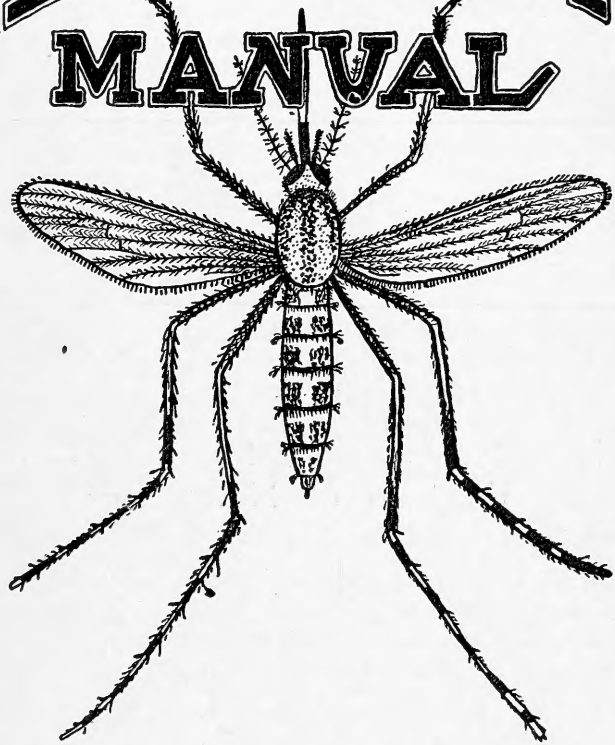
Circular 130

A MOSQUITO MANUAL



FOR USE IN NEW JERSEY SCHOOLS

New Jersey Agricultural Experiment Stations
New Brunswick, N. J.

Published by the New Jersey Agricultural Experiment Stations in cooperation with the

County Mosquito Extermination Commissions

for use in

The Schools of the State

I believe that a knowledge of the history of this pestiferous insect and the methods by which it can be exterminated will result in great good. There is no better medium than the schools for doing this.—John Enright, Commissioner of Education.

Compiled by the

Associated Executives of Mosquito Control of the State of New Jersey

---

ENDORSED BY THE

NEW JERSEY STATE DEPARTMENT OF PUBLIC INSTRUCTION

AND BY THE

NEW JERSEY MOSQUITO EXTERMINATION ASSOCIATION

The Story of the Mosquito

The Mosquito is an Ancient Enemy

The mosquito has been a pest since the times of early history Ancient writers record how the warriors of the old days were forced to fight mosquitoes as well as their other enemies. According to the early historians, these insects swarmed in such prodigious numbers in old Egypt that the natives of marshy regions built towers on which to sleep, since the mosquitoes did not fly high. Also, mosquito nets and canopies were used. The army of Julian, the Apostate, on one occasion was so fiercely attacked by mosquitoes as to be driven back. In Ancient Greece, the inhabitants of cities were sometimes forced to abandon their homes on account of mosquitoes. Sapor, the King of Persia, it is said, was compelled to raise the siege of Nisibis because a plague of "gnats" attacked his elephants and beasts of burden, and so caused the rout of his army.

In the neighborhood of Crimea, according to later writers, the Russian soldiers were obliged to sleep in sacks to defend themselves from the mosquitoes; and in spite of this protection some of the men died in consequence of severe bites by the furious blood-suckers.

Spenser, the English writer of the Seventeenth Century, referred to the great swarms of mosquitoes in both England and Ireland. The lines of his "Faerie Queene,"

> Whiles in the air their clust'ring army flies
> That as a cloud doth seem to dim the skies,
> Ne man or beast may rest or take repast * * *

indicate the magnitude and fierceness of the pest. Describing the Irish mosquitoes, he said they "doe more to annoy the naked rebels and doe more sharply wound them, than all the enemies' swords and speares."

