steamer, this is tied up at night often close to a native village; and when travelling by land it is usual to camp in or near a native village. Under these circumstances attention to this rule will do good. But even in Central Africa it must be remembered that Europeans do not select a site near a native village (either for residence or for a halt) accidentally or from preference, but because either the work they are engaged in necessitates it, or for convenience or protection. How far it is practicable to live, or even rest, apart from native settlements is a question that will be decided in each place according to the local and individual circumstances. I have little doubt that in Africa something can be done to reduce the number of susceptible natives in the neighbourhood of European settlements, and that this reduction may be sufficient for the residue to be treated with quinine.

In Demerara and the malarious West Indies the inhabitants of the towns have adopted European customs and houses, so the conditions are different, and all races must be considered together. The danger of the aggregation of susceptible persons is the same, and affords an additional argument against the overcrowding so prevalent in the poorer parts of the towns.

CONCLUSIONS.

From the above it will be seen that no method is or can be of general application, to the exclusion of others. A combination of methods strictly in accordance with local conditions promises the best results. The outlook is hopeful, as any reduction in any factor by any one method will increase the effect of any other methods adopted.

The greatest difficulty I anticipate will result from the scepticism with which the subject will be met in the tropics. With this scepticism I sympathise, and two years ago, before I had investigated the matter, I fully shared in it.

This question has received careful attention in England, and has been considered in all its known bearings in a manner quite different from that in which we have been accustomed to see questions relating to tropical medicine and hygiene treated, but the distrust resulting from the older method will not immediately disappear.

It is unfortunate that statements regarding malaria and mosquitos, in themselves of minor importance, have been made by writers with no personal acquaintance with the subject, which will be used by some as an excuse for scepticism.

Sufficient regard to the species of *Anopheles* has not yet been paid in describing their habits and breeding places. The very local distribution of some of the species indicates some important differences as yet unknown.

It is, I consider, requisite for each species of *Anopheles* that direct proof should be obtained whether the human malaria parasites develop in them or not; in only a few is the proof at present conclusive, and it is, I think, being too hastily assumed that the whole genus is implicated.

NOTES ON THE LIFE-HISTORY OF "ANOPHELES MACULIPENNIS" (MEIGEN).

(With Chromolithographic Plate.)

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SINCE Ross's discovery that mosquitos of a peculiar kind (genus *Anopheles*) are the alternative and definitive hosts of the parasites of malarial fevers, many papers and articles have appeared on the structure and biology of these dipterous insects. A fair amount of this literature, being the outcome of careful observational work, has added considerably to our previous knowledge. It might perhaps seem fruitless to go over the same ground and necessarily repeat many things which have been already admirably described, but the literature on the subject is so greatly scattered that it has appeared justifiable to publish the following notes.

The study of the life-history of mosquitos imposed itself already twenty years ago, when Dr. Manson discovered that *Culex ciliaris* (Lin.) fostered the larvæ of filaria Bancrofti (Cobbold), but at that time tropical diseases attracted little attention, and Manson's admirable researches failed to rouse the collateral investigations of entomologists. The recent researches by Manson, Ross, Grassi, Bignami, and Bastianelli

on the rôle played by mosquitos in the propagation of malarial fevers, and the discovery made by Grassi and Noë that another hæmatozoon of animals, the filaria immitis (Leidy), is likewise harboured and transmitted by mosquitos, has at length induced a number of medical men and entomologists to study minutely the life-history of these dangerous insects with a view to their possible extermination.

Amongst the recent contributions are important papers by Ficalbi, Giles, Grassi, Noë, and Skuse. The United States Department of Agriculture has published a special bulletin on the mosquitos of the United States, written by its learned entomologist, Mr. L. O. Howard; and the Natural History Department of the British Museum, having received large numbers of mosquitos from various parts of the world, is preparing a monograph of the *Culicidæ*.

The following notes were collected together with Dr. G. C. Low in the district of Ostia during the fever season of June to November, 1900, and refer to *Anopheles maculipennis* (Meigen), which is the species most common in the Roman Campagna.

