

NATURE AT THE DESERT'S EDGE

STUDIES AND OBSERVATIONS
IN THE BAGDAD OASIS

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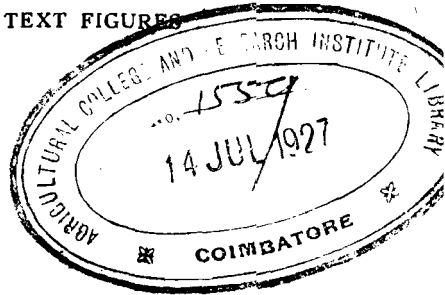
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Everest Expedition, 1924.*

AUTHOR OF

"A NATURALIST IN HIMALAYA," "A NATURALIST IN HINDUSTAN"

WITH PLATES AND TEXT FIGURES



LONDON

H. F. & G. WITHERBY
326 HIGH HOLBORN, W.C.

1925

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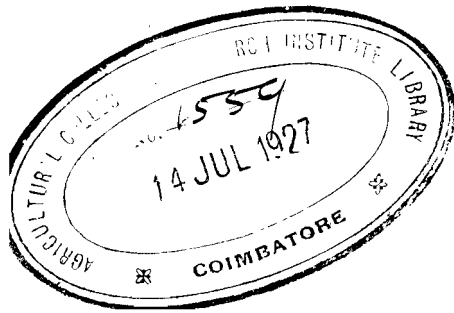
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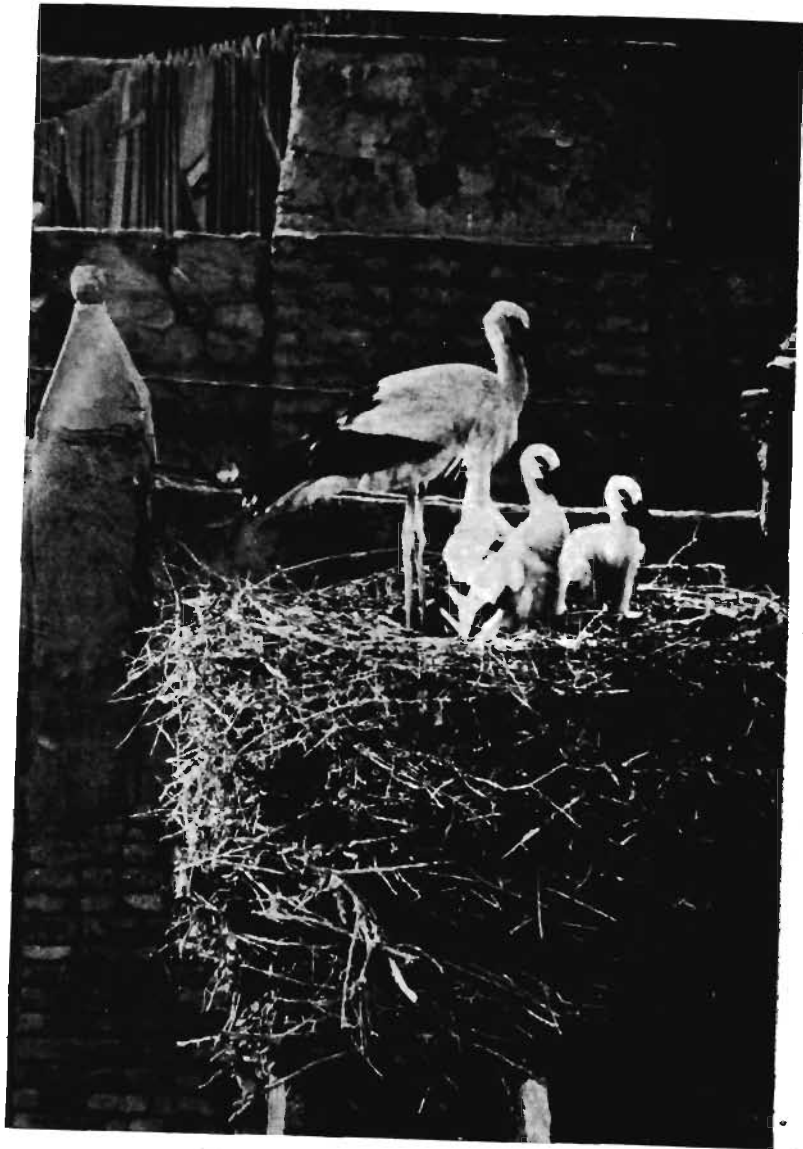
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BIRDS OF THE HOUSE-TOP.
(*Ciconia Alba*, THE WHITE STORK.)

(*Frantispiece*)

Phata. Eric Boesinger.

PREFACE

THIS volume contains the observations of a summer made at an oasis in the vicinity of Bagdad. It deals exclusively with the habits and behaviour of animals, attention being concentrated on insects and spiders, which, though humble, are not uninteresting groups. Insect life in this oasis was moderately abundant, but appeared in a state of full activity for a period of only four months. A Bagdad summer is severe and short. The air is dry, the soil parched, and the desert glows with an intense heat. In harmony with this is the life of the season, a sudden appearance, a short activity, a period of quick decline. There is none of that continuous richness of the tropics nor of that wealth of life which on the plains of India is awakened by the burst of the monsoon.

A brief note on the oasis will be a suitable commencement. I will then discuss the habits of the hunting-wasps. There is one kind which pursues the cockroach in the palm groves, a second which prefers to explore the ruins, a third

which drives out the *Lycosid* from its burrow, a fourth which investigates a web-strewn cliff. I then pass to three chapters of observations on caterpillars. One describes the growth of the larva of the puss moth and its remarkable machinery of defence. A second deals with the caterpillar of the lappet moth and the use of its extraordinary tufts. A third is concerned with the oleander caterpillar, its protective devices and manner of growth. Two chapters are given to the behaviour of spiders. One describes the habits of a circular architect and certain additions made to the snare for the purpose of securing defence. A second chapter deals with a tent-like tabernacle and the wonderful skill possessed by its owner of casting a lasso around the prey. Allied to the spiders are the desert *Solipugæ*. Their structure and habits receive attention, especially their manner of growth and development and the terrible battles that they wage by night. The last chapter will deal with some impressions of the desert, and observations on the locust swarm.

The photographs and sketches should add interest to the volume, the one being illustrative of local scenery, the other making clear the subject matter of the text. Wing-Commander Wiseman has very kindly presented me with photographs,

PREFACE

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and I am permitted by Mr. Eric Boesinger to make use of copies obtained from him. I have also to express my thanks to Miss Tassart for the care she has given to the preparation of my sketches when busy with other important work.

My record is largely one of battles and struggles, and of methods adopted by the different creatures to maintain their own in the contest for life. It is the product of individual study and taken direct from Nature's work. An oasis at the fringe of a burning desert is not the site that a naturalist would specially select, but we cannot always choose our place of study, and often an uninviting tract may be found to possess some charm. I have tried to make the best of what it offered and to glean from some of its most humble creatures the secrets of their little lives.

R. W. G. H.

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CHAPTER I

AN OASIS IN THE DESERT

Physical features of Iraq—Influence of river—Oasis near Bagdad—Gardens of oasis—Birds of palm grove—Returning to roost—The river—Birds of river—The desert—Fauna of desert.

IMAGINE a vast plain of desiccated mud, for the most part a barren waste. Spread it out in the shape of an elongated tongue. Traverse its whole length with two powerful rivers that flow like sinuous streaks of silver through the dismal sea of sand. Adorn these two streams with a mere fringe of vegetation, in which the tree of most abundance is the tufted palm, and the result is a moderately accurate picture of that tract of country which includes Iraq.

Iraq is that portion of southern Mesopotamia which is situated between the rivers. It is a strip of land, some 350 miles in length, with the Tigris on the east, the Euphrates on the west, its base at the north where it merges into Jezireh, and its apex at the head of the Persian Gulf. Throughout its whole extent it is a perfect plain. Its level uniformity is monotonous in the extreme, there not being a natural elevation of any kind to relieve the sameness of the unobstructed view. There is not

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even a pebble to be found on its surface. It is composed of the finest silt brought down from the mountains, and built up from an unknown depth by the sediments of its enclosing streams.

Considered as a whole, its aspect is forbidding. The bare desert, with no mantle but a scanty scrub, the miles of arid unproductive soil, the oppressive monotony of the endless plain, the dust, the heat, the unbroken landscape, and, not least, the character of the inhabitants themselves create an immediate aversion to Iraq.

But here and there, even in this wilderness of sand, are some pleasing and attractive nooks. They are mostly to be found in that fringe of verdure which clings close to the river bank. It is there that the naturalist will direct his interest. He will turn instinctively from the waste of desolation to explore the narrow belt of trees. He will descend expectantly into the river-trough where the folds of water swing across the plain in a changing sinuous course. It is only in that moist and fertile streak, in that line of silver edged with green, that he will find any richness of life.

He will soon observe how the bends of the river affect the objects which he has in view. For the Tigris pursues a most tortuous course. So acute and unexpected are its winding folds, that, in places, as he stands within a loop of the river, he may find himself encircled by the sails of boats as if they floated on the desert sand. These convolutions have a striking influence on the vegetation. In the concavities of the river the flow is swift, the

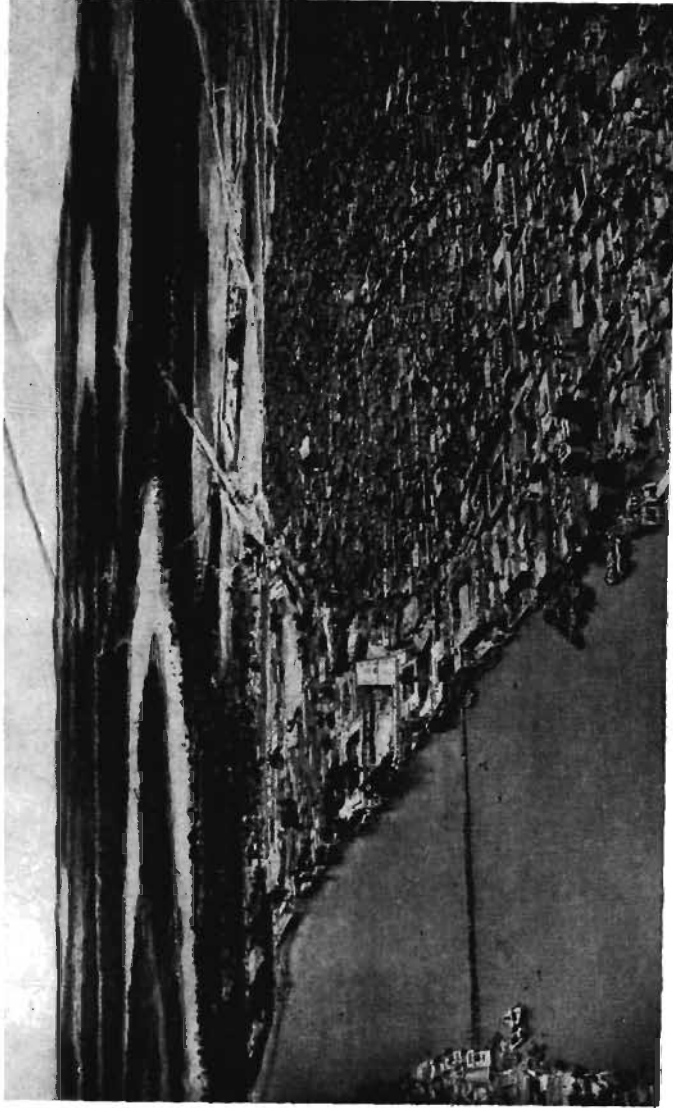
water is deep, the banks are sheer. On the convex sides the stream is shallow and the bank a low shelving shore. Water is thus more abundant on the concave sides, and, as a consequence of this, irrigation is possible. The bank is, therefore, lined with lifts and water-wheels constructed for the labour of the pony and the ox. The convexities, on the other hand, present considerable difficulty. The shallow water, the shifting bed, the long stretch of shelving and retiring sand are unsuited to the primitive arrangements of the country for raising the water on to the soil. The result is a remarkable contrast in the vegetation. The very existence of the verdant belt depends on the sufficient supply of moisture brought from the river to irrigate the sand. In the absence of water all is desert; with it there is a profusion of fertility and life. On the concave banks the animating fluid is driven in abundance over the plain. Enriched by the moisture, the soil bursts with fertility, and gardens, dense with an exuberant foliage, spring up beneath its living flow. Palms expand their graceful tufts and glow with luscious fruit. The water circulates in channels through these gardens and out into the cultivated plains. Villages collect along this fertile bank, and around them are the flocks of sheep and goats with the patient oxen straining at the wells. Moisture has clothed this concave shore and has filled it with a varied life.

Gaze across the river to the convex bank and we behold a barren desert. The contrast is often significant and profound. It is a testimony to the

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living force of water and the luxuriance that follows in its course. It gives the mind an impression of how a sinuous stream not only erodes on one bank and deposits on the other, but how it regulates the growth of natural abundance, and, as a consequence, the prosperity and existence of a people. It may be said that the water is the life-blood of this soil. Wherever it circulates through the thirsty earth it brings forth a profusion of life. We wander through the peaceful solitude of the gardens and feel the contrast with the encircling waste. We gaze with admiration on the mass of the vegetation, the stateliness of the trees, the splendour of the fruits, the brilliant colours of the varied flowers, the richness of the diverse forms. Lost in the silence of this crowded verdure, we recall the history of a prolific past when networks of irrigation vivified the desert, when the land was so nurtured and its produce so luxuriant as to make Babylonia "the granary of the world." We wonder if the future will repeat the past, and the desert again glow with life. To the river we look for the reinvigoration, trusting that the fluid will again circulate through the soil to yield its rich increase of vegetable life beneath the guidance of an industrious and enlightened people.

Let us concentrate attention, for the purpose of this volume, on one of these rich concave bends. It is situated three miles down stream from Bagdad, where the Tigris has ploughed an extensive hollow into its eastern bank. The city of the Caliphs will scarcely concern us. Its narrow streets, its roofed



HAVANA FROM THE AIR. Photo. W. Bourne.

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bazaars, its spicy perfumes and nauseous odours, its conspicuous mosques, its hidden churches, its jostling throng of oriental peoples—all these have an interest and diversion of their own. We see the Arab, the Jew, the Armenian, the Persian, the Syrian, the Chaldean, the Sabian, the Kurd; there are others such as the Turk, the Yezidi, or the negroid descendant of some African slave. It is a motley crowd of varied races that mingles in these gloomy streets. How many great nations do they call to mind, how many conflicts between mighty powers to achieve the conquest of the world! The empires of antiquity are represented in this flow. Babylonians and Assyrians, Medes and Persians, Hebrews and Saracens, they are all here, now fallen to a low estate and lost in the common drift of life.

But our business lies not with the motley crowd. Rather we will pass to the rich oasis that has formed in the concave bend. It is suitable ground for the investigations of the naturalist, being one of the most luxuriant of the many bends made by the river between Bagdad and the sea.

In this oasis the gardens are the most attractive feature. They are composed, in the main, of rows of date-palms, each tree exactly like its neighbour, tall and straight and branchless, and bearing at the summit a tuft of leaves. From a distance the palms appear dense and tempting; everything seems cool and sheltered beneath the rows of tufted heads. But the palm is an elusive type of vegetation. In reality it gives little protection from the sun.

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Between the separate tufts, even between the fingers of the drooping leaves, the fierce rays pour down on the underlying soil. So scanty is the shade afforded by the palms that other kinds of fruit trees ripen freely in the grove. Beneath their heads a garden often lies concealed. Though no thick undergrowth binds trunk to trunk, yet the ground is often sown with wheat; limes and apricots are planted in the grove, vines entwine their tendrils round the trunks, and pomegranates thrive beneath the shelter of the branches. A glow of colour fills these gardens when the fruit trees are in full flower. But they are specially alluring when the fruit is ripe. The season opens in May with a harvest of mulberries, soon followed by the apricots, apples and plums. In July appear the peaches, in August the figs and grapes. September is the month of chief importance for it is then that the dates are ripe. The huge masses of fruit hang down from the tuft which shelters them in an arching canopy above. Each is like a bunch of golden grapes, but immense and massive, and bending the stalk by reason of its great weight. There are some which are purple like dense heaps of plums, but for the most part they appear as golden clusters drooping from the roof of green. The cold season arrives with the plucking of the dates, but it does not end the succession of fruits. In November appears the autumn harvest of pomegranates, oranges and limes. It is not only the delightful wealth of vegetation, but the wonderful profusion of these many fruits that makes such a contrast with the surrounding waste.

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The summer evenings in these gardens never fail to be delightful, so profound is the relief on entering the verdure from the stretch of barren sand outside. The glare, the dust, the desolation are forgotten as we plunge into this mass of green. In places the gardens lie in deep shade, not cast by the palms, but by the thicker trees. In other parts the sun pours down between the branches brightening the interior with patches of light. There is a tropical stillness within the vegetation. The air is calm, being confined by the foliage, and laden with moisture from the water-sodden ground. Not a breath may exist to move the branches or relieve the feeling of oppressive heat.

But all parts of the oasis are not so cultured. Certain patches of it suffer from complete neglect, being in some way unsuitable for the making of canals. There the native vegetation is established, either a jungle of liquorice or of thorny acacia, a profuse abundance of bushy tamarisk or a thicket of small poplar trees. It is a coarse and dusty brushwood tangle compared with the fertile groves. Yet there is something of a simple charm in its roughness. For this is the natural covering of the country, the best produce of its untilled soil.

The gardens are the home of many kinds of birds. For some it is a place of permanent residence; others come to it as seasonal visitors; others halt in it just for a day or two while passing on their migrant flight. The black and white crow lives in the palms from where it makes journeys to the river bed, the babbler loves to skulk in the trees,

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while the bulbul flies from branch to branch and utters its pleasing note. In the groves we hear the gentle cooings of the doves, we see the wood-pigeons clattering their wings in flight, the rollers flashing in streaks of blue while pursuing their nuptial evolutions in the air. A delightful little warbler visits it in summer. This is the grey-backed *Agrobates*, confiding, active, always flirting its tail, hiding its nest behind the stem of a palm and lining it with the skins of snakes. In winter come the song thrush and the Persian redbreast, birds with the same familiar habits as those of an English hedge. At this time we see the kestrel hovering in the air, and the buzzard either searching the edge of a jungle or seated on some conspicuous point. Many birds of passage halt in the oasis. One day we see numerous chats and warblers; on the next we find that all have disappeared. In the scrub we are likely to meet other kinds of birds. A wren warbler runs through it like a frightened mouse, a partridge shoots up with a whirring noise, a nightjar rises from the broken clods, then turning aside with a sudden swerve, sails off in a noiseless flight.

At evening a varied throng of bird life pours into this verdant tract. When the sun is near the horizon the flow commences, down the stream and in from the corn lands, attracted by the dense growth. From the city come the sparrows in multitudinous flocks, from the fields the doves in smaller parties, in September come troops of migrant wagtails making a halt in their south-easterly course. At sunset the oasis is alive with birds, especially an

island laden with scrub cut off from the main mass of land. The air is then filled with their moving flocks and the trees with their chattering noise. Myriads of winter visitors roost in the oasis. Here comes a party of clamorous starlings, here a detachment of leisurely kites, here black clouds of tumbling rooks, collecting, wheeling, breaking asunder, and then disappearing through the heads of the palms.

The river, which is the source and life of the oasis, adds its own share to the attractiveness of the spot. Inconstant in volume and ever changing in direction, it varies considerably at different seasons of the year. In March and April it is swollen to a flood derived from the melting of the snow on the mountains; in winter it is studded with shifting islets and contracted to a scarcely navigable stream. The river is delightful on those summer evenings when the gardens still retain their oppressive heat. There is a feeling of relief with the sinking sun. It either pales away in a cloud of dust or else disappears through a pure sky illuminating the water in a blaze of fire. The tempestuous floods have then subsided and the river moves with a placid flow. It is usually laden with a fine silt, and though never blue or of clear transparency, yet its glassy surface mirrors back to view the images of graceful palms. We hear the echo of voices, the moaning of water-wheels, the splashings of reptiles as they slip from the banks, or the fish when they spread their circles on the stream. The gulls and the terns often congregate in flocks, either falling precipitately into shoals of fish or snapping up

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insects from the surface of the water. The stately herons parade the shallows; the storks sail down in wedge-shaped order or circle in majestic flight. We see the kingfishers employed at their persistent work, the pied species hovering stationary in the air, the little blue kind perched upon some point of vantage waiting its chance to make a downward plunge. Certain shore birds come out to hunt the water. The bee-eaters drop into it after the manner of the kingfishers, the pratincoles scour it in circling flocks, the hirundines just gently touch its surface as they glide to it in graceful curves. In winter we see the wagtails searching the banks and the sandpipers racing along the islets of mud. We hear the greenshank uttering its piping cry and the lapwing its more plaintive note. The voices of the birds that visit the river are in keeping with the peaceful scene.

Beyond the reach of the river and outside the vegetation there is nothing but the silent desert. The contrast is profound. Here is the deep green of the majestic trees, there the brown inconstant sand, bare, immense, apparently illimitable, shimmering with heat, blazing with light, and smooth as an even sea. The desert presents to us a boundless landscape "like the round ocean girdled with the sky." It is more impressive than a prospect near at hand, than the view of a forest dense with verdure or the vision of a mountain range. The mind is here affected not by what we see, but by the consciousness of all we are unable to grasp. It is the silent solitude, the limitless immensity, the

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feeling that our vision is extending to the infinite and that we are lost in the vastness of things.

At first sight the desert looks utterly barren. What can inhabit this ocean of sand? Where is the moisture to supply drink, the food to support life? But we find that it is not so completely destitute. Here and there it supports a thorny growth, either a plant called "shok" which the Arabs use as fuel, or a mimosa on which the camels feed. Even animals frequent it in fair abundance. Of these the gazelle is the most attractive. Gracefully built and possessing wonderful speed, it roams the desert, feeding on rough herbage, sometimes in considerable herds. In broken places we will meet with the desert fox, an elegant little species, grey to brown in colour, with a white tip to its luxuriant brush. Its haunts are the mounds and the old canals where it hides in a substantial den. The jumping jerboa is a pretty little creature and eminently fitted for a desert life. It is like a small rat with soft silky fur pale as the desert sand. It moves in leaps like a tiny kangaroo, its long hind legs being specially built for that purpose, and its slender tail, ending in a tuft, that enables it to twist and swerve.

The desert is the home of certain kinds of birds, most of which blend with their desolate haunts. Vast clouds of sand-grouse often blacken the sky as they move from their feeding-grounds to the places where they drink. We may chance to see a bustard racing over the sand or a cream-coloured courser crouching low on the ground in the hope of

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being passed unseen. Summer is the time when the Persian bee-eater collects in large flocks that nest in the sand and speckle its surface with points of green. In winter arrives the little desert wheat-ear, an active species of an isabelline colour, that loves to flit about the thorn. The same season brings the steppe eagle and the buzzard. From a distance we may note their conspicuous shapes as they rest on the bare expanse. They have no need of a protective colouring. No enemies more powerful than them exist; their struggle is for sufficient food.

Such is a brief outline of this varied tract. Three elements compose it, each with its attractions: the luxuriant oasis, the sinuous river, the sea of level sand. It is the oasis which will chiefly concern us. Let us pass to consider its natural history. We shall try to glean a few facts of interest from this garden in the sandy waste.

CHAPTER II

THE HABITS OF THE AMPULEX

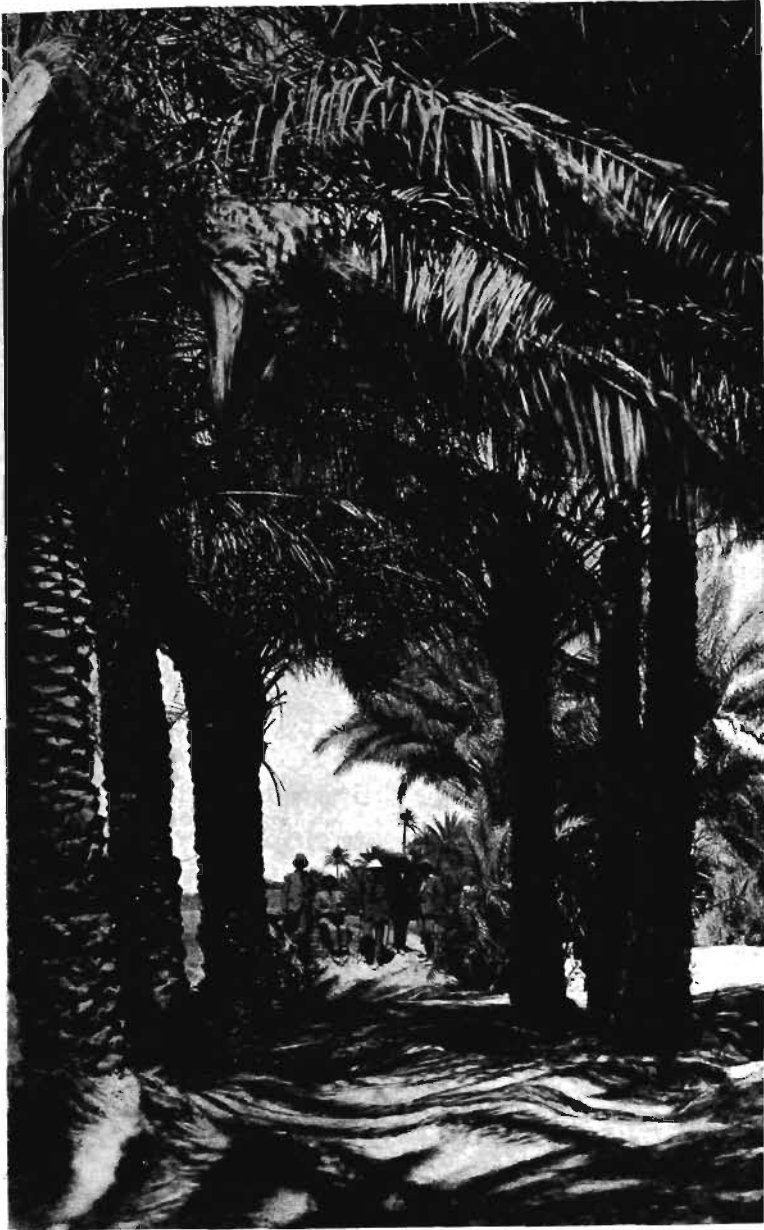
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Search for victim—Characters of victim—Mode of expulsion—The pursuit—The struggle—The conquest—The place of internment—The transportation—The internment—Nature of sepulchre—Condition of occupant—Anchorage of egg—Development.

LET us visit in June one of the more open palm groves, not those filled with a dense vegetation where the orange, the pomegranate and other splendid fruit trees cast a deep shade amidst the stately palms. A less obstructed garden will better suit our purpose, one which is given up exclusively to the date-palm except that the underlying soil has been turned over by the plough. There is little to be seen but the long rows of masts with their summits crowned in tufts of leaves and supporting green bunches of fruit. The sun is blazing with an intense heat; it pours like a furnace through the scanty foliage, streaming in between the spreading leaves that hang down like graceful plumes. The broken soil beneath is baked and fissured, the surface vegetation parched into dry stalks, the trunks of the trees are burning to the touch, and the air is like that which issues from an oven, unless tempered by some welcome breeze. The noble

palms, too, would wither in the heat were it not for the network of artificial streams.

Delighting in this fiery blaze of summer, and increasing in enthusiasm as the thermometer rises, is a little blue wasp, the *Ampulex assimilis*, Kohl, of which numbers at this season pursue their activities throughout the burning grove.

Though of small proportions, it is rich in colour and shines like a brilliant azure jewel in the strong illuminating rays. It is a lustrous diamond of the first water, far exceeding in its coat of splendour the host of unassuming inhabitants of the grove. The female is perceptibly larger than the male. In proportions she is slim, in appearance constricted, and in length about three-quarters of an inch. Her flattened head projects into a broad beak which overhangs the curved, pointed jaws. On either side are the black, bulging eyes and in front the long, articulated antennæ twisted into spiral threads. A slender neck unites the head to the complicated thorax, which is fashioned in three conspicuous parts. The front piece is small, oval and depressed; the intermediate segment stout and massive and raised into an irregular hump; the third piece is a square-cut block ending in a truncated base. The waist is a delicate, ant-like thread; the abdomen an elongated oval mass with a constriction at the anterior end and terminating in a fragile sting. The legs are of the ordinary wasp-like pattern, and the wings transparent without any colour beyond a faint dusky tinge. She is clothed in a scarcely perceptible garment of a few pale scattered hairs.



A PALM GROVE NEAR BAGDAD.

Photo. Wing Commander Wiseman

THE HABITS OF THE AMPULEX 31

Let us look more closely at her manner of adornment. A profuse and delicate pattern of sculpture is carved on her chitinous skin. Little pits have been dug into her head and chest, also on her abdomen and the bases of her legs. Furrows have been gouged out of the hind segment of her thorax, and these have been connected by a transverse series of fine striated lines. Her whole body appears as if fashioned by the chisel, and this delicate workmanship must be the main cause in the production of her iridescent sheen. For though so sparsely clothed, yet she is rich in beauty. Every part of her sculptured surface radiates a metallic gloss. For the most part the colour is a deep blue, but it flashes and fluctuates into other tints like the lustre from a precious stone. Different lights give forth inconstant gleams. We see the violet of the amethyst, the green flash of the turquoise illuminating the intense blue. The *Ampulex* is a living jewel passed unnoticed in the grove of palms.

The main business of this wasp is the pursuit of the cockroach. We observe it incessantly racing up the date-palms, its metallic coat glistening in the sun, quick and active in every movement, the tips of its antennæ gently curled outward and all the time trembling and playing on the tree. There must be hundreds of them thus engaged in the exploration of the palm grove. Every tree is submitted to examination, and, though each individual keeps strictly to itself, yet at times we may see two or three or even more busy on the

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same trunk. It is moderately shy, and suspicious of intrusion. Up one tree, then down to a neighbouring tree, every day and all day, even when the sun is hottest, the gaily-coloured insect is continually on the move. Life seems to have for it no other purpose beyond this everlasting bustle and haste.

Both males and females are to be seen on the palm trees. The males are distinctly the more abundant; they are smaller in size and more agile in their movements. The females, in comparison, are decidedly sluggish, inclined to delay and to push themselves into crannies, while the males race upward with scarcely a pause. The insects seem clearly in search of something. The fine trembling of the antennæ is an indication of ardour, and there is an air of exploration in their incessant haste. Moreover, in their ascent, they often deviate to one side as if to determine if there is anything to be found. The fact is that they are making the keenest scrutiny. For the males it is the amorous pursuit of the females; for the females the capture of a living prey.

Let us follow the females in their absorbing quest. It will need some patience to determine all the details, and our efforts will largely depend on chance. Though less energetic than the ardent male, and on the whole quieter than many of her tribe, yet she is equally tireless and persistent in her search. There is no noisy buzzing nor flirting of her wings, but she pursues a quiet and methodical investigation as befits the deadly purpose in hand. Holes and crevices are the places that attract her

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whether the search is made on the soil or on the tree. We follow her in and out amongst the nodules of earth, now pushing in between them, now penetrating underneath the lumps. Likely spots are the hollows under broken clods, especially where the soil has been ploughed up or heaped at the margin of an irrigation stream. We see her similarly investigating the trunk, visiting every hole in her ascent. She plunges into cavities, dips into round tunnels, sometimes merely pushing her head curiously into them, at other times remaining for a minute or two inside. On occasions she may drag out material from some fissure, realizing that beneath is a likely cavity which it is worth her labour to explore. At length in her ascent she arrives at the summit, finds her way into the tuft of leaves and there continues the same careful search.

Though crevice after crevice produces nothing, yet never does she seem depressed by failure nor lose the ardour for this untiring work. Sometimes she seems to realize the whereabouts of her quarry, giving vent to an outburst of additional enthusiasm as she searches for some fissure through which to drive it forth. Never for an instant does she appear idle. Her whole effort is given to the task. What profusion of energy does she not expend when all the enthusiasm of a short existence is concentrated on one vital act.

In her mode of exploration she is distinctly systematic. She first alights at the foot of one tree, steadily ascends until she reaches the summit and then flies down to the foot of the next. This

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is a procedure which many creatures follow when exploring a perpendicular stem. We see the woodpeckers and the creepers adopting it in the forest, the humble bees when they visit a spike of flowers. Thus the wasp pursues a not uncommon habit, though it does not always keep rigidly to such a plan. A downward climb is a frequent occurrence, and often it suddenly abandons the tree long before arriving at the top. The sun is the timepiece for these operations. Work begins in the morning soon after its appearance, and continues until it sets. A cloudy day, rare at this season of the year, will bring the operations to a temporary check. It is when the orb is at its brightest and hottest that she revels in excessive ardour and haste.

All this effort is directed to the capture of a cockroach. It belongs to the species *Shelfordella tartara*, Sauss, and is an oval-shaped, flattened, mahogany-coloured insect of considerably larger dimensions than the wasp. Its head, which is fashioned like a rounded shovel, mounts a pair of long antennary threads. Its abdomen is divided into conspicuous segments exposed owing to the abbreviated nature of the wings. Being swift of foot, it is difficult to capture, while its smooth, compressed and polished body allows it to slip into the narrowest clefts. It inhabits no particular burrow, but lives in broken soil or under lumps of earth or in a tunnel on the trunk of a tree. Any odd crevice in almost any place may supply a valuable conquest for the wasp. In its movements it is almost exclusively nocturnal, coming out after dark for

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the purpose of scavenging, but remaining in strict seclusion by day. Being so reclusive, it must be sought for in order to be seen. In the dusk we may observe it prowling about, or we may happen to alight upon a compact group if we turn up the clods of soil. So far as I have seen it is this species only which fulfils the requirements of the wasp.

If we persist in our close attention we are likely to witness a successful search. The wasp disappears underneath a clod. Suddenly a cockroach comes out with a rush, clearly expelled from its dismal hiding-place and aware of the close proximity of its foe. Without a moment's hesitation it dashes off, slipping over the ground at considerable speed. If the wasp is well placed, she will be close upon its heels. The pursuit may then be short, perhaps only a foot or two, being just a swift rush and the capture is secured. But often she is slow at following up, and may be still searching underneath the clod while the cockroach slips into some fissure elsewhere. In this way she loses many a chance, the cockroach is so quick, almost like a pink flash, and the wasp can follow only by sight. At other times I see a long and difficult pursuit. The huntress, though soon drawing near to her quarry, seems unable to come to immediate grips. Both race madly over the soil, the wasp just a little in rear of the cockroach, the latter often making unexpected turns, doubling skilfully around obstructions like a hare in its efforts to shake off pursuit. Yards may be covered in this exciting contest, impediments such as lumps of earth and fallen debris may be

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circumvented, but the wasp keeps persistently at the closest quarters, following scarcely more than an inch behind her quarry, and watching for an opportunity to get a grip. If the cockroach finds a chance it will slip into some fissure or quickly thrust itself beneath a pile of leaves, but the active wasp is soon behind it; the quarry is again driven to the exterior and the mad enthusiastic chase resumed. The cockroach relies altogether on its speed. Moreover, being wingless, it must keep to earth and put up the best contest there. Such a spectacle is not uncommon and is easy to witness. The palm grove gives shelter to many a tragedy, but few are more fascinating than the azure wasp swiftly pursuing the tawny cockroach in the mad race for life or death.

All of a sudden the contest terminates. Some advantage has offered, though we cannot detect it, and the wasp, coming in with a final rush, grips the escaping prey. She seizes it by the projecting edge of the thorax, holds it down firmly to the ground and immediately applies her sting. The wasp, when introducing it, lies almost on her back. Her abdomen is bent in beneath the body of the cockroach, the tip is then directed upwards, the long and slender spear extruded and plunged straight into the victim's breast. The thrust seems to be made a little to one side, though it may be actually in the middle line. She now remains motionless, fixed in this position, her jaws rigidly clenching the thorax and her sting plunged in the ganglionic cord. It is a prolonged operation. The barb is kept in

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place for perhaps half a minute, the wasp all the time remaining firm as a statue while the poison flows into the vital point. It is a skilful thrust of incomparable perfection, striking down the victim at a single blow. The cockroach puts up an indifferent struggle, though it has not a chance against so powerful a foe. At length the huntress withdraws her sting. The cockroach, though injured, is not sufficiently overcome. It makes a half-hearted effort to escape, which again excites the fury of the wasp. The same dramatic scene is then repeated. Another stab is given, equally steady, equally prolonged, and exactly in the same spot. This is the final stroke of victory, and ends the battle near the foot of a palm.

What possible chance has the feeble cockroach? Its jaws, though fairly strong, are unfitted for fighting, and its legs, even with their system of sharp radiating spines, are quite useless as weapons against the armour of the wasp. The cockroach is unable to assume an offensive. Once the grip is taken, the end is sure. All that is necessary is one further stroke to decide the conflict in favour of the wasp.

Such is the general plan of battle. On a subsequent occasion I see another contest. It is merely a repetition of the previous strategy, the same grip on the thorax, the same quick tussle, the same straight plunge into the front of the chest. But in the previous contest two stings were given, while on this occasion only one is required. Thus sufficient are applied to fulfil the purpose. For the

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hymenoptera deal in no half measures. Victory must be thorough and complete.

The struggle is over, and the defeated cockroach lies paralysed on the ground. Then follows the withdrawal of the weapon, an operation performed with the same steadiness as when it was thrust in. Before sheathing, it may need a little attention. The wasp will then stroke it with her hind legs as if to cleanse it after the deadly work. This is a sign of final victory, an indication that she feels the tragedy to be complete. She now makes no further delay or hesitation, scarcely gives even a glance at the object of her conquest, but turns aside from the helpless victim and makes off in the direction of a neighbouring tree.

This is the opportunity to examine the cockroach. Though prostrate, nevertheless it is far from dead. It appears completely dazed and unable to exert itself, yet, when examined, is found not to be so helpless. It can stand up, can move its antennæ, can exert its legs, though not very efficiently, and, when pushed, may even make an attempt to walk. But, unless urged, it shows no sign of movement. The wasp has rendered it so quiescent that it lies immobile until her return.

Also we observe that the cockroach is a female. This is the case with every capture. Never does the *Ampulex* secure a victory over one of the sterner sex. The reason is explained on more intimate acquaintance. We will notice that, sometimes, the wasp drives forth, not the ordinary wingless quarry, but a pale yellow cockroach with large wings and

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excellent powers of flight. This paler insect is the active male. Like the female he is eager to escape his pursuer, but, being better equipped, he can take to the air and thus more easily escape the wasp. The female is the invariable victim, because, being wingless, she must keep to the soil. She now lies completely defeated, and we wait in patience for the next act.

The *Ampulex* has gone off to find a place for internment. If fortune favours, this may be an easy matter. She may meet with a tunnel close at hand, though more likely she may have to make a search. While thus employed, she cannot keep guard over her capture, nor can she drag it indiscriminately about. For a time it must be completely abandoned, and allowed to remain exposed on the soil. In her absence there is not much risk of its escaping; her work has been too perfect to permit of this. Sometimes the search may be so prolonged that she will not see her capture for half an hour, yet, on her return, it is in the same place, so efficiently has her paralysing operation been performed. She has more to fear from the numerous marauders in the neighbourhood. There are beetles in search of animal refuse to whom a helpless cockroach would be a valuable prize. The social hymenoptera will take it if they find it, so will the spiders that climb about the bark, or the active companies of carnivorous ants. Its immobility will prevent it attracting much attention. Also, at intervals, she may return to inspect it. But beyond this she takes no elaborate precautions.

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She relies on the hope of no plunderer finding it, and on her own rapidity in discovering a lair.

Her search for a cemetery is made on the palm tree. As a rule there are holes available in plenty. Longicorn beetles have been boring in the palm-trunk, and have left behind them well-protected galleries excellently fitted for the purpose of the wasp. If these are not at hand, there will be tunnels in the ground. The sun has split the soil into numerous fissures, and there are holes once occupied by cylindrical roots. But the trunk of the tree is the place of selection. Nothing could be better than the galleries of the beetles. They are cemeteries ready for immediate occupation, deep, capacious, secure from interference, and surrounded by a rigid wall.

She is meticulously careful in the selection of a burrow. Attention may be given to fifty or more of them, the full height of the tree may come under observation before the final choice is made. No doubt its depth and dryness have to be considered, also the capacity of its interior, and probably the smoothness of its walls. Depth and dryness must be essential with regard to security, while sufficient capacity and internal smoothness will be necessary requirements for the occupant's growth.

Having finished her long and careful survey, and having settled at last on a suitable cemetery, she returns to drag her captive off. In this she shows an excellent memory for location. While absent she has busied herself with numerous investigations, examined and re-examined all kinds

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of places. Her mind must have received a crowd of impressions, yet she returns with accuracy to the scene of the tragedy, and, after making a few short turns in the vicinity, comes direct to the helpless spoil. Its removal to the cemetery is her next undertaking. There is not much trouble about this operation. The wasp is strong, the cockroach not too burdensome; moreover, she is very skilled in this particular manipulation, and can drag the load, with scarcely a halt, up a perpendicular ascent. She seizes the cockroach by the base of the antennæ, and advances backward, straining steadily on the ropes. Here she may encounter some preliminary obstruction. The victim, though paralysed, may still make resistance. As she drags on its antennæ it may refuse to budge, and thus give her a little annoyance before she gets it properly on the move. Soon, however, it desists from a futile opposition, and then, as a rule without further obstruction, she steadily forces it to yield. It comes head foremost, as if in ordinary progression, though not so helpless as to prevent the normal movements of its legs, which make it look like a captive being walked along. As a man when he drags an unwilling animal, so does the wasp haul on the cockroach through the intermediation of the antennary ropes. Occasionally the victim is transported on its back. This is more laborious owing to the friction involved, and is, therefore, less efficient than the reverse method by which the stupefied capture is made to walk to its doom. The haulage is a quiet and persistent effort. There is no delay, neither is

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there any bustle; it is just a steady and unyielding pull. She is as perfect at these funereal ceremonies as she is at the application of her murderous strokes. Superficial obstructions scarcely impede her. On she goes over clods of ploughed up earth, in and out amongst the shrivelled stalks of grass, then up the slippery trunk of the date-palm in the direction of the selected hole. When some little distance from the place of internment, she temporarily lays down her load. Abandoning it for a moment, she runs off to the tunnel, returns again, hauls it on a little further, and makes three or four more similar examinations before finally bringing it to the gate.

The chief point to notice in this act of haulage is the persistent utilization of the antennæ as ropes. The wasp never fails to employ them for this purpose. Moreover, it is a habit of considerable importance. For if she fastened on a leg, or on the flank, or on the tail, or anywhere else except the head extremity, she would certainly lose the important advantage of being able to make the capture walk to its grave. While the cartage is in progress I sever the antennæ. The wasp seizes on the broken stumps, and these shortened tow-ropes serve her purpose fairly well. I then cut off the stumps almost flush with the head. Just the tiniest tags of antennæ remain. Yet the wasp persists in getting a hold of them; she will clutch her capture nowhere else.