Today mosquitoes are found in all lands and in all climes. They are abundant in the torrid countries of the tropics and they are common in the frozen regions of Alaska. They pester the untutored native of the Malay States and attack with equal ferocity his more civilized brother of the Western countries. The mosquito is no respecter of persons, boundary lines or races. It is an undesirable inhabitant of the earth, and furthermore it is an unnecessary one

Why Mosquito Extermination Was First Attempted

Means of controlling the mosquito perhaps would not have been discovered had it not been for the same underlying cause that brings to light so many great facts, namely, the saving of human life. The mosquito as a pest might be tolerated, the mosquito as a spreader of disease and death *must* be eradicated. Such was the conclusion reached by the United States government when, at the time of the construction of the Panama Canal, it was conclusively proven that the mosquito and the mosquito alone was responsible for the transmission of the disease of malaria. Likewise, during the Spanish-Ameri-

can war, it was demonstrated that the mosquito was the carrier of yellow fever. The successful control of the mosquito in Panama and in Cuba by the United States government and the consequent reduction and final control of these great diseases, is a matter of record that will always occupy a prominent place in the history of modern sanitation. Of equal note is the record of the United States Army in the recent World War. In spite of the fact that many of the southern training camps were placed in what is widely known as the malarial belt, malaria was not present among troops at any time in sufficient quantity to prove a serious factor.

This is in striking contrast to the conditions that existed in camps during the Spanish-American War, when malaria and yellow fever were prevalent and more lives were lost from these diseases than from Spanish bullets. This was all because the medical authorities did not then understand the relation of the mosquito to these diseases and the importance of eliminating mosquito breeding in and around the encampments.

Of the anti-mosquito work that has been undertaken in this and other countries during the last twenty years, in no place has it been more extensively developed than in our own state.

Many Varieties of Mosquitoes in New Jersey

It has taken years of study to find out what we do know about the different kinds of mosquitoes. There are many varieties in the mosquito family. There is the *Anopheles* which carries malaria, the *Stegomyia* which transmits yellow fever, the *Culex* which infests the bedroom at night, the *Aedes* which causes discomfort on the porch and in the garden. These groups again are subdivided, as the *Anopheles punctipennis,* the *Anopheles quadrimaculatus,* the *Culex pipiens,* the *Aedes sollicitans,* the *Aedes sylvestris,* etc. Each of these groups has its own peculiar markings, characteristics and habits. Only by an intensive study could one become familiar with all these, and it is not the purpose of this manual to describe the species in detail.

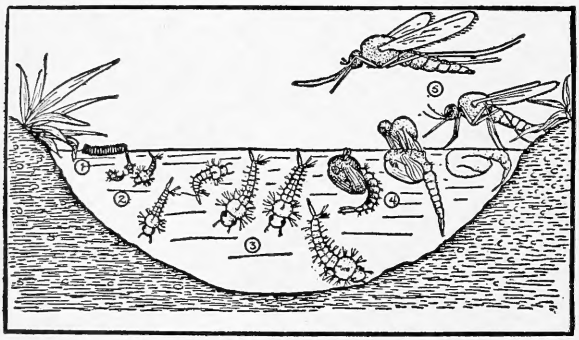


Fig 1—Life History of the House Mosquito
1, eggs; 2, hatching larvae; 3, grown larvae or wrigglers; 4, pupa; 5, adults emerging from pupae and flying away.

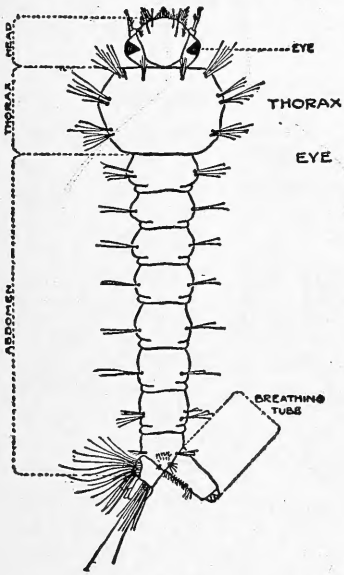
Of the many different kinds of mosquitoes there are only about a dozen that are common to this state, and of this number, not more than six are of real economic importance. For the purpose of study, these might well be classified under the salt-marsh, the inland-swamp and the house group.

All Mosquitoes Breed in Water

All mosquitoes breed in water and in water only. They do not breed in damp grass or dew. The life cycle is fundamentally the same in all groups and the stages of development are practically similar. If we review the life history of one kind, therefore, it will apply to the others equally as well. As the house mosquito is better known than the others, it is here described as a typical example

Typical Life History

All mosquitoes originate from an egg and water is necessary in order to hatch this egg. The female mosquito, flying along, sees a small pool of water, an uncovered rain barrel, an upturned pail full of water, or some other container full or partly full, and there she drops her eggs. The eggs are laid in small black masses of from



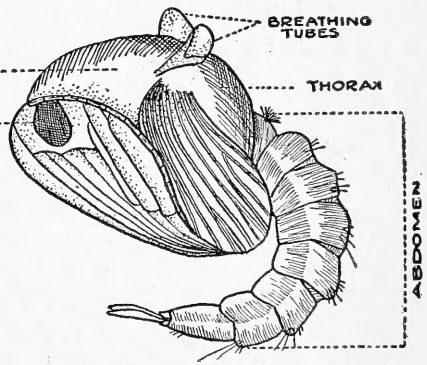


FIG. 2—(*to the left*). DIAGRAM OF MOSQUITO LARVA. Note breathing tube and tufts of hair.

