THE PATHOGENIC MOSQUITOES OF JAMAICA.

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The importance of the Culicidæ as carriers of the essentially "tropical" forms of disease is, as I know, fully realised by all the officers of the Corps. Here, in Jamaica, one has unequalled opportunities of making the acquaintance of certain species of this group of the diptera, each of which in itself is the carrier either of malaria, filariasis, or yellow fever, respectively. The species alluded to are, Culex fatigans, the carrier of filariasis,¹ Stegomyia fasciata and Stegomyia mosquito (Robineau-Desvoidy), the carriers of yellow fever, and the five species of Anopheles found in this island. These are: Anopheles punctipennis, Arribalzagia maculipes, Cellia argyrotarsis, and Cyclolepidopteron grabhamii, together with Cellia albipes, the commonest form of Anopheles. In addition there are numerous other species of Culex, but as these are not yet proved to be pathogenic, I do not intend to take further notice of them. They are a source of annoyance, as many of them are vicious biters, but they have been so admirably described in the monograph on the "Culicidæ of Jamaica," by Drs. Grabham and Theobald, that I would refer those desirous of further information to that work.

The method of working I have adopted has been to collect water containing "wrigglers" in wide-mouthed quart bottles. The neck is guarded with a piece of gauze, to prevent the escape of the mature insect, and the edge of the bottom of the bottle smeared round with a half-inch ring of carbolised vaseline to prevent ants gaining access to the interior. Ants are extremely fond both of mosquito larvae and the fully developed insect. It is astonishing to see the skill the ant displays in catching these; he crawls to the edge of the water, and seizes the larva by the respiratory syphon, or the mosquito by a leg, drags him, or her, away up the side of the bottle, and devours the insect with the help of his companions. An important point is the depth of the water in the bottle. In the larval stage the insects have to go to the bottom to feed; if the

¹ The author assumes throughout that in filariasis the actual infection by the mosquito has been proved. There is, however, no good experimental evidence, and the most that can be said is that this mode of infection is probable, though there are anatomical difficulties.—Ed.
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depth exceeds six inches they will not descend readily, and in consequence die off rapidly. Another important point in breeding out larvae is to place some nitrogenous food in the breeding medium, such as small pieces of meat, dead insects, &c. If this is not done, the larvae prey on each other, and on more than one occasion, before I learnt the importance of this fact, I found that nearly all my larvae had disappeared, as they had been devouring each other.

Again, in collecting larvae, it is worth while remembering that it is no use to take water from pools or ponds of any depth over four feet. The larvae cannot get their food at a depth of over three to six inches. Again, ponds covered with duckweed, or containing confervae, never yield "wrigglers," as in addition to preventing the larvae getting to the surface to breathe, collections of water of this description invariably contain the predatory larvae of the water-beetle and the dragon-fly, in addition to others which feed voraciously on the larvae of the diptera. It is hardly necessary to point out that no larvae will be found in collections of water which contain small fish, provided, of course, that the edges of the pool or pond are not overgrown with weeds, through which the fish cannot penetrate. Minnows and small fish of all varieties feed eagerly on larvae, and as I have found from experience in India, these are the best agents for ridding standing collections of water of the larvae of diptera contained in them. The larvae of Anopheles and Culex, in my experience, as regards this island, require different surroundings to hatch out in satisfactorily. That of Anopheles prefers clear, clean water, that of Culex fatigans and Stegomyia will flourish in absolutely foul and offensive water. I have introduced the larvae of Anopheles into foul water swarming with the larvae of C. fatigans and Stegomyia, and none attained the pupal stage. I have never succeeded in finding Anopheles larvae except in clear, shallow rain-pools, or pools formed by dripping taps, such as one finds in the gardens surrounding houses and quarters in barracks. On the other hand, Stegomyia and C. fatigans larvae are found abundantly in any collection of water, in old tins, disused pails, broken bottles, &c. In hatching out larvae, the bottles containing them should be kept in a shaded place, and not exposed to bright light. Normally the fully developed insect changes from the pupal stage to that of the imago in the evening, i.e., after sunset. If the larvae are kept exposed to light, they undoubtedly develop less rapidly, and the fully developed insect emerges in the daytime, with the result that it is overcome by the light, and is drowned before it can clear its wings and fly. This is a fact I
have noticed repeatedly. It makes all the difference to the number of perfect insects one obtains from a brood of larvæ if they are kept in a darkened situation during their transformation from the pupal stage to that of the imago. When the perfect insect has emerged it should be removed from the breeding bottle to a dry, wide-mouthed bottle, in which is subsequently suspended a fresh piece of banana, or raw, juicy meat. The transference is easily effected by removing the gauze cover, giving the bottle a rapid twist, at the same time inverting the dry bottle over the mouth of the breeding-bottle. The insect will fly up into bottle No. 2, a piece of cardboard is then placed beneath it as it is removed. The banana is suspended in the bottle by a piece of thread, and the mouth closed by a piece of gauze or muslin. The imprisoned insects soon begin to feed, and subsequently copulate. If water, to about the depth of one inch, be poured in, the females will lay their eggs within twenty-four to forty-eight hours (the males dying at the end of this period), and the development of the insect may be followed throughout its successive stages, from the egg to the imago.