The last of her preliminary inspections of the tunnel is made when the capture is almost at the

door. On emerging this time, she takes a final purchase and walks the cockroach head-first in. Now she remains some minutes in the interior. Important manipulations are occupying her attention. An egg is being layed, not just haphazard and deposited anywhere, but being applied with the most perfect nicety at one fixed and all-important point. At length she emerges, content with her performance, takes her stand at the entrance, licking her tarsi and stroking her antennary threads. She may give another short glance into the gateway; then she is off to find a nodule with which to bar the gate.

The work of closure, which she now undertakes, must be completed without delay. It is not enough to lodge the capture in a sepulchre; the entrance of the vault must be firmly barred. She may find material for this purpose in the neighbourhood. On the other hand she may have to travel long distances in search of it, even descending to ground for the necessary stuff. On the tree-trunk she meets with a mixture of materials, little pieces of wood, dry fibres of the palm, the dusty remains of tattered cobweb, perhaps the scales of a cast-off snake-skin or the flakes of broken shells. On the ground she will find a richer supply in the form of nodules of earth. All these things may go to the manufacture of the barrier. First she brings one piece, carries it in, takes it down until almost in contact with the occupant, then goes off to fetch another lump. More and more of the heterogeneous fragments follow, some small and not unshapely,

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about the size of a pea, others larger and more irregular chunks that only just fit into the hole. She works with the same persistence as in all her operations. Dozens of loads follow one after the other. The tunnel is deep. It is almost the dimensions of the little finger. Hence much labour will be necessary and many loads must be carried before the cavity is filled to the brim. The searching is more tedious than the actual transportation. Often she may wrestle with some woody fragment too firmly fixed to be torn from the tree, and three or four minutes may sometimes be spent in the search for a suitable load. In the end, however, she completes the rampart. It is a close-fitting, tight and compact plug. Beneath it is left a substantial prison in which the occupant has room enough to turn about.

I have said that sometimes an internment takes place in the soil. But the conditions there must be less satisfactory. The walls are not so rigid; the surroundings are porous. The one advantage is the quantity of earth in the vicinity which can be used for closing the gate.

The wasp resents interference while employed at the imprisonment. A male happens to invade the sanctity. She rushes to oppose him. This is not the time for amorous advances, hence he is quickly driven off. While in search of material she encounters a female. A contest, with some show of resentment, follows. Facing one another, they come to blows, each dashing at her opponent, head to head, until after six or eight rushes and retire-

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ments the enemy is driven away. I alarm her myself by too intimate inspection when she is engaged at the building of her plug. She immediately *flies off, makes a few frightened circles in the vicinity, and then thinks of returning to her work.* But, like a bird, when turned away from her eggs, she does not come back direct to the nesting-place; she alights on the tree a little distance away, from where she makes a tentative advance.

I have seen her, after dragging the cockroach to its sepulchre, become suddenly dissatisfied with the nature of the cell. An outburst of active annoyance followed. She came out from the tunnel, rushed into it again, then bustled about in the near vicinity, thrusting herself into other holes, returning to the previous one, and all the time most obviously disconcerted, and far from satisfied that all was well. There was another hole close by to which she paid attention. This she selected as an alternative sepulchre, dragging out the victim from its original tunnel and lodging it in this second grave.

I open one of these tunnels after the plug has been secured. The wood has to be hacked away with a knife in order to reach the bottom of the well. I find the tunnel to be deep and substantial. In section it is oval, wide enough to admit the point of a finger, and about three inches in depth. It is directed vertically downwards, furnished with smooth and rounded walls, and on the whole a most excellent cemetery perfectly secure in the impervious wood. At the extreme bottom lies the cockroach,

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its ventral surface directed upward and its antennæ turned towards the gate. It does not show much sign of serious injury, appearing as if dazed rather than paralysed. Its antennæ work, it can raise its legs, and shift about in a half helpless way. I remove it from the chamber and it kicks vigorously. When placed on its back it can easily right itself. It makes attempts to walk, though its efforts are disordered, being still under the influence of the poisonous thrust. But it has clearly undergone a kind of resurrection. While the gate was being closed much vigour has returned to it, and now it could easily escape from the chamber were it not for the thickness of the plug.

This rapidity of recovery explains the purpose of the operator. Her object is to secure a temporary paralysis, to lay the cockroach low and keep it stunned until the duties of burial have been brought to an end. The stab into the chest secures quiescence till such time as the wasp shall have found a cemetery. During this critical period the capture must be abandoned, and were it not placed in a comatose condition, it would make its escape in the absence of the wasp. All the labour and spoils of battle would then be hopelessly lost. There are other wasps which bring about a permanent paralysis, as, for example, the *Eumenes* and the *Rhynchium*, which store caterpillars in cells of clay. In their case the paralysis, by being so prolonged, may be a necessary condition for the growth of the larva. But here we have merely a temporary purpose, though one indispensable to the

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work of cartage and the duties connected with the closure of the grave.

A brief inspection shows the further design of the wasp. Her egg is attached to the body of the cockroach. The middle leg on the right side is the place selected, and the egg anchored to the outer surface of the thigh. The femur of the cockroach is broad and flat. It is also smooth, with good surface for anchorage. The egg lies obliquely along it, occupying about one-half of the length of the shaft. It is firmly held by one point of fixation with its upper end tucked in beneath the edge of the thorax and its lower end turned down towards the femoro-tibial joint. The egg itself is like a tiny sausage, one-tenth of an inch in length.

This place of anchorage is invariably chosen. On subsequent occasions I find other examples with the egg always in the same place. The only deviation is in the side selected. She may fix it indifferently to the right or left, but always to the outer surface of the middle leg. When the cockroach moves we see the purpose of this instinct. During the ordinary action of progression the egg will not be liable to suffer harm. Being fixed to the outer side of the appendage, it cannot touch either the leg in front or behind, nor that of the opposite side. Moreover, it is safe from external objects by the thorax, which juts over it like the edge of a roof. Thus the cockroach can kick and turn about, while the egg, though it moves with the movements of the limbs, yet is not exposed to pressure or friction nor likely to come to any harm.

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We know that wasps of the genus *Sphex* are equally careful in the affixation of their eggs. They always secure it to the breast of the capture, which is usually a cricket expelled from the soil. The great observer, M. Fabre, gave an explanation of this instinct. He believed that the one insensible part of the cricket was the spot where the wasp had inserted her dart. That spot is the front of the thorax, and the wasp gains a special advantage by choosing that particular point. For it is there that the larva will begin its feed. The time will come when it must nibble at its host, and if the skin is sensitive, then the cricket will struggle and in all likelihood shake the larva off. The wasp selects the insensitive spot because there the larva can commence operations while the cricket is oblivious of its doom. Compare this with the instinct of the *Ampulex*. In her case we must look for a different explanation. She attaches her egg to the femur, a part of the body no more insensitive than any other spot on the cockroach's skin. The purpose in view is here more simple. She chooses the spot where her egg will be secure.

Such is the fulfilment of all the wasp's activity. The long search, the struggle, the cartage, the internment find their climax in the anchorage of this tiny egg.

Let us consider the developmental changes that occur in the dark recesses of this grave. The living occupant is so buried that it cannot escape. Its future is to render up its substance to provide nutriment for the offspring of the wasp.

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The egg is elongated, with rounded ends, bent along its length into the very slightest curve, and of a slender ovoid shape. Its colour is a palish yellow and its surface delicately smooth. No change occurs in it on the day following the laying, but on the subsequent morning I observe that it has burst. Through a rent in its capsule a larva has emerged and has fixed itself to the same spot. It is pale in colour like the fragile egg, fusiform in shape, with pointed extremities, and body faintly divided into rings. Its emergence does not seem to have affected the cockroach, which is quite active, without any sign of injury, and, if released, will run off with the larva attached.

Such success as this does not always follow. Often the egg fails to develop, probably owing to an absence of fertilization by the male. Its capsule collapses, it becomes dark in colour and shrivels into a mere speck. On such occasions the cockroach seems to recover completely, which shows that the stab, in spite of its virulence, can have no permanent effect. I kept one for a week after the egg had died. It showed no sign of any weakness or injury, but ran about ordinarily on the floor of its box as though it had never experienced a sting.

But we must follow the stages of the living larva. By the evening of the third day it has grown considerably and its colour is a trifle darker in shade. It is fixed in exactly the same position, lying against the upper end of the femur, immediately below the basal joint. The cockroach still

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shows no sign of inconvenience and passes its excrement into the cell.

By the fourth day it is oval, smooth and shining. Its integument is thin and tightly stretched; through it the deeper organs can be seen pulsating like waves of fluid beneath the skin. The rings on its body are definitely marked. It is pale towards the head extremity, darkish at the other end, and is marked with a thin white line along the length of either side.

It has reached the full length of the cockroach's femur by the morning of the fifth day. It is now a bulbous mass, looking something like a swollen tick filling up the cleft between the first and second legs. A fine dark streak has appeared along the middle line of the back, and a delicate system of white radiating tubes shows through the thin skin. It is still attached to the same point, where it nibbles away at the surface of the femur, sucking up nutriment from the integument of its host. The larva must be now an inconvenience to the cockroach, since it has grown to the size of the latter's head. Nevertheless, the cockroach is still fairly vigorous and can kick about within the confines of its cell. The marks of the parasite are visible on its body. The surface of its femur is roughened and corroded due to the action of the larva's jaws. They are the earliest external traces of the slow consumption of its living flesh.

On the evening of this same day I look to it again with the object of recording its further growth. But, to my surprise, the larva has

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vanished. It is no longer attached to the cockroach's body, nor can I find it in any part of the cell. At first I imagine that the cockroach has devoured it and thus got rid of a loathsome guest. But the conditions are not likely to permit of such an accident. The position of the larva is so advantageous that the mouthparts of the cockroach are unable to reach it, and the strength of its anchorage is so firm that it cannot be shaken off. But the larva, in reality, has suffered no disaster. Its disappearance is explained by a dissection of the cockroach. I then find that it has burrowed through the integument of its victim and is now embedded within the skin. Hitherto it has been a mere appendage; it is now an internal guest. The change is necessary for its further development. While small, it gained sufficient from the surface of the femur, the erosions showing that from the hard appendage it could suck out a little food. But such will not provide for its increasing bulk. Hence it penetrates the body of its host. But how will the cockroach endure such a catastrophe? Strange to say, it is extraordinarily active. I remove it from the chamber in my search for the lost larva and it makes a fair effort to escape.

The next morning I make a more careful examination. The larva has grown immensely in size. It is lodged in the front of the cockroach's belly, where it fills about the anterior half. In appearance it is a large white fleshy maggot, which wriggles about in the midst of the entrails and pulsates beneath the rigid covering of its host. Having incarcerated

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And here I must leave the story of its development. I am called to the hills on other duties and can no longer wait for the inmate to emerge. My last act is to open the abdomen of the cockroach. Within is a partially developed wasp, delicately formed, gently folded, and lying in a passive dormant state. Soon it will awaken from this peaceful slumber. It will burrow through its enclosing sheaths, ascend the tunnel, eat through the plug and come out to explore the grove.

CHAPTER III

A HUNTRESS OF THE RUINS

Ruins of Iraq—Characters of wasp—Her explorations—Subterranean penetrations—Amours—Her quarry—Her enemies—Expulsion of spider—The pursuit—Sight or smell—The combat—Severity of paralysis—The period of delay—The transportation—Contests with plunderers—Reason for delay—Attempts at disinternment—The sepulchre—Closure of grave.

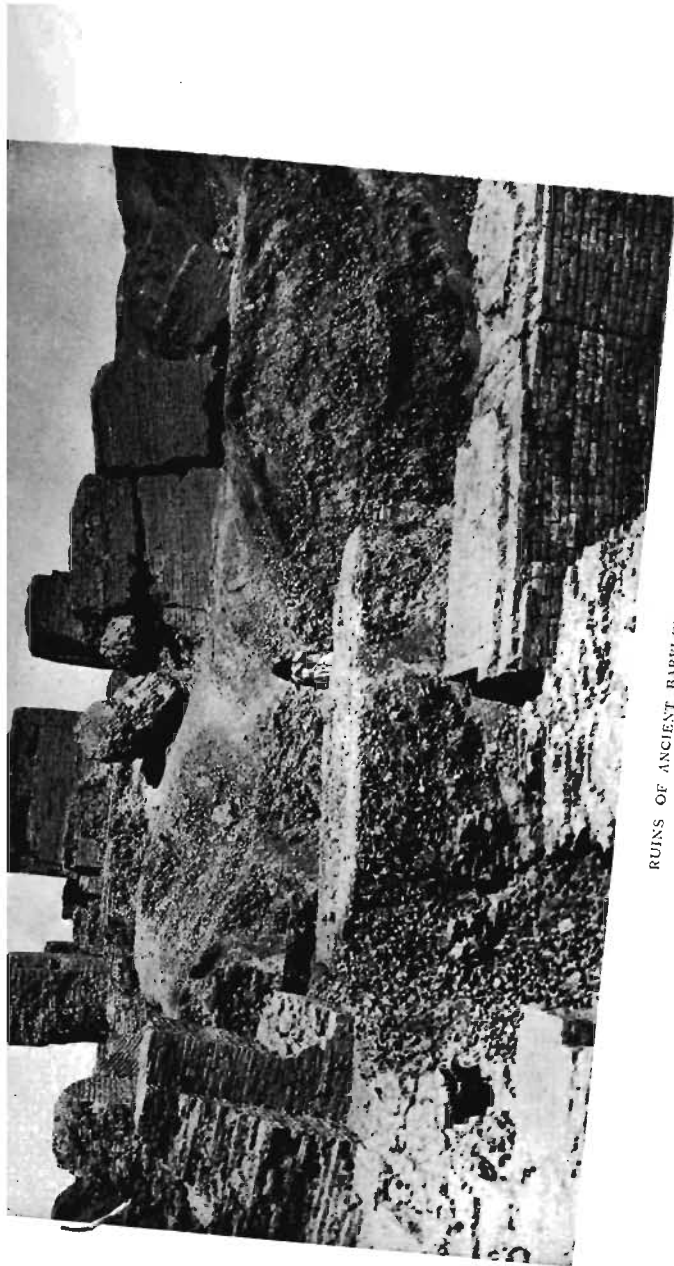
THE plain of Iraq, though without a natural eminence, yet is studded with innumerable mounds. They are usually smooth and low-backed elevations that rise gently from the sheet of sand. Superficially they appear as heaps of debris, a litter of bricks and broken pottery scattered through a pile of dust. A mere glance thus reveals their artificial origin. The mounds are the last stages in a human handiwork. Beneath the covering of dust and accumulated rubbish are the walls and streets and houses that went to build an ancient city.

This plain has passed through a tempestuous history under the Persian, the Greek, the Parthian, the Sassanian, the Arab and the Turk. But the mounds are the graveyards of still older nations. They carry our minds back from this succession of invaders to the royal pride of Babylon. They tell us something of the greatness of that empire, its

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advanced civilization and extensive power. The lead us further still into more remote times when "men found a plain in the land of Shinar and dwelt there," and "the whole earth was of one language and of one speech." They reveal a trace of even earlier history, an inkling of those Turanian settlers, the earliest of known peoples, who, before the first records of Biblical history, constructed cities, cultivated the soil and worshipped their demon gods.

Those cities, which were once the pride of civilization and whence men scattered over the face of the earth, are now choked with the desert sand. Many are wrapped in utter desolation, barren of every trace of verdure, a mere heap in a sterile waste. The largest of the mounds, such as those of Babylon and Ur, are conspicuous landmarks for miles around. Even on their surface are many objects of interest. We may see something of the foundation platform of the city or of the old walls projecting through the mound. The coloured fragments of pottery tell of ancient enamel work, and the pitch between the bricks of that historic masonry, when "they said to one another, go to, let us make brick and burn them thoroughly. And they had brick for stone, and slime had they for mortar." The square towers or ziggurats are fine examples of their architecture. We may see the earthenware pipes for the drainage of their cities, the dish-cover coffins for the internment of their dead. Cuneiform marked bricks are likely to be found, each stamped with a king's name, and with



RUINS OF ANCIENT BABYLON. *Photo. Wing Commander Wiseman.*

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the separate letters perfectly distinct after a lapse of four thousand years.

It is in the midst of all this ruin and antiquity, where the present is lost in the speculations of the past, that the subject of our chapter finds a suitable home.

This inhabitant of the ruins is a dark coloured wasp belonging to the species *Psammochares melas*, Ki. The female is four-fifths of an inch in length. Her head is shaped like an oval disc, with large variegated eyes, one on either side, and two spiral antennæ thrust out in front. Her thorax is a solid, substantial mass, her waist distinct and moderately slender, her abdomen of the pointed, wasp-like pattern, ending in a fine sting. Round her elongated legs is an armoury of spines, short ones that bristle along the shafts, and long ones that project like thorns from the joints. Triangular-shaped membranes of transparent gauze serve her as well-developed wings. She is bare of covering except for a few hairs, a fine cluster like a brush at the tip of the abdomen, another like a gorget on the front of the neck. Her colour is a deep mahogany brown, with the exception of the wings, which are a golden yellow terminating in black tips. The male is fashioned on a similar model, but is a more delicately constructed insect and scarcely half the female's size.

This wasp will relieve the dull tedium of the desert if we watch its operations on the crumbling mound.

The female, as usual, is the source of interest.

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Her hunting is a very intensive business, even more ardent than that observed in the case of the *Ampulex*. There is a keener enthusiasm, a greater activity, a more dashing about from place to place. Untiringly she conducts her explorations through the ruins, now up along the crumbling walls, now over the piles of fallen masonry, occasionally making sallies further outward in order to explore beneath the scattered bricks. Every corner of the ruins is subject to examination, the cracks between the bricks, the eroded summits of the walls, the littered pottery, the upturned graves, the sacred temples of deities, the palaces of kings; all this crumbling dust of ages is now given over to the investigation of the wasp. Her long legs carry her swiftly over the debris, her body is slightly curved as though prepared for operations, her bronze-coloured wings elevated and at intervals vibrated, her antennæ either constantly beating the air or else applying their tips to the ground. In the excitement of the search she halts scarcely for a second, but is all the time hastening from brick to brick, just glancing into one crevice, pushing bodily into another, at a third remaining some minutes in the interior, no doubt investigating the cavern beneath. She seems to show some preference for shady places, searching most assiduously in old doorways and dark arches, especially in the gloomy remains of habitations and the debris on the sheltered sides of walls. The blacker the recesses, the more they attract her. In the shade she has, at least, a cool surface to work

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over, since the brickwork, where exposed, is burning to the touch. Her quarry, too, haunts the *obscurest corners*, and thus she is drawn to them by the instincts of the chase. But her main interest lies in the underground galleries which ramify amidst the fallen bricks. On the surface she squeezes into a narrow fissure, lowering her wings, trailing backward her long legs, thus making her bulk as small as possible so as to permit her slipping into the hole. Once within, however, she enters a deep cavern, a maze of branching clefts and passages in which her victims love to hide. In such places she often remains for a long time, having found her way into a maze of tunnels which intercommunicate on every side. Pieces of cobweb at times impede her penetrations. These, however, she brushes aside, showing no alarm at the possibility of entanglement as do insects of less robust build. She is thus to a great extent a subterranean huntress, and is very persistent in her gloomy operations, often searching hundreds of underground galleries before meeting with any success. On unsuccessful days she continues up till sunset, persevering at her labours till the birds have gone to roost.

Though the search over the brickwork is conducted on the ground, yet very frequently she employs her wings to carry her from place to place. If one spot is unfruitful she will not waste more time over it, but will fly off to some other corner of the ruins and there commence operations afresh. In this act she displays her sharp powers of vision.

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For on the wing she observes the best places for investigation and drops down beside the likely holes. She can also detect the movements of her quarry while she herself is in active flight. Occasionally she allows herself a brief rest, just a halt in the shade of a loose brick where she shelters for a moment from the merciless sun that beats down upon these crumbling piles. On emerging from a hole she sometimes waits for a moment, especially if she has had a tedious search inside. This is for the purpose of cleansing herself of cobweb. She rubs her tarsi and strokes her antennæ, thus brushing off the adhesive fragments of web which she has brought from the dusty galleries beneath. The burnishing, if possible, is done in the shade, and, when complete, she resumes the business of the hour.

At intervals she may encounter one of the other sex. The males are on the watch in likely corners of the ruins. Compared with herself, they are of lighter build and quicker in their movements on the wing. Their life is one of continuous gallantry. They do not toil at these endless explorations, never push themselves into holes, nor chase elusive victims. Their time is spent at idling in shady nooks or in flitting about from one shelter to another waiting for an opportunity to find a mate. They also fly in circles low over the ground in the hope of discovering a female at her toil. In this, however, they usually fail, with the result that they resume their stations on the brickwork before breaking into amorous circles again. When she meets

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one, there follows a display of emotion. He breaks into flight, pirouettes around; two or three may compete with some show of rivalry, but she persistently refuses to receive their advance. While on the search her enthusiasm is otherwise expended. She has then no desire to accept a partner, and thus passes him without a sign of regard.

Hour after hour we follow her investigations. It is a tiresome and perplexing business. I know nothing more wearisome than the scrambling over walls, the plunging beneath archways, the stumbling amidst bricks, the long tedious waiting in the blazing sun, perhaps for days, before we witness the climax of her toil. The Arabs who pass are amazed at such behaviour, seeing a man dashing excitedly about, without any apparent cause. Fortunately they are gifted with an apathetic disposition, and, as a rule, pass silently on.

The quarry of this *Psammochares* is a large greyish coloured spider belonging to the genus *Sparassus*. In appearance it is formidable owing to its size and its widespread radiating legs. Though the body may not exceed three-quarters of an inch, yet the legs extend so wide around it that they measure three inches from tip to tip. When at rest, it lies low and flat against the surface; even when in motion its body is pressed close against the masonry, an effort to assimilate its greyish colour with that of the surrounding bricks. The portion which combines its head and thorax is a broad, substantial, triangular mass welded to the abdomen by a stout waist. At the apex of the

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structure are two solid jaws ; above them eight eyes arranged in a crescent, and on either side a conspicuous palp like a stem supporting a bulbous growth. The abdomen is oval and comparatively small, and the legs encircle the flattened body like eight extensive spokes. The spider is well clothed in a covering of fur. Spots of black appear at some projecting joints, such as the eyes, the jaws, the clubs on the palpi, the tips of the legs ; but otherwise the body is coloured throughout in a uniform palish grey.

This forbidding-looking creature is reclusive in its habits. By day it remains in the darkest places, usually inhabiting some gloomy chamber, and emerging after sunset to explore the mound. It is of a wandering disposition ; never, like many other spiders, constructing a network, but merely paying out a single filament when it moves from place to place. On speed and strength depends its power to take a capture, since its strategy consists in springing on those victims which it meets during its nocturnal prowls. The wasp pursues only this one species. In her search she may encounter other kinds. There are small ones which run towards her when she touches their webs ; there are larger and more daring ones which even venture a spring at her ; but she disdains all these, scarcely halting even to notice them ; the only kind that will meet her requirements is the monster that inhabits the gloomy clefts.

While at work she is comparatively free from danger. Her most formidable enemy is probably

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the blue-cheeked bee-eater, a beautiful bird clad in brilliant green and displaying a chestnut throat. It is attracted by the hymenoptera that haunt the ruins, often collecting in a clamorous flock, or sailing in graceful circles through the air. At intervals one of them makes a downward swoop, cleverly seizes a wasp or hornet in such a manner as to avoid the sting. This it carries to some selected point on the masonry and hammers to death against a brick. The habit is like that possessed by the kingfisher, a very necessary preliminary act before swallowing so well-armed a prey.

But persisting in her efforts and escaping all dangers, she at length succeeds in starting a pursuit. She remains beneath the bricks for a longer period than usual, indicating that her business is no mere cursory investigation. Possibly a skirmish is taking place in the interior, and the spider is being forced from corner to corner refusing to be driven out. But at last it emerges from the narrow entrance. Round about it are the widespread raking legs, and its colour blends with the mouldering dust. In an instant it is away from the dangerous hiding-place. There is a rush which passes into a swift run; off it goes with extraordinary rapidity; a few paces brings it clear of the pile of debris and it immediately dashes up a wall. The excited wasp is on its heels. Swift as are the movements of the terror-stricken spider, the wasp possesses a still greater speed. For the pursuer it is a difficult field of operations. On every side are holes and fissures. The pile of debris and the old wall are a labyrinth

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of tunnels into any one of which the quarry may escape. Moreover, the spider is built for speed. Its long legs are supplied it for pouncing on its victims, and these are now turned into organs of escape. All is not the plainest sailing for the huntress. A vigorous pursuit at the closest quarters will provide the best hope of success. Such, therefore, is the strategy of the angered wasp. Up the wall the pursuit continues, the grey spider scarcely visible save for the movements of its legs, the huge wasp, conspicuous from a distance, every turn of its dark body bent on destruction and its golden wings shining in the sun. As they race along they twist and swerve, now across the wall, then back upon their tracks, the huntress skilfully turning after her quarry, yet scarcely quick enough to secure a hold. At length she comes to grips. The spider is seized, but only for an instant; it is sharply jerked from its foothold on the wall, and thrown down into the pile of bricks. Without an instant's delay the wasp dives after it. The spider, by its fall, is free from the pursuer, but, after a moment's respite, the chase is resumed, now over the broken heap. In and out amongst the bricks, down into the crevices, expelled from one shelter, darting terrified into another, the spider makes good use of this more favourable ground. In its efforts to escape it breaks into quick leaps, springing across the chasms between the bricks; but even this skill is of little advantage, since the wasp now follows it in bursts of flight. A time comes at length when the opportunity offers. Throwing

herself madly on the top of her quarry, the wasp seizes it by any convenient spot, flings her long slender legs about it, and brings it to a sudden halt.

But every chase is not so immediately successful. Frequently the wasp is late in its emergence, and the quarry has then a good chance of getting clear. It may dodge into a crevice, or double round a wall, or escape over the bricks to so considerable a distance as to pass beyond the vision of the issuing wasp. The huntress, on emerging and finding herself foiled, gives vent to an outburst of accentuated rage. She dashes over the soil, her wings buzzing with excitement, darts in and out amongst the bricks, makes short sudden flights which more resemble leaps, and then breaks into sweeping circles through the air. She knows that her quarry is somewhere in the neighbourhood, having already seen it in the recesses of the cave. She is also aware of its successful expulsion, and is mad at being baulked of her prey. Her sole chance now lies in finding it at a distance. She may still encounter it racing over the soil seeking for a crevice in which to hide. Hence she spreads herself abroad in widening circles, sweeping low over the ground, occasionally alighting, scanning keenly every object in the hope of detecting its quick, jerky gait. But, more than likely, by this time the spider has vanished, having either dodged into some convenient crevice or else adopted the plan of lying motionless in the hope of escaping through its harmony with the bricks. Then, finding her wild

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burst of enthusiasm unavailing, the wasp settles down to a more methodical search. Every cranny in the vicinity is repeatedly examined, but with a more intensive ardour than before. Her expulsions are so rare that she must lose no opportunity, hence every corner in all directions is most persistently explored. Such perseverance is almost certain to bring ultimate success. In all likelihood she will again come upon her victim, when it will be driven to the open once more.

In the chase she works mainly by the sense of vision. It is by sight that she follows the movements of her quarry, or re-discovers it at a distance when making her disappointed circles through the air. Occasionally her keen eyesight may lead her into error. By mistake she may run after some useless kind of spider, or even chase one of the larger ants along the wall, confusing its quick movements with those of her prey. But her faculty of smell is also of use to her. There are certain indications which suggest its operation. For example, I see a spider, expelled from its burrow, rush off for some six or eight feet over the bricks, then plunge into another hole. The wasp, on emergence, sees not a sign of it. An outbreak of the usual excitement follows, but after a few minutes the huntress settles down to a quieter and more steady search. I note that she works in the direction of the spider; indeed I am satisfied that she makes some effort to follow along its trail. It is not that she accurately pursues the track, as does an ant when it follows the path of a comrade, or a

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dog on the scent of its prey. She makes wide deviations from the correct line, investigates many remote places, but is drawn again and again to the track, which she follows each time a little further, and in the end comes on the required hole. Though the sense of smell is not acutely developed, yet it plays a part in the successful chase.

But let us return to the moment of capture. The grip is followed by a mortal duel. There is a wild whirl of entangled limbs, and both bodies roll over in a common heap. At first the spider seems thrown upon its back, though it is difficult to follow the minutest details in this swift encounter on the ruined dust. The wasp has to fight for a good position. She cannot operate from any direction. The overcoming of resistance is not the only necessity; she must also fix herself in a suitable attitude for the application of the final stroke. In addition she must beware of the spider's weapons. For its legs are spined and its jaws so powerful that they can penetrate the human skin. The manœuvre for position may continue for some seconds, the spider all the time valiantly struggling in its efforts to break away. But the wasp has secured a firm grip. She drags the spider over on its belly. Very soon we see the abdomen bent in beneath the victim, its point raised towards the side of the thorax; then follows that attitude of rigid flexion which marks the steady application of the sting. The operation, though the sequel of a more vigorous engagement, is not unlike that performed by the *Ampulex*.

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Here again the thorax is the vital point, and the deed is accomplished by a single stroke.

The battle is now over. Again, as with the *Ampulex*, victory is decisive, and the spider falls over on its back in the dust. The collapse brought about by this single thrust is to all appearances absolutely complete. Occasionally the legs may give a faint twitch, but otherwise there is not a trace of movement; the spider with its legs all huddled together looks like a stricken corpse. Thus concludes another of these tragedies of nature, the battle and the ruin of a tiny life amidst the ruins of four thousand years. I examine the spider an hour after the deed. It is still in a state of complete paralysis. The body is without a quiver, the jaws and palpi without a tremble. I extend the legs and just a faint contraction follows, the only apparent sign of life. On the following morning there is still no change. The spider is as helpless as when first struck down. How different from the cockroach overcome by the *Ampulex*, which could be made to walk when dragged to the internment, and had sufficiently recovered to stagger of itself by the time the tunnel was sealed. The stab of the *Psammochares* is a more perfect operation. Yet the poison injected is minute in amount. A sting from this wasp gives just a trace of numbness, quite unlike the pain caused by the social wasps; yet such is sufficient for its only purpose, the paralysing of this special prey. I kept one in a box for nine days. There was no recovery from this state of helplessness, not a movement except that

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when the legs were straightened they were again slowly drawn back into place. The tenth day showed some signs of a possible resurrection. The spider was able to stand, to cling to objects, to attempt a feeble walk. But this was only a dying vigour. By the next day all signs of recovery had disappeared, and the spider was at last dead.

I anticipate that the *Psammochares*, having gained the victory, will proceed to drag her capture off. But in this she differs from the method of the *Ampulex*. The destroyer of the cockroach, having paralysed her victim, immediately takes up the next step in her work. Not so with the more powerful huntress of the ruins. Having struck down the spider, she first begins to examine it, touches it all over with her quivering antennæ, investigates its legs, its head, its tail, strokes it, behaves, in fact, as if she were proud of it, like a hunter over his slaughtered game. Having completed the inspection, she starts to clean herself. I expect to see her enter on the work of transportation, but she shows not the slightest inclination to begin. At most she drags her capture to a shady corner, apparently undesirous of keeping it in the sun, and yet unwilling to cart it away. All she does is to stand over the fallen victim which lies underneath her like a huddled corpse. Her toilet is then performed quietly and with care. There is a repeated rubbing and polishing of the appendages; the mouth parts are employed to cleanse the fore tarsi, and these are brought forward to stroke the

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antennæ; the hind tarsi are steadily rubbed together; they are also applied to the point of the abdomen, which part receives prolonged and repeated care. While thus tediously burnishing herself, she never leaves her capture. For a long time she stands over it or else close beside it, her attitude being that of a victor over the vanquished taking a pause on the conclusion of the fight. Nothing but the rudest interference will disturb her. A male comes buzzing round, but she scorns to notice him. Amorous attentions have no place in her thought. Other intruders will be driven aside, since the conquest gained by such strenuous labour must not be yielded without a fight. All this time there is not the slightest movement from the spider. The wasp too seems to pass into a state of somnolence, standing for a long time without a motion, even her antennæ now quiescent as though enjoying a well-earned rest. Sometimes she awakens for a minute or two, again examines her capture, perhaps pulls it about a little, never, however, leaving it for an instant, and soon resuming the sleepy state. Evidently haste is not a sequel to victory. Perhaps all this weary wait is a necessity. She is far too provident to waste her time unless for some important end.

To the observer this delay is peculiarly annoying. When the conquest was made the sun was high in the heavens. Ever since it has been blazing with tropical force, and the ruins glow with a desert heat. Yet not for a moment can any shelter be taken, otherwise the next step in the

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drama may be missed. The long dream, at length, comes to a conclusion, having lasted for two hours. The sun is now below the horizon, the stars have commenced to twinkle brightly, and the evening silence has fallen on the mound. The nomad Arabs have driven home their flocks, the marauding hymenoptera have hidden themselves in crevices, the birds have slunk away to roost. All her companions of the day have disappeared; she alone prolongs her business into the night. The bats and goatsuckers are now abroad. I see the hedgehog come forth from a dusty cavern, the owl from a tunnel in the brick wall, while every crack sends forth a myriad of sand-flies which plague me with their irritating bites. Only the last trace of light remains. If the wasp does not hasten to conceal her capture, in a few minutes it will be too late.

She proceeds to do so at the eleventh hour, and I find it difficult to observe her behaviour in the gloom. After some preliminary testing and pinching of the quarry, she manages to get a grip of a hind leg. Seizing it close to its attachment to the thorax, she uses this part as the point of traction, and with remarkable quickness backs away over the bricks. The capture follows, lying on its side, its long legs trailing helplessly in the dust as it is dragged onward without a pause. She now adopts a procedure like that of the *Ampulex*. At intervals she halts, abandons her capture, runs about in the vicinity in search of a crevice, then returns to pull it on again. She is

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very speedy in this important operation; moreover, there are holes innumerable throughout the bricks, any one of which should serve her purpose fairly well. Sometimes, before she temporarily leaves her victim, I see her turn in her abdomen beneath it as though giving it another sting. It is not a long stab like the original thrust, but a quicker and more superficial insertion, probably in the nature of an additional safeguard to prevent any possibility of escape. The first hole that she meets with will not necessarily suit her. She examines a number of them, at intervals pulls her victim on a little further, and, after a few more minutes, finds an opening which seems to fulfil her needs. Then she makes one last journey to her capture and drags it sideways into the cleft.

Let us now investigate the reason for the wasp's procrastination. For what purpose does she keep her capture so long in the open, sitting for hours over it, watchful to retain it, all the time confronted with the possibility of losing it, when she is able in a few minutes to inter it in the ground? There are few wasps more skilled at transportation and burial, yet she prefers to expose it to outside dangers rather than drag it to a secure place. Moreover, it is a fixed and important instinct, for, on the three occasions when I witnessed its occurrence, the wasp postponed the removal of her capture until the last few minutes before complete dark.

A little careful observation will explain its meaning. The wait is essential for the safety of

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the prize. The wasp has many dangers to contend with in these ruins, especially when burdened with this valuable prey. The huge hornets, of the species *Vespa orientalis*, are searching diligently amongst the bricks. They are exploring the crevices, examining the walls, in the hope of finding some suitable provender for the larvæ developing within their combs. The paralysed spider will suit them excellently, and, unless carefully guarded, will fall into their claws. One of them approaches in the hope of pillage. The *Psammochares* immediately turns round to meet it, and, in spite of its size and more powerful weapons, forces it to move off. A red-tailed *Pompilus* is another dangerous marauder, but it too is attacked with the same vigour and driven from the inviolable soil. A fiercer and more stubborn defence is necessary should another huntress of her own species come by chance upon the scene. It is well that the owner is seated on her capture, for this new arrival is a formidable antagonist, and a battle is certain to ensue. Her opponent is probably as eager as herself, having searched unsuccessfully for hours amidst the ruins with the prospect of a fruitless day. Here is an opportunity not to be missed, a victim paralysed and ready for internment lying prostrate before her on the ground. The two wasps immediately come into opposition. The rightful owner rushes forth to encounter her enemy. They meet one another face to face, their legs become entangled, their abdomens curl inward; mad with anger they grip and wrestle, rolling one over the

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other in the midst of the debris, and each determined to secure the spoil. For half a minute the round continues. Then they separate. A respite follows for a few seconds. The rightful owner of the spider runs back to her victim; the intruder, after taking a few turns on the bricks, thinks of re-entering the fray. Further contests then develop similar to the first, though declining in intensity as the minutes advance. The owner of the spider puts up the sterner combat, no doubt strengthened by the moral force of possession. The intruder, after a little while, seems to lose heart, and retires from the unequal fray.

But the point for us to note is the multitude of dangers which beset the huntress after she has gained her prize. All her troubles do not end with the piercing of her victim. She may have to fight many a serious battle before the fruits of conquest are secured. It is for this reason that the tedious wait is necessary. Her delay is essential for the safety of her spoil. Certainly the long wait exposes it to dangers, but these dangers would be increased rather than diminished were she to attempt to haul it off. For the transportation to the burial place is a risky procedure. Frequently the capture must be left to itself while the wasp runs off in search of a tunnel. These are occasions of considerable danger. In the presence of the enemies that are watching to plunder her it is more than likely that she would lose her treasure if she attempted such methods while they were on the prowl. See how fixedly she has to watch it during

the period of waiting. It is far safer to delay the work of transportation until all have retired to their secluded nooks. She has then only a few minutes of daylight left. But they are minutes during which she can leave her capture, when she would certainly lose it in the light of day. Hence her customary strategy is to wait for hours rather than follow that burning enthusiasm to carry it immediately under the ground. For, at all costs, she must not lose the product of her labour, her toil is so continuous and her conquests so few. It is for the same reason too that she is so speedy at the transportation. She has been specially gifted with skill and rapidity both in moving the burden and finding a hole. Otherwise she could never complete the internment during those last minutes of fading light.

In the gloom I can make out the opening of the grave. Superficially it appears of no particular construction, being merely a cleft in the substance of the debris, similar to many others that lie around. Since night has fallen, I can do nothing further. Next morning I proceed to the place of burial in order to follow up the subterranean events. Everything at first seems plain and simple, just a matter of separating the loose bricks and tracing down the intervening clefts. But the result is very different from this hopeful expectation. I extract the bricks, and down falls the rubbish, blocking and concealing the passages beneath. It is a very different operation from the enucleation of the cockroach. This is no straight shaft easy to follow. The

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narrow entrance, on the contrary, passes down into a labyrinth with irregular ramifications amongst the enclosing bricks. The search is continued through these dusty catacombs; each separate cavern is systematically examined, and passages are broken into neighbouring vaults. The disinternment assumes the nature of an archæological excavation, exposing the retreats that have lain concealed for ages, and disturbing the lizards, the solpugids and the spiders in those haunts which they have chosen for concealment by day. As the work advances, the ramifications of the tunnels grow more complicated, and it becomes difficult to find anything in the heaps of nodules and the increasing labyrinth of passages and holes. Further exploration is only waste of time, so I abandon a fruitless search. The wasp has, in truth, found a place of safety, having hidden her capture in some dingy ramification, a black sepulchre strewn with dust and cobwebs, perhaps many feet beneath the surface of the ground. After the days of exploration, the chase, the battle, the patient hours of waiting, the contests with marauders, the jeopardy involved in the transportation at dusk, she at last has her capture safely lodged in some deep inaccessible cleft.

But all my efforts to unearth it fail. Three times have I been present at these ceremonies of internment. On each occasion I have dug into the subterranean labyrinth, but the walls have fallen in and the intricacies increased, with the result that my labour was lost. Another time I attempted to

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guide the wasp. So intently is she fixed on the work of transportation that she allows me to transfer both herself and the spider to a spot of my own choice. I place her near a hole of my own preparation, one from which the spider can be easily uprooted, since it does not lead into a labyrinthine maze. But the wasp refuses my attempt to serve her. She examines my tunnel but will have nothing to do with it. There are no other holes available, night is approaching; she dashes about in the most excited manner, and in the end has to abandon her prey.

Thus, the only place that suits her is the cavern in the bricks. There she lays her egg in strict seclusion, no doubt fixing it to the spider's body as is the custom of others in her tribe. The persistence of her searchings, the patience of her waitings, these are well rewarded by the close security which she gains for the object of her toil.

But there is still a final touch to complete her operations. Early one morning I see her engaged at what are clearly the last stages of her work. She is sealing up the mouth of a crevice, having, no doubt, at dusk on the previous evening lodged a spider beneath. Fragments of brick are lying about, and these are being used to block the hole. Whatever is available is dragged to the aperture, both the tiniest pebbles and the bulky nodules as big or bigger than herself. She seems to collect them with a little circumspection, taking them from the debris in the near vicinity and fitting them carefully into the gate. At intervals she also kicks in

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the dust so as to fill the chinks between the fragments of her barrier and make it flush with the surrounding soil. The males come around her with more than usual enthusiasm, but, as before, she continues persistently to ignore them and sticks to her strenuous toil.

Having finished, she flies off to a neighbouring pile. The crevice is concealed by the plug of debris. There is nothing to attract a plunderer to the spot. Again I expose the never-ending chambers, but fail to defeat the ingenuity of the wasp. We have learnt, however, the last stages of her labour. Having lodged her capture in some suitable chamber, she, no doubt, lays her egg at the time of the incarceration, and then sits guard over her treasure all night. The final steps in the internment are postponed till morning. The door is then closed to prevent the ingress of invaders, and not only blocked with a barrier of fragments, but made to blend with the surrounding soil.

Such are the details of these patient operations, not the narrative of any one completed incident, but collected piecemeal through many hours of waiting by securing here and there an occasional fact. At last we conclude the tedious round of observation. We have seen her prolonged and industrious searchings, her swift chase over the brickwork, her frenzied struggle, her cautious waiting, her rapid transportation, the inaccessible depths in which she buries her capture, and her manner of securing the grave. Let us leave her in peace on the ruined mound to pursue her work

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amidst the sunbaked bricks. Nothing would induce me to look again into her labours, to pursue her through the dust beneath the blazing sun, backwards and forwards across the dreary waste. It has taken me four weeks of persistent effort to disclose these secrets of her murderous work.

CHAPTER IV

A COMPARISON IN BEHAVIOUR

A fissured patch—Wasp and her habits—Tunnel of spider—Expulsion of spider—The chase—The battle—Characters of vanquished—Reason for its colour scheme—Spider's appreciation of danger—The transportation of the capture—The acts of reconnaissance—Fixity of direction—Visual and topographical senses—The internment—Reason for immediate transportation—Attempts at disinternment—Summary of comparison.

