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Some mosquitoes of Mississippi and how to deal with them

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SOME MOSQUITOES OF MISSISSIPPI AND HOW TO DEAL WITH THEM.

BY

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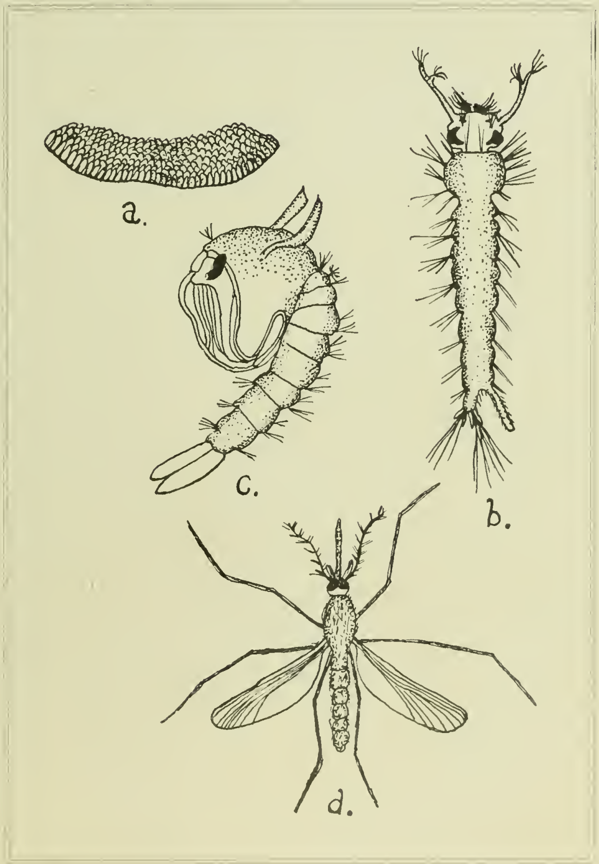

Fig. 1—The Life History of a Common Mosquito, Culex. A—Mass of Eggs; B—Larva ("wiggle-tail"); C—Pupa; D—Adult Female.

AGRICULTURAL COLLEGE, MISS.,
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SOME MOSQUITOES OF MISSISSIPPI AND HOW TO DEAL WITH THEM.

It is not the purpose of this bulletin to give an extended account of the relations existing between mosquitoes and malaria, and yellow fever. It is rather the intention to give some account of the habits, breeding places, life histories, etc., of some of the more common mosquitoes of the State, together with the methods used in getting rid of them. From scientific researches and practical experiments, it has been demonstrated beyond the peradventure of a doubt, that certain mosquitoes inject the malarial germ into the blood of human beings, thereby causing that much dreaded disease, malaria. It has also been shown with what seems almost positive evidence, that these insects are the carriers of yellow fever, from one individual to another. Some of the proofs of the relations existing between mosquitoes and malaria, and yellow fever, will be very briefly given before entering upon the real work of this bulletin. For a more extended discussion the reader is referred to Dr. Howard's book, on "Mosquitoes; How They Live; How They Carry Disease; How They are Classified; How They are Destroyed."

Relation of mosquitoes to malaria.—How often the following sentence is seen in the advertisements of summer resort hotels: "The region in which the hotel is situated is free from malaria and mosquitoes." In the minds of the advertisers there is not an inkling of the connection between the two, yet how naturally and surely the two are always mentioned in the same breath. As though if one is absent both are absent.

It has always been common knowledge that if one goes within doors at early dusk and remains until broad daylight one is not apt to take chills and malaria. In common with this we know that mosquitoes fly and inflict their injuries mostly between dark and daylight.

Everyone knows that malaria and chills are prevalent in regions of marsh and swamp. *Now* we know that just such regions are the homes of mosquitoes. So again we have this strange connection between malaria and these insects. It is remarkable that with all this circumstantial evidence more people did not grow suspicious of mosquitoes long ago. It was not however until 1882, that the idea, that mosquitoes conveyed the malarial germ and deposited it in the blood of human beings was forcibly put before the world. Little notice was taken of it even then, and it failed to come before the people in a convincing manner until the summer of 1900. Then it was that the Italian, Grassi, demonstrated by actual experiment that if people were protected from the bites of certain mosquitoes they could live free from malaria. Again during the late summer and autumn of 1900, two English physicians, Sambon and Low, lived in a house standing in the most malarial portions of the well known Campagna. The house was thoroughly screened so that mosquitoes could not enter. The two men during their entire stay were free from malaria and chills, while the people living outside in unprotected houses were suffering from chills and fevers. At the same time an Anopheles mosquito that had bitten a malarial patient was sent to England and there allowed to bite a person who had probably never had malaria, at least not since childhood. In due course of time after being bitten, this person developed a typical case of malaria.

Finally it has been determined that the germ causing malaria passes certain phases of its life history in a particular kind of mosquito, and certain other phases of its development in the blood of the human body. Furthermore after passing through those stages in the mosquito it is conveyed by that insect and injected into the human blood there to pass the other stages of its development, in the passing of which, malaria is produced.

Relation of mosquitoes to yellow fever.—It is too early to state anything positive in regard to the relation of mosquitoes to yellow fever. We shall simply and briefly give the experiments made in Cuba by a medical commission from the U. S. army.

In a field near Quemados, Cuba, the commission of surgeons erected a small wooden building tightly ceiled and with the windows and doors closely screened so that no mosquitoes could enter. In this house during a total of sixty-three days, seven non-immune men were kept. They used the unwashed pillow slips, sheets and blankets, that had previously been used on the beds of genuine yellow fever patients in Havana and elsewhere. Neither during that time nor subsequently did one of those seven men develop a case of yellow fever. This would seem to indicate that yellow fever is not carried by clothing.

Another house was built in this same field and divided by wire screen from floor to ceiling into two rooms. The doors and windows of both rooms were closely screened with fine wire netting, so that no mosquitoes could enter. All bedding and material carried in was disinfected by steam. In one of the rooms, mosquitoes of a certain kind that had previously bitten patients with yellow fever, were placed. In the other room none were allowed. Non-immunes were placed in both rooms. Of those in the room containing no mosquitoes none had yellow fever. Six out of seven of those in the other room that were bitten by mosquitoes developed cases of genuine yellow fever. This would seem to indicate almost conclusively that mosquitoes of a certain kind are responsible for the transmission of yellow fever from one individual to another.

With all the foregoing knowledge concerning mosquitoes and their positive relations to malaria and their apparent relations to yellow fever, the question of suppressing these insects or keeping out of the way of them becomes a very important one to every person in the State. It has already become a question of life and death with us, and the time has come we believe, when every person should inform himself in regard to the life history, habits, and breeding places, of mosquitoes. If the experiments of the army surgeons in Cuba, demonstrate that quarantine and fumigation are useless, and that yellow fever epidemics can be controlled by controlling the mosquitoes, or by keeping inside of a wire screen out of their way, then we venture to predict that those experiments will go down in the annals of the State as the most important of the 19th Century.

