The Distribution of Mosquito Breeding by Type of Container in Honolulu, T. H.*

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During the late summer of 1943, because of the outbreak of dengue fever, there was established in Honolulu a mosquito control unit under the auspices of the Board of Health of the Territory of Hawaii, with funds and personnel supplied by the Honolulu Chamber of Commerce, the U. S. Public Health Service, and the U. S. Army. In the Territory of Hawaii, there are three species of mosquitoes: *Aedes aegypti* (L.), *Aedes albopictus* (Skuse), and *Culex quinquefasciatus* Say. Both of the *Aedes,* or "day-biting" mosquitoes, are known vectors of dengue fever (Cleland, J. B., Bradley, B., and McDonald, W., 1916; Chandler and Rice, 1923; Siler, Hall, and Hitchens, 1924; and Simmons, St. John, and Reynolds, 1930); hence, the primary function of the mosquito control unit was to inspect for and, eliminate the breeding places of the *Aedes* mosquitoes. Incidental to this primary function, samples of mosquito larvae were collected which serve as the basis for this paper. Acknowledgment is made to the many mosquito control inspectors who gathered the larval mosquito samples.

Previous studies on the bionomics and more particularly the breeding places of these species have been made in other areas by Liston and Akula (1913), MacFie (1915), Senior-White (1934), Sen (1935), Robertson and Hu (1935), and Wijesundara (1942). Studies of breeding preferences have been made in relation to various physical factors, including salinity (Woodhill 1938, 1941), hydrogen-ion concentration (Senior-White, 1926), organic nitrogen concentration (Beattie, M.V.F., 1932), and "water-finding" (Kennedy, 1942). Van Dine (1904), Williams (1944), and Usinger (1944) have studied and reported on the biology of the three species of mosquitoes in Hawaii.

Although it has been generally known that *Aedes albopictus* and *Aedes aegypti* breed primarily in domestic containers, more information was desired on the distribution of *Aedes* breeding in Honolulu. To obtain this information, a census was taken for a period of 22 months, not only of the places where *Aedes* mosquitoes were found breeding, but also of the numbers of all types of possible or potential breeding containers. Since a mosquito control inspec-

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tor inspected all premises in the city of Honolulu at least once every four weeks, this census is fairly accurate with reference to area coverage. However, among a large number of different individuals there are certain variations in the manner of counting. The resulting variations in recording were somewhat reduced by the fact that the inspectors were rotated from area to area, which would tend to level out these differences. Perhaps, the most serious error lies in the fact that a large accumulation of bottles or tin cans in one location was considered not in absolute numbers but as "more than 10" or "10 plus." The result was a reduction in the absolute numbers of these containers recorded and hence, a reduction in the apparent percentage with respect to other containers. This error is not as bad as it would appear since the same method was used in all cases of both breeding and non-breeding situations and thus tends to balance the results, enabling one to make a satisfactory comparison.

The distribution of "potential" or "possible" mosquito breeding containers in the city of Honolulu is presented in Figure 1. These percentages are based upon a total count of 4,450,041 containers and show the relative importance of the different categories. The group entitled "others" includes such miscellaneous possible breeders as tarpaulins, odd pieces of junk, tree holes, roof gutters, etc. Interior containers include all those used for flower or plant holders inside dwellings, such as vine bowls and flower vases. The ape plants (*Alocasia macrorrhiza* var.) and lily plants, including pineapple lily (*Bilbergia thyrsoidea*) and the spider lily (*Crinum asiaticum*), are found in approximately equal numbers and are potential mosquito breeders owing to the water retained in the leaf axils. The other groups are self-explanatory.

