

Status of *Toxorhynchites* in Hawaii

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(Submitted for publication December, 1962)

The attempt to utilize *Toxorhynchites* species for biological control of *Aedes albopictus* (Skuse) in Hawaii began in 1929 when Pemberton first introduced *T. inornatus* (Walker) from New Britain. Although specimens survived for at least six months, and larvae were reported several miles from the original point of release, none have been recovered in recent years (Bonnet and Hu, 1951). In 1950, J. Muspratt of the Entomology Department of the South African Institute for Medical Research, in correspondence with C. E. Pemberton, offered to send sufficient larvae of *T. brevipalpis* Theobald from South Africa to Hawaii to reintroduce *Toxorhynchites* spp. The offer was forwarded to the Department of Health, and in August 1950 the first air shipment of 22 *T. brevipalpis* larvae from Johannesburg (Bonnet and Hu, 1951) was received. Beginning on November 27, 1953 the first of several shipments of *T. theobaldi* (Dyar and Knab) (introduced as *T. hypoptes* Knab) in larval and pupal stages was received from Lt. Col. Franklin S. Blanton, 25th Preventive Medicine Survey Detachment, Ft. Clayton, Panama. On or about December 1, 1953, *T. splendens* (Wiedemann) was introduced into Hawaii by Stephen M. K. Hu when he brought back 95 larvae and pupae on his return to Honolulu from the Eighth Pacific Science Congress in Manila. Of the three species introduced, two, *T. brevipalpis* (Bonnet and Hu, 1951) and *T. splendens*, were successfully propagated in the laboratory. The third, *T. hypoptes*, was difficult to rear and the laboratory culture of this species was discontinued (Hu, 1955).

From 1950 to 1957 periodic field releases were made, initially limited to the principal island of Oahu. The plan of release (Hu, 1955) called for the liberation of batches of about 500 adults from time to time near the heads of valley and mountain forests where there are abundant tree holes and other breeding places. In June 1954, the field releases of both species were extended to the neighbor islands. A recapitulation of the

¹The principals responsible for the introduction and successful colonization of the species, Stephen M. K. Hu and David D. Bonnet, were no longer connected with the Department when the author joined the staff in 1958. Unpublished information presented in this paper involving work done prior to 1958 was obtained from correspondence and records on file, as well as from remaining staff members who have actively assisted in the project since its inception in 1950, especially Tomio Mukaida who was in charge of the insectary.

numbers of *Toxorhynchites* released by islands during the span of seven years is present below:

Species and Stages of Releases, 1950–1957

	<i>T. brevipalpis</i>			<i>T. splendens</i>		
	Larva	Pupa	Adult	Larva	Pupa	Adult
Oahu.....	600	10,462	76,804		13,638	15,836
Hawaii.....		300	18,631			1,797
Kauai.....			15,261			1,939
Maui.....			13,261			391
Molokai.....			209		627	732
TOTAL.....	600	10,762	124,166		14,265	20,695

Based on larval recoveries to date, it appears that establishment in several areas has occurred. Earlier, it was reported by Nakagawa and Hirst (1959) that *T. brevipalpis* and *T. splendens* were established on Oahu in Palolo (Waiomao Valley), Haiku, Wahiawa, and Makiki, and *T. splendens* on Kauai in Lihue. Subsequent areas of establishment on Oahu include upper Kalihi Valley, Waiahole Valley, Maunawili Valley, and Waimanalo Valley. On Kauai, *T. brevipalpis* is probably established, as a batch of 10 larvae was recovered in July 1962 at Lihue. On Hawaii, the recovery of two larvae in a former *T. brevipalpis* release site at a refuse dump in Keauhou, Kona, on January, 1962, indicates at least a light establishment on that island.

The Maunawili Valley and Waimanalo Valley foci on Oahu are indicative of the successful natural spread of the species. In both instances the nearest release points were in respective adjacent valleys 3.5 to 4 miles away, and separated by ridges 1,000 to 2,000 feet high. The ability of *Toxorhynchites* to disperse has been established on several occasions by staff members who have answered calls for assistance from frightened people who claim to have discovered "giant mosquitoes" on their premises. These *Toxorhynchites* adults had apparently dispersed from liberation sites at the heads of valleys 3 to 4 miles away. As an indication of its probable flight range, a case history on file documents the recovery of *T. splendens* on Kauai over an estimated distance of 15 miles.²

Under Hawaiian conditions, both species appear to be highly domesticated, breeding extensively in artificial containers such as tin cans, automobile tires, refrigerator shells, and buckets. In fact, highly successful areas for establishment have been refuse dumps in high rainfall areas.

²On February 29, 1956, Stephen Au, Entomologist with the State Board of Agriculture, while driving in upper Kalaheo, Kauai, heard a strange humming sound, then saw something on his windshield which he immediately caught. Suspecting it to be the newly introduced *Toxorhynchites* he sent it in to Honolulu where it was identified as *T. splendens*. The only release point of this species on Kauai up to that time was in upper Wailua River Valley, approximately 15 miles across the island over a ridge ranging in height from 3,500 to 5,000 ft.

On the other hand, breeding in natural niches such as tree holes, bamboo stumps, and leaf axils seems to be negligible. In spite of heavy releases both species have failed to establish themselves in a seemingly highly favorable forest area where natural breeding containers predominate, located in upper Nuuanu Valley, Oahu, with an annual rainfall of 100 to 120 inches. Of as many as 1,318 bamboo holes which were examined, 684 or 52 percent were found breeding the host, *Aedes albopictus*, yet none contained any *Toxorhynchites* larvae.

As stated by Bonnet and Hu (1951), the introduction of *Toxorhynchites* into Hawaii was geared to meet a very specific control need—that of trying to contribute to the control of *Aedes albopictus* beyond the range of the existing routine control program. Under such circumstances, *Toxorhynchites* will undoubtedly contribute somewhat to the reduction of the total host population. Under stricter control prerequisites, however, such as the attainment of an effective sanitary threshold of the vector population, the value of *Toxorhynchites* is questionable. Nakagawa and Hirst (1959) reported consistently observing the overwhelming presence of the adult host species in areas successfully colonized by the predator, which would lead to the conclusion outwardly, that the predator is ineffective. To justify such a contention, a cursory survey covering an area of approximately one square mile was recently conducted in a well established area (upper Palolo Valley, Oahu).

The findings revealed that of 298 artificial containers (such as tin cans, buckets, and tires) examined, 211 were found to be breeding *Aedes albopictus* in varying degrees, and only 51 or about 24 percent contained the predator. Furthermore, of the 24 percent of the containers successfully colonized by the predator at the average rate of 2.2 larvae per container, the surviving prey population averaged 5.6 larvae. Very few natural breeding containers were present in the area sampled. Of five tree holes inspected, five were found to be breeding *A. albopictus*; however, none of them contained any *Toxorhynchites* larvae. The foregoing preliminary findings, although based on minimal sampling, do serve to imply certain shortcomings on the part of the predator and serve to support Newkirk's conclusion (1947) that such intrinsic factors as long life cycle, few offspring, and its low survival rate tend to nullify its importance in biological control.

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