MOSQUITOES: THEIR HABITS AND DISTRIBUTION.

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MOSQUITOES:

THEIR HABITS AND DISTRIBUTION.

BY

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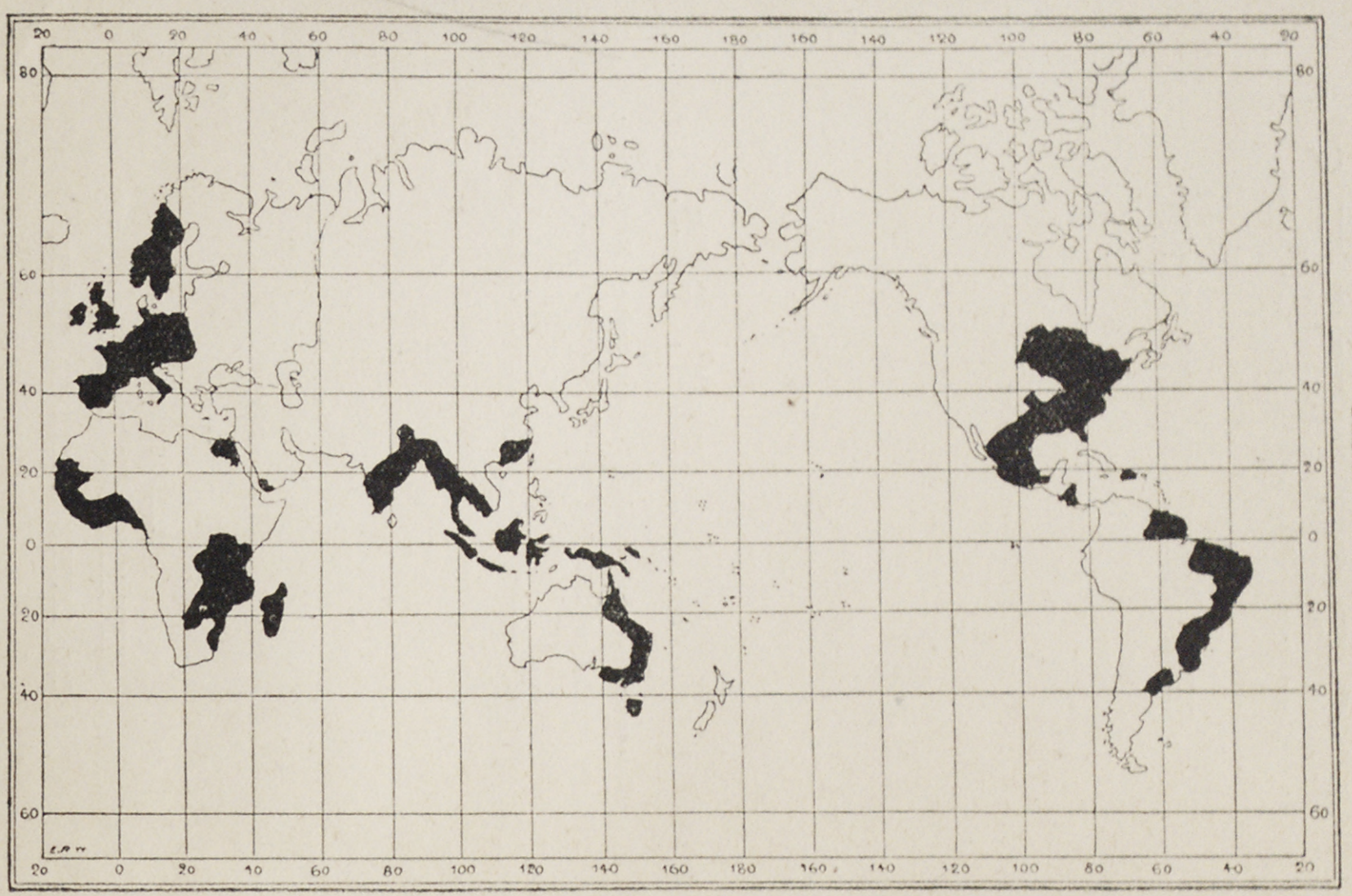

Range of *Anopheles*.

PLATE I.

PREFACE.

AS Nature Study, in its manifold forms, now bulks so largely in the *curriculum* of our public schools, the matter contained in this little volume is published in the hope that it may be of assistance to that body of hard workers, the teachers.

The subject-matter of this paper formed the theme of a "Gallery Demonstration" given by me, in the course of my official duties, to School Teachers some time ago at the Australian Museum. In response to a request for its publication, and by the kind permission of the Trustees of that institution, it is now issued in book form to the public.

In the preparation of this booklet the author has consulted the writings of specialists who have made the Mosquito their principal, if not sole, study, chief amongst whom are: Theobald, author

of "The Culicidæ of the World"; Giles, "Gnats and Mosquitoes"; Felt, "Mosquitoes of New York State," and Skuse's papers on Australian Diptera, in the "Proceedings of the Linnean Society of New South Wales"—all of which are works inaccessible to the ordinary teacher. It is the hope of the author that this little work will induce bush-dwellers to pursue the study of the life-history of our native Culicidæ, for, although many species are known to specialists in the adult form, very little has so far been learned of their earlier stages. In this respect there is ample opportunity for enthusiastic and intelligent workers in each district of every State in the Commonwealth.

W. J. R.

March, 1908.

"The man who cannot stoop to the study of that which is small will never be able to comprehend that which is great."—A. G. BUTLER, in *"Science for All," vol. ii.*

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MOSQUITOES: THEIR HABITS AND DISTRIBUTION.

Introductory.

IN a country like ours, where the climate ranges from tropical to temperate, it is only natural that INSECT LIFE should be both abundant and varied. So far as mosquitoes are concerned Australia is peculiarly rich both in number of species and individuals, hence it follows that the Culicidæ, as a group, is one with which we are all more or less familiar—often painfully so. But, beyond the irritation caused by the buzzing and biting of these tormentors, there are other considerations of such paramount importance as to make the universal study of this family of the DIPTERA imperative, and one of these is their baneful influence upon public health.

Individually, the mosquito is not only one of

the smallest, but also one of the most fragile atoms of the Insect World. If one of these insects be taken between the finger and thumb, the slightest pressure will disable, even if it does not crush it out of all shape.

Collectively, owing to their persistence, spitefulness, and intolerable persecution, these insects command respect—that respect which compels us at certain seasons to adopt measures for our protection.

Historical.

From an historical point of view mosquitoes are venerable. They have a record that goes far back into bygone ages. We do not know whether they were included in the plague of flies recorded in Exodus, but it is not unlikely that they were, for mosquitoes have always been exceedingly common in the land of the Pharaohs. Bearing in mind this fact, it seems curious that there should be no reference to this insect in the Old Testament, and only one in the New—"Ye blind guides, which strain at a *gnat* and swallow a camel." There are, however, plenty of references in ancient history, for many of the old

historians have written about them. It is on record, for instance, that Sapor, King of Persia, was compelled to raise the siege of Nisibis owing to a visitation of these insects, for we are told that myriads of mosquitoes attacked his camp and beasts of burthen, causing the latter to stampede, and so bringing about his defeat. Of course, as was only in keeping with the ancients, this incident was regarded in the light of a miracle, wrought for the salvation of the beleaguered capital of Mygdonia.

Geological.

Putting on one side the question of ancient history, mosquitoes have, in addition, a geological interest. A wingless form has been described from the Purbeckian rocks of England, and this shows that mosquitoes existed as far back as the Secondary Epoch. In Tertiary ambers mosquitoes are fairy plentiful. Species of well-known genera found in these have been recorded both in Europe and America. A form has also been recorded from the Tertiary strata. This latter was collected in Germany.

Popular Names.

In Great Britain these insects are known as *gnats*, but in other parts of the world as *mosquitoes*. The term mosquito is derived from the Spanish *mosca*, a fly. This is also a common Portuguese word. In America, in addition to being known as mosquitoes, these troublesome insects are also called *gallinippers*.

Insects Confused with Mosquitoes.

Besides mosquitoes, the great order DIPTERA includes a number of other insects with which they are often confused. Some of these are the irritating sand-flies. These insects occur in all parts of the world, from Iceland to the tropics. Their mouth parts are as fully developed as those of the mosquito, and many of them are capable of inflicting severe punishment.

Distribution.

No insects are more widely distributed than mosquitoes. It matters not whether it be the tropics, the temperate zone, or the Arctic Circle,

there they are, and they are as intolerable in Greenland and Lapland as they are with us in Australia. Nansen says:—"Greenland is one of the countries of the world which is most visited by this plague." And, again, in his book, "The First Crossing of Greenland," he tells us that—"Whole clouds of these bloodthirsty demons swooped upon my face and hands, the latter being at once covered with what might well have passed for rough woollen gloves."

In Lapland they are a veritable scourge, and the natives are often driven to frenzy by their attacks. In North-West America they occur in vast numbers, and are so ferocious that whole herds of horses and stock stampede, whilst the natives constantly move their habitations and herds, so as to escape the intolerable persecution.

