

## The Introduction of *Toxorhynchites brevipalpis* Theobald into the Territory of Hawaii

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The purpose of this brief paper is to place on record an account of the introduction of the South African mosquito *Toxorhynchites* (= *Megarhinus*) \* *brevipalpis* Theobald into the Territory of Hawaii. The importation of this insect and its establishment would, it is believed, aid in the control of the forest day mosquito, *Aedes albopictus* Skuse.

Any type of container, whether it be a natural container such as a tree hole, bamboo stump, pineapple lily (*Bilbergia* sp.) or rock hole; or an artificial container such as a vine bowl, tin can, tub, auto tire or bottle, when filled with water, can serve as a breeding location for *Aedes albopictus*. This varied breeding habit complicates control as it necessitates the treatment or elimination of a multitude of large and small water-holding containers. Adequate control has been obtained in the urban areas of Hawaii by premises-to-premises inspection, and householder cooperation, following usual *Aedes aegypti* (L.) control procedures. There are, however, large areas outside the cities where such control measures are not feasible. These areas are principally mountain forest regions which contain a sufficient number of natural breeding situations to maintain a large mosquito population. This population of *Aedes albopictus* serves not only as a health menace and as a reservoir for reinvasion, but also discourages extensive use of many fine recreation areas.

From time to time, it has been suggested that a natural predator be introduced to Hawaii to aid in the control of this mosquito. Members of the genus *Toxorhynchites* appear suitable since the larvae of these mosquitoes are known to be carnivorous and to eat other mosquito larvae, while the adults feed exclusively on flower nectar and fruit juices and are structurally unable to bite and suck blood. Buxton and Hopkins (1927) suggested that species of *Toxorhynchites* be introduced into Samoa as a measure of control for the vector of filariasis. Pemberton, in 1929, introduced *Toxorhynchites inornatus* (Walker) from New Britain into Honolulu; and although they survived for at least six months, and larvae were reported several miles from the original point of release (Williams, 1931), no specimens have been recovered in recent years. Paine (1934) introduced *Toxorhynchites splendens* (Wiedemann) from Java into Fiji where it became successfully established in several areas.

\* Stone (1948) has recently shown that the name *Megarhinus* for this genus of mosquitoes was unavailable due to preoccupation and states that the next available name is apparently *Toxorhynchites* Theobald.

Early in 1950, Mr. J. Muspratt, of the Entomological Department of the South African Institute for Medical Research, collected a number of specimens of *Toxorhynchites brevipalpis* from a forest reserve at Margate on the coast of southern Natal, South Africa. These specimens were taken principally from the leaf axils of a species of *Strelitzia* and served as the source material for a colony which was established at the South African Institute in Johannesburg, Union of South Africa. Mr. Muspratt studied the bionomics of this species, and, in correspondence with C. E. Pemberton, Entomologist of the Hawaiian Sugar Planters' Association in Honolulu, offered to send sufficient larvae from the South African colony to start a colony of *Toxorhynchites brevipalpis* in Hawaii.

Mr. Pemberton forwarded the offer to the Department of Health, and with the permission of the President of the Board of Health and of the Director of the Division of Sanitation, the present authors undertook the necessary arrangements preparatory to the establishment of a colony here.

Through the kindness of the H.S.P.A. Experiment Station, and particularly of Dr. H. L. Lyon, Director Emeritus, a building located at the Forest Arboretum in Manoa Valley, Honolulu, was loaned to the Health Department. A large room was completely screened and a double door entry provided. Subsequently, the room was filled with potted plants of various sorts in order to simulate natural conditions and assist in maintaining a high humidity. These plants were obtained through the kindness of Dr. Lyon and the Foster Garden, Honolulu. Temperature and humidity recorders were installed.

The necessary Federal permits were obtained from the Division of Entomology and Plant Quarantine, U. S. Department of Agriculture, and arrangements were made with the Board of Agriculture and Forestry to facilitate the importation.

The first shipment consisting of 22 *Toxorhynchites brevipalpis* larvae were shipped by air from Johannesburg on August 13, 1950, and arrived in Honolulu on August 18, 1950. A total of four separate shipments has been received in Honolulu. Pertinent information concerning these shipments is presented in Table 1.

