Measures Instituted for the Control of Aëdes aegypti*

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IN military warfare it is an established fact of many centures' standing that, though the weapons themselves change, the principles of tactics are the same today as when Alexander conquered the then known world.

A parallel may be drawn on the health official's fight to control the *Aëdes aegypti,* the yellow fever mosquito. The big job still is to eliminate standing water from artificial containers near human habitation, just as it was for Gorgas, Carter, and Le Prince in the early days of the present century when yellow fever was stamped out of North America.

To continue the parallel with the military, as the army still considers the foot soldier the decisive element in winning its battles, the house-to-house inspector is still the " doughboy " of the *aegypti* fighters. Only by careful, painstaking inspections on foot can all of the artificial containers around premises that produce *aegypti* be found and either destroyed or controlled.

The habits of the *aegypti* mosquito are better known today then they were at the turn of the present century, and the inspector is trained to look particularly in certain places for larvae because this species prefers to breed in fairly clean water in places not exposed to direct sunlight. He has been taught to give each householder information about mosquitoes, their breeding places, and reasons why they should be controlled.

The inspector keeps record of all of the premises he visits, records the number of containers producing mosquitoes, the number of water-holding containers that could produce mosquitoes, and by symbols notes the kinds of mosquito producing containers found. He records places where his foreman should visit because of difficulties encountered, and also notes water-holding containers whose permanent correction has not been possible. To sum up, the main duty of the house-to-house inspector is to locate all mosquito producing containers and to eliminate permanently as many of them as he can.

A foreman is assigned a number of inspectors, depending upon local conditions. It is his duty to follow the inspectors to see if mosquito producing containers have been overlooked by them, to assign the inspectors to new areas as they work along, to spray oil on water-holding containers that cannot be emptied or drained, to investigate complaints about mosquito troubles in his district, etc. He checks over his inspectors' daily reports and summarizes their results in a daily report of his own.

The house-to-house inspections will

* Read before the Public Health Engineering Section of the American Public Health Association at the Sixty-eighth Annual Meeting in Pittsburgh, Pa., October 17, 1939.

reveal that there are always some water-holding containers that cannot be destroyed because they are put to some particular use. These include cisterns, wells, fish ponds and bird baths in yards and estates, cesspools, privies, water baths required in industrial processes, cemetery flower pots, floor drains in garages, outside drain boxes, catch basins, etc.

Control of such perpetual offenders is usually attempted by a " 10 day " inspector. As the name suggests, it is his job to visit these offenders every 10 days or oftener. In most cases light Diesel engine fuel oil is applied to the water surface by hand operated compressed air spray guns. Catch basin breeding is usually controlled by applying oil from a motorcycle or a light truck equipped with an oil pressure tank, hose, quick operating valve, and extension spray nozzle.

In some cities, such as Key West, Fla., the citizens depend upon the storage of rainwater in cisterns located partly underground in yards for their drinking water. In a city of this kind cisterns could not be ordered destroyed because no other fresh water for drinking is available.

When the motorized *Aëdes aegypti* Control Unit of the U. S. Public Health Service was ordered to Key West in December, 1938, it was soon discovered that it would not be possible to institute measures to require all unprotected and improperly protected cisterns to be made mosquito proof immediately.

It was known, though, that top-feeding minnows had been used successfully in open containers in yellow fever control in Tampico, Mexico,[1] and Guayaquil, Ecuador,[2] and in malaria control.[1] Records of experiments showed that *Gambusia holbrooki* feed mainly by attacking food eagerly when it is in motion as in sinking, and it had been concluded that top-feeding minnows could not see if introduced into the dark covered cisterns, such as those so common in Key West.

It was found that *Gambusia* were found alive by our inspectors in some cisterns in which small numbers had been placed in 1935 by McCready of the Florida State Board of Health. Based on this information it was decided

FIGURE 1—A cistern unprotected against *Aëdes aegypti* mosquitoes, typical of many that were stocked with *Gambusia holbrooki* minnows

to stock every cistern in Key West unless it was constructed mosquito-tight, or unless the householder would not permit the cistern to be stocked and would agree only to the cistern's being oiled regularly by one of our inspectors. Cisterns were stocked using one adult fish per square foot of water surface, roughly, or 50 fish to an average cistern. The shallow fresh water wells also were stocked with *Gambusia.*

The laboratory experiments made by our entomologist disclosed that the ability of *Gambusia holbrooki* minnows to eat mosquito larvae seemed to depend more upon their appetite or capacity than upon the amount of light present. Also, none of the minnows " ate themselves to death " in the presence of a large number of larvae as has been reported for certain fish in the tropics used there in *aegypti* control.[3] A brief test was made with *Mollienesia latipinna* which indicated that they would eat in darkness as well as in light. They are herbivorous, eating mosquito larvae only in the absence of plant food. Accordingly in nature they would be " virtually valueless as a destroyer of mosquito larvae." [4] Also, they were highly susceptible to handling and chlorination injuries.