The Italians have used the name *A. claviger* (Fabricius) for *A. maculipennis*, but erroneously, because the former term was applied by Fabricius, not to a species, but to a faulty description. *A. quadrimaculatus*, Say, is another name for the same species, since Mr. F. V. Theobald has proved that the American *A. quadrimaculatus* is identical with the European *A. maculipennis*.

In describing the life-history and habits of mosquitos, it is essential to mention not only the genus, but also the species under observation, because species differ not only in structural details, but also in life-habits. Even the same species may show different habits in various localities, in accordance with peculiar surrounding conditions. However, in a general way, the life-history of *A. maculipennis* may be taken as a good type to illustrate the biology of malaria-bearing mosquitos. In Europe it is certainly the chief propagator of malarial fevers, hæmameba malarie, hæmameba vivax, and hæmomenas præcox, have all been found in its stomach walls or salivary glands in the corresponding phases of their exogenous cycles.

THE OVUM.

Anopheles maculipennis does not construct, like *Culex pipiens* (Lin.), the characteristic canoe-shaped mass (Coloured Plate, Figs. 4 and 5) of eggs described by Réaumur, in which about 300 subconical ova are agglutinated together perpendicularly like the cells of bees' combs and wasps' nests, but lays about a hundred eggs, which float horizontally close to each other, forming irregular clusters (Fig. A), which are easily scattered by the wind. The egg of *A. maculipennis* is about 0.7 mm. long by 0.16 mm. broad; it has the shape of a boat, being fusiform in outline, strongly convex below and almost plain above. It is surrounded by a reticulated membrane, which forms a striated rim much wider in the middle third of each side. This membrane is undoubtedly a floating arrangement; it is filled with air, and serves the same purpose as the air-tight chambers along the sides of our lifeboats. The ova are whitish when first laid, but they soon acquire a dark greyish-brown colour. They usually hatch on the second or third day, the length of the egg period varying with the temperature. The larva escapes from its eggshell by opening a conical-shaped lid formed by the extremity corresponding to its head.

THE LARVA.

The larva of *A. maculipennis* differs somewhat in appearance according to the stage of development. The most striking difference being the relative size of the thorax which in the full-grown larva becomes much larger in comparison with the other segments of the body. The larva goes through several moultings, and when full-grown measures from 7 to 8 mm. in length. Like the larvæ of all other *Culicidæ* the larva of *Anopheles* foreshadows the form of the imago to a somewhat greater extent than is usually the case with those insects, as flies for example, which pass through a complete metamorphosis. If we imagine the adult *Anopheles* body to be provided with tufts of hairs instead of wings, legs and proboscis, we get a fair idea of the appearance of the larva. Each segment along the sides is furnished with a tuft of branched filaments curved slightly forwards. The last segment, besides

two tufts of long hairs, projecting backwards and upwards from the posterior edge of its dorsal aspect, is furnished on the ventral side with a long fan-like whisk which dips vertically and serves the purpose of a caudal fin. The head is small, globular, and almond-shaped. The eyes are situated laterally at the broadest part, and above them, about the middle of each side are the antennæ. On the dorsal surface between the antennæ is a wide pigmented band with six branched hairs which probably serve to support the head while reversed and tilted upwards for the purpose of feeding. The ventral surface of the head is provided with strong biting jaws above which are two wing-shaped bunches of filaments called the whorl-organs. The penultimate abdominal segment carries the spiracles of the large tracheæ and the lower edge of its dorsal aspect slightly overlaps the anal segment. This last segment is armed at the tip with four leaf-like flaps, which are probably both respiratory and locomotory in function and analogous to those of the dragon-fly (odonata) larvæ. The larvæ of *Anopheles* are easily distinguished from those of *Culex* (Coloured Plate, Fig. 2) on account of the smaller head, the branching of the lateral hair on each segment, and the absence of a long respiratory tube.