FIG. 3—(*above*). DIAGRAM OF MOSQUITO PUPA. It is from this form that the adult emerges

fifty to four hundred each. They look like a tiny boat floating on the water surface and for this reason are often referred to as "egg boats" or "rafts." From the egg comes the larva, commonly called "wriggler" or "wiggle-tail." The wriggler is an energetic individual and gets its name because of its rapid "letter S" motion in the water. It feeds on the organic matter in the water and gets its air supply by sticking its long tail-like siphon through the upper surface. That is why it always comes up tail first with head down. The larva stays as such for 6 days to 3 weeks, depending on the temperature, and then becomes a pupa. This is a decidedly changed form. The head becomes enlarged and the tail curls up. Breathing is now done through two little horns at the top of the head. In the water, the pupa resembles a comma in shape, and though it still retains its rapid methods of locomotion, it is not as active as the larva. After 24 to 72 hours, the pupal skin cracks and the adult mosquito emerges

in the form familiar to all. It pauses for a brief time resting on the discarded pupal skin until its wings dry a little, and then flies away on mischief bent. Such is the evolution of a mosquito: (1) egg; (2) larva; (3) pupa; (4) adult.

Not everyone knows an adult mosquito when he sees one. It may be confused with the shad fly, the crane fly or the darning needle. The mosquito is a true insect with three pairs of legs, two wings, a head, thorax and abdomen, a sharp beak and a visibly scaly exterior.

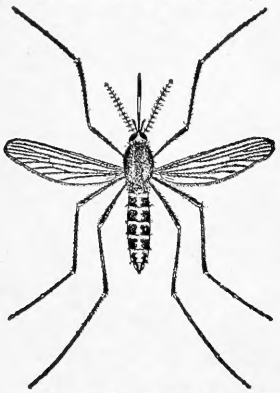


FIG. 4—WHITE-MARKED SALT MARSH MOSQUITO
(*Aedes sollicitans* Wlk.)
Distinctive marks: Palpi not more than one-fourth as long as beak: Beak and feet clearly white-banded: A yellowish-white stripe lengthwise on the upper surface of the abdomen.

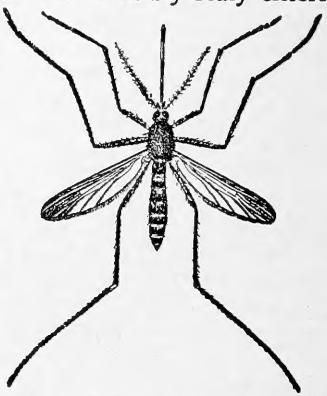


FIG. 5—BROWN SALT MARSH MOSQUITO
(*Aedes cantator* Coq.)
Distinctive mark: Palpi not more than one-fourth as long as beak: Beak unbanded, feet white-banded: Transverse yellowish-white bands on abdomen

The Salt-Marsh Mosquito

Of the salt-marsh mosquitoes two are well known in New Jersey. The *Aedes sollicitans,* the "white-banded" salt-marsh mosquito; and the *Aedes cantator,* the "big brown" salt-marsh mosquito. The former is the most numerous and is the one usually referred to as the Jersey Mosquito. It is especially abundant along the Jersey coast from Hackensack south. It is sometimes called the "convict" because its body is marked with black and white stripes. There is also a broad white stripe across the beak and a longitudinal stripe down the middle of the back. These markings are most pronounced and anyone who has had this mosquito pointed out to him usually recognizes it without hesitation. The other common salt marsh mosquito, the *Aedes cantator,* is the predominant one in the coastal areas of the northern part of the state. This mosquito is a large, robust mosquito of a general brown color; the thorax[1] is covered with distinct spiny hairs; the tarsi[2] show a white band at the base of each joint, but the bands are not well marked and merge gradually into the ground color; each abdominal[3] segment shows a whitish band at its base, but the bands are rather indefinite and not constricted at the center.