The most common mosquito of Mississippi.—As far as our investigations have gone, the mosquito known as, Culex pipiens, has proved to be the most common one found in the State. We have found it in abundance in all localities in which mosquitoes abound. It is a so-called European species but has now been determined as present quite generally over the Southern States. So far as is known it neither transmits malaria, nor yellow fever, nor any other disease, to human beings. It is, therefore, of importance only because it greatly annoys man. We portray its life history and habits here, because it is familiar to everyone and thus serves as a familiar example to show how mosquitoes live. It breeds in almost every place in which fresh water may be found, in quiet pools, road side ditches, sewer ditches, hollow stumps, rain-barrels, cisterns, tin cans, watering-troughs, etc. Some instances of curious places in which the larvæ have been found will be given later.

Life history.—The life history of this mosquito is made up of four distinct stages, as follows: egg, larva, pupa and adult, (Fig. 1).

Eggs.—The eggs of Culex pipiens are laid on the surface of the water in more or less boat-shaped masses, (Fig. 2). These masses usually taper toward either end and are convex below and concave above. Hence the boat shape, In many cases coming under my observation one end of the mass is wide and rather blunt, while the other is tapering and pointed. Each mass contains from 75 to 300 eggs consequently they vary much in size, as shown by Fig. 2. They measure from ⅛ to ¼ of an inch in length and are plainly visible to the eye. The eggs stand on end in regular rows with the larger

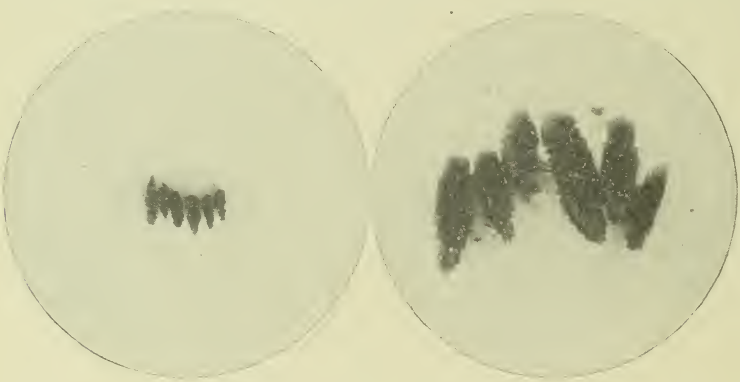

Fig. 2.—Egg-masses of Culex. At left, natural size. At right, enlarged.

ends down. When first laid the masses appear yellowish white because the individual eggs are of that color. A little later they become dark brown in color and appear as small dark objects floating on the water. The under side of the mass appears silvery white because of a film of air beneath it that prevents the eggs from getting wet. It is practically impossible to wet the egg mass. If pushed beneath the surface repeatedly, it as often comes up dry as ever. Very often where there are many egg masses on the water, several of them will run together by capillary action and form a raft of eggs on the surface. I have seen as many as six of these egg masses clinging to each other. Fig. 2 (left) shows these masses as they appeared on the water natural size. Fig. 2 (right) shows the same very much enlarged, and also shows how the masses are made to taper at each end. The rows as they reach the outside shorten. The eggs are loosely held together in the mass and soon break apart after hatching.

Each individual egg is long and cylindrical, larger at the lower end, and tapering to the upper end. As seen from the side it resembles the blade of a knife (Fig. 3). They vary from .88 mm. to .91 mm. in length and from .17 mm. to .20 mm. in width at the base. The lower end is blunt and furnished with a cup-like frill (Fig. 3). In the center of the cup is a papilla-like projection (Fig. 3). Both the papilla and fringe, or frill, break away when the egg hatches and the young larva emerges through an opening made by a sort of lid that breaks away for its egress. In the center of the lid is what we have termed an eye-spot (Fig. 3). In looking over notes made in June 1901, it is found that in no case did the eggs hatch in less than 24 hours. Although the eggs were seen as they were being deposited it was under conditions that prevented me from noting the exact time taken to hatch them.

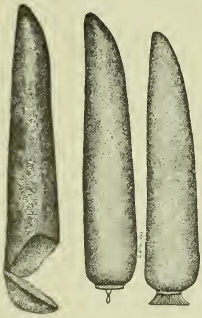

Fig. 3.—Eggs of Culex pipiens, enlarged.

Egg-laying of Culex pipiens.—On July 17th, in the back yard of a hotel at Magnolia, Mississippi, the writer found a pig trough five feet long, containing water to the depth of about six inches. On the surface of this water by actual count there were 257 masses of eggs of *C. pipiens*. Since there were less than five square feet of surface, one can imagine the density of egg population. It was noticed that about a dozen of the egg masses were white, or yellowish white, in appearance. This led to a more careful examination, which resulted in the discovery of a female about to finish laying a batch of eggs. Time, 6 A. M. At this time it was broad daylight and evidently all of the white masses had been laid within the hour. From repeated observations made at other times I am convinced that the eggs are laid in some instances during the night at least some time before daylight. The mosquito was so busily engaged that I could watch her with a hand lens. She rested on the surface of the water with her slender legs spread out and supported by the surface film, exactly as the water-striders or Hydrobatidæ. This is contrary to the idea heretofore held, that the female when depositing eggs, rests on some floating object. The abdomen was held at a slight angle to the surface because the caudal end was nearly touching the surface. The mosquito stood at one end of the mass, with her head away from it. As the eggs were deposited, the mass was gradually pushed away from her. The end of the abdomen was slowly carried from side to side, so that the eggs might be placed across the end and the whole mass filled out and completed as she progressed. The process may be compared with the action of the hand as a bobbin is wound with thread. The eggs always came forth with the small end first. This end, since the abdomen was held close to the mass, would strike the other eggs and appear to be slipped along the perpendicular sides of the others, and thus be brought to an upright position. However, the tip of the abdomen was curled slightly upward, so that the egg was directed upward and very likely would have been deposited in an upright position in any case. It would have been interesting to have seen the first egg deposited. There was an appreciable interval between the deposition of each egg, perhaps two seconds, although we did not time it.

Larva.—When the egg hatches there issues from it what is known as the larva, or "wiggle-tail." Every-one that has looked into rain barrels that have stood for some time during hot weather has surely seen "wiggle-tails." These are the products of mosquito eggs. The larva of Culex pipiens rests for the greater part of the time with the tip of the abdomen at the surface of the water, and the head hanging downward at an angle of about 40 degrees. The head of the young larva is very large in comparison with the rest of the body (Fig. 4). Soon however, the thorax becomes larger. At the tip of the eighth abdominal segment is a long tube known as the respiratory tube (Fig. 5 R.) It is through this tube that the larva takes in its supply of air. This fact accounts for its position with the tail end up and the breathing tube just at the surface of the water, so that air may be drawn through it to sustain life. At the same time two dark

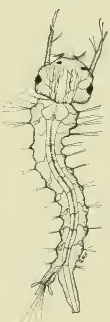

Fig. 4. Larva of culex pipiens, just hatched,—enlarged.