Theobald, in his monumental work, "The Culicidæ of the World," says that—"Judging by accounts given by travellers, I should think the mosquito is a more terrible nuisance in cold regions than in the tropics."

D'Albertis, writing from New Guinea, in 1881, said:—"For some nights we were not able to sleep, owing to mosquitoes and sand-flies. These

small and almost microscopic insects put us to real torture. My people, to defend themselves against their attacks, sleep in an open place, surrounded by great smoky fires." And yet again, from the same country, he wrote:—"Sand-flies and mosquitoes torment us from morning to night."

Such experiences as these are not without parallel in Australia; indeed, some districts are almost uninhabitable for them. Even in temperate climes, in such places as the Alps, South Norway, parts of Italy and Great Britain, mosquitoes at times cause a good deal of suffering. We, here in Australia, especially in the vicinity of swampy and undrained lands, know what a scourge these vicious pests are.

In the Cook's River district, near Sydney, residents suffered bitterly during the months of March and April in 1905 and 1906. The wretched little persecutors invaded dwellings in swarms, and, by their persistent attacks and incessant buzzing, hopelessly wrecked many a good temper.

Of late years, in all parts of the world, collectors and investigators have been busy collecting and studying these insects, and from their labours it is clear that, with the exception of a few oceanic

islands, the Culicidæ are cosmopolitan. But even from these islands, although so far as we know at present immune, records of their presence may yet be forthcoming, for as commerce extends, and ships visit them, they may become acclimatized. Indeed, they may exist now in districts from which we have no records, for it is not improbable that many places have not been properly "collected." It is not wise, therefore, to say that because mosquitoes have not been obtained from a certain district they do not occur there.

To those persons who have not studied the subject it may seem absurd to be told that property in the vicinity of great cities has been rendered valueless owing to the presence of mosquitoes. Yet, nevertheless, it is quite true. Felt, who monographed "The Culicidæ of the State of New York," has shown that such was the case at New York. The expenditure of large sums of money for draining off and breaking up breeding-grounds had to be made by the authorities before the district could be utilized. Coming nearer home, I have it on the authority of a well-known Sydney solicitor that he was once unable to sell some land between Sydney and Parramatta, owing to the

presence of vast hordes of mosquitoes. He was anxious to close an estate, and took up some prospective buyers, but so great were the swarms of these insects, and so vicious their attacks, that it was impossible to do any business. No one would buy.

Some genera of this family have a much more extended range than others. The notorious *Anopheles* (Plate I.) is widely distributed, but the species are most abundant in warm climates. Twelve species occur in India and Malaisia, four in the West Indies, six in West Africa, five or six in Europe, and four in Australia. They are not common in New South Wales or Victoria, but in Queensland and around Port Darwin they are reported as being numerous.*

Mosquitoes may be distributed in several ways. They may be carried from one country to another in ships by means of water tanks and even in cabins. Skuse says they are carried from one locality to another by the agency of railway trains. The former would appear to be a very probable way, else why are some species, such as *Culex pipiens*, *C. fatigans*, and *Stegomyia fasciata*, so

* Since the block was made specimens collected at Port Darwin have been received in Sydney.

widely distributed? The latter method of distribution, although it has been questioned by some authorities, does not appear to me to be without reason.* It is well known that these insects are not capable of maintaining a prolonged flight, and that they seek shelter in windy weather, hence both the agencies referred to above may easily be responsible for extending their range.

Diseases Spread by Mosquitoes.

The chief feature of interest attaching to the species of the genus *Anopheles* is the fact that some of them are now known to be the medium by which malaria is transmitted to man. And not only has it been demonstrated that some species of this genus transmit malaria to man, and from one human being to another, but also that the blood parasites—Hæmamæbidæ—actually undergo part

* This method of distribution is confirmed by Evelyn G. Mitchell in her work "Mosquito Life" (1907):—"A mosquito in Winchester, Va., was as rare as a horse in Venice . . . . until a train of parlour-cars was started on the Baltimore and Ohio railroad to run from Camden station, Baltimore, during the summer. A few years later the insects became a positive annoyance."

of their developement within their bodies. Indeed, so far as man is concerned, without these mosquitoes the Hæmamæbids would be impotent. Hence, no *Anopheles* no malaria.

Experiments have been made with various species of the genus *Culex* in respect of malaria, but it has not yet been found that the human malarial protozoon will develop in any of them. On the other hand, whilst it is now known that certain *Anopheles* are responsible for conveying malaria, it has not yet been proved that all the species of that genus can do so. It is therefore most important that the species in which malarial parasites are known to develop should be accurately determined, and their geographical distribution defined. The mere fact that *Anopheles* occurs in a district is not sufficient—*we must know the species.*

Now, when the distribution of the genus *Anopheles* is carefully studied, it is found, as Theobald points out, to tally very well with the chief centres of malaria. These insects are only found in swampy, marshy localities, and rarely on high lands.

In the Mauritius, wherever malaria is rampant, *Anopheles* is abundant. From parts of South

America, few of these mosquitoes have been collected, but from such fever-stricken districts as the West Coast of Africa, the Malay Peninsula, the West Indies, and British Guiana, *Anopheles* have been collected in numbers.

Wherever these insects abound it has been found that they breed readily in small pools and puddles, which are frequent after rains. In malarial districts serious epidemics have followed rain, the breaking up of soil, and the building of railways. The explanation of this is that the *Anopheles* are afforded opportunities of breeding in larger numbers than usual.

A most interesting fact has been established—that amongst aborigines an enormous percentage appear to contain malarial parasites in their blood, although the disease does not affect them. The intermediary hosts, therefore, have always plenty of opportunity to become infected, and so distribute the disease to the stranger within their gates.

A recent West African traveller attributed his immunity from fever to camping some distance from native quarters, and to other safeguards, such as working under a mosquito curtain. There can be little doubt that, so long as natives have

this fever parasite rife amongst them, Europeans mixing with them, and living near their quarters, will always be subject to infection. It is interesting to note that, although, as pointed out above, natives living in malarial districts, and having the malarial parasite in their blood, do not appear to suffer much, or at all, from fever, their babies and growing children do.

It is not alone malaria that is spread by these insects. Filaria is another disease. This malady causes considerable mortality in tropical and sub-tropical climes. The filarial blood-worm, like the malaria parasite, undergoes important, and—to it—necessary developmental changes in mosquitoes that have ingested human blood containing them. The development of this worm has been found in a species known as *Culex fatigans*. Other mosquitoes, equally common, do not seem to be able to develop this helminth. Elephantiasis is also spread by mosquitoes.

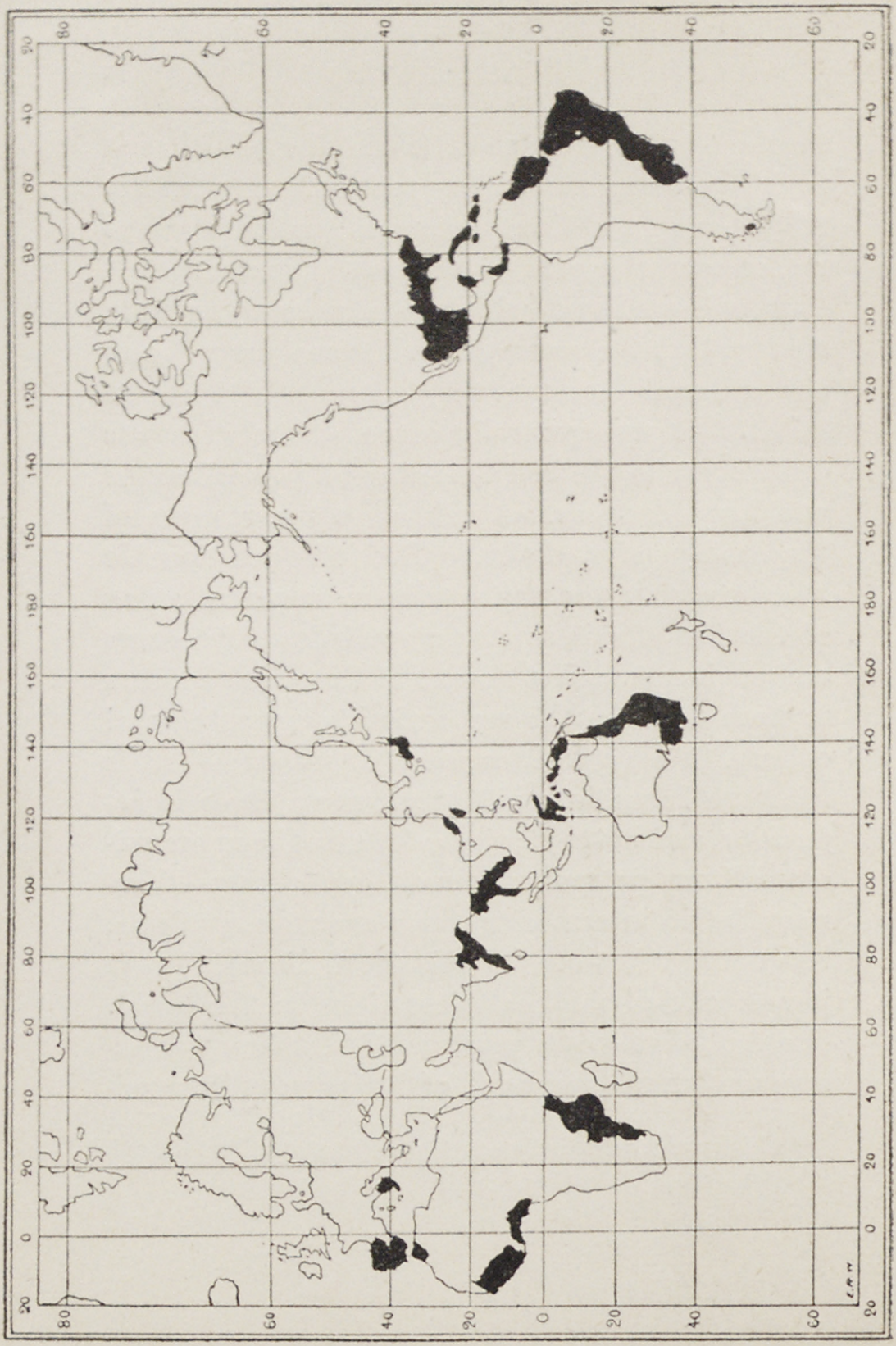
Investigation has, therefore, proved that the depressing malaria and the dreaded filariasis is promoted by certain species of Culicidæ. But, in addition to these, the deadly yellow fever must also be cited, and in connection with this the Tiger Mosquito, *Stegomyia fasciata*, has been proved to