Table 1

Shipment	Date of Arrival in Honolulu	Elapsed Time	No. Sent	No. Arrived Alive	Per Cent Survival
1	August 18, 1950	5 days	22	13	59
2	October 1, 1950	15 "	108	66	61
3	October 19, 1950	13 "	44	24	54
4	October 26, 1950	7 "	22	18	81
TOTAL			196	121	62

The larvae were shipped by an ingenious method devised by Mr. Muspratt. This method depended upon the discovery that larvae of

this species could survive periods of starvation if immobilized between layers of moist filter paper.

The larvae shipped to Hawaii were laid in the folds of a moist filter paper and packed in a glass vial (1x3 inches). Each vial contained 18 to 22 fourth instar larvae. The vial was closed with a stopper which had two grooves cut into it to admit air. The tubes were placed in individual wooden-block mailing containers and wrapped together in the usual manner for mailing. This method proved entirely successful and good survival was obtained in spite of the great distance and time involved. There apparently was some mortality as a result of cannibalism in the package. This could undoubtedly be avoided if fewer individuals were placed in each vial and care taken to isolate the larvae. The availability of a satisfactory method of shipment will aid immeasurably in the distribution of the species in the Territory of Hawaii and in possible future shipments elsewhere in the Pacific.

Upon arrival the larvae were placed in individual containers, either bamboo or glass, together with *Aedes* or *Culex* mosquito larvae. The *Toxorhynchites* larvae immediately became active and feeding occurred without delay.

After arrival, it required from 5 to 10 days for the larvae to pupate. Between pupae and imago, about 6.5 days elapsed. Upon emergence, the sex of the adults were determined and they were released into the insectary. This room is approximately 27 feet in length, 11 feet wide and 9 feet in height and has 3 standard windows along one side, and a window at each end. The temperature, without artificial heat, ranged between 64°-87° F., with an average room temperature of 74° F. during the

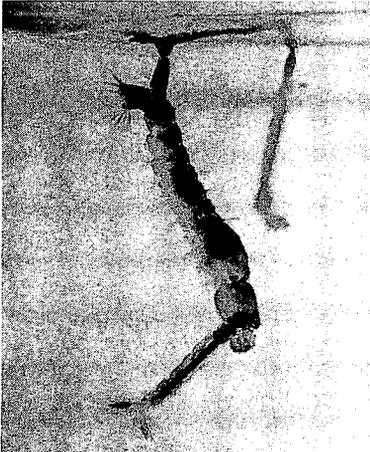


Fig. 1

Fig. 1. Fourth instar larva of *Toxorhynchites brevipalpis* feeding on fourth instar *Aedes albopictus* larva. Enlarged 1.5 times.

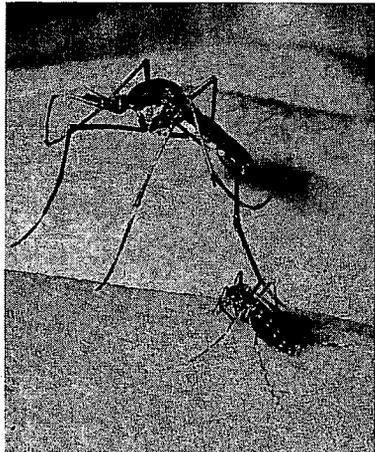


Fig. 2

Fig. 2. Adult female of *Toxorhynchites brevipalpis* (above) and adult female of *Aedes albopictus* (below), to show relative size. Enlarged about 2 times.

period. The relative humidity ranged between 70 and 80 per cent. Fruit and fresh flowers were placed in the room as food for the adults. In addition, cotton balls soaked in 10 per cent corn syrup or honey were suspended on strings at strategic locations. Various water-holding containers including bamboo pots, wooden tubs, glass jars, tin cans, pineapple lilies (*Bilbergia thyrsoidea*), aye plants (*Alocasia macrorrhiza* var.) and small *Strelitzia* plants were distributed throughout the room as egg-laying receptacles. Several bamboo pots, glass jars and tin cans were placed on shelves near the ceiling or hung on wires.

The first shipment showed a disparity of sexes in the emerged adults. The first 11 to emerge over a period of 3 weeks were males. The 2 females emerged when there were very few males surviving. In spite of this difficulty, and although no copulation or egg-laying was observed, 6 *Toxorhynchites* larvae were found in a wooden tub on the floor (1 recovered September 18, 5 recovered September 21). Thus the first larvae of *Toxorhynchites brevipalpis* produced in the Hawaiian colony were recovered one month after the shipment was received from South Africa.