The larva of *A. maculipennis* lies usually extended at the surface of the water (Fig. B) with the penultimate segment just awash, so that the breathing stigmata may open freely at the surface. The rest of the body is inclined slightly below the surface, and kept in position amongst the vegetation of the surface film by the setæ projecting from the anal segment and by the long balancing filaments on the metathorax and first three abdominal segments. The larva may dip the anterior part of its body at various angles with the surface, and sometimes, almost vertically, whilst browsing on submerged particles, but its almost parallel attitude is so constant that it becomes a valuable character to distinguish it at a glance from the large-headed larva of *Culex*, which holds its body obliquely at an angle of from 50 to 60 degrees with the surface. *Culex* larvæ may also hold their body parallel to the surface (Fig. C), but they only take this position exceptionally and for a very short time, and even then they can be easily distinguished, because their body is kept at a greater distance from the surface on account of the length of their respiratory tube. A larva which might be more easily mistaken for an *Anopheles* is that of *Dixa* (Coloured Plate, Fig. 3), which has a small head, and likewise may remain extended at the surface of the water, but the usual position of the *Dixa* larva is at the edge of the water close to the bank, where, emerging the middle part of its body out of the water, it assumes the shape of a horseshoe with the concavity towards the water; the last segment with its long setæ resting on the surface, and the head somewhat below and turned upwards. The larva of *Dixa* can be easily distinguished from that of *Anopheles* on account of its very small thorax, uniform segments, and larger stigmata.

The *Anopheles* larva, if undisturbed, may remain a long while at the surface apparently motionless. If there is any slight movement of the water it may drift gently with the current or turn round its own body axis. It is usually found amidst a veritable Sargasso of floating plants and duckweed, resting with its hinder and lateral hairs amongst the floating vegetation for support. Watching closely the larva which was absolutely motionless, one may see it suddenly twist its head right round. This remarkable movement is accomplished by a rotation of 180 degrees, which suddenly brings the ventral aspect of the head uppermost. In this position the mouth-parts are turned and inclined towards the surface, and the whorl-organs, mandibles, and maxillæ begin immediately to work with extraordinary rapidity. The constant and rapid motion of the whorl-organs creates an eddy or current of water which brings to the mouth the tiny animalculi (cyclopes, cypris, etc.), diatoms and algaë spores on which the larva feeds. After a time, the larva may suddenly stop its whorling-organs and turn its head once more right round, then it may remain quite motionless for a few seconds, or it may dart rapidly away, moving always backwards in a curious zigzag manner produced by quick, vigorous, lateral movements of its body. Having settled in a new place, it again suddenly twists its head and resumes its whorling. When disturbed, it often dives to the bottom, displacing itself from among the surrounding weeds by means of a few downward jerks, and then letting itself fall by virtue of its

specific gravity, which is greater than that of the water. At the bottom it settles among the sunken *débris* sideways, or with its ventral aspect upwards, and remains perfectly still and immovable, simulating death. After a time, which may be considerable, it wriggles back to the surface with a series of jerks or whip-like movements of its posterior abdominal segments, which are always directed foremost. Whilst floating at the surface, the larva frequently assumes a circular attitude to steady against the last segments of its body any particle on which it may be scavenging, or to clear the spiracles of its breathing tubes.

The colour of the larvæ varies greatly, according to food and other surrounding conditions. Those artificially reared in large white earthenware basins with a handful of sand and a few grains of rice at the bottom, were of a light greyish colour, whilst those found in natural pools were mostly olive-green. In some pools within a pine forest and in a stagnant canal containing slightly brackish water many larvæ were found of a beautiful jet black. Very frequently both the green and black larvæ were mottled with silver-white spots on one or more segments along the middle line of the back.

After a period which varies considerably according to temperature, food, and amount of water, the larva transforms to pupa.

THE PUPA.

The pupa (Coloured Plate, Fig. 8) differs greatly in appearance from the larva; it strikes one as small compared to the full-grown larva, which therefore appears to have shrunk somewhat at the last ecdysis. Its head and thorax are closed together within a common transparent shell, through which one can also trace the antennæ, the wings and the legs of the perfect insect. The abdominal segments remain free, and acquire a pair of chitinous leaf-like paddles which form a sort of sculling apparatus. A remarkable change is that of the respiratory organs, which do not open any longer on the penultimate segment of the abdomen, but on the thorax by means of two trumpet-shaped tubes. This change in the location of the breathing spiracles brings about a reversion in the attitude of the body, so that the pupa is enabled to float in a position better suited to the liberation of the perfect insect. During the pupal stage the short biting organs of the larva transform into the long sucking apparatus of the imago, thus, being unable to feed, the head is swaddled up with the thorax. Notwithstanding its clumsy appearance, the pupa is quite as active as the larva, and when disturbed it at once wriggles violently below. However, it rises again almost immediately to the surface, where it usually remains. There is a very striking difference in the sinking and rising movements of larva and pupa; the larva is heavier than the water, and therefore sinks quite easily, but must wriggle very actively to rise again to the surface; the pupa, on the contrary, is lighter than the water, therefore it has to struggle violently to sink, but rises without the slightest effort.