[1]The portion of the body to which the legs and the wings are attached.
[2]The tarsus is the last section of the leg, consisting of several short joints.
[3]The abdomen is the jointed portion of the body to the rear of the thorax.

Is a Natural Migrant

The mosquitoes are of economic importance because they breed in such enormous numbers and because they are naturally migrants and will fly in large broods for ten, twenty, or perhaps thirty miles from the marsh in which they breed. Sometimes they sweep unannounced into an inland community like a huge conquering army

Does Not Breed in Fresh Water

In spite of the fact that these mosquitoes are so often found in inland towns and cities, they always breed in salt or brackish water. The egg is deposited in the soft salt-marsh where it is floated out by the high tides or rain. In a few hours the larva issues from the egg and wiggles around in the water of the pool. After 6 days to 3 weeks, depending on the rainfall and temperature, the larva becomes a pupa just as explained in the case of the house mosquito, and in a few hours the full fledged adult appears. It is strong of wing and after a day or two starts its migration in search of food and shelter. This mosquito does not ordinarily enter the house, but confines its visits to the garden and porch, where it is especially active about dusk.

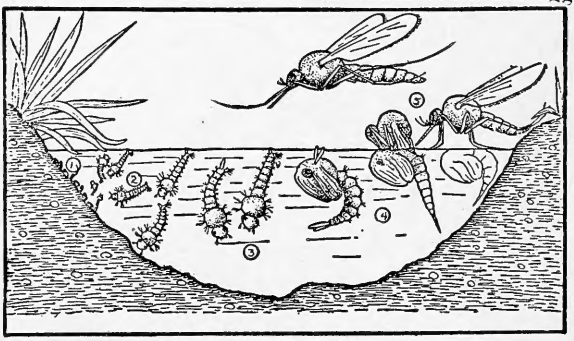


FIG. 6—LIFE HISTORY OF THE SALT-MARSH MOSQUITO
Compare with Figure 1 and note difference in egg stage

Inland Swamp Mosquito

In the inland swamp group we find the fresh-water swamp mosquito, *Aedes sylvestris*, and also that bred in the woodland pool, *Aedes stimulans*. There are others, of course, but these will serve as types. The swamp mosquito winters in the egg at the bottom of the pool in which it breeds. Early in the spring the eggs hatch and the larvae appear.

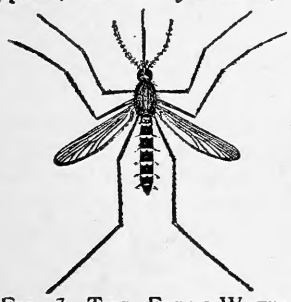


FIG. 7—THE FRESH-WATER SWAMP MOSQUITO
(*Aedes Sylvestris* Theob)
Distinctive Marks: Small, with narrow white band at joints of legs; indentation in white markings on abdomen, resembling series of little "letter B's."

The *sylvestris* is a small mosquito with a narrow white band at the joints of the legs and a noticeable indentation in the white markings on the abdomen. This constriction on the abdomen gives the appearance of a series of little "letter B's" on the back of the mosquito and is the distinguishing feature of this species. This mosquito is especially prevalent during wet seasons for it is quick to take advantage of temporary rain-pools as well as the larger

permanent swamps. It is not strictly a local form, a migration of 10 to 12 miles being quite possible. For the past few years, the *sylvestris* has been the prevailing species in the northern part of the state. It is especially troublesome to the gardener.

The Woodland-Pool Mosquito

The *Aedes stimulans* (formerly called *subcantans*) resembles closely the big brown salt-marsh mosquito of which we have previously spoken (see page 6), and is easily mistaken for it. There is a white band at the base of each tarsal segment and a white band at the base of each abdominal segment. This mosquito also winters in the egg stage and produces a large brood early in the spring. It is not considered migratory and does not trouble man greatly except as he builds nearby, or otherwise penetrates its haunts. The *stimulans* is often a nuisance to camping parties and has caused the listing of mosquito netting as a necessary part of a camper's outfit

The House Mosquito Group

In the house mosquito group we will consider two of the five important members, the *Culex pipiens* and the *Anopheles quadrimaculatus.*

Dr. J. B. Smith, the pioneer of mosquito work in New Jersey, characterizes the house mosquito as follows: "It is of medium size, deep yellowish to dark brown in color, the legs and beak are not banded, and the abdomen has a narrow whitish band at the base of each segment. It is rather a slight species and not especially hairy, having indeed, 'a lean and hungry look.'" The *Culex pipiens* passes the winter as an adult female hiding away in cellars, buildings and other protected places. When warm weather comes in the spring, she sallies forth and lays her eggs, which go through the transformations outlined above.