I PASS from the ruins to a somewhat different soil. A piece of worthless land at the edge of the oasis has been exposed by the retreating flood. It has dried into a hard and brittle cake. The sun has cracked it into deep fissures which join into a system of reticulated rents that look like a network cut into the soil. A low thorny scrub has taken root upon its surface, chiefly composed of a rank acacia that thrives on the most arid ground. Here and there its substance has been broken by the plough, channels have been made in it by some enterprising Arabs and water conveyed to it from the shrunken stream. But their efforts meet with a scant success. The shallowness of the river is unfavourable for irrigation. Hence this patch, in the main, has had no attention, being merely a dry fissured waste.

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Nevertheless it attracts the subject of our chapter, the *Cryptocheilus rubellus*, Ev. Its features, as we shall see, are well suited to her requirements. But, at times, I encounter her in other places also, even in the open groves, the habitation of the *Ampulex*, or near those ruins where the *Psammochares* so strenuously toils. Let us compare her behaviour with that of the *Psammochares*. It will provide us with suitable material for contrast, indicating how insects with similar habits have yet their own distinctive methods and ways.

Superficially she is not unlike the huntress of the ruins. Each has a disc-shaped pattern of head, a stout thorax separated from an oval abdomen by a well-developed waist. Each mounts the same type of spiral antennæ and has her legs encircled in many spines. The wings too are very similar in appearance, in each being coloured a glistening yellow and terminating in darkish tips. The *Cryptocheilus*, however, is a larger wasp, and evidently the more powerful insect of the two. Further, she is clothed in a lighter-coloured vesture, being for the most part of a yellowish tawny colour, though dark almost to black on the base and sides of the thorax and along the proximal portions of the legs.

In her explorations she differs a little from the *Psammochares*. Though equally ardent at her efforts for discovery, yet she sticks more persistently to the surface of the soil. She seldom breaks into bursts of flight. Ordinary holes and crevices do

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not attract her; she is interested in only one type of tunnel and takes little notice of anything else. Indeed, at first sight, she seems engaged to no other purpose than that of actively perambulating the surface soil. Consequently she is easier to follow than the *Psammochares*. Though her movements are quick and her paces rapid, yet she does not disappear in those exasperating flights which send one scrambling over the piles of bricks. Like the *Psammochares* she is remarkably intent on her duty. Her antennæ are incessantly playing on the surface, obviously in search of the information required. Sometimes she climbs into the branches of the acacia as though expecting that her quarry might be hidden in the thorns. But the essential difference between the two species is that the wasp of the ruins is a subterranean huntress, while this wasp keeps mainly to the surface of the ground.

This difference depends on the nature of their objectives. The quarry of the *Psammochares* inhabits underground caverns of which the heaps of bricks contain an endless maze. The victim of the *Cryptocheilus* makes a special burrow dug into the compact soil. Thus the huntress of the ruins must explore the catacombs, while this wasp need only perambulate the surface until she finds the particular hole.

The special tunnel which she seeks is the lair of a *Tarantula*. It is a cylindrical shaft, carefully constructed, with its wall strengthened by a layer of web. In dimensions it is considerable owing to the bulk of the occupant, being wide enough to admit a

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couple of fingers, and descending four inches into the soil. The expulsion takes place from the bottom of this burrow. On finding the aperture, the wasp immediately enters it, perhaps brushing aside some loose tags of webbing in order to make clear the way. For a few seconds she remains in the interior; then all of a sudden an immense spider makes its appearance at the open gate. It is a fierce and unexpected apparition. The quarry of the *Psammochares* was sufficiently formidable, but here we are faced with a prodigious giant, a threatening, ponderous, globular-bellied monster that comes out like an ogre from his den. Moreover, as if its structure was not sufficiently enormous, it presents in its coloration a contradiction to nature, since its upper surface is a pale grey, while underneath it is a glaring black. Here indeed is a powerful and venomous quarry worthy of her strength and skill. It will not give in without a stubborn battle, nor will it quietly submit to the sting.

Its expulsion is followed by a swift rush. A chase develops like that of the *Psammochares*; the spider, though so ponderous, yet is nimble enough, and makes every effort to escape by speed. But the powerful huntress is immediately in rear. I imagine that in a moment she will come to grips; when all of a sudden the spider turns, apparently realizing that speed is unavailing and determined to show a fight. This is very different from the quarry of the *Psammochares*. There is no such boldness about the spider of the ruins; it relies for escape

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almost solely on speed. The *Cryptocheilus*, on the contrary, prepares itself for battle. It turns so as to confront its huntress, stands erect on its hind legs, displaying its broad chest and the black of its belly direct in the face of its foe. While thus elevated, it opens its poison-fangs, at the same time expands its remaining limbs, the fore ones being raised and thrust apart like diverging arms above its head. It thus assumes a wrestling attitude, prepared to strike should the enemy advance and to seize her in a close embrace. The *Tarantula* clearly will not fall without a contest, but offers a determined battle front to the onslaught of the angry wasp.

The huntress is alarmed at the sudden apparition. She will follow swift enough while engaged in the pursuit, but now she has to face the weapons of her prey. She dare not advance so as to meet them fairly, and thus the antagonists stand for a moment, neither desirous of coming to grips. The huntress then has resort to strategy. She begins by working round to the rear of her opponent, and there assumes a greater show of audacity, being less exposed to the enemy's fangs. She then tries to get a sting into the belly of the spider. It is not a paralysing thrust that she attempts, but merely a quick and sudden dart into the least protected portion of her foe. Its purpose is to gain advantage by weakening the adversary and prepare it for the final blow. Even in this operation she is extremely circumspect. She will not approach close up to the spider, but clings hold of some

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object a little distance away, pushes out her abdomen to the full length, and, in this peculiar attitude of extension, tries to get in a stab. She directs her sting towards the tip of the spider's belly, but she is so timid and reluctant to come near, that the slender weapon only quivers in the air, being unable to reach its mark. Again and again she attempts these tactics, wary efforts unredeemed by any show of bravery, but on each occasion she conspicuously fails. On one point, however, she is firmly determined, namely to avoid the spider's jaws.

For a little while I watch this extraordinary contest. Then the spider, perhaps seeing a special opportunity, makes another attempt to escape its foe. It is a rush as before with a similar pursuit, and again the quarry is brought to bay. This is soon followed by a third bid for freedom, during which the spider, instead of sticking to the open, runs for safety underneath a clod. A tremendous advantage now falls to the wasp. The spider is hampered in the narrow limits of its hiding-place, its legs are cramped and it cannot spread them for the fight. The huntress follows it into the crevice, there immediately seizes the advantage and gives it the final stroke. Unfortunately, I fail to observe the thrust since this act in the drama is concealed beneath the clod. But in this case the huntress is not satisfied with her operation. Probably she was unable to work efficiently within the confines of the narrow space. For she quickly drags her capture out into the open, clinging

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ferociously to one of its flanks. There she stabs it in the orthodox manner straight into the under surface of the chest. This must be a repetition of the hidden performance. Nevertheless, though prolonged, it is insufficient, and is soon performed for the third time. All is now over with respect to this duel. The spider has been pierced in a vital point and lies outstretched on the fissured soil.

I will mention a few points in a second contest which I happened to witness on the same patch. On this occasion the chase was more prolonged, the spider frequently making its escape, yet the huntress, with remarkable cunning, tracking it again to the new lair. The same tactics follow as in the previous conflict, but I have a better view of the final stroke. I see the huntress get in her preliminary stings, four or five little darts into the oval belly, which have clearly the effect of incapacitating the spider and of checking its power both to fight and to escape. The spider, though wounded, still continues resistance; but the wasp now throws herself fearlessly upon it, grips it by the back, turns it belly upward and bends her abdomen across its chest. Then she begins to search for the point at which to strike. The finding of the spot is no easy matter, and it is obvious that she must have the victim powerless before she can effect this final stab. She repeatedly and tentatively probes the thorax, now searching in front, now at the sides. At length she insinuates the tip of her abdomen into the cleft between the

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bases of the second and third legs. This is the exact point of penetration. From there she sends her sting into the side of the chest, the usual prolonged and deadly blow. In this second battle the one thrust is sufficient to render victory complete.

Here, therefore, we observe a very different spectacle from that displayed by the huntress on the mound. A fierce grip and a stab was sufficient for the *Psammochares*, while the *Cryptocheilus* must join in a dangerous battle and use special strategy to overcome the prey. The difference depends, of course, on size and strength. The wasp of the ruins is so proportionately superior that she cares little for the spider's jaws. The huntress of the patch must face a powerful antagonist with an armoury of poison and fangs. She must at all costs evade the sharp sickle-like hooks that curve in from the tips of the massive jaws. The spider is skilful in their method of use; they communicate with receptacles of subtle venom, and once they penetrate the wasp's integument, she is certain immediately to succumb.

Let us look to the monster lying vanquished on the soil. In bulk it far exceeds that of the huntress, being heavy and massive, with a stout thorax, and a large abdominal mass. Its legs too are particularly powerful, being built both for strength and speed. Its head is deserving of special attention. From each side project the angulated palpi like a pair of downwardly directed clubs. On the roof is a regular battery of eyes. There are

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four in front like black glistening beads arranged in a transverse semicircular line. Behind these is a pair of larger globules, coal black spheres with a glassy lustre that project through the hairy skin. Posterior again is still another pair. In shape and size they are like those in advance, but are so placed as to see objects on either side while the anterior pair maintains vision in front. The head, in addition to this multiple vision, is exceptionally well armed. The jaws are particularly stout and massive, each firmly fixed on a broad base and terminating in a curved fang. The spider from above looks the colour of the soil, being clothed in a vestment of greyish hairs with longitudinal brownish bands. But from beneath its appearance is strikingly different, the whole under surface being a vivid black, with similarly coloured bands across the appendages, and on the abdomen some orange spots. This dense breast-plate of black is glaringly conspicuous, though hidden when the spider moves ordinarily on the sand. It is this fierce black-bellied *Tarantula* alone that the *Cryptocheilus rubellus* pursues to the death.

The fight which we have witnessed suggests an explanation of the strange arrangement of this colour scheme. For the spider is not clothed in natural colours. In animals it is the rule for the under surface to be pale whenever it differs from the surface above. But here we observe a remarkable exception, so much so that it strikes one as unnatural at a glance. There must be a good reason for this contrary arrangement. Let us

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remember the details of the spider's battle, how it stands erect, separates its legs and thus opens its front to the onslaught of the wasp. By so doing it exposes its conspicuous breast-plate; a wide expanse of glaring black being suddenly raised before the enemy's eyes. The wasp, in all likelihood, sees the apparition since colour and movement influence her vision, as much, or probably more, than actual shape. In consequence she immediately turns aside and sweeps round to the spider's rear. The black under parts thus serve as a kind of protection by adding to the ferocity of the spider's appearance and alarming the angry foe. It is of defensive value against the chief of enemies; but the manner of the contest must first be seen before we can realize the function of this shield.

These spiders are well acquainted with the dangers that surround them. We see this in their determined efforts to escape when the huntress is close upon their heels. We note other examples when the wasp is on the search. Often, as she perambulates the broken soil, she meets with spiders that spring out of her path. She does not notice them. They are not of the kind which she wants for a victim, nevertheless it is clear that they fear her advance. Each of them probably has some special enemy, and thus they look on the whole tribe of hymenoptera as foes. It is the same as we observe amongst the higher creatures. Sometimes, as I walk along an irrigation stream, I may chance to see a water-snake exploring the edge. In undulating bends it works along the shallows,

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stealthily advancing close to the margin, and intervals thrusting its head ashore in the hope of seizing an unsuspecting frog. But the frogs are well aware of the insidious enemy. Though apparently so sleepy, they are wide awake. As the snake advances they leap from the mud, making their springs before it has time to reach them, and alighting safely far out in the stream. A quick dive and a plunge into the mud at the bottom then conceals them securely from the treacherous snake. So it is with many of the humbler forms, and particularly with the varied kinds of spiders that are harassed by the hunting wasps.

Let us now resume the next step in her operations. Her conquest is followed by immediate transportation. In this she differs from the huntress of the ruins. We remember how the *Psammochares* made great delay, sitting for hours over her prostrate victim and refusing to commence the cartage before dark. This species, however, behaves quite differently. She may wait for a minute or two, standing near her capture. I see some stroking of the antennæ and polishing of the legs, but without further delay she takes hold of the burden and begins to haul it along. The grip is secured on one of its palpi, the spider being dragged head foremost through the dust, with its ventral surface directed to the ground, its globular belly lumping on the clods, and its legs trailed out behind. By making traction at the head she gains some advantage, since the spider's legs tend to collapse against its body, and are thus less liable

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to catch in obstacles than if she had seized it at any other point. The experience of generations has taught the species that such a method of transport is best. The huntress of the ruins had a different plan. She gripped her capture by the base of a leg, and transported it while lying on its side. A slow, steady and laborious effort is now required for the continuation of the work. There is none of the speed and haste of the *Psammochares*. The bulk of the capture will not permit of this. Nor is it a mere pull over just a few feet, a quick transportation to some neighbouring crevice, such as we observed in the case of the huntress on the bricks. On the contrary, it is a long and tedious march necessitating perhaps an hour of laborious toil. All kinds of difficulties interfere with the conveyance. The capture must be dragged over ploughed-up clods, through obstructions caused by the stems of the acacia, across sticks and leaves and crumbling ruts, over miniature precipices and up steep inclines. Her swiftness and enthusiasm in the deadly chase are equalled by the dogged and persistent effort which she puts into this laborious haul. The breaks in the ground cause her special annoyance. She may find trouble in dragging her burden up a slope, bringing down the dust in precipitate clouds through her efforts to grip the soil. On the other hand she must sometimes descend the hill, to effect which she turns round in respect to her burden and lowers it before her down the slope.

We will remember how the *Psammochares*,

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when engaged at transportation, from time to time abandons her victim, makes a search in the vicinity for some suitable tunnel, and then returns to the shifting of the load. We see no such ceremony on the part of the *Cryptocheilus*. Certainly, at intervals she may leave her capture for a moment, take a rapid run over the soil in the vicinity or perhaps make a speedy survey on the wing. Her purpose, however, is not to find a fissure; it is done with the object of reconnoitring the route. The act usually consists of a few sweeps through the air made in the direction towards which she is dragging the load. In her absence the spider lies exposed, but she may push it into a temporary hiding-place if available, perhaps a cleft in the soil or a tuft of grass. Having made her survey, she returns to the spider, finding it as a rule with but little difficulty, though often she has to make a hesitating search before locating the exact spot. Then, harnessing herself in the same manner as before, she resumes the steady pull.

The direction of her transportation is thus prearranged, and she never deviates from the established lines. She may stumble into trenches or come up against embankments, but such obstructions only temporarily deflect her; she always returns to the original course. In this again she differs from the huntress of the ruins, for that wasp will pull in any direction until by chance she discovers a hole. This maintenance of a fixed undeviating line is a common occurrence in insect life. We observe it amongst butterflies at the

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time of their migrations, amongst termites when emerging on a nuptial flight, amongst dung-rolling beetles when manipulating their pills. As a rule we are lost in our attempts to understand it, being able merely to record the facts, and knowing nothing of the guiding force. But we are not so helpless in the instance under observation. The wasp maintains her determined course by the guidance of her sense of sight. Her excursions are literally surveying operations. We have seen how she makes them in advance of her position. As she circles in the air she actually sees whether or not she is on the right road. She probably investigates the objects beneath her, taking note of landmarks already known to her and memorized in her tiny brain. Her world is the broken, scrub-covered soil spread out on this neglected patch. She has made herself acquainted with the features of this world, having visualized the various objects that compose it, and knowing them when she sees them again. When she makes her quick circles to examine the route I believe that she employs her topographical knowledge to keep her on the right course.

Here are some observations bearing on the subject. I notice at the moment when she leaves her capture, that she may take a short turn in the near vicinity before commencing her hurried survey of the road. It is just a few circles on the ground or in the air, and its purpose, I imagine, is to fix some object, to form in the mind a geographical picture so that on her return she may

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recognize the place. Though her memory for location seems to be excellent, yet she may not come direct to the exact point. She returns without difficulty to the whereabouts of her spider, but she may have to make a little local search before coming on the spot where it actually lies. I imagine that at the time when she leaves her capture and makes her quick circles to fix its position, she then notes some conspicuous object in her memory, some leaf or stone or tussock of grass which will serve her as a geographical guide. On her return she quickly picks up that object and therefore comes without fail to the locality. But it does not lead her to the definite point. After this she must make a short local exploration before finding the spot where her spider lies.

But why this prearrangement with respect to direction? Why does this species choose a fixed course, and refuse so persistently to deviate from her plan? The huntress of the ruins did not act so inflexibly. All she required was a convenient hole. Let us therefore pursue her to the end of her task. For an hour I watch the steady transportation. Never does she halt save to make a survey; never does she swerve from the original course. At last she reaches a huge fissure, a broad sun-crack, more than an inch in width, which passes down into a yawning cleft. She approaches it straightforwardly, not searching to find it; in fact from a distance I perceive her object and see her pull the burden direct to the gate. It is clear that she is acquainted with the location of this fissure.

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Perhaps she has already made some adjustments in its interior, but, at least, if she has not actually garnished it, she has fixed it as part of her pre-arranged plan. The usual formalities take place at the threshold. There is a quick examination, the spider being abandoned for a moment near the gateway, after which it is pulled head first in.

It is now clear why the wasp is so persistent in direction. She will not deviate from the course which she first establishes because the place of internment is already fixed. Before going off in search of plunder she must first have located this yawning cave. In all likelihood she explored it, and, having found it suitable, kept it in mind as a receptacle for her prey. Thus again we have proof of her topographical memory. We realize how efficient and exact it is when we see her arrive with such precision at the gateway, and observe her absence of all doubt and hesitation throughout the exigencies of the long march. Her fixed direction is thus part of the plan of operations. She refuses to turn from the straight line that leads to the remembered tomb.

These same observations will explain another matter, namely why it is that this wasp starts immediate transportation while the huntress of the ruins makes a long delay. The wasp on the brickwork fears the daylight because she will expose her prey to pillage on those occasions when she leaves it to go in search of a den. Consequently she delays operations till nightfall when her enemies have slunk away to rest. But the species

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under discussion need have no such timidity. The enemies of the daylight are of little importance to her, since the place of internment is already arranged, and she has not of necessity to interrupt her work. Certainly, at times, she makes transitory surveys, but these, as we have seen, are rapid performances during which the danger of pillage is slight. Thus the one, though she endures a tedious wait, need but drag her burden to a neighbouring hole, while the other can commence transportation immediately but must indulge in a laborious haul. How wonderfully adapted are instincts to their purpose, though in this case it is doubtful which has the advantage, the wasp that goes in for patience or the one that depends on toil.

Another little point also made clear is the reason why this special tract of land is so favoured by this hunting wasp. Obviously because it has within it the two requirements necessary for her task. Scattered on the surface are the burrows of the spiders, while here and there is a suncrack of exceptional depth which will serve as a suitable tomb. Each wasp is drawn to its particular haunts, one kind to the ruins, another to the waste. In each case the motive of attraction is the same, depending on the fact that the special quarry lives in the neighbourhood of a capacious grave.

The huntress shows no sign of reappearance after dragging her capture into the cleft. Her business in the interior is a lengthy operation. I wait for an hour, and, since she does not emerge, begin to think it time to see what has occurred.

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The conditions look promising for successful excavation. There is here no pile of bricks which we have found so impossible, yet the crack descends deep into the ground and joins at either end with that system of fissures into which the soil has split beneath the baking sun. Again I am seduced into an elaborate excavation, for these are not the sun-cracks of the temperate region, but huge clefts brought about by a tropical heat. I follow it down to a depth of four feet, dig at either end into the reticulated system, but am baffled as hopelessly as when rooting in the bricks. In some deep and inaccessible corner of the system the huntress has lodged her prey. How determined are these wasps to secure their off-spring! Any ordinary tunnel will not satisfy requirements. The one seeks the labyrinthine depths of the ruins, the other the bowels of the earth.

Let us summarize our contrast between the two wasps. The *Cryptocheilus* is somewhat more bulky than the *Psammochares* and of proportionately greater strength. The *Cryptocheilus* hunts on the fissured waste; the *Psammochares* seeks the ruined pile. The *Cryptocheilus* gives chase to a black-bellied monster, an inhabitant of a specially constructed burrow and prepared to show fight to the death. The *Psammochares* pursues a spider of moderate size, one that lives in the fissures between the bricks and is unable to resist attack. The *Cryptocheilus* persistently perambulates the ground, taking little note of the cracks and holes; the *Psammochares* more frequently makes sallies in the

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air and investigates every fissure that she meets. The *Cryptocheilus* drives her quarry from a special tunnel; the *Psammochares* expels it from the fissures in the bricks. For the *Cryptocheilus* the contest is a deadly duel in which she must employ her strategical skill; for the *Psammochares* it is little more than a grip and a stab without danger to either life or limb. The *Cryptocheilus* begins the work of transportation immediately on the conclusion of the fight; the *Psammochares* stands guard for hours over her victim, refusing to move it until the sun has gone. The *Cryptocheilus* conducts her transportations by daylight since her methods expose her to less danger on the route; the *Psammochares* postpones the operation till night-fall as otherwise she will surely be robbed on the way. The *Cryptocheilus* drags her capture by one of its palpi; the *Psammochares* takes hold of a leg. The cartage of the *Cryptocheilus* is a laborious operation which may continue for over an hour; the *Psammochares* drags her victim with such rapidity that in a few minutes the business is complete. The *Cryptocheilus* pursues a fixed direction, stubbornly refusing to turn from the path; the *Psammochares* may deviate in one way or another as opportunity happens to decide. The *Cryptocheilus* abandons her capture for a moment in order to make a survey of the road; the *Psammochares* adopts a similar behaviour but does so for the purpose of finding a hole. The *Cryptocheilus* prearranges a tunnel of internment to which she drags her victim from the scene of the fray; any

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deep fissure will suit the *Psammochares* provided it leads into the catacombs beneath. The *Cryptocheilus* brings her victim to a tunnel in the soil, the *Psammochares* to a cavern in the pile of bricks.

Thus the main point of interest is the comparison in behaviour. The ultimate object in both species is identical and the operations are conducted in the same general way. But in each we have seen certain modifying details which indicate how adaptable is the force of instinct to the minute and particular requirements of the wasps.

CHAPTER V

A HUNTRESS OF THE CLIFF

Haunts of wasp—General appearance—Her mode of search—Special senses—Expulsion of quarry—Chase in the entanglement—The battle—Characters of spider—Sexual performances—The temporary concealment—The transportation—Error in instinct—The sepulchre—Final disposal of capture—Interdependence of habit in huntress and prey.

LET us leave the ruins and the suncracked patch. We will descend into the trough of the river bed, where the Tigris, now shrunk from its ample volume, has retired from the enclosing banks. The month of August has just set in, and the warm season is approaching an end. Four months ago the river was a roaring deluge. The wide trough was filled with its swirling waters; eddies and whirlpools seethed upon its surface; in places huge masses were torn from its banks, and the torrent, having heaped itself above its confines, poured in a flood over the surrounding land. By now its wild turbulence has died away, and it has contracted to a passive stream. Its surface moves in a gentle flow, reflecting like a mirror the adjacent objects, and bearing calmly within its substance the revolving layers of silt. Its rough depths are replaced by peaceful shallows; flat islets of sand now project



BAGDAD AND THE RIVER TIGRIS. *Photo, Eric Baosinger.*

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above the water; the banks, which were torn by the irresistible current, are now bare perpendicular cliffs. It is here that we find another of these huntresses. She has certain special habits that deserve our attention, so let us watch her with a little care.

Her most favoured haunts are the earthen cliffs on either side of the river bed. They have been cut perpendicularly by the force of the water, levelled in places into terraces and ledges, indicating successive stages of erosion during the contraction of the swollen stream. Spiders have swarmed to these cliffs and ledges. They have occupied every nook and fissure, and have spread abroad their tangled sheets from the entrance of every retreat. The steep bank looks as if it were appropriated by spiders, so profuse is their scattering of webs. There are others which live near the water's edge, speckled kinds that take their captures with a rush, and hide in the fissures of the sand. The varied huntresses have followed their quarry to these haunts. We see the black and yellow *Sceliphron* hovering against the precipice and the slender *Trypoxylon* exploring the sand. Amongst them associates an active little species, the *Psammochares rutilus*, Ki.

She is a small edition of the previous species, being in length scarcely more than half an inch, though built on the same general plan. Bulging from the sides of her yellowish head are the black elliptical eyes; on the roof are three black points, the minute ocelli; in front are the antennæ twisted

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into coils. Her abdomen and legs are dull yellow in colour, and so is her chest anterior to the wings. The hind part of her thorax, however, is blackish, with a dark tinge along the bases of the legs. Her dusky wings have a purple gloss with the colour at the tips deepening to black after the pattern of the previous wasps. She is armed with particularly powerful spines, and bears a long slender sting.

Her search along the cliff is fairly steady and methodical. For the main part it is conducted on the soil, but she often makes short flights from place to place. She is likely to attract immediate notice, not indeed from her size, for she is insignificant enough, but because of the striking contrast in her colours, the lustrous metallic purple of her wings being so conspicuous against the tawny body underneath. Her zeal for exploration seems particularly fervid, partly owing to her energetic movements, but more especially because her wings are in continuous motion like purple sails vibrating in a breeze. Her jerky gait, her tremulous antennæ, her short hurried flights, combined with this incessant flirting of the wings, give her a peculiarly fussy appearance and exaggerate to the full her ardour for the search. Such impatient action and restless agitation are very different from the quiet methodical progress with which the *Cryptocheilus* perambulates the ground.

This rustling of the wings is not uncommon amongst those wasps which drive out spiders from their dens. It is chiefly to be seen amongst the smaller kinds. There were two others on this

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cliff with a similar habit: one clothed throughout in a funereal black, the other more gaily and prettily decked in transverse silvery stripes. Both were possessed of this fussy behaviour and conducted their search in the same impatient way. It may be that the rustling is but an effervescence of their energy, but I imagine that it gives some mechanical assistance to their quick and jerky gait.

As we watch her bustling about on the cliff, we soon detect the places which attract her most. She thrusts herself frequently beneath pieces of earth or into tunnels dug in the steep wall of sand. It is the web-strewn areas that she explores with most persistency, climbing up on the entanglements, penetrating the tubes, thoroughly investigating the retreats of the architect, and if necessary remaining some time in the interior engaged in an industrious search. See how boldly she walks over the entangled sheet. The mere touch of a filament gives her no alarm as it does to so many that fall into the net. She takes no notice of such trivial inconveniences, but just brushes aside the loose pieces of webbing and marches forward on to the sheet. Unhesitatingly she plunges into the spider's tunnel, fearing nothing either from the entanglement or from the creature that inhabits the lair. Sometimes we see her scuffle a little in the soil. At other times she makes a more extensive excavation, raking up the loose sand with her fore tarsi, then shooting it backward between the hind legs, employing her mandibles to drag out larger obstructions, and thus constructing a shallow pit.

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Into this she thrusts herself head first, burrowing into the sand which is interwoven with webbing so as to seem like a tissue of granules and threads. Sometimes she gets into a deep hole. There she may remain for a protracted time, not always in pursuit of the desired object, but just lazily resting in the dark hollow as though enjoying the cool shade. Like the huntress of the ruins, she sometimes halts to brush herself, legs and antennæ receiving attention after the usual manner characteristic of her tribe. These cleaning operations are of some importance, since her body, when excavating, becomes grimy from the sand, and shreds of network stick to her appendages when she carries her investigations into the snares. Though she toils independently, yet she is often not alone. Two or more may be seen on the same inviting cliff. Each may be working in opposite directions, though more than likely they will occasionally meet. Both may invade the same tunnel when a contest between the rivals is almost certain to ensue. There is a sudden, quick and excited scuffle; legs clutch one another, bodies bend, and the two opponents turn in the air. Then they as rapidly break away, and each resumes its independent course.

Much of the investigation is unsuccessful; many lairs are examined without finding a victim and numerous tunnels are fruitlessly explored. The expulsion may take place from various situations, from the shelter of a clod, from the interior of an entanglement, perhaps from underneath the

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crumbling sand. Often it is effected with some little labour, the huntress having to tunnel into the debris, upturn or extract the more substantial nodules and thrust the looser material aside. Many are driven forth which she does not seem to notice, for she hunts mainly by the sense of sight. Others are disregarded from some different motive, probably because they do not suit her taste. These often run but a foot or two away. There they wait till the danger is passed, after which they return circumspectly to the lair.

But, like the wasp of the ruins, I see reason to believe that she employs the faculty of smell also. A spider may rush forth from one side of a clod. The wasp has approached on the opposite side and has not seen the expulsion take place. For a minute or so she is unaware of the occurrence. Soon, however, she becomes excited, and seems to realize that a spider has been under the clod. She explores it attentively, but, finding nothing, starts off on an active search. Her examination leads her along the track of the quarry, with sufficient accuracy and in the right direction, until she comes on where it lies concealed. It is not mere chance that brings her to the spot. To find it she pursues a somewhat complicated journey which can be performed only by the sense of smell.

The true expulsion produces intense excitement, the quarry often bursting up through the sand. Compared with the monster chased by the *Cryptocheilus*, this is a very insignificant foe. It is just a finely speckled greyish coloured spider

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unequipped for a deadly fight. There is the usual rush, as previously described, the wasp dashing madly after her quarry, not on foot, as with the larger kinds, but pursuing it swiftly upon the wing. The spider leaps from place to place, makes turns around the clods or dives underneath them. The huntress for the most part keeps to the air, now seeing her quarry, makes a pounce upon it, now turns in a circle in order to find it, and in the end the spider usually escapes. Sometimes the pursuit may continue to the river. The spider will then rush out upon the water. Many are almost amphibian in their habits, being equally at home on the moist sand or running freely on the surface of the stream. In this way the huntress is completely balked since she dare not venture on to the flood. The chase is often a protracted business owing to the wasp continually losing her quarry, making circle after circle in order to find it, repeatedly startling it and as frequently losing it, and returning again and again to the pursuit.

But the incident worth seeing is the chase in the entanglement. Many of these webs are in successive layers with sufficient room between the tiers for the spider to move to and fro. Also, there may be more than one aperture in the network, perhaps three or four separate gates of entry into the substance of the sheet. In this case the spider is not the owner of the web. It belongs to the class of homeless vagabonds that prowl the surface, hide themselves in crevices or get underneath the sand. But often it makes use of some deserted web, either

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pushing its way into the tunnel or entering between the layers. When the hunt takes place in such a complicated system there follows a remarkable exhibition of skill. The wasp dives into one of the apertures. Out comes the spider between the layers and then issues through an exit hole. There is a furious rush along the surface of the web, then a few swift excited turns, after which the spider darts again between the layers. The huntress is wild with the ardour of the chase. She either sweeps in circles or skims on foot over the sheet, dashing about in different directions, in one aperture, out of another, closely pursuing the terrified spider through the gateways or between the layers. It is like a furious game of hide-and-seek, one in which a vast amount of energy is expended, since this incessant dodging to and fro may continue for half an hour.

There are certain points worth notice in this hunt amidst the network. The spider knows well its position of security. Though frequently driven from the interior of the web, yet it always dodges back to the safety of the layers. It may be forced as far as the outskirts of the entanglement, but it will not take to the open soil. It realizes its ability to dodge the huntress so long as it is on this favourable ground.

A more striking point is the capacity of the wasp to move so freely over the spider's sheet. She seems perfectly free in this complicated structure, now squeezing herself through some narrow aperture, then racing swiftly across the entanglement, at other times thrusting her head into the

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tissue and burrowing from layer to layer. Never does she stumble or catch in a filament. She is as free in the intricate maze of lines as is the nimble architect herself. This is wonderful when we reflect on the nature of the labyrinth. It is composed of a fine-spun, interlacing network. The threads are arranged in no special method; the spider emits them as a bunch of filaments which she spreads about in every direction so as to produce an entangled sheet. It is over such a layer of intermingled threads that the huntress moves with such facility and speed. Her legs are armed with many hairs and spines; at the ends of the tarsi are two divergent claws; one would think that these were the very implements likely to catch in the innumerable threads. Yet no such accident is ever seen to occur. Though at every step her claws hook over the lines, yet so well is she adapted to the place of her hunting that nothing for an instant impedes her course.

While the chase through the network is in active progress, we may perhaps observe some minute parasites watching their opportunity near the margin of the sheet. They are tiny, delicate, dark-coloured hymenoptera, with long, slender, hair-like ovipositors which they seem to drag somewhat helplessly behind. As patient spectators they watch the manœuvres, with a deadly purpose ready for fulfilment should the huntress secure her ends. But, if the chase is abandoned, they too disappear, probably following up the wasp in her exploration of other haunts.

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The chase, though often considerably prolonged, yet frequently results in failure for the wasp. Her enthusiasm to the end shows no sign of abatement; she just seems to become sensible of her own inferiority, and to realize that in this endless round of dodging the spider has the upper hand. The spider escapes, not alone by virtue of its swiftness, but by its special skill in doubling through the apertures and making use of the intricacies of the sheet. Hence the wasp may, in the end, just abandon the contest and fly off to examine more fruitful ground. Very soon the spider is aware of her departure. It comes forth from the entanglement, examines the surroundings and may leave the torn sheet. Thus the wasps expend much fruitless labour in many a prolonged and unprofitable chase.

We did not observe this repetition of failures in the wasps of the ruins and the fissured patch. Those kinds less often meet with a quarry, probably, as a rule, not for several hours. But they are specially skilful at achieving a capture. This wasp, on the other hand, makes numerous expulsions, perhaps three or four per hour on this web-strewn cliff; but only now and again after repeated failures does she succeed in running down her prey.

The actual battle is comparatively orthodox. The huntress suddenly grips her victim, her body glistening, and her lustrous wings refulgent in the blaze of light. The spider is thrown over in a succession of somersaults, the captor at the same

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time being whirled about, at one moment on top, at another underneath. Again and again she attempts the thrust. The thorax as before is the selected place. She bends her sting towards it at least a dozen times, making one attempt from the head end, another from the flank, but on no account will she make just an aimless plunge. The final penetration must be delayed until she can enter the precise spot. Hence the contest may be of somewhat long duration with many a whirl and attempted stroke before the giving of the deadly blow. It comes at last in the orthodox manner, straight into one side of the chest.

Her victim, thus laid low, is a speckled *Lycosa*. As an example of the tribe, it is small and inconspicuous, being in length only one-third of an inch. Its furry body is a dull grey, mottled with streaks of brown, while its legs are marked with bars and specks and bristle with projecting spines. This pattern of coloration is excellently adapted to conceal the spider on the dry sand. The fine streaks and specks on its greyish body harmonize with the scattered grains. We have seen in the case of the black-bellied *Tarantula* how the plan of coloration is of value to its host. Here we observe a different effect, though also of a defensive kind. When we witness the pursuit we immediately recognize how important to the spider is this colour scheme. For the spider, when pursued, does not rush away aimlessly; it employs some strategy in its method of escape. If the danger is imminent it may lie close against the sand, its colour concealing it amongst

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the scattered nodules and the speckled layer of grains. In this way the huntress may be temporarily evaded, and then the spider, seeing its opportunity, makes a quick run into some convenient cleft. The value of this harmony of colour is clear, both the manner in which it deceives the wasp and the instinctive method by which the spider employs it to the best use.

At this time, when the wasp has overthrown her victim, the amorous males are likely to appear. Their size is only half that of the huntress, but in return for this they are proportionately more active, and arrive with remarkable precision on the scene. Perhaps they have been following the female at a distance, though it is only, as a rule, when the capture is secure that they definitely appear in view. They seem to come as if by magic, either darting excitedly around the arena, or impatiently alighting at the edge of a snare awaiting the successful issue of a chase. Nuptial union is thus a sequel of victory in battle. It is marvellous how the males seem to realize this opportunity and arrive at the exact time. The place of conquest is the site of union, the rites being conducted somewhere on the soil close to the vanquished prey. I see the male dart down to join his partner. There are some quick evolutions, looking almost like a scuffle; it is little more than a momentary embrace, after which the male disappears.

We now come to the act of transportation, in which she differs a little from the methods described. Harnessing herself to the prostrate capture, she

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first drags it to a neighbouring hole. It may be a fissure just a foot or so away; often it happens to be a spider's den, either the hollow in the sand from which it was evicted or the interior of a silken tube. There she remains with it for a few minutes, pulls it about as though impatiently adjusting it. Then there follows some polishing of her body, after which she makes off in a direct flight. It seems at first as if she had effected the internment, but on examining the crevice I find that this is not the case. The spider is lying just within the entrance. There has been no attempt to bury it deeply, nor has the huntress anywhere anchored an egg. This is clearly but a temporary arrangement. The crevice which she has chosen is merely a hiding-place, where, during her absence, the capture will be safe. Sure enough, in five minutes I see her return. She soon finds her victim in its place of concealment, drags it straightway into the open and begins a steady haul. Thus we observe an interesting modification. The four wasps we have described have each its special behaviour following immediately on the successful fight. The slayer of the cockroach leaves her treasure in the open while she climbs the tree in search of a hole; the wasp of the ruins patiently guards it; the huntress of the patch drags it off direct; this fussy little species temporarily hides it until she is ready to commence the haul. Thus each is provided with its own peculiarity in some way best suited to the purpose required.

The haulage is conducted in a similar manner to

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that employed by the huntress of the bricks. The spider is on its belly; it is gripped by a leg and dragged sideways along the cliff. The transportation is performed with the usual efficiency, the smaller wasps being as skilful as the larger ones in shifting the valuable load. Clods and debris cause her very little trouble; she even drags her burden across the netted sheets and straight up the perpendicular wall. I follow her as she makes the vertical ascent. Sometimes she has difficulty in hoisting the weight, and in her efforts falls down the cliff. Occasionally she may halt to apply her sting, an accessory blow to secure quiescence should she find it troublesome to get her capture on the move. Her difficulties are repeated and often considerable; the previous huntresses met no such obstructions as those encountered on this web-strewn cliff. The sheets of netting are by far the most formidable impediment, the load becoming always entangled in their meshes, and having often to be torn through the substance of the tissue before it can be got free. Enemies too will attempt to rob her. The great hornet may surprise her at the act of transportation, but, little though she is, she dashes at the monster and literally drives it off. Thus, up the steep cliff and over the summit I follow her at last into the vegetation on top. She now struggles through the thorny jungle. Again and again she is almost lost to view, but at length I trace her to a large opening into which the capture is dragged.

I observe a little act, while the transportation

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is in progress, which indicates the manner in which instinct errs. The load becomes caught in a sheet of web. The huntress pulls on it, causes it to quiver, but for a while is unable to make it advance. She repeats her efforts, then becomes annoyed, and at last turns round in anger on the spider, which she stings a number of times in the chest. She acts as if the capture and not the web was the actual cause of the delay. This, I take it, is an error in the operation of instinct. A half-paralysed capture must frequently impede her by clinging to objects with its extended legs. The application of the sting is suitable to such occasions. Indeed no better procedure can possibly be imagined than this paralysing thrust into the ganglionic chain. But in the instance here quoted she employs it incorrectly. It is the web and not the spider which is the cause of the obstruction, and the huntress fails to differentiate between the two.

The den, in which she finally lodges her victim, is well hidden in the midst of the scrub. Like those previously examined, it is of great depth, and my efforts to uproot the spider fail. I have little doubt that the cavern had been previously arranged, and that the wasp, at the time when she hid her capture, went off to determine if the grave was in readiness to receive the newly stricken prey. Her mode of reaching it is sufficient to make clear her object. There is no hesitation about any of her actions; every obstruction is brushed aside. Whether on the river-bed, or on the vertical cliff, or in the dense vegetation that clothes the summit, she advances

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straight and with undeviating purpose direct to the hidden den. In this respect her plan of operations is similar to that of the huntress on the fissured patch.

It is interesting to observe these variations in method with regard to the final disposal of the prize. The *Ampulex* makes no provision. Her arrangements for burial are not given a thought until the capture is finally secured. A prolonged search is then undertaken; the tree is explored from top to bottom, and it may be an hour before a grave is found. The *P. melas* shows a similar lack of foresight. But with her the deficiency is of less importance, since the pile of bricks supplies innumerable cemeteries and she is not forced into a tedious search. The *Cryptocheilus* and the *P. rutilus* reverse the performance. They work on methods which to us suggest prudence and care. Prearrangement and preparation is their principle of action. The grave is marked down and put into readiness before ever they go off to hunt for prey.

A last point which we appreciate from these observations of habit is the reason why each of the separate wasps sticks so persistently to its own prey. For they never vary in the species of spider selected. The *Cryptocheilus* will not chase the victim of the *Psammochares*, nor the *P. rutilus* the quarry which the *P. melas* expels. It might be thought that each spider is specially chosen as being in some way best suitable for the development of the egg. This suggestion has been made by the illustrious Fabre, with regard to the *Cerceris* that captures a weevil.

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Is this predilection for a single species adequately explained by the greater flavour and succulence of the prey? Do the grubs find in this monotonous diet juices which suit them and which they would not find elsewhere?" He does not think so, and clearly he is right. The true explanation is far more simple. Our observations have been made with sufficient detail to determine at least this little fact. It depends on an interrelationship of habit. Each spider has its specially selected haunt, each makes its escape after a certain manner, each has its particular capacity for defence. For example, the *Sparassus* of the ruins is of intermediate bulk; it lives in a complicated labyrinth of passages; it escapes by leaping from brick to brick and has little power of putting up a fight. The black-bellied *Tarantula* is a ponderous monster; it inhabits a straight and simple shaft; it escapes by a cumbrous rush over the soil, but, when overtaken, turns on its pursuer and puts up a fierce battle for life. The speckled *Lycosa* is diminutive in size; it resides in a crevice on the bank of the stream; it makes its escape by running out on to the water or by dodging through the layers of a netted sheet. Thus each spider has a different combination of habits, and consequently each wasp must have suitable instincts in order to contend with its particular prey. The hunter is fashioned to pursue the hunted. The lives of the two are so interlinked that every feature in the behaviour of the spider must be met by a counter-ruse on the part of the wasp. Thus the instincts of the *P. melas* must keep her in the labyrinth

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the *Cryptocheilus* must send her in search of a tunnel, of the *P. rutilus* must despatch her to the web-strewn cliff. The *P. melas* must be built for a chase amidst the brickwork, the *Cryptocheilus* for the skill of a strategical contest, the *P. rutilus* for dodging through the layers of a web. Each wasp must, therefore, stick to her particular quarry, and employ all her efforts to a single end. For efficiency is so essential in these tragedies of nature that each wasp is like a highly specialized workman equipped for one particular task.

This concludes my observations on the hunting wasps. A solitary toil, a persistency of effort, a glowing enthusiasm, a deadly skill, such are the most impressive features of their lives. Here they find the haunts in which they most delight, through months of dryness, the blazing heat, the broken ruins and the sandy waste. Few soils can be more suited to the solitary wasps than that which fringes the desolation of Iraq.