The pupæ of *Anopheles* can be easily distinguished from those of *Culex*. The pupa of *Culex* floats in a more perpendicular attitude than that of *Anopheles*, the posterior edges of its abdominal segments project more and give a serrate appearance to its "tail curve," and the respiratory tubes differ greatly in shape and in the position of their spiracles.

The duration of the pupal stage is about two days. When the time of emergence arrives, the abdominal segments are extended backwards at the surface, and the pupa case splits longitudinally through the middle of the back. Now the imago gradually extricates itself, using its hind legs to push with and balancing itself with the anterior and middle pairs. The perfect insect usually remains for a few minutes on the surface of the water free from its pupal case, holding up first one leg, then another. It is enabled to stand on the surface of the water just like a pond-skater (*gerris*) on account of the peculiar disposition of its ungual apparatus, but the water must be very smooth. The slightest rippling may wet its wings and drown it. After from five to fifteen minutes it usually takes wing and joins its companions in their mazy dance.

THE IMAGO.

Anopheles maculipennis in its perfect state (Coloured Plate, Figs. 6 and 7) varies greatly in size. Including the proboscis, it may measure from 7.5 to 10 mm. in length. The antennæ of the female insect are com-

posed of fourteen joints, and are each provided with a circlet of fine hairs of no very great length, those of the male have fifteen joints, and are beautifully plumose, the hairs being much longer and more thickly set, especially on the proximal joints. By means of these striking feathery antennæ the male insect may be easily recognised. The palpi, or maxillary feelers, in both sexes are black and nearly as long as the proboscis. They are clavate in the male. The long palpi of the female *Anopheles* at once distinguish it from all species of *Culex*. The dorsal aspect of the thorax is of a dark grey colour, with fine yellowish hairs. It is striped by three longitudinal brown lines. The wings are brownish, with four dark spots. Three of these spots are found extending along one of the veins near the costal vein, while one is somewhat posterior to the last two spots. These spots are due to a thicker accumulation of the black chitinous scales which cover the veins, they are quite apparent to the naked eye and are more conspicuous in the female. The border of the wing is adorned with dark brown scales, which fade off at the apex to a light yellowish tint, and thus form a fairly distinct spot. Behind the wings, on each side of the metathorax, are the halteres, two long-knobbed stalks, which are the rudiments of the second pair of wings. The legs are slender, very long, and of a dark brown colour, somewhat lighter at the tips of femora and tibia. The femora of the anterior pair are not enlarged at their base, as is the case with those of *A. pseudopictus* and other species. The abdomen is of a dark-brown colour, with long yellowish-brown hair on both the dorsal and ventral aspects.

Anopheles maculipennis is very widely distributed throughout Europe and North America. In Italy it is by far the most common species of the genus *Anopheles*. Like *Musca domestica*, *Pulex irritans*, *Cimex lectularia*, and other insects, it has linked itself with man, and is now found in all the houses and stables placed in the neighbourhood of its breeding grounds.

BLOOD-SUCKING APPARATUS.

The proboscis or suctorial apparatus consists of an upper

Fig. D.—Blood-sucking apparatus of *Anopheles*.

lip (labrum and epipharynx) and a lower lip (labium) enclosing a tongue (hypopharynx) and four piercing organs (mandibles and maxillæ). All these mouth parts combine to form the long beak-like appendage which points forward from the head, exceeding the length of the antennæ.

The labrum and epipharynx (Fig. D, c) combined form a long, pointed, and grooved instrument, which tapers uniformly from the base to the apex.