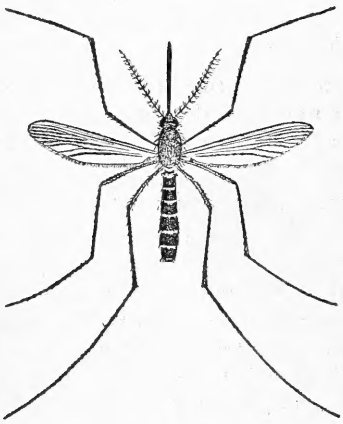


FIG. 8—HOUSE MOSQUITO (*Culex pipiens* Linn.)

Distinguishing marks: Palpi not more than one-fourth as long as beak: Beak and feet without white bands: Transverse white bands on abdomen.

A Most Unwelcome Guest

The house mosquito is found everywhere about human habitations. It breeds in large numbers wherever water stands long enough; in rain-barrels, water tubs, tin cans, broken bottles, cellar excavations, even a broken bit of crockery. It breeds in abundance in foul, polluted water, cesspool overflows, house sink drains, etc. The man who designed the typical city corner sewer catch basin befriended the mosquito, for he provided a place where dirty, stagnant water lies for weeks and unless these basins are oiled, they produce mosquitoes in untold numbers.

Will Force Its Way Into the House

The *pipiens* mosquito penetrates screens, flies down the chimney, comes up from the cellar, and in through a partly closed door. It is most persistent and ingenious in its desire to get inside the house And once in, a few of these pests can make life miserable for the family.

FIG. 9—A BREEDING PLACE IN PASSAIC COUNTY
A continuous breeding place; draining impossible; filling in the only preventive.

FIG. 10—FOURTEEN OF THESE BARRELS, IN A YARD IN ATLANTIC CITY WERE FOUND BREEDING MOSQUITOES

The Anopheles Quadrimaculatus Carries Malaria

The other mosquito which we will consider in this group is the *Anopheles quadrimaculatus.* It is practically the only agent within

the state of New Jersey which transfers malaria from infected to well persons. At this point it should be said that a well person can obtain the disease of malaria only through the agency of the mosquito and that of all the species of mosquitoes within the state this is the only one which is responsible to any considerable extent for the transfer of malaria.

This mosquito also passes the winter as an adult female in cellars or other sheltered places. The eggs are laid singly or loosely grouped on the surface of the water. From fifty to seventy-five seems to be the usual number. Its life cycle is similar to that of *pipiens,* with the exception that the larvae when resting do not hang head downward, but float with the body almost parallel to the water surface The adult is readily distinguished from all other mosquitoes by the fact that the palpi (slender organs, one on each side of the beak), are three-fourths as long as the beak, whereas those of other species are only one-fourth as long. It is brownish black in color and has four brownish black spots on each wing. This mosquito also forces its way eagerly into

FIG. 11—(*above*). CELLAR EXCAVATION IN CRANFORD.

Temporary pools of this kind are among the worst breeding places of house mosquitoes.

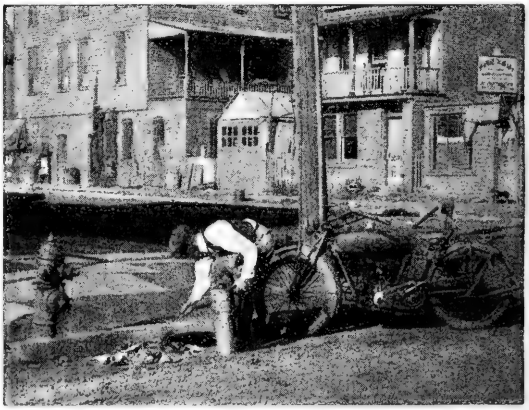


FIG. 12—(*to the right*). INSPECTOR, WITH MOTOR-CYCLE EQUIPMENT, OILING SEWER CATCH BASIN IN ATLANTIC CITY.

the house and is a particularly unwelcome visitor in the sickroom.

If the *quadrimaculatus* bites a person whose blood is infected with the malarial parasite it may get some of the parasites with its meal. These parasites will then undergo a complete development within the mosquito's body and eventually will appear in the saliva. If perchance, after this stage is reached, the same mosquito in its quest for food bites a healthy person, some of the

saliva containing the parasites is injected into him in the blood-sucking process. The parasites then will attack the red blood corpuscles of that person and cause a series of changes which produce malarial fever.

