THE SIGNIFICANCE OF WATER-HOLDING CAVITIES OF TREES AS MOSQUITO FOCI WITH SPECIAL REFERENCE TO *AEDES AEGYPTI* CONTROL PROGRAMS

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Entomologists have long exhibited interest in the public health significance of mosquitoes breeding in tree holes. Jenkins and Carpenter (1946) reported on the habits and distribution of eight species and one subspecies of mosquito which usually breed only in this habitat. Among these species they recorded that malaria has been carried experimentally by *Anopheles barberi* Coq. and yellow fever by *Aedes triseriatus* (Say). The distribution of *Aedes triseriatus* corresponded well with a 1941 outbreak of eastern encephalomyelitis in Massachusetts. Bonnet and Chapman (1956) reported upon the importance of the tree-hole-breeding mosquito, *Aedes polynesiensis* Marks, with reference to filariasis in Tahiti. Shute (1954) indicates that indigenous malaria in England may be transmitted by tree-hole-breeding *Anopheles plumbeus* Stephens. The threatened introduction of yellow fever from South and Central America, coupled with the recovery in 1955 of *Haemagogus equinus* Theobald larvae from tree holes in the vicinity of Brownsville, Texas, (Trapido and Galindo 1956; Eads and Strom 1957) has served to intensify the examination of such cavities in and around airports and dock areas receiving international traffic in the southern United States.

In the conduct of yellow fever control programs it is desirable to have all vestiges of *Aedes aegypti* breeding eliminated, otherwise the program becomes one of constant surveillance with the possibility of continuous reinfestation from hidden sources. Tree holes, frequently so minute as to be easily overlooked, can harbor these mosquitoes.

The *Aedes aegypti* Detection and Control Units assigned to the Brownsville, Texas; Miami Beach, Florida and New Orleans, Louisiana, Public Health Service Quarantine Stations have been actively searching since late 1957 to determine the importance of *aegypti* breeding in various tree holes in these locations.

Although species known to associate with the yellow fever mosquito were recovered in all three areas, *aegypti* larvae have been encountered frequently in these tree hole surveys in south Florida only. A total of 2237 tree hole inspections have been made in this region between 1958–1961; 99 of these inspections were positive for *aegypti*. In one particular area where 380 premises are routinely inspected, 24 of these premises had one or more tree holes that were inspected. Thirteen of these premises were positive for *aegypti*. Thus, while all the artificial containers might be treated for *aegypti* breeding on these premises, there would still be an *aegypti* index of 3.4 percent (13 positive tree holes ÷ 380 premises examined). These untreated tree holes could then serve as foci to reinfest the treated areas.

A number of species of trees in urban areas have been examined. Table 1 lists the trees and the species of mosquitoes recovered from them. It is apparent that the species of trees involved does not necessarily dictate the species of mosquitoes to be found. It does, perhaps, indicate that certain trees lend themselves more readily to forming cavities and rot

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TABLE 1.—Species of trees containing rot-holes, depressions and cavities and the species of mosquito larvae recovered from them [1]