The distribution of "actual" breeding, according to the same classifications, is presented in Figure 2 and is based upon 41,226 samples of *Aedes* larvae. A comparison of Figures 1 and 2 shows that most of the containers have a different importance when considered from the standpoint of breeding. For example: although *barrels* constituted only 8.4% of all containers, we find that they contained 10.7% of all discovered *Aedes* breeding. Similarly, although the *ape* and *lily plants* were approximately equal in number, constituting 7.4% and 7.1% of the breeding sources respectively, the *lily plants* are more important as breeders since 12.6% of all breeding was found in this type of container, whereas *ape* plants contained only about 4%. Records reveal an interesting correlation between the type of container and the amount of mosquito breeding. In *interior containers* which constituted 10.9% of all containers examined there was found 10.6% of all mosquito breeding recorded.

The most extreme difference to be noted between number of containers and amount of breeding found in them is that of the

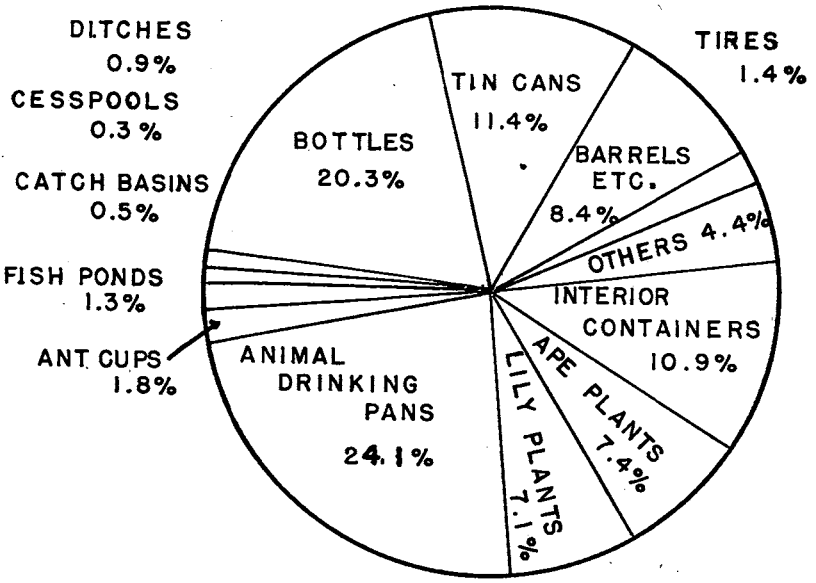

FIG. 1

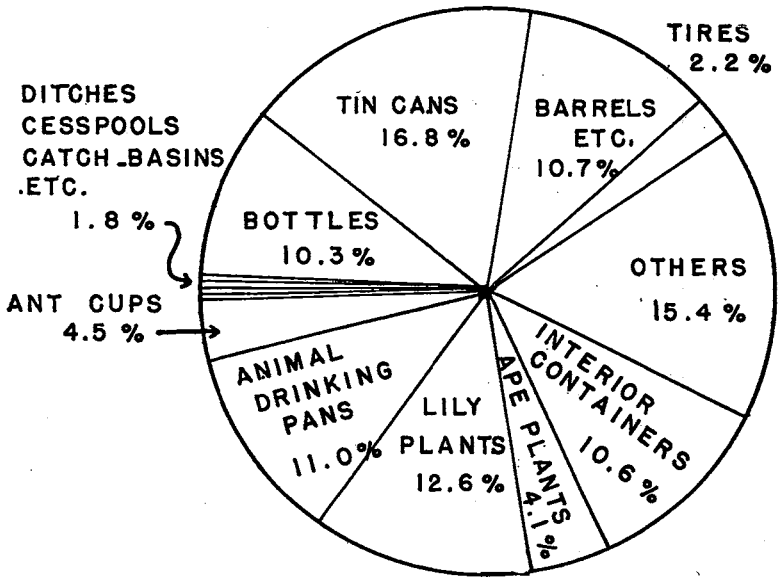

FIG. 2

Figure 1.—Distribution of containers in Honolulu according to container type.
Figure 2.—*Aedes* mosquito breeding in Honolulu according to container type.

miscellaneous group labeled "others." Although this group was reported as only amounting to 4.4% of the containers in the city, they contained 15.4% of all mosquito breeding. This great difference may be somewhat fictional since this group includes breeding found in containers that one would seldom count as a "potential" or "possible" breeding container, such as an old shoe, boats, tarpaulins, pipe fence posts, and a hundred other locations. Since it is known that breeding may occur in almost any location that will hold water for from 10 to 14 days, this not surprising.