In biting, the *Anopheles* is easily distinguished from the other species, for it holds its body almost perpendicular to the biting surface (practically stands on its head), as in contrast to other mosquitoes which hold the body almost parallel to the skin surface in biting. The *Anopheles* breeds in clear, clean water. It may find its way to maturity in a rain-barrel or tub or along the grassy edge of a stream or pond. Breeding is continuous from spring until fall, but is especially noted from mid-July to early September.

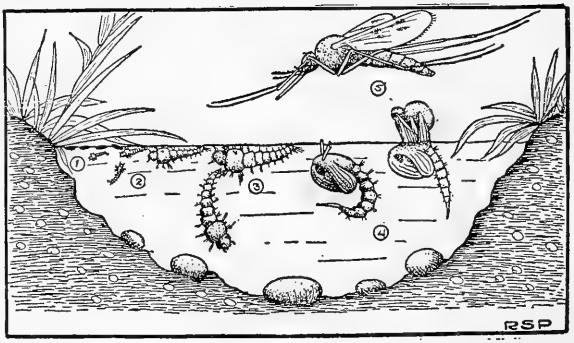


FIG. 13—LIFE HISTORY OF MALARIAL MOSQUITO
Compare with figures 1 and 6, noting position of larvae

Methods of Control

Since each group of mosquitoes is different in the places it seeks for development, naturally the work of control also is divided into distinct classes. All successful mosquito control work is directed against the breeding place. In the larval state, one can kill a thousand mosquitoes with the same amount of effort and expense that it costs to kill one on the wing. Although the same fundamental principles underlie all anti-mosquito work, each branch nevertheless presents its own problem. Each one is here discussed in turn.

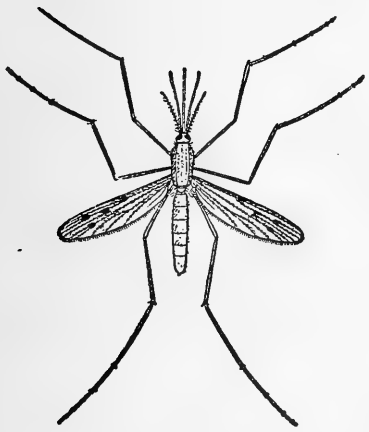


FIG. 14—MALARIAL MOSQUITO
(*Anopheles quadrimaculatus* Say.)

Distinctivee marks: Palpi three-fourths as long as beak: No white bands: Four blackish spots on each wing.

On the Salt Marsh

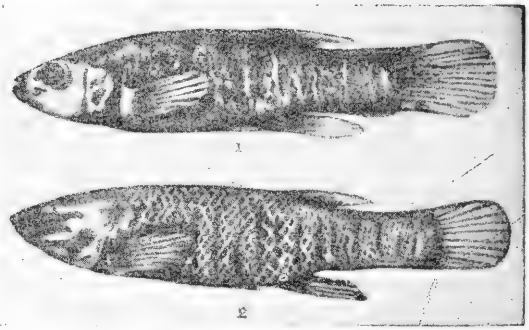
The salt marshes of New Jersey cover thousands of acres, and account for many millions of mosquitoes. After heavy rains, the water from the surrounding uplands settles on these marshes. After abnormal high tides, the water brought up is not all drawn off on the low tide, but remains in all the holes or depressions on the meadow

surface and soon becomes stagnant. Heavy mosquito breeding follows. The problem, therefore, is to devise a drainage system that will provide adequate outlets for the highland storm water and will be so arranged that tide-water will circulate and change with the ebb and flow of the tide and not remain pocketed on the marsh surface. This, of course, is a problem in engineering, the solution of which is too detailed to be more than outlined in a booklet of this nature.

Where the meadow under consideration is an open one, fairly high and not too remote from its ultimate outlet, a series of ditches 10 inches wide and 30 inches deep is dug to provide channels, and shallower spur ditches are cut to reach isolated pools and holes. These ditches are not designed to run entirely dry; the

FIG. 15—(above). THE RESULT OF DRAINAGE
Shallow salt-marsh pool dried out by drainage, killing the mosquito wrigglers.

