THE IMPORTANCE OF MOSQUITO BREEDING IN TREE HOLES WITH SPECIAL REFERENCE TO THE PROBLEM IN TAHITI

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Although it is a well-known fact that the tree hole serves as a common site for the breeding of certain mosquitoes, this location is frequently dismissed as a source of minor importance. This may be the result of beliefs that (1) the species involved are exotic forms of interest only to the taxonomist, (2) the species are unimportant as vectors of disease or as pests of man, (3) tree holes are uncommon, and (4) production of mosquitoes from tree holes is small compared with other types of breeding locations.

It is the purpose of this account to show that tree holes, under certain conditions, constitute a breeding place of major importance. These observations are based primarily upon recent work carried out in Tahiti during the course of studies on the ecology of *Aedes polynesiensis* Marks in connection with the joint Filariasis Control Program of the Institut de Recherches Medicales de l'Oceanie Francaise and the University of California, Los Angeles.[3]

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IMPORTANCE OF TREE HOLES AS SOURCES OF MOSQUITOES. In the recent compilation of information on approximately 1,800 species of mosquitoes, Horsfall (1955) has listed the common breeding sites for about 1,300. Of these, almost 350, or one-quarter, are reported to be found breeding in tree holes, rot holes or bamboo stumps. The species are distributed among 17 genera and include at least 12 species of *Anopheles* and approximately 190 species of *Aedes*.

Nasir (1952) made the observation that "the output of mosquitoes from small, obscure and negligible water collections like tree holes and bamboo stumps may be

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very considerable under tropical conditions." Shute (1954) has stated that indigenous malaria in England is apparently transmitted by the tree hole breeding *Anopheles plumbeus* Stephens. Portmann (1951) reported that in the Sacramento Valley Area, California, the tree hole breeding *Aedes varipalpus* "was a severe pest in areas heavily treed with stands of old trees." Gray (1951) has mentioned briefly that the "larvae of this species have been found in over 15 species of trees in California." In Tahiti, of the 9 species of mosquitoes known to be present, three, *Aedes polynesiensis* Marks, *Aedes aegypti* (Linn.) and *Culex atriceps* Edwards, are regularly found breeding in tree holes. A fourth species, *Culex quinquefasciatus* Say, is found occasionally in association with these other species.

Aedes polynesiensis, the vector of nonperiodic filariasis in the South Pacific, is the most common tree hole breeding mosquito in Tahiti. The larvae of this species are found also in rat-eaten coconuts, bottles, tin cans, drums, crab holes, etc. Of the various types of breeding containers, the tree hole is important for this species in Tahiti because of its permanence, abundance and proximity to human habitation.

Larvae of this species have been found commonly in rot holes or tree holes in the following common trees of Tahiti: Breadfruit, *Artocarpus incisa;* Mape, *Inocarpus edulis;* Coconut, *Cocos nucifera;* Mango, *Mangifera indica;* Avocado, *Persea gratissima;* Guava, *Psidium guajava;* Burau, *Hibiscus tiliaceus;* and Flame Tree, *Poinciana sp.* Almost all of these trees are of economic importance in Tahiti and are usually planted close to dwellings. Since *Aedes polynesiensis* has a short flight range (Jachowski, 1954), this becomes a matter of importance in the transmission of filariasis in Tahiti.

In an effort to determine quantitatively the importance of the different types of trees, a total count of the various trees in an area 100 meters by 2,000 meters was made, i.e., fifty meters on each side of the circumferential road for a distance of two kilometers. A total of 2,416 trees was enumerated and a total of 84 tree holes with larvae of *Aedes polynesiensis* was found. The ranking order for each species of tree was as follows:

TABLE 1

	No.	No. Breeding	Percent Breeding
Flame Tree	11	5	45.4
Breadfruit	291	56	19.2
Mango	115	8	6.9
Miscellaneous *	149	10	5.3
Burau	193	3	1.6
Coconut	1,657	2	0.1

* Includes Bamboo, Ironwood, Kaya, Kapok, Acacia, Guava and others not furnishing breeding places frequently enough in this survey to count separately.