The preceding information is presented graphically in Figures 3 and 4. These graphs merely group the different types of containers to show the relative number of container types and the relative amount of breeding respectively, according to the larger classifications used in control operations. The *accidental containers* include all unnecessary incidental types of containers, such as bottles, tin cans, barrels, tires, etc. The *interior containers,* which may be considered semi-useful, include flower vases and vine bowls; *outdoor plants* include *ape* and lily plants; *semi-permanent useful containers* include animal drinking pans and ant cups, while *permanent useful containers* include cesspools, fishponds, sumps, and ditches.

If *Aedes* mosquito breeding occurred at random in all types of containers, one would expect that the distribution of mosquito breeding would be in the same proportion as the relative numbers of containers; that this is not the case is indicated by comparison of the above figures and is an indication that these mosquitoes show definite preferences for the places that they choose to lay their eggs.

Further evidence of such preference is presented in Table 1, which lists the percentage of a random sample of each of the three species found in Honolulu according to the container in which they were found. This table is presented according to rank for *Aedes albopictus,* and immediate differences may be noted when this column is compared with the columns for *Aedes aegypti* and *Culex quinquefasciatus.* In examining these data, allowance must be made for the fact that the information has been gathered during regular inspection-control operations by a large number of different individuals and that certain errors in recording data were made. This is particularly true in the case of *Aedes* larvae being reported in ditches and ground pools. Investigation of all reported instances showed that only rarely was there an actual case of breeding in an earth-lined container. Usually the apparent presence of mosquito breeding there occurred as a result of a bucket, tin can, or bottle which contained breeding mosquitoes having been emptied into the outdoor pool by the householder in anticipation of the inspector's visit when he was observed next door. These data are, therefore, useful only in a relative way and permit only an approximation of the differences in preference of *Aedes aegypti, Aedes albopictus,*