FIG. 16—(*to the right*). KILLIFISH—THE GREAT NATURAL ENEMY OF THE SALT-MARSH MOSQUITO.
1—Male; 2—Female.



water changes with each tide and the killifish (a natural enemy of mosquito larvae), enter upon the scene and devour such wrigglers as occur in the ditches themselves. In some places, certain natural formations make the standard 10-inch ditch impractical and a 20-inch, 30-inch, or even wider ditch is used.

Sometimes a salt marsh has been practically cut off by a railroad or highway and has settled to such an extent that gravity drainage is not feasible, or sometimes the marsh is so low that good drainage cannot be obtained by means of ditches only. In such cases, the area is completely shut off with dikes fitted with tide-gates. The dike is practically a sea wall or small levee. The gates work automatically. When the tide comes up, the gates close and when the tide goes out, the gates open and release the water accumulated during

FIG. 17—FORDSON TRACTOR ADAPTED TO SALT-MARSH DITCHING

the flood tide. In this way all tide-water is absolutely excluded from the meadow, and it is then necessary to provide for surface and storm drainage only. If sufficiently rapid drainage does not follow this method, an auxiliary pump may be installed and the water pumped out. Filling also is a means of ridding the salt marsh of

FIG. 18—THE PLOW HANDLED BY THE TRACTOR, THROWING OUT THE SODS IN TWO RIBBONS

mosquito-breeding places, but the cost of filling large areas is generally prohibitive and the usual means of control are ditching, diking and tide-gating, and filling of small areas, or large areas when feasible. The steps in salt-marsh ditching are shown on this page. The method of diking and tide-gating is shown on page 14.

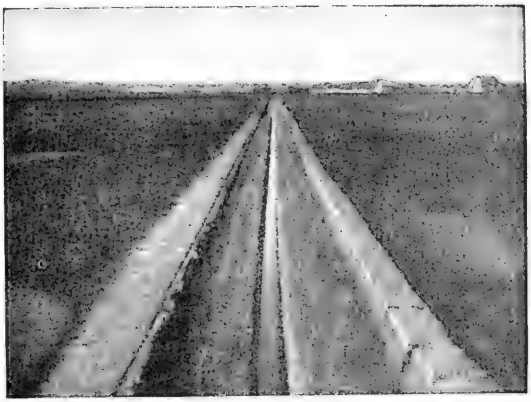


FIG. 19—A COMPLETED DITCH IN ATLANTIC COUNTY

On the Upland

On the upland, also, the chief problem is one of drainage. Here we no longer have the tide action to take into consideration but must depend solely on gravity. The elimination of the many large fresh-water swamps is again an engineering problem. Systems must be worked out providing sufficiently rapid outlets of the water to prevent its standing and breeding mosquitoes. Open ditches ordinarily are used, although tile drains or filling is recommended when the expense is not too great. Doing the work with tile, or filling-in gives a more permanent result and does away to a large extent with the necessity for future maintenance. Over-

FIG. 20—(*Above*). A DIKE ON THE ESSEX COUNTY MEADOWS

FIG. 21—(*to the right*) A TIDE-GATE AT LOW TIDE IN BERGEN COUNTY

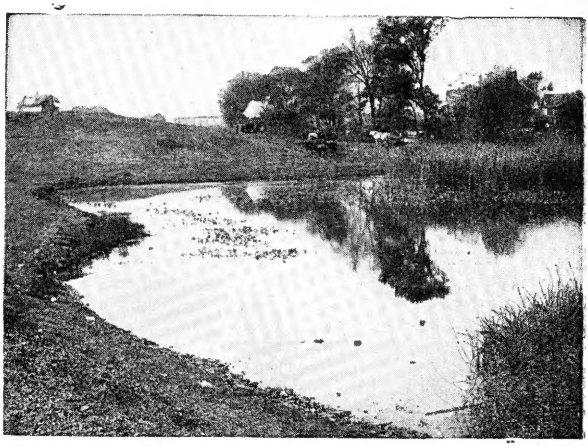
grown ditches, grassy gutters, etc., should be thoroughly cleaned and the edges cut sharp and clean to prevent mosquitoes from breeding.

It is astonishing how often places of this character are absolutely neglected by the property owners and municipal authorities. Where pools or ponds containing fish have become overgrown, the edges should be thoroughly cleaned to allow the fish a chance to get at the wrigglers. If fish are not present, the pools should be drained or else stocked with fish. In temporary places, and in such permanent places as corner catch-basins which cannot be drained or filled, oil or a larvicide is used. Oil forms a film on the water which cuts off the air from the larva. In trying to get its breathing tube through this oil film, the larva absorbs the oil and is killed. Larvacides permeate the water and have a poisonous effect on the larvae and pupae.

