

8) The residual activity of Cidial, applied to fir-wood and poplar plywood panels, against 48- to 72-hrs. females of *C. pipiens*, *A. gambiae* and of a strain of *A. albimanus* resistant to DDT and diel-drin proved very high (140-210 days) and was found to be as good as that of fenthion (Lebaycide WP 40) and much superior to that of malathion (Fig. 8).

9) All the experimental products tested on plastered panels showed a low degree of residual activity (3 to 20 days) against the three above mentioned species. A

formulation especially adopted for use on porous substrata could allow decidedly better results.

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## DAMAGE CAUSED BY *LANKESTERIA CULICIS* (ROSS) TO *AEDES AEGYPTI* (L.)<sup>1</sup>

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A search for *Aedes aegypti* pathogens which might be used as biological control agents is being made by the *Aedes aegypti* Eradication Program. Surveys conducted during 1966 and 1967 established that *A. aegypti* has disappeared in recent years from many communities in East Texas and along the Texas Gulf Coast, and the reason for the natural disappearance of the species is being investigated. *Lankesteria culicis*, a protozoan parasite of *Ae. aegypti*, was found in Houston, Texas, in June, 1967, and the parasite has been observed to damage larvae, pupae and adults under field conditions.

*L. culicis* has been known for over 70 years (Ross, 1897, 1906). The life cycle of the parasite is described by Wenyon (1911, 1926).

Ray (1933) describes a protozoan seen in *Aedes albopictus* as *L. culicis*.

Several authors have reported death of mosquito larvae due to heavy infestations of *L. culicis*. Feng (1933) states that death of larvae due to heavy infection of *L. culicis* has been observed in *Aedes koreicus* in Peiping, China. Ganapati and Tate (1949) report death of *Aedes geniculatus* larvae that were heavily infected with *L. culicis* at Cambridge, England. Hati and Gosh (1963) state that heavy mortality of wild *Ae. aegypti* larvae growing in pots and heavily infected with *L. culicis* was observed in Calcutta, India, in November, 1962.

Some illustrations and descriptions of *L. culicis* reported from species of mosquitoes other than *Ae. aegypti* in publications cited above differ from the appearance of *L. culicis* as seen in *Ae. aegypti*. A new protozoan species which resembles *L. culicis* in appearance and life cycle was found by the author in *Aedes triseriatus* at Houston, Texas, in August, 1967, but the species does not readily infest *Ae. aegypti*. Review and revision of the identification and classification of the protozoan species are needed. The published observations are of value, however, in that

<sup>1</sup> From the *Aedes aegypti* Eradication Program, Environmental Control Administration, Consumer Protection and Environmental Health Service, U. S. Department of Health, Education, and Welfare, Houston, Texas.

they report the death of larvae of mosquito species related to *Ae. aegypti* as a result of infestations by parasitic species which are similar to *L. culicis*.

In Houston, between July 14 and December 31, 1967, 96 of 231 field collections of *Ae. aegypti* larvae were found to be infested with *L. culicis*. Larvae infested with *L. culicis* were found throughout the parts of the city that are heavily infested with *Ae. aegypti*.

Field-collected larvae have been seen to contain up to 800 trophozoites, but larvae that contained more than 250 trophozoites were almost always thin and stunted, and dead or dying larvae were often seen. Of the 96 larval collections found to be infested with *L. culicis*, 36 contained stunted larvae and 34 contained dead larvae. Aside from possible secondary bacterial infection in mid-gut cells, *L. culicis* infection was the only evident cause of larval morbidity and mortality. Field-collected larvae that contain 100 or less trophozoites do not ordinarily show damage.

Field and laboratory observations have shown that pupae and adults produced from larvae stunted by *L. culicis* are also stunted, and their Malpighian tubes are severely damaged by the development of gametocysts within the tubes. The cells that line the Malpighian tubes are distorted and damaged in the pupal stage, and the cells degenerate when the late pupal and early adult stages are reached.

Wenyon (1911) described dilation produced in the Malpighian tubes of pupae by gametocysts of *L. culicis*. He stated that "the cells of the malpighian tubes become excavated to accommodate these comparatively large gregarine cysts," and published an illustration to show the cysts and cellular distortion which he saw in pupae. Wenyon published no observations to indicate that he observed the extensive degeneration of Malpighian tubes that occurs in adults.

Figures 1 and 2 are photomicrographs of damaged Malpighian tubes typical of those seen in adult *Ae. aegypti* reared

from field-collected larvae infected with *L. culicis*.