be the agent by which it is distributed—that it is, in fact, the host of the yellow fever parasite. A glance at the chart (Plate II.) will show the reader how widely this insect is distributed.*

It will be well within the memory of my readers that the attempt made some years ago to cut a canal through the Isthmus of Panama failed. It was generally conceded that this was due largely to the bad financing of M. de Lesseps and his colleagues, as well as to the ravages of the deadly yellow fever. But it is questionable whether the latter was not the more potent agent of the two, for it simply mowed down labourers and engineers. Yet no one at that time appears to have fastened the responsibility upon the real culprit, the Tiger Mosquito, *S. fasciata*—for it must be borne in mind that yellow fever is *infectious*, and not *contagious*; it cannot be communicated from person to person by contact—there must be an intermediary. Havannah, in Cuba, was another hot-bed for this dread disease, but it is now one of the healthiest cities in the world. For forty-five years prior to 1901 there was an average annual death-roll of 730 persons from yel-

* This species has also been collected from the Port Darwin district since the block was made.

PLATE II.



Range of *Stegomyia fasciata*.

low fever alone, but as a result of the breaking up of breeding-grounds by levelling and draining, this fearful mortality was reduced to eighteen persons in 1901, and in 1902 so thoroughly had the work been done that not a single death was recorded. The Americans, taking this lesson to heart, applied themselves to the task of stamping out *Stegomyia* from the Isthmus of Panama, and as a result yellow fever has disappeared from that region. As a result of this achievement, we may now look forward confidently to, in the not far distant future, the uniting of the Pacific and Atlantic by the long-promised canal. In America it was at one time a popular belief that yellow fever had been introduced with and by the importation of slaves, notwithstanding the fact that the latter were comparatively immune. In 1881 Dr. Chas. Findlay noted that in Havannah the mosquito season and yellow fever were synonymous, and it was he who first suggested what is now proved to be the source of all the trouble.

Two or three years ago, during the latter part of the summer and the autumn months, a serious epidemic of dengue fever occurred in Queensland, and this, too, was believed—as is most probable—

to have been spread by *Culex fatigans* and *Stegomyia fasciata*.

Now, all the mosquitoes responsible for the various ills I have mentioned are found in Australia. So far as malaria and filariasis are concerned, both occur in tropical Queensland, but yellow fever is altogether unknown on our continent. Malaria may possibly occur at times within our temperate zone, but we have little to fear, I think, from filariasis and yellow fever. Nevertheless we cannot afford to treat our local forms of mosquito as negligible, for they may have a greater influence upon us than we think. It is owing to the important part played by these insects in the spreading of disease that they have been so systematically studied of late years; and, as a result of scientific and intellectual activity of many men in many lands, more has been written about mosquitoes than any other group of insects. I feel confident that, notwithstanding the great achievements of these earnest and able men, we are as yet only upon the borderland of a vast domain of knowledge of what is styled for convenience "tropical medicine," and that as the decades of the twentieth century pass by we shall learn prodigious lessons fraught with

the greatest import to the human family. But a few years ago the conquest of yellow fever areas was considered an impossibility; to-day Havannah and the Isthmus of Panama stand forth to the world as examples of what can be done, and as incentives for further efforts, the results of which will probably be to give to settlement and economic uses vast tracts of land now regarded as uninhabitable.*

Passing from human beings to the lower animals, we learn that the latter are also subject to certain specific ailments that can only be transmitted by the agency of the active and aggressive mosquito; but it is curious and interesting to note that the form of malaria from which human beings suffer cannot be transmitted to the lower animals, nor can the form peculiar to the latter be transmitted to man.

I think I have dwelt long enough upon this side of the question of mosquito life; nevertheless it

* "Mosquitoes also come under the accusation of conveying that most loathsome disease, leprosy. As leprosy is due to bacteria, it follows that any mosquito might carry the infection under the proper conditions. Other biting insects, as fleas and bed-bugs, also fall under a ban in this respect."—E. G. Mitchell, "Mosquito Life," p. 119 and Appendix.

is necessary that the facts I have detailed should be more generally known than they are at present. It is also important that we should not only know what species are innocuous, but also, should they occur in a district, that they be accurately determined. This latter lies within the province of the Entomologist.

The Mosquito: its Structure.

Mosquitoes belong to the great order Diptera, or two-winged insects. In addition to the wings there are present two other lateral organs known as *halteres*, or balancers, the function of which is not known, but they are regarded by many as atrophied wings (fig. 1). Included in the order are a few degraded forms entirely devoid of wings, such as, for instance, the irritating flea and the so-called sheep-tick. These latter are wholly parasitic.

Like all insects, a mosquito's body is divided into three main parts: the head, thorax, and abdomen. Each of these is again separable into minor, though albeit important, functional parts. Thus, the head is provided with sensory and masticatory organs, such as the eyes, antennæ, and

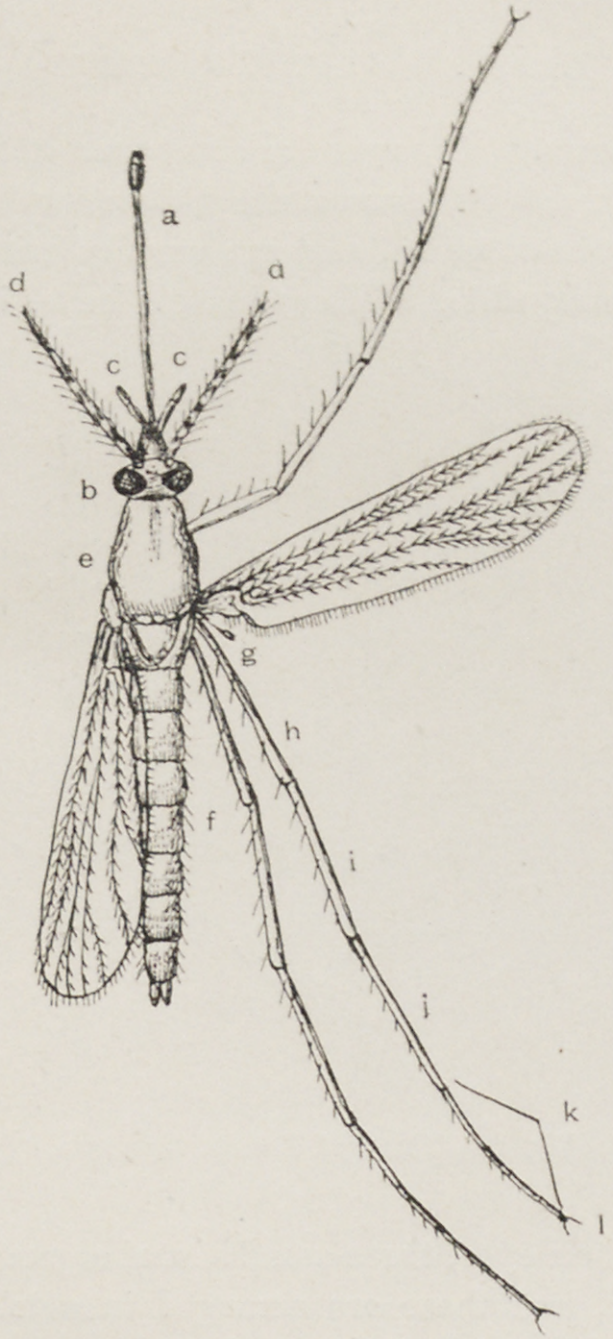


Fig. 1.—Adult Female Mosquito: a, beak; b, head; c, palpi; d, antennæ; e, thorax; f, abdomen; g, haltere or balancer; h, femur; i, tibia; j, metatarsus; k, tarsus; l, tarsal claws.