House-Mosquito Control

The methods of control outlined above are applicable where the *pipiens* or *Anopheles* breed in pools, puddles, or running streams with

grassy banks. Where they are found breeding in rainbarrels, tubs, tin cans, cesspools, cisterns, etc., the surest and safest means of eradication is to destroy the breeding place. If it is a barrel, dump it; if a tub, overturn it; if a tin can, punch a hole in the bottom of it; if a cistern, cover it tightly; if a cesspool, clean it out and screen it tightly; if a corner sewer catch-basin, oil it completely and periodically at intervals of not more than 10 days throughout the breeding season.



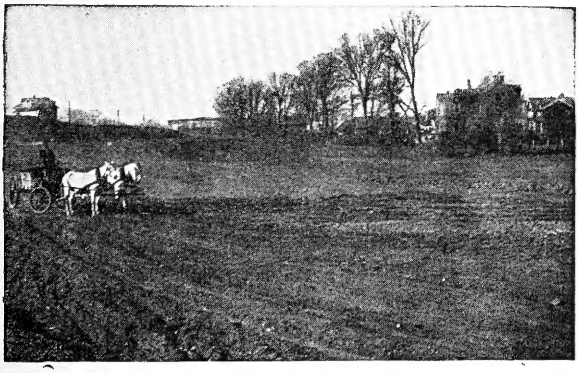


FIG. 22—(*above*) A BAD BREEDING PLACE IN UNION COUNTY.

FIG. 23—(*to the left*) THE SAME LOCATION FILLED AND CONVERTED TO BUILDING SITES

Man complains most bitterly about the house mosquito and yet man is clearly responsible by his own carelessness or indifference for the existence of its many breeding places. Don't breed mosquitoes on your property. Remember that the ingrate mosquito will most certainly bite the "hand that breeds it."

Organizations for Control

A word should be added concerning the control organizations at work on this problem in New Jersey.

To the late Dr. John B. Smith, former State Entomologist, goes the credit of demonstrating the practicability of mosquito extermination in New Jersey. Through his efforts the State Experiment Station dug thousands of feet of ditches in different parts of the state before the present county commissions were organized. Mosquito extermination, of course, is a health measure and the sanitary code of the State of New Jersey makes it a specific offense to cause or maintain mosquito-breeding places. Most local boards of health

also have passed ordinances covering this subject. The State Legislature in 1912, however, decided that the county rather than the city or borough was the most efficient control unit. Therefore, a state law was passed providing for a mosquito extermination commission in each county of the state. These commissions are appointed by the Justice of the Supreme Court presiding over the courts of the county. They are composed each of 6 men who serve without compensation. They appoint a superintendent or chief engineer, who trains and supervises inspectors and laboring gangs. The funds used are raised in the regular county tax budget. The State Experiment Station supervises and directs the work of these several county mosquito commissions and the Director must approve all budgets before money is appropriated and pass in general on all policies adopted. The Experiment Station organizes mosquito work in counties or municipalities where it has not yet been taken up and contributes help to others where state aid is necessary to maintain or encourage local endeavor.

Ten counties in the state are now doing active anti-mosquito work on a large scale. About a quarter of a million dollars a year is being expended on this great project, and the results already attained may be measured by the growth of suburban communities and industrial centers, the continued influx of farmers to Jersey's fertile soil, and the general steady upward trend of tax ratables throughout the state. The benefit to be derived by the people of the state when it is successfully concluded is estimated in the billions. It will take time, it will take money, but it must be done. The mosquito is the greatest pest in the state. Other lesser pests have been stamped out and now the ultimatum has been issued: THE MOSQUITO MUST GO.

Summary

In conclusion, the important facts about mosquitoes may be summed up briefly. All mosquitoes breed in water. They swim before they fly. They do not breed in wet vines, trees or brush, but in water only. To get rid of them all the breeding places must be discovered and each treated effectively according to its needs. Mosquito control has passed the experimental stage; it is here to stay. Just as soon as people become educated to the point where they understand the important facts about mosquitoes and mosquito breeding just so soon will rapid strides be made toward the object in view—a mosquitoless state!

The boys and girls of our schools, the future men and women of New Jersey, can help materially. Let them think what it really means. Let them study the question. Let them get interested in it. Let them get their parents interested in it. Let them help those who are trying to help them and see to it that they use their influence and power to stamp the great mosquito pest out of the state