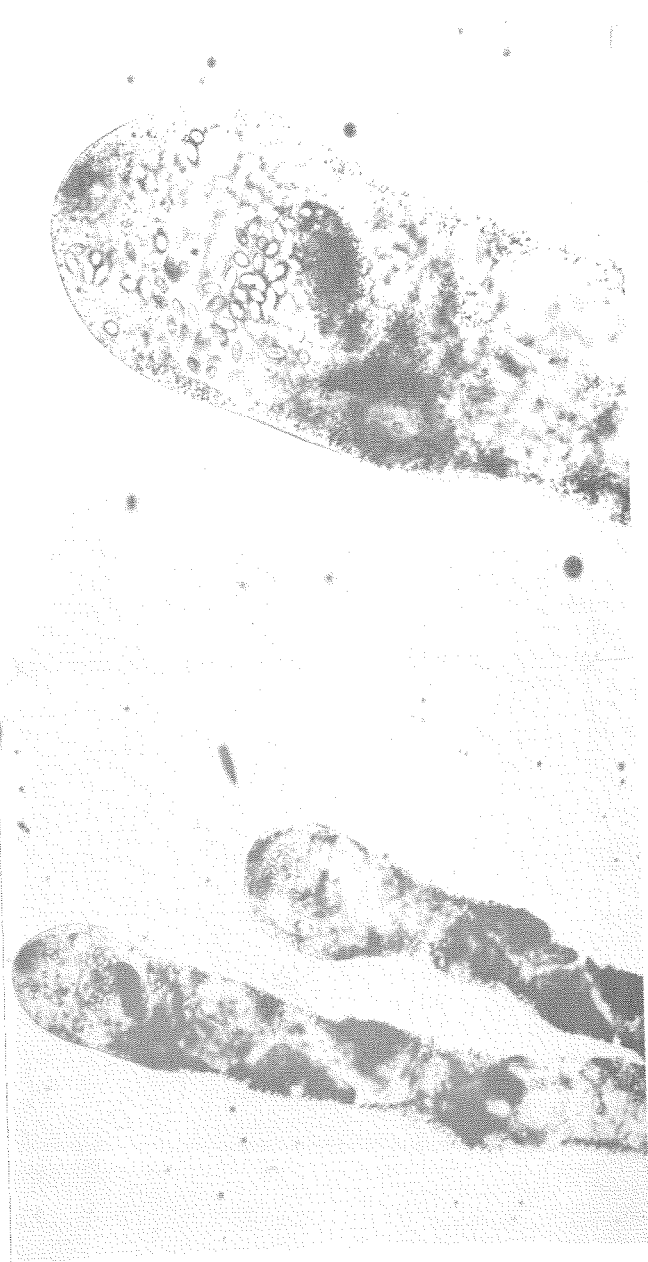
In Figure 1, the cells that normally line the tubes have disappeared, leaving the relatively clear basement membrane of the tube. The death of the cells probably resulted from pressure necrosis due to distention of the tube by gametocysts. The gametocysts have disintegrated and released their sporocysts. Numerous sporocysts can be seen through the basement membrane in the lumen of the damaged tube.

Figure 2 (lower position) shows a longer section—the distal one-third—of the Malpighian tube pictured in Figure 1, and also (upper) the distal one-fourth of another Malpighian tube. Both tubes illustrate extensive histopathological destruction extending along the entire length of the portions that were photographed. Malpighian tubes of pupae that have not been parasitized and damaged are opaque and relatively uniform in diameter throughout their length, and the outside of the cellular lining can be seen through the basement membrane.

The extent of damage in the Malpighian tubes is proportional to the number of trophozoites in the larva, the age and size of the trophozoites at the time of pupation, and the amount of stunting that has occurred during development of parasitized larvae under field conditions. One or two gametocysts may destroy the cells in the tip of a Malpighian tube.

Eight to 25 gametocysts may destroy the apical one-third of a single Malpighian tube. In greater numbers, gametocysts may destroy the distal two-thirds of a Malpighian tube, but a pupa will generally die if that amount of destruction occurs in all tubes. Gametocysts are generally rather equally distributed in the five Malpighian tubes of a pupa.

The effects of the Malpighian tube damage in relation to malfunction or reduced function of the tubes remain to be studied, and resultant effects on adult feeding and longevity and on egg production



FIGS. 1 and 2.—Photomicrographs of Malpighian tubes of adult *Aedes aegypti* which have been severely damaged by *Lankesteria culicis*.

and egg viability should be investigated.

The basic physiological processes that affect the parasite in the Malpighian tubes and which may be affected in the host by the parasite's damage along varying lengths of the Malpighian tubes also remain to be studied.

*L. culicis* has not been found in larvae of *Aedes triseriatus*, *Culex quinquefasciatus*, and *Orthopodomyia signifera* that were associated with *L. culicis*-infected *Ae. aegypti* larvae.

The extent of damage to larvae, pupae and adults caused by *L. culicis* indicates the need for further studies of the effects of the parasite on the entire biotic potential of *Ae. aegypti*. These studies should include elucidation of possible complex associations of organisms in dual and multiple infections of larvae, and the development of methods of cultivation and dissemination of pathogens which appear to hold promise for biological control of container-breeding mosquitoes.

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Dr. Howard E. Buhse, Jr., Mr. Jerome

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Photomicrographs were made by Mr. R. D. MacIntyre, Department of Visual Education, Baylor University College of Medicine, Houston, Texas.

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