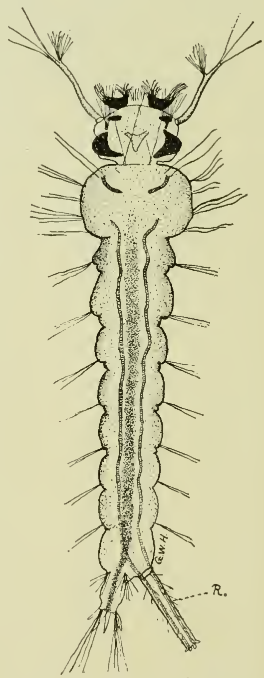

Fig. 5.—Larva of Culex pipiens, nearly mature. R.—Respiratory tube.

brushes of hairs about the mouth can be seen in constant vibration, by which currents of water are set up and food thus brought to the animal. In a jar containing many of the "wiggle-tails" some may always be seen wriggling to and from the bottom. If any one be singled out and watched, it will be found that it remains at the bottom only a very short time. This depends upon the amount of food and its availibility. That is to say, in repeated observations, I have never seen them stay at the bottom in jars containing plenty of food that they can easily get longer than one to two minutes at a time. Where there is a scarcity of food they will occasionally add a minute to this time. Like Culex pungens it is heavier than water and descends to the bottom with very little effort. In ascending it puts forth considerable effort and wriggles violently.

Dr. Howard in his observations on Culex pungens says, that "they appear to pass through three different stages of growth." No doubt the larvæ of Culex pipiens do the same but we have been unable to determine definitely. One thing however is certain; namely, that the young larvæ molt within one to two days from hatching. On the second or third day the cast skins may be seen in abundance floating on the water. Of course the time of molting will depend somewhat upon the supply of food.

The larval stage lasts from five to six days. Our entries run as follows: Eggs hatched June 5th. By noon of the 11th, there were several pupæ. Eggs hatched morning of the 24th. On the morning of the 29th there were six pupæ in jar. On morning of the 30th there were a great many pupæ in jar.

Pupa.—The illustrations show the great differences between the larva and pupa. The pupa (Fig. 6) is mostly head and thorax, with but a slender abdomen. The breathing apparatus now consists of two respiratory tubes instead of one and moreover are situated on the thorax instead of on the end of the abdomen as in the larva. As a result of the change in position of the breathing tubes, the pupa floats in the water with the head up. It is as active as the larva, when disturbed. When undisturbed it floats at the surface of the water without effort because it is lighter than water. It takes no food consequently does not need to move except for protection. When in motion downward, it wriggles violently, similar to the

Fig. 6.—Pupa of Culex pipiens, enlarged.

movements of the larva, but when ready to ascend simply floats to the top without wriggling.

At noon of June 11th, there were several pupæ. On the morning of the 13th, several adults were taken from the jar.

June 29th, there were six pupæ. On July 1st, several males were taken from the jar but no females.

This gives the pupal stage as existing from one and a half to two days.

Note that males preponderate during the first day. This was true in every case observed.

The time then necessary for the full development of a generation of mosquitoes, in hot weather, is from eight to ten days.

With these facts before us imagine how many mosquitoes might have come from that one little pig trough during the month of July.

Adult.—The full-grown Culex pipiens is a moderate sized mosquito. The wings are slightly darker than those of Culex pungens, and appear somewhat heavier, (Fig. 7). In order to be able to distinguish between this common mosquito and the malarial mosquito, it will be necessary to note in particular the appendages about the mouth. In the first place look at the figure of the head of the male Culex, (Fig. 8), and note the two feathery appendages bearing long hairs. These are the antenæ. On the other hand note that the antenæ of the female, (Fig. 8), bear only a few short hairs. The males of all mosquitoes may be known from the females by this difference, except in possibly, very rare cases. Again in looking at the head of the female Culex only one long projection will be seen running straight out from the head. This is the proboscis. On each side

Fig. 7.—Adult female of Culex pipiens, enlarged.

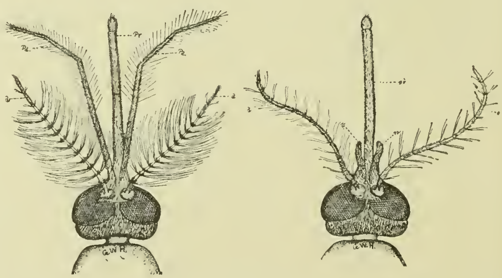

Fig. 8.—At left, head of male of Culex. At right, head of female of Culex. a. Antennae; pa. palpi; pr. proboscis.

of the proboscis near its base is a very short projection. These are known as the palpi. In the female Anopheles these palpi are nearly as long as the proboscis. Consequently the malarial female mosquito will always have three long projections from the head, whereas Culex has only one. (See figure 14.)

Malarial mosquitoes of Mississippi.—So far as is known there are only three species of malarial mosquitoes in the United States, and they all belong to the genus Anopheles. In fact so far as is known all malarial mosquitoes belong to this genus. Up to the present time one of these only, has been taken in Mississippi.* That one is Anopheles punctipennis. It has been taken at Agri. College out doors in June and October, and in the house in January. During July the writer found it in abundance in McComb City. Mr. James Brodie has sent it to us from Biloxi. There is no doubt that it is distributed widely over the State.

Breeding places.—Some time during the latter part of May, 1901, a ditch about four feet in depth was dug for the water main to the new textile building on the campus. The ditch was dug in sections, one of which ran down a considerable slope just at the end of the photographic building. This section of the ditch soon became partly full of rain water. At the lower end the water was two and a half feet deep, but the water did not extend more than a third of the length of the ditch up the slope. At the upper and shallower end of the body of water, it soon became covered with a thin green slime, which upon examination proved to be wholly of Protococcus. In this shallow, slimy water on June 4th the writer discovered an abundance of larvæ of Anopheles Punctipennis. They were recognized at a glance as larvæ of Anopheles from Dr. Howard's excellent drawings and descriptions of the larvæ of Anopheles maculipennis. Glass jars were immediately called into requisition, and many larvæ were carried to the laboratory, from a study of which the following notes were made. It might be of interest to say just here that there was also an abundance of larvæ of Culex pipiens in the same water in company with Anopheles.

In McComb City they were found in pools along the street-side ditches, only one block from Main street. At the time I took these specimens there was a severe case of malarial fever in the hotel not twenty rods from their breeding places. The pools were free from any algal growth on the surface but the bottoms were covered with

*Since writing the above I have taken A. maculipennis meigen, at Agricultural College. December 11, 1901.

a fine slimy sediment. In one of the pools where the larvæ were most abundant, cows driven along the street were in the habit of drinking. Another pool was a favorite place for swine to wallow. The water was muddy in both but not foul.

In Mocksville, North Carolina I found them abundant in pools left from dry brooks. The water was clear and wholesome, without plant growth on top. They were also found in the large quiet pools of a constantly flowing brook but not in abundance. It is interesting to note that on each side of this brook was a severe case of malarial fever.