Species of Trees	*Aedes aegypti*	*A. triseriatus*	*A. zoosophus*	*Culex nigripalpus*	*C. pipiens-quinquefasciatus*	*C. restuans*	*Deinocerites cancer*	*Haemagogus equinus*	*Orthopodomyia alba*	*O. signifera*	*Toxorhynchites r. rutilis*	*T. rutilis septentrionalis*
Avicenna nitida (Black mangrove)	..	x	..	..	..	..	..	..	..	..	..	..
Bambusa sp. (Bamboo)	..	x	..	..	x	..	..	..	..	..	..	..
Bougainvillaea (Bougainvillea)	..	x	..	..	..	..	..	..	..	..	..	..
Casuarina sp. (Australian pine)	..	..	..	x	..	..	..	..	..	..	..	..
Celtis spp. (Hackberry)	..	x	x	..	..	..	..	..	..	x	..	..
Cornus florida (Flowering dogwood)	..	..	..	..	..	..	..	..	..	x	..	x
Diospyros texana (Chapote)	..	..	..	..	..	..	..	..	..	..	..	x
Ficus spp. (Banyan & Strangler fig)	x	x	..	x	x	..	x	..	..	x	..	..
Kigelia pinnata (Sausage tree)	x	..	..	..	..	..	..	..	..	..	..	..
Lagerstoemia indica (Crepe myrtle)	..	x	..	..	..	..	..	..	..	..	..	..
Pithecolobium flexicaule (Texas ebony)	..	x	x	..	..	..	..	x	..	..	..	..
Poinciana regia (Royal poinciana)	x	x	..	..	x	..	..	..	..	x	..	..
Pongamia pinnata (Pongam, Poonga Oil Tree)	x	x	..	..	..	..	..	..	..	..	..	..
Prosopis sp. (Mesquite)	..	x	..	..	..	..	..	..	..	..	..	..
Quercus spp. (Oaks)	x	x	x	..	x	x	..	..	x	x	x	x
Salix sp. (Willow)	..	x	x	..	..	..	..	..	..	..	..	..
Sapindus sp. (Chinaberry)	..	x	x	..	..	..	..	..	..	..	..	..
Ulmus sp. (Elm)	..	..	..	..	..	..	..	..	..	x	..	..

[1] Based on data from the *Aedes aegypti* Detection and Control Units of the Brownsville, Texas, Miami Beach, Florida and New Orleans, Louisiana, Quarantine Stations.

hole conditions that will hold water and thus make them more attractive for breeding.

It is desirable to be familiar with these frequently-hidden sources of breeding. Recognition of the "offender" is only part of the battle. Action must be taken. Ordinarily the domestic mosquito control man is not prepared for an extensive tree hole mosquito control project. Robinson (1959) recently reported treating 4500 tree holes in one month in Alameda County, California, raising his winter-season tree hole treatment to 22,936. Undoubtedly many areas in the sub-tropics and tropics could duplicate these results in the event of a thorough survey. Since trees in sub-tropical parts of the United States present an abundance of mosquito-breeding cavities several avenues of approach may be taken. Public Health Service Quarantine personnel have routinely made monthly tree hole surveys, inspecting many trees in the areas of coverage. Records are kept of the location, the species of trees involved, the presence or absence of water and/or mosquito larvae and pupae.

Different conditions will dictate different methods of control. Control measures for tree hole mosquitoes used in the past and those that might be useful in the future are as follows:

I. PERMANENT CONTROL MEASURES:

A. Cultural Procedures:

1. Removal of offending trees and replacement with species less apt to have, or develop, water-holding cavities.
2. Pruning of trees to remove cavities.

3. Insertion of drains into cavities.
4. Filling of cavities with cement or tar.
5. Relocation of sprinkler heads.
6. Topping cavities with living plants.

Of these measures, because of the nature of the most common offender in south Florida (the various species of *Ficus*, i.e., strangler fig and banyan) periodic pruning would be required to prevent formation of new water-holding cavities. In most cases it is not feasible to attempt to locate and fill all water-retaining areas in trees. Improperly placed lawn sprinkler devices are surprisingly common conditions. A word spoken to the owner of the property, where lawn sprinkler devices keep tree holes perpetually wet and breeding mosquitoes, is often sufficient to obtain the necessary changes. Except in the limited areas near places of international traffic, hand methods of eliminating tree holes by cultural procedures are probably not feasible in the United States. The education and encouragement of property owners to treat their own trees may be a practical approach. A novel approach requires partial filling of cavities with dirt and gravel and placing a living plant, usually a fern, on top.

B. Biological Measures:

The practical use of predaceous *Toxorhynchites* mosquitoes has not been determined for this country. These mosquitoes have, however, proved of little value in the Hawaiian Islands, (Bonnet and Hu 1951.)