FIGURE 2—A pile of old automobile tires in a second-hand yard that were producing *Aëdes aegypti.* Production was controlled by Paris green dusting.

Care was necessary in handling *Gambusia holbrooki,* the pregnant females being even more susceptible to handling and chlorination injuries than the delicate males. When reasonable care was exercised little harm resulted to either males or females, and they could be poured into cisterns or introduced with soup ladles through small openings when necessary.

These minnows were obtained from small fresh water ponds on adjacent Stock Island. They were acclimated by being placed in successive containers of pond-cistern and of cistern waters.

As means of protecting himself against criticism for possibly introducing contamination into those cisterns that he had stocked with *Gambusia,* the sanitary officer of Monroe County, Fla., had subjected the minnows to an overnight bath in chlorinated water before introducing them into cisterns. This practice was continued by us, and experiments to find the tolerance of *Gambusia holbrooki* to chlorinated water, plus experience gained, resulted in the use of dosages of hypochlorite that would produce a chlorine residual of 0.1 to 0.15 p.p.m. Over-contact with chlorinated water always caused high mortality of fish.

A survey of the Key West cemetery showed extensive *aegypti* breeding in flower containers. Pellets were made of a wet mixture of 1 part of Paris green and 4 parts of plaster of Paris. One pellet was placed in each flower vase. In the third inspection of 631 flower containers that contained *aegypti* larvae before the pellets were added only 3

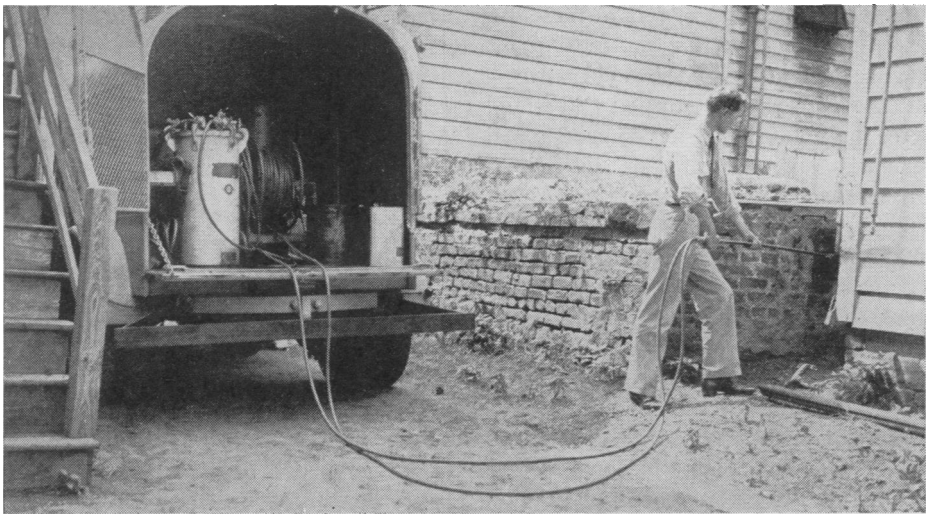

FIGURE 3—Unused cistern not mosquito-tight being sprayed with oil, using a power driven oil spraying unit

were found breeding. Additional pellets were added during each inspection.

All cisterns not stocked with *Gambusia* were sprayed with sufficient kerosene every 10 days to form an unbroken film on the water surface. Kerosene evaporates quickly and there was little danger of its being drawn into the water pipes because the drop pipes of the suction pumps extended down almost to the cistern bottoms.

It was found that *Gambusia* were not able to remove heavy infestations of larvae from cisterns. In these cases the cistern was first sprayed with kerosene to kill the larvae, and *Gambusia* were introduced later to prevent re-infestation. Apparently the kerosene film was not harmful to the *Gambusia*.