CHAPTER VI

THE TIGRIS PUSS MOTH

The poplar grove—Eggs of puss moth—Habits of young caterpillar—The moult—Development of caterpillar—Machinery of tail—Contests with ants—Purpose of tail—Further growth of caterpillar—The facial mimicry—Habits when full grown—Pupation—The chrysalis case—Method of emergence—Characters of adult—Its fertility—The struggle for life.

ALONG the fringe of my small oasis there occur in many places thick growths of poplar delightfully green and refreshing to the eye. The tree is of the species *Populus euphratica*, being often little more than a straggling bush, though sometimes it grows to a considerable height of thirty feet or more. The trees usually keep to the bank of the river, where they clothe with a rich but simple vegetation those areas unsuited to the production of groves. To this native jungle we now direct attention, since the puss moth of the district selects the poplar as a suitable foliage for the affixation of her eggs.

We are not likely to make her acquaintance, for, though her eggs are abundant in the early spring, yet the moth herself is rarely to be found. She belongs to the species *Dicranura vinula*, L.,

but is probably a different subspecies from that of the English type.

Her season for laying is the end of March. If at that time we examine the leaves of the poplar we are likely to meet with little white specks dotted about on the background of green. They are not confined to any special position. The moth has scattered them in careless profusion: one on the upper surface of a leaf, another underneath, one near the margin, another near the midrib, another at the extreme tip. Nor has she confined herself strictly to the foliage. Here and there we find an egg attached to a stalk, more often perhaps to a hard stem, and even sometimes to the rough bark of the tree. The eggs, as a rule, are distributed singly, an indication of the restless movements of the moth, how she flitted about from place to place hovering for a moment to fulfil the act. Sometimes we find groups of three or four, more rarely a heap of perhaps eight or ten, which suggests that the moth on these occasions remained patiently seated in the one spot. Each egg is shaped in the form of a hemisphere, firmly anchored by its flat base and rising from the leaf like a rounded dome. In diameter it is only one-thirteenth of an inch. Its surface is smooth, its shell hard, and it looks as if it were fixed to the leaf by a spot of transparent glue. When first laid, its colour is a rosy pink. Soon, however, it bleaches to a glossy white like a speck of porcelain. But its surface is soiled by faint brownish mottlings. Also on the summit is a black ring encircling a white pupillary point.

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There is no particular external sign of the changes occurring within the shell. The first manifestation is a rent in the cupola. The little inmate has eaten through the summit of its dome, and in the opening its head is visible gnawing persistently at the edge of the breach. It is constructing an oval gateway through which it can escape from the rigid shell. The crater at length gives forth the occupant, a minute caterpillar, velvety black with a faint suspicion of a bristly coat. In length it is only one-tenth of an inch, excluding a pair of slender filaments which project from its pointed tail. Its shape is something after the pattern of a club, broad at the head end, narrow at the tail; it has three pairs of legs beneath the front part of the body, and four pairs of suckers under the posterior half. The base of the club supports two projections which stick up like ears from behind the head. But the filaments on the tail are its conspicuous feature. They appear like two diverging threads, mobile and flexible, ringed with short bristles, lying in apposition when the little creature is at rest, but opening out when it crawls along the leaf.

Having obtained its freedom, it is fairly active and wanders about near the empty shell. Though so minute, it is not inconspicuous, appearing like a thin short line of black against the green foliage behind. In action it is deliberate and slow; its stumpy head explores the way before it, and its body oscillates in gentle waves. When it moves it erects the filaments of its tail, which sway with the

rhythmical motions of its body and separate like horns unnaturally placed. On the day of its emergence it begins to feed, just nibbling at the superficial tissue of the leaf. Unlike papilio caterpillars and those of certain moths, it commences life with no specialized meal. For these kinds begin by devouring their egg-shells, thus securing a few rich and tender mouthfuls as an introduction to the coarser food. But here we observe no such careful preparation; the white hemisphere with its oval crater just lies neglected where originally attached. This caterpillar goes direct to its vegetable diet, not necessarily attacking the tender margin, but eating anywhere into the substance of the leaf.

At first its efforts are but feeble bites, but in forty-eight hours it has burrowed through the leaf. By this time its length has increased a little, and its spiny surface is becoming smooth. There is also some sign of a change in colour, mainly in the appearance of a bright red spot at the tip of the filaments that project from the tail. The third day brings additional points to notice. The deep black of the vesture when newly hatched is now becoming less intense. A dusky tinge is appearing through the pigment with a faint suggestion of dull green. For the most part the caterpillar remains at rest, making no attempt to find concealment, but just lying fully exposed on the leaf. In this attitude of rest it keeps its tail extended, the filaments being applied one to the other and appearing continuous with its body length. Touch it, how-

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ever, and a transformation follows. The tail processes rise up, they diverge from one another, and then turn forward over the head. This is the caterpillar's protective device, more easily investigated at a later stage.

Its appetite increases with its size and strength. In many spots the leaf shows marks of perforation, and as the vegetable tissue is rapidly assimilated, so does the green colour intensify in its skin. On the fifth day after birth it becomes very sluggish. Its nibblings at the foliage also cease, and it may remain for a whole night stretched along the same spot. If we examine it carefully when in this inert state we will find underneath it a glistening layer composed of fine silken threads. The caterpillar has fashioned a lustrous bed, not only a fabric on which to rest, but more particularly to fix it tightly to the leaf.

This anchorage and inactivity are very important, since their object is a preparation for the subsequent moult. The caterpillar now throws off its integument and emerges in a somewhat different dress. The green tinge which we saw through the dusky coat was merely a sign of underlying changes. The obscuring veil is now removed, and the hidden transformation perfectly revealed. For the skin splits at the head extremity, and the caterpillar, now clothed in yellowish green, comes forth through a wide breach. It pulls itself forward with its pointed legs while the skin remains attached to the leaf by means of the underlying threads. The suckers and tail processes are drawn

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out of their sheaths; a little wriggling may be necessary to free the latter, but in the end they come complete from their tubes, and the caterpillar literally walks out of its skin. The black integument is left behind. It is merely a shell of the most delicate tissue fixed to the foliage by lines of silk.

The caterpillar, now freed from both integument and anchorage, advances to investigate the leaf. The black pigment of its youth has completely disappeared. Viewed from the side it is yellowish-green, but the front of the head and the middle line of the back are coloured a reddish-brown. The surface of the skin is now delicately smooth, the moult having removed the last trace of bristles, though the ear-like processes still persist, and the pair of filamentous threads. Its length at the time of this important occurrence is two-fifths of an inch, including the tails.

Soon after the transformation it returns to its food. It moves about freely, but is less conspicuous than before owing to the harmonization of its new dress. Sometimes it assumes a kind of suppliant attitude, fixing itself by the posterior suckers only, and raising the anterior portion of its body so as to seat itself half erect. But its usual posture is full length along the midrib, its head towards the apex, its tail to the stalk, and as a rule on the upper surface of the leaf. This attitude is probably the best for harmonization, since the dark line along its back seems a continuation of the midrib and its green sides shelve into the colour

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of the leaf. Its voracity seems to alternate with periods of rest. When hunger calls, it advances to feed, and, when satisfied, resumes its position on the rib. For it is now more attentive to the margins of the foliage, chewing especially at the extreme tips or eating pieces out of the edge. Its attack on the vegetation is not indiscriminate. For days it may remain on the same leaf, usually eating it up completely before passing on to devour the next.

On the tenth day its length is half an inch. Thus, compared with many other kinds, its growth is tardy, nor are there now any changes worth special notice beyond its steady increase in size. To all appearances it is only a fleshy tube that eats and grows and drops its excrement beneath the tree. Subsequent moults follow on the first. One takes place on the thirteenth day. Indeed its life is a succession of two important alternations, the one a period of slow development, the other a preparation for the next moult.

I will not enter too minutely on small changes in appearance that occur during the next week. It is rapidly becoming a substantial caterpillar. The yellow is showing signs of predominating over the green, and by the fifteenth day a line of black rings has made its appearance along either side. The filaments on the tail have become proportionately smaller. At birth they were longer than the rest of the body, now they are only one-quarter its length. The caterpillar has assumed a more angulated appearance, in part from the bluntness

and squareness of the head, but mainly owing to the development of a sharp elevation on the roof of the segment that supports the third pair of legs.

The nineteenth day marks another shedding of the skin. The reddish brown of its back has become slaty in colour bordered by a yellow edge. The rings along its sides are more definitely marked, each a clear black iris with a white pupillary spot. A further shrinkage has occurred in the filaments of the tail; their colour too has changed into a variegated speckling and they terminate in white tips. On the twentieth day its length is one inch; thus we have before us a sturdy grub. And here we will pause in the course of its development. It is a fitting opportunity to examine more carefully the interesting and remarkable function of the tail.

I commence the investigation with a fine needle and touch the caterpillar gently on the flank. Immediately the long flexible tails shoot upward, their points diverge like elastic horns, and the whole structure bends over the back until its tips almost reach the caterpillar's head. At the same time we are witness to a strange apparition. Each of the tails is observed to lengthen, and a fine scarlet filamentous thread is seen to protrude from their extreme tips. The tails are then turned to the offending object; the red protrusions are made to touch the needle, and, after a moment's contact, are again removed. I withdraw the needle. The caterpillar's abdomen is immediately lowered; the

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divergent tails approximate to one another, and the protruding filaments are at the same time sheathed. (See Plate, page 126.)

Such a mechanism requires more detailed observation. It is a very extraordinary and surprising apparition, reminding us of the horn-like protrusions of the papilio that shoot forth from the back of the caterpillar's neck. As an example of a startling and unexpected extrusion there are few things more impressive in insect life. The tail processes of this caterpillar are propulsive organs; they contain in their interior elastic filaments which in reality are slender tubes. These filaments are shot forth by telescopic action and by a similar mechanism rolled back into place. Each is composed of a most tender skin, is extremely delicate and highly flexible. Its surface is moist, its colour a dark scarlet, its base encircled with a white ring and at its tip a minute point. It is so pliant that, when unsheathed, it coils into a spiral, the extremities being often turned towards one another like a pair of incurved horns. Sometimes, when the caterpillar is specially excited, it will be observed that a drop of greenish fluid exudes from their extreme tips. The contrivance has obviously a defensive function. The tails are in the nature of a telescopic armamentarium forced out as a result of pressure from within. The exuded fluid is a foul discharge particularly offensive to insect foes.

Let us examine the apparatus by a more natural experiment. I place a caterpillar near the nest of



1. CATERPILLAR OF THE TIGRIS PUSS MOTH (ALARM ATTITUDE).
2. CATERPILLAR OF THE LAPPET MOTH (ALARM ATTITUDE).
3. CATERPILLAR OF THE OLEANDER HAWK MOTH (ALARM ATTITUDE).

a *Messor* ant. The workers of this species are peaceful harvesters. They are content to indulge in domestic operations without any desire to join in a fight. Thus they take but little notice of this strange intruder. Now and then one approaches as though in curiosity, gives it a momentary touch with the antennæ, and then moves off in search of seeds. The caterpillar reacts to the slightest contact. At the touch of the antennæ its tail processes diverge and its head bends round so as to face the ant. I arouse the workers by killing a few of them. Even the harvesters resent the destruction of their comrades. Their peaceful avocations turn to anger. The presence of the corpses arouses such hostility that the ants run about with open jaws. Some of them soon happen to encounter the caterpillar, when they immediately commence an attack. Up go the tails, the long telescope protrudes, the scarlet filaments coil and quiver; the hidden battery of fluid is then released and the jet exuded on the body of an ant. The effect produced is almost immediate. For a second the attacker maintains its hold, then detaches itself, withdraws in alarm, staggers about in confusion on the ground as though half stupefied by what has occurred. The caterpillar is safe, its adversary senseless. The noxious fluid has half paralysed and confounded it. There is no doubt that this double-barrelled weapon has served its owner with remarkable effect. A second worker advances to continue the contest. Again the strange machinery comes into operation, victory as before follows the

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bombardment, by which time the anger of the harvesters has lessened and the caterpillar finds a chance to crawl away. It will take a more formidable opponent than the harvester to contend with such a subtle armamentarium as this.

I repeat the experiment with another kind of ant. The *Myrmecocystus iraticus* is a ferocious species, one of the largest and most powerful of oriental ants, and armed with strong dentated jaws. It lives in sandy places, where it establishes a nest and scours the vicinity in search of prey. I place the caterpillar near the gate of a colony situated on a sloping bank. The workers are immediately enraged at the intrusion. There is here no hesitation, as in the case of the harvesters; no artificial stimulation is necessary; the first one that appears comes direct to the attack and grips the caterpillar by one side of its head. Instantly the machinery of defence comes into action; the stupefying fluid issues forth with the result that the assailant releases its hold. It falls back about an inch, and soon retires into the nest. A second worker then takes the caterpillar by the flank. But this one too is similarly expelled, and staggers down the sandy slope. A third attack meets with more success. The worker happens to gain the advantage by fastening its grip on the base of the tail. By so doing it evades the obnoxious weapons. The filaments certainly act with vigour, but they cannot bend down to the point gripped. They twist, they curl, they sway about; here we see the battery in most forcible action, struggling to belch

forth its liquid spray, yet unable to range on the exact point. The caterpillar is now in a most dangerous situation. It is held unrelentingly in a strategical grip. Its ammunition is expended, the enemy is beyond its reach, its strength too is becoming exhausted since it has already suffered in the previous frays. The huge ant now begins to drag it about. Other workers at the same time join in the subjection. They come forward now with greater boldness, the caterpillar's defence being almost broken, some at the head, others on the flank, until five of the strongest are engaged in the assault. They have little to fear from the exhausted weapons since their enemy's resistance is almost gone. Its attackers mangle it; they bite through its skin, and it soon rolls over on one side, unable to put up any further fight. It is clearly the loser in a hopeless struggle, yet its defensive machinery continues in operation, the red filaments being thrust out and feebly moved so long as any strength remains. In a few more minutes it is utterly vanquished. One worker takes it by the head, another by the tail, and between them they haul the prostrate victim down into the tunnels of their nest.

Thus the final victory has fallen to the ants. Most valiantly have they opposed the enemy's vapour and fought through the poisonous barrage. The complicated living artillery is beaten. And what wonder. For these ants are among the most powerful of adversaries; we have witnessed a contest with the bravest and best. But it has shown

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us more clearly the nature of the armoury, and we realize more fully how efficient it is when we see it employed against such formidable foes. Poisonous fluid and direct fire, on these the caterpillar depends for life. Such equipment must be of vital importance to it in its ordinary habitat amongst the leaves. There it will not meet with these implacable monsters, though numerous smaller ants haunt the vegetation against which the battery can act with effect. But there are other foes still smaller, yet infinitely more dangerous. The parasitic hymenoptera are in search of victims. Their object is murderously slow and insidious. They have eggs to be deposited in the bodies of caterpillars, and the grub of the puss moth will suit them well. One thrust of their ovipositor and the deed is done. The egg is inserted; a new life commences, and with it the fate of the caterpillar is sealed. Though death is not immediate, yet a languishing follows, and the victim undergoes a slow dissolution during which its entrails are being eaten away. It is against these that the poisonous artillery is directed. The caterpillar must be ever on the watch against them in order to escape a miserable death. Watch a fly when it alights upon the leaf. See how the caterpillar feels the vibration. At the very first tremor the filaments fly upward; the caterpillar is ready to meet invasion long before it is actually touched. Hence the purpose of the battery of obnoxious fluid. It is a defence against the most insidious and important of enemies, the minute parasitic foes.

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Now that we understand the defensive machinery—at least that supplied for this period of existence—let us follow the caterpillar in its further growth. We left it when exactly one inch in length. It was square-set at the head, tapering to the tail, somewhat angular in body owing to a blunt tooth projecting from the front of its back. Its general colour was a yellowish green, with the upper surface brown to slaty, and a line of rings along the sides. By the twenty-third day it has grown another quarter of an inch, continuing stout and solid in proportion. Its voracity too is daily increasing and, as a consequence, it is lengthening more rapidly than before. The sides of its body remain a leafy green, but the slaty hue of its back is perceptibly changing, as though about to pass into the colour of the flanks. Another point of particular interest to us is the continued degeneration of the armament on the tail. It is strong in its movements amidst the foliage, climbing about from leaf to leaf, clinging to one spot with its rows of suckers while it thrusts its body across the gap. On the evening of this day it grows quiescent. This is the signal of a coming transformation, made certain by the fact that it ceases to feed.

Now comes the moult that brings forth a revelation, quite as remarkable as the machinery of the tail. I observe that, in the instance under observation, it takes place on the morning of the twenty-fourth day. There is nothing particular about the casting of the skin; the fascination lies in the new pattern of dress. I must describe in

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brief this changed appearance since it adds another kind of defensive machinery to that supplied by the battery on the tail. The body now glows in a brighter green suffused with a golden yellow hue. The black rings along the sides are very conspicuous, and the back has changed to a silvery purple, delineated by white and tinged with mauve. The appendages too have undergone a transformation. Each leg is adorned with three spots of black, each sucker encircled with two black rings, and the filaments of the tail are profusely decorated with a sprinkle of black shining specks. But it is the head that displays the most striking of changes. Let us concentrate attention mainly on this in order to understand an extraordinary effect.

I will ask the reader to turn to the illustration. (See Plate, page 126.) Though deprived of all the magnificence of colour, yet the sketch will give a better impression than any description could possibly supply. Before the transformation the head was inconspicuous, being merely a bulbous swollen end coloured a yellowish brown. There was nothing in its external covering to suggest the glow of pigment developing underneath. At the moult a kind of yellowish film is shed; the dingy covering is drawn aside, and, like a countenance exposed from behind a tantalizing mask, the new features are fully and ostentatiously displayed. The head then appears as a square-shaped mass, fitting into the front of the first segment of the body, the latter being hollowed out to receive it and surrounding it in a collar-like ring. The collar is

really a circular fold, like the edge of a glove half drawn over the finger, and so flexible that the head can be pulled back into it or pushed forward out of the ring. Let us touch the caterpillar so as to make it sit erect and expose its features to a better view. We immediately notice that its head is fashioned with all the appearance of a mammalian face. The resemblance is more startling than one might easily believe, while the glow of colour makes a splendid exhibition. If magnified to the scale of any ordinary mammal it would certainly be a hideous and alarming sight. Let us look to the separate features in its composition. Above is the brow, a rose-coloured band, formed by that portion of the flexible collar prolonged over the roof of the head. It mounts two black spots, one on either side, glaring, conspicuous, and so well placed that they appear like a pair of eyes. External to the eyes the collar bends downward, changes in colour from red to yellow, where it forms the convex cheeks. The front of the face is brown and shining. A triangular depression with diverging lines gives the appearance of a snubbish nose. The addition of two appendages make imaginary nostrils. The lower margin of the head acts as a chin, the legs which are raised and thrust a little forward look remarkably like dentated jaws, while a gap is allowed to remain between them so as to give the impression of a mouth. Thus all the essential parts exist for the production of this extraordinary face. A brownish front, a rosy forehead, yellow cheeks, penetrating eyes, flattened nostrils, black

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incurved jaws, the whole passing into a green vertex and encircled in a black ring. Such a combination of features can scarcely be accidental, their disposition so accurately delineates a face. It is splendid, in a sense, from the variety of colour, though this is responsible for the frightful effect.

The remainder of the caterpillar is in harmony with such extravagance. Its body is clothed in the richest green. While thus erect, it curves into the alarm attitude when there is something snake-like in the black rings that glare out from its brilliant sides. The armament of the tail adds further to its splendour. The diverging sheaths are now handsomely variegated, and the scarlet filaments coil and quiver after the manner already seen. Just a jar on the tree or a touch on the leaf, and we immediately observe the double apparition of the face and the trembling tails.

What can be the purpose of this facial mockery except to serve as a signal for alarm? If the caterpillar is touched, its head turns towards the intrusion; designedly it opens its monstrous features, displaying them arrogantly close to the foe. It is not reasonable to think that insects would be terrified by such a countenance. The sudden show of colour might easily alarm them, but scarcely its arrangement into a mammalian face. More than probable this device is against larger enemies, such as lizards and birds which search the vegetation. The tails were the weapons for the hymenopterous parasites; the face is an addition at a larger stage

when the larva might be preyed on by insectivorous birds.

The splendid caterpillar, though so strikingly decorated, is not conspicuous amidst the green leaves. Being hairless and fleshy it assimilates with the foliage. Thus protective coloration lends a further aid to the specialized devices of the face and tails. Its strength is now great and it climbs with vigour. There seems to be no limit to its gluttonous voracity. It now enters on a period of incessant chewing. Hitherto its appetite was comparatively mild. Now it scarcely ceases night or day from one continuous gorge. The attack on each leaf commences at the margin. It first takes a firm grip with its suckers, then fixes the edge of the leaf with its legs and applies its destructive jaws. The foliage is thus eaten from the edges to the midrib, so that in the end nothing may be left beyond a handful of bare stems. Even these too, together with the stalks, may disappear in the insatiable gorge. Bursting with this aliment, it seems to visibly enlarge. The tardy progress of its youth, when it just occasionally nibbled, is now changed into a lavish growth. Its length doubles in the five days that follow on the first appearance of the face.

On the thirty-first day it is full grown, a magnificent retractile fleshy tube, two and a quarter inches in length. Its irritability is vanishing and it is less easily provoked. The specialized machinery is almost obsolete. It shows no desire now to display its armaments or assume the extra-

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ordinary attitude of alarm. Structure too has atrophied along with function, since the long extensile filamentous threads have now shrunk into stunted tags. Like a swollen sausage, and overburdened with food, it just lies passively in the midst of the vegetation, wrapping its legs and suckers round the stems and relentlessly eating at the edges of the leaves. It seems careless now of invasion or attack. Rapid development is the purpose of its life; thus its whole attention is resolutely fixed on the all-important gorge.

Pupation takes place on about the thirty-second day. A sluggishness comes over the satiated grub. Then follows a fading of its vernal coat and a shrinking of the processes that project from its tail. Soon its bright vesture becomes sadly dull. At the same time it wanders impatiently about searching for a spot at which to spin its case. The journey will bring it to the trunk of the poplar, down which it may climb almost to the ground before fixing on a suitable site. At length it is satisfied, having chosen most probably a depression in the bark as most favourable for the pupal sleep. There it commences to spread out a tissue composed of extremely delicate threads. These are woven into the shape of a capsule, the caterpillar systematically manipulating its head so as to bend the filaments round about itself. The capsule thus developing, is comparatively roomy. There must be sufficient space in its interior for the occupant to turn from side to side. While at this work the architect looks cramped and awkward, since it tries to reduce itself

to the smallest bulk. It assumes a kind of half curled attitude, incessantly pressing its mouth against the capsule and at every touch adding to the threads. This, however, is not continued indefinitely. It forms an excellent foundation-work or scaffolding. But the architect requires a stronger protection. Its edifice will be exposed to the roughest elements, and a filamentous structure will not suffice. Consequently it ejects a kind of gummy material, at first moist and glistening in appearance, but later hardening into a tough glue. This stiffens the threads, fills up the gaps between them, perhaps adheres to loose fragments lying in the neighbourhood which it gathers into the substance of the wall. The result is the formation of a rigid prison composed of an intermingling of threads and glue. Within this casement the caterpillar undergoes contraction, shrinking to a fraction of its previous bulk. We recall its magnificence at the full-grown stage, not only its rich colour, but its great mass, and we are amazed at the degree to which it has dwindled when we see it squeeze into so small a cell.

The resulting chamber is remarkably efficient. In length it is about an inch, in colour a dark brown, and its wall is as rigid as a box of wood. There is nothing elaborate in its architectural features; it is merely a uniform oval chamber attached by a flat base. It is its toughness and rigidity that chiefly surprise us. It has the strength to endure injury from without and its gluey composition of waterproof material will protect the tender occupant

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inside. Nothing could be better for prolonged exposure in the vicissitudes of wind and rain. But the caterpillar has trusted not in strength alone. It has taken refuge in protective coloration also, that widespread defence so commonly adopted and which served it so well at an earlier stage. The chambers, so far as I have seen, are fixed to the bark. There they form excellent examples of harmonization, their brown surface being identical in colour with the tree. Moreover, they are frequently flush with the bark, since the instinct of the caterpillar is to find a depression before commencing to attach its threads. They will be discovered only by the closest inspection, at least while in the perfect state. Once the prisoner has emerged the search is more successful, as the aperture of exit then attracts attention and leads us to the empty shell. Thus the caterpillar seems to know the best adapted places, particularly choosing the roughened bark at the extreme base of the tree. Its protection is assured by the combination of two instincts: that of building a suitably coloured shelter and that of finding a well-adapted site.

I open a chamber ten days after construction. Its interior is smooth and shines as if with varnish, thus providing a fit surface on which the occupant can rest. The pupa almost fills its rigid prison. It is smooth and oval, reddish brown in colour, and four-fifths of an inch in length. The head end is blunt, the tail more pointed. Its posterior half is encircled in rings which divide it into freely

movable segments that bend to either side when its surface is touched. Within the prison it has fashioned a second covering, a kind of thin but firm skin. Thus the pupa is enclosed in a double wrapping, the outer being the rigid chrysalis case, the inner the true cocoon.

This condition of torpidity lasts a variable time. Of a number which pupated in the month of April some remained for twenty days, others for over thirty days before awakening from the long sleep. The emergence consists of a double penetration, first through the cocoon and then through the case. A transverse rent occurs in the blunt end of the cocoon. This extends a short distance down the middle of the back, and through it appears a little fluffy nodule which is the head of the emerging moth. Very soon an enlargement occurs in the gateway owing to the legs being pressed against two lines of weakness and forcing out a triangular flap. Through this then project the head and antennæ; the thorax follows with the folded legs, and the prisoner is ready to leave the cocoon. I now observe a significant occurrence. A globule of fluid makes its appearance as an exudation from the moth's mouth. It is a single drop of watery material, slightly viscid in consistency and comparatively clear. This vomit issues forth in advance of the protrusion, the prisoner, it may be said, belching it forward through the triangular rent in the cocoon. There can be no doubt about the purpose of this sudden vomit. We may regard it as another of the specialized machineries

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and add it to the list of those already described. It is an erosive fluid to break down obstructions, a very necessary contrivance at this particular time. Let us remember the position of the moth at the moment. It is partially extruded from the inner of its sheaths; its face abuts against the outer case-ment which stands before it like a wooden wall. Unaided it cannot perforate this rigid structure. I fail to pierce it without using the point of a knife, yet through it the weak moth must force its way. Hence the emission of this destructive vomit, a fluid possessing certain qualities fitted to dissolve the gluey substance of the case. At exactly the right moment it is belched forth, and directed to the one particular spot through which the prisoner can head first make its escape.

The hole burnt by this fluid is a ragged aperture, apparently too small for the exit of the moth. Nevertheless the inmate squeezes herself through it, and is liberated safely from the double wrap. The ruptured cocoon remains within the case, also a heap of fluff which the occupant had shed before finally breaking through the wall. On first emerging, it is fairly active on its legs but quite helpless with respect to flight. Its wings are stunted, weak and limp, their shrunken arrangement within the prison having prevented the development of both rigidity and strength. Its first act is to eject an ochreous excreta. Then it gets into a stationary attitude so as to permit of the hardening of the wings. In a few minutes it begins to carefully manipulate them, just raising them

gently and returning them to its sides. They have been compressed so as to occupy the smallest space, but now we observe a gradual expansion. The crumplings open, the longitudinal foldings insensibly separate, the curls at the tips imperceptibly unroll. The whole procedure occupies about ten minutes. The moth is then to all appearances perfect, though its wings are still too limp for purposes of flight.

My remarks on the adult had better be brief. Though not brilliantly decorated, it is quite attractive, looking like a heap of grey silky fluff. In length it measures only one inch, a rather poor finale to the caterpillar stage. Its body is clothed in a thick layer of down, beautifully soft as the finest wool. This covering is densely massed along its ventral surface, and a dense growth encircles the legs. Its grey colour is decorated with a pretty pattern of black. There is a group of spots on the dorsal surface of the thorax, a transverse series of bands across the back of the abdomen, and a delicate ornamentation of specks and streaks suffused over the surface of the wings. The antennæ spring out of a heap of fluff and give off a number of branching processes which give them a resemblance to delicate combs.

In confinement this moth is extremely sluggish, permitting itself to be gently handled without making an attempt at flight. For the greater part of the time it remains quite motionless; the male, however, shows more signs of activity, no doubt influenced by the calls of sex. The female just clings to some suitable support, and seems to have

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no other object except to wait for the extrusion of the eggs. Her resting attitude is a little quaint. Her wings are fixed like a sloping roof, her antennæ bent back and concealed from view, while her fore legs project like fluffy feelers one on either side of the head.

While thus confined she will tell us something of the starting of her progeny. Egg-laying commences on the day after emergence. The moth hangs quietly to a stem or leaf. There is no demonstration, no sign of enthusiasm; the eggs just come forth as a passive extrusion, and are gently affixed to the required spot. But under natural conditions the affair must be more active, since the scattered arrangement of the eggs on the poplar suggests a fluttering from leaf to leaf. Here is the record of one individual. Her clutch on the first day numbered 159. On the second day another batch of 50 follows. Three days later 59 are laid, and on the seventh day a final cluster of 10. What an excellent example of prolific reproduction! A total of 278 eggs within a period of seven days.

And this leads to the concluding subject of my chapter. How fruitful is this moth in the generation of a family, yet how rarely is it found in the adult state. A tree may literally be strewn with ova. I can collect a hundred in a few hours, but where and when do the crowd of moths assemble of which these ova are the earliest stage. Throughout the season I have met with only two examples, both lured after dark to the searchlights of a ship

while steaming past dense poplar groves. The same question arises with respect to the caterpillars. When first hatched they are abundant. A sharp eye and a little patience is sure to find them. But with increasing size they grow progressively rarer, and the full-grown caterpillar is as much a rarity as the moth. The reason is that the insect is subject to a slaughter such as Nature inflicts on many of her creatures at some particular period of their lives. We know how the white ants at the hour of their emergence are massacred in thousands by insectivorous birds. We have seen how the egg-clusters of certain spiders are so widely infected by ichneumon wasps as to ruin them in countless broods. The white ant shows us war directed on the adult; the spider on the delicate eggs. With the puss moth the hour of carnage is somewhat different, though not its intensity nor its sure success. The blow is directed at the growing caterpillar, and with greatest intensity at its earliest stage. So insidious is it that we scarcely observe the onset, but the chief of the agents must be hymenopterous parasites, no doubt helped by other enemies that haunt the leaves. It is quiet but relentless, and deadly efficient. Of the hundreds that are generated by a single adult possibly one or two survive.

Since the details of this carnage are so largely hidden, let us seek for a comparison in what is fully exposed. We will pass from the jungle to the edge of the river, where, freed from the obscuring veil of foliage, we can witness an episode in this battle for life. It is not a moth, but a magnificent may-fly.

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March and April are the months that signalize its contest. At the time when caterpillars are being decimated on the poplar the may-flies are being swept from the surface of the stream. The water then presents a wondrous spectacle. Its surface is literally covered with *Ephemeridæ*. Fragile and delicate, yet peculiarly graceful, they skim along the water with fluttering wings, supporting their bodies on its glassy surface by a pair of diverging tails. Males and females are present in the multitude. They too have just burst from their narrow prisons. The warm sun has called them forth, and now, like dancing flakes of snow, they skip and glide from point to point. Indeed they are frequently spoken of as "snow-flies," believed to have been born on the icy summits of Armenia and swept down by the first thaw of spring. The males, the more numerous, make chase after the females. Their energy is boundless. They dash about enthusiastically in their search for partners, as a rule unable to leave the water, though on calm days occasionally taking to flight. Their lives are short. The whole of it is concentrated on this sexual pursuit. A female is encountered. Union follows. For a few hours they leap and revel in the daylight impelled by the fleeting thrill of life. But soon they languish. The ova have been scattered, and by sunset on the day that gave them birth the vast and beautiful multitude is dead. Next morning another fresh swarm appears, and by evening all have faded away.

Now let us turn to the deadly battle waged on

these successive swarms. Enemies encounter them on every side as day by day they sail along the stream. Numbers fall a prey to ravenous gulls, which gather around them in busy companies or wait for them at the edges of the banks. They persistently engulf them till filled to repletion and then have to rest to digest their gorge while the multitude flutters gaily round. Other birds join in the destructive feast. The terns seem to know of their emergence with the sun, and like beautiful white hirundines patrol the banks. Bee-eaters come floating on them from the edge of the jungle and take them like a flash of green. The swallows fall down on them in undulating curves, the black kites grip them with their incurved claws, even the kingfishers leave their accustomed food to join in this relentless war. And not only does the air rain down destruction. Dangers rise up to meet them from the depths, or confront them from the muddy shores. From the bottom the mudfish ascend to devour them, frogs await them on the shelving bank, and, when stranded, the carnivorous ants retrieve them as juicy provender for the subterranean nest. Many are overwhelmed by the wind and waves, and are sometimes washed ashore in so dense a myriad as to form a white fringe to the river bank. At times the water is a fluttering sheet, and as their numbers are great and new swarms are generated, so still more intensive is the loss of life. And though they meet with enemies on every side, yet their struggle is as hard against the ordinary elements. The winds and the waves

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so batter their frail bodies that on one strip of shore four feet in length I counted 450 of their dead. Nevertheless, though so delicate, they struggle well against the elements. If the water is broken they may be frequently submerged, yet again and again they make attempts at flight. But a multitude falls in the ruthless slaughter. Those that live survive by reason of their numbers, for their enemies, becoming gluttoned with such rich profusion, are forced to abandon the feast. It calls to mind the ruthless destruction of the termites and gives us some impression of the havoc to the moth. Moreover, it tells the further lesson of how Nature often reaps her victims at one particular period of their lives.

We reflect on the fruitfulness of organic beings. We might have thought that on the fringe of this Arabian desert the fertility of nature would have been subdued. A wilderness of sand, a scanty rainfall, a suffocating heat; these are not the agents usually believed as likely to stimulate the procreation of life. Yet when we see the ova scattered through the poplar and the swarms of may-flies dancing on the stream, we might repeat the words of Humboldt, as applied to the tropics, that nature in these climates appears "more fruitful, we may even say more prodigal of life."

CHAPTER VII

THE MESOPOTAMIAN LAPPET MOTH

The eggs—Emergence of caterpillar—Characters at birth—Its development—Manner of defence—Protective coloration—Machinery of tufts—Use of tufts—Experiment with ants—Function of hairs—Other defences—Final development—Pupation—The chrysalis—Exit of moth—Characters of moth—Experiments on colour sense.

IN those gardens of the oasis rich in culture the pomegranate is a striking tree. Its height is no larger than a tall bush, and thus it finds room between the bare trunks and beneath the tufted summits of the palms. A thick foliage of small leaves profusely clothes it, but its chief adornment are the tubular blossoms which glow like vivid spots of crimson through the compact mass of green.

While inspecting it closely in the month of May, taking note of a little beetle which mimics the ants, and of the semicircles which the bees have cut out of its foliage, I happen to observe on one of its leaves a cluster of insect's eggs. They are seven in number, lying close together in a double row, and tightly anchored to the upper surface about half an inch from the extreme tip. These are the ova of the Mesopotamian lappet moth, *Taragama siva*, Lep. of the family *Lasiocampidæ*.

As insects' eggs, they are comparatively large,

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being about one-tenth of an inch in width. Consequently the cluster is fairly conspicuous, and stands out from its floor of green. Broadly oval, almost spherical in shape, each egg has a shallow dimple on its summit as though the sphere had been pressed in. Its shell is hard, its surface smooth, and its colour a dirty white. In addition, it is marked with brownish patches something after the manner of the egg of a bird. At one pole are three or four irregular blotchings with a scattering of small dots. At the other is a well-defined central spot encircled by a figure shaped like a star with seven radiating points. The pattern of colour is not without some elegance, especially when viewed from the stellate pole. The manner of attachment is apparent to the eye. Each egg has been fixed to the surface of the leaf by a flake of transparent gum.

Emergence takes place through a central crater after the manner observed in the caterpillar of the puss moth. The area eroded is the decorated pole. The stellar ornamentation is broken down, and a caterpillar, clothed in silky hairs, crawls out from the gaping shell. Its length at birth is one-fifth of an inch. It seems much too large for the oval prison, and must have been most neatly coiled upon itself when accommodated within the shell. For a little while it sits upon the rows of eggs as if to develop assurance and strength. It has been suddenly thrust into a new world and must take time to make itself familiar with life. Let us take the opportunity to note its appearance. When examined with the lens it is a splendid little mite. The whole of its

body is stiff with bristles. They are thickly spread in greyish tufts, soft and long and beautifully silky; those on the back stand up erect, those on the flanks jut out like a fringe, those at the extremities are as long as the caterpillar and project like feelers from either end. The little mite looks smothered in this bristling armour, which envelops it as with a dense brush. The hairy garment almost hides the colour of the skin. But we can see the black head, the pale bluish body, the tiny yellow papillæ that bear the tufts of hair, and a pair of transverse brownish bands on the middle of the front of the back. While resting on the eggs, it nibbles at them slightly. But I have seen it make no more than just a passing bite. There is none of that complete engulfing of the egg-shell such as we observe in certain other bristling forms belonging to the *Lymantriid* group. In fact, no tender introduction to its pasture is necessary. Neither appetite nor jaws need any stimulus, for within a few hours of its entrance to the world, there are marks of its commencing ravage on the leaves.

Very soon after birth it begins to exert itself. The leaf on which it rests is a sea of green. A large expanse is therefore open to its earliest explorations, and we soon find it eating bits out of the edge. With growth its bristles become even more prominent. At birth they seemed to lie a little down over the body, the result, no doubt, of pressure from the wall of the egg. But in a day or two they are more rigid, standing firmly erect with their tufted arrangement very distinct. Certain

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characters of structure have become apparent which are specially important at a later stage. We notice how the body is flattened like a strap, thus enabling it to lie close against the stem. We observe how the legs are scarcely visible, being nothing more than minute tags projecting through the tufts of hair. The suckers, on the other hand, are very conspicuous since they are thrust out horizontally on either side with the object of embracing the support.

The first moult takes place on the fifth day, when its length has increased to two-fifths of an inch. Up to this time it has shown little signs of voracity. A few occasional nibbles seem sufficient to satisfy it, and in the intervals it enjoys long periods of rest. By nature too it is extremely sluggish, scarcely ever moving about of its own inclination, but just lying full length along a stem, fenced in by its armoury of spines. The shedding of the skin is, as usual, complete; even each of the crowd of individual hairs is drawn out of its separate sheath. A change is apparent in the new dress. The hairs have become even still more bristly. From the head they project in a vast profusion, and from either side in a luxuriant fringe. A double row of orange coloured nipples stands up conspicuously through the dorsal hairs. There is a pair on every segment of the body, and each of the nipples forms a base from which project five slender spines. These spines are stiff and sharply pointed; those on the tail are somewhat longer than the rest, while those supported by the nipples of the head

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are more than twice the average length. Thus the caterpillar is furnished with an even better armour as a consequence of the first moult.

Let us hasten to complete these tedious details. By the twelfth day the caterpillar is one inch in length. The yellow nipples have changed to red, the grey silky coat has become beautifully speckled, and black tufts of hair with paler edgings have sprung up behind the head. It still remains sluggish and eats only in snatches. The stem is the place that suits it best. From there it occasionally pushes out its head to bite at the foliage within its reach. But it seems reluctant to advance boldly, as though fearing some danger in the open leaves. While feeding it keeps its head in continual vibration. But it tries to make as little movement as possible, and even this ceases whenever it is disturbed. Where it rests it often spreads a thin skein of silk. As a consequence, when many use the same support, the latter becomes clothed in a transparent film as if a coat of varnish had been spread around the bark.

Let us follow our plan in the chapter on the puss moth, and pause to consider this caterpillar's defence. In the first place we observe its remarkable capacity of finding concealment in its natural haunts. We must remember the details with respect to its habits. The greater part of its life is spent aligned along a stem. It seldom moves about, and then with circumspection. On the slightest alarm it immediately halts and remains absolutely still. Only at long intervals does it

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climb into the foliage, where it quickly takes in sufficient for a meal and then returns to its place on the stem. Such habits as these immediately suggest that the stem is the place where it feels most secure. A few brief observations will confirm this idea. For not only do its habits conform to the environment, but its colour, its shape and the attitude it assumes are especially adapted to conceal it from view. The stem is chosen with the object of harmonization. Its pattern of colour blends well with the bark. Both the stem and the caterpillar are the same grey shade and both shine with the same silky gloss. Moreover the excrescences and rings on its body are not unlike the marks on many a stem. Its flattened shape is well fitted to make it inconspicuous by causing it to approximate closely to the bark. Its attitude helps to a similar objective, since it always lies along the length of the stem, wraps its body tightly around it, spreads out its suckers as if trying to embrace it, and flattens down the lateral hairs until they are neatly pressed against the bark. Thus the caterpillar, though in reality a bristling tube, yet is extraordinarily well hidden in its natural haunts. It scarcely resembles a living creature, so much does it look like an inert band tightly stretched along the grey bark. It seems as if an actual part of its support, or at most nothing else than an elongated thickening along one side of the cylindrical stem. Hence its reluctance to remain in the foliage, and the strong attraction of the safer haunts. The caterpillar's instincts conform to its structure. Its preference for the stems

is very decided. I place a number of them in a glass-covered box. At first they occupy the sides and the floor, this being the only available space. Later I supply them with some stems of the pomegranate. Soon they are aware of this more natural surface. They all desire to occupy it together, and there is not sufficient room. They crowd themselves around it, overlap one another, and end by encircling it on all sides in a solid hairy mass. Assimilation of colour with suitable instincts is thus a part of the protective scheme.

But all this is purely a passive affair. The caterpillar has also an active defence. It is supplied with a device of peculiar interest, a highly specialized type of machinery, as strange as that observed in the caterpillar of the puss moth, but fashioned on a different plan. We proceed to investigate. I touch the caterpillar on one of its spines. In addition to an armour, these are tactile bristles, and the caterpillar is immediately on the alert. It draws back a little at this insolent intrusion. At the same time it brings its machinery into action. On the front of its back, just behind the head, two fissures open like a pair of mouths. Their posterior margins are rolled backward and from their interior is thrust out a black tuft of velvet hairs. (See Plate, page 126.) What an abrupt and astonishing performance, a kind of magic, a demoniacal growth! It is as striking as that displayed by the caterpillar of the puss moth. It seems as if the skin had burst asunder in order to shoot forth these bristling tufts. The extrusion of the brushes is so

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unexpected, and there is something so malignant about their appearance, that one feels that it is wiser not to interfere. For a little while the growths remain protruding, but soon the caterpillar gains reassurance. The widely opened lips then come together; the hairs of the tufts roll down on one another until hidden by the closed mouth.