These figures apply only to the particular area where the census was made, as the distribution of trees varies from area to area and it would be necessary to determine the importance of each species of tree for each area. A careful examination was made of the breadfruit trees in an area of 1 hectare around two native style houses. The following results were obtained:

TABLE 2.—Area—10,000 square meters or approximately 2 acres

Number of breadfruit trees—27
Number of trees with one or more tree holes—13, or 50 percent
Number of tree holes—47, or an average of 1.7 per tree
Number of tree holes with water—43, or 91.5 percent
Number with larvae of *Aedes polynesiensis*—14, or 29.6 percent

This can be compared to a survey of rat-eaten coconuts made in an area of equal size. (See Table 3)

The breadfruit tree stands out as a major source of mosquito breeding in Tahiti because of the native agricultural practice of "topping" the trees. This is done

TABLE 3.—Area—10,000 square meters or approximately 2 acres. Area not cleaned up but coconuts partially removed

No. of trees—95
No. of rat-eaten coconuts on ground—542
No. of rat-eaten coconuts with water—147, or 27.1 percent
No. of rat-eaten coconuts with larvae of *Aedes polynesiensis*—8, or 1.4 percent

for the purpose of stimulating the growth of side branches and causing the fruit to develop within reach. The breadfruit when undisturbed grows to great heights with a large single trunk. It is extremely rare to find a breadfruit tree which is not a pollard. This operation initiates an area of center rot and a large cavity usually results. The cavity may be found as high as 90 to 100 feet above the ground and containing immense numbers of larvae.

The tree most frequently found in Tahiti is the commercially important coconut tree. It is widespread in the shore regions and surrounding all areas of habitation. Water-holding cavities may develop in the trunk as the result of cutting climbing steps. Fortunately this is infrequently done in Tahiti. Rat-eaten coconuts are a more important source of mosquitoes than the coconut trees. They are being reduced gradually through a tree-banding program promoted by the French Government in Tahiti.

The problem of the breeding of *Aedes polynesiensis* in tree holes is complicated by the resistance of the eggs to drying (Ingram 1954). First stage larvae have been taken from tree holes within 30 minutes of the introduction of water into dry holes. On several occasions, 4th stage larvae and pupae have been recovered from the moist but not wet debris removed from the bottom of a tree hole after a period of dry weather.

METHODS OF CONTROL. Various methods for the elimination and control of mosquito breeding in tree holes are undergoing trial in Tahiti. Although sufficient time has not yet elapsed to permit a complete appraisal, it is believed that a summary of the methods on trial may be of value to mosquito control workers in other areas with similar problems. The methods can be conveniently considered under (1) chemical treatment, (2) filling and (3) natural control.

CHEMICAL TREATMENT. Herms and Gray (1944) recommended the use of undiluted cresylic acid as a larvicide for tree holes that could not be filled with cement. They also suggested that DDT would probably be more effective because of its strong residual effect. DDT, lindane and dieldrin have all proven effective in Tahiti in tree holes for periods up to three months. The insecticides were applied in concentrated form by means of a hand-oiler and no attempt was made to measure the dosage accurately. The inspector placed one or two squirts from the machine into the hole irrespective of the size. Variations in effectiveness appear to depend upon the amount of debris in the holes, the amount of rainfall and the quantity of insecticide introduced. In general, chemical control for mosquito breeding in tree holes is considered to be of limited value because of impermanence and necessity of repeated applications.

FILLING. The use of tree surgery and subsequent filling with a cement mortar has much to recommend it, as a permanent means of eliminating mosquito breeding tree holes. The usual procedure is to cut out all rotten wood and fill the cavity with a mortar composed of one part Portland cement mixed with 3 parts of sand, with enough water to give a semi-solid mixture. If large holes are to be filled, wire reinforcing will be necessary. If properly done, the growth of the cambium layers of the tree eventually closes over the hole. The coconut tree does not have a cambium layer and hence this overgrowth does not occur. Secondary rotting around the edges of the cement will occur unless precautions are taken to allow complete drainage of water. Thus, holes in coconut trees are not readily eliminated by cementing. This method is excellent for urban areas where the numbers of trees

are small, but is of limited use in extensive rural sylvan areas owing to the cost of materials and semi-skilled labor. Recently trials have been initiated using asphalt asbestos cements (Texacote 370 and Texaco Plastic Car Cement) to top off a filling of sand and gravel. These plastic materials have the advantage of adhering firmly to the edge of the cavity, being flexible and not requiring extensive tree surgery. As yet, it is not possible to make any statement on the permanence or cost of control by this method.