mouth parts. The eyes are compound or faceted, usually reniform, surrounding more or less the base of the antennæ, and are usually brilliant in colour during life. Many insects have, in addi-

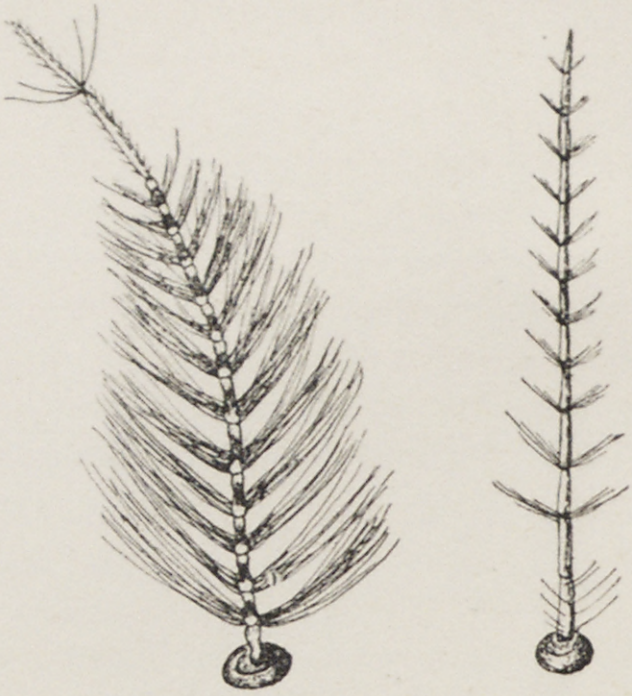


Fig. 2.—Male and Female Antennæ.

tion to their eyes, three small visual organs known as ocelli, and these are arranged in a triangular form at the vertex of the head, and occupy a position midway between the eyes. If you look at a

Cicada you will see them quite distinctly. Ocelli have never been detected in mosquitoes.

The antennæ arise from the front. The basal joint is large, and may or may not be clothed with scales. In the female the antennæ are made up of fourteen joints, and are furnished with moderately thick, verticillate hairs. In the male the bases of the joints are more oval and swollen, and the hairs with which they are clothed dense and long; hence, we speak of them as being plumose (fig. 2).

The mouth of a mosquito consists of a distinct proboscis, composed of an upper lip and epipharynx; two lance-like pieces known as mandibles; two other needle-like organs, barbed at their summits; the maxillæ; a thin tubular thread, the so-called hypopharynx; and finally the lower lip. The hypopharynx is connected with a poison-gland. The mouth-parts are fairly consistent throughout the entire family, and so afford little assistance as an aid in the determination of the species (fig. 3).

The thorax, as in all insects, is divided into three parts: the pro-thorax, meso-thorax, and meta-thorax. The meso-thorax is much the largest of these, and in fact forms the chief region

of the mid-body. The thorax carries the necessary organs of locomotion—the wings and legs—

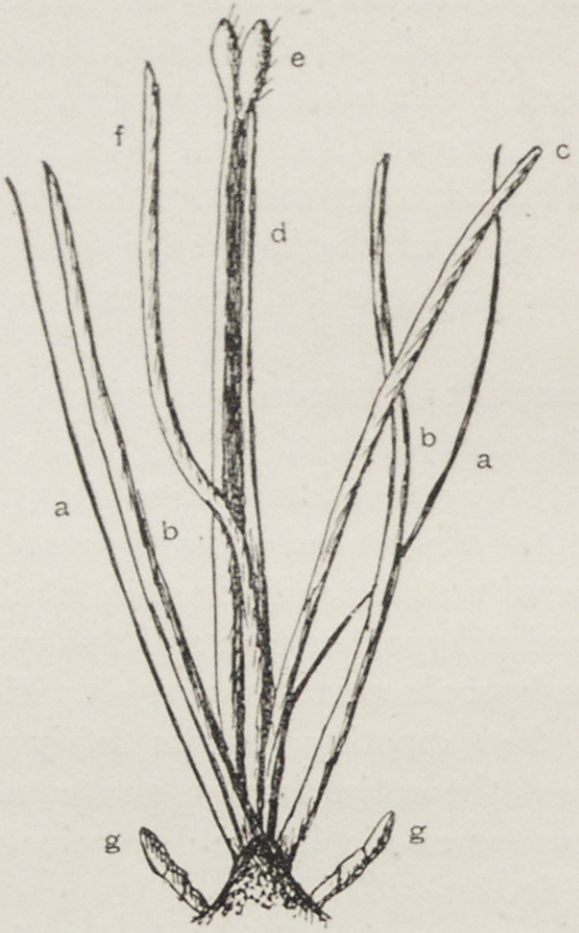


Fig. 3. — Mouth-parts: a, a, maxillæ; b, b, mandibles; c, upper lip and epipharynx; d, lower lip; e, labella; f, hypopharynx; g, palpi.

and in connection with these there are powerful muscles.

The abdomen is long and slender, and more pilose in the male than the female; it consists of nine segments, each of which is provided with two breathing tubes or spiracles—one on each side.

The wings have the veins clothed with scales, which vary in different genera. The halteres have the knob mostly cup-shaped and scaled.

The legs are long and frequently present important specific characters.

Scales.

The body of a mosquito, like that of a butterfly, is clothed with scales. It is these which give the insect its predominant hue. But the scales are of various shapes; those upon the wings being different to those upon the body, and those upon the latter differing again from the leg scales. In the determination of both genera and species the scales are often of the highest importance; hence, in making a collection specimens should be handled with the greatest care. Microscopically they are beautiful objects. Some mosquitoes are

of a dull tint, others are clothed with metallic scales, and some are beautifully iridescent.

Fig. 4.—Scales (after Theobald).

Ova.

From what little we know concerning the ova of mosquitoes, it appears that each genus has not only differently formed eggs, but often a different manner in depositing them. In the typical genus

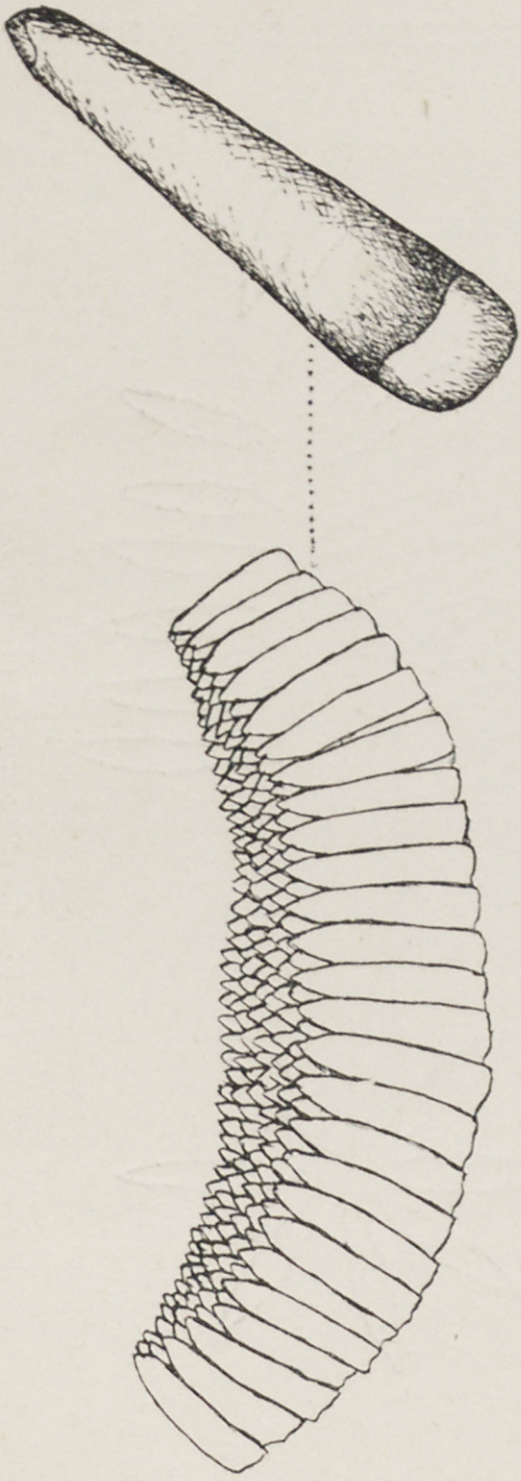


Fig. 5.—Egg-raft and Egg of *Culex fatigans*.