On October 31st, near the College, I found Anopheles punctipennis (larvæ and pupæ), in shallow pools formed in impressions in the mud made by the feet of cattle around the edges of a large surface pool. These tiny pools contained no visible plant life on the surface, but the bottoms were of very fine slimy sediment and probably contained an abundance of food. Here also there has been considerable malaria among students and faculty. It will be noted in a study of the above breeding places that not one of them contains foul water, like the sewage water in which Culex was found. Evidence so far obtained indicates, that A. punctipennis does not breed in foul water. On the other hand while examining one of the sewer ditches spoken of above, I found an adult female Anopheles punctipennis clinging to the grass blades, growing close to the water's edge. Very careful search, however, failed to disclose any larvæ or eggs on the water anywhere along its course. It will further be noted that in not every case by any means, was there an algal or slimy growth on the surface of the water, although there was in every case an abundance of food on the sides and bottoms of the pools.

Dr. Howard has found the larvæ of Anopheles maculipennis, a very closely related species, breeding in very foul water, and it may be, that later we shall find this true of A. punctipennis.

Life history.—Like Culex pipiens the life history of Anopheles is made up of four distinct stages. (See figure 1).

Eggs.—The eggs of Anopheles punctipennis are laid singly and at random on the surface of the water, but naturally run together and cohere in loose irregular groups or strings of from three to a score or more. This is totally different from the boat-shaped masses of Culex eggs. The individual eggs differ greatly in shape from those of Culex. The egg of Anopheles is strongly convex below and concave above. As seen from the side it is canoe-shaped. One end is larger and more blunt while the other and sharper end curves upward, (Fig. 9). Along each side runs a transparent and transversely wrinkled appendage, called the clasping membrane. It is said that this is for the purpose of keeping the concave side of the egg uppermost. When handled a great deal and especially after being kept in alcohol, this membrane breaks entirely away from the egg. This was especially true of the eggs put through several different strengths of alcohol and then brought from North Carolina. These eggs did not show the hexagonal markings seen in the first ones studied which is somewhat puzzling. The eggs varied from .55 mm. to .57 mm. in length.

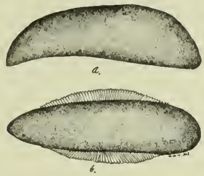

Fig. 9.—Eggs of Anopheles punctipennis. a. side view. b. from below, enlarged.

They hatched in 24 to 48 hours after being brought in, but no record was obtained as to the actual time of hatching after being laid, as none of the females laid eggs in captivity. It is probably safe to say, however, that they accord in this particular very closely with *maculipennis*.

Larvae.—As we have already pointed out the larvæ of Culex

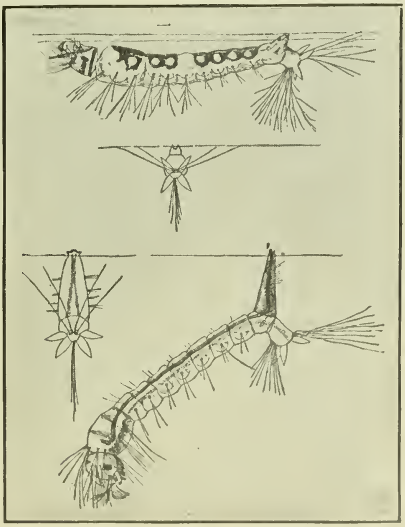

Fig. 10.—At top, half-grown larva of Anopheles in feeding position just beneath surface film. At bottom, half-grown larva of Culex in breathing position. Enlarged. After Howard.

pipiens hang from the surface of the water, as it were, with the head downward. On the contrary, the larvæ of Anopheles (Fig. 10) lie in a horizontal position, apparently on the surface of the water. Really they are just beneath the surface film. Their breathing tube is very short and consequently they are obliged to lie close to the surface in order to get air. They can be readily recognized by this horizontal position. When disturbed they wriggle across the water in a horizontal direction, especially the younger larvæ. It will be recalled that the larvæ of Culex are constantly diving below in a vertical direction. As the larvæ of Anopheles become older they more readily wriggle downward. Among the microscopic differences may be mentioned the hairs along the sides of the body. In Culex these hairs are not branched, while in Anopheles they are. (Fig. 11). The young larvæ have a decidedly streaked appearance owing to at least three whitish stripes running transversely across the body. The hinder part of the third abdominal segment is more or less transparent and appears to the naked eye as a white streak. The forward part of the thorax is also transparent and appears as a white streak. Finally the hinder part of the seventh segment and the forward part of the eighth is somewhat transparnet and forms the third streak of which we have spoken. Besides these transverse streaks the whole body has a more or less mottled appearance owing to transparent spots in the body. As the larvæ grow older they lose the streaked appearance but retain the mottled effect to a considerable extent.

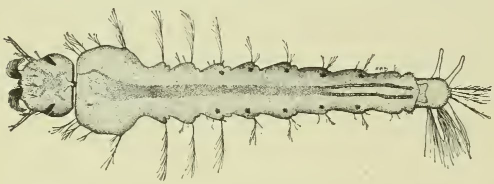

Fig. 11.—Larva of Anopheles punctipennis as seen from above, enlarged.

The feeding habits of Anopheles larvæ are very interesting and remarkable. The head is joined to the rest of the body by a very slender neck, on which it readily and rapidly rotates, at least half way around. When in position beneath the water film the body is in a normal position. That is, the upper side of the body is uppermost and the under side faces the bottom of the jar. The head however, is turned just half way around so that the under side is uppermost. This is its customary feeding position. If for any reason it attempts to swallow a piece of food too large and there is difficulty in getting it down, the head turns back with lightning-like rapidity. All the time the brushes of hairs about the mouth are in motion bringing to it particles of food.

The duration of the larval stage, under normal conditions with plenty of food, varied from twelve to fourteen days.

On June 5th three larvæ were placed in a jar containing very little food. What food there was lay among some sand at the bottom. Two of them were very young, while the third could not have been more than half grown. These larvæ remained there until June 29th, when the two younger died. These two did not go to the bottom after food and probably starved. The third and more mature one did go to the bottom after food and remained alive until July 3rd, when it was transferred to water containing an abundance of food. In a few days it transformed to a pupa. In this case the larval stage was over a month and could doubtless have been prolonged.

Pupae.—The pupæ of Anopheles are not strikingly different from those of Culex pipiens to the unaided eye, A close observer, however, can learn to distinguish the two with the eye by the difference in length of the respiratory siphons. Those of Anopheles are much shorter and wider as shown in figure 12. The head of Anopheles is narrower and more pointed than that of Culex (Fig. 12). The difference in size and shape of the thorax is also shown in figure. Like the larvæ the pupæ tend to wriggle in a horizontal direction when disturbed. They are not as active as those of C. pipiens, which fact is brought out very forcibly when one attempts to make a camera lucida drawing of the living pupæ of both in their natural position in the water.

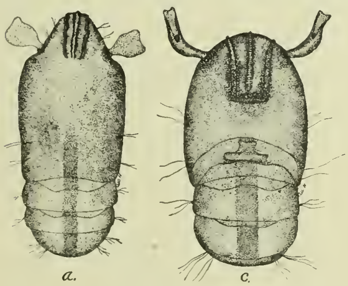

Fig. 12.—Pupae of Anopheles punctipennis.—a, and Culex pipiens, c, as seen from above in their natural position in the water, enlarged.