NATURAL CONTROL. The introduction of predatory mosquitoes living in tree holes belonging to the genus *Toxorhynchites* was first suggested by Buxton and Hopkins (1927) and Muspratt (1951). Paine (1943) reports that 10 years after the introduction of *Toxorhynchites splendens,* it has been recovered from eight different islands of Fiji. The African species, *Toxorhynchites brevipalpis,* was introduced into Hawaii in 1951 (Bonnet & Hu 1951) and subsequently a colony was established in Tahiti. Although over 3500 larvae and adults have been released in Tahiti since 1954 in a single location, no wild bred specimens have been recovered.

Although this method of control is without cost and continuous when the introduction is successful, it is doubtful that the resulting control is very effective, owing to the fact that predator species do not reproduce as fast as the mosquitoes they are intended to control.

A new type of natural control which has proved successful in the rural areas of Tahiti is almost filling the tree hole with dirt and gravel and placing a living plant, usually a fern, at the top. The roots of the plant penetrate the soil and rocks and act as a "sponge" to withdraw water from the tree hole cavity. This water is then given off by the plant by transpiration. Various species of ferns have been utilized, particularly *Asplenium* sp. If the tree hole is in a pasture and near the ground, a fern must be chosen which is unattractive to cattle. This can be easily determined by observing the plants present in the pasture, and not eaten by the cattle. Usually one can be found which will serve the purpose. As the fern grows, it completely adjusts to the cavity of the tree even though the tree hole may increase in size. The fern roots firmly attach the plant so that it is not dislodged by heavy rains or wind. A series of tree holes with mosquito larvae were treated in this manner in Tahiti, and after nine months the ferns had grown actively. Also the tree holes contained no water or larvae. This method has the obvious advantages that the materials are always at hand, can be applied by unskilled workers. It is esthetically attractive and inexpensive, as well.

SUMMARY. A review of the problem of mosquito breeding in tree holes is presented with particular reference to the control of *Aedes polynesiensis,* the vector of filariasis in Tahiti. A survey showed that the most important species of tree was the breadfruit (*Artocarpus incisa*) because of its abundance, proximity to dwellings, and the agricultural practice of "topping" or pollarding, resulting in rot holes. A survey showed that there was an average of 1.7 rot holes per tree and that of these 29.6 percent contained larvae of *Aedes polynesiensis.* Methods for the elimination or control of mosquito breeding are discussed including chemical, filling and natural methods. A new method is presented which is cheap, simple and relatively permanent. A fern or similar plant is placed in the rot hole after partial filling with dirt or gravel. The growth of the fern roots the plant firmly in place, and water is withdrawn from the hole by transpiration. Preliminary trials of 9 months duration have shown this method to be effective in eliminating mosquito breeding.

References

BONNET, D. D., and HU, S. 1951. Hawaiian Entomological Soc. Proceedings, 1951, XIV, #2, 237–242.

BUXTON, P. A., and HOPKINS, G. H. F. 1927. Researches in Polynesia and Melanesia. Parts I–IV London School of Hygiene and Tropical Medicine.

GRAY, H. F. 1951. Annual Report 1951, Alameda Mosquito Abatement District, Oakland, Calif., p. 8.

HERMS, W. B., and GRAY, H. F. 1944. Mosquito Control. Commonwealth Fund, New York, 419 pp.

HORSFALL, W. R. 1955. Mosquitoes. Ronald Press, New York, 723 pp.

INGRAM, R. L. 1954. American Journal of Hygiene, v. 60, #2, 169–185.

JACHOWSKI, L. 1954. American Journal of Hygiene, v. 60, #2, 186–203.

MUSPRATT, J. 1951. Bull. Ent. Research, v. 42, #2, 355–370.

NASIR, U. M. 1952. Pakistan Journal of Health, v. 2, 110–112.

PAINE, R. W. 1943. Bull. #22, Department of Agriculture, Fiji 2nd Ed.

PORTMANN, R. F. 1951. Proc. and Papers of the 19th Annual Conference of the California Mosquito Control Association, Berkeley, Calif.

SHUTE, P. G. 1954. Monthly Bull. Ministry of Health and Public Health Laboratory Service, v. 13, 48–51.

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