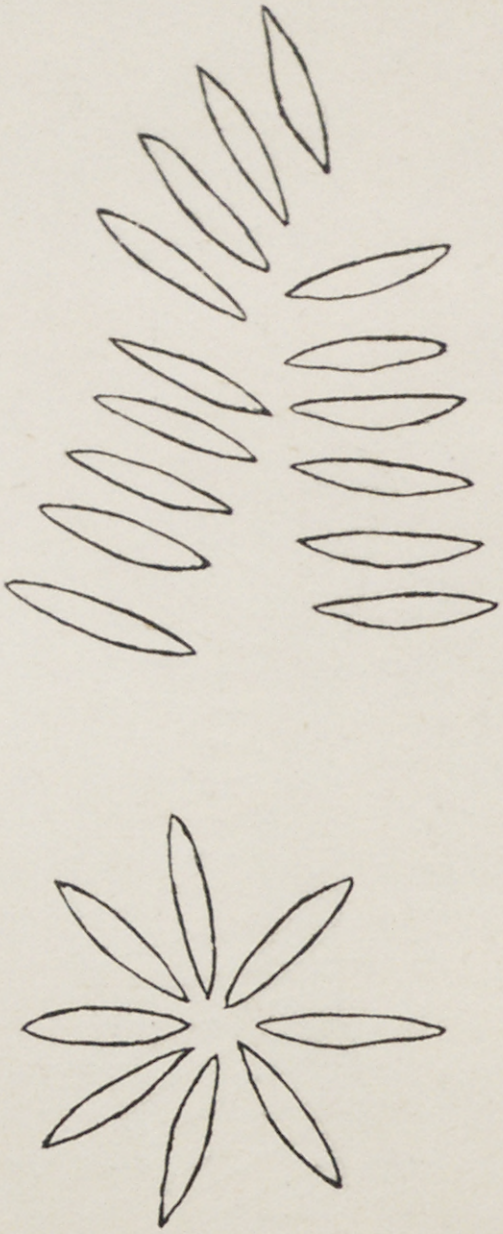


Fig. 6.—Egg-groups of *Anopheles*.

Culex (fig. 5) they are almost invariably laid on the surface of the water in boat-shaped masses; but others are deposited singly, as in the genus *Anopheles* (fig. 6) and cohere by their ends, sometimes forming stellate masses. The ova of some species adhere to floating objects.

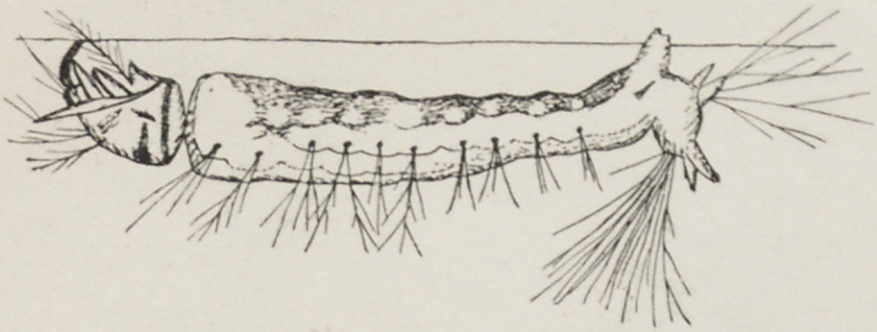


Fig. 7.—Larva of *Anopheles*.

Larvæ.

Passing from the egg-stage we come next to the larvæ, and here again we find as much variety in structure as exists in the adults of the different genera. In fact, it is this variety that lends such a charm to the study.

Speaking generally, one may say that at this stage the head, though large, is much smaller than the thorax; the abdomen is long and narrow,

and consists of nine segments. On each side of the head there is a large, dark eye; the antennæ arise from processes near the eyes, and are short,

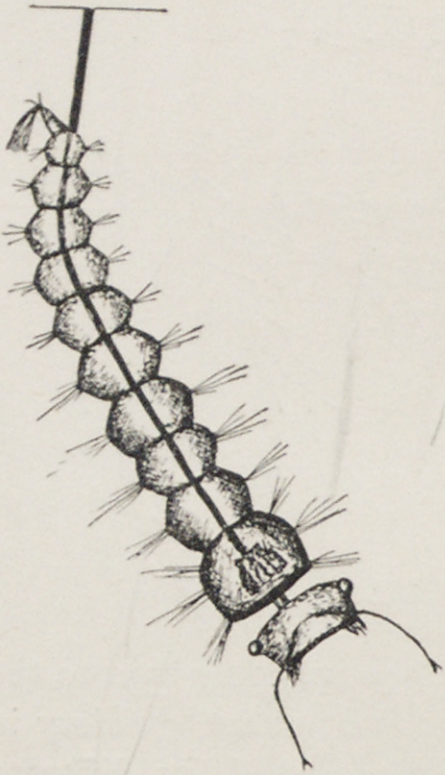


Fig. 8.—Larva of *Culex*.

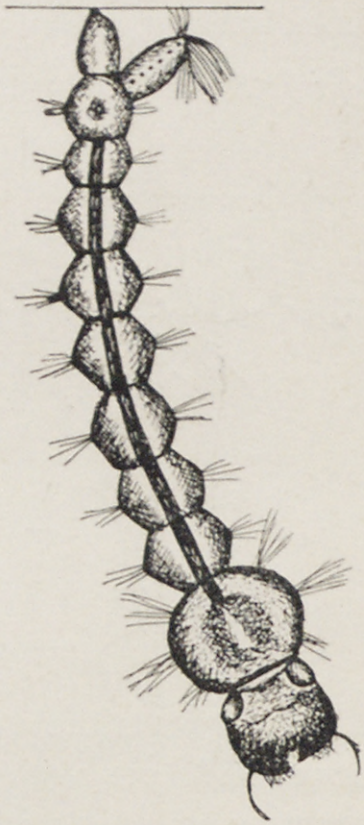


Fig. 9.—Larva of *Stegomyia*.

stubby-looking organs. From the eighth abdominal segment there arises on the dorsal surface a tube—the respiratory siphon, the end of which

is provided with valves and guarded openings. In *Anopheles* (fig. 7) and *Stegomyia* (fig. 9) it is short, but in *Culex* (fig. 8) it is long.

Fig. 10.—Pupa of *Anopheles*.

Pupæ.

The pupa is an extraordinary looking creature, with an enormous head and thorax. In the larval

stage, as we have seen, the breathing organs were attached to the tail, but now we find them attached to the head, and also that there are two instead of one, and that they are situated later-

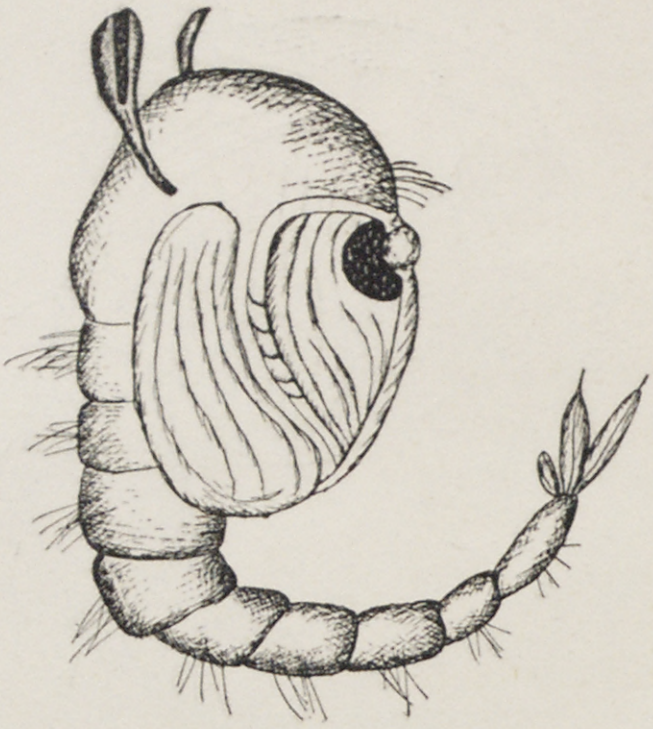


Fig. 11.—Pupa of *Culex*.

ally. From the ninth abdominal segment two caudal fins extend. As with ova and larvæ, so with pupæ, we find great variation in the different genera. Note the difference in figs. 10 and 11.

Culicid pupæ, contrary to those of other insects, are exceedingly active.

Breeding-Grounds.

Our knowledge of the habits of Culicid larvæ is very incomplete, but, as far as we know, they are all aquatic, and the majority are to be found in fresh water. Some species, however, breed freely in salt water. We know of at least three that do so in Australia. Larvæ are to be found in a variety of situations—still waters, salt and fresh water marshes, temporary pools or puddles, such as occur after rain, cesspools, and brackish waters. None care for deep waters, nor for running streams, though gently-flowing waters often contain them. Some species seem to prefer water free from vegetation, whilst others thrive better where there is a good growth of algæ. For some species shady situations are best, but others, such as *Anopheles*, prefer pools exposed to the rays of the sun, a fair amount of light being essential to their well-being. Water flowing at the rate of 1,900 yards per hour is free from mosquito life in any form.

Habits and Food of Larvæ.

The habits and food of larvæ vary in different genera. The larvæ of *Culex* and *Stegomyia*, when undisturbed, float on the surface of the water head downwards; but when disturbed wriggle immediately to the bottom. *Anopheles* larvæ occur mostly in shallow puddles, small ponds, slow and small runnels of water, rock pools, and the margins of sluggish streams; they float on the surface of the water like sticks, and progress by a peculiar backward skating movement. Some of these "wrigglers," as Culicid larvæ are popularly termed, are of carnivorous habits, whilst others are vegetable feeders.