As regards the extermination of mosquitoes, the practical deductions from the facts I have narrated are these: (1) In deep water, i.e., water of over three feet deep, mosquitoes cannot readily develop. It is in the shallow water at the edges of the pond that they can reproduce themselves, so that in dealing with large ponds or pools, it is essential that their edges be deepened to at least two feet, so that the sodden margins of the area dealt with may be thereby drained. (2) Collections of water covered with duckweed, or containing conferva or spirogyra, need not be dealt with. If the mosquito lays her eggs in such situations, the larvæ are not likely to attain maturity, as they are either devoured by the predatory larvæ of other insects which flourish in such collections of water, or become entangled in the strands of the conferva, and are thus unable to reach the surface to breathe. (3) It should be borne in mind (as pointed out by J. B. Smith, Entomologist to New Jersey, U.S.A.) that though larvæ will not develop readily in bright light, neither will they do so in dense shade, so that pools, &c., overgrown with tall water-plants, such as bulrushes, cat-tails, and so forth, which cut off the light of day from the water in which they grow, are not likely to afford a breeding ground for mosquitoes. (4) From my own experience in India, as mentioned previously, I have no doubt that fish, more especially the smaller varieties, such as minnows, &c., are the most efficient destroyers of mosquito larvæ.
In one station, in which I did duty for fifteen months continuously, the bungalow which we occupied was at first swarming with various species both of Anopheles and Culex. In the garden there were three shallow irrigation tanks which contained larvae of both species in abundance. I imported minnows from the Indus, a few miles off, and within a month the bungalow was free of the pests. It is hardly necessary to point out that fish cannot exterminate larvae if they are put into ponds the edges of which are shallow and overgrown with weeds, and through which the fish cannot pass to reach their prey. As regards the use of mineral oil, it is worth while remembering that the oil not only kills the larvae by preventing them from coming to the surface to breathe, but also acts as a direct poison on the females, if they attempt to deposit their eggs on water covered with a film of paraffin. This fact has been conclusively proved by experiments made in New Jersey, U.S.A., under the auspices of J. B. Smith, Entomologist to the State. He has also demonstrated that one ounce of kerosene oil sprayed over water will efficiently protect fifteen square feet of surface.

The commonest variety of mosquito met with in Jamaica, and the most obtrusive, on account of the fact that it bites viciously throughout the day as well as the night, is the *S. fasciata*, together with its closely allied congener, *S. mosquital* (Robineau-Desvoidy). The two species are very similar in appearance. Even to the naked eye they are handsome insects, the body and legs, banded with black and white stripes, reminding one of a piece of shining ebony set with pearls. Under the microscope with a half-inch objective, the beauty of the insect can be still more realised. The *S. fasciata* differs from the *S. mosquital* in that the former has two median parallel yellow lines on the thorax, which are absent in the latter. The Stegomyia is a domestic species, breeding readily in the neighbourhood of dwellings, in water-barrels, tins, broken bottles, &c. It feeds mostly in the early afternoon, between mid-day and four p.m., but, as mentioned above, the members of this species will attack one practically at any hour of the day or night. They are formidable insects, owing to the fact that the females, which alone bite, are good travellers, and have been known to live for sixty-five days or more in captivity. I have had specimens brought to me in Jamaica, from the Spanish main, which though corked up in a one-ounce bottle without food of any sort, reached me alive at the end of two weeks. As *S. fasciata* is the undoubted carrier of yellow fever, its vitality emphasises the
importance of taking all possible measures to prevent their transference from their present habitat to countries such as India proper, where a population possibly susceptible to yellow fever exists. The "wriggler," or larva of this species, can be readily identified by the fact that the respiratory syphon, or air-tube at the tail, is thick and very short, and that the transverse diameter of the head is smaller than that of the thorax, in contrast to the larva of \( C. fatigans \), which spend most of their time at the surface, and whose respiratory syphon is thin and elongated, with a head equal in diameter to that of the thorax.

The larva of Stegomyia remain at the bottom of the collection of water in which they live, and only occasionally rise to the surface for air. Being members of the Culex family, they of course, when at the surface of the water, rest in a vertical position, \( i.e. \), head down, as contrasted with the Anopheles, which assume a position parallel with the surface. This rule as regards the "surface" position of the larva of these two sub-families is of great practical value, but to every rule there is an exception. In Jamaica it is exemplified in the case of \( Grabhamia jamaicensis \). This mosquito is a true Culex, and I may add a vicious biter, but its larva is often found floating on the surface in an approximately horizontal position; on close observation one can see, however, that it differs from the larva of Anopheles, in that the middle segment of the body hangs down, curved like a piece of slack rope, between the head and the respiratory syphon.