This machinery is worth a little intimate inspection. The mouths are in the form of transverse slits that cross the whole width of the caterpillar's back. At ordinary times the lips are in contact. They may separate just slightly when the caterpillar moves, but in the resting state they are in close apposition and the tufts are completely hidden from view. A stimulus is required to open the fissures and convert them into yawning clefts. The lips themselves are prettily adorned. The skin of the front lip is tinged with red, and on it is mounted a pair of papillæ, each with four erect spines. The hind lip, on the other hand, is marked with blue, which adds not a little to the wonder of the apparition. For the tufts themselves are so intensely black that the gaily coloured lips on either side exaggerate the strange effect. On the hind lip, especially of the posterior mouth, there is in addition a peculiar arrangement of elongated whitish scales. These scales are obviously specialized hairs. Each is shaped like the blade of an oar, as if the hair had been flattened and expanded so as to fit it for the manufacture of a fringe. These tiny oars have an imbricated arrangement, as a result of which they form a flap that serves to cover and protect the

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slit. The extruded hairs are soft and silky and set in lateral tufts. They look so forbidding on account of their colour that they immediately suggest a poisonous effect. We know of other caterpillars of the family *Lymantriidæ* which are venomous by reason of their hairy tufts. When touched, they give rise to a violent urticaria from the poisonous hairs breaking into fragments that scatter and penetrate the skin. But there is nothing like this in the brushes of the *Lasiocampidæ*. I rub some of the hairs into the skin of the wrist, but there is not the slightest trace of irritation. Moreover, under the microscope they show no complicated structure as do those of the *Lymantriidæ* with their multitude of spines. They are merely simple pointed bristles like any ordinary hair.

The sudden protrusion of these black tufts must be for the purpose of exciting alarm. Like the facial apparition on the caterpillar of the puss moth they scare a too inquisitive intruder away. I have little doubt that the sudden unexpected protrusion would suffice to intimidate an insectivorous bird. It is as good an example as we may hope to see of a machinery contrived for its frightening effect. The caterpillar often helps to make it fully impressive by assuming a special attitude of alarm. It increases the size of its bushy head by thrusting out its hairs and whiskers and expanding its lateral fringe. At the same time it elevates the front of its body and bends it into a sharp hump. This latter manœuvre is particularly important since it brings the fissures to the most conspicuous position,

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namely to the summit of the hump. The result is, of course, to exaggerate the apparition, and add still more to its terrifying pretence. The very slightest intrusion will rouse it to this counterfeit. Just the touch of a needle or a puff of breath, and the terrifying attitude will be made to appear. Nothing causes more disturbance than the advent of a fly, if it happens to alight on the caterpillar's back. There is a sudden quiver, a quick erection of the head, and no doubt the further machinery would operate did not the insect immediately make off.

But in addition to this specialized protrusion of tufts supplied for the purpose of causing alarm, the ordinary hairs that fence the body are of great importance as a kind of shield. Possibly they are of more protective value even than the extraordinary mechanism on the back. An experiment with the ants will explain this. The large black ants belonging to the genus *Camponotus* establish their nest near the foot of a tree. They are powerful and pugnacious, especially the soldiers, and violently resent any intrusion on the sacred threshold that surrounds the nest. I supply them with a full-grown hairy caterpillar. The nest is populous and the ants enthusiastic, since the commune is engaged in sexual activity and a number of workers are gathered round the gate. A few of them are quickly aware of the intruder. They approach the caterpillar with the object of examining it, but the moment they come in contact with the fringe of hairs, they immediately draw back in alarm. They

are clearly reluctant to touch the bristles, no doubt apprehending some kind of entanglement, for the hairs are quite harmless and even delicately soft. Thus the caterpillar seems to be comparatively safe, though on this dangerous threshold in the midst of the ants. Hence we see the value of these radiating bristles. They envelop the caterpillar in a tufted armour which serves as a protection from insect foes. For, as mentioned, when discussing the caterpillar of the puss moth, it is probably the tiniest insect parasites, rather than the conspicuous insectivorous birds, that cause the chief loss of life. And against the attack of insidious parasites the hairs are a defensive shield. Also for this reason they are mainly arranged in the form of a lateral fringe. Hairs, of course, project from all parts of the body, and thus serve as a protection from every side. But they are longer and more luxuriant along either flank, and the caterpillar, when at rest, spreads out these fringes so as to encircle its body in a ring. As a consequence any insect exploring the bark will immediately encounter the edge of this fringe if it happens to approach where the caterpillar lies. Danger is more likely from a prowling enemy than from one alighting directly from above. Hence we realize the value of the hair arrangement in the form of a ringed fence. Many insects are particularly timid of hairs. They possibly imagine the danger of a trap, since a hair will feel to them like a slender thread which the spiders spread on every side. Plants take advantage of this timidity. Certain kinds grow hairs

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around their stems in order to hinder the ascent of ants; other kinds collect them within the inflorescence so as to prevent the ravagers from stealing the juice. The caterpillars have joined with the humble plants in the development of a similar device.

I return to the caterpillar near the gate of the nest. Did I not interfere, it would crawl from the arena since the ants are afraid to penetrate its shield. But by repeatedly annoying a few of the soldiers, I so enrage them that they break through the hairy armour and begin to investigate the caterpillar's skin. The fissures on the back then immediately open, and out come the black tufts. These do not appear to alarm the ants; the hairs are the defence against insect enemies, the tufts are for larger foes. But the caterpillar turns on its dangerous assailants. It raises its body to try and shake them off, especially one which has gripped it by the tail. It bends its head in the direction of another and vomits forth a considerable quantity of a yellow slimy juice. These efforts meet with some success, but are insufficient to repel the invasion of so powerful an enemy as these enraged ants. A soldier at last gets a grip on its head and lacerates its tender skin. Then the caterpillar throws itself into violent contortions, gives forth another discharge of juice, and endeavours by a writhing and twisting of its body to shake the assailant off. At the same time it throws itself down to the ground—for by now it had climbed a little up the tree—and in this act

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we see a simple ruse for escaping from the danger zone. The battle continues on the soil below, ants and caterpillar being joined together in a common struggling mass. But the hairy defences have been overcome; moreover, the caterpillar is now badly wounded and soon becomes a total wreck.

These incidents are sufficient to indicate clearly by what a combination of different devices this caterpillar secures defence. First we have observed the scheme of coloration in which instinct and habit and pattern of dress all make for concealment in the natural haunts. More important still is the fence of hairs which shields it from predaceous and parasitic insects, especially those that might approach it on a flank. Then again there is the sudden extrusion of the tufts, a device to intimidate the larger enemies that hunt their prey by sight. Should these defences fail and a struggle develop, then the caterpillar has resort to other arms. A nauseous juice is at its disposal, and this it can vomit direct on the foe. It has also its own strong muscular contractions, and the instinct of suddenly dropping to the ground in order to escape the danger zone. By such a combination of different devices does this caterpillar hold its own in the struggle for life.

I return to the final stages of its growth. Full development is reached on the twenty-fifth day, though the period is very variable, even amongst those of the same brood. By then it is thicker than a stout pencil and three and a half inches in length. A shrinkage has occurred in the spines

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and bristles, which exposes more of its bare skin. Its grey mottled coat is remarkably handsome, the hairs about its head are like luxuriant whiskers, the body has now a sheen of silver with a delicate bluish tinge. All these combine to clothe the caterpillar in a truly magnificent dress. It is never more splendid than when it sits erect, displaying its black brushes through open mouths and spreading out its lateral tufts. These last days of its existence, as with the caterpillar of the puss moth, are marked by an exorbitant craving for food. Hitherto it was desirous chiefly of rest; now it prefers to attack the provender the moment a supply is put into its cage. At this stage it might cause considerable destruction should a number ravage the same tree. Nor is it over nice in the nature of its aliment. I supply it with other varieties of foliage, with the rose, the castor oil plant, the desert acacia. The caterpillar seems pleased with the change of diet, and soon begins to nibble at all three.

This voracity terminates in the usual sluggishness that marks the entrance to the pupal state. The gorge ceases. The caterpillar remains for a long time quiet. At last, having chosen a place for transformation, it commences to weave the nest. The silk is spread out after the accustomed manner, the caterpillar steadily oscillating its head, working first at one end, then at the other end, and anchoring the threads at suitable points. They are of the usual delicate glistening character, and cross one another so as to form a network which by further

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additions is strengthened to a sheath. The caterpillar, as it works, keeps its body contracted, by which means it is able to weave a capsule much shorter than its own length. The structure, thus formed, is a spindle-shaped edifice, one and a half to two inches long, and about half as much in width. It is white in colour and closely woven, but at one extremity the texture is more open, a special device on the part of the architect to allow of the subsequent escape of the moth. Near one end we will notice a small black patch. This is the last of the alarm tuft. It is shed, being of no further value to the caterpillar, and is left as a conspicuous object on the sheath.

The occupant of this cell becomes a bulky chrysalis. It is over an inch in length and stout in proportion. Its head end is blunt, its tail tapers to a point, and its body is divided by transverse rings. On its surface is a coat of reddish hair, thickened to a fringe across each segment and somewhat luxuriant at the blunted end. It is particularly sensitive to external interference, wriggling more vigorously than is usual with a chrysalis when removed from its enclosing sheath.

This imprisonment lasts for ten days. All in the family emerge at evening, a little fact which suggests a protective value by shielding the moth from diurnal enemies while in the state of helplessness following on birth. Its exit takes place through one end of the chamber, the tissue being there particularly open, and the moth coming through a scarcely visible breach,

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The female is distinctly larger than the male. Her appearance is elegant, well clothed in fur, with handsome tawny wings. Her mate is prettily, though less strikingly adorned, since his wings, instead of being richly coloured, are variegated with yellow and brown. In both the head has a kind of proboscis, which gives an elephantine appearance to the moth, and in the male the wings fall short of the body, which projects beyond them in a hairy tuft that looks like an upturned tail. Their first thought is for reproduction, the female being ready to receive her mate almost as soon as she is out of the cell. The male is somewhat active at the period of courtship. He flutters about from place to place, his expanded wings quivering with emotion and his toothed antennæ thrust out like rakes. Union follows on these endeavours. The female is more passive and awaits acceptance. She is little more than a sexual apparatus designed for the production of heaps of eggs. On the night after emergence I see the ova appear. The act, no doubt, is always performed in darkness, since the life of the moth would soon be finished did she flutter about in the light of day. It is a peaceful process without any excitement, the eggs just flowing from the point of the abdomen while the moth clings to some suitable support. The outpouring, as with the puss moth, is wonderfully profuse. I count two hundred and fifty eggs as the content of a single brood. They are laid in clusters, variable in size, six to eight in the smaller collections, fifteen to twenty in the larger groups.

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Their arrangement is commonly in neat rows; at other times they are piled into hillocks or else accumulated in a compact mass.

And this ends our story of the insect's growth. The members of the family discovered on the pomegranate have supplied me with a new generation of eggs. I have them in abundance, in hundreds, if not in thousands, and they all hatch on the sixth day. Their development is now of no further interest; let us, therefore, try to put them to some other use. We will take the opportunity of this richness in caterpillars to make a few experiments on the special senses of the group. We have noticed their peculiarly sluggish nature, their instinctive desire for long periods of rest, with occasional snatches of food. What need have they for refined sensibilities? Their business is just to eat and grow and lie full length along a stem. Their sight can scarcely be very efficient. They have no true eyes like the adult insect, but merely a cluster of minute ocelli, six in number on either cheek. Their preference for certain foliage suggests a sense of taste, and they certainly have an excellent perception of touch. Perhaps we may add the sense of smell, and such should be sufficient for their torpid lives. Nevertheless I will show by some simple experiments that they are gifted with a perception of colour also. Though possessed of only the simplest eyes, yet they act as if they recognized the different colours that go to compose the light.

The problem is investigated in the following

manner. I prepare a special experimental box. Its four walls are papered with different colours, its floor is strewn with a layer of provender, and it is covered with a sheet of glass. To this prison I transfer twenty-five caterpillars at the stage when they are half grown. The floor is kept littered with fresh supplies, and the inmates thrive in the multi-coloured cell. They continue, as far as possible, their natural habits, descending to the leaves for the purpose of feeding, after which they withdraw to the sides of the box. Thus the walls of the prison represent the stems where the caterpillars spend the greater part of their lives. A few, however, show some little independence, and prefer to hide underneath the provender instead of lying along the wall.

We will utilize this habit of resting on the wall in order to examine their colour sense. We will allow them to feed, wait till they retire, then count the numbers on the different walls. In this way we may learn of some influence of colour, and, if so, which kind the caterpillars prefer. The direction of the light may make a possible error by putting one side of the box a little in the shade. It will, therefore, be more accurate to eliminate its influence. Hence, after a count we will rotate the box, turning it each time through one right angle, and then strike an average of four counts.

The colours employed in the first experiment are red, green, blue and white. It would be tedious to give the details of each calculation. But after

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four rotations I summarize the counts. This is the result in percentages of caterpillars. There have been 35 per cent. on the red, 20 per cent. on the green, 12 per cent. on the blue, 7 per cent. on the white, while the remainder do not come into the calculation, having remained hidden underneath the leaves. Here, therefore, we have a clear indication that the caterpillars show a preference for red and green. I repeat the experiment under slightly different conditions. On the first occasion the box was placed in the window; let us try it this time in more subdued light. The result is much the same as in the first experiment; 27 per cent. on the red, 26 per cent. on the green, 16 per cent. on the blue, 2 per cent. on the white. Their aversion to white is particularly apparent; it was strikingly obvious in every experiment that went to make up these composite results.

I exchange the white for a dark brown. I remove what is specially repellent to the caterpillars. I supply in its place what I hope to be attractive, since the brown resembles the colour of the bark. Perhaps they will show a particular liking for the colour on which they are accustomed to lie. Again I make the counts and the four rotations. But the result is contrary to what I anticipate. There are 29 per cent. on the red, 23 per cent. on the green, 18 per cent. on the blue, 3 per cent. on the brown, the remainder, as before, not coming into the count. The red again stands first on the list, and there is no attraction in the colour of the bark. Indeed, they seem to

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dislike the brown just as much as they do the white. Though they gain protection through harmonization, yet it is not because of the blend in colour that they are led to their place along the stems.

There is clearly some special kind of allure^{ment} in the colours red and green. Every experiment confirms the fact. But how is this remarkable influence effected. The caterpillars have only simple ocelli, which can scarcely be elaborate organs of vision. Yet they are influenced not only by ordinary illumination, but are capable of appreciating the different rays that go to make up the light.

The caterpillars, when in darkness, are uninfluenced by colour. I exclude all light from the experimental box. Again I go through the same round of calculations. The following is the result, quite different at a glance, from that obtained in the full light. There are 13 per cent. on the red, 33 per cent. on the green, 10 per cent. on the blue, 26 per cent. on the white. When in darkness the caterpillars have no preference for red, or no special reluctance to remain on the white. Colour will have no effect on the caterpillars except when associated with light.

Thus the caterpillars, though apparently so dull and torpid, yet react to those delicate ethereal tremors which make the world so wonderful and beautiful to us. Here we see the elements of a colour perception, of that sense which fills us with such happiness and delight. We think for a

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moment of what it means, of the blue of the ocean, the splendour of the rainbow, the glow of the sunset, the beauty of the flower, all that rich and changing colour which illuminates both heaven and earth.

CHAPTER VIII

THE OLEANDER HAWK MOTH

Splendour of moth — Geographical distribution — The eggs — The young caterpillar—Its development—Methods of defence—Contest with ants—Further development—Further contest—Increasing growth—Its alarm devices—Colour transformation—Pupation—The chrysalis—Summary of defence.

My oasis provides me with a little garden, nothing elaborate, but yet delightful when compared with the desert spread around. In April and May it glows with colour. The roses, the hollyhocks, the oleander bushes vie with one another in the richness of their flower. It is the last of the three which here concerns us, since it is the plant selected by the oleander moth.

What a splendid example of insect structure! What strength, what speed, what elegance, what beauty are exemplified in this magnificent moth! What strength! Look at the bulk of its muscular development. Take it in the hand and feel the beating of its wings, and close tight upon its powerful struggles to get free. What speed! See it sweep through the air less like an insect than a bird. Watch it darting and swerving in the swiftest evolutions. These hawk moths are the swallows of the insect world. What elegance!

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Consider the harmony of every proportion, its body shaped on the plan of a torpedo, the sharp-cut style of its triangular wings, its graceful tapering lines. Every feature in its perfect structure seems fashioned for the conquest of the air. What beauty! Who could describe the vernal colours that decorate its velvet coat? We see spots and lines and curves and blotches, splendid in profusion, infinite in variety, yet applied with the skill of such a master hand that the pattern itself seems associated with speed. The rich green of the foliage is painted on its wings, intermingled with yellow and brown.

It is the well-known species *Deilephila nerii*, in body length about an inch and three-quarters, but proportionately greater in strength and bulk. We will scarcely come across it in our morning explorations. Its habits appear to be exclusively nocturnal, and at dark we may observe it flashing past the lights. Sometimes it is drawn to the seductive glare, when it hurls itself violently on the fatal lure, and, dazzled into helplessness, comes crashing to the ground. When at rest it adopts a suspended attitude, hanging loosely from the edge of a leaf which it grips with its front legs.

Though so large in size and so strikingly beautiful, though it specially obtrudes itself by coming to the light, yet in England it is one of the rarest of moths. The few occasions of its capture have been carefully tabulated; one at Dover in 1833, a second at Brighton in 1852, a third at Hastings in 1862, and so on at such extended

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intervals as to make each capture an entomological event. Its true home is in the warmth of more southern climates, where it lives along the balmy shores of the Mediterranean, spreads southward into the African continent, and eastward through Asia Minor to the peninsula of India. It is by no means uncommon on the banks of the Tigris. The land of the date palm seems to suit it well. Four captures are recorded by different entomologists during the years of our military operations against the Turks.

It was the grandest visitor to my little garden, and often of an evening I saw it darting past the lamps. The bushes of oleander were there to attract it, compact shrubs with tapering leaves and clusters of pink flowers. I search their foliage at the end of June, carefully examining them leaf by leaf. Here and there I happen to find an egg, a tiny pale green delicate sphere lost in the mass of leaves. These are the treasures of the oleander moth. They are rare and widespread and demand much search. But, after careful scrutiny, I possess myself of ten, certainly not a very large collection, yet sufficient to disclose the details of growth. Let us attend to them with a little care. The splendour of the adult would excuse the inquiry, did we not find that the caterpillar has points of interest too.

The egg of this moth is a uniform sphere, in diameter about one-seventeenth of an inch. Its surface is smooth and devoid of decoration, while the enclosing shell is firm to the touch. But its attractive feature is the delicate colour, a pale soft

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green with just a tinge of yellow, not easily seen against the darker leaf.

The first change that we notice is a wrinkling of the surface. The shell shows signs of collapsing a little, which indicates that the hour of hatching is near. If at this time the egg is examined in sunlight, the outline of the inmate can be seen through the shell. It is observed to lie in a horizontal position, closely coiled, something after the manner of a woodlouse, so as to occupy the smallest space. It may also be noticed to make attempts at movement, while the darkish colour of its tail appendage is evident through the transparent shell. As the hours advance its movements strengthen. At length its impatience gets beyond control. It eats its way through the wall of its prison, and walks out from the fragile case. The breach has been cut in one side of the sphere. It is an ill-shaped opening made at the spot which happened to lie beneath the inmate's jaws.

At birth it measures one-fifth of an inch. There is nothing very striking in its first appearance. Its colour is a pale and uniform yellow. Its body is smooth like a fleshy maggot. A strong lens will show a scattering of short hairs, but there is no suggestion of a spiny coat. Its most conspicuous feature is a thorn on the tail. This is a straight and simple spine, about two-thirds as long as the caterpillar's body, somewhat stouter at the base where it is hinged to the integument and tapering gradually to a fine point. The little mite has this thorn under its control, being capable of pressing

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it down on its back or raising it erect in the air. Exposure soon changes the colour of the spine. At first it has just a darkish tinge. But within an hour of birth it becomes distinctly brown, and by the next day it is a dense black.

The caterpillar wastes no time in commencing to feed. Almost immediately after birth it starts to nibble at the egg-shell, first gnawing at the edge of the aperture of exit, and in a few minutes engulfing the lot. Thus its earliest meal is particularly delicate; it may contain some specially nutritious material, and is, at least, a very much more tender morsel than the leathery substance of its later food. But it does not long refrain from the coarser diet. Having devoured the egg-shell, it rests for a little. I observe it lying like a tiny rod along the midrib of the leaf. Hunger, however, soon claims attention. The foliage of the oleander is stiff and tough; it is also extremely bitter to the taste. Nevertheless the caterpillar soon attacks it, the implements employed for escaping from the prison being equally suitable for hacking at its food. How efficient they are in this infant state. On the day of its birth it cuts the epidermis, eats away the hard tissue in ragged patches, and even nibbles a tunnel through and through the leaf. It is very erratic in these earliest efforts, first gnawing at one point, then at another, and thus marking the foliage with eroded spots. Every young caterpillar is not quite so voracious. Here and there on the bush I find an empty egg-shell, just a flimsy capsule of transparent tissue,

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indicating that the inmate had attacked the vegetation without first devouring its prison wall.

By the second day its colour has become a brighter yellow with the faintest tinge of green. This grows more intense as the day advances, and by evening it has passed into an orange hue. The caterpillar is now active and quick in its movements; its little jaws, though scarcely visible, must be wonderfully strong, with such force does it tear at the leathery food. Nevertheless it must be careful with its infant weapons. Consequently it prefers the softest foliage, choosing, if available, the young tender tops. It spends most of its time full length along the midrib. This portion of the leaf is lighter in colour, and the caterpillar there blends better with its background than it would against the tissue on either side. It is very sensitive to any interference. If touched, it immediately jerks back its head, then sweeps it across the body in such a manner as to brush the intruding object aside. The act is peculiarly quick and sudden. It is no doubt the device for expelling an enemy at this very earliest period of life. Even at this stage it may be preyed on by parasitic insects, and the sweep of the head will banish these. The spine on the tail does not come much into use. Whether the caterpillar is resting or moving about, this thorn is maintained permanently erect.

The third day marks the first of its moults. The skin is thrown off in the usual manner, the caterpillar coming forward out of its tube, leaving on the foliage the skin of its body and the covering of

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its erect spine. It is now an even more vivid yellow, and looks charmingly attractive in its new dress. Being free from the integument, it has room to expand, and consequently grows at an increasing rate. By the fourth day it has reached half an inch in length. Its golden colour is changing to a rich green hue. Just behind the head we see three tiny legs, while under the posterior half of the body are the four pairs of sucker feet. The spine on the tail is also developing, but it cannot keep pace with the body growth. Its voracity too is at the same time increasing. A few days ago it nibbled an occasional crater; now it tears the edges out of the leaves. The fifth is a day of fasting and torpidity. For twelve hours it just lies along the midrib, no desire for food, for activity, for anything; it is clearly preparing for the second moult.

This event takes place later in the day. I am not witness to the act, so must learn from its relics. Of the caterpillar's skin I find only a few fragments; there is the hard shield which encased the head, the stiff tubular covering which enclosed the spine, but where is all the softer tissue, the main portion of the caterpillar's skin. I cannot find a trace of this more pliable material. It must have been devoured by the gluttonous owner as soon as it was cast off. The caterpillar has despised the indigestible portions, the casing of the head, the covering of the spine. But every fragment suited to its stomach has been completely wolfed. It is an instance of those numerous economies in nature where all that is nutritious returns to the host. We

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observe it at the moult of certain long-horned grasshoppers which devour every fragment of their cast-off coat. We see it in the case of the geometrical spiders when they take their architecture back into their bodies and refashion it into a wheel. The caterpillar practises a similar economy. There is first the devouring of the empty egg-shell, later of the discarded skin. Soon after the moult its activity returns. Now newly clad and with head erect, its spine glittering with a fresh sheen, it feeds with even a greater enthusiasm than before.

It increases rapidly in length and thickness. By the sixth day it measures almost an inch. There are now some signs of its future adornments, chiefly in the form of a line of eye-spots closely arranged along either side. A greater mobility is developing in its spine. For the first few days it merely stood erect, now it is more definitely fixed upon a hinge and bends down when the caterpillar is touched. This spine is another of these special mechanisms supplied with the object of securing defence. Observe in how simple a manner it works. I touch the caterpillar gently on the flank. Immediately the vertical spine descends; it may bend forward to such an extent as to lie horizontally along the back. I withdraw the stimulus and the spine ascends, returning to the vertical position once more. How can this be of very much use to the caterpillar? The lowering of the spine is such a limited action. It cannot be twisted or bent to one side; it cannot be made to touch other parts of the body; it is merely a spike on a simple hinge.

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In what way can it give any useful defence? We can understand it only by combining observations, and seeing exactly how the caterpillar behaves. I have said that, when touched, it sweeps round its head in order to brush the intrusion aside. The head is in fact a kind of battering-ram employed for its mechanical effects. In this way it can protect the greater part of its body; the front of the back, and, of course, the flanks are all within reach of this sweep of the head. Any small enemy is thus easily expelled should it come within range of the battering-ram. And if the muscular blows prove insufficient for the purpose, the larva can support them with another device. It has the power to spit forth a greenish liquid, that substance so obnoxious to insect foes. Thus the front of the body and the two sides are protected by the ram and the nauseous juice. But there is one part which the head is unable to reach, namely that portion of the middle of the back immediately in front of the caudal spine. Here is an area open to invasion, a spot which enemies would surely find, were it not supplied with some special defence. There must be no joint in the defensive armour, otherwise all effort will be thrown away. Hence I understand the purpose of the spine. It is a device for the protection of this particular area. It is fixed to the tail in order to be lowered on the unprotected spot beyond the reach of the head. Its descent is sufficient to alarm an enemy, and, being so completely under control, it can be lowered when occasion requires. Thus protection is assured by the

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triple combination of the battering-ram, the juice and the spine.

How various are the methods supplied by Nature for the shielding of caterpillars from their insect foes. We have seen the long filaments from the larva of the puss moth, the remarkable manner in which they are extruded, and the jets of poison which they shoot forth. We have examined the black tufts on the caterpillar of the lappet moth, how the fissures open just behind the head, and the brushes come out from the gaping mouths. Here we have a simpler, though quite a wonderful arrangement, a pointed spine on a movable hinge capable of being lowered when necessity demands. And we have seen how it forms only a part of the machinery. It must be combined with the battering-ram in order to supply a complete defence. So delicate an apparatus would, of course, be valueless if employed against large enemies such as insectivorous birds. But I have already made it clear that the greatest danger is to be expected from parasitic foes. Unless we bear this fact in mind we will fail to understand the purpose of these mechanisms. The tiniest diptera, the parasitic hymenoptera; it is these that take the toll of caterpillar life. It needs little to alarm such minute invaders, a sharp touch of the head, a sudden jerk of the body, a little jet of poison, a contact with a hair. If we realize this we will gain an idea as to why these extraordinary mechanisms are supplied.

Let us give the caterpillar to a nest of ants. I

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choose an example about a quarter grown, one of the precious family of ten. A swarm of *Phidole* will serge as the enemy. They are small, but active, and of dauntless courage; they will not easily be driven off. A worker on the prowl soon meets with the caterpillar. There is a brief examination, a few turns around it, a few taps with the antennæ, and the ant hurries back with the news of its find. In a moment out comes the rescuing legion, and the larva is threatened with a dangerous host. We observe how it resents the very first interference. Though so small and delicate, yet it knows how to defend itself. See its body thrown into quick contractions, the sudden blows given by its head, also the descent of the caudal spine as soon as ever it is touched. The effort would probably drive away a parasite, but it will not expel a swarm of ants. Nevertheless the first invaders are shaken off. The caterpillar, though so small, can contend with a few; but soon it is besieged by increasing numbers and falls to the combined assault.

We will follow its development a little further. The third moult takes place on the seventh day. Again I find nothing but the shell of the head and a portion of the membrane that enclosed the spine. Thus it varies its feast on alternate days by the swallowing of its own skin. Having cast its vesture for the third time, it comes out in a more variegated coat. The prevailing colour is still bright green, rather more vivid than that of the leaves. Hitherto the green was suffused with yellow, but this is now

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condensed into narrow bands that extend along either side. Beneath these is a crowd of black and white ocelli, some seven or eight in each separate segment, and still further beneath a row of black spots, one on each of the rings. The thorax is free from this adornment of ocelli, with the exception of one specially conspicuous pair. The spine, which was hitherto a uniform black, retains only a ring of its former colour, being otherwise a plain green. The method of protection remains unchanged. The sweep of the head is more forcible and sudden in accordance with its greater strength. But the working of the spine seems less efficient, since the point of the organ is becoming fragile as though signs of degeneration were setting in. It still prefers to lie along the midrib, thus securing to the full the protective value supplied by its leafy coat.

Its beauty improves with increasing bulk. By the next day further additions are apparent. The yellow band along the side becomes more conspicuous, the eye-spots change into a dark blue, the tag-like legs underneath the thorax assume a reddish tinge. It is now a well-developed fleshy caterpillar, its body smooth, yet tense and firm, its head pointed, its tail broad and square-shaped, and all its actions strong and muscular as is necessary for the tearing of the rigid leaves.

The ninth day is distinguished by a fourth desquamation. A period of stupor as usual precedes it. I see the caterpillar glued by its suckers to the leaf. All it does, when disturbed, is to jerk

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its head, while it stubbornly refuses a morsel of food. Its successive garments are increasingly more elegant. There seems no restraint to the artistic touch. Beauty is lavishly added to beauty. New marks, new tints, new blends of colour come out at every moult. The yellow bands have now become a pure white, the ocelli are tinged with a delicate purple, the black spots have enlarged into ovoid marks. The large ocelli on the thorax are conspicuously changing; they have become the most striking features of the caterpillar, each displaying a pure white centre enclosed in a maroon-coloured ring. With this wealth of adornment we see the spine becoming smaller. Its rapid degeneration is very pronounced. Half of it vanished with the last moult. Its mobility at the same time is fast disappearing, and it is now little else than a tuberculated knob.

A fresh contest with the ants is now worth consideration. The previous battle was fought in childhood; we can now observe it in the lust of youth. The result is a stronger and more stubborn defence. As before it exerts itself in vigorous contractions, quick and forcible rammings of the head together with occasional flicks of the tail. This is sufficient for the first invaders, which are easily beaten back. Soon, however, the swarm advances. Three or four of the leaders attack it on the flanks. Then we see it break into intensive efforts. The front half of the body is thrown from side to side, the head is shaken with a terrier-like action, then swept backward across the body so as

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to clear the enemy away from its flanks. By this means many in the army are expelled, especially as the head can be carried backward almost as far as the tail. The spine is no longer of any service, being merely a useless tag. But the ants refuse to admit defeat. Their number is legion, and their swarms augment. They drive their tiny mandibles into the skin of the caterpillar, and some of them become so resolutely fixed that they cannot be thrown off. The result is more violent and still more violent contractions and fiercer blows of the battering-ram. By such strength it will probably make its escape, dragging itself bodily out of the multitude, perhaps, hauling the more stubborn besiegers along with it, while others follow on the line of retreat. If on a bush, it can effect a similar retirement. It lets go its foothold, makes a sudden jerk, and thus throws itself direct to the ground.

Our register brings us to the tenth day. Its length has reached two and a half inches and its fleshy body is proportionately thick. What rapidity of growth! It seems to swell visibly from hour to hour. What insatiable voracity! Its powerful mandibles are ever at work breaking down the toughest leaves. Everything now is sacrificed to growth, as though its development was contending against time. As a consequence its body becomes very tense. Its substance is so firm and elastic to the touch that it feels as if a prick were made in the integument its entrails would come bursting through the skin. Still more and more its adornment improves. Its body has passed into a shade

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of lemon, and its stunted spine has an orange tint. Its ejections have a very peculiar appearance. They consist of dark green cylindrical lumps, each divided into a pattern of squares by transverse and longitudinal grooves. Such are the moulds of the terminal gut, and when their characteristic appearance is known, they will lead to the discovery of the caterpillar on the tree.

The eleventh day shows another perceptible increase. Its body is becoming peculiarly retractile; it is losing all sign of its previous activity, being merely a thick voracious maggot that clings helplessly to the tuft of leaves. Everything gives way before its monstrous gluttony, not only the edges, but the fibrous midribs, though it still has a liking for a tender morsel, and prefers, if available, the oleander tops. It is not easy to interpret its manner of defence on reaching this bulky stage. The spine is completely out of count, and the larva has grown so stout and heavy that it can no longer make those muscular efforts so efficient in its earlier youth. What protection it had gained from harmonization must also be now an affair of the past. The green dress has become a coat of many colours which refuses to blend with the background of the leaf. Perhaps we should consider its variegated beauty as being in the nature of a terrifying device. There is something a little snake-like in its brilliant ornamentation, particularly in the rings and conspicuous spots that decorate its fleshy sides. These may serve to frighten certain kinds of enemies, possibly the insectivorous birds.

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But more important is the special operation of the head, which by means of a peculiar retractile performance is made to act as a signal of alarm. Ordinarily it projects like a blunt proboscis, but the caterpillar, when in danger, draws it back into the thorax, and thus converts its anterior extremity into a kind of swollen bulb. We saw the caterpillar of the puss moth make a similar exhibition. The first segment of its body was used as a collar, and the head, when retracted into this ring, assumed the appearance of a mammalian face. Here we have a completely different caterpillar, yet it possesses the same strange device. For the extremity, by its retraction, is not only expanded, but in addition appears as if it were possessed of a pair of wide-open eyes. Let us observe the manufacture of this ocular apparition. I have already drawn attention to a pair of ocelli—the most conspicuous features in all the adornment—mounted on the side of the caterpillar's chest. They are broad and oval, handsomely attractive; each is composed of a large white pupil encircled in a maroon-coloured ring. Under ordinary conditions they look far back on the body, on a level with the second and third pairs of legs, and certainly give no indication of having anything to do with the formation of a mask. But their position quite changes when the head is retracted. With the dilatation of the extremity they come forward on the collar, and glare out from either side of the bulb like a pair of piercing eyes. The result is to give the caterpillar a dangerous appearance by convert-

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ing its naturally innocent extremity into an expanded and angry-looking head. (See Plate, page 126.) The caterpillar may give further assistance to the apparition. Sometimes it raises the extremity in the air, thrusts its legs forward underneath the bulb, thus making the head peculiarly prominent and holding aloft the signal of alarm. At other times it makes a bend in the bulbous knob, with the result that the eye is dilated to the full and looks out with an intensive glare. Thus the principle is like that in the caterpillar of the puss moth. But here the machinery of production is more sluggish, the resemblance to a face is not so perfect, nor is the mechanism on quite so elaborate a plan. Nevertheless it is instructive to see such different caterpillars employ a method so extraordinary, yet in principle so similar, clearly for the purpose of its frightening effect.

This spectacular device must serve the caterpillar for its few remaining days. Such a huge and variegated helpless sausage can do nothing better than make a practice of deceit. Thus its eye-spots continue to grow more and more elegant. The pink iris develops a margin of black, and the pupil, at first a pure white, becomes suffused with an azure blue. It is all a part of the plan of Nature to intensify the penetrating glare. In all likelihood at this period the caterpillar is distasteful. For the oleander is a particularly bitter shrub and very few insects care to eat its leaves. This bitterness is transferred to the caterpillar's juices. I find that its body is distended with slime, slightly acid to

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the human taste, and not unlike that of the defensive liquid which caterpillars are accustomed to spit at their foes. Distastefulness may, therefore, be a further defence, and, moreover, one related to the attitude of alarm. For the strange apparition and the brilliant adornment will also be a kind of warning device to inform the enemy of the nauseous taste.

Our record brings us to the thirteenth day, one of some importance in this series of events. A great change has occurred during the preceding night. We have been accustomed to see adornment added to adornment; now we find the process suddenly reversed. A shrinkage has occurred in the fleshy sausage. Its capacity for food has at the same time diminished. I observe it in a box still investigating the provender, but instead of chewing at the tempting foliage, it is inclined to wander restlessly about. But it is its colour which displays the most striking transformation. Yesterday it was yellow with an almost golden tinge and magnificently marked with multicoloured spots. To-day a dense pall has fallen on its vesture; its body has darkened, its splendour disappeared. For the most part it is now a dingy brown, in places even darkening almost to black. What a fall from a nobler state, all brought about in a few hours! The thorax, the last segment, the sides of the body still show a trace of the old decoration, in that they are coloured a kind of tawny hue. The bare outlines of its spots and markings are apparent, though their beauty is lost in the

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funereal coat. But it is the caterpillar's back which has been chiefly involved. This is now a deep and uniform brown; all the splendour of bright colour has vanished from it; the caterpillar looks like a huge maggot that had been wallowing in semi-liquid mud.

What is the reason for this sudden change? Why should it be an advantage for the caterpillar to assume such a dismal garb? Here again, as in most matters concerning caterpillars' coloration, we will find that there is a protective purpose involved. The caterpillar is nearing the close of its existence. The gorge is over; the time of stupor is approaching. It already feels the powerful call to attend to the work of its cocoon. But it cannot do this on the open foliage. Such is not the habit of the hawk moth family. It must descend to the soil and bring together some rubbish in order to fulfil what instinct requires. This demands a long and precarious journey. It must first make its way over the branches, then climb down along the main stem, then wander about on the leaf-strewn soil until it finds the material suited to its needs. It would be dangerous for the caterpillar to undertake this journey if clothed in the bright colours which it wore when on the leaves. What could be more prominent than its golden yellow against the bark or the earthy ground? Hence the remarkable and very necessary transformation. The habitat changes; so also must the dress. The beauty of adornment is cast aside; in its place is assumed a dingy coat that will harmonize

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with the bark and soil. Only once in its life will it make the journey, yet for this it must be specially clothed.

Having examined the debris at the foot of the oleander, the sticks, the fallen leaves, the layer of broken earth, and having shuffled about in the midst of this material, it at length finds a place in which to pupate. Its first business is to fashion a suitable receptacle. Thrusting itself into the scattered leaves, it begins to bend and turn about. At the same time it emits a thread of silk which it anchors here and there at various points. Though it works its head in a series of oscillations, yet it follows no very definite plan. Wherever any point of vantage offers, there it fixes the filamentous line. But in addition it collects materials from outside. It is a builder as well as a weaver. From time to time it stretches out its head, takes hold of a leaf in its powerful jaws, which, unlike the remaining appendages of its body, retain some of their previous strength. Then, by thrusting back its neck, it hauls the leaf over itself, fixes it loosely with a few threads, and, if necessary, drags in more. For hours it persists at this operation, building a chamber with whatever is convenient, hollowing it out by turnings and oscillations, constructing the wall by raking in materials and cementing the pieces with strands of silk.

The receptacle, thus fashioned, is a roomy cavern without any particular shape or strength. Its wall is not built for rigid confinement, but is merely a collection of miscellaneous fragments

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sufficient to shield the inmate from view. The structure is thus merely a concealment chamber on the floor of which the chrysalis can sleep unseen.

The main portion of the day is devoted to this task. But as the hours advance its activity diminishes; its body too continues to shrink, and its appearance becomes even more muddy than before. Food has not the slightest temptation for it; also its discharge of excrement has ceased. On the foliage everything was sacrificed to appetite; now all its efforts are directed to its cell. The strength is disappearing from its powerful claspers; those organs on the tail which gripped like a vice are contracting into helpless stumps. Its legs still carry out such movements as are necessary, helped by a wriggling of its sluggish mass; but the expanded suckers have collapsed into mere tags and never attempt to clutch the ground. Size, strength, and beauty are all disappearing as it passes to the drowsy state.

The change continues till it shrinks to less than half its bulk. The fleshy feel has left its body, which is becoming rigid and the integument stiff. The suckers atrophy to papillary warts, and the legs, which at first could drag it about, degenerate into functionless spines. But even still we see a trace of that old mechanism on the tail. A drooping, stiff and horny knob recalls the protective machinery of youth. In fact all its structure is being gradually moulded to a uniform spindle shape.

Though its power to walk no longer exists,

nevertheless it is by no means totally inactive. A new form of muscular effort is appearing, for, when touched, it jerks itself from side to side, reminding us of its juvenile strength. Even now, though sheltered inside a capsule, yet it still has some power to resist attack. The act, however, is something better than a jerk. The head in addition is made to rotate, first turned to one side, then to the other, with the purpose of sweeping an object aside. The body too is given a twist, and this has the special effect of screwing it from an intruder's grip. Such sudden contractions seem very effective. They will easily jerk it from between one's fingers, or quickly invert it if turned upside down. Probably this combination of jerking and rotation is of service as a mode of defence.

A final moult is the sequel to these rapid changes. The act brings forth a magnificent chrysalis, one of the most splendid examples of its kind. We see it lying on the floor of the chamber, slightly curled upon itself, and occupying but a part of the roomy cell. It may reach a length of two and a half inches, if the caterpillar has lived continually on the tree. But when reared in confinement, the chrysalis is smaller, being dwarfed as a consequence of the unnatural growth. Its shape is of the usual torpedo pattern, its colour a deep and glossy brown; encircling it are the clefts between the segments, and its sides are marked with a line of spots.

The period of pupation lasts thirteen days. When ripe for rupture, the integument darkens. Then comes the bursting in the customary manner,

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and the moth escapes through a triangular breach opened in the broad end. We have already observed it in its strength and splendour, a fitting consummation to the handsome larva that preceded it on the oleander leaves.

Let us end with a summary of the various defences observed during the process of growth. The eggs are preserved by being scattered widely, and also by their greenish tinge. The caterpillar, in its youth, possesses various weapons. Especially important are its muscular contractions, which can shake an enemy from a firm grip. Its head is employed with particular vigour, being used as a kind of battering-ram, while assistance is given at the other extremity by occasional flicks of the tail. An accessory to these is the nauseous juice which the caterpillar can discharge at will. Another device is the movable spine, capable of being lowered on that part of the body beyond the reach of the head. The green colour too must be of some importance, and, therefore, it prefers to lie along the midrib, which is the part of the leaf that conceals it best. When grown heavy and corpulent, its muscles degenerate, and so also does the working of its caudal spine. A change then takes place in its defensive methods. It assumes a garment of brilliant colours so marked that it is likely to create alarm through having some resemblance to a snake. Also it manufactures a special apparition, expanding its extremity into a bulb on which are mounted two penetrating eyes. And combined with this are the bitter fluids which give it a nauseous taste,

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Another change occurs when it leaves the vegetation. For its journey down the bark it needs a different coat; hence its colour changes to a dingy brown. On the soil it seeks defence by constructing a chamber. It also develops new muscular power, exerting its body in a useful combination of forcible jerks and twists. Finally the moth has its own defences. Its strength, its speed, its nocturnal habits will take it out of reach of numerous foes. And by day its rich vernal pattern of colour will hide it in the green leaves.

CHAPTER IX

THE BAGDAD ARGYOPE

Habitat of *Argyope*—Anatomical characters—Her snare—Protective coloration—Capture of prey—Shaking of snare—Devouring of snare—Difficulty in emitting thread—Her zigzag ribbon—Purpose of ribbon—Ribbon of Indian *Argyope*—Other examples of the zigzag—Snare with single pellet—Snare with string of pellets—Snare with diametrical ribbon—Snare with combination of ribbon and pellets—Other methods of defence.