Length of Egg, Larval, and Pupal Stages.

In all groups of insects, the period of egg, larval, and pupal life varies, and in this respect the Culicidæ offer no exception. In the typical genus, *Culex*, some species have hatched out in about twelve hours after oviposition, and others in about twenty hours. The shorter period was, of course, in warm weather, and under favourable

conditions. In cool weather the period of incubation is naturally much longer.

Some species exist in the larval stage from two to four weeks; others from a week to ten days. One writer has stated a period of three days as the larval life of a species of *Anopheles*, but this was doubtless an error. Conditions, such as warmth and abundance of food, undoubtedly induce early pupation, whilst the lack of both or of one of these will retard it. During its larval existence, each "wriggler" moults, or casts its skin, three times. Broods of larvæ live through the winter, but during that season grow very slowly.

Habits of Adult Mosquitoes.

Not only are mosquitoes numerous in point of numbers and species, but they are also exceedingly diverse in habits, and certain forms show great partiality for certain localities.

The more brilliant and iridescent forms are included in the genera *Megarrhinus* and *Toxorhynchites*, and these are found almost exclusively in tropical jungles. In such localities, wherever man has taken up his abode, they have proved ex-

ceedingly annoying. One species, formerly recorded as pertaining to the genus *Megarrhinus*, but now transferred to *Toxorhynchites*, occurs in Queensland. Other forms may yet be found to occur there.

Anopheles is much more widely distributed (see Plate I.) These insects chiefly inhabit swampy regions, and the neighbourhood of human dwellings; they prefer noisome situations, and are rarely found on high lands. They are usually very local, and are naturally most numerous where they can feed easily and breed freely. Many people think that mosquitoes can be blown into new or different localities by strong winds, and it has been asserted that *Anopheles* are so distributed, but this is a popular error.

In point of species and individuals *Culex* is the most numerous genus of the family Culicidæ. It is to this genus that those forms that so persistently invade our homes belong. One in particular, *Culex fatigans*, is common around Sydney. It is small, but active; musical and aggressive—even vicious. In habits it is gregarious, and far and away more domestic than any of the preceding genus. It is after nightfall that it makes itself so objectionable. And who does not know

its pipe and tune? And who has not at some time suffered by its sanguinary attentions? In one respect it is like the rain, falling "upon the just and the unjust." None of the Culicidæ are really fond of high situations, though they may occasionally be found in such places. When they occur in the upper rooms of high buildings, such as some of our leading hotels, it is almost invariably found that they have been transported thither by the agency of the lift.

Resting.

In respect of the manner in which certain mosquitoes rest, a peculiar habit has been noted, and one which will enable an observer to decide at a glance whether the insect that has settled in front of him is an *Anopheles* or not. Having alighted upon a horizontal surface—such as a table, for instance—the *Anopheles* usually poise their body so that the beak or rostrum points directly to or touches the surface upon which it chances to be standing. The body of the insect is usually elevated in a perpendicular position (fig. 12), and sometimes it is held at an oblique angle. *Culex* (fig. 13), on the other hand, assumes a hori-

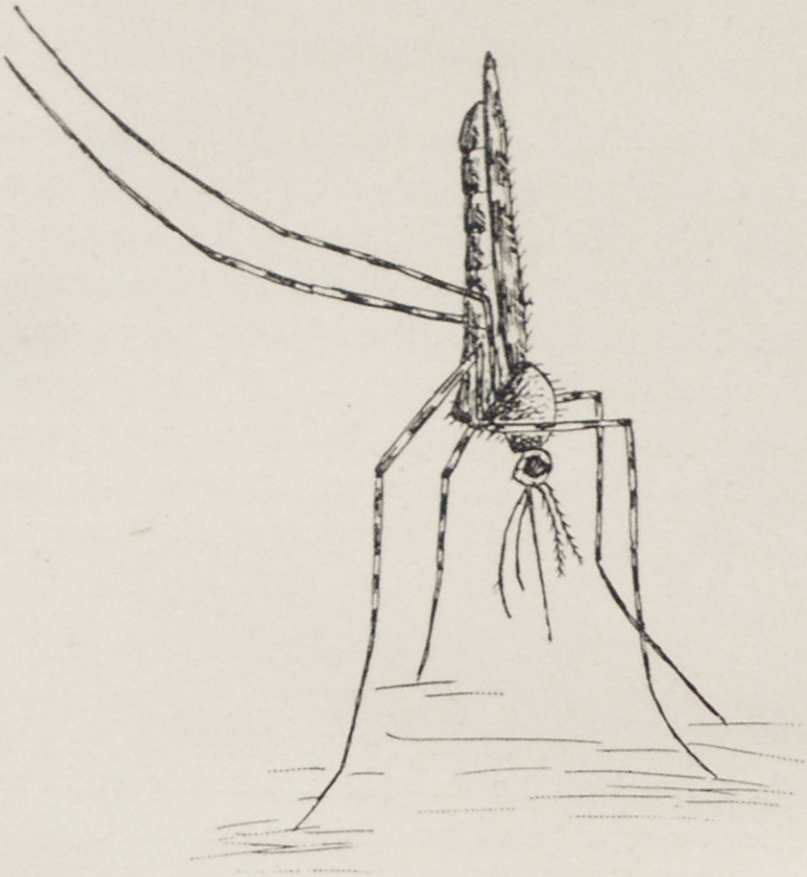


Fig. 12.—*Anopheles* resting.

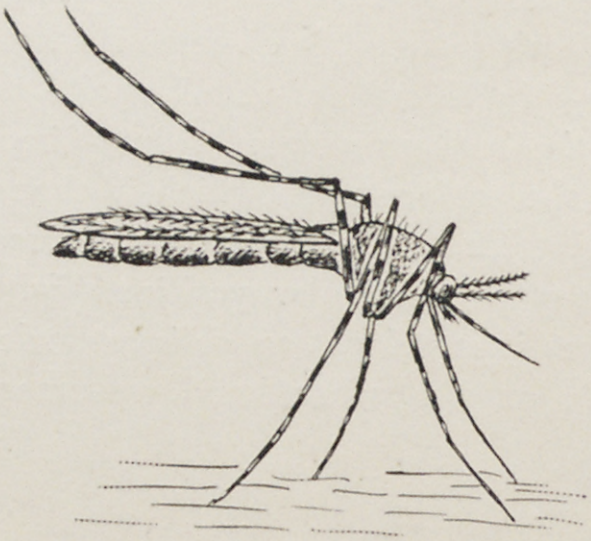


Fig. 13.—*Culex* resting.

zontal position, as do, also, the species of other genera.

Haunts and Colour.

Many species of *Culex* are almost exclusive house-dwellers in the adult stage, but others never enter habitations. Where the former occur, and make their presence felt as is their wont, the breeding-grounds will be found close at hand. The house-visitants usually rest during the day-time in all sorts of nooks and corners and out-of-the-way places, under tables and chairs, and behind books stacked on open shelves—in fact, wherever it is dark. They are also fond of lurking within the folds of draperies or garments hanging upon walls or in wardrobes. It is interesting, too, to notice how they discriminate between black and white fabrics. The former proves a great attraction to them, but they do not seem to appreciate the latter. I have tested this in my own home during the mosquito season by hanging dark and white garments side by side. From the former I have taken as many as twenty specimens, and from the latter only three or four, and even these from amongst the folds. I have repeated this simple experiment at various times,

and although the number of specimens collected varied, the relative proportions were always much the same. The explanation of this is that dark fabrics afford protection. Mosquitoes are often found during the day-time lurking amongst bed-hangings, such as mosquito-curtains, but then it is almost invariably between the folds, that screen them from the light. It has been found that dark blue, red, scarlet, black, slate-grey, olive-green, violet, and pearl-grey are each more or less attractive, that white is objectionable to them, and yellow positively distasteful. From this it would seem that yellow bed-hangings are superior to white.

The free-flying or arboreal species—by which term is meant those living entirely in the open, and which never or rarely enter dwellings—invariably rest upon or amongst bushes, or in forest depths.

Mosquitoes and Weather.

Mosquitoes, like most insects, are affected by climatic changes. Warm, humid weather suits them admirably, and calls them forth in numbers, but a cold snap or strong winds will send them

under cover, and keep them there. Severe and long-continued frosts may destroy some "wrigglers," but if it does so it can be only very few, since upon the approach of warm weather adults appear in myriads. This is proved by the discomfort experienced by those living within or near the Arctic Circle during the short Arctic summer. In Alaska they mercilessly persecuted travellers during the rush to the Klondyke. Damp, humid localities, such as New Guinea, Northern Queensland, and the Gold Coast, West Africa, are admirably adapted to mosquito-breeding.

Mosquitoes During Winter.

In tropical and sub-tropical climates mosquitoes breed all the year round, with periods of rest, however, during the spring and summer months. Arctic mosquitoes are, naturally, active for a much shorter period.