\( C. fatigans \) is, next to the Stegomyia, the commonest variety of Culex found in the island. This insect, although it breeds in similar situations to those in which the Stegomyia reproduces itself, differs from it in that, while the latter is active both by day and night, the former makes itself evident at night only, \( i.e. \), after sunset. The imago is a dull, brown-coloured mosquito, and is often confounded with Stegomyia, as white spots (not bands) are present on the apices of the tibiae and femora, in contrast to the Stegomyia, in which the legs are obviously black and banded with white at these situations. Again, the female of the Stegomyia lays her eggs singly, while those of the \( C. fatigans \) are laid in "rafts." Their flight is quite distinct from that of Stegomyia or the various varieties of the Anopheles; both of these fly in a straight line from one position to another, while \( C. fatigans \) flies in a series of undulating curves, which when once recognised makes it easy to identify the latter. As it is a domestic species, and a weak flyer, it is easy to destroy it in the larval stage.
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Five species of Anopheles were met with in the island. Those most commonly met with in this part of the island, i.e., Kingston and Up Park Camp, are Cellia albipes, argyrotaisis and Cyclolepidopteron grabhamii. The remaining two species, Arribalzania maculipes and Anopheles punctipennis, are only found in the north-east and north-west districts of the island. These species as a whole are very rare; for seven months continuously I collected larvae from collections of water in pools, bottles, tins, &c., and though I obtained many most interesting specimens of Culex larvae, I only became the fortunate possessor of less than two dozen specimens of Anopheles; these were all Cellia albipes and C. argyrotaisis, with one example of the species discovered by Dr. Grabham, of Kingston, in this colony, the Cyclolepidopteron grabhamii, so called on account of the curious pear-shaped scales on the wings of the mature insect, which are only found in this species of Anopheles. The larvae seem to require more air than those of Culex, as they only descend to the bottom of the breeding bottle when disturbed, in marked contrast to the Culex larva, which are to be found constantly feeding beneath the surface, rising from time to time to breathe. The eggs again are laid singly, and float lengthwise, though they may often adhere in small masses. The eggs of the majority of the Culex float, as a rule, on end. The larvae of the Anopheles have the curious habit of harmonising themselves with their surroundings as regards colour, and may be easily mistaken for floating particles of vegetable débris or rubbish, until actually touched. As far as my experience goes they are not canni-balistic, as are the larvae of the Culex.

The appearance of the mature insect is unmistakable. Owing to its large palpi and proboscis the anterior extremity of the mosquito is torpedo-like in appearance. Its attitude, when resting, with the head placed between the forelegs and its body at right angles to its resting place, makes it at once recognisable. A point not often emphasised, but brought to notice by J. B. Smith, of New Jersey, U.S.A., I have verified by many observations. This is, that in Anopheles, when the insect is at rest, the hindlegs are held high in the air and extended beyond the body. In Culex, on the contrary, the hindlegs are curled over so that the ends of the feet almost touch the body. The rarity of this variety of the Culicidae in Up Park Camp, the cantonment of this colony, may be realised by the fact that true cases of malaria are quite uncommon, and the

1 Is this a legitimate inference?—Ed.
few that present themselves are mostly soldiers who have recently returned from the West Coast of Africa, or men who have contracted malaria elsewhere, either in India or in the malarious districts of this island. Cases which, before the days of microscopical blood examination, were returned as ague, or simple continued fever (of which many, even now, present themselves), and in whose blood no malarial parasites are found, are, in my opinion, undoubtedly cases of so-called paratyphoid, the result of infection by a colon bacillus, or some blood parasite, bacillary or protozoal, not hitherto discovered. Such cases do not react to quinine, and must be familiar, especially in India, to many officers who have served in that empire.

As regards the habits of the Anopheles found in this station, they are all night-fliers, concealing themselves by day in dark corners, outhouses, cupboards, and on dark-coloured clothing. Owing to the development of the head appendages, fortunately for humanity, they cannot travel far, their limit being from half to one mile at the utmost. Of course, this does not take account of the help they may obtain in their flight from prevailing winds, and the possibility of conveyance in railway trains, vessels, vehicles, &c., must also be borne in mind. They do not bite so viciously as the various species of Culex, and hence often escape after attacking one, whereas the Culex, owing to the discomfort at once evident on its attempting to bite, draws attention to itself, and with a little practice on the part of its victim is easily killed.

From the preceding short and, I am afraid, imperfect sketch of the three varieties of mosquitoes I have attempted to describe, I have omitted purposely any approach to a detailed description of the anatomy of the larvae or the mature insect. This is of a purely technical matter and uninteresting to any but those who have studied the diptera thoroughly. As it is obviously a matter of great importance to be able to recognise these enemies of mankind in their various stages, I have taken upon myself to place on record the facts that have been noted after several months' study, both of the larvae and the perfect insect of these species of the Culicidae, and have therefore ventured to describe them in this article.

1 A good many of the so-called simple continued fevers in India do show a malarial parasite, and the same has been observed in St. Lucia.—Ed.