A SPLENDID spider inhabits the palm groves. She is striking in appearance, large in size, and follows the customary habit of her tribe in constructing a circular net. Well shaded places are her favourite haunts. There she likes to spread her snare upon a bush, or to sling it across an open space by powerful cables from the trunks of the palms.

My garden attracted one of these architects. She found there a site suited to requirements, a pomegranate bush well sheltered from the sun and frequented by small diptera and moths. On this she constructed an immense net, quite two feet in the diameter of its spiral area, and with cables of anchorage all over the bush. An architect so accomplished deserves detailed study. We must, however, be content with occasional facts. She is peculiarly reclusive in many of her operations, yet

those which she reveals are not without interest, since they will either corroborate previous observation or will indicate certain significant deviations from the generally established habits of the tribe.

See her stationed in the centre of her lines. She belongs to the species *Argyope clarki*. What an oddly fashioned type of creature; her head and thorax moulded to a flat triangle, her legs arranged in the form of a cross, her abdomen, like some kind of circular saw, ringed around with teeth. Six beady eyes are mounted on her head, two hairy palps jut forward in advance, her mouth is furnished with ponderous jaws. Look at the peculiar structure of the belly. Instead of being globular, it is pressed out flat. It is broadly triangular with the apex behind. Its surface is dug into troughs and mounds, its edge is cut into dentated points. How singular too is her style of dress. See the thorax clothed in a silvery fur, the legs grey with brownish bands, the abdomen above like a glistening mirror and beneath mottled in a rich profusion of varied yellow and brown. In size she is amongst the largest of spiders. Her raking legs have a span of over three inches, and her body is one inch in length.

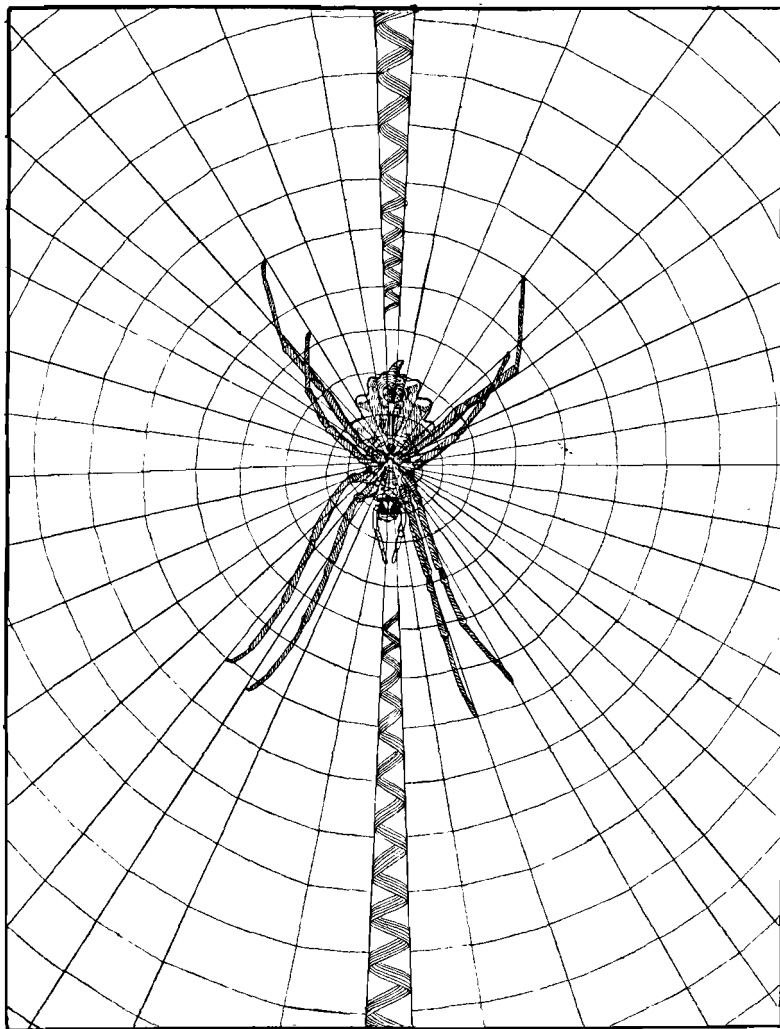
She fixes her snare in the vertical plane, giving it at the same time a gentle inclination, and remaining herself on the under aspect of the slant. As is usual with so many of these circular architects, she takes up a position at the centre of her web. She has no hiding-place, constructs no shelter. For hours she clings motionless to the centre, her head turned downward, her raking legs spread

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round about her, and all her body exposed to view. The centre is thus her place of consummate importance. It is the hub that supports her architectural framework, her permanent resting-place night and day, the point at which she patiently awaits her victims, and feels the thrill from every part of the snare; it is the spot where she feeds continually for hours, and in all probability, as in the cast of the *Nephila*, the place where she conducts her amorous affairs.

How conspicuous she is at this central point! She looks handsome, thus passively suspended in the air and spread-eagled at the hub of her silken wheel. Her legs are arranged in a very definite manner. She collects them into pairs, one pair being formed by the first and second leg, the other by the third and fourth. The two legs in each pair are kept close together, and the pairs are so placed as to form a cross. The tips of the legs are fixed on the radii so as to catch the vibrations on every side. (See Plate, page 194.)

The *Argyope* is marked with such a vivid pattern that she might not be thought to gain any advantage from the manner in which her colours are disposed. A dead specimen in the museum would never suggest it, but her lesson is otherwise in the natural haunts. For the snare, as I have said, is spread against a bush; also it is fixed somewhat on a slant, so that one surface is turned a little to the sky, the other to the green leaves. And the coloration of the spider is adjusted to this slant. Her ventral surface is always directed a



SNARE OF THE ARGYROPE SPIDER.

little upwards. It is this surface which is viewed from above against the leaves, and, as we have seen, it is mottled with colours, which blend fairly well with the bush behind. On the other hand, when the spider is inspected from beneath, her dorsal aspect is seen against the sky. And this surface is almost a pure white so as to harmonize I imagine, with the high lights above.

I would have thought that this might have been a mere coincidence were it not that another quite different spider has her colours arranged on a similar scheme. An *Argyæpeira* in Northern India is very common at the end of the rains. She spreads her net, of the same circular pattern, over the bushes and lower branches of the trees. She is moderately large and possesses long legs, yet is not conspicuous in her arboreal haunts. Like the *Argyope* she rests with her ventral surface upward as she hangs back downward from the centre of the snare. This is the surface seen against the vegetation and is beautifully ornamented with bright green bands. Her back, on the contrary, is decorated with silver, which, though highly conspicuous when the spider is reversed, yet, in her customary attitude on the bushes, blends harmoniously with the bright sky. Thus we see how it depends on the tilt of the snare, and we realize the necessity of basing conclusions on observations made in the natural haunts.

We pass to her method of dealing with a capture. Like the *Nephila* she operates with leisure and precision; in addition, she moves her legs with such a steady deliberation that the details of the act

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can be clearly seen. I throw a grasshopper into the snare. At first she seems to show but little interest. The thrill is felt, but there is no haste. The line is first tested to assure herself of the occurrence, after which she advances leisurely enough, taking long paces across the net. Approaching within reach of the entangled grasshopper, she thrusts forward her long fore legs and draws the capture in towards herself. I now expect to see the act as shown by the *Nephila*, a fierce and deadly grip with the jaws. But the *Argyope* has a different routine of procedure. She does not immediately strike her victim. There is no preliminary injection of poison direct into the nervous centre of the prey. This act is reserved for a later period. The *Argyope* inverts the routine of the *Nephila*, and undertakes the business of sheathing the victim before making use of her poison-glands. This wrapping of the capture is a wonderful operation. The *Argyope* displays it in unusual perfection, each little detail being clearly shown. It begins with a slight preliminary act necessary to bring forth the first threads of the sheaf. This consists in her lifting the spinnerets to a radius, there securing a special anchorage from which she can draw on the innumerable lines. Then she allows herself to make a short drop, nothing more than a fraction of an inch, yet sufficient for the weight of her body to pull from the abdomen a bundle of threads. Thus in this little action we see the manner in which she makes use of her great bulk. The sheaf is out, and the spider suspended. Immediately the next act

takes place. Fixing herself as before to the network, she thrusts her hind legs underneath the sheaf, then works them in a steady alternating manner—a rhythmical hand-over-hand movement—by which action the threads are hauled rapidly out. The bundle emerges as a flat sheet of transparent glistening silk. It appears to come forth from the whole width of the spinnerets, is spread out more widely by the tarsi that pull on it, so that it diverges from the abdomen like a broad triangular fan. Apparently it does not come forth with ease. The spider has to exert a decided strain in order to haul the sticky tissue from its tubes. Immediately the work of sheathing begins. Her legs set to at the rolling of the fan, the hind tarsi hauling it out in bundles, the fore and middle tarsi twisting the capture so as to envelope it in the silken layer. The hind legs are thus the investing organs, the fore- and middle legs the machinery of rotation, while the quivering palpi are applied to the capture and guide it into the layers of the shroud. The whole operation is remarkably rapid. Twelve to fifteen twists may be sufficient for the purpose, after which the grasshopper is closely sheathed. It is mercilessly caught in a winding-sheet, absolutely helpless in so tight a prison, and unable even to move a limb. This method of restraint is remorselessly efficient. While the sheathing is in progress I take the capture in a forceps and try to rob the owner of her prize. But she immediately pours out huge quantities of silk. The interference means to her that the prey is escaping. Her plan of prevent-

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ing it is to cast out threads and add more coils to the cruel shroud. This she does with increasing effort until forceps and grasshopper are both engaged in the turns of her winding-sheet. Of all her actions this is the best worth seeing, so neatly does she spread the glistening fan and so skilfully sweep it around her prey.

Having in this way firmly bound her victim, she now proceeds to give the deadly stroke. She takes the grasshopper between her mandibles, fixing them on either side of its head. First she applies a few gentle pinches as if feeling about for some special spot. Then we observe a more determined effort, a prolonged and steady bite direct into one side of the insect's head. This corresponds to the act of the *Nephila*, with the difference that the *Nephila* fastens on the thorax and commits the deed before the sheathing is commenced. The *Argyope* waits till her victim is enveloped, and sends her poison direct to its brain. The routine of operations is now over. The capture is not only bound in fetters, but in addition it is stupefied and almost dead. I immediately extract it from the winding-sheet, which, when cut open at one extremity, can be rolled back over the body like a tube. The inmate, on removal, is absolutely paralysed, as helpless as the cockroach struck down by the *Ampulex* or the spider after the *Cryptocheilus* has inserted her sting. There is no external mark of injury on its head, but for purposes of resistance it has lost all power. The legs make an occasional attempt at movement, like the muscular

tremors preceding death; but otherwise the subtle venom of the *Argyope* has produced its overwhelming effect.

All is now ready for the opening of the feast. She may take her prey to the centre immediately, that being the spot where mastication occurs. On the other hand, if hunger makes no pressing claim, she may leave it for a time at the place of capture suspended in its silken cloak. But sooner or later the process begins, when she sucks out the juice in the usual manner until nothing but an empty shell remains.

This prolonged operation associated with capture, the sheathing, the poisoning, the slow sucking of the carcass, is employed only in the case of a substantial prey. The smaller captures, the minute moths and insignificant diptera, which form the larger portion of her ordinary victims, need none of this elaborate device. They can be sucked to death without special difficulty. The winding-sheet is required only for those captures which must first be subjected to an artificial restraint.

Another of her habits well worth our notice is the remarkable manner in which she shakes her architecture if for any reason she becomes alarmed. Most spiders are accustomed to vibrate their snares, throwing the network into a trembling motion, the instinct, no doubt, being given for the purpose of jerking objects out of the web. But the *Argyope* is not content with a mere quivering action. She rather gives it a swaying movement, forcible, regular, with oscillations as slow as about one a

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second, during which the whole structure rises and falls in a steady rhythmical swing.

Its mode of production is very simple. The moment the *Argyope* is aware of danger, she immediately contracts her widespread legs. By this means she exerts a strain on the architecture, draws the whole structure towards herself, and at the same time pulls her body close to the snare. The sudden strain makes the structure shake, and, since she repeats the action at regular intervals, the necessary result is a rhythmical motion, the whole of the radiating system of network being thrown into an even swing. The danger passes. She stops her recurring pulls upon the web. As a consequence the pulsations of the architecture cease, dying away gradually of themselves. When seriously alarmed, she makes tremendous efforts. Her legs then pull with all their might. Her huge body heaves. All her great strength is thrown into the operation, with the result that she forces the elastic network into swings with an amplitude of as much as six inches, causing the whole of this complex structure to throb with the most powerful shakes.

Like many of her tribe, she devours her architecture, taking the whole structure back into herself before commencing to rebuild it anew. The deglutition reminds us of that of the *Nephila*. It severs the foundations of her widespread circle and it falls together in a straggling mass. Soon the *Argyope* comes forward to investigate, rakes it together with her fore and middle legs, and gathers

it up into a woolly heap. With a few deft strokes of her mandibles she then severs its attachments, and, having cut it completely free from its foundation-lines, holds it before her in a fluffy lump. Hanging to a line by the tips of her hind legs, she immediately begins to feed. Supporting the mass in her ungainly tarsi, guiding her actions with the delicate palpi, she proceeds to engulf what remains of her snare. First she thrusts her head into the bunch of silk, attacks it with her jaws, chews at it, macerates it, turns it about in different directions, slowly working it into a compact ball. This process of consolidation occupies some fifteen minutes. The resulting ball is scarcely larger than a small pea, to such a degree can the architecture be reduced when compressed into a solid lump. It is black in colour, with the surface moist owing to the quantity of saliva squeezed into the mass. The architect holds it tightly in her jaws, chewing it persistently all the time, and supporting it with the palpi on either side. Also it is kept in continuous motion, being turned about in different directions, so that first one surface then another is presented to the saliva and jaws. The saliva is, no doubt, of great importance, by possessing the power to dissolve the tissue or to make it in some way suitable for food. This grinding of the pellet is a tedious process, though apparently much less so than in the case of the *Nephila*, which I watched thus occupied for a whole day. I revisit the *Argyope* an hour after its commencement. I expect to find the pellet being still devoured. But the spherical lump has

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completely disappeared, no doubt having first been dissolved into fluid and then sucked down into her narrow throat. Thus does the architect gather back into herself every thread of her inimitable work.

With the exception of one point to be considered in a moment, there does not appear to be any special peculiarity in the architecture of her large snare. I see no deviation from ordinary principle. The framework is first fixed, then the radii inserted, then the spiral filaments attached. The radii, however, are disproportionately numerous, there being forty in the snare under examination while the turns of the spiral are only twenty-five. The disproportion is, no doubt, a mechanical necessity, since a net of such specially large dimensions will need more of the supporting spokes.

A little matter to be noticed about her weaving operations is the difficulty which she has in drawing out her thread. Small spiders, like the *Araneus*, hasten round their snares, anchoring their filaments without a moment's hesitation and then skipping on to the next spoke. Their thread almost seems to be shot forth, with such ease does it slip from the spinning points. But the *Argyope* cannot weave with such rapidity as this. All her actions are slow and laboured; she moves tediously round the circle of her snare. Her thread will not come forth without decided effort. She must drag upon the line with one of her tarsi in order to bring it from the spinning-wheel.

But the point of special interest with regard to

her workmanship is the fact that, in addition to her radii and spirals, she introduces a peculiar zigzag structure along the vertical diameter of her snare. (See Plate, page 194.) It is not like one of her usual filaments, fine, transparent, scarcely visible to the eye. On the contrary, it is a broad and prominent ribbon, white in colour, very conspicuous, and obviously produced by a different machinery from that which generates the ordinary threads. This ribbon is stretched out on either side of the centre to a distance of about half the diameter of the snare. Its vertical position seems of some importance, for if it is removed by cutting down the snare, it is always reconstructed in the vertical line. The centre of the snare is left free from this ribbon. The spider will have no such obstructions in her resting-place. Round the centre for a space of about two inches the web must be kept clear. The angular points that compose this zigzag are closely and fairly regularly laid. They average about sixteen to the inch, and in a zigzag system along one radius I count seventy-four angulated points. The whole structure is inserted between a pair of radii to which it is fixed by the tips of its angles. On these radii it exerts a strain, with the result that they are brought closer together than those in other parts of the snare.

Beneath the microscope I see something of the detailed structure of this ribbon. It is composed of a multitude of individual threads, each of the slenderest and most delicate substance, and all closely massed together like fibres woven into a

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rope. At the edges of the ribbon the structure is more open, the threads appearing there as if spread apart, but in the middle they are tightly pressed together and agglomerated into an opaque layer. How very different is this from the ordinary filament! Many hundreds of threads must emerge together when the spider gives forth this zigzag sheaf. It is the most profuse of all her spinning operations, being produced, I have no doubt, by the same machinery as that which generates the winding-sheet. And how great is the expenditure involved in its manufacture when the length of the ribbons, if pulled out straight, may measure as much as two and a half feet.

It is natural to seek for a reasonable explanation as to why this peculiar angulated structure should be fixed to the spider's snare. There must be some valuable end secured to repay her for the labour and expenditure of silk. The suggestion may perhaps seem somewhat forced, but I have reason to believe that the purpose of the zigzag is to supply the spider with a protective device. This ribbon attracts immediate attention, not only because of its white colour, but even more on account of its angulated shape. It is distinctly a more prominent feature in the network than is the outline of the architect at the centre of the spokes. As a consequence it literally absorbs attention. The result is that notice is withdrawn from the spider, while the zigzag, by appearing continuous with her body, gives her an unnatural and unspiderlike shape.

Some better examples of an analogous nature will show more clearly what I wish to explain. There is another species of the same genus *Argyope*, either *A. pulchella* or a closely allied form, which occurs in the forests of Northern India. Though smaller, she is adorned with an equal elegance, and she weaves her snare in the depths of the jungle beneath the shelter of massive trees. Like the Bagdad *Argyope*, she rests at the centre, her head directed towards the ground, and her legs similarly arranged in pairs. She too introduces a ribbon into her network, the same kind of white angulated structure as seen in the snare already described. But this species distributes her ribbon differently. She does not place it in the vertical diameter, but rather manufactures it like the letter X, in four separate diverging limbs that radiate from the centre of the snare. (See Plate, page 206, Fig. 1.) Each limb occupies about two-thirds of a radius, not reaching all the way out to the circumference, and also falling short of the central point. They are applied tightly and draw the radii together; indeed the spokes may at times be almost brought into contact, so great is the binding strain. In the snare they appear in the form of a cross, the limbs of which are evenly separated showing that the spider has taken special care to fix them at equidistant points.

Now the attitude of this spider in the centre of her snare bears a different relation to the zigzag ribbons than that of the species discovered in Bagdad. The ribbon, in the case of the Bagdad

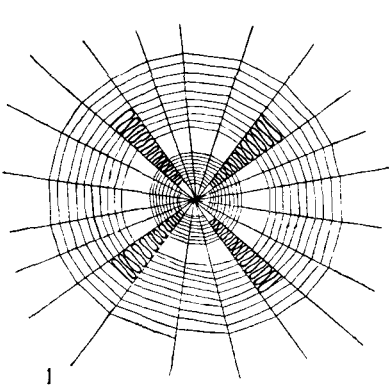
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Argyope, is vertically placed and in line with its body; in the Indian species it is shaped like a cross, and each of the divergent limbs of the cross is in line with one of the pairs of legs. There is no variation in this particular arrangement. The legs and the limbs always coincide. This relationship, I think, is of considerable importance. It means that the spider so fixes her body that her outstretched legs appear continuous with the ribbons. In fact, the whole apparition—the combination of the spider and the ribbons—is that of a conspicuous cross. The result is that the outline of the spider is lost. She seems as if a part of the complicated zigzag, and has no longer the appearance of a living thing. Thus the purpose of the ribbons is more easily understood when we see them arranged like the letter X. But in the Bagdad *Argyope* the intention is the same. The one is lost to view in the centre of a cross; the other as part of a vertical line.

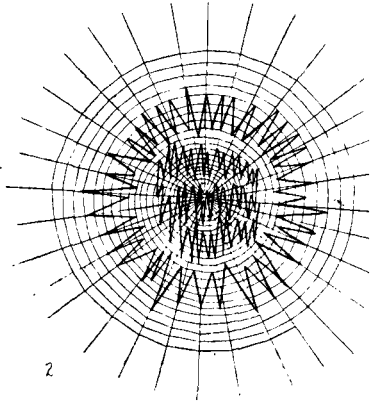
How strange and subtle are the various contrivances employed by Nature for the purpose of defence. We have seen their complexity in the case of the caterpillars; the brushes, the filaments, the hairs, the spines. Here we find a cunning arrangement of zigzags in the perplexities of which the architects hide.

I pass to a more convincing example. It is a little brown spider, insignificant in appearance, that inhabits the jungles of Hindustan.¹ It

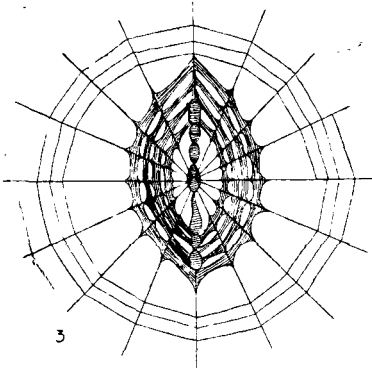
¹ Our knowledge of Indian spiders is still so imperfect that it has not been possible to identify this species and a few other obscure forms.



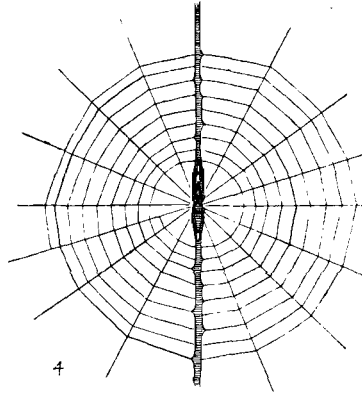
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CONCEALMENT DEVICES IN SPIDERS' SNARES.

1. ZIG-ZAG IN FORM OF CROSS.
2. COMPLICATION OF ZIG-ZAGS.
3. COMBINATION OF OVAL BANDS AND PELLETS.
4. VERTICAL LINEAR BAND.

fashions a network on the usual pattern, just a delicate web a few inches in width, a mere miniature of the *Argyope's* sheet. Size, however, does not mean perfection. This little structure is without a fault. Its radii, its spirals are all accurately placed, and its centre is supplied with an extensive hub. But its remarkable feature is the system of zigzags. Here is an arrangement even more elaborate than in either of the *Argyope's* snares. (See Plate, page 206, Fig. 2.) Look at the extraordinary angulated ribbon carried completely round the network, and attached to every spoke. See its sharp points and confusing outline. Remember that it is composed of white material, more conspicuous than, and quite different in appearance from, the ordinary transparent filaments of the snare. This, however, is but a part of the arrangement. The centre of the wheel is simply massed with zigzags. For the most part they are spread from side to side, but they overlap one another and are intermingled, and have obviously not been constructed with any special geometrical care. They cover the whole of the central area, thus clothing the spider's habitual seat in a dense confusion of angulated lines.

In this we see a better type of zigzag system, in that its function is more clearly displayed. Again the purpose is one of protection. The spider is hidden in the midst of the confusion. All we can see is a maze of angles. The shape and outline of the architect is lost behind the intricate veil.

Spiders are surrounded with a host of enemies,

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both marauding hymenoptera and insectivorous birds. Protection is, therefore, of the first importance. Some hide themselves in shelters, others harmonize with their surroundings, others resemble inorganic fragments or a leaf or a portion of a flower.

I will mention a few of the unusual devices. A minute spider in Central India is in the habit of collecting the remains of her captures and heaping them together at the centre of her snare. She keeps them in position with threads of silk which bind the whole into an irregular mass. The lump of fragments is greyish in colour, mainly on account of this tissue of threads. It hangs loosely from the centre of the network, and on it the spider takes her seat. The shells of her captures have been made into a cushion on which she is accustomed to rest. Her colour also is a mottled grey, similar to that of the cushion of debris. Moreover, she is so minute as to be insignificant when compared with her bulky seat. As a consequence she is excellently hidden from view. From the cushion she stretches out her legs, takes the radii in the tips of her tarsi, and in this way maintains communication with her snare. But her body is ingeniously hidden on the debris. An inspection of the snare will disclose her cushion, in appearance a ragged lump of tissue of which the spider forms a part. In this we see a curious defensive method. The spider makes use of her eviscerated victims, weaves them together into a lump which serves both as a cushion and a shield.

In my *Naturalist in Himalaya* I have told of a *Cyclosa* which strings a line of pellets across her architecture, while she herself remains in the middle of the line. These pellets she fashions out of captured flies by enveloping their corpses in a capsule of silk. Both in colour and shape she looks exactly like a pellet, since she tucks in her legs and remains quite motionless; in fact she cannot be distinguished from them unless her habitual resting-place is known. This is an advance on the previous species, which constructed merely a single lump, and gained security by blending with its mass. The plan of the *Cyclosa* is distinctly more elaborate. She manufactures not one but a number of globules. Also she does more than just blend with the background, for her body is so fashioned and her habits so formed as to make her resemble a complete lump.

In the palm groves I met with still another type of this peculiar method of securing defence. It was the work of a minute pale yellow *Uloborus* that had found a place for her own architecture in the tangle of a *Cyrtophora's* dome. Her snare was of the usual circular pattern, but of small dimensions so as to suit the owner, being not more than three inches in width. The architect remained at the centre of her wheel. There she assumed an important attitude, her first and second pairs of legs held out in front, her third and fourth pairs similarly thrust out behind, and the pairs on opposite sides being brought together so as to seem continuous with the body length. This is

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the attitude of the *Tetragnatha* spiders. Its effect is to produce a linear appearance, destroying the natural resemblance to a spider and converting it into an elongated flake.

This attitude alone has some defensive value. But it is not sufficient for the species of the palm grove. She has in addition a special device, which, when combined with her elongated attitude, produces an excellent concealing effect. She has laid out a thin ribbon along one diameter, or rather two ribbons in line with one another, leaving a gap at the centre of the snare. The ribbon is composed of a matted tissue, similar in composition to that of the *Argyope*, but infinitely more delicate and thin. There is nothing of a zigzag in its appearance; it is merely a plain straight flocculent ribbon, drawn out here and there to a lateral point by one of its anchoring threads. (See Plate, page 206, Fig. 4.)

The position of the spider is of first importance in relation to the working of this device. Indeed, the two are interdependent. For the spider takes up her position at the centre exactly in line with the diametrical band. She fits accurately into the gap left at the centre, and, moreover, as a consequence of her elongated attitude, appears to be a part of the linear device. The whole adjustment is most perfect for the purpose of concealment. The immobility of the spider, her position at the centre, her elongated posture, her accurate adaptation to the width of the gap, her fixed attitude in line with the ribbon and the structure of the ribbon in harmony with herself, each has a place in the multiple combination

developed for the production of a concealing effect. It is an excellent illustration of the purpose gained by the fixing of ribbons in the circular snare.

See how these devices are fitted to their architects. A rounded spider, such as the *Cyclosa*, makes a long string of globular pellets because she can herself best resemble a pellet on account of her globular shape. An elongated spider, like the *Uloborus* of the palm grove, manufactures a narrow diametrical ribbon since she places herself in a linear attitude and is best concealed as part of a line. So it is in principle with the giant *Argyope*. Her outstretched legs in the form of a cross give her a characteristic angulated appearance, and, as a consequence, she is best concealed by blending with an angular device.

The *Uloborus ceniculatus* of the Indian plains is another spider which adopts this method of placing a diametrical ribbon in her snare. She likes to spin in the midst of the cactus where the numerous spines supply favourable points to which she can attach her threads. The ribbon which she fashions is of fluffy material. It stretches from the margin almost to the centre, but, like this species in Bagdad, leaves a gap in the middle, just sufficiently large to take the spider's length. Concealment is brought about with the same efficiency; the shape, the position, the attitude of the *Uloborus* being perfectly adapted to the line of fluff.

I come to a last and interesting example. She is an Indian species so obscure and insignificant that I cannot supply her with a scientific name.

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Let us look, however, to herself and her workmanship. Her dress is a mottled pattern of brown with a pretty silvery gloss upon the back. Her web is placed in a shady situation, either in some nook hidden by the foliage or against the trunk of a large tree. Consider how nice is her plan of concealment. She is not content with just one device. A few pellets or a ribbon is not sufficient. She fashions a structure which combines both. She follows the *Cyclosa* in manufacturing pellets, the *Uloborus* in constructing a band. (See Plate, page 206, Fig. 3.) The device is, therefore, in two separate portions. The pellets are arranged in a vertical string. They are made out of silk and insect fragments, but sometimes she uses pieces of leaves or seeds of the jungle grass. No doubt she employs whatever is available; any suitable object that sticks to her network may be woven into the string. The ribbon is of quite a different appearance. It consists of four concentric ovals, situated one within the other, so placed as to surround the centre, and attached to every spoke. Like the previous examples, it is white in colour and woven of the same multiplicity of threads. At each attachment to the radii it is drawn into a point, and this gives it something the appearance of a zigzag, or at least breaks up the regularity of its shape. But where is the architect of this complex system? She is wonderfully hidden somewhere in the midst of it. I defy anyone to find her out unless he knows that she occupies the central point. Touch the pellet where the radii meet. It looks no different from the others

in the string, nevertheless it immediately becomes alive. It opens out, its legs unfold, it either drops like a pebble to the ground or runs off along one of the threads. The spider is nothing but an ordinary pellet in the midst of the concentric rings. Her contrivance is efficient, her protection complete. Though the whole arrangement is conspicuous enough, yet the architect herself is lost to view in this system of pellets and bands.

How severe must be the daily struggle of a spider when we see the elaboration of these extraordinary devices to serve as a shield in the battle of life. Yet such are but a few of the more peculiar adaptations; there are numerous other less spectacular ruses which different kinds of spiders habitually adopt. An *Araneus* may look like a lifeless nodule, a *Tetragnatha* like a stalk of grass. A little species in Bagdad spins against the wall where it looks like a piece of clay; another fixes its snare to the palm tree and resembles a flake of bark. Many, like the *Cyrtophora*, fall to the ground the instant their webs are touched; some, in addition, simulate death, refusing to move from their place on the soil until the danger has passed. There are certain kinds which fear to come out in the open, but either hide in a crevice or build a shelter, and keep touch with their network by a special line. A common trick is to mimic an ant. In this way numbers escape the enemy by resembling an insect better armed than themselves. What a host of spiders are protectively coloured. We find those on the tree trunks the colour of the bark,

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those near the water the colour of the sand, those on the leaves the green colour of the foliage, those on the ruins the colour of the bricks. There are others which are clothed in a variegated dress to fit them for a life in the interior of flowers.

But all these we may consider as ordinary methods. I will not weary the reader by discussing them here. My attempt has been to show the more remarkable contrivances, especially the use of the strings of pellets and the function of the zigzag bands.

CHAPTER X

THE TENT-BUILDING SPIDER

Uses of the spider's thread—Characters of tent-spider—Sites selected for tent—Structure of tent—Tent as a habitation—Capturing ground—Architecture of tent—Competition on the wall—Varieties of victims—Mode of capture—Architectural instinct of spider—Extrication of entangled prey.

It is an old and well-established principle that "Nature is prodigal in variety, though niggard in innovation." We see this maxim well exemplified in the case of the spider's thread. The manufacture of the filament is the fundamental operation, since it is employed in some way by every kind of spider; it is the striking and important innovation which Nature has distributed throughout the whole group. Yet consider what a variety of ingenious contrivances has this silken filament been made to serve.

Many spiders weave it into a receptacle for their eggs, intertwining it externally into a firm layer and internally into a flocculent heap. Some, like the *Lycosids*, drag their eggs behind them, and, in doing so, put the threads to an additional use by employing them as harnessing ropes. For others, such as the *Sparassus*, this protection is insufficient, so they wrap the cocoon in a blade of

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grass, then bind the sides of the chamber together by encircling it with many turns of the thread. There are many kinds that use the thread for their safety or their transportation. The *Epeiridæ* employ it as a suspension rope on which they drop to find attachments for their snares; for the *Attid* it serves as a filament of anchorage to prevent a fall during a sudden leap; for the young of many kinds it is an aerial balloon to float them away on the breeze. The *Lycosids* manufacture it into a silken tube with which they line a tunnel in the soil, while that more cunning architect, the trap-door spider, fabricates in addition a closely fitting lid which it fastens to the gateway by a hinge. Some spiders build habitations from the threads. An example of these is the *Araneus mitipica*, which spreads a tabernacle in the concavity of a leaf. Others weave their tents beneath the surface of the water. The *Desis* submerges it at the fringe of the ocean, the *Argyroneta aquatica* in a fresh-water lake where it serves the purpose of a kind of diving-bell to hold a supply of air. A common use of the thread is to act as a gangway on which the spider can climb to and from its snare; another purpose is that of a telegraph wire by which the spider can gain information whenever a capture falls into the web. But the threads are employed in a more ingenious manner when spread abroad for the entanglement of prey. The *Hippasa* extends them in a widespread sheet, a cunning platform of close-spun filaments on which the insects alight and are enmeshed. The *Cyrtophora* weaves them into a

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wonderful hammock, a concave network suspended from staylines in which the captures are most ingeniously entrapped. The *Nephila* spins them into a cartwheel pattern, laying out the lines in radii and spirals and smearing the adhesive filaments with gum. The *Stegodyphus* has developed an equal ingenuity in that it beats the threads into a multitude of springs that grip the capture in their coils.

Thus the thread is made to serve in a host of devices. It is a sac for the eggs, a soft lining for the young, a hauling line for the capsule, a winding rope for the chamber, a suspension cable, a filament of anchorage, an aerial balloon, a tunnel with a doorway, an arboreal tabernacle, a subaquatic diving-bell, a gangway, a telegraph wire, an entangled platform, a complicated hammock, a viscid wheel, a multiplicity of springs. Here indeed is Nature prodigal in variety with respect to the uses to which she has put this thread.

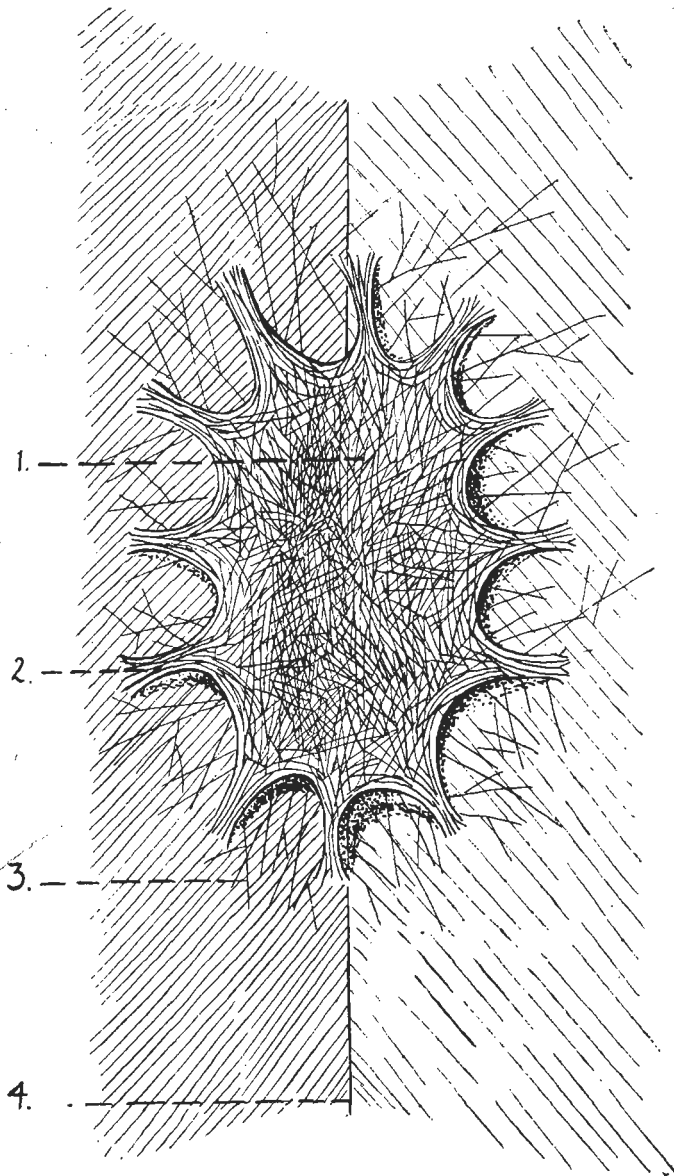
But we have not yet exhausted all the devices. There is another contrivance which I have recently observed. It is the employment of the thread as a lassoing rope which is cast with incredible speed around the victim so as to secure it in the successive coils.

The spider which has elaborated this mode of capture is an insignificant invader of human habitations, living for the most part a secluded life beneath the shelter of a silken tent. It is common, both in Bagdad and in Northern India, and in any verandah its tabernacle may be found pitched on

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some ledge or in an angle of the wall. It is best to look for it in dusty places which have not been swept for a long time. These spiders belong to the family *Urocteidae*. It is their habits alone which concern us here, and these appear to be much the same in both the Indian and Mesopotamian examples of the group. We will here consider the Bagdad species. In size it is minute, only one-eighth of an inch in length. Its body is smooth and modestly clothed, the head and thorax being a pale yellow supporting a cluster of black eyes, the abdomen larger and more conspicuous in appearance owing to a mottling of dark brown.

This spider, as a rule, pitches its tent in some convenient corner of a neglected wall. It prefers the verandahs to the interior of the rooms, for there it is usually left undisturbed and its handiwork is less likely to be brushed away. It is an advantage to the spider for the erection of its tent that there should be some irregularity on the surface of the wall. If there happens to be some slight depression in the masonry it can all the more easily spread its tent across the hollow and fasten down the staylines to the edge. For the same reason it finds its way into chinks and angles where walls or ledges join. Often in a verandah a long series of these tents may be seen erected in fairly regular succession along the line where two walls meet. But the spider does not confine itself to the shelter of the verandah. When opportunity offers it invades the rooms. It also spreads itself into the jungle, either



TENT AS SEEN FROM ROOF.

1. ROOF OF TENT.
2. STAY LINE.
3. THREAD OF SURROUNDING TANGLE.
4. ANGLE WHERE WALLS JOIN.

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fixing its tent over hollows in the bark or more often in the natural concavities of the leaves.

The tent is circular or oval in shape, consisting of a closely woven silken roof bound down all round by stays. (See Plate, page 218.) There is nothing definite with regard to its position of erection. The spider may pitch it with the roof directed upward, or may apply it sideways to a vertical wall, or even, at times, may completely invert it so that the roof is turned to the ground. In dimensions these structures vary greatly, some being less than half an inch, others an inch in width. The smaller ones seem to be inhabited by younger individuals, which, as they develop, weave more spacious tabernacles to suit their increasing size. When we examine this structure with a little care we find that it is composed of two separate layers; it therefore bears some resemblance to the tropical tent constructed with a double fly. There is, however, a great difference in its mode of use. In the tropical tent the two layers compose the roof; in the spider's tent the inmate lives between the layers, the outer one going to the formation of the roof, the inner one serving as a floor. The roof is the stronger and more resistant of the two, being woven into a closer texture and more tightly stretched between the connecting points. It is either flat or very gently convex so as to fit it to the purpose of a roof. The inner layer, on the other hand, is of a looser material, being spun into a softer and more open fabric which is less securely laid. In contrast with the roof, it is slightly concave; moreover, it is so held down by

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underlying attachments that a space is left between it and the upper layer in which the spider can comfortably dwell. The tent is securely held in position by a number of surrounding stays. These are the ropes and pegs of the tabernacle that brace it down to the wall. They are usually ten to twelve in number, evenly distributed around the circumference, drawn tightly upon their attachments so as to fix the structure on every side. The tent, when thus pitched, is remarkably secure. It cannot be destroyed by stress of weather; only a formidable tear can drag it from its hold. The interval between each pair of stays serves the purpose of a door, a place of entrance and exit for the spider, through which it can dash out upon a victim, or, in time of danger, can escape from the tent. Thus the structure differs from the work of the clotho spider, which constructs a somewhat similar type of tent. For the clotho maintains a gateway between only one pair of stays, the remaining arches being rigorously closed. This spider is surrounded by a ring of gateways and is thus less safe in the shelter of its tabernacle, though, if danger presses, it can more easily escape. The threads that enter into the composition of this tent are infinitely fine and sharp. They are highly elastic, cross one another so as to form a tangle, so delicate that, when examined beneath the microscope, the impalpable dust that clings along them is like ponderous debris interwoven in the skein.

The spider spends the greater part of its time seated quietly in the interior of this tent. There is

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a strong roof above to shield it from view, a soft carpet beneath on which to rest, and a series of open gates all round through which it can dash out on an unwary prey. It occupies the very centre of the tent, its abdomen being raised into a rounded heap which fits into the hollow of the roof. Round about it are spread its legs; they are widely extended at even intervals, and, since their tips are thrust out in the direction of the stay-lines, they include the floor of the tent within their grasp. Thus the spider is enclosed in a delightful little edifice. Over its head is a rigid canopy, beneath it a silken fleece. Only a small proportion of the tents are occupied. The spiders seem to be repeatedly changing and reconstructing them. Thus many happen to fall into disuse, and these are often appropriated by other kinds of spiders which are unable to build shelters for themselves.

The owner is the solitary occupant of the tent, but we may sometimes find the remains of a victim in the interior, usually the shell of a worker ant either affixed to one of the stay-lines or dragged bodily inside. It is partly a habitation and partly a charnel-house. As a rule there is nothing else in the edifice beyond a scattering of dust.

There is one other little point about the structure of this tabernacle which is important in connection with the capture of prey. The under layer or carpet of the tent is prolonged outside beneath the margin as a fine and almost invisible meshwork of threads. It is merely a thin irregular tangle that surrounds the edifice for about an inch in width

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and rests close against the wall. Though scarcely visible, yet it is a valuable structure, since it serves the spider as a capturing ground in which to entangle its prey. Its mode of operation is very simple. An insect, in its wanderings, happens to touch one of the threads. The nature of the network impedes its progress, and the filaments, since they are continuous with the spider's carpet, instantly supply the news. As a consequence the spider is ready for action; it can dash immediately through the nearest gateway and fall on the embarrassed prey. Hence we see the reason for the numerous gateways which permit it to run out in every direction, and for its manner of resting with extended legs which keep it in communication with all parts of the platform through the intermediation of the underlying floor. It is also clear why these tents, though aligned along a ledge, never actually touch. Each is encircled by its own entanglement, which is the capture-ground for that special tent. Hence must the structures be erected at intervals, sometimes with such regular spaces between them as to suggest a well-ordered camp.

There is some resemblance between the tent with its surrounding entanglement and those snares constructed in the form of a sheet. The latter, such as is manufactured by the *Hippasa*, consists of a retreat shaped like a tube from the mouth of which is spread a platform of silk. Here the tent replaces the tube, and the platform is represented by the filamentous layer that encircles it on every side.

