the call. As, however, creoles have very little faith, the beenas are not so effectual with them as with the Indians.

Love beenas are used by creoles to some extent. They generally include the head of a hummingbird pounded and mixed with some perfume. It appears that the soft parts only are used after drying and these may be mixed with part of a male bat and a caladium similar to that used to invoke good-luck. It may be possible to find cases of success among the more ignorant, but we need not expect such certainty as with native Indians.

Beenas suggest the beginnings of what we may consider primitive religion. First we have man's great struggle for success, which means mastery over other animals. He tried his best by inventing weapons and partially succeeded. But he was never uniformly successful, for although his bows, arrows and blow-pipe were in good order and nothing was faulty with his eyes, something might go wrong, and there would be no meat. He seems to have got the idea at a very early period that he could be assisted. How it first came is naturally very obscure; we see it as the result of long use of beenas. Possibly a caladium may have been found growing among the remains of some game animal, and thus have given the idea of connection between them. It is interesting to note that there is a beena to promote the growth of cassava; this is interesting in view of the ideas of corn spirits in the Old World, and points to the probable rise of the cult when man grew roots. It is to be noted that, as beenas are mostly used by men, that they were generally connected with the mastery over beasts, women and perhaps unknown influences partially idealized as bush spirits.

When we search for the Indian's gods we fail; his devils are wood and water spirits, which may be compared with goblins and fairies. They are hardly malicious, for like all ideal spirits they are reflections of the character of their makers. We should not expect to find the ogre with his "Fee-fi-fo-fum" among a good-tempered people, but we do expect the better type supposed to assist us when we treat them properly. Most of the wood-spirits are supposed to be either animals or to take their forms when they find it necessary; here there is some resemblance to the Old World ideas.

Are the beenas gods or guardian spirits? The Indian is too matter-of-fact for such ideas. And yet they are something more than caladiums and frogs. I am hoping that someone will be better able to find out than I can with my very limited opportunities.

LIST OF BEENAS.

Tapir, 2 var. black-eared and white-eared.
    Caladium bicolor and *Phyllomedusa bicolor*
Peccary, 2 species.
    Caladium and *Xanthosma atrovirens* var. *appendiculatum*
Water-haas, Capybara,
    Caladium
Labba or Paca
    Caladium and *Dioscorea*
Acouri or Agouti,
    Caladium; Hyla septentrionalis and *Dendrobates trivittatus*
Adouri, or Tailed Agouti
    Tradescantia umbellata

Deer,
Cipura paludosa and a frog sp.?
Wirriboceri Deer,
Hyla punctata
Ant-bear,
Caladium
Sloth,
Caladium
Monkey,
Caladium
Monkey, Coati
Caladium
Armadillo, round-eared,
Aroid
Armadillo, thin-eared
Aroid
Savanah Fox
Caladium
Kibihee, Coati-mundi,
Caladium,
Jaguar,
Caladium.
Snakes,
Deacontium foecundum.
Alligator,
Caladium.
Turtles and their eggs,
Caladium.
Maam,
Caladium.
Powis or Curassow
Calathea sp.? and *Leptodactylus mystacinus.*
Macaws,
Piriqueta villosa.
Duruquara or Guiana Partridge
Calathea.
Marudi or Guan
Calathea.

FISH.

Pataka, Huri, (*Hoplias malabaricus*)
Caladium.
Haimara, (*Hoplias* sp.?)
Caladium.
Umiri, (*Sciadeichthys* ?)
Caladium.

Kassi, (*Rhamdia sebae*)
Caladium.
Lukunanni, (*Cichla ocellaris*)
Caladium.
Gilbaker, (*Sciadeichthys parkeri*)
Caladium.
Barubata, (*Eigenmannia virescens*)
Caladium.
Cartabak, (*Metynnis?*)
Caladium.
Kaweri (*Hoplosternum littorale*)
Acontias helleborifolius
General,—To promote success with all game.
Whip of Mauritia fibre: tiny frog swallowed alive; larvae.
Shooting—To help the aim; not to miss.
Caladium.
Huntsman—To assist in tracking.
Caladium.
Huntsman—to prevent his getting lost.
Caladium.
Huntsman—To increase his courage.
Caladium.
Huntsman—Against snakes and other noxious animals.
Several Aroids and Marantaceae.
Boy at puberty—To promote general success and as ordeals.
Stinging ants, wasps, and scorpions.
Paiman—Preparatory ordeals.
To eat only jacamars and drink tobacco water.
Dogs—To improve their scent.
Caladiums; also offal of game animals; gland of peccary for that animal, rubbed on lacerated muzzle.
Love, Man.
Dioscorea sp.
Love, Woman
Several *Caladiums.*
Love, to retain, also to drive away.
Caladium.
Courtship, to promote happiness.
Caladium.
Courtship, to gain favor from parents.
Entada polystachya.
Marriage, for children, woman.
Calathea sp. and birds-nest fungus.
Marriage, to use after the birth of a child.
Calathea sp.
Children, to make them teachable.
Caladium.

Medicinal, Against pains in general and for the eyes and ears.
Cipura paludosa, etc.
Medicinal—to increase the appetite.
Caladium.
Mental, to keep the memory, or retain or restore.
Calathea.
Friendship, to promote sociability.
Caladium.
Friendship, to bring back absent friends.
Caladium.
Friendship, to increase.
Caladium.
Enmity, to bring on a disturbance.
Caladium,
Enmity, to bring trouble.
Caladium.
Enmity, to gain success in a blood-feud.
Caladium.
Water-mamma or Manatee, to conciliate; against dangers on the water.
Hippeastrum equestre.
White man, to gain favor in a court of justice.
Calathea.
Rain, to use in a drought.
Pedilanthus tithymaloides.
Provision ground, to insure fertility.
Xanthosma.

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