The hypopharynx (d) is an equally long, slender, lanceolate rod of transparent chitin, grooved on its dorsal aspect, which, placed in apposition with the upper lip (labrum epipharynx), forms a tube for the ingestion of blood or plant juices. These are imbibed by the œsophagus, which is expanded into a bulb behind a valvular constriction of the pharynx, and acts as a suction pump. The groove which runs along the hypopharynx is connected at the base of the organ with a short salivary duct, which divides into two smaller ducts, each terminating into three tubular glands arranged like the leaves

of a trefoil, and situated in the antero-inferior region of the prothorax. These are the veneno-salivary glands described by Macloskie.

The mandibles (e) and maxillæ (f) are four fine-pointed needle-like rods of chitin. The mandibles have slightly broadened lancet-shaped tips with harpoon-like teeth, and the maxillæ have serrated or saw-like outer edges. It is chiefly through the cutting action of the latter that the skin is pierced.

The labium (g) is a long, slightly tapering, sheathing-organ, which encloses in its groove all the other mouth parts. It is covered outwardly with an abundance of fine hairs and scales, and ends in two fleshy, finger-like appendages called labellæ. These labellæ are furnished with muscles by which they can be dilated or contracted.

When the female *Anopheles* "bites," the proboscis is pointed downwards, and the labellæ are pressed against the skin of the victim. The labrum, the hypopharynx, the mandibles, and the maxillæ are pressed together into one solid boring instrument, like the parts of a trocar. Their common tip is forced down at the angle between the spread labellæ, which serve to hold and direct these clustered parts. Whilst the piercing organs pass into the tissues, the

Fig. C. Larva of *Culex*; attitude at surface of water.

labium bends backwards at about a third from its base, and its angle pointing towards the breast of the insect becomes more and more acute with the deepening of the piercing mouth parts. The palpi (*b*), which usually lie parallel with the proboscis, are raised and diverged during puncture.

The habit of sucking blood is an acquired habit, confined to the female *Anopheles*. The male insect will at times alight on a hand held perfectly immobile, and will probe about with its suctorial mouth as if inclined to bite, but will invariably fail to do so. In a species of *Culex* (*Culex elegans*) the male is also a blood-sucker, and quite as voracious as its female. The female of *A. maculipennis* will readily bite when enclosed in a test-tube, the open end of which is held in contact with the skin; but it is almost impossible to induce some *Culices* to bite under such conditions. *A. pseudopictus*, like the *Culices* experimented upon, would not bite when enclosed in a glass tube. *Anopheles* of both sexes will readily suck up the juices of plants and the females can be kept alive for several months by feeding them with sliced ripe fruit. The habit of sucking blood from a vertebrate is not peculiar to mosquitos only, but is exhibited by various diptera. In some it is common to both sexes, but usually it is confined to the female, and may probably be connected with the development of the eggs.

Fig. B.—Larva of *A. maculipennis*; attitude at surface of water.

attitude in *A. funestus* (Giles) and *A. costalis* (Loew) at Free-town on the West African Coast, mentioned it in his report of the Liverpool Malarial Expedition as a striking character which might enable anyone to distinguish at a glance these *Anopheles* from the *Culices* of the locality. Unfortunately

this character, which held good only for the species of a certain locality, was erroneously interpreted by subsequent writers as a general means of distinction between the *Culex* and *Anopheles* genera.

A character which seems to be truly diagnostic between the *Culex* and *Anopheles* genera is that pointed out by Mr. Waterhouse. In *Culex* (Fig. G.) the head and thorax form an angle with the abdomen which gives the insect a curious humpbacked appearance; in *Anopheles* (Fig. H.) the head, thorax, and abdomen are almost in a straight line.

BREEDING GROUNDS.

In the district of Ostia *Anopheles maculipennis* was very widely distributed. Its larvæ were found in almost every water collection from the broad emissary of the swamp to a small tub half-full of rain water near the pumping station. The region is being partially reclaimed and is intersected by a vast system of drainage canals which during the summer were stagnant and overgrown with aquatic vegetation. Larvæ of *Anopheles* were found in the majority of these canals, especially

Fig. E. *A. maculipennis*.