The construction of the tent is an interesting

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operation. We drive the occupant from one of its shelters. It comes dashing out between the pair of stay-lines, makes away at the greatest speed, then casts itself about in different directions so as to scour the surface of the wall. Its first instinct is to ascend and plunge into some empty tabernacle close by. But if it finds none, and is in the mood for architecture, we may have the good fortune to witness the work.

It is an amazingly swift operation, especially when compared with the strenuous labour which the architecture of other species often requires. The *Nephila* takes a night to complete its snare, the *Hippasa* will continue for a number of days to make repeated additions to its sheet. The tent-spider, on the other hand, is a most impetuous architect; it weaves its tabernacle with such rapidity that in two or three minutes the structure is complete. It is impossible to follow the closest details of the architecture. In the first place the motions of the spider are so swift; in the second place the threads are so infinitely slender that they cannot possibly be seen. First we see it make a succession of whirls in one direction, each circle following rapidly on the other, while all the time a thread is being secured. Soon the circle changes to the opposite direction; more and more lines are added to the texture and the fabric begins to assume its shape. Then the application of the stay-lines begins. The spider makes quick rushes outward from the structure, each time carrying out a line with it and securing an attachment to the wall. Instantly it

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is back to the body of the fabric, runs out a line in a different direction, and thus fixes a thread of another stay in place. In this way it is seen dashing backward and forward, all the time spreading filaments in different directions which go to form the separate stays. This continues for a couple of minutes, the spider, in its swift and zigzag motions, all the time increasing and anchoring its lines. In this way it weaves a tent over itself, for it performs all the work from underneath and constructs the fabric over its head. When all is finished and the layer is complete, it takes its station under the canopy and later on supplies the tabernacle with a floor. The tent is now of the most transparent texture. Through the roof the occupant can be seen within. But the dust of the country soon collects upon it and obscures the silken film.

Let us turn to their manner of securing a livelihood. What captures can they take on these lime-washed walls, and how do they secure their prey? They would seem to have chosen a most unfruitful hunting ground. Nevertheless we find there a ceaseless competition; a skirmish in the great universal battle takes place even on a lime-washed wall. In India I have often taken note of these competitors. Certain ants seem to have a special predilection for this masonry, especially the formidable workers of the black ant and the foraging streams of the *Prenolepis* that emerge from a formicary established in the bricks. They scour it in search of refuse or prey; the *Prenolepis* may

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join battle with its larger competitor, while in the company of each comes a little spider most closely resembling them in colour and shape. These latter are the mimics of which the ants are the models, and the part that they play in this mural skirmish is to fall on their respective ants. There are mason-bees which attach their chambers to the wall, and parasitic hymenoptera that patiently watch them waiting for an opportunity to introduce their eggs. Beetles occasionally climb up from the ground, little diptera may arrive, or protectively coloured moths, and for these there is a jumping spider ever on the watch and a gecko lying in wait.

The part which the tent-spider plays in the skirmish is to confine its attention almost exclusively to the ants. If another insect happens to come its way, should a little moth, for example, alight on the entanglement or a beetle get foul of it while ascending the wall, the spider will not reject so fortunate a windfall, but will immediately take it in its toils. Nevertheless the trap is spread mainly for the ants, and chief amongst them, for the *Prenolepis longicornis*, which often infests the verandah wall. This particular victim is an agile little ant. For the most part it keeps to a regular track along which the workers pass and re-pass between the hunting-ground and the nest. But there are some which stray away from the general track in order to explore the wall for fragments, and it is usually one of these aimless wanderers that happens to fall a victim to the spider in the tent.

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If fortune favours we will witness the tragedy and observe the remarkable lassoing of the prey. An ant is casually exploring the wall. Unwittingly it enters the danger zone, coming within half an inch of the tent. Suddenly it feels a few threads about its feet. In its alarm it stumbles on the network and tries to make off at the greatest speed. But the ever-watchful spider is waiting its chance. It feels the thrill through the intermediation of its floor. It also, I think, employs its sense of vision, for I have seen it dash off to take a capture, even though the tent had been destroyed. All of a sudden there is a swift rush. The spider comes dashing out between the stay-lines and makes direct for the escaping prey. Its rapidity is amazing; it goes like a flash over the smooth wall, sometimes following a zigzag course so that no pursuer could ever take it nor any insect escape its speed. It relies on its swift rapidity of motion, for it is a creature of little strength. In an instant it overtakes the ant, makes a skilful turn around it, paying out a filament as it goes. In this way a single thread is cast around the victim and its retreat is momentarily cut off. It is remarkable to see the ingenuity of this operation, the enveloping of the ant in an invisible nooze so that it has little chance of escape. The retreat of the ant is thus efficiently barred, but the capture is by no means complete. The ant, finding its course obstructed by the line, endeavours to escape elsewhere, but the spider is prepared for such emergencies. It is not satisfied with a single loop, but, without a moment's hesitation, casts the nooze

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again. It sweeps round its victim in successive circles, at each turn leaving an invisible filament behind it, and thus surrounding its capture in a number of rings. Having made some ten or more circles, it halts, while the ant, now securely held, struggles in the centre of the loops. If the spider is a large one, this may be sufficient, and the tragedy ends by the victim being gripped and whisked into the tent. But more often the struggle continues further. The spider then turns about, resumes the operation in the opposite direction, casts out a second series of rings so as to hold the capture in double toils. The ant kicks and struggles to escape; it tears and drags at the filamentous bonds, but its contention is all in vain. The more it fights, the more and more often does the spider circle, now to the right, now to the left, ever more closely enveloping its capture in this rampart of transparent threads. In this way it continues to cast its circles, working alternately in opposite directions until the capture is finally subdued. At length it ceases, grips the ant in its mandibles, no doubt, at the same time, injecting a little poison so as to give it a deadly stroke. Its last act is to drag the capture to the tent, manipulate it between the stay-lines and under the canopy, where it sucks away the vital juice.

I will conclude with a few observations relating to instinct. Though these spiders live mainly on the *Prenolepis* ant, yet the larger ones will take the big workers of the *Camponotus*, which are far more powerful and difficult to overcome. I watched a

spider at its victorious battle. After a long struggle it overcame the *Camponotus*, but was unable to get its victim into the tent. The ant was too large to fit between the stay-lines; it just stuck in the narrow gate. The spider then transferred it to another entrance, and again tried to force it between the ropes. Failure followed in the same way as before; indeed, wherever the spider made the attempt, the *Camponotus* refused to come in. But the spider declined to admit defeat. Though it would not devour its capture in the open and was unable to draw it into the tent, yet it had another method of solving the difficulty. It came out from the tent, dragged its capture a few inches to one side, and there it constructed a new tabernacle over the carcass of its prey. In a few minutes, so rapid were all its movements, it had completed to satisfaction the silken roof and carried out the supporting stays. Then it spread out the underlying carpet and devoured its victim in peace. Hence we see the efficiency of the architectural instinct, since it is employed not only in the permanent edifice, but can also be used, when necessity demands, for the construction of a temporary receptacle for the prey.

The other observation relates to the ants. A *Prenolepis*, when enmeshed, puts up a good fight, violently kicking and struggling in the nooze and making every endeavour to escape. Another worker from the same nest may happen to pass close by. It soon becomes aware of its comrade in difficulties, probably seeing it entangled in the threads. Now, if the captured worker happened to be free

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and walking leisurely over the wall, the new-comer would certainly take no notice. But an ant in difficulties is not considered a companion; the remainder of the commune seem to regard it as an enemy. At least so it is in the incident under review. The new-comer runs in on the entangled worker, seizes hold of its unfortunate companion and drags it out of the encircling snare. At first sight it looks like an act of rescue, but such altruism is rare in the life of ants. A comrade in difficulties is a victim for capture. For this reason, therefore, it is extricated from the net, not to be given an immediate release, but to be carried for provender into the nest.

Thus the tent-spider supplies us with another illustration of the numerous devices for the employment of the line. There are others of far more elaborate complexity, such as we observe when it is woven into a geometrical pattern or twisted into a multitude of springs. But the plan of the tent-spider is efficient for its purpose; there is a kind of simple and human ingenuity about the casting of this deadly nooze.

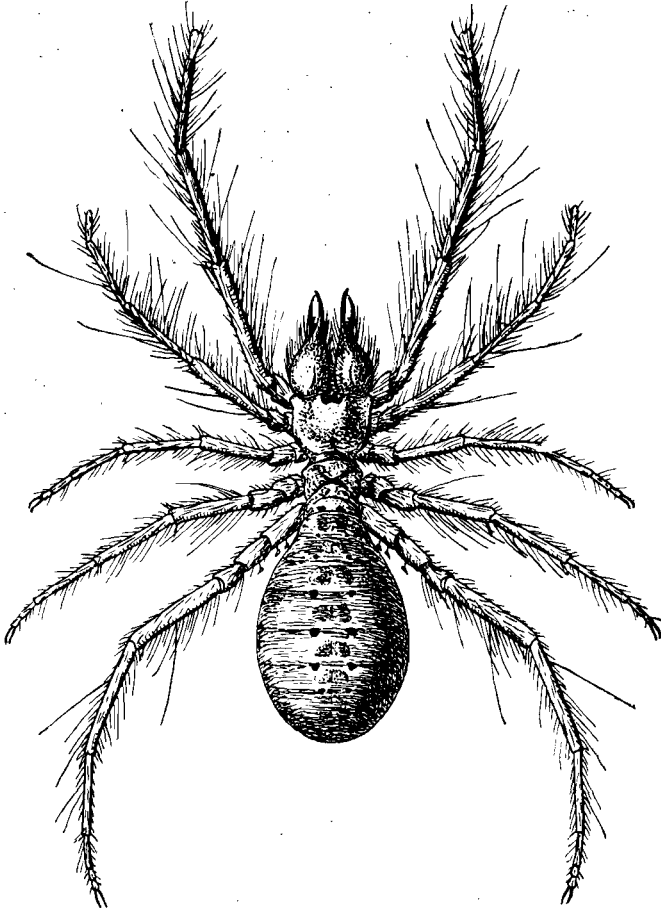
CHAPTER XI

THE SOLIFUGID—LIFE HISTORY AND HABITS

Systematic position—Distribution—Arrangements in captivity
—Anatomical structure—General habits—Movements—
Function of pedipalps—Food—Mastication—Excavations
—Pregnant female—The eggs—Unfolding of embryo—
Emergence of young—Habits and development of young
—Hibernation.

HERE is an odd creature, a monstrous apparition. How weirdly fashioned, how ill-proportioned, how evil and forbidding in its hideous shape and coat of bristling hairs! It might be some antediluvial form specially preserved for this unkindly soil. For somehow it seems suited to its barren haunts, the parched and crumbling waste. There we expect to find something unnatural; ordinary life seems so out of place in the wilderness of desiccated sand.

Strictly it is not a genuine spider. Here are some important points of difference. It does not possess the narrow waist of the spider. Its abdomen is divided into a series of rings, while that of the spider is unsegmented and smooth. It has no machinery for the manufacture of silk, while the spider is furnished with nipple-like projections from which the slender filaments emerge. Its jaws are more like those of a lobster than a spider, since each ends in a pair of fangs instead of in a single point. Also they are used as grinding organs, and, unlike those of the



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spider, have no poison receptacle nor an aperture of exit at their extreme tip. Yet most people at first sight take it to be a spider. Europeans call it the "Jerrymunglum" or the "camel spider," or sometimes incorrectly they speak of it as the "tarantula." Scientifically it belongs to the order *Solifugæ*, and the one under discussion is the species *Galeodes arabs*.

The solifugid is essentially a lover of warmth, and this species in particular of the tracts of sand. They do not occur in higher latitudes. The cold of England is altogether unsuited to them. It is southern Russia, the fringe of the Mediterranean, a considerable expanse of south-western Asia and almost the whole of continental Africa that provide these anomalous creatures with a home. My oasis was too fertile to attract them in abundance. Occasionally a straggler came wandering round the light. But they prefer the utterly neglected places where the soil is broken and bare. Further to the north they exist in numbers, especially on the Tigris in the neighbourhood of Shergat. There, I am told, the desert is more elevated; also it is strewn with rounded boulders which provide suitable places of retreat. Fearful pictures are drawn of the hideous fauna of that region, of the hairy solifugids, the immense black scorpions, the long green centipedes and venomous spiders that emerge at night from underneath these stones. Such are the uninviting haunts beloved of the solifugid and its kind.

Were I dependent solely on the inhabitants of

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the oasis, I would learn but little of the habits of the group. One or two may be secured by persistent search. But my soil has not a pebble to give them shelter, and the vegetation drives them away. Fortunately I have collaborators in other places. They send me examples from more favoured districts, from Hinaidi, from Shergat, from Ramadi, from Kirkuk. I soon have sufficient to serve my purpose. Early in June the first arrivals reach me, and by the end of the month I am fully supplied.

Owing to their love of fighting they are caged separately, each beneath a cover of wire gauze standing in a wooden trough. On the floor of the cage is a layer of sand to make it resemble their natural haunts. The cages stand in a row upon the table, and the hideous looking inmates, so far as I can see, appear fairly content with their lot. Sometimes, indeed, they show signs of resentment; they try to dig beneath the cover, or force up the edge, or pace impatiently up and down the sand, or bite at the wire bars. But they accept such food as I can procure for them, and do not seem to suffer from this close restraint. The colony will supply us with material for study, which, combined with occasional observations in the open, should disclose the essential features of their lives.

Appearance and structure must be first considered. It often grows to an immense size. I measured one with a length of four and a half inches from the end of its abdomen to the tips of its pedipalps, but of this the pedipalps accounted for

half. It could span an area five inches in diameter, as much as might be covered by a man's hand. The formidable appearance of the solifugid is magnified by its unusual bulk. Its huge head, as in the case of the spiders, is firmly fused to the front of the thorax, where it forms a solid quadrangular mass. In the spiders, however, the whole thorax is involved, while here the hind segments are free and distinct. The head is deeply hollowed out in front in order to receive the immense jaws; above it is limited by a sharp edge in the centre of which are two black papillæ, the conspicuous protruding eyes. The thorax is raised into a sloping arch. On either side it has facets for the reception of the eyes, and is connected behind to the front of the abdomen by a broad and flexible waist.

The huge mandibles which project from the quadrangular head are the most striking features in the solifugid's structure and the chief cause of its repulsive effect. Their size, in the first place, is proportionately immense, being as large as the head and thorax combined; in addition, they are so remarkably constructed that each supports a pair of fangs. This gives the solifugid an extraordinary appearance. Instead of the usual arrangement of mandibles, four powerful weapons project from its head. Each jaw consists of a basal portion and a pair of terminal fangs. (See Fig., page 258.) The basal piece is stout and strong; it is the broad column to support the fangs and protect the machinery for their intensive work. The fangs are the organs for bruising and mastication and

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for taking the capture in a sudden grip. The upper one is continuous with the basal piece, the lower is fixed to it by a broad hinge. Both are shaped like pointed sickles, and are armed along their opposing edges with blunt tuberculated teeth. Few creatures are better furnished with prehensile organs for seizing and crushing their prey.

From either side of the head the long pedipalps project. These have the superficial appearance of legs, being jointed appendages of great length, indeed much longer than the body of the spider or than any of its four pairs of limbs. They are thrust far in advance of the head, and at ordinary times bent into an arch with their tips resting in front on the sand. They are clothed in long slender silky hairs, sensitive filaments which supply the solifugid with its exquisite sense of touch. Behind the thorax comes the fairly stout abdomen, oval in shape, unwieldy in appearance and divided into conspicuous rings. The four pairs of legs are strong and jointed. Like those of a spider, they are widely spread and are clothed in numerous hairs. They are thus not only organs of locomotion, but, through the medium of these projecting hairs, become valuable instruments of touch.

Turn the solifugid over on its back and we will see some very peculiar structures on the under surface of its hind legs. They consist of a series of ten flattened processes, each of which looks like a white leaf growing down from the base of the limb. The leaf has a stem and an expanded portion, the latter of which rests on the sand. All

are arranged in a transverse line which is bent round the front of the abdomen so as to enclose it in a kind of shield. The function of this foliage is probably a support. The solifugid is a particularly weighty creature, especially when laden with eggs. At ordinary times, even when at rest, its bulk presses heavily on the hot sand. It needs something special in order to sustain it, and to check the friction of its belly on the soil. Hence it has been given these peculiar structures to act as supporting leaves. I thought that they might also serve as organs of sensation. But the microscope showed nothing to suggest this; no hairs, no papillæ, nothing but a plain smooth fibrous membrane spread out from a main stem. They have probably no other function beyond mechanically supporting the solifugid on the sand.

Just a brief remark on the solifugid's colour. Its body is a pale and almost uniform yellow, the colour best adapted to its desert haunts. Its mandibles, however, have a reddish tinge; there is often a shade of purple on the segments of its pedipalps; its abdomen too is distinctly darker and may be marked above with a longitudinal band.

These repulsive creatures are nocturnal in their habits. Throughout the day they lurk in sheltered places, in fissures of the soil, or beneath stones, or in crevices under the eaves of a roof. Those in the cages crawled into a corner and remained there in a huddled position, perhaps without a motion for the whole day. Often they rolled themselves over on one side, appearing as if asleep. Whether or

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not it was a real somnolence, at least it was a kind of vacant state from which they wakened at the slightest touch. At sunset they become extremely active. Emerging from their crannies, they explore the desert, investigating the sand, prowling through the ruins, entering rooms, climbing up walls, and frequently attracted to an artificial light. At night there is incessant activity in the cages, the inmates all the time roaming about, perambulating the prison from end to end, rooting and scuffling in the layer of sand, now trying to dig under the edge of the enclosure, then climbing up along the dome of gauze. During winter they totally disappear from view. Food is absent, the cold is severe; there is nothing to attract them on the surface of the sand. Hence they retire into deep tunnels which they dig for themselves and then close the gate. At the bottom of these they huddle up their legs, pass into a kind of hibernating stupor until the warmth awakens them again to life.

When on the prowl, they are remarkably active. They run over the sand at a great speed, their long legs working after the manner of a spider, and the pedipalps, looking like an additional pair, elevated and thrust out in front. The little ones especially are quick as a flash, racing over the ground and darting up the walls with such speed as to make them very difficult to catch. On this quickness depends their power to make a capture. They weave no snares, construct no artifice of any kind, but take their prey in sudden rushes by virtue of activity and strength. For this purpose the long

pedipalps are of great importance. They are the organs which detect the quarry through the intermediation of their tactile hairs. But in addition to their use as instruments of touch, they have a special value in climbing operations. At the tip of each pedipalp is a sheathed sucker. At ordinary times it is carefully covered. But, if necessity arises, the organ can be opened. It can take a grip on a slippery surface and thus support the solifugid in an awkward corner which happens to provide no foothold for its claws. In another way also they serve as climbing organs, their ends being made to bend round an overhead object so as to function as a pair of hooks. Sometimes they are used as implements for feeding. I have seen one stretched forward like a long arm, seize hold of a piece of food with the terminal sucker and draw the morsel into the jaws. They are of service even for the purpose of drinking, their tips being brought together, thrust into the fluid, and then employed like a pair of hands to lift the liquid up to the mouth. In the hour of battle they are of supreme importance. They seek out the weak points in the adversary's armour; and when two solifugids engage in a duel their pedipalps come together like pairs of buffers to keep the opponent at arm's length.

The amputation of these organs is a serious injury, since it means the loss of the chief instruments of touch. Nevertheless it does not cause an absolute enfeeblement. The fore legs, to some degree, take on the duties of the palps. They are thrust forward into the place of the amputated

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organs; they apply themselves to an object and even bend themselves around it as though they were the primary instruments of touch. They will also lend an aid in the work of mastication, replacing the duty of the pedipalps as feelers to examine the morsel as it enters the jaws. This expedient, however, is only temporary. So serious an injury as the loss of the pedipalps brings about death in twenty-four hours.

The solifugid seeks its prey as it roams over the desert. All its deeds of murder are committed by night. If opportunity offers, it takes its station near a lamp at the time when insects are attracted to the glare. Like the toads, the bats, the mantids and others, it knows that in the vicinity of a light it is likely to find abundant food. Often in the midst of a cloud of diptera, mainly composed of tiny *Chironomids*, this ravenous monster will take its stand. Of all places it prefers the interior of a tent, where it loves to ascend into the illuminated roof and gorge itself on the dazzled flies.

Is there any living thing within the power of the solifugid which it will not ravenously devour? I give them locusts and dragon-flies, small beetles and moths, and all are immediately ground to pulp. Caterpillars and spiders are more tender morsels; many kinds of larvæ are deliciously soft and easily gulped down. Nothing suits them better than an enormous mole-cricket; they can soak their jaws in its luscious belly swollen with juicy flesh. Even nauseous insects are not always rejected. They will swallow stinking *Coreid* bugs and distasteful

leathery *Danaid* butterflies, leaving nothing but the indigestible wings. Nor will the weapons of the capture check their voracity. They eat up the mantis with its scissors-like legs, the earwig with the incurved spines upon its tail, the spider furnished with massive jaws, the centipede with its poisonous fangs. Also the deadly scorpion, when defeated in battle, may be taken into the omnivorous maw. When supplies are scanty I feed them on young lizards, which they bruise, bones and skin and flesh, into one pulpy mass. Those in the cages take everything I give them, such as house-flies and flesh-flies, leaf insects and stick insects, a convolvulus hawk moth, a *Pierid* butterfly; I expose the soft parts of a *Buprestid* beetle and they eat the entrails out of the shell. In confinement they are most confirmed cannibals; nothing is more hideous than to see a solifugid tearing at the tissues of another in its cage. But I do not pander to their varied appetite. I feed them for the most part on a moderate diet, chiefly of grasshoppers, crickets and flies. They are eager for water as well as food. Those sent me from a distance suffer much from thirst. Some succumb during the journey; others arrive in a moribund state. When released from their boxes they require immediate attention. Water, above all things, is a pressing need. They thrust their heads and pedipalps down to the fluid, even climb completely into the trough. Refreshed by this, they soon revive and are ready for a substantial gorge.

Their mode of mastication is very remarkable.

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I bring a grasshopper in a pair of forceps between the outstretched palps. The solifugid leaps forward, grips it by the thorax, seizing it transversely in its double pair of fangs. Immediately the mandibles come into action. They bruise and cut into the tissues of the thorax, and I hear the hard integument crack beneath the strain. Now we see their complicated plan of operation. The pair on one side acts alternately with the pair on the other side. When the right pair opens the left pair closes. As a consequence they grind the grasshopper in turns. At the same time they work it across the machinery until its whole length from head to tail is macerated in the double vice. It is first chewed from the thorax to the head, then carried back between the alternating teeth and crushed to the tail end. In this way it moves from side to side, each portion in turn being squeezed in the machine, then leaving it and entering it again. By this means the grasshopper is soon bruised out of recognition. Legs, thorax and abdomen are crushed into one another, and in a short time the whole body is reduced to a uniform pulp. Still the work of trituration continues, the solifugid being unable to swallow the material until it is squeezed into a semi-liquid state. For this further reduction to the finest substance another mechanism comes into use. Observe the stout basal portions of the mandibles, that is the columns which support the pincers, and we will see them working one against the other after the manner of a grinding machine. It is a slow deliberate sliding movement;

one column works backward and forward against its fellow; the whole head and thorax join in the action, of which the purpose is, no doubt, to triturate the food into the necessary juicy state. Thus the mechanism of chewing is a somewhat complicated arrangement, though marvellously efficient in reducing the food. The fangs are the gripping and bruising agents which work alternately in the vertical direction and crush the locust throughout its whole length. The basal portions, on the other hand, move horizontally; they are lateral mills which slide on one another and grind the material into a juice. Everything can be dealt with in this multiple machinery, though, if the grasshopper is large, its tough appendages may be refused. The smaller ones, however, are so thoroughly masticated that every portion is swallowed down. The whole is a striking exhibition of voracity, with such steady and remorseless action is each living victim forced into the mill.

The solifugid is not so deadly as it seems. It possesses no kind of subtle poison. Its bite is harmless, though very powerful. The sharp teeth will sink into the skin of the finger, but nothing is felt beyond the piercing of the fangs. It relies altogether on the strength of its mandibles, though many a person will refuse to believe that it is not a malignant and venomous foe.

The camel-spiders have the power to conduct excavations, though they do not dig with any great skill. Their method is laborious even in friable soil. They have no implements specially adapted

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to the purpose, and bore with difficulty through the compact ground. But where the sand is loose they can shuffle with efficiency, ploughing a furrow with their pointed mandibles, and raking back the soil with their hairy legs. When thus digging, they remind one of the hunting wasps. They face the excavation with outstretched limbs; the long pedipalps are thrust forward to explore the way; the first pair of legs also is advanced, but it is the second pair that fulfils the purpose of rakes. These are pushed into the loose sand, their ends being turned inwards so as to gather it in armfuls. They are then retracted with a forcible effort which sends the sand underneath the abdomen and shoots it out between the hind legs. The whole strength of the body is put into this effort, and the rakings are repeated in such rapid succession that the sand comes spouting from beneath the belly in a rhythmical series of jets. From time to time the solifugid reverses its position. It lowers its abdomen into the excavation, thrusts its head into the place which it previously raked and employs its mandibles after the manner of a plough. It shovels up the debris with its broad head, especially any of the larger fragments which it cannot so easily dislodge with its rakes. Then it again turns about and resumes the scuffling with its second pair of legs. Its method is, therefore, an alternating sequence of raking with the legs and ploughing with the jaws. This mode of operation is very impressive, the huge hairy creature looks so ungainly in its efforts to get underneath the soil.

Nevertheless it works with a fair efficiency and by methods well suited to the loose sand.

Their mode of propagation deserves detailed notice. I can speak of it only as seen in confinement. It may differ somewhat in their natural seclusion; but the cages will reveal the general features of what happens on the open sand. I know nothing of their courtship or mode of union. What a spectacle of interest is in store for some one! How strange, perhaps how hideous, may be those ceremonies enacted under cover of night! I commence my record with the gravid female. The ninth of July is a red-letter day. A huge female arrives from my collaborator at Shergat.¹ She is heavy and swollen, advanced in pregnancy, and a hopeful addition to my barren stock. The expectant mother receives studied attention. Her cage is established underneath a fan. It is cooled daily with a sprinkling of water. She is supplied with the most juicy morsels available, the entrails of grasshoppers, the abdomens of spiders, succulent larvæ, tender flies. These she takes from the points of a forceps, and, unless gorged with a recent meal, usually eats them without delay. This care is necessary to ensure her preservation. The mortality in my cages is by no means inconsiderable, but on no account must any neglect endanger this prospective brood.

What a hideously repulsive creature she is! Her belly is swollen into a globular shape. It is

¹ I am much indebted to Lieutenant Katial, I.M.S., for a regular supply of living solifugids sent me throughout the season from Shergat.

the size of a large walnut, tense and shining, with the furrows between the segments stretched out of existence, and looking as if it were about to burst. The congested ovaries fill this globe. So intense is the pressure exerted by them that the skin is stretched to a transparent film. Through it can be seen the ripening organs, daily growing with the force of reproduction, and speckled like fishes' roe. The dragging of this weight is a burdensome business. When she moves it follows her like a massive globe, is bumped about on irregular nodules and lumbers heavily over the sand. What a wonder that it does not rupture; its integument, stretched as thin as a wafer, seems unfitted to such rough use. When stationary, she is very much more at ease, since she usually rests with her swollen belly lying heavily on one side. But in spite of her load she is remarkably active. She can still move energetically over the sand, can twist around to face an antagonist, can ascend the perpendicular or cling beneath a roof when her belly hangs down like a ponderous ball.

She has lost none of her natural pugnacity. I quietly approach her with the points of a forceps. She shoots out her pedipalps to meet the intrusion and with their terminal suckers clings to the blades. At the same time her huge jaws commence to slide on one another; then her fangs open to grip the points, and I feel the grating of her teeth upon the steel. Her appetite is voracious while thus burdened with eggs. I supply her with large grasshoppers at intervals throughout the day. She

grinds them and eviscerates them with insatiable greed. There seems no limit to the quantity of insect tissue which she is ready to devour. This must be a period of intense metabolism. The development of the enormous mass of ova demands a proportionate supply of food. And this she must secure though so heavily burdened. Her difficulties are greatest when her needs are most exacting. She must make the most captures when hampered with a weight that incommodes her at every turn. Nature has, however, made allowance for these difficulties. Her period of reproduction is the month of July. At that time insects are present in profusion, and captures can, no doubt, be easily made. The cycle of existence is so arranged that the young solifugids are brought into being at the most abundant season of the year.

Her movements grow more laboured as maturation advances. Ten days after her coming into my possession I notice on her belly a few white patches not unlike small leprous spots. At first I fear some malady as a consequence of confinement, especially as she also seems weak upon her legs and is less inclined to accept food. But the spots soon grow into circular discs, at first just scattered here and there on the ovaries, and conspicuous through the thin skin. It now becomes obvious that these are the ova ripening and assuming shape. Her abdomen at the same time shows signs of shrinkage, the intense ovarian congestion diminishing along with the maturation of the eggs. As the days advance the discs increase in number. At length

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they run together into a mass, at first dense only on the flanks, but soon filling the whole of the cavity almost in a solid heap.

For eleven days more she remains thus burdened. But at last she gains relief by a large evacuation. I see her lying on her side in a corner of the enclosure. She is very listless and disinclined to move and looks almost as if she were dead. Her labour follows while in this sluggish state, the eggs slipping quietly from her and collecting in clusters on the sand. The point of exit is at the front of the under surface of the abdomen where the genital aperture appears as a slit in the middle of the first ring. The eggs are white and glistening spheres, with the surface smooth to the naked eye, and shining with a beautiful metallic lustre as if made of mother-of-pearl. In the sun they reflect the light most brilliantly, breaking up the rays into the colours of the spectrum and glowing with a rainbow sheen. They are moderately firm, but not rigid to the touch, the shell being merely a thin membrane enclosing the more pulpy material within. In diameter they measure one-seventh of an inch, which makes them appear of considerable size; but in addition to these there are a number of smaller ones darker in colour and immature. These delicate and strikingly attractive objects stick to one another in compact heaps. They are not bound together by any fibrous substance, but adhere merely through the hardening of the fluid which covers the shell in a thin layer. In both size and appearance they

exactly resemble a pile of lustrous pearls. The microscope discloses the cause of the opalescence. It is due to the shell not being absolutely smooth, but studded with a number of minute pits closely arranged and evenly distributed over the whole surface of the sphere.

These glowing pearls look out of place thus scattered on the dry sand. It may be that she shields them with a greater care when living in her natural haunts. Perhaps she scuffles out a superficial chamber, or conceals them in the bottom of some cleft or tunnel, since it is difficult to believe that such tender objects can be exposed to the burning sun.

On the morning after the laying she is again more active, having relieved herself of two hundred and three eggs. This, however, is not the whole of her brood. Through the skin of the abdomen I see many more, chiefly collected along the sides. Nevertheless she must experience considerable ease, since the belly now shows signs of collapse, and the original furrows between the segments are reappearing as in the undistended state. Her appetite has not suffered as a consequence of the evacuation. She eagerly devours a couple of grasshoppers on the morning after the eggs are laid.

The eggs too have undergone a change. Though only one day old, they have burst asunder. The pearly capsule has automatically ruptured. A tiny embryo has unfolded itself from the interior; indeed a trace of its structure was visible through the shell at the time when the egg

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was layed. The unfolding is a gradual process, increasing slowly as the day advances. By evening the different parts of the body are apparent; the enveloping membrane has been completely shed, and the imperfect outline of a solifugid is clearly revealed to view. Its head extremity ends in a stout bifurcation, the branches of which, like a pair of teeth, correspond to the future jaws. The separate parts, though rudimentary, are quite distinct. We see the basal portion that will become the mill and the points that represent the terminal fangs. The pedipalps, even at this stage immensely developed, are prolonged backward along the sides of the body; while the legs, like curled and pointed hairs, are bent in beneath the chest. These appendages, however, are very rudimentary. I see no trace of the long sensitive tactile hairs, no vestige of claws at the tips of the legs, nor any sign of those remarkable leaf-like processes which serve to support the solifugid on the sand. The greater part of its bulk is made up of the abdomen; indeed everything else is but a little nodule projecting from the front of this ovoid mass. The tiny creature is extremely delicate; its body too is altogether naked and of the same white colour as that of the egg. Moreover, it scarcely shows a sign of life, merely lying passively in the unfolded state with rarely a motion in any part. At long intervals, however, it may make a feeble effort, straightening out its back, contracting its legs, opening and closing its rudimentary jaws. They are only faint and helpless spasms; nevertheless they show us that move-

ment is possible and that the embryos are actually alive.

Thus commences the life of this desert monster. First a glowing opalescent sphere, then a bursting of the fragile coat, then a slow unfolding of the embryo which reveals a rudiment of the solifugid shape. How simple it looks in its infant form, so harmless while deprived of its forbidding features, so helpless in its state of motionless collapse, so tender in its pallid swaddling dress. There it rests peacefully on the rough sand with the glittering remnant of its opalescent skin lying rejected by its side. How delightful are the earliest beginnings of existence! Who would imagine that the tiger of the desert came out from this glittering pearl?

Let us pursue the course of their development. For days they remain in this inert state, most of them lying on their dorsal surfaces, sitting, as it were, on the back of the abdomen with head and appendages thrust up into the air. Were it not that their bodies remain perfectly limp, and their tiny legs pliable and soft, it might easily be imagined that the little embryos were dead. For six days no sensible change takes place, no alteration in external structure, no perceptible increase in size. But on the seventh day after the laying an alteration in colour begins to appear. The little embryos are losing their delicate pallidity; a faint reddish tinge is developing in the integument, at first confined almost solely to the appendages, especially to the rudimentary jaws. As the days advance this colour deepens, passing at length into

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a tawny hue. It is the outward sign of more important changes taking place within the embryonic sheath.

At length these changes reach their climax. On the ninth day after the laying of the eggs a rift occurs in the embryonic sheath. The breach takes place at the head extremity. Through the opening a tiny solifugid emerges, a pale but perfect miniature of the adult. As it makes its exit, the sheath slips back over its body; its appendages at the same time are withdrawn from their coverings, and the skin is cast off at the posterior end. This sudden transformation marks a great advance. The first unfolding brought out an embryo, hairless and delicate, with its parts defined, though in a very rudimentary state. Now we observe a complete creation. From the helpless embryo that lay like a corpse there comes out a little jerrymunglum apparently perfect in every part.

In length it is scarcely two-fifths of an inch, yet all its organs appear intact. The jaws are furnished with stout basal mills, the eye-spots are apparent on the top of its head, the legs and the pedipalps have their tactile hairs, even the supporting leaf-like processes are evident at this early stage. The body looks elongated out of proportion, but all the parts exist entire. The little creature seems to require nothing beyond steady and regular growth. At first it is, of course, extremely delicate, and its colour is almost a pure white. The casting of the skin leaves it prostrate for a time. It lies motionless on one side, the slender appendages trailing

from it, but with scarcely the strength to pull itself about. When disturbed, however, it displays some energy, and in a little while is able to turn on its belly and make a fair attempt to crawl. How am I to rear these tender creatures? I cannot leave them with the mother. She cares nothing for them. In the desert she may show some parental solicitude, but here she is an actual danger to her offspring. Beneath the gauze she displays the most degraded cannibalism since she eagerly devours her own eggs. The hot, dry sand seems scarcely the place for them. I, therefore, transfer them to a moist surface, which, by evaporation, remains pleasantly cool. It seems advisable to keep them in darkness also. Their pallid appearance immediately suggests that their natural residence is some tunnel in the soil. Such arrangements appear to me best suited for their nurture. But knowing nothing of their lives in the natural state, I doubtfully assume these foster duties, and feel that some essential factor may have been omitted from their infant cage.

We must not forget to take a glance at the parent. Her belly has by now considerably contracted. Being more at ease, she increases in activity, so also does the volume and variety of her appetite, for she will now take every kind of insect food. A little incident at this stage suggests the fact that under certain conditions the nuptials of the solifugid may conclude with a cannibal feast. After the eggs have been deposited and the abdomen has contracted I introduce a male into the female's cage. My object is to observe a second impregna-

tion. But all I see is the usual antipathy. They approach one another, the pedipalps touch, and they immediately retire to different parts of the cage. Up till bed-time nothing more important occurs. In the morning, however, the male has disappeared. Some remains of his legs and horny jaws lie scattered on the bed of sand. These are the relics of a midnight gorge. The female has destroyed the proffered partner and has eaten out the entrails from his shell. It is more than likely that the desert nuptials end in a similar matrimonial feast.

Our glance at the mother tells us nothing further. Let us turn again to the developing young. On the day after the transformation they are decidedly more vigorous and crawl actively over the sand. Their motions, however, are very ungainly owing to the difficulty in employing such thread-like legs with any degree of efficiency or grace. The question arises of providing them with food, an important duty for a foster nurse. At first I supply them with the entrails of grasshoppers, the juiciest fragments that I can obtain, but they show no desire to touch the morsel. No food of any kind is taken during the night subsequent to birth. Their colour slightly darkens as their strength increases, so much so that by the evening of the tenth day their sallow appearance has almost disappeared.

By the twelfth day they have become both vigorous and agile. They can skip along the ground, can climb up the perpendicular; in fact are

miniatures not only in structure, but also in the activity of the adult. Their sense of touch is well developed at this early stage. When undisturbed, they prefer to remain motionless, but a breath of air will immediately rouse them and cause the family of little jerrymunglums to scatter through the artificial nest. A jar on the box will produce the same effect, the feel of the thrill being, no doubt, experienced through the medium of the tactile hairs. Certain of the peculiar habits of the parent are present in these little mites. For example, they rest peacefully throughout the day, and like to throw themselves over on one side in a kind of side-long sleep. Unlike the adults, however, they show no sign of pugnacity. There are no combats, no traces of cannibalism. All live together as an amicable family within the confines of the same nest. Indeed, at this stage they possess some communal instinct. The members of the family like to congregate together, usually forming a compact cluster in one of the corners of the box. There they remain in a stationary group, but, on the slightest alarm, scatter from one another and go dashing hurriedly through the nest.

I am still in difficulties with respect to food. Nothing seems to suit their taste. The inside of a young lizard, the softest parts of a mole-cricket, the tenderest flies are all rejected. I give them a few drops of water on a leaf, but they do not appear to suffer from thirst. Nevertheless they grow in size and strength. From where do they obtain the necessary sustenance, since they stubbornly refuse

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the good things I offer them, and they can gain nothing from the barren sand? There must still be reserves of food within their bodies, potential substance inherited from the parent to supply the necessary material for growth.

How nimble they are by the sixteenth day! I must be careful when opening their enclosure. Given the slightest chance, they will slip from the prison and make away at the greatest speed. See how expert they have become at climbing operations. They can ascend a perpendicular sheet of glass, clinging to it with the suckers at the ends of their palps. By now they have assumed the colour of the adult. Also they have acquired an inclination to burrow, digging into the sand after the method of their parents, kicking back the dust with their slender legs, using their little jaws to haul out the nodules, and their heads for pushing back the soil. In this way they make burrows in the floor of the nest and thus manage to conceal themselves underneath the sand. I now observe at last that they begin to feed. Part of a young lizard is placed in their box. Two of them grip it in their tiny jaws, grind at the tough skin after the solifugid manner, and possibly extract a little nutriment from the corpse. They have entered into a new stage of life, that in which they are prepared to seek sustenance for themselves.

Day by day their appetite increases. In one night the family will eviscerate a cricket, and try to drag a small carabid under the sand. Signs of cannibalism also are appearing. I begin to find the remains of their corpses, usually the head and the

hairy legs. The distinction between the sexes has become very definite. The females are larger and darker in colour, somewhat more sluggish in their ordinary movements, and with swollen bellies ovoid in shape. The little males, on the other hand, run about with more activity; their abdomens are slender and furrowed transversely and coloured a pale yellowish hue. By day they remain underneath the sand, often a number in the same retreat. But after sunset they awaken and emerge from retirement, especially the nimble energetic males. All seem to thrive in the unnatural surroundings, and I am satisfied that my attempts at nurture are likely to meet with moderate success.

It is now three weeks since the laying of the eggs. The family, owing to cannibalism, has become reduced. At times I see a female absorbed in the act. Two or three will gorge together on the carcass of their sister, and now only a dozen remain out of the original brood. These survivors, however, are healthy and vigorous. The death-rate is due to their own enormities and not to any carelessness in my efforts as a nurse. I transfer them to a more capacious chamber with a floor of compact earth. Their increasing size and internecine slaughter show that they require more freedom and space. The females here display their efficiency at excavation. They easily uproot the firm layer of earth, hide themselves at the bottom of substantial tunnels, and then shovel up a heap of sand in order to close the door. They not only inter themselves beneath the soil, but take care that the burrow is concealed from view.

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Their subsequent release presents no special difficulty. They simply shuffle their way through the stopper of earth and come out on the floor of the cage. But very soon they completely disappear. They hide themselves permanently at the bottom of these shafts, scarcely ever emerging night or day. I try to draw them forth with tempting morsels of food. But, though succulent fragments are kept in the chamber, the buried jerrymunglums refuse to appear. The new home has become a kind of living sepulchre in which each solifugid has its own cell. It is the females which are specially desirous of confinement. The few surviving males sometimes run about the surface or shuffle in loose patches of the soil.

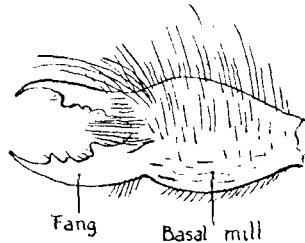
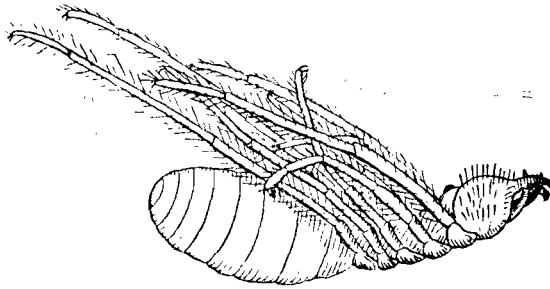
I expose some of them when thirty-five days old. They have passed into a lethargic state, lying belly downwards or else on one side. But this is merely a transient slumber. The month of September is not yet concluded. The days are still intensely hot and the nights uncomfortably warm. Hence their sleep is evanescent. A rise in temperature is likely to arouse them. A few will then emerge from their seclusion, revived by the glow of heat. Hunger returns; they again feed, and their cannibal instincts find fresh scope. By the ninetieth day the family is decimated. All have been devoured except a single female. One by one they have passed into each other's stomachs, so that she contains the sum total of all. She has grown considerably on this rich diet, her body from the head to the tips of the hind legs measuring one inch in length. What a

horrible end to the agile brood. Mutual destruction, unlimited voracity; how soon do they acquire those powerful instincts characteristic of the solifugid type.