The pupal stage of both males and females lasted with great regularity just about two days. At least it could not have varied more than a few hours from this, as the adults were found in every case on the second morning subsequent to the morning on which the pupæ were found.

To sum up then, the entire duration of the early stages of Anopheles punctipennis under normal conditions in July was sixteen to eighteen days. That is, the egg stage was two days; larval stage, twelve to fourteen days; pupal stage two days. This indicates that in a pool where these mosquitoes breed there can be developed every sixteen to eighteen days a new lot of adult mosquitoes ready to convey malaria. It further indicates that if such a pool be treated with kerosene oil, it will need an application once in every sixteen to eighteen days or three weeks at the most, to be perfectly safe.

Adults.—The full-grown male and female Anopheles punctipennis, (Fig. 13) are somewhat larger than those of Culex pipiens.

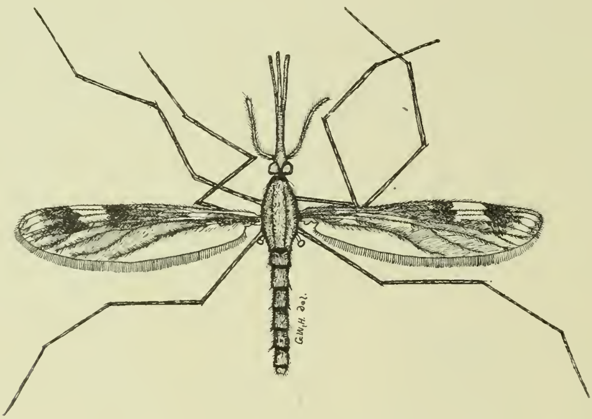

Fig. 13.—Female of Anopheles punctipennis; enlarged.

The wings appear of a heavier texture and show a spotted appearance owing to the well defined spaces covered with whitish scales. Situated on the front margin of each wing, three-fourths of the length of

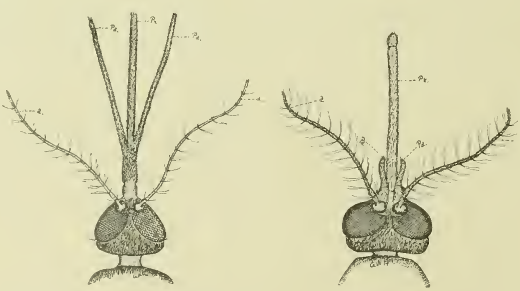

Fig. 14.—At left, head of Anopheles showing appendages. At right, head of Culex showing appendages. a, antennae; pa, palpi; pr, proboscis.

the wing from the body, is a yellowish white spot. These two spots together with the other smaller ones give the mosquito a very handsome and distinctive appearance.

As we have explained before, the female Anopheles may also be distinguished from Culex by the three long projections on the head, (Fig. 14). That is, in A. punctipennis the palpi are nearly as long as the proboscis.

As has already been pointed out there are three species of Anopheles in the United States, only two of which we have as yet found in Mississippi. The other one however, has been seen in New Orleans in enormous numbers and there can hardly be a doubt that it occurs in this State.

Yellow fever mosquito.—The mosquito used in the experiments already detailed in Cuba, and that was there responsible for communicating yellow fever to six out of seven people bitten, is common in Mississippi. It is known to most of us as the "day mosquito." It is easily recognized from the habit of flying and biting during the day and from its white banded legs and body. We have taken this mosquito here at the College, at Summit, Miss., and at Magnolia, Miss. It is common in all the warmer countries of the earth. It has been taken in Cuba, West Indies, Louisiana, Texas, Arkansas, Georgia, and as far north as Virginia. It is a significant fact that its range is coincident with that of yellow fever.

At present I can say nothing of its breeding places in Mississippi. Of course it breeds in water like other mosquitoes and has been found by other observers, breeding in cisterns and rain-water tanks. Dr. Howard figures the larvæ and pupæ and says that these stages do not differ greatly from those of the species of the genus Culex.

This mosquito has in fact, been included heretofore in the genus Culex under the name Culex fasciatus. It has now been placed in a separate genus under the name Stegomyia fasciata, Fabricius.

Other species of mosquitoes taken in Mississippi.—Culex pungens Wied., Agr. Coll. Culex tarsalis Coq., Agr. Coll. Culex confinis Lynch., McComb City. Culex consobrinus Desv., Biloxi. Psorophora ciliata Fabr., Biloxi. Conchyliastes musicus Say, Agri. Coll. Anopheles maculipennis meigen, Agri. Coll.

Culex confinis.—On July 15, 1901, at McComb City I found many large larvæ among thousands of smaller Culex larvæ in a sewage ditch and in some roadside pools. They were so large that they attracted my attention at once. Several of them were collected in wide mouthed bottles, transported some distance, and the adults obtained. The pupal stage was passed in about three days but I believe it was somewhat hastened by the unfavorable conditions.

The larvæ bore such a strong resemblance to those of psorophora ciliata that I referred to them, in my notes made at the time, as such. The breathing tube is larger than that of Culex pipiens or pungens. The four anal flaps are longer and more pointed.

Adult.—The mature mosquito is considerably larger than Culex pipiens. The legs are banded with white. In this respect it resembles Stegomyia fasciata but is larger and has not the conspicuous silver stripes on the thorax.

Breeding places of mosquitoes.—In trying to get rid of mosquitoes it is essential, first of all, to find their breeding places. Consequently it becomes of prime importance to know the nature of the places in which the eggs, larvæ and pupæ may be found.

In general, it may be said that almost any body of fresh water in almost any situation if left standing long enough, will become infested with larvæ of mosquitoes. The favorite breeding places at the College, are three ditches, all of which receive sewage. The waters in all are loaded with filth and at times reeking with foul odors. In the ditch that receives the sewage from the main system I have seen a black fringe of larvæ on both sides for over a mile. It is interesting to note that the tributary ditches to this one, containing water uncontaminated with sewage, have no larvæ in them.

It is ordinarily supposed that mosquitoes breed only in stagnant water or water that is changing very little. Here however we have found them breeding in considerable numbers in at least three different troughs for watering stock. These are furnished with hydrants, and in one case the water ran in at one end and out at the other all the time. In the other two the water was turned on only when the stock was drinking. In each case there was plenty of plant food on the sides and bottoms of the troughs for the larvæ to eat.

Here then in these cases we have the extremes of conditions. In the first, the water was full of decaying animal and vegetable matter and mosquitoes bred there by the million. In the latter the water was comparatively fresh and pure, yet they bred there in considerable numbers. Cisterns tight enough to be dark within often become infested with mosquitoes.

The Experiment Station office building suddenly became overrun with mosquitoes in the early part of July. It occurred to me to investigate a room in the second story left vacant by students about June 25th. As was expected they had left a bucket two-thirds full of slop water which was swarming with larvæ and pupæ. After being emptied the mosquitoes disappeared in the course of a week.

Mr. W. J. Gallaway tells me of finding an abundance of "wiggletails" in a glass globe of water standing on a table in the parlor of a house at which he was visiting. Fish had been kept in the globe, among some water plants growing there. The fish had died some time before and been thrown out and now the family were wondering where the mosquitoes were coming from.