Fig. F. *A. pseudopictus*.

Fig. G.—*Culex* (after Waterhouse).

Fig. H.—*Anopheles* (after Waterhouse).

RESTING ATTITUDE.

A. maculipennis usually when resting on a vertical surface sits with its body at an angle of about 30° (Fig. E.), the angle however varying somewhat according to the position of the legs, the development of the ovaries, and the state of engorgement. This attitude is very different to that of *A. pseudopictus* (Fig. F.). The latter, when resting on a wall, seems almost perpendicular to it, because in fact the body of the insect and the supporting surface usually form an angle of about 70° and sometimes one of almost 80° .

Mr. E. Austen, the distinguished dipterologist of the Natural History Museum, having noticed this peculiar perpendicular

on the leeward side of bridges. In the wider canals and larger pools the larvæ were mostly along the banks in the little shallow bays and inlets formed by the union of clumps of reeds. Together with the larvæ of *A. maculipennis* were frequently found several species of *Culex* larvæ, usually *C. penicillaris*, and *C. annulatus*. In a pool within the pine forest of Castel Fusano and in some pools and ditches within the cane jungle beside it were also found larvæ of *A. pseudopictus*. In the brackish water near the closed-up outlet of the emissary, amongst large brown clumps of floating algæ and seaweed, the larvæ of *A. maculipennis* were very plentiful. In pools entirely covered by duckweed (*lemna*) *Anopheles* larvæ were never found. Larvæ in all stages of development were constantly

found from the beginning of June to the end of October, thus showing a continuous, irregular, succession of generations.

The number of larvæ in the different pools and at different times varied greatly without any apparent reason. A striking instance of this was that of a small pool in Castel Fusano: On September 20th this pool contained absolutely no larvæ either of *Culex* or *Anopheles*; but a fortnight later it was found to be simply teeming with both in all stages of growth, and on its surface were floating innumerable *Culex* egg-masses.

Fig. A.—Eggs of *A. maculipennis*.

In all the pools and canals were enormous numbers of frogs, besides swarms of larvæ of dragon flies and water beetles. The emissary and the wider canals contained, moreover, several species of fish, amongst which the young of grey mullet (*Mugil cephalus*) were innumerable, but the *Anopheles* larvæ occupied the shallows at the edge of the stream, where they were greatly protected by the dense aquatic vegetation.

After torrential rain the number of larvæ remained almost the same in those pools which were under cover of trees and were not liable to be scoured out by the rain, on account of the depth of their banks, but they diminished somewhat in the smaller shallow pools in more open places, and almost entirely disappeared from the emissary after its outlet had been opened and a strong current established by the accumulation of water due to rain and pumping operations.

The adult insects were found in great numbers in the houses and stables of the district. In stables they seemed to rest by preference on the old, dusty cobwebs which heavily curtained the ceilings. In the houses they chose the darkest corners, often resting under beds, tables, and chairs, or on dark-coloured clothing, but more frequently on the ceilings, especially when these were begrimed with the smoke of winter fires, and well out of the way of danger. In the bedrooms of an inn at Ostia, which had a blue stripe all round their whitewashed ceilings, the *Anopheles* seemed to settle by choice on the dark stripe for protection. It is almost ridiculous how these insects escape detection by those who are not in the habit of looking for them. One may often collect 10 or 20 specimens in a room which after a cursory search seemed to be absolutely deprived of them. The same difficulty is experienced in the detection of larvæ. One must learn first how to look for them, and then how to see them. The best places in which to find adult *Anopheles* are stables, hen-coops, and pigsties. In human habitations they usually occupy the kitchens and rooms on the ground floor. In an old, filthy wineshop in Ostia they could be collected by hundreds towards the end of June. During the summer months both sexes are found in the houses and stables, although the females are always by far the most numerous, but in winter only the hibernating females are found especially in small, dark cellars and cupboards, where they are not likely to be disturbed. During summer, the *Anopheles* do not seem to remain long in the houses and stables. Their number varies greatly from day to day in the same room, and specimens captured in rooms inhabited by malarial patients or filariated dogs are usually found to harbour only the earliest exogenous phases of these parasites. Fresh specimens arrive every evening, gorge themselves on the blood of men or domestic animals, hide for some hours in the darkest corner they can find, and go out again in the morning or the next evening. The female *Anopheles* feed every two or three days; they may oviposit more than once. Their life-cycle is short during summer; those who are unable to oviposit at the end of the warm season hibernate and deposit their eggs in the spring, towards the end of March. In some localities a few *Anopheles* larvæ may be

found throughout the winter, as if, like in some species of *Culex*, the insects were able to pass the winter in a long protracted larval stage.