Many adults hibernate during winter in such sheltered and congenial positions as afford them the necessary warmth and protection. In such secluded corners the colder months are passed in a more or less torpid condition. Some species

appear able to withstand the rigours of very low temperatures. Hofman saw mosquitoes in the Western Urals in June, before the snow had commenced to thaw, and Mr. Moreau collected mosquitoes from the snow at Antonio, near Rydal, New South Wales. It may, however, be accepted as an established fact that mosquitoes normally hibernate during winter in temperate and Arctic regions, and that even in tropical and sub-tropical climates they pass a period in a semi-dormant state, when conditions for breeding are unfavourable.

Where waters are comparatively warm, larvæ may be found at all times of the year. Some "wrigglers" are capable of surviving climatic conditions that are fatal to adults.

Mosquitoes and their Food.

Prior to the time when it had become an established fact that certain species were responsible for the propagation of diseases, mosquitoes were not taken seriously; their only claim to attention was their persistent and irritating habits. There are some species that do not bite, and it is owing

to this that they are only known to naturalists. None of these are at present known to occur in Australia, and I merely mention it here as an interesting fact, and as a link in the chain of evidence that originally mosquitoes undoubtedly subsisted entirely upon vegetable fluids. Indeed, many millions of mosquitoes are born every year, perform their allotted functions in life, and pass out of existence without ever having a chance to taste the blood of any mammal. The habit of blood-sucking has been acquired through ages, and in acquiring it the mouth-parts have undergone considerable modifications. It follows, therefore, that of those best known to man their thirst for blood is proverbial. For experimental purposes mosquitoes may be kept for a long time in captivity if fed upon bananas. For this purpose the fruit should be sliced and perfectly fresh.

Biting: Allegations against Male Mosquitoes.

For a long time it has been a generally accepted fact that the female mosquito is alone responsible for biting and blood-sucking, but it now appears that the males of a few species, at any rate, are

guilty of the annoying and distressing habit. Our great Australian authority on mosquitoes, the late Mr. F. A. A. Skuse, was evidently unaware that such a habit had been acquired, for in a popular paper he said, with brutal bluntness—"The female mosquito, like the rest of her sex, does not only all the buzzing, but all the biting." Dr. Ronald Ross, author of "Mosquito Brigades and How to Organize Them," who has studied the habits of these insects in connection with the Liverpool School of Tropical Medicine in West Africa, writes:—"As a rule it is only the females which feed on blood." And, again, Major G. M. Giles, M.B., of the Indian Medical Service, in his work, "Gnats and Mosquitoes" (p. 94), says:—"The usually harmless male mosquitoes can be distinguished from the females (which in the majority of species alone suck blood)." Further, Ficalbi has recorded the fact that the males of a few species certainly do bite and suck blood. These recorded observations are certainly significant, for they show that the mouth-parts in the males of some species, like those of the females, have become modified, in the process of evolution, to enable them to obtain nourishment by sucking the blood of birds and

mammals, including man. And if the males of some species have acquired this objectionable habit, may not others in the course of time do so? It is interesting to note that *Stegomyia fasciata*, a form occurring in Australia, is alleged to be one of those in which the males have acquired the biting habit, but it does not appear to have been noticed here. If such a practice has been observed it has certainly not been recorded.

I would urge upon readers, into whose hands this booklet may fall, to carefully observe the habits of our native species, and to record any peculiarities that may come under their notice. By doing so, much useful information will be gained. Indeed, under a careful and intelligent teacher, this is a branch of Nature Study that might advantageously be carried out in some of our country schools.

Swarms of Mosquitoes.

Occasionally immense swarms of mosquitoes occur, and such occurrences have been noted both in this country, in New Zealand, and in England. So dense have they been upon occasions that the air was darkened by them. They have been

observed flying in compact masses, moving up and down in a wave-like motion ten or twelve feet from the ground, whilst the noise produced could be heard a considerable distance away.

On 24th October, 1906, a cloud of mosquitoes passed over Port Phillip. While the s.s. *Bombala* was lying alongside the wharf at Melbourne, and was being painted, millions of these insects closed over the steamer, and for a minute or two darkened the atmosphere, thousands of the insects being caught in the wet green paint. The *Bombala* reached Sydney a couple of days afterwards, with the insects still attached to her side, and was visited by many who were curious to see the extraordinary sight.

It was recorded in a number of *The Entomologists' Monthly Magazine* that in New Zealand "a train passed through a wall of mosquitoes twenty feet high and eighteen inches thick." Again, Romolo Gessi Pascha, in his book, "Seven Years in the Soudan," speaks of "myriads of mosquitoes which obscured the air." The cause of these phenomena is unknown, but it is interesting to note that on the occasions of the occurrence of these great swarms males predominated.

Natural Enemies.

All insects—including mosquitoes—have natural enemies, but it is only occasionally that a predatory animal is able to stamp out, or reduce to a minimum, any species that is inimical to our comfort or welfare. Still, they are of value, as they assist in maintaining an equable balance in the economy of nature.

Mosquitoes have many enemies, but few are of importance or real value—if regarded singly—as a check upon their numbers. Amongst the most valuable, fish certainly occupy pride of place. Some of the latter, such as Carp, Minnows, and the like, devour quantities of eggs, larvæ, and pupæ. The common Gold Fish is one of these, and in some parts of India they are kept as much for this reason as for their beauty. In country districts Carp might certainly, with advantage, be introduced into tanks, wells, or waterholes near human habitations. Of course, these fish have their natural enemies, and amongst them are eels.

Quite recently we have heard a great deal about that pretty little Australian fish the "Blue-eye" (*Pseudomugil signifer*, Kner), and the enormous

number of mosquito larvæ and pupæ it devours. That it does so is quite true. But the discovery is not a new one. My old friend and colleague, Mr. Edgar R. Waite, noted the fact some years ago, when he established his splendid private aquarium at Mosman, Sydney. He not only used to collect, but he even bred the larvæ in order that he might feed them to his "Blue-eyes." I doubt not but that others who kept fish were cognizant of the fact before his time, for he never claimed it as a "discovery." The fact that certain fishes did subsist upon them was too obvious. In fact, they are an ideal fish food. The argument I have raised that a natural enemy is unable to wholly cope with a pest is borne out by this fish. Vast schools of Blue-eyes have sported in the waters of Cook's River, New South Wales, doubtless for ages, yet mosquitoes exist in millions upon its banks. It is certainly an interesting experiment, the transporting of this species of fish to the mosquito-ridden districts around Rome, and one that will be watched with much interest by those engaged in pisciculture, but I doubt whether any benefits will accrue. At any rate, time will tell.

Numbers of small birds devour mosquitoes

amongst other insects that constitute their food. Dragon-flies destroy a great number, and many are ensnared in spiders' webs. The larvæ of some aquatic insects have also been cited as feeding upon Culicid larvæ. But most of these, although distinctly carnivorous and insectivorous, are of little value as a check upon mosquitoes, owing to the fact that they roam about the bottoms of pools, whilst the "wrigglers" and pupæ are continuously rising up and down, and keep, in fact, invariably near the surface, so as to have access to the air. Moreover, the former are usually the inhabitants of deep waters, owing to the permanency of the latter, whilst mosquitoes prefer shallows and marshes for their breeding-grounds, and utilize to an enormous extent such puddles as occur after rain. Amongst the reeds and weeds that fringe water-holes and rivers there are usually numbers of mosquito larvæ.

Another point to bear in mind is that mosquitoes, in common with all animals, are liable to disease, and doubtless many species have their ranks decimated by this agency. A form of the deadly entomogenous fungi often attacks them in an epidemic form.

Methods of Control.

It is quite right and proper that we should protect and encourage all those predatory creatures which, by destroying these insects in the egg, larval, pupal, or adult stage, materially contribute to our comfort. But if we are really anxious to control the pest, and bring it into subjection, we must not be content to let the matter rest solely with natural enemies—*we must help ourselves.*

For a long time it was considered an impossibility to do more than exclude them from our habitations, by the aid of gauze screens to our doors and windows, and so the little wretches were to a certain extent tolerated. Abating such a nuisance appears at first sight a herculean, if not impossible, task; but it can and has been done.

Notwithstanding the fact that it has been proved beyond cavil that mosquitoes are the purveyors of disease, and that by common-sense methods of controlling them these diseases may be considerably mitigated, if not stamped out, there are nevertheless cranks openly hostile to every honest endeavour. These people frequently air their absurd views in the public press. Some have

urged that, in order to stamp out mosquitoes, and prevent them from breeding, it is necessary to *kill every female*! They fail to grasp the question of larvæ. Others, owing to misconception, have ridiculed the question, because they supposed it was intended to endeavour to exterminate mosquitoes in whole continents—a feat humanly impossible. But the most ridiculous of all was that urged by a correspondent in an English newspaper. This good man maintained that it was *wicked* to even suggest stamping the pest out, because "God had sent them here in order to punish us for our sins!" Oh! the cheerful soul! It never occurred to him that the pest is often present as a result of sanitary neglect—the direct result of stagnant pools and loathsome marshes; nor did it occur to him, either, that allowing these latter to continue, and so spread disease and death, was culpably wicked. Often, where mosquitoes occur, people are undoubtedly punished by them for their sins, but they are the sins of ignorance, stupidity, and neglect. Some writers to the press have maintained that the carrying of disease by these insects had not been established, and that it was merely an opinion—a fetish—of some medical men, and "what *do they* know?"