As before related I found 257 egg masses in a small pig trough. In fact they breed in tin cans in which water is left standing or in almost any receptacle containing water.

The number of mosquitoes that may be produced from a small area of water.—In the case of the pig trough we had about five square feet of surface. If there were on an average 150 eggs in each mass, then this five square feet of water surface would furnish 38,550 wiggle-tails. If only one-half of them reached maturity it would be sufficient to stock a whole town.

Enough mosquitoes would develop from a rod of either of the ditches mentioned above to make every house on the campus uncomfortable.

Enough developed from the one bucket of water left by the students in their room, to necessitate using a bed net in every room in the Station building in order to sleep with any comfort.

It is interesting and enlightening to give in this connection some figures by Dr. Lugger, as to the actual number of mosquitoes bred from an ordinary rain barrel during the summer season. Dr. Lugger says, "on July 6th. the water in one barrel was filtered. It contained 35 grams of mosquitoes (wiggle-tails), each gram by count numbering 217, hence 35x217 equals 7,595 larvæ and pupæ. Besides this, 32 egg masses each containing on an average 302 eggs were found, which would hatch into 302x32 which equals 9,664 mosquitoes." In other words one rain barrel on July 6th. had in it potentially 17,259 mosquitoes.

How far do mosquitoes fly?—Only one personal observation can be added to this already much discussed but still unsettled subject. During the summer of 1899 while absent from the College, the mosquitoes became exceedingly abundant in the houses on the northern end of the campus, while those on the southern end were practically free from them. These houses are about one-half mile apart. About ten days to two weeks from the time they appeared on the northern end they became somewhat annoying on the southern end of the campus. By that time their breeding place had been discovered and the larvæ and hundreds of the adults had been killed with kerosene. It is important to note that they did migrate at least one-half a mile. It should be said however, that there were buildings all the way between the two ends of the campus, whereas had it been clear open ground, perhaps they would not have gone so far.

Dr. Howard gives several observations to show, that in cases where people thought they were troubled by mosquitoes that had come from a long distance, they were really troubled by those breeding in over-looked pools near by. He does not believe that these insects fly far except under conditions that do not ordinarily occur.

The question is an important one, because it would be very discouraging and seem almost useless to spend time and money in destroying mosquitoes near at home, if one's neighbor two or three miles away allowed them to breed there.

How late in the year will mosquitoes breed in Mississippi?—As this paragraph is being written, on the 11th. of November, mosquitoes are depositing eggs freely and developing in abundance everywhere.

From some observations made in the autumn of 1900, it will be seen that under certain conditions mosquitoes will breed much later than this. During the late summer of 1900, my cistern had been emptied of water, repaired, and allowed to remain in that condition awaiting the winter rains. Some time in December, mosquitoes became abundant in the house. Later my attention was called to the fact that they were also in abundance in the mouth of the cistern which was covered with wire gauze. On the 24th. of December the writer examined the cistern and found four or five inches of water in the bottom that had run in before the inlet had been closed. In this water we found a considerable number of larvæ and pupæ. In the neck of the cistern were many adult, active mosquitoes, of the genus Culex. Undoubtedly they would have gone on breeding in there for some time, because the air in the cistern was warmer than the outside air although it had been a very mild autumn.

These observations are important, to show how late in the season one must fight mosquitoes to keep rid of them. It will not do to relax in our warfare before December in ordinary cases and in special cases considerably later than this.

Remedies for mosquitoes.—To fight mosquitoes effectually we must attack them in some one of their immature stages; namely, egg, larval or pupal stage. It is not practicable to destroy the adult insect in any numbers.

The three principle means by which we can destroy the larvæ and pupæ of mosquitoes are as follows: by draining a pool, by introducing fish into a body of water, and by placing a thin film of oil on the surface.

Drainage.—This remedy hardly needs discussion. It is obvious that if a pool be drained or a bucket or barrel be emptied no mosquitoes can breed there. In our work against mosquitoes here at the College, in some cases, tanks not especially needed have been taken down. This should always be done whenever possible because a tank down and out of the way will be sure to give no trouble. All receptacles, like buckets, barrels, etc., are carefully looked after and emptied at least once a week and permanently if possible. The two ditches that have troubled us most are to be tiled and the water conducted to the main sewer in which it will be carried a long distance from the College. When this is done I confidently expect that our trouble from mosquitoes will be entirely stopped. In many cases, it is much easier to draw a wagon load of earth or even more to fill up a small shallow pool than to dig an outlet. Draining is the most desirable means of fighting mosquitoes because if once well done it is always done and needs no attention afterward.

Fish.—Much of the drinking water for the stock in this State is caught and stored in surface pools. The stock is allowed access to these pools at any and all times. The consequence is, that the water is apt to become more or less filthy and in addition a breeding place for mosquitoes. Such pools cannot be drained because the water is absolutely essential for the stock. Neither is it desirable to pour oil on the surface because the water is thereby rendered unpleasant and obnoxious to the animals. In such cases the best remedy against mosquitoes is the introduction of certain kinds of fish into the pools. There are on the College campus no less than four such pools. They are all stocked with fish and up to the summer of 1901 I had never seen a "wiggletail" in any of them. In the early part of the summer I found a great many mosquitoes coming from one of them, and since this particular pool was of no actual necessity it was drained. In the draining very many fish were taken from it. They were all of a species of trout and were remarkably similar in size, ranging from seven to eight inches in length. I believe that these fish had grown too large to be of any value as destroyers of "wiggletails." They had become too large to enter the shallow places about the edges of the pools and these are just the situations for mosquitoes to breed. Another fact should be mentioned. A year ago large numbers of small bull-head fish in the pool died from the effects of a peculiar and unknown disease. It is quite possible that these smaller fish had been the means of keeping the pool free from mosquitoes and at their death it became an open breeding place for them. It is evident that small, active fish with voracious habits of eating, is the kind needed for destroying "wiggle-tails," and pupæ. A species of fish meeting these requirements is one known as the Top-minnow (Gambusia affinis). These never grow to be more than one to one and three quarter inches long. They are active and voracious and feed near the top and penetrate to the shallowest parts of the pool about the edges. Here they find themselves safe from their enemies, the larger fish, and at the same time in the presence of desirable food. They are common in all the streams of the Gulf states, hence just suited to their environment. Dr. Howard writes of this fish as follows: "It feeds largely on vegetable matter but also on insects. Larval mosquitoes have been found in its stomach." Again he says, "Dr. H. A. Veazie, of New Orleans, writes me, that this little fish is common about New Orleans and that where it is present he has not been able to find mosquito larvæ of any kind."

One objection to using the Top-minnow is that it easily falls a prey to other fish from the fact that it is a soft-rayed fish and thus without means of defense.

A fish which will perhaps answer better than the Top-minnow although larger, is the common "Pumpkin-seed" or Sunfish. It will answer better because it is wholly a carnivorous fish and because its fins possess spine rays and afford it protection from being eaten by larger fish. The latter fact makes of it an available fish for pools already inhabited by larger fish. It is a very prolific fish and its young do not grow rapidly. They therefore will remain small enough during the first year to enable them to penetrate the shallowest parts of a pool. By the next season there will be another generation of small sunfish and thus the supply of small fish is maintained from year to year.