Occasionally severe infestations of adult mosquitoes were found inside houses, under houses, etc. To disinsecticize these places they were sprayed thoroughly using a mixture of 1 part of a concentrated extract of pyrethrum in oil (extract from 20 pounds pyrethrum flowers to each gallon) and 4 parts of light oil (refined kerosene). A pressure spray gun operated by a portable air compressor was used. The Public Health Service now is trying out a large insecticide spraying truck designed for this purpose.

In the *aegypti* control activities of the Public Health Service the *Aëdes aegypti Index* used currently by mosquito control workers has been employed as a means of observing the progress made in reducing the *aegypti* infestation in a community or any selected area. Stated briefly, it is the percentage of premises inspected found producing mosquito larvae multiplied by the percentage of samples collected containing *aegypti* larvae. The first mentioned percentage discloses the index of "domestic" mosquitoes and multiplying it by the percentage of samples containing *aegypti* larvae is an attempt to arrive at a figure that will indicate the infestation of *aegypti*. Samples of larvae were collected from every piece of property where domestic mosquito production was found by the evidence of larvae present. The collections were identified later by the entomologist.

To discover how long *Aëdes aegypti* eggs would remain viable when kept in the dry state and at room temperature, Sanitary Engineer H. A. Johnson, U. S.

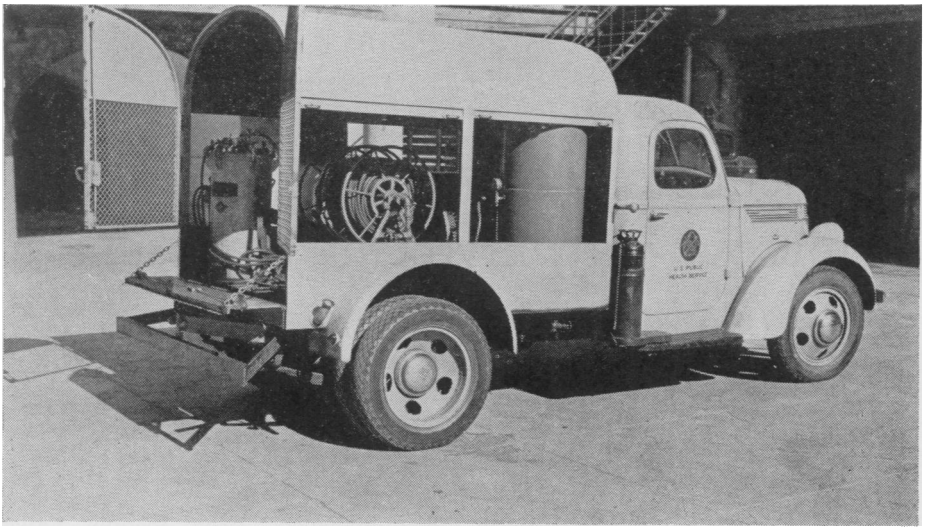

FIGURE 4—Power driven insecticide spraying truck designed by the U. S. Public Health Service. (It is also used for spraying oil larvicide.)

Public Health Service, when on duty in Miami, Fla., began an experiment by placing away, on June 12, 1938, 4 wooden egg troughs on which *aegypti* eggs had been laid. Exactly 1 year later when they were placed in water the author was able to find a few larvae hatched out after a day's immersion. Several larvae that were set aside were reared through to the adult stage. There is record of Passed Asst. Surgeon (later Medical Director) Edward Francis at Mobile, Ala., having placed away *aegypti* eggs August 16, 1906, and having hatched them out 6½ months later. They were reared through to adults.[5] These experiments demonstrated that *Aëdes aegypti* will survive a southern winter in the egg stage as well as by adult hibernation.

CONCLUSIONS

The control of *Aëdes aegypti* is accomplished only by repeated painstaking inspections from house to house to find and to eliminate *all* artificial containers that produce them.

Gambusia holbrooki were used successfully in Key West, Fla., to control *aegypti* production in dark covered drinking water cisterns. These minnows were subjected to an overnight bath in chlorinated water before being placed in the cisterns.

Houses with a severe infestation of adult mosquitoes were disinsecticized by spraying with a concentrated pyrethrum extract in oil.

Aegypti production in cemetery flower vases in Key West was controlled by placing Paris green pellets in them.

It is possible for *Aëdes aegypti* eggs to remain viable in the vicinity of Miami, Fla., at least one year.

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