II. TEMPORARY CONTROL MEASURES:

A. Sand or earth fills of tree hole cavities:

B. Insecticides:

1. *Hand applications.*

Since *aegypti* have been found breeding in tree holes from near ground level to 34 feet (Kellet and Omardeen, 1957) the hand application of insecticides would be difficult and expensive. In areas where many small containers breeding *aegypti* have been involved, such as cemetery urns and tree holes, use has been made of various types of insecticidal briquettes that would gradually give off their toxicant and provide control over a longer period of time. Kellet and Omardeen used briquettes of benzene hexachloride in plaster of paris for *aegypti* breeding in tree holes in Trinidad. Le Van (1940) used paris green with plaster of paris for *aegypti* breeding in cemetery urns in Key West, Florida. The application of dieldrin-cement pellets will prevent breeding of *aegypti* in containers up to a year, (Elliott, 1955 and Public Health Service, 1961). Briquettes of these same ingredients were effective in maintaining fire barrels free of reinfestation for a five-month inspectional period (Evans and Fink, 1960). One of the authors (JEP) has maintained mosquito free conditions in tree holes with dieldrin-cement briquettes for over eight months at Miami, Florida.

2. *Power application.*

The use of power machinery in the application of insecticides has become increasingly popular in the United States because it enables a few men to cover a large area with insecticide at a minimum cost. However, it is doubtful if aerosols would occur in high enough concentration to be toxic to tree hole larvae.

Larger insecticidal particles would have difficulty in penetrating the leaf foliage whether applied from the ground or the air. Perhaps a fine dust might be satisfactory. Certainly more consideration should be given to control of mosquitoes breeding in tree holes if successful *aegypti* eradication is to be accomplished.

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References Cited

BONNET, D. D. and CHAPMAN, H. 1956. The importance of mosquito breeding in tree holes with special reference to the problem in Tahiti. Mosq. News 16(4):301–305.

BONNET, D. D. and HU, S. 1951. The introduction of *Toxorhynchites brevipalpis* Theobald into the Territory of Hawaii. Proc. Hawaiian Ent. Soc. 14(2):237–242.

EADS, R. B. and STROM, L. G. 1957. An additional United States record of *Haemagogus equinus*. Mosq. News 17(2):86–89.

ELLIOTT, R. 1955. Larvicidal control of peridomestic mosquitoes. Roy. Soc. Trop. Med. and Hyg. Trans. 49(6):528–542.

EVANS, B. R. and FINK, E. J. 1960. Dieldrin cement briquettes in controlling *Aedes aegypti* in fire barrels. Mosq. News 20(4):388–389.

JENKINS, D. W. and CARPENTER, S. J. 1946. Ecology of the tree hole breeding mosquitoes of Nearctic North America. Ecol. Monog. 16(1): 31–47.

KELLET, F. R. S. and OMARDEEN, T. A. 1957. Tree hole breeding of *Aedes aegypti* (Linn.) in Arima, Trinidad, B.W.I. West Indian Med. Jour. 6(3):179–188.

LE VAN, H. J. 1940. Measures instituted for the control of *Aedes aegypti*. Amer. Jour. Public Health 30(6):595–599.

PUBLIC HEALTH SERVICE. 1943. The *Aedes aegypti* program. Public Health Service. MCWA Separate. 8 pp.

———. 1961. Public Health Pesticides. Communicable Disease Center, U. S. Public Health Service, Department of Health, Education and Welfare. 11 pp.

ROBINSON, C. 1959. In "News and Notes," Mosq. News 19(2):126.

SHUTE, P. O. 1954. Indigenous *P. vivax* malaria in London believed to have been transmitted by *Anopheles plumbeus*. Monthly Bul. Ministry of Health and Pub. Health Lab. Service 13:48–51.

TRAPIDO, H. and GALINDO, P. 1956. Genus *Haemagogus* in the U. S. Science 123:634, April 13, 1956.