One of the best solutions, so far developed, of the mosquito question in permanent pools is the introduction of one or more of the species of fish mentioned above. There still would remain those tiny pools made in the foot-prints of stock, about the permanent pools in which I have especially noted the breeding of Anopheles punctipennis. These pools of course could not be reached by any fish from the main pools, because they are transient and isolated. These must be treated in a manner to be explained in the following paragraphs.

Oil as a remedy for mosquitoes.—The power that oil has, to kill the larvæ and pupæ of mosquitoes has been known for some time. Its practical use against these insects has been of comparatively recent date.

How it kills.—If oil be poured upon water it will sooner or later spread evenly over the surface in a thin film. This film has a comparatively strong tension, and speaking from the standpoint of an insect, is very difficult to break. The larvæ and pupæ of mosquitoes as we have already shown breathe air direct by thrusting the ends of the respiratory tubes out of the water. As they come up beneath the oil film, to obtain air they are unable to push their tubes through the oil and thus are completely shut off from the air and in a short time drown from suffocation. It may also be that the oil as it comes in contact with the respiratory tubes produces injury which hastens death. If any eggs are lying on the surface of the watər and are touched by the oil they are destroyed. Likewise the adult female mosquitoes are caught in the oil and killed when depositing eggs.

Results of work with oil at the College.—As before stated our trouble with mosquitoes has come from the two sewage ditches described above. The banks of both these ditches are covered with grass and weeds that in many places overhang the water. The current in each is plainly noticeable. For instance, a straw will float steadily down stream, perhaps one-fourth as fast as a man can walk. This current has exercised a decided influence upon the manner of the application of oil to be detailed below. In the summer of 1899, in which the mosquitoes became so abundant in the ditch receiving the hospital sewage, I used an ordinary five gallon knapsack sprayer and a Deming "Bordeaux" nozzle to distribute the oil which was ordinary illuminating oil. I found that in so doing literally thousands of adult mosquitoes, that were resting unobserved on the grass and weeds that overhung the water and arose in swarms as the oil struck them, were killed and fell back to float away with the larvæ. This summer upon my return to the College in September, I found the other sewer ditch in precisely the same condition and gave it exactly the same treatment with identical results. If the oil had been quietly poured on the surface the adult mosquitoes would not have been touched because the current would have carried the oil away before night came. Again, by spraying the oil, it reached the shallow places along the bank and drove the larvæ and pupæ out into the current where they floated down stream, in millions, to be drowned. Had the oil been poured on, it would not have reached the shallows as will be shown in the next paragraph owing to the strong current. In such case a majority of the larvæ and pupæ would have escaped.

Is the pouring of oil into water-closets effective in sewer ditches?—It has been asked of the writer so many times whether or not the same thing could be accomplished by pouring oil into the closets and allowing it to run down the sewer pipes, as by spraying, that it seemed worth while to give this point considerable attention. Accordingly I poured two quarts of illuminating oil on the surface of the water in the main sewage ditch near the mouth of the tile to watch its effect below. A fairly quiet pool about two rods long and about fifteen rods below the outlet was selected as the first place of observation. Both sides of the pool were lined with multitudes of larvæ and pupæ lying in the shallows and in the miniature bays hollowed out of the sides of the bank. The current was about the rate described above. By the time the oil reached the pool it was well distributed. The result was, however, that the current was too strong to allow it time to spread into the quieter parts and bays of the pool. It was carried for the most part straight by. Many of the larvæ and pupæ however, lying next to the current were so greatly disturbed that they blundered into the middle of of the stream and were drowned beneath the film of oil. In a second and similar pool, about ten rods farther down, the effect was noted again. The oil had spread out even more by this time but the effect was about the same. The majority of larvæ and pupæ escaped, because the current gave the oil insufficient time to spread over them. Nevertheless, I believe that several applications of oil say one or two hours apart would kill the majority of larvæ and pupæ in such pools. A similar experiment repeated in another ditch gave precisely similar results with one additional point worthy of note. In one of the pools carefully observed, a thin mass of Algæ and scum rested over quite an area adjacent to one of the banks. In it were many larvæ and pupæ. Into this mass the oil never penetrated and in my opinion with that current never would, no matter how many applications were made.

It would seem then, that the only sure and quick remedy for such places is to spray the oil on. By this method many adults are killed at the same time. If poured into the sewer several successive applications must be made to be in any great degree effective, and even then in pools where there was Algal slime it would have no effect. It is evident that if the sewer pipes empty into pools or bodies of water with no current the above conclusions would not apply.

Success attending the application of oil to the breeding places of mosquitoes.—Up to the time the writer left the campus, August 7th. no one had had any occasion to use a mosquito bar. In fact there were no mosquitoes on the campus. All tanks and vessels containing water had been carefully looked after and either treated with oil or emptied. The ditches in question had been treated every two weeks with a coat of illuminating oil. It was only after my absence when there was no one to look after the ditches that they became breeders of mosquitoes. I am thoroughly convinced that any neighborhood in Mississippi, under ordinary conditions, can keep free from mosquitoes if the proper effort is put forth. Every man should become interested enough to take care of his own premises, and a reliable, observing, careful man should be detailed and paid to look after all places that seem to fall to no one especially.

Kinds of oil to use.—In all my experiments here, ordinary kerosene oil, such as is used for illuminating purposes was used. In the first place the ditches with their strong currents, needed a light oil that would spread as rapidly as possible. In the second place, petroleum has cost us just as much as the refined oil, even if bought by the barrel. Now that the Beaumont field has been opened up, perhaps we can buy petroleum more cheaply. For bodies of water that have no current a heavy oil would be superior to ordinary kerosene because the former would not evaporate so quickly and thus need not be applied so often. On the other hand, an oil too heavy will not spread easily but will gather in spots here and there over the surface, thus losing its effectiveness. Dr. Howard says, "so long as the oil flows readily and is cheap enough, the end is gained, provided it is not too light and does not evaporate too rapidly." Other experimenters have found, that what is known as "Light Fuel Oil" sold by the Standard Oil Co. is the most satisfactory.

Amount of oil to use.—It takes six gallons of oil to spray the shorter ditch of which we have spoken, if the weeds and grass along the banks are sprayed as in the first case. This ditch is about thirty rods long. Ordinarily the sides are not sprayed and in this case three gallons are amply sufficient. The ditch can be given a good spraying by one man in half an hour. The expense of one spraying then is as follows: Three gallons of oil at 18 cents each equals 54 cents; one hour of a man's time, 15 cents; total 69 cents. At this rate it would cost $1.38 per month to keep this ditch free from mosquitoes if sprayed twice a month as it ought to be. With care it could be done more cheaply.