Yes, indeed; what *do* they know? There are people, as Dr. Ronald Ross points out, who will argue every point with their medical man, but who would, nevertheless, conscientiously refrain from doing so with their engineer or lawyer. The two latter may know what they are talking about; but, *doctors!*

There are two important phases in this problem of mosquito control: first, the destruction of the insects that enter our houses; and, secondly, and by far the most important, the annihilation of the swarms of larvæ that breed in fresh and salt-water marshes and pools.

To successfully combat these insects, *we must fight them through their larvæ*, by abolishing, as far as possible, their breeding-places. Marshes, swamps, and stagnant pools should be drained off; where there are large sheets of water, the surface could be treated with kerosene, or any oil, in fact, that will spread and form a film. Crude petroleum will last longer than the refined, but in order to insure it spreading it should be applied with some force. Merely pouring it on is not sufficient. Oil on the water's surface is fatal to "wrigglers" and pupæ. A little kerosene poured into tanks containing drinking water will not harm

the latter if it be drawn off, as it usually is, from the bottom by means of a tap.

Where mosquitoes abound it is wise to carefully screen windows and doors of dwellings, so as to preclude as far as possible, the entrance of these insects; and this if for no other reason than adding to the comfort of the inmates. We may not have much to fear in our temperate zone, so far as tropical diseases are concerned, but our personal comfort deserves some consideration. On the other hand, our tropical and sub-tropical zones are an important question to us in respect of mosquitoes and tropical diseases; and we must also bear in mind that the completion of the Panama Canal, now within sight, will bring the yellow fever areas much closer to Australia than ever.

In our dwellings mosquitoes may be checked by burning pyrethrum powder, which should be moistened, formed into cones, and dried in an oven. If the cones be lighted at the tips, they will smoulder slowly, and give off a not unpleasant odour. Sprinkling oil of citronella or spike lavender will be found very beneficial.

It must be urged that these methods of fighting mosquitoes and their larvæ must not be spasmodic or panic-like: *the work must be continuous.*

Once breeding-grounds are broken up, they should not be allowed to re-form, and the authorities should have power to punish individuals who by carelessness or neglect allow them to do so.

Rather more than 300 species of this family have been described from different parts of the globe, and of these about thirty-five are known to occur in Australia.

As the study of the life-histories and habits of this group of insects is of such importance from a public health point of view, I give a few simple directions as to the forming and management of collections. There are numbers of educated and intelligent men dwelling in the wilds of the Australian bush whose help would be most useful. As they must, naturally, be more or less interested in this question, they may, perhaps, by reading this booklet, be induced to give it some study and attention in their leisure hours. School teachers will be doing good work by training their pupils to observe and make notes.

In conclusion, I may state that I shall be glad to receive specimens from all parts of Australia, and to give such information as may lie within my power.

HINTS ON COLLECTING AND BREEDING.

Mosquitoes may be collected by slipping over them as they rest a small wide-mouthed killing-bottle. For this purpose those vended by dealers are altogether too large. Take a phial about 3½ inches high and 2 inches wide, fitted with a well-fitting cork or a metal screw top. If the latter be selected remove the disc of cork within the metal cap, and substitute one of thick rubber. The latter may be secured in position by means of ordinary bicycle tyre repairing cement. Next mix equal bulks of coarsely-powdered cyanide of potassium and dry plaster of Paris, and put a depth of three-quarters of an inch in the bottom of the bottle; dust over this a little dry plaster, and then pour over all to about half-an-inch in depth plaster that has been mixed with water to about the consistency of cream. When this is set the bottle is ready for use. Such a bottle enables the collector to take specimens without injury. If a

mosquito is caught by using a net, the bottle should be slipped over the insect, but care must be taken not to handle it, because irreparable damage to the specimen would result. Mosquitoes should not be allowed to remain in the killing-bottle for more than a minute and a half, or they will become too stiff to be conveniently set. They should be pinned instantly upon being withdrawn from the bottle. Upon no account use chloroform for killing, as specimens so treated quickly revive.

Where mosquitoes are active a net will prove a useful implement. It should be attached to a wire ring having a diameter of about 9 inches, and be about 2 feet deep; the best material to use for the bag is fine silk gauze (chiffon); the handle should be about 2 feet long.

It is well for the young naturalist to endeavour to breed out specimens, and for this purpose ordinary clear glass tumblers are most convenient. Put about a score of fully-grown larvæ and pupæ, in the water in which they have lived, in one of these vessels, and tie over it a covering of gauze supported on a twig or piece of wire bent into an arch. When the perfect insects appear slices of banana should be introduced to enable the insects to feed, and so fill out to their proper pro-

portions. Some of the larvæ and pupæ should be preserved in a small tube in rectified spirit, or in 4 per cent. formalin solution. Insert in the tube a small, narrow, neat slip of paper, upon which has been written in lead-pencil a distinguishing letter or number corresponding to the label attached to the pin that carries the adult insect.

Preserving, Mounting, and Labelling.

The requisites necessary for preserving and mounting are neither many nor expensive. It must be borne in mind by the collector that specimens should be dry and pinned. Those mounted in Canada-balsam as microscopic objects, or preserved in liquid, are absolutely useless for identification, because important and specific characters are lost thereby. Nevertheless wings may be mounted for microscopic examination upon glass slips. Such will be useful in studying venation; but they should each have a distinguishing number or letter written neatly upon a small gummed label to be attached to the slip, and this should also correspond to the number or letter upon the pin that carries the insect.

No. 20 entomological pins should be used, and

these may be obtained from dealers in natural history wares. They cost about 7s. 6d. an ounce, or 2s. 6d. a quarter of an ounce, and as they are very small, thin, and light, the latter quantity, even, would last a long time. Next, take a 20-bore gun-punch, and cut from thin card a number of discs. A small, flat piece of cork, covered with white paper, is necessary. Place the insect on its back upon the cork, and having made a slight puncture in the centre of a disc, take a No. 20 pin in a pair of forceps (fig. 14) near the head,

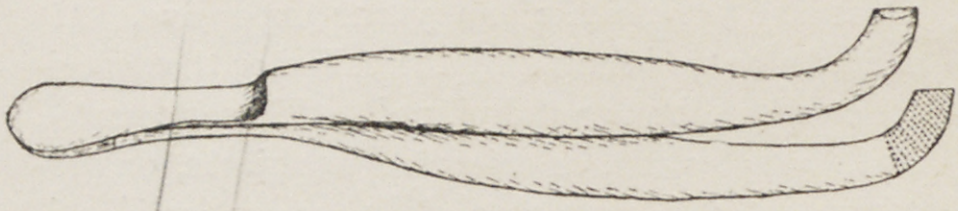


Fig. 14.—Forceps.

and, holding it so, pass the point through the card, where it has been perforated, and then through the thorax of the insect between the bases of the legs, right through the back, so that the point abuts (fig. 15). The wings and legs should then be arranged; the latter may be retained in position by smearing the surface of the disc with a thin film of gum tragacanth. Having secured the specimen thus, a common pin may

now be run through the disc near the edge. Prior to mounting the insect upon the disc it is advisable to write on the under side its name, date, and locality, also such information as may be helpful, such as "House," to indicate that it was collected in a dwelling, or "Sylvan," if such be its haunts, and if necessary the word "Bites." An additional free label containing the corresponding

Fig. 15.—Mosquito mounted.

data may also be impaled upon the common pin. This will obviate the necessity to lift the specimen, whilst the information upon the disc will be a safeguard against the loss or damage of the free label. A few trials in the pinning and mounting of specimens, even though they be punctuated at

first with failures, will soon enable the collector to show good work. It is wonderful how soon an intelligent person will, with perseverance, become an adept in the art.

An insect box will be required. This may also be obtained at the dealer's. The cost is very little. A man handy with tools may, of course, make his own. It should, however, be not only dust-proof, but as nearly air-tight as possible. A small bag made of mosquito-netting or muslin, and charged with naphthaline or camphor, must be securely pinned in a corner of the box. This is imperative. Should the dreaded *Anthrenus* appear and threaten the collection, their depredations will be easily checked by the application of a little bisulphide of carbon.

With care, specimens, mounted or unmounted, may be transmitted through the post. If mounted they may be packed in a cigar-box, provided the bottom has been "carpetted" with solah pith or cork. Wine corks, cut into discs about a quarter of an inch thick and glued to the bottom of the box, will answer admirably. Short lengths of glass tubing may be used for unmounted specimens. The diameter should be sufficiently large to admit the insects, but too

small for them to shake about easily. It is not wise to plug the ends; the better way is to tie up each tube in a small square of muslin or mosquito-netting. Specimens in plugged tubes are apt to become mildewed, and mildewed specimens are worse than useless. *On no account pack insects in cotton-wool*, as it is impossible to extricate them from the tangled fibres without serious damage.

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