My solitary female, the sole relic of the family, has secured safety by engulfing all. The chill of winter is now approaching, and she requires some safe and permanent retreat. A tunnel is dug into the sandy bed. She soon strikes the bottom of the chamber, and must extend her shaft horizontally along the floor. In the desert she probably goes down much deeper, perhaps a foot or more underneath the sand. This marks her final retirement for the winter, her habitation for many months. In mid-November I follow down her excavation. By this time insect life is scanty, all the solifugids appear to have vanished, the cold is becoming severe. I find her in a state of permanent hibernation, a strange condition between life and death, not identical with anything that I had seen before. She is absolutely quiescent, her body stiff, her legs thrust back like rigid stalks. (See Fig., page 258.) Her jaws are fixed, her palpi motionless, nowhere is the slightest quiver to be seen. She lies in her burrow perfectly helpless; one would think that she was quite dead. It is the legs especially that look so peculiar. Instead of being angulated and spread about her body, they are hoisted up over the abdomen and bunched together like a cluster of twigs. The long palpi too are drawn back into the bunch instead of being held in front of the head. This attitude is not without some little importance.

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It results in the appendages being so arranged as to lie extended along the burrow and thus fit into a narrow space. I touch the slumberer. She is clearly alive. She wriggles her abdomen, squirms a little. But there is no co-ordinate attempt at movement. She cannot flex her stiff appendages or straighten out her palpi, and by no possibility can she get upon her legs. What movements she makes



(Upper) Young Solifugid in Hibernating Attitude.

(Lower) Jaw of Solifugid.

are like those of a chrysalis which bends its body whenever touched. Her trance is thus a permanent rigidity. It is the stiffening of a lengthened stupor, reminding us of the rigor of death.

How extraordinary is this condition of hibernat-

ing coma. It is scarcely life, and yet not death, but rather a kind of cataleptic state. Vitality is reduced to the very minimum, and the spark is kept just feebly burning by the store of accumulated food. Like the pupa of the puss moth in the wooden case or that of the ampulex in the belly of the cockroach, here we see something of a similar nature in this stiff unconscious state.

Month after month she remains asleep. While all life on the surface shrivels from the cold she remains secure and sheltered from the elements beneath the thick layer of sand. But what of the mother while all this is in progress. She too has dug herself into the soil. I find her buried at the bottom of the cage, a huddled, motionless mass. For a time she exists in this stupid drowse, the same kind of peaceful lethargy that has fallen on her insensible brood. Possibly in the desert the sleep continues and carries her through to the next year. This, however, does not happen in my cages, for she dies at the first snap of cold.

Thus concludes my picture of one season's life. A round of activity and steady growth terminates in a prolonged sleep. The following year brings forth a resurrection. The gates of the sepulchres are broken down, and the host of slumberers scattered through the desert come out on the open sand. But certain little problems remain unsolved. Do the parents persist right through the winter? Will they generate new broods in the following season? What is their length of life? Will the young of this year be the parents of the next? If not, how

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soon do they become mature? These are questions that I cannot answer. My observations are limited to a single season. They commence with the heap of opalescent eggs and end with the sleep in the sand.

CHAPTER XII

THE SOLIFUGID—WARFARE

Nocturnal ravages—Special senses—Contest with spider—
With centipede—Internecine contests—Cannibal feasts—
Contest with scorpion—Strategy of solifugid—Appreciation
of danger—Expression of terror—Instinctive knowledge—
Battles of the desert.

NIGHT in the desert is wonderfully impressive and
pictured correctly in Southey's lines:

“ How beautiful is night!
A dewy freshness fills the silent air;
No mist obscures, nor cloud, nor speck, **nor stain**,
Breaks the serene of heaven:
In full-orbed glory yonder moon divine
Rolls through the dark blue depths;
Beneath her steady ray
The desert circle spreads,
Like the round ocean, girdled with the sky;
How beautiful is night! ”

The camel-spiders choose these silent hours for
their work of plunder on the sandy waste. They
race about, conduct their amours, glut themselves
on innumerable insects to supply the requirements
for a six months' sleep. They are the rapacious
tigers of the desert, whose business is to plunder,
ravage and gorge. They overwhelm with ease the
greater number of their victims. A squeeze is

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sufficient for the flies and moths; even locusts require just a firm grip and a steady working of the jaws. But the contest is not always so conclusively one-sided. At times they will encounter a more powerful adversary, a centipede, a scorpion, perhaps another solifugid which will not submit without a stubborn fight. Many a duel is fought on the desert; many a fierce and mortal combat in which the solifugid renders up its life.

Here I will tell something of these grim encounters. But first let us look to the special senses. It is these that regulate the search for victims and guide the solifugid in the deadly fight.

They do not appear to have much faculty of vision. There are two black eyes on the upper surface of the head, but these are organs of feeble power. The fact of the solifugid being lured to a lamp shows that some degree of sight exists, and my collaborator tells me that nothing so attracts them as the presence of a freshly white-washed wall illuminated by an artificial gleam. But I doubt if they are able to do much more than just distinguish between darkness and light. I move my hand in front of a solifugid while it rests in the passive state. It shows no indication of seeing anything; perhaps it is half asleep. I repeat the act when the solifugid is aroused. Still it appears to appreciate nothing. I bring a glass rod between the pedipalps, until it is almost in contact with the eyes; but again the solifugid takes no notice unless I happen to touch a hair. Should this occur, it is instantly alarmed,

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either springs forward to clinch the rod or retreats with a sudden rush.

Hearing seems to be no better than sight. I make noises quite close to them when they lie in the cage. They seem completely unaffected by the hammering on a tin. I blow a whistle, then ring a bell. Of these they seem to show just a bare appreciation. It is probably not so much an auditory perception as a stimulation caused by the aerial vibrations acting on their tactile hairs. If these creatures possess an auditory sense, it must be in a very rudimentary state.

Taste too is but poorly developed. Hence all kinds of insects are acceptable to them; so long as the substance is living flesh it is fit for the mandibular mill. I gave one a foul smelling *Coreid* bug, which, though most offensive to the human senses, was ground down in the orthodox way. Even quinine, which is so intensely bitter and which so many insects refuse to touch, does not seem to stimulate their sense of taste. They seized a grasshopper that had been soaked in a solution of quinine, chewed it up with the usual enthusiasm, and swallowed the mass complete. I filled the belly of a locust with the bitter substance, and this too was eaten entire, the solifugid showing no dislike to the flavour and appearing none the worse for so large a dose. They certainly are not in any way fastidious even if they possess a gustatory sense.

They are better provided with the faculty of smell. I soak a pellet of wool in a solution of camphor and place it on the sand in front of their

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jaws. Others I test with oil of eucalyptus, still others with oil of aniseed. At first the solifugids show no sign of disapproval, though these are substances with a powerful odour which many kinds of spiders and insects dislike. In a minute or two, however, I observe a change. The solifugids withdraw about an inch, and take up a new position on the sand. They have found the atmosphere in some way unpleasant. Presumably they have perceived the odour of the substance by means of their olfactory sense.

But the faculty of main and incomparable importance is the wonderful sense of touch. It is touch that tells them of the presence of danger, that enables them to find their numerous captures, that guides them in the strategical fight. The sense is exerted through the widespread hairs. They extend from all parts of the solifugid's body. Those on the head and thorax are short and strong, those on the legs of intermediate size, while the palpi support the slenderest filaments, some of which are over an inch in length. Touch one of these hairs ever so lightly and the spider swings round to meet the intrusion. They serve as a kind of tactile shield, those on the pedipalps guarding the front, those on the legs protecting the flanks. They thus extend the tactile zone. Like the spiders which spread out diverging radii, so have these allies an encircling system for the purpose of expanding their sense of touch.

Thus equipped, the solifugid is ready for battle and prepared to face almost every foe. Let us

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witness some of the more interesting contests. They will teach us the principles of desert warfare, its ferocity, its strategy, its skill.

I throw a big *Lycosa* into the arena. It is the largest spider that inhabits the oasis; nevertheless it is a dwarf when compared with the solifugid, though powerfully armed and of considerable strength. Such a foe is nothing to the inhabitant of the cage. What occurs is scarcely worth calling a fight. The solifugid certainly finds difficulty in gripping it, since this species of spider is particularly active and repeatedly escapes the thrust. But in the end the solifugid gains an advantage, rakes the intruder into its jaws, and grinds it immediately to the usual pulp.

Similarly it makes rapid work of the centipede, seizing it transversely across the writhing body which twists and lashes in the dreadful jaws. There must be no delay with so dangerous an enemy, since the centipede possesses a supply of venom and is well equipped with poison fangs. Hence the solifugid employs all its speed, crushing the long body in a series of swift clenchings which follow rapidly one on the other until the victim is macerated from head to tail. The contest is more an exhibition of swiftness than of any particular strategical skill. Victory, as usual, ends in a gorge. The centipede is taken into the mill and triturated to a succulent food.

More prolonged and even are the internecine contests, for these creatures hate one another's presence and immediately come to blows. I have often been witness to these strange encounters. It is a striking spectacle of internecine fury. The

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solifugid by itself is sufficiently unattractive, but a pair enraged and joined in battle presents a far more repulsive sight. It is the simplest matter to bring about a contest. I transfer one to another's cage. Both are males, strong and active, and grown to the full size. For a moment the intruder wanders about, being at first unaware of the fact that it is not alone in the cage. Soon, however, its long hairs touch those of its companion. Each is immediately on the alert. Not for an instant will they tolerate one another. They whirl themselves about, come face to face. Their heads are raised, their legs spread out, their pedipalps widely stretched apart and bristling with tactile hairs. Their jaws begin to work as though in preparation, the huge lateral mills sliding on one another and eager to join in the fight. This is the attitude of readiness for action when both the opponents prepare to strike. They may stand thus just for a moment. Then they rush at one another head to head, the pedipalps taking the immediate shock and warding off the ponderous jaws. After this the contest becomes very variable. Sometimes they rock from side to side, their bodies kept apart by the projecting pedipalps; they look like wrestlers at arm's length, each manœuvring for a better position and waiting for a chance to secure a grip. At other times they come quickly into closer apposition. Forcing their way past the barrier of the pedipalps, they lock together, jaw in jaw, and the contest is inseparably clinched. The panting bodies heave and sway, gripped together with the tenacity of bulldogs, and never daring to relax their

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hold. Each struggles for the chance to get a vital grasp. They endeavour to drag, to overthrow one another, and the unwieldy bodies roll heavily in the fight. Give one the very slightest opportunity and it will drive its fangs into the soft parts of its opponent with the result that the struggle ends.

Very often the contest is even and prolonged owing to the opponents being well matched. The interlocking jaws will then disengage and the wrestlers will spring apart. At other times I observe a more immediate victory. One makes such a rush as to overwhelm the other. There is a swift confusion of tangled limbs. The more powerful of the two thrusts its pedipalps across the other, bending down the long sensitive feelers and clutching the body in a pair of arms. For a second the two pedipalps violently quiver, then they curl in, then fasten on the victim, then sweep it to the open jaws. The mandibles grip it at the same moment. Whatever part that offers is taken between them; it may be the throat, the thorax or the flank. The grip is tenacious to the last degree. The hard skin can be heard to crack beneath its pressure; the tuberculated teeth grind into the flesh. Once secured by this bull-dog method, the adversary is completely overthrown. A few weak kicks, a faint attempt to struggle, these are its last efforts in the fight.

The victor steadily clings to its prize. Possessing no poison for the stupefying of its captures, it must hold them rigidly until the struggles die away. At length it relaxes, drops the carcass, perhaps abandons it and retires from the scene. But if

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suffering from hunger, it indulges in an orgy. It begins by carrying the corpse about the cage, winding its pedipalps around the body and gripping it firmly by the narrow waist. Soon it changes its hold to the abdomen. Then the massive jaws set deliberately to work. They grind ferociously at the prostrate victim, which may still retain a spark of life. The contest thus ends in a cannibal feast. It is a most loathsome spectacle, more repulsive even than the ghastly fight. The monster quickly settles down to its gorge. The gluttony commences at the succulent abdomen. The skin is eaten through, the entrails exposed, and all is ground into the ordinary pulp. The juicy substance, a black jelly-like mass, passes backward into the mill. There it is triturated with a quiet persistency and forced down into the narrow throat. Soon the whole of the abdomen is finished, and this, in the instance under observation, marked the end of this disgusting feast. All the succulent material has been eagerly swallowed; the remainder, being hard indigestible refuse, is allowed to lie on the floor of the cage.

But there is a still more deadly enemy which the solifugid must often encounter by night. This is the scorpion that haunts the desert, a large, black, powerful, well-armed antagonist that hides by day in some suitable concealment and emerges after dark to explore the sand. Swift and decisive are the vicious duels fought by these ill-assorted foes.

The scorpion is a rival worthy of respect. It is massively built, with a broad flat thorax, long diverging lobster-like claws, a muscular abdomen that

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curls over the back and terminates in a poisonous hook. Moreover, it is quick and nimble in its movements; its skill in action is swift and cunning, and its body is enclosed in a coat of armour formed by the hardened skin. This is the most formidable of all possible opponents, having at its control a rich supply of venom which will cause death at a single stroke. It looks more dangerous even than the solifugid, the curved sting at the point of the tail appearing more evil than the monstrous jaws.

Let us pass to observe the mode of battle. An Arab gardener supplies requirements for the spectacle. He finds the scorpions in the substance of a decomposing palm trunk or else digs them from the vegetable mould. More than sufficient for the purpose are obtained, since the gardens abound with creatures of this kind. The arena as before is strewn with sand, and the combatants placed quietly within. The solifugid begins by withdrawing to a corner, having at the time no murderous intentions, and desiring only to be left in peace. The scorpion, on the other hand, shows more activity. It immediately begins to explore the amphitheatre, traversing the floor, climbing up the gauze, its immense claws thrust out before it and poison fang turned up over its back. Soon it happens to fall in with the opponent. Again we see the immediate appreciation; again we see the lightning turn which brings the antagonists face to face. This is the only position of security; on no account can either expose its flank in the presence of so dangerous a foe.

The antagonists present a striking appearance.

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Each is so powerful, each so well armed, each so vigilant, so cautious, so alert. The one is a ponderous yellow monster, with legs outstretched, enveloped in bristles and furnished with tremendous jaws. The other is filled with a satanic cunning, crouching low, flat upon the sand, its claws outstretched, its poison sting elevated, its black body the emblem of malice and death. The contest is a trial of different weapons. Strength and subtlety are matched with one another. The immense mandibular mills of the solifugid are pitted against the scorpion's poison and sting.

Each seems immediately conscious of its danger, realizing clearly the nature of its enemy the moment they come face to face. For some seconds neither makes an advance. They just stand at their posts and watch one another. Each fears to enter so dangerous a contest, yet it dare not turn aside. A false movement may place it at a disadvantage, perhaps expose an unprotected flank or even lay it open to a vital thrust. How remarkably well they seem to know the awful danger that has suddenly appeared. Without further warning the duel opens. The scorpion makes a lightning rush. Its long pincers are stretched out like a pair of arms, the strong claws at the tips being opened to the full in readiness to take a grip. The sting too is equipped for action. All that is required is one successful thrust. But the solifugid is prepared to meet the impact. Its legs are spread so as to clutch the sand, its pedipalps are elevated and pushed far in front, their purpose being to detect the advance and, if

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necessary, receive the force of the attack. The rush is usually short and sudden, moreover it is likely to be indecisive, since the scorpion fears the closest grips. It dashes in between the open pedipalps, shoots forward its tail with a sudden lash, the thrust being swift and forcibly directed straight at the hairy body of its foe. But the stroke, as a rule, is ineffective. The scorpion has not dared to come in contact with the jaws; hence it cannot reach sufficiently far forward and its blow is wasted in the air. Nevertheless, the attempt is violently made, the poisonous dart being shot out straight, and the scorpion sometimes almost standing on its head in the effort to get its thrust home. Half a dozen or more of these rushes follow, each culminating in a similar stroke, which the solifugid successfully turns aside. The solifugid is terrified at the awful danger, perhaps realizing instinctively that all is over if once it is touched with the poisonous dart. Thus, seizing an opportunity, it springs aside, outmatching the scorpion in its wonderful agility; then it rushes across the arena, leaps up upon the wire gauze, where it tries to eat through the narrow bars. There it may hang in a half-stupefied manner, or else come down again to the floor and move with circumspection over the sand. It is obviously terror-stricken at this frightful experience. In its movements it shows every sign of anxiety, springing and snapping at harmless objects as though in dread of again encountering the foe. The scorpion, on the other hand, makes no use of its advantage, and never attempts to follow up the retreat.

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Sooner or later they must again meet. Then we see another succession of rushes, a repetition of the *same faint-hearted duel from which the solifugid will probably escape*. But the scorpion seems now to have gained more courage. It shows less timidity on meeting the enemy and comes more quickly into the fight. The solifugid at the same time is becoming more artful. If it sees a chance of approaching from behind it advances a little on the scorpion's tail. Sometimes it assumes a more daring attitude. I see it clutch the tail with the tip of its pedipalp and try to rake the structure into its jaws. But in this it acts with the greatest circumspection. It knows that the sting is the point of danger, yet this is the spot which it wishes to grip. On no account will it make a frontal onslaught; it refuses to advance in any direction other than on the deadly sting. Thus a rear attack is the strategy of the solifugid. It is useless for the scorpion to try similar tactics. If it happened to approach the enemy in rear, the latter immediately makes a spring and twists round to confront its foe. The solifugid, though wary in these earliest efforts, gains confidence as the minutes advance. Perhaps it realizes that escape from the enclosure is impossible, and that it must of necessity enter the fight. Again and again it tries to grip the tail, being now less inclined to dart away, and at times even making a valiant advance. Nevertheless, it is clearly in the greatest dread. It will not close except on the most favourable advantage, and, as a consequence, makes numerous futile attempts. The share taken by the pedipalps is very important. We

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see them carefully applied to the scorpion's body, made to search out the shape and position of the parts, fulfilling the purpose of long sensitive arms that serve as a guide to every action and direct both the moment and the method of the fight.

These manœuvres, however, cannot last indefinitely. All of a sudden and quite unexpectedly the skirmish changes to a savage fray. The combatants come together with a vicious rush. There is a whirl of tangled limbs and bodies. In the confusion we see the short swift stabs of the scorpion and perhaps we may detect the fatal blow. The scorpion has succeeded in getting home a thrust. As a consequence the wild excitement ceases. The combatants remain locked at the closest quarters, the scorpion standing erect on its head, having withdrawn its dart from the solifugid's back. The solifugid has been instantly staggered by the stroke. It falls over half helpless, its legs twitching, its abdomen pulsating; it is not immediately struck down dead, though wounded by a mortal blow. I separate the combatants now the strife is over. The solifugid seems at first to recover partially, and can take a few steps across the floor of the cage. After an hour, however, it sensibly weakens, then spreads itself out like a corpse on the sand. The poison of the scorpion is taking effect. All muscular response soon fades away and the contest terminates in death.

But success does not always fall to the scorpion. We have seen how the solifugid manœuvres for

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position, how its daring and subtlety are both directed to one strategical point. The solifugid fights more by cunning than by strength, and often carries the day. Let us follow the course of this victory by craft. The solifugid is approaching the scorpion from behind, working its way to the tip of the tail. There is a fierce pounce, incredibly swift. The solifugid has hurled itself on the scorpion's rear, seized its enemy across the tail immediately in front of the base of the sting. The tail is the point of tactical advantage; it was there that the solifugid had fixed its attention throughout the manœuvres that preceded the pounce. The scorpion, thus gripped, is comparatively helpless, at least with respect to its poison and sting. It can still employ its claws to good effect. While thus held in the vice it bends itself double, clings with its pincers to the enemy's legs; but the solifugid cares nothing for these prehensile weapons; it seems to know with instinctive certainty that it must at all costs control the venomous sting. The scorpion does its best to employ its poison, turning up the dart and making efforts to strike, but the stabs fall upon the hard mandibles owing to the manner in which the tail is gripped. Against these the venomous weapon is powerless, and the solifugid is safe from immediate death. The solifugid makes the most of its strategical advantage. It grinds into the scorpion, chews at the hard tail, and so crushes the organ in its powerful mandibles that the enemy is deprived of the use of its sting. Thus a well-fought victory falls to the solifugid. A battle has been fought with

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swift audacity combined with tactical knowledge and skill. The solifugid does not enter the contest blindly. It knows the awful danger that it has to face; it realizes the nature of its opponent's weapons, their position, their use, the deadliness of their effect. In addition it understands a way to circumvent them; hence it approaches the enemy in rear and goes straight for the strategical point. Such is its knowledge, or its apparent knowledge. It is a remarkable example of instinctive appreciation applied to the furious battle of life.

Thus end the duels as seen in my arena. I have little doubt that they occur with the same ferocity in the freedom of the desert sand. The clash of arms gives a wild excitement to the spectacle, but the lessons in instinct are of chief importance, the capacity of the solifugid to realize its danger and its knowledge of the strategical point. This appreciation of danger is commonly met with amongst creatures that contend with special foes. The spider, when driven out by the wasp of the ruins, is aware of the murderous character of its huntress, and strives to escape by artifice and speed. The *Cryptocheilus* in its duel with the black-bellied *Lycosa* keeps well out of reach of its opponent's mandibles and concentrates on a rear attack. A *Libythea* butterfly, when snapped at by a bird, will sometimes close its fluttering wings and throw itself headlong to the ground. These creatures seem to know the awful fate that lies in store for them if they do not escape by some suitable ruse,

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So it is with the solifugid of the desert. When engaged with another of its own kind it loses heart the moment it is seized. In fact it becomes so stupefied with terror that it will not attempt another blow. It rolls over as if struck dead, makes no attempt at further resistance, but just draws in its legs and pedipalps and resigns itself to the awful fate. Nevertheless, it may not be seriously injured. Its enemy has it in a tight hold, but no vital damage may have been inflicted, and, when released, it may run rapidly off. Indeed at times its appreciation is so acute that the presence of a scorpion will paralyse it with fear. Once in my attempt to originate a contest I threw the scorpion on the top of the solifugid and repeated the act three or four times. The solifugid was struck with immediate terror. It stood absolutely motionless, its legs and palpi bent, with froth exuding from the tips of its feelers, and its body heaving as if gasping for breath. It was evidently suffering great distress. For a moment I thought that the scorpion while falling must have in some way got in a blow. I straightway removed it to a safer chamber. Very soon it recovered from this state of shock. In half an hour it was as active as ever, the paralysis being due to nothing more serious than the consequences of extreme fear. The emotional feelings and their vigorous expression are not the prerogative of higher types of life. Those passions which sway us like a leaf in the wind occur to some degree in the humbler forms, though seldom displayed in so conspicuous a manner as when the solifugid quakes with fear. They too are moved by

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the impulse of the moment. The seeds of all the deep emotions—of the fires of love, the black gloom of hatred, the seething menace of unbridled passion—are sown in the simplest minds.

I have elsewhere shown that even higher faculties exist far down in the animal scale. In the insects we see signs of an intelligent behaviour. I stake the pellet of a *Gymnopleurus* beetle. It finds the obstruction, cleaves the pellet and cleverly unites the halves. I perforate the nest of a *Rhynchium* wasp. It discovers the damage and proceeds to repair it in a workmanlike and intelligent way. It is not instinct alone that guides these little creatures. The higher faculties of intelligence and the deeper feelings of emotion influence the current of their daily lives. Often, no doubt, the influence is feeble. Admittedly it is imperfect, very rudimentary, seldom made manifest except through experiment, and never but by careful search. But still it exists in some degree. There is no sharp line in psychological development. Nowhere can we say that this is an instinctive and that a purely intelligent being. Evolution is a slow and gradual transition. Nothing exists but what has grown from something simpler. The higher faculties are born of more primitive material. Our intelligence, our emotions, as well as our instincts, have their roots in the humbler forms of life.

We leave this subject of the solifugid's emotion and turn to its knowledge of the vital point. In this we see a wonderful example of prescience. It knows exactly the place of danger. In the fight it

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holds nothing of any importance provided it avoids the tip of the tail. Other creatures display a similar kind of knowledge. The different varieties of hunting wasps—the *Psammochares* that drives the spider from the masonry, the *Sphex* that expels the cricket from its burrow, the *Ampulex* that chases the slippery cockroach—all act as if acquainted with the nervous spot into which they must plunge their venomous darts. So it is with certain spiders in the slaying of their victims. The *Tarantula* which takes the insect at the threshold of its tunnel, the *Hippasa* which secures it on a fine-spun sheet, the *Nephila* which drags it from the meshes of a network, all send their fangs into the nervous apparatus as though they knew the anatomical structure of the prey. It is the same with the solifugid in its duel with the scorpion. So clear is its perception of the enemy's configuration that it concentrates solely on the vital point. This knowledge, I have little doubt, is instinctive in character, similar to that of the wasps and spiders when they strike at the nervous spot. I placed a half-grown solifugid with a small type of scorpion, and it entered the battle with the same strategy as that already displayed by the adult. In all likelihood they adopt these strategical measures the very first time that they engage in a fight. It can scarcely be a knowledge acquired by experience, since, if the solifugid is ignorant of its tactics, the first of such experiences will result in death. Nor is it possible to imagine that the young are taught in such a way as might occur amongst mammals or birds. It is rather an example of instinctive

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capacity, that wonderful inherited driving power, that feeling, that impulse, that untaught knowledge, the same that guides the swallow on its migrant journey or the infant to its mother's breast. It is the accumulated experience of countless battles, the lessons of the past transmitted to the offspring with an undeviating accuracy and force.

There is a vicious facies about this desert fauna. Poison and sting and herculean strength are the weapons that engage in the battle of the night. At times I have caught a glimpse of it with the aid of a lamp, and more often I observe a contest by day. One time it is a centipede fastened on a beetle, at another time a scorpion with a cricket in its pincers, still again a solifugid munching at diptera or raking a locust into its mill. Spiders have their snares in the dusty thorn and seize on the victims that fall into their nets, others live under broken clods, others at the bottom of cylindrical burrows and come forth at night to join in the chase. By day the ants cause tremendous destruction. We see a cricket, a beetle, a locust, a larva carried successively through the gate of a nest; on the sand we see them grip the unwary diptera or drag the terrestrial molluscs to their store. The robber-flies are watching on points of vantage, the dragon-flies are decimating clouds of chironomids, the ant-lions are waiting in their funnel-shaped pits. Solitary wasps are chasing cockroaches and spiders, others are seeking out flies and caterpillars, others hauling crickets over the sand. How vast, how deep is this complex scheme of the interdependence of living beings! Each

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creature is in arms against its fellow. The tangled skein of desert life oscillates in every thread. Yet the whole is fixed in a perfect balance, guided, no doubt, by as unswerving laws as those which move the planets in their paths.

CHAPTER XIII

IMPRESSIONS OF THE DESERT

Appearance of desert—The mirage—The veil of dust—The dust—storm—The desert sunsets—The locust invasion—Observations on their flight—Their rate of progress—The swarm of hoppers—Their instinct of direction—Their special senses—Their enemies—Conclusion.

LET us pass for a little while beyond the oasis and take a survey of the arid waste. How wonderfully even is this sheet of sand! Nowhere is it heaped into rolling dunes. Its surface is as level as a lake. How vast it all seems, this unbroken landscape, with no limit but the sinking of the heavens to the earth. We see an Arab encampment like a speck on the waste, a line of camels like a passing ship that crosses the horizon and then fades from view. How sterile and unprofitable does it all seem! How lonely, how silent, how bare! What freedom for the elements to work their will, for sweeping winds, for vortices of dust, for those vague mysterious aerial shapes that glimmer on the inconstant sands.

We will glance at a few of its most striking features. What a wonderful phenomenon is the mirage! How delusive when we see the wilder-

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ness of sand transformed into a watery sheet. It is specially impressive in a strong wind when the heated air can be seen in motion and swept along in visible waves. We carry our glance out over the desert. At our feet the sand is calm and unobscured; there is here no trace of the mirage. We raise our eyes a little further. We begin to observe a dim indistinctness, a faint perceptible tremor in the air. A little further we come upon a shimmering haze which grows into a dense mist. The sands are now becoming obscured; objects are beginning to lose their distinctiveness. A steamy sheet undulates over the desert, dancing in the sun and dimming the vision with its veil of misty fumes. In the strong wind we observe the mist in motion. At one time it appears like clouds of vapour driven onward roll upon roll, at another time it resembles foaming breakers curling in upon a shelving shore. Further on still it is an even sheet, a white and ghostly layer of vapour in which all the unrealities of the desert appear. How weird are the shapes that rise out of this ocean. What illusive and fantastic visions mock us from this open sea. All objects are confused, all outlines distorted. Men come tramping through imaginary waters. They seem as if marching ankle deep in shallows with their quivering bodies lengthened into trees. The tents of an encampment are a fleet of sails scudding before a strong breeze, the matted huts of the Arabs are an island dwelling standing in a smooth lake. Groves of trees are floating gardens, ruined mounds are



THE DESERT AROUND BAGDAD. *Photo. W. Bourne.*

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elevated cliffs that border on a seashore. Slow unwieldy camels shimmer in the haze as if they were cavalry advancing at a trot; a large bird is like an ostrich standing in the water; sheep are magnified into hairy monsters like mammoths risen again to life. Every object is distorted and unreal. The mind is mocked with innumerable phantoms as we contemplate the wonderful mirage.

These illusions vanish with the setting sun. The desert cools, the hot aerial currents cease to rise, the dancing sands sink into repose. By day the desert is in tremulous motion; it looks as if the tiny grains of sand were vivified into organic life. But evening brings a change to reality and rest. The sand is then swept of its currents of air; all motion gradually dies away, and the wilderness becomes clear and calm.

If we look to the sky we see another kind of haze, the veil of moving dust. In summer it fills the air as with a cloud. The sun is changed to a silver disc and screened of its blazing light. The dust must rise to many thousands of feet. It is not carried up by the impetuous wind, but by the convection currents of air that rise from the hot sand. For in winter it never so fills the atmosphere, and in the summer evenings as the desert cools so does the dust simultaneously subside. But the wind must drive it over immense distances, perhaps carry it from continent to continent through the upper regions of the air. It is instructive to see this fine powdery material conveyed by the wind at so great a height. It explains to us the

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atmospheric powers of transportation, how the dust is raised from the plains of India and deposited on the Himalayan snows, how the powder shot forth from a volcanic vent is swept for thousands of miles through the sky, how the light siliceous remains of the *Diatomaceæ* are wafted down from the Polar seas to the tropical zone of the Atlantic ocean.

What a splendid example of desert fury when the dust is associated with a storm! How fierce is its violence as it sweeps the sand! Preceding its onset is a period of stillness, a breathless suffocating heat. The air is for a time an absolute calm, the body pours with incessant perspiration and thousands of insects begin to appear. In the far horizon is an ominous mass, a thick and dirty yellow cloud where the sky is laden with the driven dust. Then of a sudden the storm breaks, first a few gentle waves of air, soon followed by an impetuous wind. With it comes the yellow cloud and the whirling grains of sand. The granules sting as they are swept along. They are blinding in their force like the snow of a blizzard, and only for a moment can we face the blast. The dust-storm is in fact the blizzard of the desert. All kinds of objects are carried aloft by it. Tents and huts are razed to the ground; lighter property is swept away. Small animals must certainly be driven before it, and also the seeds of the desert plants. In this way the winds will have some effect in increasing their geographical range. Sometimes there are signs of great electrical disturbance. At

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night we may see the iron spike of a tent pole glowing with a bright light. The wind burns like the blast from a furnace, due to the innumerable granules of sand. Finally the drops of moisture fall. It may be only a gentle sprinkle, or perhaps a deluge may clarify the air. Then the wilderness becomes wonderfully clear. The skies are washed of their clouds of dust and the desert of its tremulous mirage. The sun now shines clear and sharp, the objects on the sand are firm and distinct. The wilderness fades away from view, not in a confusion of fantastic mockeries, but in a well-defined horizon where earth and heaven join in a real line of sight.

How beautiful is sunset in the open desert when the sky is cleansed of dust! It is not only in the western horizon, but often we see the whole arch of heaven glow with a radiant light. Sometimes we observe a double sunset. Both east and west so blaze with colour that we scarcely know if it is a sunset or a dawn. This appearance may be made remarkably conspicuous when the sky is overhung with mammillated clouds. The sun from the west sends up radiating beams made visible by the vapour through which they pass. These shafts of light diverge into the zenith. In their course they illuminate the globes of cloud and are then lost in the canopy above. But soon again they appear in view, now as beams converging to the east. The clouds in the zenith have caught these rays. Like a concave mirror they have bent the light and directed it to the eastern side of the sky.

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Thus the rays seem to diverge from opposite horizons; a point in the east and a point in the west both send forth these visible beams into the black firmament above. The sky is thus spread with lines of light, and the earth is arched with a luminary dome. It is an inspiring, though an evanescent, spectacle. A sun might exist both in the east and in the west as though the dusk was contending with the dawn.

A feature of the desert is the locust invasion. My opportunities allowed of no detailed observations, but on a few occasions I secured a glimpse of these seething ravaging swarms. Once I was present at the entrance of the host. An immense army passed overhead, advancing from the south-east. The swarm was visible while still far off, in its thickest part like a black nimbus or a pall of sooty smoke. Everywhere the sky was alive with insects. On all sides were millions of fluttering wings, closely packed where the cloud was dense, but still crowded even at the outskirts of the flight. A grove of date-palms seemed at first to attract them. The cloud wheeled from its original course in order to investigate this green expanse. But the cluster of trees must have proved unsuitable, for the swarm, after hanging a little while over it, swerved again to its previous course. The movement was performed with excellent precision. All in the swarm changed direction together, wheeling in a common mass. What is it that guides these aerial evolutions? Do those in advance select their object and the others follow

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obedient to their will? Or do all wheel by some guiding instinct that permeates the whole swarm? The locusts now resumed their progress to the west. I saw the cloud fade away in the remote horizon and disappear over the bare sand. Till nightfall scattered individuals followed, like stragglers that had fallen to the rear of the host.

Here are a few points that struck my notice with respect to this special swarm. Though all moved in a disciplined body, yet sometimes a locust seemed to lose its way. As we watched the army in its steady progress, all advancing in the same direction, now and again one would turn aside and flutter transversely across the course. This usually happened at the edge of the swarm. Perhaps in those places where the cloud was thin the instinctive feeling of direction was less strong, and, as a consequence, the locusts at the outskirts were more likely to stray from the common route. Another little point was that the locusts near the ground moved more rapidly than those higher in the air. This may have been due to the effect of wind. For the swarm is much influenced by aerial currents. While those near the ground can proceed with less obstruction, others in the cloud at a higher level may be swept from the true course. I observed that, when the swarm changed direction, the locusts near the ground and those higher up did not always turn at the same time. Those at one level might have made the wheel while those at another had not yet commenced. Indeed it seemed that the swarm had separate layers, that

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the locusts in one layer all worked in a body and to some degree independently of those in the other layers. Here is another peculiar fact. The locusts did not move in the direction they faced. Their wings seemed to drive them at right angles to their length. This resulted in a strange appearance. We saw a host of insects in vigorous flight all drifting sideways to the north while their heads at the same time were directed to the west. It was like a little fleet of tiny ships falling to leeward while facing the breeze.

I tried to estimate the rate of movement of the swarm. A single locust in five seconds travelled a distance of twenty yards. Thus the whole swarm probably advances at somewhere about eight miles per hour. A swarm of locusts will fly a great distance. More than once I have seen them alight on a ship when well out of sight of land. In the Red Sea a locust came on board when 73 miles from the African and 87 miles from the Arabian shore. On the 6th of March, while in the Persian Gulf, a small company of locusts invaded the ship. They seemed to be striking a course for Arabia and came from the direction of the Persian coast. The weather was fine, the sea calm, and the vessel about sixty miles from shore. Yet the locusts seemed well acquainted with their course, though far out of sight of land. They rested on the ship just for a little while, then, either as individuals or in small parties, launched themselves into the air. Without hesitation they resumed their line and bore away for the Arabian

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shore. How marvellous it is that a group of insects—or indeed a solitary individual—can pursue a steady and determined course over miles of unbroken sea! It is no mean flight across these arms of the ocean. Reckoning their speed at eight miles per hour, it will take them fifteen hours to negotiate the Gulf and twenty-two hours to make a journey over the Red Sea. Thus part of their migration must extend into the night, and I have seen a locust strike the ship some hours after the sun had set.

On another occasion I encountered a swarm, not this time of the full-grown flying locusts, but rather of the insects in their wingless state. This was a multitude of immature hoppers, all creeping or jumping or clinging to the scrub. The desert for miles was covered with locusts which day by day pursued a steady march. I have no idea of their full extent, but it may have reached for hundreds of miles. In one place their ranks appeared more open, perhaps a mile or two of desert might be free from the investing layer. In another place they densely clothed the ground in what looked like a grassy lawn. The swarm of hoppers was in continuous motion. All advanced in a fixed direction with the same persistency as the aerial host. Their rate of progression was slow but steady. I reckon that they moved about one mile in every three hours. Their progress was orderly, they advanced in a body, a rigid discipline pervaded their ranks. Each individual crept forward a few inches, then halted for a moment or

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two, then again walked on a little, perhaps advanced by a series of hops or climbed over a piece of scrub. All in the host moved in the same manner and combined to form a steady stream. But not only did the swarm advance in mass, it also sent forth subsidiary columns, which, like a river breaking into smaller branches, divided and redivided and again rejoined. These columns looked like a flow of water, the alternating rhythm of halts and creeps giving the appearance of ripples to the stream. And as a tributary pouring through the bank of a river may change the direction of the main flow, so did one column of locusts on joining another compel the latter to bend from its course. Or what was adopted on other occasions. The incoming stream changed its direction. It carried out an organized wheel so as to come into line with the second flow, after which the two become evenly absorbed. The army thus advanced in masses and columns. The desert provides few attractions for a halt, but at length some fertile area is reached. The army then stops to enjoy the pasture and devours every green thing. Locusts in different stages of development were found in the same stream. Some were small and darkly coloured with only the faintest suggestion of wings; others were more than twice their size with wings half an inch in length.

In this swarm the general trend was to the north. With great determination they maintained this course, forcing their way past every obstacle,

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either climbing over it or making a detour. At one place the swarm reached the bank of the Euphrates. Here was an unsurmountable barrier, a great river miles in width. For this was the season when the floods were at their highest. The river had burst through its elevated banks and had spread itself over the surrounding plains. The locusts were confronted with a sheet of water, so vast that, like an ocean, it stretched to the horizon with no trace of any further shore. Yet even this did not deflect the swarm. The locusts did not turn when they reached the river. On the contrary they continued their march into the water and forced their way out upon the waste. More and more followed in the wake of the leaders. They spread themselves out over the glassy surface and were carried downward in its steady stream. Drowning insects were visible on every side as far as the eye could reach. What an excellent example of the instinct of direction. How blind in its relentless, its undeviating course. Better self-destruction than instinctive deviation. For nothing must check that all-powerful impulse. At all costs it must follow the appointed line. The living machine must fulfil its purpose though annihilation lies ahead.

Locusts are not the strictest vegetarians. Given the opportunity, they will devour one another. An injured member of the swarm is set on by its neighbours and sucked dry of its body juice. There is no succour for the sick and wounded. It is each for itself in the competition of the desert.

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Those that fall by the way feed their cannibal comrades and are soon transformed into empty shells. I will make a few remarks on the senses of locusts, so far as my brief study of the swarm allowed. They seem to be particularly intolerant of cold. When the sun was hidden and the wind was from the north the flow of hopping locusts ceased. The swarm disliked the cold northerly breeze and broke up into separate clusters which sought protection in the lee of the tufts. They again became active on the reappearance of the sun. The clusters emerged from the shelter of the tufts, groups joined with one another, new streams developed, the migrant army reformed its ranks and resumed its original course. Each locust possesses the directive sense. Scattered individuals kept to the line as closely as the compact swarm. From one locust I removed the antennæ, another I enclosed in a tin box which I twisted about in different ways. But neither experiment confused the locusts. When released, they joined the living current and flowed with their fellows in the common stream. Locusts possess a good sense of smell. I killed a few and hid them in a tuft a little to one side of an advancing stream. The migrants soon became aware of the corpses. It was interesting to see how a locust halted when four or five inches from its dead companions. Then, as though perceiving something in the air, it turned sideways out of the current and crept towards the grassy tuft. Of course it was drawn there from cannibal motives, a dead companion being valuable

food. But the wonderful thing was its power of appreciation, for the corpse was completely hidden from view. What can inform it but some sense of smell, some wafting of particles through the air which excite it and draw it from the stream? Moreover this sense must be extremely acute. How can the smell of a freshly killed locust differ very much from one that is alive? Yet this sense is capable of perceiving the difference. It enables the locust at no comparatively short distance to distinguish the dead of its own species from the teeming living that are gathered around.

The swarm seemed particularly immune from enemies. In this it differs from other insect throngs, from the termites that are decimated as they leave the nest, or the may-flies as they dance along the stream. Here there was no destructive army. The roller and the bee-eater were the only birds that showed any inclination to make a feast. Perhaps the barrenness of the desert and its unsuitability for birds helps them to evade attack. For it is not the enemies but the supplies of food that check the unlimited increase of the swarm.

The same thoughts must ever impress the mind at the sight of these moving streams. How immense is the living flow; how powerful is the generative force that has brought these millions into being! How wonderful is the sense which guides the swarm across the trackless waste! I know of nothing in the world of life that can compare with this incalculable host. We think of the stars that stud the heavens or the sands

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on the seashore, but any attempt to conceive the multitude is beyond our finite minds.

These are some of the most striking features which we meet with on the wilderness of sand. It is in these vast and silent solitudes that we come closest to the infinite and the unknown. No narrow straits confine our senses, and our thoughts seem to lead us deeper and further into the heart and springs of life. In the desert waste as on the lofty mountains we are free from all constricting bonds and are face to face with the unfathomable, the unknowable infinitude of things. How easy is it here to perceive infinity! In this unbroken wilderness of sand the infinite lives in every scene. An infinite sky above, an infinite desert around, rivers that seem of infinite length wind through infinite sands, an infinite ocean laps the nearest shore, the very locusts, like the whirling grains of sand, seem infinite in their countless myriads. When we leave the narrow barriers of civilization our minds grow more attuned to Nature and expand in keeping with her endless scene. Here, when confronted with her vastest spectacles, we seem to learn something of her deepest truths. We perceive at least her infinite dominion, her infinite wonder, her infinite beauty, her infinite work, her infinite power.

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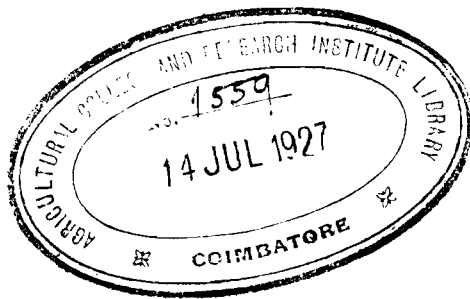
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