Later shipments did not show an abnormal sex ratio and males and females emerged in about equal numbers. With adequate numbers of adults in the room, copulation and egg-laying have been readily observed and are worthy of description. The adults are not active and are usually seen resting on the walls or on the vegetation. This is particularly true where the temperature is below 70° F. When a female is flying about, a male will dash out from his resting place and clasp with the female in mid-air. The two insects lose directional flight and tumble downward, falling a distance of 4 to 6 feet. During this time, copulation is apparently consummated. Near the floor, the male releases the female and flies away. The female may continue to the floor, where she rests a short while before flying back to the wall or foliage. Mating can occur within a day after emergence and egg-laying begins approximately one week later.

Egg-laying occurs only when the temperature has risen above 72° F. This occurs most frequently during the afternoons. The female flies about searching for water-containers and, finding a suitable one, will hover for several seconds over the water surface at a height of 1 to 3 inches. As she hovers, she moves up and down in a rhythmic manner. As the egg is produced, the abdomen is depressed in a convulsive movement which ejects the egg forward from the female at an angle of approximately 30° to the surface of the water. Occasionally the egg will not land on the water but will stick to the side of the container at a height above the water surface. This hovering has been observed on several occasions to continue until from 2 to 7 eggs are laid in the same container. The female then flies off to repeat the performance in other containers. These observations on copulation and egg-laying are similar to those described by Muspratt in his manuscript on the bionomics of *Toxorhynchites brevipalpis*, which he was kind enough to send us before its publication.

The choice of egg-laying site does not appear to be restricted, since eggs or larvae have been recovered from all types of containers. These

include not only the preferred bamboo pot and wooden tub, but also tin cans, glass jars, trays and vine bowls. Perhaps the most unusual example has been the recovery of larvae from beer cans which have only a triangular opening produced by a can punch. Rusty water has not proved to be a deterrent to egg-laying, and eggs have been recovered from a rusty tin plate and from rusty tin cans on several occasions. Whether this will occur outside the laboratory colony is not known.

The eggs that are found are placed in individual test tubes and held for hatching. This occurs in approximately three days and our records indicate that 66 per cent of the eggs have produced larvae. These larvae are raised in individual glass tumblers in order to eliminate possible cannibalism.

The *Toxorhynchites* larvae are fed on various sizes of *Culex* larvae during their development. Pupation occurs in approximately 4 weeks. The pupae are removed to a cage in order to determine the sex of the emerged adults. A total of 575 pupae has been produced through December 1950, and a total of 245 females and 252 males has emerged. The loss of 78 (13 per cent) pupae which failed to emerge is unexplained and an effort is being made to reduce this mortality. The number of larvae lost during development varies, and it is difficult to determine an accurate mortality figure. It can be estimated, however, that from approximately 1500 eggs, 1000 hatched, and of this number, 497 adults have emerged—giving an over-all larval and pupal mortality of approximately 50 per cent. Starvation, particularly during the youngest stages, appears to be the principal contributing factor and recent changes in technique will, it is hoped, reduce the mortality.

As of December 30, 1950, a total of 103 adults (68 females and 35 males) has been released in the bamboo forest in Nuuanu Valley, Honolulu, but it is too early to determine if they have become established. In the meantime, colony breeding is being continued and expanded, to provide as many individuals as possible for release into suitable natural locations. At the present time there are approximately 800 specimens on hand.

#### SUMMARY

A laboratory colony of *Toxorhynchites brevipalpis* Theobald has been successfully established in Honolulu, from 121 larvae imported by air from South Africa. Breeding has occurred readily in the insectary and both copulation and egg-laying have been observed.

Approximately one-third of the eggs laid failed to hatch, and of those that succeeded, only 50 per cent have been raised to adults. This mortality appears to be the result of starvation during the early stages. Although bamboo pots and wooden tubs appear to be preferred sites for egg-laying, eggs or larvae have also been recovered in the insectary in both clean and rusty tin cans, glass jars and the axils of plants. Egg-laying is apparently inhibited by temperatures less than 72° F.

A total of 68 mated females and 35 males has been released in a bamboo forest close to Honolulu during the month of December 1950. The colony

is being maintained and further releases will be made as the insectary population warrants it.

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