In Ostia the adult specimens of *Anopheles maculipennis* were very abundant throughout the month of July, and continued so till the middle of September, when four days of torrential rain greatly diminished their numbers. After this, however, the number again increased, and remained fairly constant till the middle of October, when the weather became cooler and the autumn rains set in. In July and August the *Anopheles* used to appear very punctually a few minutes after sunset and disappear again a few minutes after sunrise. In September and October, when there were several dull and cloudy days, a few stragglers were occasionally seen on the wing throughout the day. They never tried to bite during the day even when disturbed from their resting places.

Anopheles maculipennis does not migrate far from its breeding grounds. It is distinctly local, but it may spread by means of human agency; thus it is often carried long distances with loads of straw and hay amongst which it may have taken shelter. The possibility of its dissemination by means of coaches and railway carriages was frequently verified. The epidemiology of malarial fevers strongly corroborates the numerous observations of entomologists as to the constant limitation of *Anopheles* to the same areas. The idea that strong winds might carry mosquitos to considerable distances is erroneous. During strong breezes mosquitos invariably take shelter in thick foliage.

The water collections chosen by *Anopheles* for the breeding of their progeny are not so likely to become entirely dried up as those of *Culicis*; however, this may happen in some extreme drought, and Nature has provided for it by enabling the larvæ to reach the pupal stage in a relatively shorter period. Experiments made by Professor Celli show that the larvæ may continue to live in the moist ground for three or four days, and that the pupæ continue to develop perfectly well even when the mud has dried up entirely.

A few experiments were made to study the relative value of natural enemies as regards the destruction of mosquito larvæ. Among insect enemies, the most destructive to *A. maculipennis* was the larva of a very common and beautiful species of dragon fly (*Libellula erythraea*, Coloured Plate, Fig. 9), the body of which is of the most brilliant geranium colour. Such experiments, however, are of little value, because it is impossible to reproduce *in vitro* the natural conditions. In fact it is quite likely that the larvæ of this dragon fly would have taken other food by preference in their natural breeding ground, as is most reasonably suggested by the size of their curious prehensile organs, usually called "masks," and by their habit of living in the soft mud at the bottom of ponds and ditches. The fact was certainly evident that countless numbers of mosquitos reached their adult stage, notwithstanding the extreme abundance of their natural enemies.

No experiments were made with larvicides; the vast extent of ground covered by innumerable pools, swamps, canals, and ditches, usually thickly overgrown with aquatic vegetation, offered such difficulties that any attempt of the kind would have been hopelessly futile. Undoubtedly there are collections of water suitable to the kerosene treatment, especially in the neighbourhood of habitations, but many of these could preferably be filled up, drained, or stocked with small fish.

The great remedy against mosquitos is the abolition of their breeding grounds; this, of course, is no easy problem. Until then, however, the recent discoveries and experiments show that protection against elephantiasis and malarial fevers may be efficiently obtained by educating colonists in the rôle of the mosquito and in the use of mosquito netting.

DESCRIPTION OF CHROMOLITHOGRAPH.

Fig. 1.—Larva of *Anopheles maculipennis* (Meigen).

Fig. 2.—Larva of *Culex*.

Fig. 3.—Larva of *Diara*.

Fig. 4.—Egg-mass of *Culex* (side view).

Fig. 5.—Egg-mass of *Culex* (from above).

Fig. 6.—Male imago of *Anopheles maculipennis* (Meigen).

Fig. 7.—Female imago of *Anopheles maculipennis* (Meigen).

Fig. 8.—Pupa of *Anopheles maculipennis* (Meigen).

Fig. 9.—Larva of dragon fly.

[All greatly magnified.]