With still quiet pools where no current exists the amount of oil to be used differs very greatly from that mentioned above. On a quiet pool where the oil remains until it evaporates, a little will spread over and cover a large space. Careful experiments in this line have demonstrated that, in general, one ounce of kerosene is sufficient for every fifteen sq. ft. of surface. At this rate a tank ten feet across would require about one and one-half pints of oil which would cost about three and one-half cents. If the ditch spoken of above had no current and averaged two feet wide for the whole thirty rods, it would cost only about ten cents for the oil to treat it. Actually in treating tanks and still bodies of water I use two or three ounces to every fifteen sq. ft. of surface. For instance, in treating a wooden tank on Nov. 9th. that was seven feet across, I used two quarts of oil which was amply sufficient. A teacupful or even a half a teacupful is sufficient for an ordinary rain-barrel.

How long will the oil remain effective?—It is important to know the length of time that an application of oil will remain effective because this will determine in some measure the frequency of application.

The tank spoken of above, stands in the north-east corner of the Station office building in an angle made by the ell and main part.

In this position it receives only the morning sun and that for only a short time. This fact must be taken into consideration in the following observation.

On the 9th. of October we treated the tank to an application of two quarts of oil. On the 16th of October, just one week from that

FIG. 15.—Spraying a grass-grown sewage ditch, with an ordinay knapsack sprayer and "Bordeaux" nozzle for mosquitoes.

time, and a week of clear, dry weather, I examined it and found a thick coat of oil on it still. In stirring the water with a broom stick the handle was so thickly coated with oil that it had to be carefully and thoroughly wiped before it could be used. It seemed to me that the oil was nearly as thick as when first applied, but of course some must have evaporated. At any rate it was sufficient to be perfectly effective against larvæ, pupæ and adults. We intended to make an observation later, but unfortunately it rained in the meantime and the tank ran over. Thereby hangs another point that should be mentioned. In treating bodies of water that are liable to overflow the application must be made oftener, because the oil is the first to run off since it is always on top.

In this instance the oil was effective for a week and I am sure would have been so for another seven days. Dr. Howard says, that the oil is effective for some days after the odor has disappeared and after the iridescent effect on the water has ceased to be perceptible to the eye.

How to apply the oil.—As detailed above the writer believes the best method of applying oil to ditches to be by spraying it on with some kind of a force pump. Our knapsack sprayer holds five gallons of oil and has twelve feet of one-half inch hose attached. The hose is furnished with a "Bordeaux" nozzle which is tied to a slender pole about six feet long. With this pole the operator can reach both sides of the ditch if not too wide without moving across, and can thrust the nozzle among the grass and reach all parts of the banks. (See figure 15).

In cases of tanks, barrels, cisterns, cans, and all quiet bodies of water, the oil may be poured on or thrown on from a cup, dipper or other receptacle. In fact it may be poured on the surface to advantage in some cases from an ordinary bucket sprinkler.

How often to apply the oil.—It has been shown in our study of the life history of Culex pipiens that the entire life cycle may be passed in eight days. In the case of Anopheles punctipennis, the life cycle lasts from eighteen to twenty days. These facts alone, indicate the necessity of frequent spraying. I have found that once in two weeks is often enough for the sewage ditches. No doubt the oil is effective along the shallow edges of these ditches for some time after it is applied. That is to say, the oil along the edges does not run off immediately because of no current. On quiet pools oil is effective for several days after it is applied because it does not readily evaporate, as shown in the case of tank.

It is safe to say that an application of oil should be made at least twice a month to be surely effective. Possibly in certain cases oftener, especially in drains where the current is fairly strong.

Will flooding ditches and drains carry away the larvae and pupae of mosquitoes?—Lest anyone be lulled into a sense of security after a severe rainstorm, by thinking that the "wiggletails" have all been washed from the drain, a final word must be said in regard to this phase of the subject.

While sojourning in McComb City in July of the past summer, the writer found a ditch running through the town one-half block from Main street literally alive with the larvæ and pupæ of Culex pipiens and of what I now know to have been Culex confinis. At the head of one pool in the ditch, a drain from a private house joined it and here were the "wiggletails". An hour after finding the pool it was my pleasure to sit on the back porch of a hotel and see that ditch become a raging, roaring torrent ten feet wide and four feet deep, because of a tremendous rain-storm. It was with pleasure, because it seemed to me that the larvæ and pupæ must be carried away by the torrent. By the following morning the ditch had assumed its normal proportions and quietness, but what was my surprise to find the majority, as I judged, of those larvæ and pupæ still in their old places next to the banks, apparently as undisturbed as ever. They had evidently risen with the flood, floated outward to the edges, and then as the brook receded, slowly drifted with the water to their normal level.

In my first attempt to rid the smaller sewage ditch of larvæ, the water from the faucets of ten bath-tubs and one three-inch hose was turned into the ditch in hopes of flooding them out, but no appreciable effect was made on them.

SUMMARY.

It has been demonstrated beyond a doubt, by scientific research and practical experiment, that the germ causing malaria is conveyed and deposited in the blood of human beings by certain species of mosquitoes. At least one of these species; namely, Anopheles punctipennis, is abundant everywhere in Mississippi

It has also been shown with apparent certainty, that yellow fever is communicated from one person to another by a certain species of mosquito (Stegomyia fasciata) which is abundant in Mississippi.

The most common mosquito in the State, is probably Culex pipiens. This mosquito lays its eggs on the surface of standing water in comparatively large masses. Here they soon hatch into "wiggletails," which finally develop into adult mosquitoes. Culex pipiens so far as is known, does not carry any disease from one person to another. These mosquitoes breed in foul ditch water, buckets of standing water, tin cans containing water, barrels of rain-water, hollow stumps, cisterns, tanks, pig troughs, pools, and even in vessels in houses containing water.

The most common malarial mosquito in the State is probably Anopheles punctipennis. Like Culex this mosquito also lays its eggs on standing water, but separately. There they soon hatch into "wiggletails" which in a few days develop into adult Anopheles. The "wiggletails" of Anopheles may be known from those of Culex by the fact that the former lie flat, on or very near the surface of the water, while the latter hang head downward in the water at an angle of about 40 degrees.

They breed in ditches, in road-side pools of water and in small pools formed in compressions made by the feet of cattle, in the mud, around the edges of large surface pools. So far as observed they do not breed in foul water.

A very great number of mosquitoes may be produced from a comparatively small body of water, hence it is important to look after the little pools of water.

It is believed that mosquitoes do not, under ordinary conditions, fly very far. In such a case one man should not deem it labor in vain to fight them on his own place even though his neighbor a mile distant, does nothing to destroy the mosquitoes there.

Mosquitoes are fought most effectually in the early stages of their development.

There are three main remedies against the early stages of these insects, namely, drainage, fish and oil, (refined or unrefined). Perfect drainage wherever it can be had is the most desirable, because it is the most effectual. By drainage, is meant either drawing off the water by an outlet or by filling up so that the water runs off. In permanent pools that cannot be drained, certain kinds of fish such as the Top-minnow (Gambusia affinis), the Sunfish or "Pumpkin-seed," should be introduced. In all other cases in which it is not desirable to use either of the above remedies, a thin film of kerosene oil or petroleum, one ounce to every fifteen sq. ft. of surface should be applied to the surface of the standing water. Cisterns from which water is drawn by a bucket can be kept closed by a wire screen door or a few fish may be placed in them. The same may be said of tanks.