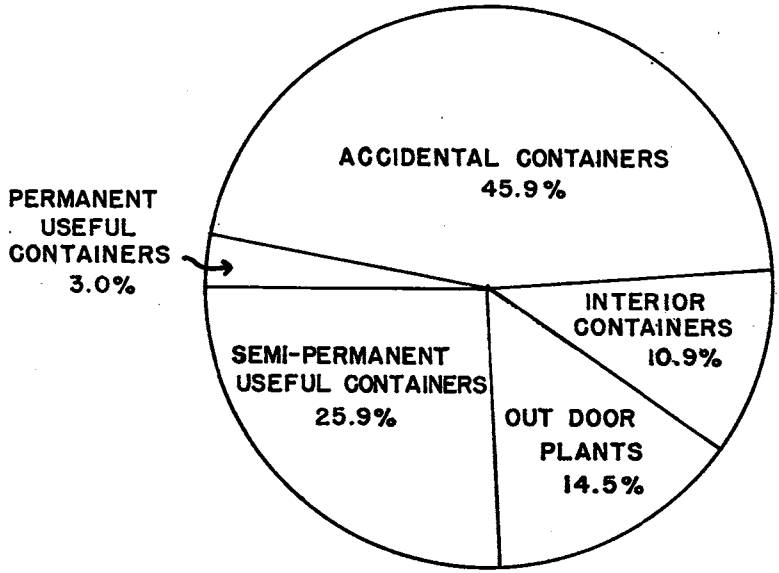

FIG. 3

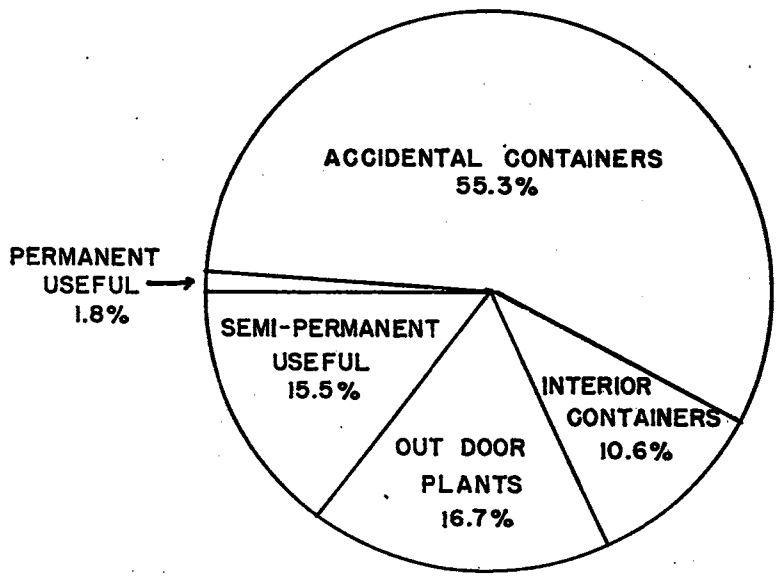

FIG. 4

Figure 3.—Distribution of containers in Honolulu according to container type.
Figure 4.—*Aedes* mosquito breeding in Honolulu according to container type.

TABLE I

Distribution of Mosquito Breeding By Species According to Container

1944 — 1945

Containers	Aedes albopictus	Aedes aegypti	Culex quinquefasciatus
No. of Samples	1014	922	924
Tin cans	19.4%	13.4%	16.2%
Flower vases	13.0	11.9	0.0
Lily plants	10.7	1.4	1.1
Vine bowls	7.8	6.9	.9
Pans	7.4	11.6	5.9
Bottles	6.5	9.9	1.4
Buckets	5.9	13.7	13.7
Jars	4.4	0.0	1.5
Ant cups	4.1	5.6	.3
Ape plants	3.9	2.0	0.0
Tree holes	3.7	1.8	0.0
Rock holes	2.1	0.9	0.0
Tires	1.5	2.9	1.5
Barrels	1.3	3.4	10.1
Fish ponds	1.1	2.3	7.0
Pipes	1.1	0.0	0.0
Bird baths	.7	.2	.3
Toilet bowls	.6	1.2	0.0
Ground pools, ditches	.6	.9	19.7
Bamboo stumps	.6	0.0	0.0
Tanks	.5	1.4	1.0
Coconut shells	.2	0.0	.1
Cesspools	.1	.2	1.2
Catch basins	0.0	2.8	2.7
Tubs	0.0	5.0	4.1
Boats	0.0	.4	1.4
Machine parts	0.0	.1	0.0
Streams	0.0	0.0	.4
Swamps	0.0	0.0	2.5

and *Culex quinquefasciatus* for breeding places. It is interesting to note the comparative rank of the four most common container types found breeding the different species as listed below:

Aedes albopictus	Aedes aegypti	Culex quinquefasciatus
Tin cans	Buckets	Ditches and ground pools
Flower vases	Tin cans	Tin cans
Lily plants	Flower vases	Buckets
Vine bowls	Pans	Barrels

Tin cans are of prime importance for all three species. *Aedes albopictus* and *Aedes aegypti* have a high degree of common preference. Although *Culex quinquefasciatus* shows a high degree of difference in its preferences, it appears more closely related to *Aedes aegypti* than to *Aedes albopictus* in its breeding habits. This

may be seen strikingly in the fact that *Aedes albopictus* was not found in catch basins, while *Aedes aegypti* and *Culex quinquefasciatus* were found there with about the same frequency.

These figures, graphs, and charts have a practical value in the operation of a mosquito control program. Although the data have certain limitations of analysis owing to the manner of collection, they emphasize the importance of all types of "accidental containers" as places for the breeding of the species of mosquitoes found in the city of Honolulu.

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